Energy Efficiency Potential Summary Study

Volume 2: Appendices E to S

CALMAC Study ID: PGE0211.03

Submitted to:

Pacific Gas & Electric
123 Mission Street
San Francisco, California 94105

Submitted by:

Itron, Inc.
11236 El Camino Real
San Diego, California 92130
(858) 481-0081

KEMA, Inc.
492 Ninth Street, Suite 220
Oakland, California 94607
(510) 891-0446

RLW Analytics, Inc.
1055 Broadway, Suite C
Sonoma, California 95476
(707) 939-8823

Architectural Energy Corp.
2540 Frontier Avenue, #201
Boulder, Colorado 80301
(303) 444-4149

Itron

May 24, 2006

Table of Contents

Appendix E

DSM ASSYST Model Inputs for Existing Industrial Buildings

The data included in this appendix are also available in Microsoft Excel format on DVD by request.[1]

E.1 Economic Parameters

Economic parameters are provided by utility and fuel type (electricity and natural gas). These data include assumptions about inflation rates, discount rates, avoided cost projections and rate projections. Avoided costs are provided by TOU period:

- SOP: Summer On-Peak
- SPP: Summer Partial-Peak
- SOFF: Summer Off-Peak
- WPP: Winter Partial-Peak
- WOFF: Winter Off-Peak

E.2 Building Stock and Load Shapes

These data are provided by fuel type. Building stock data consists of base energy consumption (annual kWh and therms) by utility and industry segment. Load shape data consists of the following:

- Factors that allocate end use energy consumption to the 5 TOU periods used in the study, and
- Factors that related peak hour demand to average demand for a given TOU period.

[1] Please contact Angela Nenn via email to request a copy of the DVD. Angela.Nenn@Itron.com

E.3 Measure Characteristics

Measure data is provided by fuels type (electric measures, followed by natural gas measures). Measure data is broken out into the following elements:

- Measure Costs – costs, units in which the costs are expressed, and measure lives.
- Technology Saturations – measure cost units per base kWh or base therm.
- Applicability Factors – the fraction of energy consumption (base kWh or therms) that is applicable for the efficient technology in a given market segment.
- Incomplete Factors – the fraction of applicable base kWh or therms that has not yet been converted to the efficient measure; that is, (1 minus the fraction of floor space that already has the EE measure installed).
- Feasibility Factors – the fraction of the applicable base kWh or therms that is technically feasible for conversion to the efficient technology from an *engineering* perspective.
- Measure Savings Fraction - the reduction in energy consumption resulting from application of the efficient technology.

APPENDIX E-1 ECONOMIC INPUTS

Electric Inputs
- PG&E
- SCE
- SDG&E

Natural Gas Inputs
- PG&E
- SCG
- SDG&E

APPENDIX E-1 ECONOMIC INPUTS

ECONOMIC PARAMETERS

UTILITY NAME	PG&E	
SECTOR	Industrial	
BATCH #	1	
UTILITY DISCOUNT RATE	8.15%	
CUSTOMER DISCOUNT RATE	15.0%	
GENERAL INFLATION RATE (Measu	3.0%	
BASE YEAR	2005	
START YEAR	2005	
DIFFERENCE	0	
UTILITY LINE LOSS RATE	0.0%	(Included in avoided costs)

ENERGY COSTS AND RATES

RATE TYPE	Industrial
ENERGY UNITS	$/KWh
DEMAND UNITS	$/KW

Rate/Time Periods	1	2	3	5	6	
Name	Summer On-Peak	Summer Partial-Peak	Summer Off-Peak	Winter Partial-Peak	Winter Off-Peak	
Abbreviation	SOP	SPP	SOFF	WPP	WOFF	TOTAL
Hours	768	896	2752	1638	2706	8760
Monthly Adjustment for rates	6	0	0	6	0	

	AVOIDED ENERGY COSTS BY TIME PERIOD					Industrial ENERGY RATES					Environmental Adder to be Subtracted for RIM
	SOP	SPP	SOFF	WPP	WOFF	SOP	SPP	SOFF	WPP	WOFF	
Year	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh
2005	0.115	0.072	0.049	0.055	0.047	0.117	0.117	0.117	0.117	0.117	0.005
2006	0.115	0.072	0.049	0.055	0.047	0.114	0.114	0.114	0.114	0.114	0.005
2007	0.114	0.071	0.049	0.055	0.047	0.110	0.110	0.110	0.110	0.110	0.005
2008	0.126	0.080	0.056	0.063	0.054	0.107	0.107	0.107	0.107	0.107	0.006
2009	0.127	0.081	0.056	0.064	0.055	0.104	0.104	0.104	0.104	0.104	0.007
2010	0.130	0.083	0.058	0.066	0.056	0.101	0.101	0.101	0.101	0.101	0.007
2011	0.135	0.086	0.060	0.068	0.058	0.098	0.098	0.098	0.098	0.098	0.007
2012	0.139	0.089	0.062	0.071	0.060	0.095	0.095	0.095	0.095	0.095	0.008
2013	0.144	0.093	0.065	0.074	0.063	0.092	0.092	0.092	0.092	0.092	0.008
2014	0.149	0.096	0.067	0.077	0.065	0.095	0.095	0.095	0.095	0.095	0.009
2015	0.153	0.099	0.070	0.079	0.068	0.098	0.098	0.098	0.098	0.098	0.009
2016	0.158	0.103	0.072	0.082	0.070	0.101	0.101	0.101	0.101	0.101	0.010
2017	0.164	0.106	0.075	0.086	0.073	0.104	0.104	0.104	0.104	0.104	0.011
2018	0.169	0.110	0.078	0.089	0.076	0.107	0.107	0.107	0.107	0.107	0.011
2019	0.175	0.114	0.081	0.092	0.078	0.110	0.110	0.110	0.110	0.110	0.012
2020	0.180	0.118	0.083	0.096	0.081	0.113	0.113	0.113	0.113	0.113	0.013
2021	0.187	0.123	0.087	0.099	0.085	0.117	0.117	0.117	0.117	0.117	0.013
2022	0.193	0.127	0.090	0.103	0.088	0.120	0.120	0.120	0.120	0.120	0.014
2023	0.198	0.130	0.092	0.106	0.090	0.124	0.124	0.124	0.124	0.124	0.015
2024	0.203	0.134	0.095	0.109	0.093	0.127	0.127	0.127	0.127	0.127	0.016
2025	0.210	0.138	0.098	0.112	0.096	0.131	0.131	0.131	0.131	0.131	0.016

APPENDIX E-1

ECONOMIC INPUTS

ECONOMIC PARAMETERS

UTILITY NAME	SCE
SECTOR	Industrial
BATCH #	1
UTILITY DISCOUNT RATE	8.15%
CUSTOMER DISCOUNT RATE	15.0%
GENERAL INFLATION RATE (Measu	3.0%
BASE YEAR	2005
START YEAR	2005
DIFFERENCE	0
UTILITY LINE LOSS RATE	0.0% (Included in avoided costs)

ENERGY COSTS AND RATES

RATE TYPE	Industrial
ENERGY UNITS	$/KWh
DEMAND UNITS	$/KW

Rate/Time Periods	1	2	3	5	6	
Name	Summer On-Peak	Summer Partial-Peak	Summer Off-Peak	Winter Partial-Peak	Winter Off-Peak	
Abbreviation	SOP	SPP	SOFF	WPP	WOFF	TOTAL
Hours	768	896	2752	1638	2706	8760
Monthly Adjustment for rates	6	0	0	6	0	

	AVOIDED ENERGY COSTS BY TIME PERIOD					Industrial ENERGY RATES					Environmental Adder to be Subtracted for RIM
	SOP	SPP	SOFF	WPP	WOFF	SOP	SPP	SOFF	WPP	WOFF	
Year	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh
2005	0.112	0.084	0.047	0.059	0.046	0.082	0.082	0.082	0.082	0.082	0.005
2006	0.111	0.084	0.047	0.060	0.046	0.083	0.083	0.083	0.083	0.083	0.005
2007	0.112	0.085	0.047	0.061	0.047	0.084	0.084	0.084	0.084	0.084	0.005
2008	0.117	0.089	0.050	0.064	0.050	0.085	0.085	0.085	0.085	0.085	0.006
2009	0.118	0.090	0.050	0.065	0.050	0.086	0.086	0.086	0.086	0.086	0.007
2010	0.122	0.093	0.052	0.067	0.052	0.087	0.087	0.087	0.087	0.087	0.007
2011	0.127	0.097	0.054	0.070	0.054	0.085	0.085	0.085	0.085	0.085	0.007
2012	0.132	0.101	0.057	0.073	0.057	0.082	0.082	0.082	0.082	0.082	0.008
2013	0.137	0.106	0.059	0.076	0.059	0.084	0.084	0.084	0.084	0.084	0.008
2014	0.142	0.110	0.061	0.079	0.061	0.087	0.087	0.087	0.087	0.087	0.009
2015	0.147	0.114	0.064	0.082	0.064	0.089	0.089	0.089	0.089	0.089	0.009
2016	0.152	0.119	0.066	0.085	0.066	0.092	0.092	0.092	0.092	0.092	0.010
2017	0.156	0.122	0.068	0.087	0.068	0.095	0.095	0.095	0.095	0.095	0.011
2018	0.162	0.127	0.071	0.091	0.071	0.097	0.097	0.097	0.097	0.097	0.011
2019	0.168	0.132	0.074	0.095	0.074	0.100	0.100	0.100	0.100	0.100	0.012
2020	0.174	0.137	0.077	0.098	0.077	0.103	0.103	0.103	0.103	0.103	0.013
2021	0.180	0.141	0.079	0.102	0.079	0.106	0.106	0.106	0.106	0.106	0.013
2022	0.187	0.147	0.083	0.106	0.083	0.110	0.110	0.110	0.110	0.110	0.014
2023	0.192	0.150	0.085	0.109	0.085	0.113	0.113	0.113	0.113	0.113	0.015
2024	0.198	0.155	0.087	0.112	0.087	0.116	0.116	0.116	0.116	0.116	0.016
2025	0.204	0.160	0.090	0.115	0.090	0.120	0.120	0.120	0.120	0.120	0.016

APPENDIX E-1

ECONOMIC INPUTS

ECONOMIC PARAMETERS

UTILITY NAME	SDG&E	
SECTOR	Industrial	
BATCH #	1	
UTILITY DISCOUNT RATE	8.15%	
CUSTOMER DISCOUNT RATE	15.0%	
GENERAL INFLATION RATE (Measu	3.0%	
BASE YEAR	2005	
START YEAR	2005	
DIFFERENCE	0	
UTILITY LINE LOSS RATE	0.0%	(Included in avoided costs)

ENERGY COSTS AND RATES

RATE TYPE	Industrial
ENERGY UNITS	$/KWh
DEMAND UNITS	$/KW

Rate/Time Periods	1	2	3	5	6	
Name	Summer On-Peak	Summer Partial-Peak	Summer Off-Peak	Winter Partial-Peak	Winter Off-Peak	
Abbreviation	SOP	SPP	SOFF	WPP	WOFF	TOTAL
Hours	768	896	2752	1638	2706	8760
Monthly Adjustment for rates	6	0	0	6	0	

	AVOIDED ENERGY COSTS BY TIME PERIOD					Industrial ENERGY RATES					Environmental Adder to be Subtracted for RIM
	SOP	SPP	SOFF	WPP	WOFF	SOP	SPP	SOFF	WPP	WOFF	
Year	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh	$/KWh
2005	0.133	0.104	0.050	0.058	0.045	0.113	0.113	0.113	0.113	0.113	0.005
2006	0.133	0.105	0.050	0.059	0.046	0.112	0.112	0.112	0.112	0.112	0.005
2007	0.135	0.106	0.051	0.059	0.046	0.114	0.114	0.114	0.114	0.114	0.005
2008	0.139	0.110	0.054	0.063	0.049	0.111	0.111	0.111	0.111	0.111	0.006
2009	0.141	0.112	0.054	0.063	0.049	0.112	0.112	0.112	0.112	0.112	0.007
2010	0.145	0.115	0.056	0.065	0.051	0.114	0.114	0.114	0.114	0.114	0.007
2011	0.151	0.119	0.058	0.068	0.053	0.114	0.114	0.114	0.114	0.114	0.007
2012	0.156	0.123	0.061	0.071	0.056	0.110	0.110	0.110	0.110	0.110	0.008
2013	0.161	0.128	0.063	0.074	0.058	0.114	0.114	0.114	0.114	0.114	0.008
2014	0.167	0.132	0.065	0.077	0.060	0.117	0.117	0.117	0.117	0.117	0.009
2015	0.172	0.136	0.068	0.080	0.062	0.121	0.121	0.121	0.121	0.121	0.009
2016	0.178	0.140	0.070	0.083	0.065	0.124	0.124	0.124	0.124	0.124	0.010
2017	0.182	0.144	0.072	0.085	0.067	0.128	0.128	0.128	0.128	0.128	0.011
2018	0.189	0.150	0.075	0.089	0.070	0.132	0.132	0.132	0.132	0.132	0.011
2019	0.196	0.155	0.078	0.093	0.072	0.136	0.136	0.136	0.136	0.136	0.012
2020	0.202	0.160	0.081	0.096	0.075	0.140	0.140	0.140	0.140	0.140	0.013
2021	0.209	0.165	0.084	0.100	0.078	0.144	0.144	0.144	0.144	0.144	0.013
2022	0.216	0.170	0.087	0.104	0.081	0.149	0.149	0.149	0.149	0.149	0.014
2023	0.221	0.175	0.090	0.107	0.083	0.153	0.153	0.153	0.153	0.153	0.015
2024	0.228	0.180	0.092	0.110	0.086	0.158	0.158	0.158	0.158	0.158	0.016
2025	0.235	0.185	0.095	0.113	0.088	0.162	0.162	0.162	0.162	0.162	0.016

APPENDIX E-1 ECONOMIC INPUTS

ECONOMIC PARAMETERS

UTILITY NAME	PG&E	
SECTOR	Industrial	
BATCH #	1	
UTILITY DISCOUNT RATE	8.15%	
CUSTOMER DISCOUNT RATE	15.0%	
GENERAL INFLATION RATE (Measu	3.0%	
BASE YEAR	2005	
START YEAR	2005	
DIFFERENCE	0	
UTILITY LINE LOSS RATE	0.0%	(Included in avoided costs)

ENERGY COSTS AND RATES

RATE TYPE	Industrial
ENERGY UNITS	$/therm
DEMAND UNITS	n/a

Rate/Time Periods	1	2	3	5	6	
Name	Summer On-Peak	Summer Partial-Peak	Summer Off-Peak	Winter Partial-Peak	Winter Off-Peak	
Abbreviation	SOP	SPP	SOFF	WPP	WOFF	TOTAL
Hours	768	896	2752	1638	2706	8760
Monthly Adjustment for rates	6	0	0	6	0	

	AVOIDED ENERGY COSTS BY TIME PERIOD					Industrial ENERGY RATES					Environmental Adder to be Subtracted for RIM
	SOP	SPP	SOFF	WPP	WOFF	SOP	SPP	SOFF	WPP	WOFF	
Year	$/Therm	$/Therm	$/Therm	$/Therm	$/Therm	$/Therm	$/Therm	$/Therm	$/Therm	$/Therm	$/Therm
2005	0.586	0.586	0.586	0.814	0.814	0.750	0.750	0.750	0.750	0.750	0.122
2006	0.587	0.587	0.587	0.812	0.812	0.752	0.752	0.752	0.752	0.752	0.136
2007	0.591	0.591	0.591	0.809	0.809	0.755	0.755	0.755	0.755	0.755	0.140
2008	0.597	0.597	0.597	0.811	0.811	0.762	0.762	0.762	0.762	0.762	0.143
2009	0.601	0.601	0.601	0.818	0.818	0.770	0.770	0.770	0.770	0.770	0.146
2010	0.617	0.617	0.617	0.839	0.839	0.790	0.790	0.790	0.790	0.790	0.149
2011	0.655	0.655	0.655	0.882	0.882	0.832	0.832	0.832	0.832	0.832	0.164
2012	0.690	0.690	0.690	0.922	0.922	0.872	0.872	0.872	0.872	0.872	0.177
2013	0.729	0.729	0.729	0.968	0.968	0.916	0.916	0.916	0.916	0.916	0.192
2014	0.767	0.767	0.767	1.012	1.012	0.960	0.960	0.960	0.960	0.960	0.207
2015	0.808	0.808	0.808	1.059	1.059	1.006	1.006	1.006	1.006	1.006	0.224
2016	0.853	0.853	0.853	1.109	1.109	1.056	1.056	1.056	1.056	1.056	0.243
2017	0.898	0.898	0.898	1.160	1.160	1.106	1.106	1.106	1.106	1.106	0.263
2018	0.947	0.947	0.947	1.216	1.216	1.161	1.161	1.161	1.161	1.161	0.284
2019	1.000	1.000	1.000	1.274	1.274	1.219	1.219	1.219	1.219	1.219	0.308
2020	1.053	1.053	1.053	1.335	1.335	1.279	1.279	1.279	1.279	1.279	0.334
2021	1.113	1.113	1.113	1.401	1.401	1.344	1.344	1.344	1.344	1.344	0.362
2022	1.176	1.176	1.176	1.470	1.470	1.414	1.414	1.414	1.414	1.414	0.393
2023	1.226	1.226	1.226	1.527	1.527	1.470	1.470	1.470	1.470	1.470	0.427
2024	1.262	1.262	1.262	1.573	1.573	1.514	1.514	1.514	1.514	1.514	0.440
2025	1.300	1.300	1.300	1.620	1.620	1.559	1.559	1.559	1.559	1.559	0.453

APPENDIX E-1 ECONOMIC INPUTS

ECONOMIC PARAMETERS

UTILITY NAME	SCG	
SECTOR	Industrial	
BATCH #	1	
UTILITY DISCOUNT RATE	8.15%	
CUSTOMER DISCOUNT RATE	15.0%	
GENERAL INFLATION RATE (Measu	3.0%	
BASE YEAR	2005	
START YEAR	2005	
DIFFERENCE	0	
UTILITY LINE LOSS RATE	0.0%	(Included in avoided costs)

ENERGY COSTS AND RATES

RATE TYPE	Industrial
ENERGY UNITS	$/therm
DEMAND UNITS	n/a

Rate/Time Periods	1	2	3	5	6	
Name	Summer On-Peak	Summer Partial-Peak	Summer Off-Peak	Winter Partial-Peak	Winter Off-Peak	
Abbreviation	SOP	SPP	SOFF	WPP	WOFF	TOTAL
Hours	768	896	2752	1638	2706	8760
Monthly Adjustment for rates	6	0	0	6	0	

	AVOIDED ENERGY COSTS BY TIME PERIOD					Industrial ENERGY RATES					Environmental Adder to be Subtracted for RIM
Year	SOP $/Therm	SPP $/Therm	SOFF $/Therm	WPP $/Therm	WOFF $/Therm	SOP $/Therm	SPP $/Therm	SOFF $/Therm	WPP $/Therm	WOFF $/Therm	$/Therm
2005	0.569	0.569	0.569	0.700	0.700	0.750	0.750	0.750	0.750	0.750	0.122
2006	0.585	0.585	0.585	0.712	0.712	0.768	0.768	0.768	0.768	0.768	0.136
2007	0.588	0.588	0.588	0.707	0.707	0.772	0.772	0.772	0.772	0.772	0.140
2008	0.594	0.594	0.594	0.707	0.707	0.780	0.780	0.780	0.780	0.780	0.143
2009	0.599	0.599	0.599	0.711	0.711	0.788	0.788	0.788	0.788	0.788	0.146
2010	0.618	0.618	0.618	0.733	0.733	0.813	0.813	0.813	0.813	0.813	0.149
2011	0.661	0.661	0.661	0.779	0.779	0.861	0.861	0.861	0.861	0.861	0.164
2012	0.701	0.701	0.701	0.821	0.821	0.907	0.907	0.907	0.907	0.907	0.177
2013	0.740	0.740	0.740	0.866	0.866	0.953	0.953	0.953	0.953	0.953	0.192
2014	0.780	0.780	0.780	0.909	0.909	1.000	1.000	1.000	1.000	1.000	0.207
2015	0.821	0.821	0.821	0.953	0.953	1.047	1.047	1.047	1.047	1.047	0.224
2016	0.866	0.866	0.866	1.001	1.001	1.098	1.098	1.098	1.098	1.098	0.243
2017	0.903	0.903	0.903	1.041	1.041	1.141	1.141	1.141	1.141	1.141	0.263
2018	0.961	0.961	0.961	1.103	1.103	1.207	1.207	1.207	1.207	1.207	0.284
2019	1.014	1.014	1.014	1.159	1.159	1.266	1.266	1.266	1.266	1.266	0.308
2020	1.069	1.069	1.069	1.218	1.218	1.329	1.329	1.329	1.329	1.329	0.334
2021	1.127	1.127	1.127	1.279	1.279	1.394	1.394	1.394	1.394	1.394	0.362
2022	1.193	1.193	1.193	1.350	1.350	1.468	1.468	1.468	1.468	1.468	0.393
2023	1.244	1.244	1.244	1.403	1.403	1.526	1.526	1.526	1.526	1.526	0.427
2024	1.281	1.281	1.281	1.445	1.445	1.572	1.572	1.572	1.572	1.572	0.440
2025	1.319	1.319	1.319	1.489	1.489	1.619	1.619	1.619	1.619	1.619	0.453

APPENDIX E-1

ECONOMIC INPUTS

ECONOMIC PARAMETERS

UTILITY NAME	SDG&E	
SECTOR	Industrial	
BATCH #	1	
UTILITY DISCOUNT RATE	8.15%	
CUSTOMER DISCOUNT RATE	15.0%	
GENERAL INFLATION RATE (Measu	3.0%	
BASE YEAR	2005	
START YEAR	2005	
DIFFERENCE	0	
UTILITY LINE LOSS RATE	0.0%	(Included in avoided costs)

ENERGY COSTS AND RATES

RATE TYPE	Industrial
ENERGY UNITS	$/therm
DEMAND UNITS	n/a

Rate/Time Periods	1	2	3	5	6	
Name	Summer On-Peak	Summer Partial-Peak	Summer Off-Peak	Winter Partial-Peak	Winter Off-Peak	
Abbreviation	SOP	SPP	SOFF	WPP	WOFF	TOTAL
Hours	768	896	2752	1638	2706	8760
Monthly Adjustment for rates	6	0	0	6	0	

	AVOIDED ENERGY COSTS BY TIME PERIOD					Industrial ENERGY RATES					Environmental Adder to be Subtracted for RIM
Year	SOP $/Therm	SPP $/Therm	SOFF $/Therm	WPP $/Therm	WOFF $/Therm	SOP $/Therm	SPP $/Therm	SOFF $/Therm	WPP $/Therm	WOFF $/Therm	$/Therm
2005	0.567	0.567	0.567	0.749	0.749	0.750	0.750	0.750	0.750	0.750	0.122
2006	0.583	0.583	0.583	0.762	0.762	0.768	0.768	0.768	0.768	0.768	0.136
2007	0.587	0.587	0.587	0.758	0.758	0.772	0.772	0.772	0.772	0.772	0.140
2008	0.592	0.592	0.592	0.760	0.760	0.780	0.780	0.780	0.780	0.780	0.143
2009	0.597	0.597	0.597	0.765	0.765	0.789	0.789	0.789	0.789	0.789	0.146
2010	0.616	0.616	0.616	0.789	0.789	0.813	0.813	0.813	0.813	0.813	0.149
2011	0.659	0.659	0.659	0.836	0.836	0.861	0.861	0.861	0.861	0.861	0.164
2012	0.699	0.699	0.699	0.880	0.880	0.907	0.907	0.907	0.907	0.907	0.177
2013	0.738	0.738	0.738	0.927	0.927	0.953	0.953	0.953	0.953	0.953	0.192
2014	0.778	0.778	0.778	0.971	0.971	0.999	0.999	0.999	0.999	0.999	0.207
2015	0.819	0.819	0.819	1.017	1.017	1.047	1.047	1.047	1.047	1.047	0.224
2016	0.864	0.864	0.864	1.067	1.067	1.098	1.098	1.098	1.098	1.098	0.243
2017	0.900	0.900	0.900	1.108	1.108	1.141	1.141	1.141	1.141	1.141	0.263
2018	0.959	0.959	0.959	1.172	1.172	1.206	1.206	1.206	1.206	1.206	0.284
2019	1.011	1.011	1.011	1.230	1.230	1.265	1.265	1.265	1.265	1.265	0.308
2020	1.067	1.067	1.067	1.291	1.291	1.328	1.328	1.328	1.328	1.328	0.334
2021	1.124	1.124	1.124	1.355	1.355	1.394	1.394	1.394	1.394	1.394	0.362
2022	1.191	1.191	1.191	1.427	1.427	1.467	1.467	1.467	1.467	1.467	0.393
2023	1.241	1.241	1.241	1.483	1.483	1.525	1.525	1.525	1.525	1.525	0.427
2024	1.278	1.278	1.278	1.527	1.527	1.571	1.571	1.571	1.571	1.571	0.440
2025	1.316	1.316	1.316	1.573	1.573	1.618	1.618	1.618	1.618	1.618	0.453

APPENDIX E-2 ECONOMIC INPUTS

Electric Inputs

Natural Gas Inputs

Building Stock Table
(Base kWh)

Segment	SIC20	SIC22/23	SIC24/25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39/21/31
PG&E	2,860,504,747	64,543,983	579,559,859	430,174,090	290,928,918	1,018,305,952	1,358,920,807	605,852,364	1,615,914,927	224,069,912	352,513,255	2,056,453,799	1,517,625,295	511,550,616	645,537,571	38,849,735
SCE	1,580,290,738	383,241,651	380,202,878	918,848,777	460,355,618	1,522,366,291	725,340,375	1,562,120,537	1,901,973,315	949,458,752	1,365,529,903	584,700,082	1,955,402,531	1,582,328,105	579,507,475	187370701
SDG&E	54,637,130	14,369,408	27,000,132	12,042,559	91,380,765	446,037,511	2,088,123	63,854,479	26,997,300	12,722,382	80,271,831	138,189,903	537,747,587	289,349,045	168,319,803	71776356

Load Shape Table
(Fraction of annual energy)

	End Use 1 - Motors					End Use 2 - Compressed Air					End Use 3 - Process Other				
SIC Group	SP	SPP	SOP	WPP	WOP	SP	SPP	SOP	WPP	WOP	SP	SPP	SOP	WPP	WOP
SIC20	0.1000	0.1184	0.3066	0.2038	0.2698	0.1000	0.1184	0.3066	0.2038	0.2698	0.1000	0.1184	0.3066	0.2038	0.2698
SIC22/23	0.1000	0.1184	0.3066	0.2038	0.2698	0.1000	0.1184	0.3066	0.2038	0.2698	0.1000	0.1184	0.3066	0.2038	0.2698
SIC24/25	0.1000	0.1184	0.3066	0.2038	0.2698	0.1000	0.1184	0.3066	0.2038	0.2698	0.1000	0.1184	0.3066	0.2038	0.2698
SIC26	0.1000	0.1184	0.3066	0.2038	0.2698	0.1000	0.1184	0.3066	0.2038	0.2698	0.1000	0.1184	0.3066	0.2038	0.2698
SIC27	0.1000	0.1184	0.3066	0.2038	0.2698	0.1000	0.1184	0.3066	0.2038	0.2698	0.1000	0.1184	0.3066	0.2038	0.2698
SIC28	0.0950	0.1109	0.3025	0.2003	0.2898	0.0950	0.1109	0.3025	0.2003	0.2898	0.0950	0.1109	0.3025	0.2003	0.2898
SIC29	0.0950	0.1109	0.3025	0.2003	0.2898	0.0950	0.1109	0.3025	0.2003	0.2898	0.0950	0.1109	0.3025	0.2003	0.2898
SIC30	0.0950	0.1109	0.3025	0.2003	0.2898	0.0950	0.1109	0.3025	0.2003	0.2898	0.0950	0.1109	0.3025	0.2003	0.2898
SIC32	0.0905	0.1083	0.3059	0.2007	0.2933	0.0905	0.1083	0.3059	0.2007	0.2933	0.0905	0.1083	0.3059	0.2007	0.2933
SIC33	0.0905	0.1083	0.3059	0.2007	0.2933	0.0905	0.1083	0.3059	0.2007	0.2933	0.0905	0.1083	0.3059	0.2007	0.2933
SIC34	0.1097	0.1159	0.2890	0.2104	0.2736	0.1097	0.1159	0.2890	0.2104	0.2736	0.1097	0.1159	0.2890	0.2104	0.2736
SIC35	0.1097	0.1159	0.2890	0.2104	0.2736	0.1097	0.1159	0.2890	0.2104	0.2736	0.1097	0.1159	0.2890	0.2104	0.2736
SIC36	0.1097	0.1159	0.2890	0.2104	0.2736	0.1097	0.1159	0.2890	0.2104	0.2736	0.1097	0.1159	0.2890	0.2104	0.2736
SIC37	0.1097	0.1159	0.2890	0.2104	0.2736	0.1097	0.1159	0.2890	0.2104	0.2736	0.1097	0.1159	0.2890	0.2104	0.2736
SIC38	0.1097	0.1159	0.2890	0.2104	0.2736	0.1097	0.1159	0.2890	0.2104	0.2736	0.1097	0.1159	0.2890	0.2104	0.2736
SIC39/21/31	0.1000	0.1184	0.3066	0.2038	0.2698	0.1000	0.1184	0.3066	0.2038	0.2698	0.1000	0.1184	0.3066	0.2038	0.2698

Load Shape Table - Continued
(Fraction of annual energy)

	End Use 4 -Lighting					End Use 5 - Cooling				
SIC Group	SP	SPP	SOP	WPP	WOP	SP	SPP	SOP	WPP	WOP
SIC20	0.1392	0.1327	0.2642	0.2387	0.2285	0.0952	0.1268	0.3478	0.1780	0.2517
SIC22/23	0.1392	0.1327	0.2642	0.2387	0.2285	0.0952	0.1268	0.3478	0.1780	0.2517
SIC24/25	0.1392	0.1327	0.2642	0.2387	0.2285	0.0952	0.1268	0.3478	0.1780	0.2517
SIC26	0.1392	0.1327	0.2642	0.2387	0.2285	0.0952	0.1268	0.3478	0.1780	0.2517
SIC27	0.1392	0.1327	0.2642	0.2387	0.2285	0.0952	0.1268	0.3478	0.1780	0.2517
SIC28	0.1342	0.1252	0.2602	0.2352	0.2485	0.0902	0.1192	0.3438	0.1745	0.2717
SIC29	0.1342	0.1252	0.2602	0.2352	0.2485	0.0902	0.1192	0.3438	0.1745	0.2717
SIC30	0.1342	0.1252	0.2602	0.2352	0.2485	0.0902	0.1192	0.3438	0.1745	0.2717
SIC32	0.1297	0.1226	0.2635	0.2355	0.2520	0.0857	0.1167	0.3471	0.1749	0.2752
SIC33	0.1297	0.1226	0.2635	0.2355	0.2520	0.0857	0.1167	0.3471	0.1749	0.2752
SIC34	0.1489	0.1302	0.2467	0.2453	0.2323	0.1049	0.1243	0.3303	0.1846	0.2555
SIC35	0.1489	0.1302	0.2467	0.2453	0.2323	0.1049	0.1243	0.3303	0.1846	0.2555
SIC36	0.1489	0.1302	0.2467	0.2453	0.2323	0.1049	0.1243	0.3303	0.1846	0.2555
SIC37	0.1489	0.1302	0.2467	0.2453	0.2323	0.1049	0.1243	0.3303	0.1846	0.2555
SIC38	0.1489	0.1302	0.2467	0.2453	0.2323	0.1049	0.1243	0.3303	0.1846	0.2555
SIC39/21/31	0.1392	0.1327	0.2642	0.2387	0.2285	0.0952	0.1268	0.3478	0.1780	0.2517

Peak To Energy Relationship Table (Utility Coincidence)
(Ratio of peak kW to average kW)

	End Use 1 - Motors					End Use 2 - Compressed Air					End Use 3 - Process Other				
SIC Group	SP	SPP	SOP	WPP	WOP	SP	SPP	SOP	WPP	WOP	SP	SPP	SOP	WPP	WOP
SIC20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC22/23	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC24/25	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC26	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC27	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC28	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC29	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC30	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC32	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC33	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC34	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC35	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC36	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC37	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC38	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC39/21/31	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Peak To Energy Relationship Table (Utility Coincidence) - Continued
(Ratio of peak kW to average kW)

	End Use 4 -Lighting					End Use 5 - Cooling				
SIC Group	SP	SPP	SOP	WPP	WOP	SP	SPP	SOP	WPP	WOP
SIC20	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000
SIC22/23	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000
SIC24/25	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000
SIC26	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000
SIC27	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000
SIC28	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000
SIC29	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000
SIC30	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000
SIC32	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000
SIC33	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000
SIC34	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000
SIC35	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000
SIC36	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000
SIC37	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000
SIC38	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000
SIC39/21/31	1.000	1.000	1.000	1.000	1.000	1.500	1.000	1.000	1.000	1.000

Building Stock Table

(Base Therms)

Segment	SIC20	SIC22	SIC23	SIC24	SIC25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC31	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39
PG&E	361,213,761	881,619	530,668	28,554,763	253,301	90,108,598	7,068,949	89,282,566	774,461,847	17,272,258	35,030	175,863,353	23,849,210	19,469,411	19,384,285	27,746,078	19196317	7,368,553	1,532,762
SCG	1,580,290,738	383,241,651	380,202,878	918,848,777	460,355,618	1,522,366,291	725,340,375	1,562,120,537	1,901,973,315	949,458,752	1,365,529,903	584,700,082	1,955,402,531	1,582,328,105	579,507,475	187370701			
SDG&E	54,637,130	14,369,408	27,000,132	12,042,559	91,380,765	446,037,511	2,088,123	63,854,479	26,997,300	12,722,382	80,271,831	138,189,903	537,747,587	289,349,045	168,319,803	71776356			

Load Shape Table

(Fraction of annual energy)

	End Use 1 - Boilers					End Use 2 - HVAC					End Use 3 - Process Heat				
SIC Group	SP	SPP	SOP	WPP	WOP	SP	SPP	SOP	WPP	WOP	SP	SPP	SOP	WPP	WOP
SIC20	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC22	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC23	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC24	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC25	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC26	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC27	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC28	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC29	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC30	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC31	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC32	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC33	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC34	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC35	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC36	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC37	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC38	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527
SIC39	0.1649	0.1649	0.1649	0.2527	0.2527	0.1144	0.1144	0.1144	0.3284	0.3284	0.1649	0.1649	0.1649	0.2527	0.2527

Peak To Energy Relationship Table (Utility Coincidence)

(Ratio of peak Therms to average Therms)

	End Use 1 - Boilers					End Use 2 - HVAC					End Use 3 - Process Heat				
SIC Group	SP	SPP	SOP	WPP	WOP	SP	SPP	SOP	WPP	WOP	SP	SPP	SOP	WPP	WOP
SIC20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC22	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC23	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC24	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC25	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC26	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC27	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC28	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC29	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC30	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC31	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC32	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC33	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC34	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC35	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC36	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC37	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC38	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SIC39	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Measure Costs

Technology Saturations

Applicability Factors

Incomplete Factors

Feasibility Factors

Measure Savings

MEASURE COSTS

Segment	Measure #	Measure Description	Savings Units	Cost Units	Unit Equipment Cost	Unit Labor Cost	NPV of Lifetime O & M Cost	Imple-mentation Cost Factor	Cost Units per Savings Unit	Service Life	Full = 1 Incr. = 0 Initial Cost	Replace Cost	Full Unit Cost	Relative Energy Reduction Factors SP	SPP	SOP	WP	WPP	WOP	End Use	Implementation Type 1=1 time 2=ROB
1	100	Base Compressed Air	$/kWh	$/kWh	$0.000	$0.000	$0.000	$0.000	1	14.5	1	1	$0.000	1.00	1.00	1.00	1.00	1.00	1.00	2	1
1	101	Compressed Air-O&M	$/kWh	$/kWh	$0.009	$0.001	$0.000	$0.010	1	10	1	1	$0.010	1.00	1.00	1.00	1.00	1.00	1.00	2	1
1	102	Compressed Air - Controls	$/kWh	$/kWh	$0.016	$0.002	$0.000	$0.017	1	10	1	1	$0.017	1.00	1.00	1.00	1.00	1.00	1.00	2	2
1	103	Compressed Air - System Optimization	$/kWh	$/kWh	$0.015	$0.001	$0.000	$0.016	1	10	1	1	$0.016	1.00	1.00	1.00	1.00	1.00	1.00	2	1
1	104	Compressed Air- Sizing	$/kWh	$/kWh	$0.004	$0.000	$0.000	$0.005	1	10	1	1	$0.005	1.00	1.00	1.00	1.00	1.00	1.00	2	2
1	105	Comp Air - Replace 1-5 HP motor	$/kWh	$/kWh	$0.048	$0.005	$0.000	$0.053	1	14.5	1	1	$0.053	1.00	1.00	1.00	1.00	1.00	1.00	2	2
1	106	Comp Air - ASD (1-5 hp)	$/kWh	$/kWh	$0.070	$0.007	$0.000	$0.077	1	14.5	1	1	$0.077	0.09	1.00	1.00	1.00	1.00	1.00	2	1
1	107	Comp Air - Motor practices-1 (1-5 HP)	$/kWh	$/kWh	$0.019	$0.002	$0.000	$0.021	1	14.5	1	1	$0.021	1.00	1.00	1.00	1.00	1.00	1.00	2	1
1	108	Comp Air - Replace 6-100 HP motor	$/kWh	$/kWh	$0.027	$0.003	$0.000	$0.030	1	10	1	1	$0.030	1.00	1.00	1.00	1.00	1.00	1.00	2	2
1	109	Comp Air - ASD (6-100 hp)	$/kWh	$/kWh	$0.002	$0.000	$0.000	$0.003	1	10	1	1	$0.003	0.09	1.00	1.00	1.00	1.00	1.00	2	2
1	110	Comp Air - Motor practices-1 (6-100 HP)	$/kWh	$/kWh	$0.005	$0.000	$0.000	$0.005	1	10	1	1	$0.005	1.00	1.00	1.00	1.00	1.00	1.00	2	1
1	111	Comp Air - Replace 100+ HP motor	$/kWh	$/kWh	$0.008	$0.001	$0.000	$0.009	1	6	1	1	$0.009	1.00	1.00	1.00	1.00	1.00	1.00	2	2
1	112	Comp Air - ASD (100+ hp)	$/kWh	$/kWh	$0.005	$0.001	$0.000	$0.006	1	6	1	1	$0.006	0.09	1.00	1.00	1.00	1.00	1.00	2	1
1	113	Comp Air - Motor practices-1 (100+ HP)	$/kWh	$/kWh	$0.002	$0.000	$0.000	$0.002	1	6	1	1	$0.002	1.00	1.00	1.00	1.00	1.00	1.00	2	1
1	114	Power recovery	$/kWh	$/kWh	$0.003	$0.000	$0.000	$0.003	1	10	1	1	$0.003	1.00	1.00	1.00	1.00	1.00	1.00	2	1
1	115	Refinery Controls	$/kWh	$/kWh	$0.003	$0.000	$0.000	$0.004	1	10	1	1	$0.004	1.00	1.00	1.00	1.00	1.00	1.00	2	1
1	116	Energy Star Transformers	$/kWh	$/kWh	$0.064	$0.006	$0.000	$0.070	1	25	1	1	$0.070	1.00	1.00	1.00	1.00	1.00	1.00	2	2
1	200	Base Fans	$/kWh	$/kWh	$0.000	$0.000	$0.000	$0.000	1	14.5	1	1	$0.000	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	201	Fans - O&M	$/kWh	$/kWh	$0.001	$0.000	$0.000	$0.001	1	10	1	1	$0.001	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	202	Fans - Controls	$/kWh	$/kWh	$0.084	$0.008	$0.000	$0.092	1	10	1	1	$0.092	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	203	Fans - System Optimization	$/kWh	$/kWh	$0.055	$0.005	$0.000	$0.060	1	10	1	1	$0.060	0.47	1.00	1.00	1.00	1.00	1.00	1	1
1	204	Fans- Improve components	$/kWh	$/kWh	$0.005	$0.000	$0.000	$0.005	1	10	1	1	$0.005	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	205	Fans - Replace 1-5 HP motor	$/kWh	$/kWh	$0.048	$0.005	$0.000	$0.053	1	14.5	1	1	$0.053	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	206	Fans - ASD (1-5 hp)	$/kWh	$/kWh	$0.070	$0.007	$0.000	$0.077	1	14.5	1	1	$0.077	0.09	1.00	1.00	1.00	1.00	1.00	1	1
1	207	Fans - Motor practices-1 (1-5 HP)	$/kWh	$/kWh	$0.019	$0.002	$0.000	$0.021	1	14.5	1	1	$0.021	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	208	Fans - Replace 6-100 HP motor	$/kWh	$/kWh	$0.027	$0.003	$0.000	$0.030	1	10	1	1	$0.030	1.00	1.00	0.50	1.00	1.00	0.50	1	2
1	209	Fans - ASD (6-100 hp)	$/kWh	$/kWh	$0.002	$0.000	$0.000	$0.003	1	10	1	1	$0.003	0.09	0.50	0.00	1.00	0.75	0.00	1	2
1	210	Fans - Motor practices-1 (6-100 HP)	$/kWh	$/kWh	$0.005	$0.000	$0.000	$0.005	1	10	1	1	$0.005	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	211	Fans - Replace 100+ HP motor	$/kWh	$/kWh	$0.008	$0.001	$0.000	$0.009	1	6	1	1	$0.009	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	212	Fans - ASD (100+ hp)	$/kWh	$/kWh	$0.005	$0.001	$0.000	$0.006	1	6	1	1	$0.006	0.09	1.00	0.50	1.00	1.00	0.50	1	1
1	213	Fans - Motor practices-1 (100+ HP)	$/kWh	$/kWh	$0.002	$0.000	$0.000	$0.002	1	6	1	1	$0.002	1.00	0.50	0.00	1.00	0.75	0.00	1	1
1	214	Optimize drying process	$/kWh	$/kWh	$0.046	$0.005	$0.000	$0.050	1	10	1	1	$0.050	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	215	Power recovery	$/kWh	$/kWh	$0.003	$0.000	$0.000	$0.003	1	10	1	1	$0.003	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	216	Refinery Controls	$/kWh	$/kWh	$0.003	$0.000	$0.000	$0.004	1	10	1	1	$0.004	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	217	Energy Star Transformers	$/kWh	$/kWh	$0.064	$0.006	$0.000	$0.070	1	25	1	1	$0.070	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	300	Base Pumps	$/kWh	$/kWh	$0.000	$0.000	$0.000	$0.000	1	14.5	1	1	$0.000	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	301	Pumps - O&M	$/kWh	$/kWh	$0.005	$0.000	$0.000	$0.005	1	10	1	1	$0.005	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	302	Pumps - Controls	$/kWh	$/kWh	$0.025	$0.002	$0.000	$0.027	1	10	1	1	$0.027	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	303	Pumps - System Optimization	$/kWh	$/kWh	$0.060	$0.006	$0.000	$0.066	1	10	1	1	$0.066	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	304	Pumps - Sizing	$/kWh	$/kWh	$0.018	$0.002	$0.000	$0.020	1	10	1	1	$0.020	1.00	0.50	0.00	1.00	0.00	0.00	1	2
1	305	Pumps - Replace 1-5 HP motor	$/kWh	$/kWh	$0.048	$0.005	$0.000	$0.053	1	14.5	1	1	$0.053	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	306	Pumps - ASD (1-5 hp)	$/kWh	$/kWh	$0.070	$0.007	$0.000	$0.077	1	14.5	1	1	$0.077	0.09	1.00	1.00	1.00	1.00	1.00	1	1
1	307	Pumps - Motor practices-1 (1-5 HP)	$/kWh	$/kWh	$0.019	$0.002	$0.000	$0.021	1	14.5	1	1	$0.021	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	308	Pumps - Replace 6-100 HP motor	$/kWh	$/kWh	$0.027	$0.003	$0.000	$0.030	1	10	1	1	$0.030	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	309	Pumps - ASD (6-100 hp)	$/kWh	$/kWh	$0.002	$0.000	$0.000	$0.003	1	10	1	1	$0.003	0.09	1.00	1.00	1.00	1.00	1.00	1	1
1	310	Pumps - Motor practices-1 (6-100 HP)	$/kWh	$/kWh	$0.005	$0.000	$0.000	$0.005	1	10	1	1	$0.005	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	311	Pumps - Replace 100+ HP motor	$/kWh	$/kWh	$0.008	$0.001	$0.000	$0.009	1	6	1	1	$0.009	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	312	Pumps - ASD (100+ hp)	$/kWh	$/kWh	$0.005	$0.001	$0.000	$0.006	1	6	1	1	$0.006	0.09	1.00	1.00	1.00	1.00	1.00	1	1
1	313	Pumps - Motor practices-1 (100+ HP)	$/kWh	$/kWh	$0.002	$0.000	$0.000	$0.002	1	6	1	1	$0.002	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	314	Power recovery	$/kWh	$/kWh	$0.003	$0.000	$0.000	$0.003	1	10	1	1	$0.003	1.00	1.00	1.00	1.00	1.00	1.00	1	1

MEASURE COSTS

Segment	Measure #	Measure Description	Savings Units	Cost Units	Unit Equipment Cost	Unit Labor Cost	NPV of Lifetime O & M Cost	Imple-mentation Cost Factor	Cost Units per Savings Unit	Service Life	Full = 1 Incr. = 0 Initial Cost	Replace Cost	Full Unit Cost	Relative Energy Reduction Factors SP	SPP	SOP	WP	WPP	WOP	End Use	Implementation Type 1=1 time 2=ROB
1	315	Refinery Controls	$/kWh	$/kWh	$0.003	$0.000	$0.000	$0.004	1	10	1	1	$0.004	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	316	Energy Star Transformers	$/kWh	$/kWh	$0.064	$0.006	$0.000	$0.070	1	25	1	1	$0.070	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	400	Base Drives	$/kWh	$/kWh	$0.000	$0.000	$0.000	$0.000	1	20	1	1	$0.000	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	401	Bakery - Process (Mixing) - O&M	$/kWh	$/kWh	$0.005	$0.000	$0.000	$0.005	1	10	1	1	$0.005	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	402	O&M/drives spinning machines	$/kWh	$/kWh	$0.029	$0.003	$0.000	$0.032	1	10	1	1	$0.032	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	403	Air conveying systems	$/kWh	$/kWh	$0.035	$0.003	$0.000	$0.038	1	14	1	1	$0.038	0.24	1.00	1.00	1.00	1.00	1.00	1	2
1	404	Replace V-Belts	$/kWh	$/kWh	$0.005	$0.001	$0.000	$0.006	1	10	1	1	$0.006	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	405	Drives - EE motor	$/kWh	$/kWh	$0.006	$0.001	$0.000	$0.006	1	10	1	1	$0.006	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	406	Gap Forming papermachine	$/kWh	$/kWh	$0.007	$0.001	$0.000	$0.008	1	20	1	1	$0.008	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	407	High Consistency forming	$/kWh	$/kWh	$0.007	$0.001	$0.000	$0.008	1	20	1	1	$0.008	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	408	Optimization control PM	$/kWh	$/kWh	$0.011	$0.001	$0.000	$0.013	1	10	1	1	$0.013	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	409	Efficient practices printing press	$/kWh	$/kWh	$0.009	$0.001	$0.000	$0.010	1	20	1	1	$0.010	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	410	Efficient Printing press (fewer cylinders)	$/kWh	$/kWh	$0.055	$0.005	$0.000	$0.060	1	10	1	1	$0.060	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	411	Light cylinders	$/kWh	$/kWh	$0.064	$0.006	$0.000	$0.070	1	10	1	1	$0.070	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	412	Efficient drives	$/kWh	$/kWh	$0.005	$0.001	$0.000	$0.006	1	10	1	1	$0.006	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	413	Clean Room - Controls	$/kWh	$/kWh	$0.020	$0.002	$0.000	$0.022	1	10	1	1	$0.022	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	414	Clean Room - New Designs	$/kWh	$/kWh	$0.120	$0.012	$0.000	$0.132	1	10	1	1	$0.132	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	415	Drives - Process Controls (batch + site)	$/kWh	$/kWh	$0.022	$0.002	$0.000	$0.024	1	10	1	1	$0.024	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	416	Process Drives - ASD	$/kWh	$/kWh	$0.002	$0.000	$0.000	$0.002	1	10	1	1	$0.002	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	417	O&M - Extruders/Injection Moulding	$/kWh	$/kWh	$0.005	$0.000	$0.000	$0.005	1	12	1	1	$0.005	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	418	Extruders/injection Moulding-multipump	$/kWh	$/kWh	$0.090	$0.009	$0.000	$0.099	1	12	1	1	$0.099	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	419	Direct drive Extruders	$/kWh	$/kWh	$0.280	$0.028	$0.000	$0.308	1	12	1	1	$0.308	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	420	Injection Moulding - Impulse Cooling	$/kWh	$/kWh	$0.063	$0.006	$0.000	$0.069	1	12	1	1	$0.069	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	421	Injection Moulding - Direct drive	$/kWh	$/kWh	$0.088	$0.009	$0.000	$0.097	1	12	1	1	$0.097	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	422	Efficient grinding	$/kWh	$/kWh	$0.210	$0.021	$0.000	$0.231	1	15	1	1	$0.231	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	423	Process control	$/kWh	$/kWh	$0.002	$0.000	$0.000	$0.002	1	10	1	1	$0.002	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	424	Process optimization	$/kWh	$/kWh	$0.027	$0.003	$0.000	$0.030	1	10	1	1	$0.030	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	425	Drives - Process Control	$/kWh	$/kWh	$0.014	$0.001	$0.000	$0.015	1	15	1	1	$0.015	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	426	Efficient drives - rolling	$/kWh	$/kWh	$0.008	$0.001	$0.000	$0.009	1	10	1	1	$0.009	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	427	Drives - Optimization process (M&T)	$/kWh	$/kWh	$0.007	$0.001	$0.000	$0.008	1	10	1	1	$0.008	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	428	Drives - Scheduling	$/kWh	$/kWh	$0.009	$0.001	$0.000	$0.010	1	10	1	1	$0.010	0.18	1.00	1.00	1.00	1.00	1.00	1	1
1	429	Machinery	$/kWh	$/kWh	$0.011	$0.001	$0.000	$0.013	1	10	1	1	$0.013	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	430	Efficient Machinery	$/kWh	$/kWh	$0.006	$0.001	$0.000	$0.006	1	10	1	1	$0.006	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	431	Energy Star Transformers	$/kWh	$/kWh	$0.064	$0.006	$0.000	$0.070	1	25	1	1	$0.070	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	500	Base Heating	$/kWh	$/kWh	$0.000	$0.000	$0.000	$0.000	1	20	1	1	$0.000	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	501	Bakery - Process	$/kWh	$/kWh	$0.046	$0.005	$0.000	$0.050	1	15	1	1	$0.050	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	502	Drying (UV/IR)	$/kWh	$/kWh	$0.068	$0.007	$0.000	$0.075	1	8	1	1	$0.075	0.57	1.00	1.00	1.00	1.00	1.00	3	2
1	503	Heat Pumps - Drying	$/kWh	$/kWh	$0.160	$0.016	$0.000	$0.176	1	15	1	1	$0.176	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	504	Top-heating (glass)	$/kWh	$/kWh	$0.004	$0.000	$0.000	$0.004	1	8	1	1	$0.004	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	505	Efficient electric melting	$/kWh	$/kWh	$0.030	$0.003	$0.000	$0.033	1	20	1	1	$0.033	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	506	Intelligent extruder (DOE)	$/kWh	$/kWh	$0.015	$0.001	$0.000	$0.016	1	10	1	1	$0.016	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	507	Near Net Shape Casting	$/kWh	$/kWh	$0.011	$0.001	$0.000	$0.012	1	15	1	1	$0.012	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	508	Heating - Process Control	$/kWh	$/kWh	$0.014	$0.001	$0.000	$0.015	1	15	1	1	$0.015	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	509	Efficient Curing ovens	$/kWh	$/kWh	$0.073	$0.007	$0.000	$0.080	1	15	1	1	$0.080	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	510	Heating - Optimization process (M&T)	$/kWh	$/kWh	$0.007	$0.001	$0.000	$0.008	1	10	1	1	$0.008	1.00	1.00	1.00	1.00	1.00	1.00	3	1

MEASURE COSTS

Segment	Measure #	Measure Description	Savings Units	Cost Units	Unit Equipment Cost	Unit Labor Cost	NPV of Lifetime O & M Cost	Imple-mentation Cost Factor	Cost Units per Savings Unit	Service Life	Full = 1 Incr. = 0 Initial Cost	Replace Cost	Full Unit Cost	Relative Energy Reduction Factors SP	SPP	SOP	WP	WPP	WOP	End Use	Implementation Type 1=1 time 2=ROB
1	511	Heating - Scheduling	$/kWh	$/kWh	$0.009	$0.001	$0.000	$0.010	1	10	1	1	$0.010	0.18	1.00	1.00	1.00	1.00	1.00	3	1
1	512	Energy Star Transformers	$/kWh	$/kWh	$0.064	$0.006	$0.000	$0.070	1	25	1	1	$0.070	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	550	Base Refrigeration	$/kWh	$/kWh	$0.000	$0.000	$0.000	$0.000	1	20	1	1	$0.000	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	551	Efficient Refrigeration - Operations	$/kWh	$/kWh	$0.007	$0.001	$0.000	$0.007	1	10	1	1	$0.007	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	552	Optimization Refrigeration	$/kWh	$/kWh	$0.099	$0.010	$0.000	$0.109	1	15	1	1	$0.109	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	553	Energy Star Transformers	$/kWh	$/kWh	$0.064	$0.006	$0.000	$0.070	1	25	1	1	$0.070	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	600	Base Other Process	$/kWh	$/kWh	$0.000	$0.000	$0.000	$0.000	1	15	1	1	$0.000	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	601	Other Process Controls (batch + site)	$/kWh	$/kWh	$0.022	$0.002	$0.000	$0.024	1	10	1	1	$0.024	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	602	Efficient desalter	$/kWh	$/kWh	$0.036	$0.004	$0.000	$0.040	1	10	1	1	$0.040	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	603	New transformers welding	$/kWh	$/kWh	$0.046	$0.005	$0.000	$0.050	1	15	1	1	$0.050	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	604	Efficient processes (welding, etc.)	$/kWh	$/kWh	$0.046	$0.005	$0.000	$0.050	1	15	1	1	$0.050	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	605	Process control	$/kWh	$/kWh	$0.015	$0.001	$0.000	$0.016	1	15	1	1	$0.016	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	606	Power recovery	$/kWh	$/kWh	$0.003	$0.000	$0.000	$0.003	1	10	1	1	$0.003	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	607	Refinery Controls	$/kWh	$/kWh	$0.003	$0.000	$0.000	$0.004	1	10	1	1	$0.004	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	608	Energy Star Transformers	$/kWh	$/kWh	$0.064	$0.006	$0.000	$0.070	1	25	1	1	$0.070	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	700	Base Centrifugal Chiller, 0.58 kW/ton, 500 tons	$/ton	$/ton	$0.000	$0.000	$0.000	$0.000	1	20	1	1	$0.000	1.00	1.00	1.00	1.00	1.00	1.00	5	2
1	701	Centrifugal Chiller, 0.51 kW/ton, 500 tons	$/ton	$/ton	$21.140	$0.000	$0.000	$21.140	1	20	1	1	$21.140	1.00	1.00	1.00	1.00	1.00	1.00	5	2
1	702	Window Film - Chiller	$/sf-window	$/sf-window	$3.070	$0.000	$0.000	$3.070	1	10	1	1	$3.070	1.00	1.00	1.00	1.00	1.00	1.00	5	1
1	703	EMS - Chiller	$/ton	$/ton	$60.000	$0.000	$0.000	$60.000	1	10	1	1	$60.000	1.00	1.00	1.00	1.00	1.00	1.00	5	1
1	704	Cool Roof - Chiller	$/sf-roof	$/sf-roof	$0.470	$0.000	$0.000	$0.470	1	10	1	1	$0.470	1.00	1.00	1.00	1.00	1.00	1.00	5	1
1	705	Chiller Tune Up/Diagnostics	$/ton	$/ton	$16.667	$0.000	$20.912	$16.667	1	10	1	1	$37.578	1.00	0.50	0.00	1.00	0.00	0.00	5	1
1	706	Cooling Circ. Pumps - VSD	$/ton	$/ton	$65.040	$0.000	$0.000	$65.040	1	15	1	1	$65.040	1.00	1.00	1.00	1.00	1.00	1.00	5	1
1	707	Energy Star Transformers	$/kWh	$/kWh	$0.064	$0.000	$0.000	$0.064	1	25	1	1	$0.064	1.00	1.00	1.00	1.00	1.00	1.00	5	2
1	710	Base DX Packaged System, EER=10.3, 10 ton	$/ton	$/ton	$0.000	$0.000	$0.000	$0.000	1	15	1	1	$0.000	1.00	1.00	1.00	1.00	1.00	1.00	5	2
1	711	DX Tune Up/ Advanced Diagnostics	$/ton	$/ton	$78.000	$0.000	$0.000	$78.000	1	3	1	1	$78.000	1.00	1.00	1.00	1.00	1.00	1.00	5	1
1	712	DX Packaged System, EER=10.9, 10 tons	$/ton	$/ton	$51.600	$0.000	$0.000	$51.600	1	15	1	1	$51.600	1.00	1.00	1.00	1.00	1.00	1.00	5	2
1	713	Window Film - DX	$/sf-window	$/sf-window	$3.070	$0.000	$0.000	$3.070	1	10	1	1	$3.070	1.00	1.00	1.00	1.00	1.00	1.00	5	1
1	714	Evaporative Pre-Cooler	$/ton	$/ton	$133.333	$160.000	$0.000	$293.333	1	10	1	1	$293.333	1.00	1.00	1.00	1.00	1.00	1.00	5	1
1	715	Prog. Thermostat - DX	$/ton	$/ton	$5.500	$15.000	$0.000	$20.500	1	10	1	1	$20.500	0.25	1.00	1.00	1.00	1.00	1.00	5	1
1	716	Cool Roof - DX	$/sf-roof	$/sf-roof	$0.470	$0.000	$0.000	$0.470	1	10	1	1	$0.470	1.00	1.00	1.00	1.00	1.00	1.00	5	1
1	717	Energy Star Transformers	$/kWh	$/kWh	$0.064	$0.000	$0.000	$0.064	1	25	1	1	$0.064	1.00	1.00	1.00	1.00	1.00	1.00	5	2
1	800	Base Lighting	fixture	fixture	$0.000	$0.000	$0.000	$0.000	1	10	1	1	$0.000	1.00	1.00	1.00	1.00	1.00	1.00	4	1
1	801	RET 2L4' Premium T8, 1EB	fixture	fixture	$25.000	$9.400	$0.000	$34.400	1	15	1	1	$34.400	1.00	1.00	1.00	1.00	1.00	1.00	4	1
1	802	CFL Hardwired, Modular 36W	fixture	fixture	$41.700	$15.450	-$8.409	$57.150	1	4	1	1	$48.741	1.00	1.00	1.00	1.00	1.00	1.00	4	1
1	803	Metal Halide, 50W	fixture	fixture	$224.700	$55.450	$0.000	$280.150	1	5	1	1	$280.150	1.00	1.00	1.00	1.00	1.00	1.00	4	1
1	804	Occupancy Sensor, 4L4' Fluorescent Fixtures	fixture	fixture	$12.250	$1.575	$0.000	$13.825	1	9	1	1	$13.825	1.00	1.00	0.50	1.00	1.00	0.50	4	1
1	805	Energy Star Transformers	$/kWh	$/kWh	$0.064	$0.000	$0.000	$0.064	1	25	1	1	$0.064	1.00	1.00	1.00	1.00	1.00	1.00	4	2
1	900	Base Other	$/kWh	$/kWh	$0.000	$0.000	$0.000	$0.000	1	15	1	1	$0.000	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	901	Replace V-belts	$/kWh	$/kWh	$0.000	$0.000	$0.000	$0.000	1	5	1	1	$0.000	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	902	Membranes for wastewater	$/kWh	$/kWh	$0.032	$0.003	$0.000	$0.035	1	15	1	1	$0.035	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	903	Energy Star Transformers	$/kWh	$/kWh	$0.064	$0.006	$0.000	$0.070	1	25	1	1	$0.070	1.00	1.00	1.00	1.00	1.00	1.00	3	2

TECHNOLOGY SATURATION (units/base kWh)

Segment	Measure #	Measure Description	SIC20	SIC22/23	SIC24/25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39/21/31
1	100	Base Compressed Air	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	101	Compressed Air-O&M	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	102	Compressed Air - Controls	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	103	Compressed Air - System Optimization	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	104	Compressed Air- Sizing	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	105	Comp Air - Replace 1-5 HP motor	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	106	Comp Air - ASD (1-5 hp)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	107	Comp Air - Motor practices-1 (1-5 HP)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	108	Comp Air - Replace 6-100 HP motor	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	109	Comp Air - ASD (6-100 hp)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	110	Comp Air - Motor practices-1 (6-100 HP)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	111	Comp Air - Replace 100+ HP motor	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	112	Comp Air - ASD (100+ hp)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	113	Comp Air - Motor practices-1 (100+ HP)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	114	Power recovery	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	115	Refinery Controls	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	116	Energy Star Transformers	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	200	Base Fans	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	201	Fans - O&M	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	202	Fans - Controls	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	203	Fans - System Optimization	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	204	Fans- Improve components	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	205	Fans - Replace 1-5 HP motor	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	206	Fans - ASD (1-5 hp)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	207	Fans - Motor practices-1 (1-5 HP)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	208	Fans - Replace 6-100 HP motor	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	209	Fans - ASD (6-100 hp)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	210	Fans - Motor practices-1 (6-100 HP)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	211	Fans - Replace 100+ HP motor	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	212	Fans - ASD (100+ hp)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	213	Fans - Motor practices-1 (100+ HP)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	214	Optimize drying process	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	215	Power recovery	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	216	Refinery Controls	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	217	Energy Star Transformers	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	300	Base Pumps	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	301	Pumps - O&M	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	302	Pumps - Controls	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	303	Pumps - System Optimization	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	304	Pumps - Sizing	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	305	Pumps - Replace 1-5 HP motor	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	306	Pumps - ASD (1-5 hp)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	307	Pumps - Motor practices-1 (1-5 HP)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	308	Pumps - Replace 6-100 HP motor	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	309	Pumps - ASD (6-100 hp)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	310	Pumps - Motor practices-1 (6-100 HP)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	311	Pumps - Replace 100+ HP motor	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	312	Pumps - ASD (100+ hp)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	313	Pumps - Motor practices-1 (100+ HP)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	314	Power recovery	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	315	Refinery Controls	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

TECHNOLOGY SATURATION (units/base kWh)

Segment	Measure #	Measure Description	SIC20	SIC22/23	SIC24/25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39/21/31
1	316	Energy Star Transformers	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	400	Base Drives	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	401	Bakery - Process (Mixing) - O&M	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	402	O&M/drives spinning machines	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	403	Air conveying systems	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	404	Replace V-Belts	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	405	Drives - EE motor	1.00000	1.00000	1.00000	0.88600	1.00000	1.00000	1.00000	1.00000	0.83300	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	406	Gap Forming papermachine	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	407	High Consistency forming	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	408	Optimization control PM	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	409	Efficient practices printing press	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	410	Efficient Printing press (fewer cylinders)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	411	Light cylinders	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	412	Efficient drives	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	413	Clean Room - Controls	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.25000	1.00000	1.00000	1.00000
1	414	Clean Room - New Designs	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	415	Drives - Process Controls (batch + site)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	416	Process Drives - ASD	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.03200
1	417	O&M - Extruders/Injection Moulding	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	418	Extruders/injection Moulding-multipump	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	419	Direct drive Extruders	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	420	Injection Moulding - Impulse Cooling	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	421	Injection Moulding - Direct drive	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	422	Efficient grinding	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	423	Process control	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	424	Process optimization	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	425	Drives - Process Control	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	426	Efficient drives - rolling	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	427	Drives - Optimization process (M&T)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	428	Drives - Scheduling	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	429	Machinery	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	0.50000	1.54300	1.00000	1.00000
1	430	Efficient Machinery	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	431	Energy Star Transformers	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	500	Base Heating	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	501	Bakery - Process	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	502	Drying (UV/IR)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	503	Heat Pumps - Drying	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	504	Top-heating (glass)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	505	Efficient electric melting	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	506	Intelligent extruder (DOE)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	507	Near Net Shape Casting	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	508	Heating - Process Control	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	509	Efficient Curing ovens	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	510	Heating - Optimization process (M&T)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	511	Heating - Scheduling	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	512	Energy Star Transformers	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	550	Base Refrigeration	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	551	Efficient Refrigeration - Operations	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	552	Optimization Refrigeration	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	553	Energy Star Transformers	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	600	Base Other Process	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

TECHNOLOGY SATURATION
(units/base kWh)

Segment	Measure #	Measure Description	SIC20	SIC22/23	SIC24/25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39/21/31
1	601	Other Process Controls (batch + site)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	602	Efficient desalter	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	603	New transformers welding	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	604	Efficient processes (welding, etc.)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	605	Process control	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	606	Power recovery	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	607	Refinery Controls	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	608	Energy Star Transformers	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	700	Centrifugal Chiller, 0.58 kW/ton, 500 tons	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135
1	701	Centrifugal Chiller, 0.51 kW/ton, 500 tons	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135
1	702	Window Film - Chiller	0.01698	0.01698	0.01698	0.01698	0.01698	0.01698	0.01698	0.01698	0.01698	0.01698	0.01698	0.01698	0.01698	0.01698	0.01698	0.01698
1	703	EMS - Chiller	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135
1	704	Cool Roof - Chiller	0.29919	0.29919	0.29919	0.29919	0.29919	0.29919	0.29919	0.29919	0.29919	0.29919	0.29919	0.29919	0.29919	0.29919	0.29919	0.29919
1	705	Chiller Tune Up/Diagnostics	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135
1	706	Cooling Circ. Pumps - VSD	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135	0.00135
1	707	Energy Star Transformers	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	710	DX Packaged System, EER=10.3, 10 tons	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079
1	711	DX Tune Up/ Advanced Diagnostics	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079
1	712	DX Packaged System, EER=10.9, 10 tons	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079
1	713	Window Film - DX	0.00991	0.00991	0.00991	0.00991	0.00991	0.00991	0.00991	0.00991	0.00991	0.00991	0.00991	0.00991	0.00991	0.00991	0.00991	0.00991
1	714	Evaporative Pre-Cooler	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079
1	715	Prog. Thermostat - DX	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079
1	716	Cool Roof - DX	0.17453	0.17453	0.17453	0.17453	0.17453	0.17453	0.17453	0.17453	0.17453	0.17453	0.17453	0.17453	0.17453	0.17453	0.17453	0.17453
1	717	Energy Star Transformers	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	800	Base Lighting	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366
1	801	RET 2L4' Premium T8, 1EB	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366
1	802	CFL Hardwired, Modular 36W	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266
1	803	Metal Halide, 50W	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266	0.00266
1	804	Occupancy Sensor, 4L4' Fluorescent Fixtures	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366	0.00366
1	805	Energy Star Transformers	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	900	Base Other	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	901	Replace V-belts	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	902	Membranes for wastewater	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1	903	Energy Star Transformers	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

APPLICABILITY FACTOR (percent)

Segment	Measure #	Measure Description	SIC20	SIC22/23	SIC24/25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39/21/31
1	100	Base Compressed Air	9%	4%	5%	4%	3%	2%	13%	4%	6%	6%	12%	16%	12%	14%	9%	12%
1	101	Compressed Air-O&M	9%	4%	5%	4%	3%	2%	13%	4%	6%	6%	12%	16%	12%	14%	9%	12%
1	102	Compressed Air - Controls	9%	4%	5%	4%	3%	2%	13%	4%	6%	6%	12%	16%	12%	14%	9%	12%
1	103	Compressed Air - System Optimization	9%	4%	5%	4%	3%	2%	13%	4%	6%	6%	12%	16%	12%	14%	9%	12%
1	104	Compressed Air- Sizing	9%	4%	5%	4%	3%	2%	13%	4%	6%	6%	12%	16%	12%	14%	9%	12%
1	105	Comp Air - Replace 1-5 HP motor	9%	4%	5%	4%	3%	2%	13%	4%	6%	6%	12%	16%	12%	14%	9%	12%
1	106	Comp Air - ASD (1-5 hp)	9%	4%	5%	4%	3%	2%	13%	4%	6%	6%	12%	16%	12%	14%	9%	12%
1	107	Comp Air - Motor practices-1 (1-5 HP)	9%	4%	5%	4%	3%	2%	13%	4%	6%	6%	12%	16%	12%	14%	9%	12%
1	108	Comp Air - Replace 6-100 HP motor	9%	4%	5%	4%	3%	2%	13%	4%	6%	6%	12%	16%	12%	14%	9%	12%
1	109	Comp Air - ASD (6-100 hp)	9%	4%	5%	4%	3%	2%	13%	4%	6%	6%	12%	16%	12%	14%	9%	12%
1	110	Comp Air - Motor practices-1 (6-100 HP)	9%	4%	5%	4%	3%	2%	13%	4%	6%	6%	12%	16%	12%	14%	9%	12%
1	111	Comp Air - Replace 100+ HP motor	9%	4%	5%	4%	3%	2%	13%	4%	6%	6%	12%	16%	12%	14%	9%	12%
1	112	Comp Air - ASD (100+ hp)	9%	4%	5%	4%	3%	2%	13%	4%	6%	6%	12%	16%	12%	14%	9%	12%
1	113	Comp Air - Motor practices-1 (100+ HP)	9%	4%	5%	4%	3%	2%	13%	4%	6%	6%	12%	16%	12%	14%	9%	12%
1	114	Power recovery	0%	0%	0%	0%	0%	0%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	115	Refinery Controls	0%	0%	0%	0%	0%	0%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	116	Energy Star Transformers	9%	4%	5%	4%	3%	2%	13%	4%	6%	6%	12%	16%	12%	14%	9%	12%
1	200	Base Fans	10%	8%	10%	16%	7%	5%	8%	7%	14%	14%	7%	6%	4%	6%	4%	4%
1	201	Fans - O&M	10%	8%	10%	16%	7%	5%	8%	7%	14%	14%	7%	6%	4%	6%	4%	4%
1	202	Fans - Controls	10%	8%	10%	16%	7%	5%	8%	7%	14%	14%	7%	6%	4%	6%	4%	4%
1	203	Fans - System Optimization	10%	8%	10%	16%	7%	5%	8%	7%	14%	14%	7%	6%	4%	6%	4%	4%
1	204	Fans- Improve components	10%	8%	10%	16%	7%	5%	8%	7%	14%	14%	7%	6%	4%	6%	4%	4%
1	205	Fans - Replace 1-5 HP motor	10%	8%	10%	16%	7%	5%	8%	7%	14%	14%	7%	6%	4%	6%	4%	4%
1	206	Fans - ASD (1-5 hp)	10%	8%	10%	16%	7%	5%	8%	7%	14%	14%	7%	6%	4%	6%	4%	4%
1	207	Fans - Motor practices-1 (1-5 HP)	10%	8%	10%	16%	7%	5%	8%	7%	14%	14%	7%	6%	4%	6%	4%	4%
1	208	Fans - Replace 6-100 HP motor	10%	8%	10%	16%	7%	5%	8%	7%	14%	14%	7%	6%	4%	6%	4%	4%
1	209	Fans - ASD (6-100 hp)	10%	8%	10%	16%	7%	5%	8%	7%	14%	14%	7%	6%	4%	6%	4%	4%
1	210	Fans - Motor practices-1 (6-100 HP)	10%	8%	10%	16%	7%	5%	8%	7%	14%	14%	7%	6%	4%	6%	4%	4%
1	211	Fans - Replace 100+ HP motor	10%	8%	10%	16%	7%	5%	8%	7%	14%	14%	7%	6%	4%	6%	4%	4%
1	212	Fans - ASD (100+ hp)	10%	8%	10%	16%	7%	5%	8%	7%	14%	14%	7%	6%	4%	6%	4%	4%
1	213	Fans - Motor practices-1 (100+ HP)	10%	8%	10%	16%	7%	5%	8%	7%	14%	14%	7%	6%	4%	6%	4%	4%
1	214	Optimize drying process	0%	0%	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	215	Power recovery	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	216	Refinery Controls	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	217	Energy Star Transformers	10%	8%	10%	16%	7%	5%	8%	7%	14%	14%	7%	6%	4%	6%	4%	4%
1	300	Base Pumps	17%	10%	13%	27%	9%	20%	52%	9%	18%	18%	9%	8%	5%	8%	5%	5%
1	301	Pumps - O&M	17%	10%	13%	27%	9%	20%	52%	9%	18%	18%	9%	8%	5%	8%	5%	5%
1	302	Pumps - Controls	17%	10%	13%	27%	9%	20%	52%	9%	18%	18%	9%	8%	5%	8%	5%	5%
1	303	Pumps - System Optimization	17%	10%	13%	27%	9%	20%	52%	9%	18%	18%	9%	8%	5%	8%	5%	5%
1	304	Pumps - Sizing	17%	10%	13%	27%	9%	20%	52%	9%	18%	18%	9%	8%	5%	8%	5%	5%
1	305	Pumps - Replace 1-5 HP motor	17%	10%	13%	27%	9%	20%	52%	9%	18%	18%	9%	8%	5%	8%	5%	5%
1	306	Pumps - ASD (1-5 hp)	17%	10%	13%	27%	9%	20%	52%	9%	18%	18%	9%	8%	5%	8%	5%	5%
1	307	Pumps - Motor practices-1 (1-5 HP)	17%	10%	13%	27%	9%	20%	52%	9%	18%	18%	9%	8%	5%	8%	5%	5%
1	308	Pumps - Replace 6-100 HP motor	17%	10%	13%	27%	9%	20%	52%	9%	18%	18%	9%	8%	5%	8%	5%	5%
1	309	Pumps - ASD (6-100 hp)	17%	10%	13%	27%	9%	20%	52%	9%	18%	18%	9%	8%	5%	8%	5%	5%
1	310	Pumps - Motor practices-1 (6-100 HP)	17%	10%	13%	27%	9%	20%	52%	9%	18%	18%	9%	8%	5%	8%	5%	5%
1	311	Pumps - Replace 100+ HP motor	17%	10%	13%	27%	9%	20%	52%	9%	18%	18%	9%	8%	5%	8%	5%	5%
1	312	Pumps - ASD (100+ hp)	17%	10%	13%	27%	9%	20%	52%	9%	18%	18%	9%	8%	5%	8%	5%	5%
1	313	Pumps - Motor practices-1 (100+ HP)	17%	10%	13%	27%	9%	20%	52%	9%	18%	18%	9%	8%	5%	8%	5%	5%
1	314	Power recovery	0%	0%	0%	0%	0%	0%	52%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	315	Refinery Controls	0%	0%	0%	0%	0%	0%	52%	0%	0%	0%	0%	0%	0%	0%	0%	0%

APPLICABILITY FACTOR
(percent)

Segment	Measure #	Measure Description	SIC20	SIC22/23	SIC24/25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39/21/31
1	316	Energy Star Transformers	17%	10%	13%	27%	9%	20%	52%	9%	18%	18%	9%	8%	5%	8%	5%	5%
1	400	Base Drives	3%	36%	47%	35%	31%	16%	0%	33%	20%	21%	22%	21%	10%	14%	13%	20%
1	401	Bakery - Process (Mixing) - O&M	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	402	O&M/drives spinning machines	0%	36%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	403	Air conveying systems	0%	0%	47%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	404	Replace V-Belts	0%	0%	47%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	405	Drives - EE motor	0%	0%	47%	35%	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%
1	406	Gap Forming papermachine	0%	0%	0%	35%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	407	High Consistency forming	0%	0%	0%	35%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	408	Optimization control PM	0%	0%	0%	35%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	409	Efficient practices printing press	0%	0%	0%	0%	31%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	410	Efficient Printing press (fewer cylinders)	0%	0%	0%	0%	31%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	411	Light cylinders	0%	0%	0%	0%	31%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	412	Efficient drives	0%	0%	0%	0%	31%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	413	Clean Room - Controls	0%	0%	0%	0%	0%	16%	0%	0%	0%	0%	0%	0%	10%	0%	0%	0%
1	414	Clean Room - New Designs	0%	0%	0%	0%	0%	16%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	415	Drives - Process Controls (batch + site)	0%	0%	0%	0%	0%	16%	0%	0%	20%	21%	0%	0%	0%	0%	0%	0%
1	416	Process Drives - ASD	0%	0%	0%	0%	0%	16%	0%	0%	0%	0%	0%	0%	0%	0%	0%	20%
1	417	O&M - Extruders/Injection Moulding	0%	0%	0%	0%	0%	0%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%
1	418	Extruders/injection Moulding-multipump	0%	0%	0%	0%	0%	0%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%
1	419	Direct drive Extruders	0%	0%	0%	0%	0%	0%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%
1	420	Injection Moulding - Impulse Cooling	0%	0%	0%	0%	0%	0%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%
1	421	Injection Moulding - Direct drive	0%	0%	0%	0%	0%	0%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%
1	422	Efficient grinding	0%	0%	0%	0%	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%
1	423	Process control	0%	0%	0%	0%	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%
1	424	Process optimization	0%	0%	0%	0%	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%
1	425	Drives - Process Control	0%	0%	0%	0%	0%	0%	0%	0%	0%	21%	0%	0%	0%	0%	0%	0%
1	426	Efficient drives - rolling	0%	0%	0%	0%	0%	0%	0%	0%	0%	21%	0%	0%	0%	0%	0%	0%
1	427	Drives - Optimization process (M&T)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	22%	21%	0%	14%	13%	0%
1	428	Drives - Scheduling	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	22%	21%	10%	14%	13%	20%
1	429	Machinery	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	22%	21%	10%	14%	13%	0%
1	430	Efficient Machinery	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	20%
1	431	Energy Star Transformers	3%	36%	47%	35%	31%	16%	0%	33%	20%	21%	22%	21%	10%	14%	13%	20%
1	500	Base Heating	8%	5%	6%	0%	0%	0%	0%	0%	23%	20%	15%	10%	15%	10%	11%	11%
1	501	Bakery - Process	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	502	Drying (UV/IR)	0%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	503	Heat Pumps - Drying	0%	0%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	504	Top-heating (glass)	0%	0%	0%	0%	0%	0%	0%	0%	23%	0%	0%	0%	0%	0%	0%	0%
1	505	Efficient electric melting	0%	0%	0%	0%	0%	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%
1	506	Intelligent extruder (DOE)	0%	0%	0%	0%	0%	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%
1	507	Near Net Shape Casting	0%	0%	0%	0%	0%	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%
1	508	Heating - Process Control	0%	0%	0%	0%	0%	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%
1	509	Efficient Curing ovens	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15%	10%	15%	10%	11%	11%
1	510	Heating - Optimization process (M&T)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15%	10%	0%	10%	0%	0%
1	511	Heating - Scheduling	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15%	10%	0%	0%	0%	0%
1	512	Energy Star Transformers	8%	5%	6%	0%	0%	0%	0%	0%	23%	20%	15%	10%	15%	10%	11%	11%
1	550	Base Refrigeration	26%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	551	Efficient Refrigeration - Operations	26%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	552	Optimization Refrigeration	26%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	553	Energy Star Transformers	26%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	600	Base Other Process	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	5%	1%	5%	4%	2%	1%

APPLICABILITY FACTOR (percent)

Segment	Measure #	Measure Description	SIC20	SIC22/23	SIC24/25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39/21/31
1	601	Other Process Controls (batch + site)	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	602	Efficient desalter	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	603	New transformers welding	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	1%	0%	4%	2%	0%
1	604	Efficient processes (welding, etc.)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	0%	0%	0%
1	605	Process control	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
1	606	Power recovery	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	607	Refinery Controls	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	608	Energy Star Transformers	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	5%	1%	5%	4%	2%	1%
1	700	Centrifugal Chiller, 0.58 kW/ton, 500 tons	2%	6%	2%	1%	8%	0%	0%	1%	1%	1%	3%	2%	4%	6%	2%	5%
1	701	Centrifugal Chiller, 0.51 kW/ton, 500 tons	2%	6%	2%	1%	8%	0%	0%	1%	1%	1%	3%	2%	4%	6%	2%	5%
1	702	Window Film - Chiller	2%	6%	2%	1%	8%	0%	0%	1%	1%	1%	3%	2%	4%	6%	2%	5%
1	703	EMS - Chiller	2%	6%	2%	1%	8%	0%	0%	1%	1%	1%	3%	2%	4%	6%	2%	5%
1	704	Cool Roof - Chiller	2%	6%	2%	1%	8%	0%	0%	1%	1%	1%	3%	2%	4%	6%	2%	5%
1	705	Chiller Tune Up/Diagnostics	2%	6%	2%	1%	8%	0%	0%	1%	1%	1%	3%	2%	4%	6%	2%	5%
1	706	Cooling Circ. Pumps - VSD	2%	6%	2%	1%	8%	0%	0%	1%	1%	1%	3%	2%	4%	6%	2%	5%
1	707	Energy Star Transformers	2%	6%	2%	1%	8%	0%	0%	1%	1%	1%	3%	2%	4%	6%	2%	5%
1	710	DX Packaged System, EER=10.3, 10 tons	2%	4%	3%	2%	10%	1%	2%	2%	3%	2%	7%	4%	7%	12%	4%	12%
1	711	DX Tune Up/ Advanced Diagnostics	2%	4%	3%	2%	10%	1%	2%	2%	3%	2%	7%	4%	7%	12%	4%	12%
1	712	DX Packaged System, EER=10.9, 10 tons	2%	4%	3%	2%	10%	1%	2%	2%	3%	2%	7%	4%	7%	12%	4%	12%
1	713	Window Film - DX	2%	4%	3%	2%	10%	1%	2%	2%	3%	2%	7%	4%	7%	12%	4%	12%
1	714	Evaporative Pre-Cooler	2%	4%	3%	2%	10%	1%	2%	2%	3%	2%	7%	4%	7%	12%	4%	12%
1	715	Prog. Thermostat - DX	2%	4%	3%	2%	10%	1%	2%	2%	3%	2%	7%	4%	7%	12%	4%	12%
1	716	Cool Roof - DX	2%	4%	3%	2%	10%	1%	2%	2%	3%	2%	7%	4%	7%	12%	4%	12%
1	717	Energy Star Transformers	2%	4%	3%	2%	10%	1%	2%	2%	3%	2%	7%	4%	7%	12%	4%	12%
1	800	Base Lighting	7%	10%	6%	3%	23%	4%	3%	10%	5%	4%	15%	14%	13%	16%	17%	16%
1	801	RET 2L4' Premium T8, 1EB	7%	10%	6%	3%	23%	4%	3%	10%	5%	4%	15%	14%	13%	16%	17%	16%
1	802	CFL Hardwired, Modular 36W	7%	10%	6%	3%	23%	4%	3%	10%	5%	4%	15%	14%	13%	16%	17%	16%
1	803	Metal Halide, 50W	7%	10%	6%	3%	23%	4%	3%	10%	5%	4%	15%	14%	13%	16%	17%	16%
1	804	Occupancy Sensor, 4L4' Fluorescent Fixtures	7%	10%	6%	3%	23%	4%	3%	10%	5%	4%	15%	14%	13%	16%	17%	16%
1	805	Energy Star Transformers	7%	10%	6%	3%	23%	4%	3%	10%	5%	4%	15%	14%	13%	16%	17%	16%
1	900	Base Other	7%	7%	6%	4%	5%	1%	1%	4%	4%	1%	5%	7%	6%	8%	5%	8%
1	901	Replace V-belts	7%	7%	6%	4%	5%	1%	1%	4%	4%	1%	5%	7%	6%	8%	5%	8%
1	902	Membranes for wastewater	0%	7%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	903	Energy Star Transformers	7%	7%	6%	4%	5%	1%	1%	4%	4%	1%	5%	7%	6%	8%	5%	8%

INCOMPLETE FACTOR
(percent)

Segment	Measure #	Measure Description	SIC20	SIC22/23	SIC24/25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39/21/31
1	100	Base Compressed Air	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	101	Compressed Air-O&M	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
1	102	Compressed Air - Controls	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1	103	Compressed Air - System Optimization	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
1	104	Compressed Air- Sizing	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
1	105	Comp Air - Replace 1-5 HP motor	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
1	106	Comp Air - ASD (1-5 hp)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	107	Comp Air - Motor practices-1 (1-5 HP)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	108	Comp Air - Replace 6-100 HP motor	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%
1	109	Comp Air - ASD (6-100 hp)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	110	Comp Air - Motor practices-1 (6-100 HP)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	111	Comp Air - Replace 100+ HP motor	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1	112	Comp Air - ASD (100+ hp)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	113	Comp Air - Motor practices-1 (100+ HP)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	114	Power recovery	100%	100%	100%	100%	100%	100%	25%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	115	Refinery Controls	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	116	Energy Star Transformers	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
1	200	Base Fans	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	201	Fans - O&M	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
1	202	Fans - Controls	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1	203	Fans - System Optimization	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1	204	Fans- Improve components	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1	205	Fans - Replace 1-5 HP motor	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
1	206	Fans - ASD (1-5 hp)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	207	Fans - Motor practices-1 (1-5 HP)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	208	Fans - Replace 6-100 HP motor	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%
1	209	Fans - ASD (6-100 hp)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	210	Fans - Motor practices-1 (6-100 HP)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	211	Fans - Replace 100+ HP motor	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1	212	Fans - ASD (100+ hp)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	213	Fans - Motor practices-1 (100+ HP)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	214	Optimize drying process	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	215	Power recovery	100%	100%	100%	100%	100%	100%	25%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	216	Refinery Controls	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	217	Energy Star Transformers	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
1	300	Base Pumps	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	301	Pumps - O&M	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
1	302	Pumps - Controls	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%
1	303	Pumps - System Optimization	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1	304	Pumps - Sizing	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1	305	Pumps - Replace 1-5 HP motor	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%	87%
1	306	Pumps - ASD (1-5 hp)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	307	Pumps - Motor practices-1 (1-5 HP)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	308	Pumps - Replace 6-100 HP motor	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%	62%
1	309	Pumps - ASD (6-100 hp)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	310	Pumps - Motor practices-1 (6-100 HP)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	311	Pumps - Replace 100+ HP motor	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
1	312	Pumps - ASD (100+ hp)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	313	Pumps - Motor practices-1 (100+ HP)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	314	Power recovery	100%	100%	100%	100%	100%	100%	25%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	315	Refinery Controls	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%

INCOMPLETE FACTOR
(percent)

Segment	Measure #	Measure Description	SIC20	SIC22/23	SIC24/25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39/21/31
1	316	Energy Star Transformers	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
1	400	Base Drives	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	401	Bakery - Process (Mixing) - O&M	70%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	402	O&M/drives spinning machines	100%	40%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	403	Air conveying systems	100%	100%	25%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	404	Replace V-Belts	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	405	Drives - EE motor	100%	100%	40%	55%	100%	100%	100%	100%	30%	100%	100%	100%	100%	100%	100%	100%
1	406	Gap Forming papermachine	100%	100%	100%	10%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	407	High Consistency forming	100%	100%	100%	10%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	408	Optimization control PM	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	409	Efficient practices printing press	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	410	Efficient Printing press (fewer cylinders)	100%	100%	100%	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	411	Light cylinders	100%	100%	100%	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	412	Efficient drives	100%	100%	100%	100%	30%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	413	Clean Room - Controls	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%
1	414	Clean Room - New Designs	100%	100%	100%	100%	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	415	Drives - Process Controls (batch + site)	100%	100%	100%	100%	100%	50%	100%	100%	50%	50%	100%	100%	100%	100%	100%	100%
1	416	Process Drives - ASD	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%
1	417	O&M - Extruders/Injection Moulding	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%
1	418	Extruders/injection Moulding-multipump	100%	100%	100%	100%	100%	100%	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%
1	419	Direct drive Extruders	100%	100%	100%	100%	100%	100%	100%	10%	100%	100%	100%	100%	100%	100%	100%	100%
1	420	Injection Moulding - Impulse Cooling	100%	100%	100%	100%	100%	100%	100%	25%	100%	100%	100%	100%	100%	100%	100%	100%
1	421	Injection Moulding - Direct drive	100%	100%	100%	100%	100%	100%	100%	25%	100%	100%	100%	100%	100%	100%	100%	100%
1	422	Efficient grinding	100%	100%	100%	100%	100%	100%	100%	100%	20%	100%	100%	100%	100%	100%	100%	100%
1	423	Process control	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%
1	424	Process optimization	100%	100%	100%	100%	100%	100%	100%	100%	25%	100%	100%	100%	100%	100%	100%	100%
1	425	Drives - Process Control	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%
1	426	Efficient drives - rolling	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%
1	427	Drives - Optimization process (M&T)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	50%	100%	40%	50%	100%
1	428	Drives - Scheduling	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	30%	30%	30%	30%	30%	30%
1	429	Machinery	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	25%	25%	25%	20%	25%	100%
1	430	Efficient Machinery	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	25%
1	431	Energy Star Transformers	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
1	500	Base Heating	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	501	Bakery - Process	30%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	502	Drying (UV/IR)	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	503	Heat Pumps - Drying	100%	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	504	Top-heating (glass)	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%
1	505	Efficient electric melting	100%	100%	100%	100%	100%	100%	100%	100%	100%	25%	100%	100%	100%	100%	100%	100%
1	506	Intelligent extruder (DOE)	100%	100%	100%	100%	100%	100%	100%	100%	100%	25%	100%	100%	100%	100%	100%	100%
1	507	Near Net Shape Casting	100%	100%	100%	100%	100%	100%	100%	100%	100%	25%	100%	100%	100%	100%	100%	100%
1	508	Heating - Process Control	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%
1	509	Efficient Curing ovens	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	25%	25%	25%	25%	25%	25%
1	510	Heating - Optimization process (M&T)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	50%	100%	40%	100%	100%
1	511	Heating - Scheduling	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	30%	30%	100%	100%	100%	100%
1	512	Energy Star Transformers	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
1	550	Base Refrigeration	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	551	Efficient Refrigeration - Operations	22%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	552	Optimization Refrigeration	15%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	553	Energy Star Transformers	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
1	600	Base Other Process	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

INCOMPLETE FACTOR
(percent)

Segment	Measure #	Measure Description	SIC20	SIC22/23	SIC24/25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39/21/31
1	601	Other Process Controls (batch + site)	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	602	Efficient desalter	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	603	New transformers welding	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	50%	100%	50%	50%	100%
1	604	Efficient processes (welding, etc.)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%
1	605	Process control	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	25%
1	606	Power recovery	100%	100%	100%	100%	100%	100%	25%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	607	Refinery Controls	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	608	Energy Star Transformers	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
1	700	Centrifugal Chiller, 0.58 kW/ton, 500 tons	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	701	Centrifugal Chiller, 0.51 kW/ton, 500 tons	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	702	Window Film - Chiller	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
1	703	EMS - Chiller	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%	63%
1	704	Cool Roof - Chiller	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%
1	705	Chiller Tune Up/Diagnostics	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
1	706	Cooling Circ. Pumps - VSD	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
1	707	Energy Star Transformers	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
1	710	DX Packaged System, EER=10.3, 10 tons	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	711	DX Tune Up/ Advanced Diagnostics	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
1	712	DX Packaged System, EER=10.9, 10 tons	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	713	Window Film - DX	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%
1	714	Evaporative Pre-Cooler	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
1	715	Prog. Thermostat - DX	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%
1	716	Cool Roof - DX	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%	61%
1	717	Energy Star Transformers	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
1	800	Base Lighting	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	801	RET 2L4' Premium T8, 1EB	84%	74%	85%	79%	82%	83%	83%	85%	89%	87%	86%	84%	84%	81%	83%	84%
1	802	CFL Hardwired, Modular 36W	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%
1	803	Metal Halide, 50W	7%	16%	12%	5%	3%	23%	23%	8%	57%	25%	24%	18%	7%	12%	22%	2%
1	804	Occupancy Sensor, 4L4' Fluorescent Fixtures	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
1	805	Energy Star Transformers	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
1	900	Base Other	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	901	Replace V-belts	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
1	902	Membranes for wastewater	100%	15%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	903	Energy Star Transformers	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%

FEASIBILITY FACTOR
(percent)

Segment	Measure #	Measure Description	SIC20	SIC22/23	SIC24/25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39/21/31
1	100	Base Compressed Air	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	101	Compressed Air-O&M	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	102	Compressed Air - Controls	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	103	Compressed Air - System Optimization	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	104	Compressed Air- Sizing	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	105	Comp Air - Replace 1-5 HP motor	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1	106	Comp Air - ASD (1-5 hp)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1	107	Comp Air - Motor practices-1 (1-5 HP)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1	108	Comp Air - Replace 6-100 HP motor	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
1	109	Comp Air - ASD (6-100 hp)	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
1	110	Comp Air - Motor practices-1 (6-100 HP)	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
1	111	Comp Air - Replace 100+ HP motor	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%
1	112	Comp Air - ASD (100+ hp)	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%
1	113	Comp Air - Motor practices-1 (100+ HP)	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%
1	114	Power recovery	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	115	Refinery Controls	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	116	Energy Star Transformers	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	200	Base Fans	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	201	Fans - O&M	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	202	Fans - Controls	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	203	Fans - System Optimization	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	204	Fans- Improve components	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	205	Fans - Replace 1-5 HP motor	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1	206	Fans - ASD (1-5 hp)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1	207	Fans - Motor practices-1 (1-5 HP)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1	208	Fans - Replace 6-100 HP motor	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
1	209	Fans - ASD (6-100 hp)	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
1	210	Fans - Motor practices-1 (6-100 HP)	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
1	211	Fans - Replace 100+ HP motor	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%
1	212	Fans - ASD (100+ hp)	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%
1	213	Fans - Motor practices-1 (100+ HP)	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%
1	214	Optimize drying process	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	215	Power recovery	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	216	Refinery Controls	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	217	Energy Star Transformers	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	300	Base Pumps	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	301	Pumps - O&M	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	302	Pumps - Controls	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	303	Pumps - System Optimization	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	304	Pumps - Sizing	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	305	Pumps - Replace 1-5 HP motor	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1	306	Pumps - ASD (1-5 hp)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1	307	Pumps - Motor practices-1 (1-5 HP)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1	308	Pumps - Replace 6-100 HP motor	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
1	309	Pumps - ASD (6-100 hp)	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
1	310	Pumps - Motor practices-1 (6-100 HP)	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
1	311	Pumps - Replace 100+ HP motor	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%
1	312	Pumps - ASD (100+ hp)	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%
1	313	Pumps - Motor practices-1 (100+ HP)	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%
1	314	Power recovery	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	315	Refinery Controls	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%

FEASIBILITY FACTOR
(percent)

Segment	Measure #	Measure Description	SIC20	SIC22/23	SIC24/25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39/21/31
1	316	Energy Star Transformers	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	400	Base Drives	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	401	Bakery - Process (Mixing) - O&M	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	402	O&M/drives spinning machines	0%	60%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	403	Air conveying systems	0%	0%	30%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	404	Replace V-Belts	0%	0%	70%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	405	Drives - EE motor	0%	0%	100%	100%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%
1	406	Gap Forming papermachine	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	407	High Consistency forming	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	408	Optimization control PM	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	409	Efficient practices printing press	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	410	Efficient Printing press (fewer cylinders)	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	411	Light cylinders	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	412	Efficient drives	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	413	Clean Room - Controls	0%	0%	0%	0%	0%	30%	0%	0%	0%	0%	0%	0%	60%	0%	0%	0%
1	414	Clean Room - New Designs	0%	0%	0%	0%	0%	30%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	415	Drives - Process Controls (batch + site)	0%	0%	0%	0%	0%	86%	0%	0%	100%	100%	0%	0%	0%	0%	0%	0%
1	416	Process Drives - ASD	0%	0%	0%	0%	0%	70%	0%	0%	0%	0%	0%	0%	0%	0%	0%	40%
1	417	O&M - Extruders/Injection Moulding	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
1	418	Extruders/injection Moulding-multipump	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
1	419	Direct drive Extruders	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%
1	420	Injection Moulding - Impulse Cooling	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%
1	421	Injection Moulding - Direct drive	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%
1	422	Efficient grinding	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%
1	423	Process control	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%
1	424	Process optimization	0%	0%	0%	0%	0%	0%	0%	0%	25%	0%	0%	0%	0%	0%	0%	0%
1	425	Drives - Process Control	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%
1	426	Efficient drives - rolling	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%
1	427	Drives - Optimization process (M&T)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	40%	40%	0%	40%	40%	0%
1	428	Drives - Scheduling	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	40%	40%	40%	40%	40%	40%
1	429	Machinery	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%	50%	50%	50%	50%	0%
1	430	Efficient Machinery	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%
1	431	Energy Star Transformers	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	500	Base Heating	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	501	Bakery - Process	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	502	Drying (UV/IR)	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	503	Heat Pumps - Drying	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	504	Top-heating (glass)	0%	0%	0%	0%	0%	0%	0%	0%	25%	0%	0%	0%	0%	0%	0%	0%
1	505	Efficient electric melting	0%	0%	0%	0%	0%	0%	0%	0%	0%	90%	0%	0%	0%	0%	0%	0%
1	506	Intelligent extruder (DOE)	0%	0%	0%	0%	0%	0%	0%	0%	0%	10%	0%	0%	0%	0%	0%	0%
1	507	Near Net Shape Casting	0%	0%	0%	0%	0%	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%
1	508	Heating - Process Control	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%
1	509	Efficient Curing ovens	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	70%	50%	50%	50%	50%	50%
1	510	Heating - Optimization process (M&T)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	40%	40%	0%	40%	0%	0%
1	511	Heating - Scheduling	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	40%	40%	0%	0%	0%	0%
1	512	Energy Star Transformers	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	550	Base Refrigeration	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	551	Efficient Refrigeration - Operations	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	552	Optimization Refrigeration	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	553	Energy Star Transformers	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	600	Base Other Process	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

FEASIBILITY FACTOR
(percent)

Segment	Measure #	Measure Description	SIC20	SIC22/23	SIC24/25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39/21/31
1	601	Other Process Controls (batch + site)	0%	0%	0%	0%	0%	86%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	602	Efficient desalter	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	603	New transformers welding	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	50%	0%	100%	50%	0%
1	604	Efficient processes (welding, etc.)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%
1	605	Process control	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
1	606	Power recovery	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	607	Refinery Controls	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	608	Energy Star Transformers	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	700	Centrifugal Chiller, 0.58 kW/ton, 500 tons	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	701	Centrifugal Chiller, 0.51 kW/ton, 500 tons	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	702	Window Film - Chiller	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
1	703	EMS - Chiller	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	704	Cool Roof - Chiller	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
1	705	Chiller Tune Up/Diagnostics	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1	706	Cooling Circ. Pumps - VSD	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
1	707	Energy Star Transformers	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	710	DX Packaged System, EER=10.3, 10 tons	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	711	DX Tune Up/ Advanced Diagnostics	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
1	712	DX Packaged System, EER=10.9, 10 tons	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	713	Window Film - DX	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
1	714	Evaporative Pre-Cooler	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
1	715	Prog. Thermostat - DX	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
1	716	Cool Roof - DX	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
1	717	Energy Star Transformers	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	800	Base Lighting	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	801	RET 2L4' Premium T8, 1EB	76%	86%	87%	80%	96%	77%	77%	80%	62%	66%	85%	87%	90%	89%	91%	93%
1	802	CFL Hardwired, Modular 36W	17%	8%	8%	16%	3%	10%	10%	18%	20%	27%	11%	9%	8%	8%	7%	6%
1	803	Metal Halide, 50W	6%	6%	5%	4%	2%	12%	12%	2%	18%	7%	4%	4%	2%	3%	3%	0%
1	804	Occupancy Sensor, 4L4' Fluorescent Fixtures	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1	805	Energy Star Transformers	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	900	Base Other	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	901	Replace V-belts	73%	71%	80%	79%	39%	0%	7%	53%	70%	20%	53%	40%	33%	55%	32%	55%
1	902	Membranes for wastewater	0%	29%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	903	Energy Star Transformers	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%

ENERGY SAVINGS (percent)

Segment	Measure #	Measure Description	SIC20	SIC22/23	SIC24/25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39/21/31
1	100	Base Compressed Air	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	101	Compressed Air-O&M	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%
1	102	Compressed Air - Controls	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
1	103	Compressed Air - System Optimization	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1	104	Compressed Air- Sizing	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%
1	105	Comp Air - Replace 1-5 HP motor	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
1	106	Comp Air - ASD (1-5 hp)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
1	107	Comp Air - Motor practices-1 (1-5 HP)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1	108	Comp Air - Replace 6-100 HP motor	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1	109	Comp Air - ASD (6-100 hp)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
1	110	Comp Air - Motor practices-1 (6-100 HP)	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	111	Comp Air - Replace 100+ HP motor	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
1	112	Comp Air - ASD (100+ hp)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
1	113	Comp Air - Motor practices-1 (100+ HP)	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	114	Power recovery	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	115	Refinery Controls	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	116	Energy Star Transformers	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1	200	Base Fans	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	201	Fans - O&M	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	202	Fans - Controls	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1	203	Fans - System Optimization	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%
1	204	Fans- Improve components	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1	205	Fans - Replace 1-5 HP motor	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
1	206	Fans - ASD (1-5 hp)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
1	207	Fans - Motor practices-1 (1-5 HP)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1	208	Fans - Replace 6-100 HP motor	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1	209	Fans - ASD (6-100 hp)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
1	210	Fans - Motor practices-1 (6-100 HP)	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	211	Fans - Replace 100+ HP motor	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
1	212	Fans - ASD (100+ hp)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
1	213	Fans - Motor practices-1 (100+ HP)	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	214	Optimize drying process	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	215	Power recovery	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	216	Refinery Controls	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	217	Energy Star Transformers	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1	300	Base Pumps	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	301	Pumps - O&M	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1	302	Pumps - Controls	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
1	303	Pumps - System Optimization	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%
1	304	Pumps - Sizing	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1	305	Pumps - Replace 1-5 HP motor	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
1	306	Pumps - ASD (1-5 hp)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
1	307	Pumps - Motor practices-1 (1-5 HP)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1	308	Pumps - Replace 6-100 HP motor	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1	309	Pumps - ASD (6-100 hp)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
1	310	Pumps - Motor practices-1 (6-100 HP)	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	311	Pumps - Replace 100+ HP motor	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
1	312	Pumps - ASD (100+ hp)	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
1	313	Pumps - Motor practices-1 (100+ HP)	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	314	Power recovery	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	315	Refinery Controls	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%

ENERGY SAVINGS
(percent)

Segment	Measure #	Measure Description	SIC20	SIC22/23	SIC24/25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39/21/31
1	316	Energy Star Transformers	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1	400	Base Drives	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	401	Bakery - Process (Mixing) - O&M	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	402	O&M/drives spinning machines	0%	16%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	403	Air conveying systems	0%	0%	41%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	404	Replace V-Belts	0%	0%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	405	Drives - EE motor	0%	0%	4%	3%	0%	0%	0%	0%	4%	0%	0%	0%	0%	0%	0%	0%
1	406	Gap Forming papermachine	0%	0%	0%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	407	High Consistency forming	0%	0%	0%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	408	Optimization control PM	0%	0%	0%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	409	Efficient practices printing press	0%	0%	0%	0%	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	410	Efficient Printing press (fewer cylinders)	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	411	Light cylinders	0%	0%	0%	0%	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	412	Efficient drives	0%	0%	0%	0%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	413	Clean Room - Controls	0%	0%	0%	0%	0%	10%	0%	0%	0%	0%	0%	0%	10%	0%	0%	0%
1	414	Clean Room - New Designs	0%	0%	0%	0%	0%	30%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	415	Drives - Process Controls (batch + site)	0%	0%	0%	0%	0%	8%	0%	0%	2%	5%	0%	0%	0%	0%	0%	0%
1	416	Process Drives - ASD	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
1	417	O&M - Extruders/Injection Moulding	0%	0%	0%	0%	0%	0%	0%	10%	0%	0%	0%	0%	0%	0%	0%	0%
1	418	Extruders/injection Moulding-multipump	0%	0%	0%	0%	0%	0%	0%	30%	0%	0%	0%	0%	0%	0%	0%	0%
1	419	Direct drive Extruders	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%
1	420	Injection Moulding - Impulse Cooling	0%	0%	0%	0%	0%	0%	0%	21%	0%	0%	0%	0%	0%	0%	0%	0%
1	421	Injection Moulding - Direct drive	0%	0%	0%	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%	0%
1	422	Efficient grinding	0%	0%	0%	0%	0%	0%	0%	0%	21%	0%	0%	0%	0%	0%	0%	0%
1	423	Process control	0%	0%	0%	0%	0%	0%	0%	0%	2%	5%	0%	0%	0%	0%	0%	0%
1	424	Process optimization	0%	0%	0%	0%	0%	0%	0%	0%	10%	0%	0%	0%	0%	0%	0%	0%
1	425	Drives - Process Control	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	0%	0%	0%	0%	0%	0%
1	426	Efficient drives - rolling	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	0%	0%	0%	0%	0%	0%
1	427	Drives - Optimization process (M&T)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	10%	10%	0%	10%	10%	0%
1	428	Drives - Scheduling	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	5%	5%	5%	5%	5%
1	429	Machinery	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	7%	7%	4%	11%	7%	0%
1	430	Efficient Machinery	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%
1	431	Energy Star Transformers	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1	500	Base Heating	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	501	Bakery - Process	37%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	502	Drying (UV/IR)	0%	26%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	503	Heat Pumps - Drying	0%	0%	22%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	504	Top-heating (glass)	0%	0%	0%	0%	0%	0%	0%	0%	4%	0%	0%	0%	0%	0%	0%	0%
1	505	Efficient electric melting	0%	0%	0%	0%	0%	0%	0%	0%	0%	10%	0%	0%	0%	0%	0%	0%
1	506	Intelligent extruder (DOE)	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%
1	507	Near Net Shape Casting	0%	0%	0%	0%	0%	0%	0%	0%	0%	12%	0%	0%	0%	0%	0%	0%
1	508	Heating - Process Control	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	0%	0%	0%	0%	0%	0%
1	509	Efficient Curing ovens	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	20%	20%	20%	20%	20%	20%
1	510	Heating - Optimization process (M&T)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	10%	10%	0%	10%	0%	0%
1	511	Heating - Scheduling	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	5%	0%	0%	0%	0%
1	512	Energy Star Transformers	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1	550	Base Refrigeration	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	551	Efficient Refrigeration - Operations	12%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	552	Optimization Refrigeration	26%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	553	Energy Star Transformers	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1	600	Base Other Process	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

ENERGY SAVINGS
(percent)

Segment	Measure #	Measure Description	SIC20	SIC22/23	SIC24/25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39/21/31
1	601	Other Process Controls (batch + site)	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	602	Efficient desalter	0%	0%	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	603	New transformers welding	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	25%	25%	0%	25%	25%	0%
1	604	Efficient processes (welding, etc.)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	25%	0%	0%	0%
1	605	Process control	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%
1	606	Power recovery	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	607	Refinery Controls	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	608	Energy Star Transformers	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1	700	Centrifugal Chiller, 0.58 kW/ton, 500 tons	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	701	Centrifugal Chiller, 0.51 kW/ton, 500 tons	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
1	702	Window Film - Chiller	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1	703	EMS - Chiller	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1	704	Cool Roof - Chiller	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1	705	Chiller Tune Up/Diagnostics	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
1	706	Cooling Circ. Pumps - VSD	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
1	707	Energy Star Transformers	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1	710	DX Packaged System, EER=10.3, 10 tons	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	711	DX Tune Up/ Advanced Diagnostics	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1	712	DX Packaged System, EER=10.9, 10 tons	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
1	713	Window Film - DX	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1	714	Evaporative Pre-Cooler	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1	715	Prog. Thermostat - DX	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1	716	Cool Roof - DX	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1	717	Energy Star Transformers	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1	800	Base Lighting	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	801	RET 2L4' Premium T8, 1EB	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%
1	802	CFL Hardwired, Modular 36W	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%	72%
1	803	Metal Halide, 50W	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%	58%
1	804	Occupancy Sensor, 4L4' Fluorescent Fixtures	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1	805	Energy Star Transformers	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1	900	Base Other	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	901	Replace V-belts	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	902	Membranes for wastewater	0%	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	903	Energy Star Transformers	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%

Measure Costs

Technology Saturations

Applicability Factors

Incomplete Factors

Feasibility Factors

Measure Savings

MEASURE COSTS

Segment	Measure #	Measure Description	Savings Units	Cost Units	Unit Equipment Cost	Unit Labor Cost	NPV of Lifetime O & M Cost	Imple-mentation Cost Factor	Cost Units per Savings Unit	Service Life	Full = 1 Incr. = 0 Initial Cost	Replace Cost	Full Unit Cost	Relative Energy Reduction Factors SP	SPP	SOP	WP	WPP	WOP	End Use	Implementatior Type 1=1 time 2=ROB
1	100	Base Boiler	$/Therm	$/Therm	$0.000	$0.00	$0.00	$0.000	1	20	1	1	$0.000	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	101	Improved process control	$/Therm	$/Therm	$0.013	$0.00	$0.00	$0.013	1	15	1	1	$0.014	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	102	Maintain boilers	$/Therm	$/Therm	$0.001	$0.00	$0.00	$0.001	1	2	1	1	$0.001	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	103	Flue gas heat recovery/economizer	$/Therm	$/Therm	$0.029	$0.00	$0.01	$0.029	1	15	1	1	$0.041	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	104	Blowdown steam heat recovery	$/Therm	$/Therm	$0.026	$0.00	$0.01	$0.026	1	15	1	1	$0.036	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	105	Upgrade burner efficiency	$/Therm	$/Therm	$0.017	$0.00	$0.01	$0.017	1	20	1	1	$0.026	1.00	1.00	1.00	1.00	1.00	1.00	1	2
1	106	Water treatment	$/Therm	$/Therm	$0.007	$0.00	$0.00	$0.007	1	10	1	1	$0.010	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	107	Load control	$/Therm	$/Therm	$0.015	$0.00	$0.00	$0.015	1	15	1	1	$0.016	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	108	Improved insulation	$/Therm	$/Therm	$0.064	$0.00	$0.01	$0.064	1	15	1	1	$0.077	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	109	Steam trap maintenance	$/Therm	$/Therm	$0.046	$0.00	$0.00	$0.046	1	2	1	1	$0.047	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	110	Automatic steam trap monitoring	$/Therm	$/Therm	$0.037	$0.00	$0.00	$0.037	1	15	1	1	$0.040	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	111	Leak repair	$/Therm	$/Therm	$0.012	$0.00	$0.00	$0.012	1	2	1	1	$0.012	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	112	Condensate return	$/Therm	$/Therm	$0.080	$0.00	$0.03	$0.080	1	15	1	1	$0.113	1.00	1.00	1.00	1.00	1.00	1.00	1	1
1	200	Base HVAC	$/Therm	$/Therm	$0.000	$0.00	$0.00	$0.000	1	20	1	1	$0.000	1.00	1.00	1.00	1.00	1.00	1.00	2	1
1	201	Improve ceiling insulation	$/Therm	$/Therm	$0.711	$0.00	$0.17	$0.711	1	20	1	1	$0.883	1.00	1.00	1.00	1.00	1.00	1.00	2	1
1	202	Install HE(95%) cond furnace/boiler	$/Therm	$/Therm	$0.263	$0.00	$0.13	$0.263	1	20	1	1	$0.390	1.00	1.00	1.00	1.00	1.00	1.00	2	2
1	203	Stack heat exchanger	$/Therm	$/Therm	$0.128	$0.00	$0.06	$0.128	1	20	1	1	$0.190	1.00	1.00	1.00	1.00	1.00	1.00	2	1
1	204	Duct insulation	$/Therm	$/Therm	$0.029	$0.00	$0.01	$0.029	1	20	1	1	$0.036	1.00	1.00	1.00	1.00	1.00	1.00	2	1
1	205	EMS install	$/Therm	$/Therm	$0.292	$0.00	$0.04	$0.292	1	20	1	1	$0.327	1.00	1.00	1.00	1.00	1.00	1.00	2	1
1	206	EMS optimization	$/Therm	$/Therm	$0.007	$0.00	$0.00	$0.007	1	5	1	1	$0.008	1.00	1.00	1.00	1.00	1.00	1.00	2	1
1	300	Base Process Heat	$/Therm	$/Therm	$0.000	$0.00	$0.00	$0.000	1	20	1	1	$0.000	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	301	Process Controls & Management	$/Therm	$/Therm	$0.055	$0.00	$0.00	$0.055	1	8	1	1	$0.058	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	302	Heat Recovery	$/Therm	$/Therm	$0.639	$0.00	$0.31	$0.639	1	20	1	1	$0.948	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	303	Efficient burners	$/Therm	$/Therm	$0.164	$0.00	$0.05	$0.164	1	10	1	1	$0.214	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	304	Process integration	$/Therm	$/Therm	$0.730	$0.00	$0.30	$0.730	1	15	1	1	$1.026	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	305	Efficient drying	$/Therm	$/Therm	$0.427	$0.00	$0.21	$0.427	1	20	1	1	$0.634	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	306	Closed hood	$/Therm	$/Therm	$0.292	$0.00	$0.12	$0.292	1	15	1	1	$0.410	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	307	Extended nip press	$/Therm	$/Therm	$0.642	$0.00	$0.31	$0.642	1	20	1	1	$0.954	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	308	Improved separation processes	$/Therm	$/Therm	$0.183	$0.00	$0.09	$0.183	1	20	1	1	$0.271	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	309	Thermal oxidizers	$/Therm	$/Therm	$1.752	$0.00	$0.71	$1.752	1	15	1	1	$2.463	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	310	Flare gas controls and recovery	$/Therm	$/Therm	$0.730	$0.00	$0.30	$0.730	1	15	1	1	$1.026	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	311	Fouling control	$/Therm	$/Therm	$0.041	$0.00	$0.00	$0.041	1	5	1	1	$0.044	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	312	Efficient furnaces	$/Therm	$/Therm	$0.096	$0.00	$0.05	$0.096	1	20	1	1	$0.143	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	313	Oxyfuel	$/Therm	$/Therm	$0.438	$0.00	$0.21	$0.438	1	20	1	1	$0.650	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	314	Batch cullet preheating	$/Therm	$/Therm	$0.234	$0.00	$0.09	$0.234	1	15	1	1	$0.328	1.00	1.00	1.00	1.00	1.00	1.00	3	2
1	315	Preventative maintenance	$/Therm	$/Therm	$0.007	$0.00	$0.00	$0.007	1	5	1	1	$0.008	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	316	Combustion controls	$/Therm	$/Therm	$0.088	$0.00	$0.01	$0.088	1	8	1	1	$0.093	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	317	Optimize furnace operations	$/Therm	$/Therm	$0.110	$0.00	$0.03	$0.110	1	10	1	1	$0.143	1.00	1.00	1.00	1.00	1.00	1.00	3	1
1	318	Insulation/reduce heat losses	$/Therm	$/Therm	$0.292	$0.00	$0.06	$0.292	1	15	1	1	$0.351	1.00	1.00	1.00	1.00	1.00	1.00	3	1

TECHNOLOGY SATURATION
(units/base therm)

Segment	Measure #	Measure Description	SIC20	SIC22	SIC23	SIC24	SIC25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC31	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39
1	100	Base Boiler	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	101	Improved process control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	102	Maintain boilers	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	103	Flue gas heat recovery/economizer	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	104	Blowdown steam heat recovery	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	105	Upgrade burner efficiency	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	106	Water treatment	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	107	Load control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	108	Improved insulation	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	109	Steam trap maintenance	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	110	Automatic steam trap monitoring	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	111	Leak repair	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	112	Condensate return	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	200	Base HVAC	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	201	Improve ceiling insulation	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	202	Install HE(95%) cond furnace/boiler	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	203	Stack heat exchanger	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	204	Duct insulation	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	205	EMS install	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	206	EMS optimization	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	300	Base Process Heat	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	301	Process Controls & Management	1.6000	1.0000	1.0000	1.0000	1.0000	0.2000	1.0000	0.5333	0.8000	1.0000	1.0000	0.9333	1.0400	1.0000	1.0000	1.0000	1.2800	1.2000	1.0000
1	302	Heat Recovery	0.2514	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.2000	1.0000	0.8000	0.8000	0.9143	0.8000	0.8000
1	303	Efficient burners	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.6000	3.1111	1.0000	1.0000	1.0000	1.0000	1.0000
1	304	Process integration	1.0000	1.0000	1.0000	1.0000	1.0000	0.2250	1.0000	0.2600	0.3900	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	305	Efficient drying	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.1966	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	306	Closed hood	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	307	Extended nip press	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	308	Improved separation processes	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	309	Thermal oxidizers	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	310	Flare gas controls and recovery	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	311	Fouling control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	312	Efficient furnaces	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	313	Oxyfuel	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	314	Batch cullet preheating	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	315	Preventative maintenance	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	316	Combustion controls	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	317	Optimize furnace operations	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	318	Insulation/reduce heat losses	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

APPLICABILITY FACTOR (percent)

Segment	Measure #	Measure Description	SIC20	SIC22	SIC23	SIC24	SIC25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC31	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39
1	100	Base Boiler	60%	61%	41%	32%	12%	71%	21%	36%	26%	51%	50%	4%	14%	13%	19%	40%	32%	34%	34%
1	101	Improved process control	60%	61%	41%	32%	12%	71%	21%	36%	26%	51%	50%	4%	14%	13%	19%	40%	32%	34%	34%
1	102	Maintain boilers	60%	61%	41%	32%	12%	71%	21%	36%	26%	51%	50%	4%	14%	13%	19%	40%	32%	34%	34%
1	103	Flue gas heat recovery/economizer	60%	61%	41%	32%	12%	71%	21%	36%	26%	51%	50%	4%	14%	13%	19%	40%	32%	34%	34%
1	104	Blowdown steam heat recovery	60%	61%	41%	32%	12%	71%	21%	36%	26%	51%	50%	4%	14%	13%	19%	40%	32%	34%	34%
1	105	Upgrade burner efficiency	60%	61%	41%	32%	12%	71%	21%	36%	26%	51%	50%	4%	14%	13%	19%	40%	32%	34%	34%
1	106	Water treatment	60%	61%	41%	32%	12%	71%	21%	36%	26%	51%	50%	4%	14%	13%	19%	40%	32%	34%	34%
1	107	Load control	60%	61%	41%	32%	12%	71%	21%	36%	26%	51%	50%	4%	14%	13%	19%	40%	32%	34%	34%
1	108	Improved insulation	60%	61%	41%	32%	12%	71%	21%	36%	26%	51%	50%	4%	14%	13%	19%	40%	32%	34%	34%
1	109	Steam trap maintenance	60%	61%	41%	32%	12%	71%	21%	36%	26%	51%	50%	4%	14%	13%	19%	40%	32%	34%	34%
1	110	Automatic steam trap monitoring	60%	61%	41%	32%	12%	71%	21%	36%	26%	51%	50%	4%	14%	13%	19%	40%	32%	34%	34%
1	111	Leak repair	60%	61%	41%	32%	12%	71%	21%	36%	26%	51%	50%	4%	14%	13%	19%	40%	32%	34%	34%
1	112	Condensate return	60%	61%	41%	32%	12%	71%	21%	36%	26%	51%	50%	4%	14%	13%	19%	40%	32%	34%	34%
1	200	Base HVAC	5%	3%	18%	10%	36%	3%	23%	1%	1%	16%	25%	4%	6%	21%	47%	22%	29%	32%	32%
1	201	Improve ceiling insulation	5%	3%	18%	10%	36%	3%	23%	1%	1%	16%	25%	4%	6%	21%	47%	22%	29%	32%	32%
1	202	Install HE(95%) cond furnace/boiler	5%	3%	18%	10%	36%	3%	23%	1%	1%	16%	25%	4%	6%	21%	47%	22%	29%	32%	32%
1	203	Stack heat exchanger	5%	3%	18%	10%	36%	3%	23%	1%	1%	16%	25%	4%	6%	21%	47%	22%	29%	32%	32%
1	204	Duct insulation	5%	3%	18%	10%	36%	3%	23%	1%	1%	16%	25%	4%	6%	21%	47%	22%	29%	32%	32%
1	205	EMS install	5%	3%	18%	10%	36%	3%	23%	1%	1%	16%	25%	4%	6%	21%	47%	22%	29%	32%	32%
1	206	EMS optimization	5%	3%	18%	10%	36%	3%	23%	1%	1%	16%	25%	4%	6%	21%	47%	22%	29%	32%	32%
1	300	Base Process Heat	29%	32%	41%	50%	28%	19%	42%	29%	65%	24%	25%	85%	72%	59%	29%	31%	33%	29%	29%
1	301	Process Controls & Management	29%	32%	41%	50%	28%	19%	42%	29%	65%	24%	25%	85%	72%	0%	29%	31%	33%	29%	29%
1	302	Heat Recovery	29%	32%	41%	50%	28%	0%	0%	0%	0%	24%	25%	0%	72%	0%	29%	31%	33%	29%	29%
1	303	Efficient burners	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	85%	72%	59%	0%	0%	0%	0%	0%
1	304	Process integration	29%	0%	0%	0%	0%	19%	0%	29%	65%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	305	Efficient drying	29%	0%	0%	0%	0%	0%	42%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	306	Closed hood	0%	0%	0%	0%	0%	19%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	307	Extended nip press	0%	0%	0%	0%	0%	19%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	308	Improved separation processes	0%	0%	0%	0%	0%	0%	0%	29%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	309	Thermal oxidizers	0%	0%	0%	0%	0%	0%	0%	29%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	310	Flare gas controls and recovery	0%	0%	0%	0%	0%	0%	0%	0%	65%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	311	Fouling control	0%	0%	0%	0%	0%	0%	0%	0%	65%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	312	Efficient furnaces	0%	0%	0%	0%	0%	0%	0%	0%	65%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	313	Oxyfuel	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	85%	0%	0%	0%	0%	0%	0%	0%
1	314	Batch cullet preheating	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	85%	0%	0%	0%	0%	0%	0%	0%
1	315	Preventative maintenance	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	72%	0%	0%	0%	0%	0%	0%
1	316	Combustion controls	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	59%	0%	0%	0%	0%	0%
1	317	Optimize furnace operations	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	59%	0%	0%	0%	0%	0%
1	318	Insulation/reduce heat losses	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	59%	0%	0%	0%	0%	0%

INCOMPLETE FACTOR (percent)

Segment	Measure #	Measure Description	SIC20	SIC22	SIC23	SIC24	SIC25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC31	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39
1	100	Base Boiler	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	101	Improved process control	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	102	Maintain boilers	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	103	Flue gas heat recovery/economizer	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	104	Blowdown steam heat recovery	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	105	Upgrade burner efficiency	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	106	Water treatment	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	107	Load control	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	108	Improved insulation	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	109	Steam trap maintenance	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	110	Automatic steam trap monitoring	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	111	Leak repair	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	112	Condensate return	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	200	Base HVAC	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	201	Improve ceiling insulation	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	202	Install HE(95%) cond furnace/boiler	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	203	Stack heat exchanger	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	204	Duct insulation	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	205	EMS install	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	206	EMS optimization	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	300	Base Process Heat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	301	Process Controls & Management	90%	90%	90%	90%	90%	80%	80%	50%	70%	80%	80%	80%	70%	100%	80%	80%	80%	80%	80%
1	302	Heat Recovery	90%	70%	70%	70%	70%	100%	100%	100%	100%	60%	60%	100%	30%	100%	60%	60%	60%	60%	60%
1	303	Efficient burners	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	70%	70%	80%	100%	100%	100%	100%	100%
1	304	Process integration	70%	100%	100%	100%	100%	70%	100%	30%	60%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	305	Efficient drying	60%	100%	100%	100%	100%	100%	60%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	306	Closed hood	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	307	Extended nip press	100%	100%	100%	100%	100%	60%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	308	Improved separation processes	100%	100%	100%	100%	100%	100%	100%	60%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	309	Thermal oxidizers	100%	100%	100%	100%	100%	100%	100%	30%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	310	Flare gas controls and recovery	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	311	Fouling control	100%	100%	100%	100%	100%	100%	100%	100%	55%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	312	Efficient furnaces	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	313	Oxyfuel	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%
1	314	Batch cullet preheating	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%	100%	100%
1	315	Preventative maintenance	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	80%	100%	100%	100%	100%	100%	100%
1	316	Combustion controls	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	60%	100%	100%	100%	100%	100%
1	317	Optimize furnace operations	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	100%	100%	100%	100%	100%
1	318	Insulation/reduce heat losses	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	10%	100%	100%	100%	100%	100%

FEASIBILITY FACTOR
(percent)

Segment	Measure #	Measure Description	SIC20	SIC22	SIC23	SIC24	SIC25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC31	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39
1	100	Base Boiler	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	101	Improved process control	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%
1	102	Maintain boilers	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
1	103	Flue gas heat recovery/economizer	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
1	104	Blowdown steam heat recovery	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%
1	105	Upgrade burner efficiency	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
1	106	Water treatment	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	107	Load control	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	108	Improved insulation	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	109	Steam trap maintenance	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
1	110	Automatic steam trap monitoring	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
1	111	Leak repair	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
1	112	Condensate return	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	200	Base HVAC	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	201	Improve ceiling insulation	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1	202	Install HE(95%) cond furnace/boiler	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1	203	Stack heat exchanger	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
1	204	Duct insulation	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1	205	EMS install	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1	206	EMS optimization	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
1	300	Base Process Heat	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	301	Process Controls & Management	60%	80%	80%	80%	80%	80%	80%	80%	90%	90%	80%	70%	80%		80%	80%	80%	90%	80%
1	302	Heat Recovery	30%	50%	50%	50%	50%	0%	0%	0%	0%	50%	50%	0%	40%	0%	50%	50%	50%	50%	50%
1	303	Efficient burners	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	62%	60%	40%	0%	0%	0%	0%	0%
1	304	Process integration	50%	0%	0%	0%	0%	30%	0%	60%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	305	Efficient drying	30%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	306	Closed hood	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	307	Extended nip press	0%	0%	0%	0%	0%	40%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	308	Improved separation processes	0%	0%	0%	0%	0%	0%	0%	40%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	309	Thermal oxidizers	0%	0%	0%	0%	0%	0%	0%	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	310	Flare gas controls and recovery	0%	0%	0%	0%	0%	0%	0%	0%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	311	Fouling control	0%	0%	0%	0%	0%	0%	0%	0%	70%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	312	Efficient furnaces	0%	0%	0%	0%	0%	0%	0%	0%	30%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	313	Oxyfuel	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	38%	0%	0%	0%	0%	0%	0%	0%
1	314	Batch cullet preheating	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15%	0%	0%	0%	0%	0%	0%	0%
1	315	Preventative maintenance	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	90%	0%	0%	0%	0%	0%	0%
1	316	Combustion controls	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	80%	0%	0%	0%	0%	0%
1	317	Optimize furnace operations	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	60%	0%	0%	0%	0%	0%
1	318	Insulation/reduce heat losses	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	80%	0%	0%	0%	0%	0%

ENERGY SAVINGS
(percent)

Segment	Measure #	Measure Description	SIC20	SIC22	SIC23	SIC24	SIC25	SIC26	SIC27	SIC28	SIC29	SIC30	SIC31	SIC32	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	SIC39
1	100	Base Boiler	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	101	Improved process control	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
1	102	Maintain boilers	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1	103	Flue gas heat recovery/economizer	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	104	Blowdown steam heat recovery	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
1	105	Upgrade burner efficiency	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
1	106	Water treatment	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
1	107	Load control	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1	108	Improved insulation	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
1	109	Steam trap maintenance	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%	13%
1	110	Automatic steam trap monitoring	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1	111	Leak repair	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
1	112	Condensate return	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1	200	Base HVAC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	201	Improve ceiling insulation	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%
1	202	Install HE(95%) cond furnace/boiler	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
1	203	Stack heat exchanger	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
1	204	Duct insulation	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
1	205	EMS install	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
1	206	EMS optimization	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
1	300	Base Process Heat	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	301	Process Controls & Management	8%	5%	5%	5%	5%	3%	5%	4%	6%	5%	5%	7%	6%	0%	5%	5%	8%	6%	5%
1	302	Heat Recovery	10%	25%	25%	25%	25%	0%	0%	0%	0%	25%	25%	0%	5%	0%	20%	20%	20%	20%	20%
1	303	Efficient burners	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	15%	20%	20%	0%	0%	0%	0%	0%
1	304	Process integration	25%	0%	0%	0%	0%	15%	0%	13%	13%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	305	Efficient drying	13%	0%	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	306	Closed hood	0%	0%	0%	0%	0%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	307	Extended nip press	0%	0%	0%	0%	0%	16%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	308	Improved separation processes	0%	0%	0%	0%	0%	0%	0%	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	309	Thermal oxidizers	0%	0%	0%	0%	0%	0%	0%	60%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	310	Flare gas controls and recovery	0%	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	311	Fouling control	0%	0%	0%	0%	0%	0%	0%	0%	7%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	312	Efficient furnaces	0%	0%	0%	0%	0%	0%	0%	0%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	313	Oxyfuel	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%
1	314	Batch cullet preheating	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	16%	0%	0%	0%	0%	0%	0%	0%
1	315	Preventative maintenance	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%
1	316	Combustion controls	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	0%	0%
1	317	Optimize furnace operations	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	10%	0%	0%	0%	0%	0%
1	318	Insulation/reduce heat losses	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	0%	0%	0%	0%	0%

Appendix F

Existing Residential Energy Efficiency Potential Results

The existing residential results are contained within multiple Excel workbooks; a residential electric and dual fuels workbook for SCE, PG&E, and SDG&E and a gas residential workbook for PG&E, SDG&E and, SoCalGas.

Within the PG&E, SDG&E, and SoCalGas workbooks are two sets of worksheets for the years 2004 through 2016. The first set of worksheets, labeled by utility and year (for example PGE2004, PGE2005, PGE 2006….) contain the disaggregated result data by climate zone, building type, and year. The second set of residential worksheets, labeled by utility, summary, and year (For example PGESummary2004, PGESummary2005, PGESummary2006 …) contain the results data by technology summarized across climate zone.

The SCE workbooks are two sets of worksheets for each scenario: Current, Average, Full, Economic, and Technical. The first set of worksheets, labeled SCECurrent, SCEAverage,… contain the disaggregated result data by climate zone, building type, and scenario. The second set of SCE worksheets, labeled by utility, summary, and scenario contain the results data by technology summarized across climate zone.

The column header names and their interpretations are similar for both the disaggregated and the summarized sheets. The column names and a short description for PG&E, SDG&E, and SoCalGas are included in Table F-1 and a list of the residential building types are in Table F-1. For SCE the column names are similar, with one scenario and multiple years per worksheet.

Table F-1 provides the column names for the residential workbooks.

Table F-1: Column Titles and Descriptions

Column Titles	Definition/Examples
End Use	HVAC & DHW
Utility and Climate Zone	IOU and Climate Zone Combination
Building Type	Residential Bldg Types
Competition Group	Internal ASSET Name - shows decision groupings
Tech Order	Internal ASSET Convention
Tech	Internal ASSET Name
Definition	Short definition of high efficiency technology
Units	Unit for Cost, Rebate, and Savings per unit
Lifetime	Expected Useful Life
per Unit kWh	Annual kWh per Unit
per Unit kW	Annual kW per Unit
per Unit Thm	Annual Therms per Unit
Current per unit Rebate (2004)	2004 Rebate per Unit
Current per unit Rebate (2004)	2006 Rebate per Unit (due to change in standards)
Average per unit Rebate	Average between current rebates and full incremental measure cost
Incremental Measure Cost (2004)	Incremental Measure Cost per Unit
Incremental Measure Cost (2006)	Incremental Measure Cost per Unit in 2006 (due to change in standards)
Maintenance Cost	For CFLs, the annual cost of incandescent repurchase due to shorter measure life.
Current Adopt (Year)	# of Adoptions given Current Rebate
Total Current MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Current kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Current Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
Incr Current MWh (Year)	MWh savings during the Year for current year adoptions under Current Rebates
Incr Current kW (Year)	kW savings during the Year for current year adoptions under Current Rebates
Incr Current Thm (Year)	Therm savings during the Year for current year adoptions under Current Rebates
Average Adopt (Year)	# of Adoptions given Average Rebate
Total Average MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Average kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Average Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
Incr Average MWh (Year)	MWh savings during the Year for current year adoptions under Average Rebates
Incr Average kW (Year)	kW savings during the Year for current year adoptions under Average Rebates
Incr Average Thm (Year)	Therm savings during the Year for current year adoptions under Average Rebates
Full Adopt (Year)	# of Adoptions given Full Rebate
Total Full MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Full kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Full Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
Incr Full MWh (Year)	MWh savings during the Year for current year adoptions under Full Rebates
Incr Full kW (Year)	kW savings during the Year for current year adoptions under Full Rebates
Incr Full Thm (Year)	Therm savings during the Year for current year adoptions under Full Rebates
Total Economic MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Economic kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Economic Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
Total Technical MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Technical kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Technical Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions

Table F-2: Residential Housing Type Description

Residential Housing Type	Description
SF	Single family
MF	Multifamily
MH	Mobile Home

The disaggregated results are presented by climate zone, building type, and measure. While it is possible to disaggregate the data to this fine level, we did not calibrate the forecast results at this level of desegregation. The calibration occurred at the measure level for each utility. The summarized results for residential closely reflect the level of calibration.

The targeted calculation of per unit KWh, KW, and Therms were calculated by dividing the forecast of incremental savings by the forecast of adoptions. If there were no adoptions for a given climate zone, building type, and measure the per-unit savings are represented as missing.

The per-unit, incremental, and total savings are gross. A net to gross ratio is included in the workbook allowing each utility to calculate their net savings.

During the calculation of technical potential ASSET allocates the savings forecast to the most efficient technology within a competition group. This may result in a forecast of zero savings for a high efficiency technology that is not the most efficient technology within the competition group. For economic potential ASSET will allocate the potential to the highest efficiency technology which passes the economic test.

Appendix G

Existing Commerical Energy Efficiency Potential Results

The potential results for existing commercial buildings are contained within multiple MS Excel workbooks; commercial enduse specific workbooks for each SCE, PG&E, SoCalGas and SDG&E. These workbooks are available on DVD by request.[1]

Within each PG&E, SDG&E, and SoCalGas workbook are two sets of worksheets for the years 2004 through 2016. The first set of worksheets, labeled by utility, enduse and year (for example PGELT2004, PGELT2005, PGELT2006….for lighting) contain the disaggregated result data by climate zone, building type, enduse, and year. The second set of commercial worksheets, labeled by utility, enduse, summary, and year (For example PGELTSummary2004, PGELTSummary2005, PGELTSummary2006 …) contain the results data by technology and enduse summarized across climate zone.

The SCE workbooks are two sets of worksheets for each scenario: Current, Average, Full, Economic, and Technical. The first set of worksheets, labeled SCELTCurrent, SCELTAverage,… contain the disaggregated result data by climate zone, building type, enduse, and scenario. The second set of SCE worksheets, labeled by utility, summary, enduse, and scenario contain the results data by technology and enduse summarized across climate zone.

The column header names and their interpretations are similar for both the disaggregated and the summarized sheets. The column names and a short description for PG&E, SDG&E, and SoCalGas are included in Table G-1 and a list of the commercial building types are in Table G-2. For SCE the column names are similar, with one scenario and multiple years per worksheet.

Table G-1 provides the column names for the commercial workbooks.

[1] Please contact Angela Nenn via email to request a copy of the DVD. Angela.Nenn@Itron.com

Table G-1: Commercial Column Headers and Definitions

Column Titles	Definition/Examples
End Use	HVAC & DHW
Utility and Climate Zone	IOU and Climate Zone Combination
Building Type	Commercial Bldg Types
Competition Group	Internal ASSET Name - shows decision groupings
Tech Order	Internal ASSET Convention
Tech	Internal ASSET Name
Definition	Short definition of high efficiency technology
Units	Unit for Cost, Rebate, and Savings per unit
Lifetime	Expected Usefull Life
per Unit kWh	Annual kWh per Unit
per Unit kW	Annual kW per Unit
per Unit Thm	Annual Therms per Unit
Current per unit Rebate (2004)	2004 Rebate per Unit
Average per unit Rebate	Average between current rebates and full incremental measure cost
Incremental Measure Cost	Incremental Measure Cost per Unit
Maintenance Cost	For CFLs, the annual cost of incandescent repurchase due to shorter measure life.
Current Adopt (Year)	# of Adoptions given Current Rebate
Total Current MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Current kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Current Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
Incr Current MWh (Year)	MWh savings during the Year for current year adoptions under Current Rebates
Incr Current kW (Year)	kW savings during the Year for current year adoptions under Current Rebates
Incr Current Thm (Year)	Therm savings during the Year for current year adoptions under Current Rebates
Average Adopt (Year)	# of Adoptions given Average Rebate
Total Average MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Average kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Average Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
Incr Average MWh (Year)	MWh savings during the Year for current year adoptions under Average Rebates
Incr Average kW (Year)	kW savings during the Year for current year adoptions under Average Rebates
Incr Average Thm (Year)	Therm savings during the Year for current year adoptions under Average Rebates
Full Adopt (Year)	# of Adoptions given Full Rebate
Total Full MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Full kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Full Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
Incr Full MWh (Year)	MWh savings during the Year for current year adoptions under Full Rebates
Incr Full kW (Year)	kW savings during the Year for current year adoptions under Full Rebates
Incr Full Thm (Year)	Therm savings during the Year for current year adoptions under Full Rebates
Total Economic MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Economic kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Economic Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
Total Technical MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Technical kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Technical Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions

Table G-2: Building Types

Building Type Code	Building Type Description
COL	College
GRC	Grocery
HLT	Health Care
LDG	Loding
LGO	Large Office
MSC	Miscellaneous
REF	Refrigerated Warehouse
RET	Retail
RST	Restaurant
SCH	School
SMO	Small Office
WRH	Warehouse

The disaggregated results are presented by climate zone, building type, and measure. While it is possible to disaggregate the data to this fine level, we did not calibrate the forecast results at this level of desegregation. The calibration occurred at the measure level for each utility. The summarized results for commercial closely reflect the level of calibration.

The targeted calculation of per unit KWh, KW, and Therms were calculated by dividing the forecast of incremental savings by the forecast of adoptions. If there were no adoptions for a given climate zone, building type, and measure the per-unit savings are represented as missing.

The per-unit, incremental, and total savings are gross. A net to gross ratio is included in the workbook allowing each utility to calculate their net savings.

During the calculation of technical potential ASSET allocates the savings forecast to the most efficient technology within a competition group. This may result in a forecast of zero savings for a high efficiency technology which is not the most efficient technology within the competition group. For economic potential ASSET will allocate the potential to the highest efficiency technology which passes the economic test.

Appendix H

Existing Industrial Energy Efficiency Potential Results

The potential results for existing industrial facilities are contained within multiple MS Excel workbooks; an industrial end-use-specific workbook for SCE, PG&E, SoCalGas and SDG&E. These workbooks are available on DVD by request.[1] The savings potentials presented in these workbooks are net. The base energy savings associated with the "naturally occurring" estimate have been subtracted from the gross forecasts to determine the net savings potentials.

The first set of worksheets contains non-additive net measure level results, first for the electric results and then for natural gas results. Column names and descriptions are provided in Table H-1.

[1] Please contact Angela Nenn via email to request a copy of the DVD. Angela.Nenn@Itron.com

Table H-1: Industrial Column Headers and Definitions for Non-Additive Measure Results

Column Titles	Definitions
Measure Number	Internal DSM ASSYST measure number
Measure	Measure name
Building Type	Building/facility type
Energy Savings Fraction	Percent net energy savings off of base use
Peak Reduction Fraction	Percent net peak reduction off of base use
Total Costs per Base kWh	Measure cost per base end use kWh
Base EUI	Base energy use index relative to average use
EUI	Energy use index after measure installation
Peak Watts per Base kWh	Peak watts per base end use kWh
Service Life (yrs)	Measure life
Technical Potential	Non-additive technical energy saving potential (GWh or therms)
System Peak Technical Potential	Non-additive technical peak reduction potential (kW, electric only)
Levelized Cost of Conserved Energy	Levelized cost per kWh saved or per therm saved
Levelized Cost of Avoided Peak Capacity	Levelized cost per kW saved (electric only)
Total Resource Cost Test (TRC)	Total resource cost ratio
Participant Test	Participant test ratio
Customer Payback (Years)	Simple payback
Revenue Test	Revenue test ratio

The second set of worksheets contains summary net achievable energy efficiency potential results by utility for the base, advanced, and maximum achievable program scenarios. Elements shown by year are:

- Cumulative net energy savings,
- Cumulative net peak demand savings (electric only),
- Incremental net energy and peak demand savings for each year,
- Program costs broken out by key element (administration, marketing, and incentives), present Values of avoided costs, program costs, and participant costs, and
- TRC ratios.

The third set of tables shows more detailed results by utility, industry segment, and end use. Results are presented first for net electric energy savings potential, then for net electric peak demand savings potential, and finally for net natural gas savings potential. Elements include the following:

- Industry segment and end use identifiers,
- Base energy use (repeated for each program scenario),
- Technical potential (repeated for each program scenario),
- Economic potential (repeated for each program scenario),

- Program scenario identifier (naturally occurring, base program, advanced program, maximum achievable), and
- Net cumulative achievable savings by year.

Appendix I

Residential New Construction Energy Efficiency Potential Results

The potential results for newly constructed residential buildings are contained within multiple Excel workbooks; included are workbooks for PG&E and SDG&E and one workbook that has combined results for the SCE/SoCalGas service territories. These workbooks are available on DVD by request.[1]

For each of the workbooks contain tabs for the years 2004 through 2016 (for example PGE2004, PGE2005, PGE2006….) contain the disaggregated result data by climate zone, building type, and year. In addition to the workbooks by year, there is an additional SCE workbook that contains a tab for each scenario: Current, Full, Economic, and Technical. These tabs are labeled SCECurrent, SCEFull,… and contain the disaggregated result data by climate zone, building type, and scenario.

The column header names and their interpretations are similar for both the disaggregated and the summarized sheets. The column names and a short description for workbooks that are presented by year are included in Table I-2 and a list of the residential building types are in Table I-1. For SCE the column names are similar, with one scenario and multiple years per worksheet.

Table I-1: Residential Housing Type Description

Residential Housing Type	Description
MF2	2-Story Multi-family Residence
MF3	3-Story Multi-family Residence
SF1	1-Story Single Family Residence
SF2	2-Story Single Family Residence
SFA	Single Family Attached Residence

1 Please contact Angela Nenn via email to request a copy of the DVD. Angela.Nenn@Itron.com

Table I-2: Column Titles and Descriptions

Column Titles	Definition/Examples
End Use	HVAC & DHW
Utility	IOUs
CZ Zone	CEC Title 24 Climate Zones
Building Type	Residential Bldg Types
Competition Group	Internal ASSET Name - shows decision groupings
Tech Order	Internal ASSET Convention
Tech	Internal ASSET Name
Definition	Short definition of high efficiency technology
Units	Unit for Cost, Rebate, and Savings per unit
Lifetime	Expected Usefull Life
per Unit kWh	Annual kWh per Unit
per Unit kW	Annual kW per Unit
per Unit Thm	Annual Therms per Unit
Current per unit Rebate	2003 Rebate per Unit (or agreed upon Rebate starting in 2006 - due to change in Stds.)
Full per unit Rebate	Weighted Average Incremental Cost
Incremental Measure Cost	Incremental Measure Cost per Unit
Current Adopt (Year)	# of Adoptions given Current Rebate
Total Current MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Current kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Current Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
Incr Current MWh (Year)	MWh savings during the Year for current year adoptions under Current Rebates
Incr Current kW (Year)	kW savings during the Year for current year adoptions under Current Rebates
Incr Current Thm (Year)	Therm savings during the Year for current year adoptions under Current Rebates
Full Adopt (Year)	# of Adoptions given Full Rebate
Total Full MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Full kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Full Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
Incr Full MWh (Year)	MWh savings during the Year for current year adoptions under Full Rebates
Incr Full kW (Year)	kW savings during the Year for current year adoptions under Full Rebates
Incr Full Thm (Year)	Therm savings during the Year for current year adoptions under Full Rebates
Total Economic MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Economic kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Economic Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
Total Technical MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Technical kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Technical Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
End Use	HVAC & DHW
Utility	IOUs
CZ Zone	CEC Title 24 Climate Zones
Building Type	Residential Bldg Types
Competition Group	Internal ASSET Name - shows decision groupings
Tech Order	Internal ASSET Convention
Tech	Internal ASSET Name
Definition	Short definition of high efficiency technology
Units	Unit for Cost, Rebate, and Savings per unit

The per-unit, incremental, and total savings are gross.

During the calculation of technical potential ASSET allocates the savings forecast to the most efficient technology within a competition group. This may result in a forecast of zero savings for a high efficiency technology that is not the most efficient technology within the competition group. For economic potential ASSET will allocate the potential to the highest efficiency technology which passes the economic test.

Appendix J

Commercial New Construction Energy Efficiency Potential Results

The potential results for newly constructed commercial buildings are contained within multiple Excel workbooks; included are workbooks for PG&E and SDG&E and one workbook with combined results for the SCE/SoCalGas service territories. These workbooks are available on DVD by request.[1]

Each workbook has tabs for the years 2004 through 2016 (for example, PGE2004, PGE2005, PGE2006, etc.) that contain the disaggregated result data by climate zone, building type, and year. In addition to the workbooks by year, an SCE workbook contains a tab for each scenario: Current, Full, Economic, and Technical (titled SCECurrent, SCEFull, etc.). Each tab contains the disaggregated result data by climate zone, building type, and scenario.

Column header names and their interpretations are similar for the disaggregated and summarized sheets. The column names and a short description for workbooks, presented by year, are included in Table J-2. Table J-1 presents a list of commercial building types. For SCE, the column names are similar, with one scenario and multiple years per worksheet.

Table J-1: Commercial Building Type Description

Commercial Building Types	Description
COL	College
GRC	Grocery
HLT	Health Care
LDG	Lodging
LGO	Large Office
MSC	Miscellaneous
REF	Refrigerated Warehouse
RET	Retail
RST	Restaurant
SCH	School
SMO	Small Office
WRH	Warehouse

1 Please contact Angela Nenn via email to request a copy of the DVD. Angela.Nenn@Itron.com

Table J-2: Column Titles and Descriptions

Column Titles	Definition/Examples
End Use	HVAC & DHW
Utility	IOUs
CZ Zone	CEC Title 24 Climate Zones
Building Type	Commercial Bldg Types
Competition Group	Internal ASSET Name - shows decision groupings
Tech Order	Internal ASSET Convention
Tech	Internal ASSET Name
Definition	Short definition of high efficiency technology
Units	Unit for Cost, Rebate, and Savings per unit
Lifetime	Expected Usefull Life
kWh Savings per Thousand SqFt	Annual kWh per Thousand SqFt
kW Savings per Thousand SqFt	Annual kW per Thousand SqFt *(If missing then there are no adoptions - it does not mean no kW savings)*
Therm Savings per Thousand SqFt	Annual Therms per Thousand SqFt
Current Rebate (kBtuh - Source Energy)	2003 Rebate per kBtuh (or agreed upon Rebate starting in 2006 - due to change in Stds.)
Full per SqFt Rebate	Weighted Average Incremental Cost
Incremental Measure Cost	Incremental Measure Cost per Thousand SqFt
Current Adopt (Year)	# of Adoptions given Current Rebate
Total Current MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Current kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Current Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
Incr Current MWh (Year)	MWh savings during the Year for current year adoptions under Current Rebates
Incr Current kW (Year)	kW savings during the Year for current year adoptions under Current Rebates
Incr Current Thm (Year)	Therm savings during the Year for current year adoptions under Current Rebates
Full Adopt (Year)	# of Adoptions given Full Rebate
Total Full MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Full kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Full Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
Incr Full MWh (Year)	MWh savings during the Year for current year adoptions under Full Rebates
Incr Full kW (Year)	kW savings during the Year for current year adoptions under Full Rebates
Incr Full Thm (Year)	Therm savings during the Year for current year adoptions under Full Rebates
Total Economic MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Economic kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Economic Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
Total Technical MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Technical kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Technical Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
End Use	HVAC & DHW
Utility	IOUs
CZ Zone	CEC Title 24 Climate Zones
Building Type	Commercial Bldg Types
Competition Group	Internal ASSET Name - shows decision groupings
Tech Order	Internal ASSET Convention
Tech	Internal ASSET Name
Definition	Short definition of high efficiency technology
Units	Unit for Cost, Rebate, and Savings per unit

The per-unit, incremental, and total savings are gross.

During the calculation of technical potential ASSET allocates the savings forecast to the most efficient technology within a competition group. This may result in a forecast of zero savings for a high efficiency technology that is not the most efficient technology within the competition group. For economic potential ASSET will allocate the potential to the highest efficiency technology which passes the economic test.

Appendix K

Industrial New Construction Energy Efficiency Potential Results

The potential results for newly constructed industrial buildings are contained within multiple Excel workbooks; included are workbooks for PG&E and SDG&E and one workbook that has combined results for the SCE/SoCalGas service territories. These workbooks are available on DVD by request.[1]

For each of the workbooks contain tabs for the years 2004 through 2016 (for example PGE2004, PGE2005, PGE2006….) contain the disaggregated result data by climate zone, building type, and year. In addition to the workbooks by year, there is an additional SCE workbook that contains a tab for each scenario: Current, Full, Economic, and Technical. These tabs are labeled SCECurrent, SCEFull,… and contain the disaggregated result data by climate zone, building type, and scenario.

The column header names and their interpretations are similar for both the disaggregated and the summarized sheets. The column names and a short description for workbooks that are presented by year are included in Table K-2 and a list of the industrial building types are in Table K-1. For SCE the column names are similar, with one scenario and multiple years per worksheet.

Table K-1: Industrial Building Type Description

Industrial Building Types	Description
CRm	Clean Room
REF	Refrigerated Warehouse
S36	SIC 36
WWT	Waste Water Treatment Plant

1 Please contact Angela Nenn via email to request a copy of the DVD. Angela.Nenn@Itron.com

Table K-2: Column Titles and Descriptions

Column Titles	Definition/Examples
End Use	HVAC & DHW
Utility	IOUs
Building Type	Industrial Bldg Types
Competition Group	Internal ASSET Name - shows decision groupings
Tech Order	Internal ASSET Convention
Tech	Internal ASSET Name
Definition	Short definition of high efficiency technology
Units	Unit for Cost, Rebate, and Savings
Lifetime	Expected Usefull Life (Range)
kWh Savings per MWh Load	Annual kWh per MWh Load
kW Savings per MWh Load	Annual kW per Thousand SqFt *(If missing then there are no adoptions - it does not mean no kW savings)*
Therm Savings per MWh Load	Annual Therms per MWh Load
Current Rebate per kWh Savings	2003 Rebate per kWh Savings
Full Rebate per kWh Savings	Incremental Cost per kWh Savings
Incremental Measure Cost per kWh Savings	Incremental Measure Cost per kWh Savings
Total Current MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Current kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Current Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
Incr Current MWh (Year)	MWh savings during the Year for current year adoptions under Current Rebates
Incr Current kW (Year)	kW savings during the Year for current year adoptions under Current Rebates
Incr Current Thm (Year)	Therm savings during the Year for current year adoptions under Current Rebates
Total Full MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Full kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Full Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
Incr Full MWh (Year)	MWh savings during the Year for current year adoptions under Full Rebates
Incr Full kW (Year)	kW savings during the Year for current year adoptions under Full Rebates
Incr Full Thm (Year)	Therm savings during the Year for current year adoptions under Full Rebates
Total Economic MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Economic kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Economic Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
Total Technical MWh (Year)	Total MWh savings during the Year for Cumulative Adoptions
Total Technical kW (Year)	Total kW savings during the Year for Cumulative Adoptions
Total Technical Thm (Year)	Total Therm savings during the Year for Cumulative Adoptions
End Use	HVAC & DHW
Utility	IOUs
Building Type	Industrial Bldg Types
Competition Group	Internal ASSET Name - shows decision groupings
Tech Order	Internal ASSET Convention
Tech	Internal ASSET Name
Definition	Short definition of high efficiency technology
Units	Unit for Cost, Rebate, and Savings
Lifetime	Expected Usefull Life (Range)
kWh Savings per MWh Load	Annual kWh per MWh Load
kW Savings per MWh Load	Annual kW per Thousand SqFt *(If missing then there are no adoptions - it does not mean no kW savings)*
Therm Savings per MWh Load	Annual Therms per MWh Load

The per-unit, incremental, and total savings are gross.

During the calculation of technical potential ASSET allocates the savings forecast to the most efficient technology within a competition group. This may result in a forecast of zero savings for a high efficiency technology that is not the most efficient technology within the competition group. For economic potential ASSET will allocate the potential to the highest efficiency technology which passes the economic test.

Appendix L

Emerging Technologies Measure Description and Selection Criteria

L.1 Data Sources

Table L-1 lists the sources reviewed in order to compile a broad set of candidate technologies.

Table L-1: Sources Reviewed to Identify Candidate Emerging Technology Measures

Source	Document	Status
ACEEE 2004[1]	Emerging Technologies and Practices for the Building Sector As of 2004	Integrated into data set
SCE 2004	Unpublished list received from SCE	Integrated into data set
ETCC 2004[2]	Summaries and Project Descriptions	Integrated into data set
PIER Program[3]	List of projects on web site	Reviewed
RER 1999[4]	Emerging Technology Efficiency Market Share Needs Assessment, Feasibility, and Market Penetration 12/99	Reviewed

The first three items listed in Table L-1 were used to develop a master list of emerging technologies that are discussed in the next section. The last two items were useful in providing background and for suggesting the screening and evaluation methods used in the present study. While both sources do provide promising emerging technologies, they were not used directly the present study. The RER 1999 report was superseded by the ACEEE 2004 study, which used the methods discussed in RER 1999 and built on and updated the earlier work. The PIER Program information described in the California Energy Commission (CEC) web site includes description of work currently being funded by the

---

1 For ease of use, this report is hereafter referenced within the text as ACEEE 2004. Full citation is as follows: Sachs, H., S. Nadel, J. Thorne Amann, M. Tuazon, E. Mendelsohn, L. Rainer, G. Todesco, D. Shipley, and M. Adelaar. *Emerging Energy-Savings Technologies and Practices for the Buildings Sector as of 2004.* Report #A042. American Council for an Energy Efficient Economy. October 2004.

2 Emerging Technology Coordinating Council (ETCC), on-line database at http://www.ca-etcc.com/.

3 Public Interest Energy Research (PIER), www.energy.ca.gov/pier/.

4 Regional Economic Research, Inc. *Emerging Technology Efficiency Market Share Needs Assessment, Feasibility, and Market Penetration Scoping Study.* Prepared for the California Board for Energy Efficiency and Pacific Gas and Electric. December 1999.

program, but does not contain information on specific technologies useful in the present assessment.

L.2 Candidate Technologies

Table L-2 lists the candidate technologies derived from the sources listed in Table L-1. To avoid redundancy, technologies that are clearly the identical technology or are a specific application of general technologies were excluded[5]. There were 65 technologies identified by the ACEEE as relevant for California,[6] excluding those technologies that are practices rather than hardware. The ACEEE designations and names of these technologies are listed in Table L-2. Based on Itron's judgment, a use category (residential, commercial, or both residential and commercial) was identified for each technology. Only 12 of the 27 ETCC[7] technologies currently in the database[8] did not correspond to ACEEE measures. These non-redundant technologies are listed in Table L-3, together with Itron's judgment of their applicable use category. All 24 technology measures used in the SCE emerging technology forecasts were judged by Itron to be covered by the ACEEE measures identified in Table L-2. Thus, 77 candidate technologies were identified.

Table L-2: Candidate Technologies – Commercial and/or Residential Sectors – ACEEE Technologies

Use Category	ACEEE Technology	NAME
Residential	A1	1 Watt Standby Power for Home Appliances
Residential	A2	1 kWh/day Refrigerator
Commercial	CA1	Variable Output (stepped) Compact Fluorescent
Commercial	CA2	Advanced HVAC Controls
Residential	CA3	Integrated Whole House Ventilation
Commercial	CR1	Hotel Key Card System
Residential	D1	Advanced Appliance & Pump Motors; CW Example
Residential	D2	Advanced Air-Conditioning Compressors
Residential	D3	Advanced HVAC Blower Motors
Residential	D4	High-Efficiency Pool and Domestic Water Pump Systems
Residential	H10a	Ground-Coupled Heat Pumps – Residential
Commercial	H10a-com	Ground-Coupled Heat Pumps – Commercial

5 For reference purposes, a table showing the correspondences between the ETCC and SCE technologies which were determined to be substantially equivalent and their ACEEE technology equivalents is presented in the appendix of this report.

6 Sachs et al. 2004, op. cit. Table B-14.

7 Emerging Technology Coordinating Council (ETCC).

8 ETCC unpublished database, December 2004. Personal Communication L. Campoy, SCE, January 2004.

Table L–2 (cont'd.): Candidate Technologies – Commercial and/or Residential Sectors – ACEEE Technologies

Use Category	ACEEE Technology	NAME
Both	H11	Leak Proof Duct Fittings
Residential	H12	Aerosol-Based Duct Sealing
Both	H13	Micro-Channel Heat Exchangers
Both	H14	Solid State Refrigeration for Heat Pumps and Power Generation
Commercial	H16	High Efficiency Gas-Fired Rooftop Units
Commercial	H17	Solar Pre-Heated Ventilation Air Systems (solar wall TM)
Commercial	H18	CO2 Ventilation Control
Commercial	H19	Displacement Ventilation
Commercial	H1a	Advanced Rooftop Packaged Air Conditioners – Commercial
Residential	H1b	Advanced Rooftop Packaged Air Conditioner – Residential
Commercial	H20	Advanced Condensing Boilers – Commercial
Residential	H2a	Cromer Cycle Air Conditioner – Residential
Commercial	H2b	Cromer Cycle Air Conditioner – Commercial
Commercial	H3	Commercial HVAC Heat Pipes
Residential	H4	CAC Dehumidifiers/Free-Standing Dehumidifiers
Residential	H5	Residential HVAC for Hot-Dry Climates
Commercial	H6	UVHVAC Disinfection
Residential	H7	Robust A/C
Residential	H8	Residential Gas Absorption Chiller Heat Pumps
Residential	H9	Adv. Cold-Climate Heat Pump/Frostless Heat Pump
Commercial	L 14	1-Lamp Fluorescent Fixtures w/High Performance Lamps
Commercial	L10	Hybrid Solar Lighting
Residential	L11a	Residential LED Lighting
Commercial	L11b	Commercial LED Lighting
Residential	L13	High Quality Residential Compact Fluorescent Portable Plug-In Fixtures
Commercial	L15	Scotopic Lighting
Residential	L16	Airtight Compact Fluorescent Down Lights
Residential	L3	General Service Halogen IR Lamp
Commercial	L4	Cost-Effective Load Shed Ballast & Controller
Commercial	L5	Advanced Day Lighting Controls
Commercial	L6	Low Wattage Ceramic Metal Halide Lamp
Commercial	L7	Hospitality Bathroom Lighting
Both	L8	Universal Light Dimming Control Device
Commercial	L9	Advanced HID Lighting
Commercial	O1	Networked Computer Power Management

Table L–2 (cont'd.): Candidate Technologies – Commercial and/or Residential Sectors – ACEEE Technologies

Use Category	ACEEE Technology	NAME
Residential	P1a	Residential Micro-CHP Using Fuel Cells
Residential	P1b	Residential Micro-CHP Using Sterling Engines
Commercial	P2a	Commercial Micro-CHP Using Fuel Cells
Commercial	P2b	Commercial Micro-CHP Using Micro-Turbines
Residential	R1	Solid State Refrigeration (Cool Chips TM)
Commercial	R2	Modulating Compressor For Packaged Refrigeration
Commercial	R3	Efficient Fan Options for Commercial Refrigeration
Residential	S1	High Performance Windows (U<0.25)
Residential	S2a	Active Window Insulation – Residential
Commercial	S2b	Active Window Insulation – Commercial
Commercial	S3a	Electro Chromic Glazing – Commercial Windows
Residential	S3b	Electro Chromic Glazing – Residential Windows
Residential	S4	Attic Foil Radiant Barriers
Residential	S5	Residential Cool Color Roofing
Residential	W1	Residential Condensing Water Heaters
Residential	W2	Instant Gas High-Modulating Water Heaters
Residential	W3	Residential Heat Pump Water Heaters
Residential	W4	Integrated Home Comfort Systems

Table L-3: ETCC Technologies not covered by ACEEE Technologies

Use Category	ETCC Technology	*MEASURE*
Industrial	24	Cloud Chamber Scrubber System
Commercial	30	Anti-Sweat Heater
Commercial	31	Display Case Shields
Commercial	36	Efficient Open Display Case
Commercial	41	High Speed Hand Dryer
Commercial	69	Adsorption Space Conditioning
Power Generation	69	Small Engine-Driven Power with Heat Recovery
Commercial	72	Professional Garment Cleaning System
Industrial	76	Efficient Thermography Printers
Commercial	85	Dual Cool Air Conditioning
Commercial	171	Reflectors with Variable Geometry
Industrial	186	Acoustic Stimulation for Aluminum Castings

L.3 Selection Procedure

The selection procedure for obtaining a manageable number of emerging technologies for inclusion in the Statewide Energy Efficiency Potential Estimates involves a screening procedure followed by application of selection criteria.

Screening Procedure

The technologies listed in Table L-4 and Table L-5 were screened to eliminate technologies and applications with the following characteristics:

- Practices (non-hardware) measures,
- Measures with only local, not statewide, applicability, and
- Measures clearly not amenable to quantification.

Table L-4: Candidate Technologies That Duplicate or Substantially Correspond to ACEEE Measures – SCE Measures

SCE #	ACEEE #	Measure
SCE34	L14	Variable Reflector Technology
SCE5	H1a	Advanced Rooftop Package A/C 10-ton w/o Economizer
SCE22	L10	Integrated Skylight Systems & Design Guidelines: High Bay with 12 T8 Lamps or 5 T5 HO Lamps
SCE23	L10+C8	Integrated Skylight Systems & Design Guidelines: High Bay with 12 T8 Lamps or 5 T5 HO Lamps L12a]
SCE24	L10	Integrated Skylight Systems & Design Guidelines: High Bay with 12 T8 Lamps or 5 T5 HO Lamps[L12b]
SCE19	L3	Halogen Infrared Reflecting A-Line Lamps
SCE17	L9	Advanced High Intensity Discharge [AHID] Light Sources [high ceiling]
SCE33	O1	Network Computer Power Management
SCE14	CA3	Retrofit Economy Cycle
SCE15	L11	LED Lighting
SCE26	L7	Motion Sensor Night Light
SCE29	L14	T5 High Output

Table L-5: Candidate Technologies That Duplicate or Substantially Correspond to ACEEE Measures – ETCC Measures

ETCC #	SCE #	ACEEE #	Measure
5		S5	Cool Roofs Install Cool Roof Technology
6		L5 (subset)	Day Lighting: Lighting Reduction for Quick Service Restaurants
7		L5 (subset)	Large Retail Day Lighting Showcases
8		D2	Discus Reciprocating Compressor
12		D1 (subset)	Refrigerated Display Case Fan Coils
13		R2	Refrigerated Display Cases
17		CA3	Night Ventilation with Building Thermal Mass – Night Breeze
18	SCE13	CA3	Integrated Ventilation Controls
19		L6	Pulse Start Metal Halide
20	SCE17	L9	Parking Lot HID Lighting Retrofits
21		CR1	Hotel Room Lighting and HVAC
22	SCE 29	L14	T5 High Output Lamps with Electronic Ballasts in Various Fixture Offerings Now Allow Indoor and Outdoor Applications
23			Centrifugal Chiller Retrofit AC2 Water-Cooled Condensing Unit
24		S3, w3	Gas-Fired Hot Water: Hot Water Heat Pumps (GHWHP)
25		L15	High Color: Fluorescent Lighting
26			High Speed Hand Dryer
27			Professional Garment Cleaning System
28			Adsorption Space Conditioning
29			Dual Cool Air Conditioning
30		W4	Displacement Ventilation is an Air Distribution System
31		H2a	Advanced Evaporative Cooler Technologies
32		Practice	Energy Management
33		H10a	Geothermal Heat
34	SCE34	L14	Reflectors with Variable Geometry
35		D2 (subset)	Variable Speed Chiller
36		D2 (subset)	Advanced Chiller

Selection Criteria

The following selection criteria were used to limit the selection of emerging technology measures to roughly10 technologies in each of the commercial and residential sectors:

- Widespread applicability. Refers to technologies that have widespread applicability within the specified sector throughout the state: i.e., many potentially appropriate applications, wide geographic potential.
- Medium to high probability of success (score of 3 or higher on a scale of 5, as rated by ACEEE).

- Medium to high probability of economic viability.
- Medium to high energy-saving technical potential in each application.

All technologies receiving an acceptable rating on the first three criteria were considered. Then approximately 10 measures with the highest energy savings were selected. The specific attributes of the criteria and the minimum acceptable ratings are defined below.

Widespread Applicability

This attribute was defined in general terms to exclude measures that have only limited applicability geographically within California or within a relatively small number of situations. For example, measures that apply only to cold climates were excluded, as few residences or commercial establishments in California would fall in this category.

Likelihood of Success Rating[9]

Success is defined as penetrating at least 50% of feasible applications by 2020. Using the 5-point scale indicated below values for variables were determined qualitatively for each measure according to the likelihood with which market and technical barriers can be overcome. Significant non-energy benefits can also offset some of the barriers and improve the likelihood of success, so where these exist, the likelihood of success is increased by one point on the 5-point scale.

- **Will be very difficult to succeed:** there are multiple major barriers that will be difficult to overcome.
- **Will be hard to succeed:** there are major barriers to overcome and while some progress can be made, substantial barriers will likely remain.
- **Moderate chance of success:** there are substantial barriers to overcome, some major barriers can be overcome, but others will likely remain.
- **Good chance of success:** the barriers appear surmountable but will take require extensive effort and time to overcome.
- **Excellent chance of success:** barriers appear to be clearly surmountable.

Only measures with a success rating of 3 or more were selected.

Cost-Effectiveness

ACEEE 2004 defines the cost of saved energy (CSE) as follows:[10]:

> *The cost of saved energy is the levelized cost of a measure over its lifetime per unit of energy saved. It is calculated by assuming each measure is financed with a loan, with a*

9 Sachs et al. 2004, op. cit., page 10, quoted, with minor editing for continuity.

10 Ibid., page 9, quoted, with minor editing for continuity.

term equal to the measure life and an interest rate equal to the discount rate and dividing the annual loan payments by the annual energy savings. These calculations are based on future measure cost estimates and a 5% real discount rate, where 5% is a figure commonly used by electric utilities for energy-saving analyses. For measures that save both electricity and natural gas, we allocated costs proportionately to the two fuels based on the primary energy savings achieved and calculated costs of saved energy separately for electricity and gas. The formula for CSE is:

$$\frac{\textit{(Measure Cost x Capital Recovery Factor) + Annual Other Costs/Savings}}{\textit{Annual kWh Savings}}$$

For purposes of the present analysis, we defined the minimum cost-effective measure as one that saved electricity at a cost less than or equal to $0.10/kWh or energy at a cost less than or equal to $4.00 per MMBtu.

Total Energy Savings

"…includes both direct use of natural gas on site, and the source equivalent energy of the fuel use at the power plant for electricity, using the projected 2020 national average heat rate, 10.10 Btu/kWh[11]*. For measures that save one fuel but use more of another fuel (e.g., gas air conditioning that saves electricity but uses gas), energy savings are expressed in Btu, valuing electricity at 10,010 Btu/kWh. It should be noted that savings often overlap between measures and that savings across measures are frequently not additive. Also, given the many assumptions made in the calculations, these estimates should be viewed as approximate and not absolute. The number of measures selected on this basis was approximately 10, but rather than applying an arbitrary cut-off, the measures with roughly the same level of savings were selected."* [12]

L.4 Selection Results—Residential

Initial Screening Results—Residential

Of the 65 technologies identified in Table L-2, 36 were judged to be applicable to the residential sector and survived the initial screening procedure outlined in Section 6.4. These measures are listed in Table L-6. CSE refers to the cost of saved energy, either electrical (kWh) or heat energy (MMBtu). The priority ratings were assigned by ACEEE specifically for California in Appendix B of ACEEE 2004. Deselection criteria, where applied, are listed in the right-most column and described below.

11 Ibid. page 14.
12 Ibid.

Table L-6: Emerging Technologies Meriting Detailed Consideration – Residential[13]

ACEEE Code	Measure Name	Savings Potential[14] (TBTU)	Percent Saved	CSE $/kWh	CSE ($/MM Btu)	Likelihood of Success Rating	Deselection Criteria
A1	1-Watt Standby Power for Home Appliances	497	1.05	0.02	1.90	4	
H11	Leakproof Duct Fittings	489	1.03	0	0.40	4	
H12	Aerosol-Based Duct Sealing	443	0.93	0.03	2.50	3	
A2	1 kWh/day Refrigerator	140	0.30	0.04	3.90	4	
L16	Airtight Compact Fluorescent Down Lights	393	0.83	-0.01	-1.2	4	
H9	Adv. Cold-Climate Heat Pump/Frostless Heat Pump	173	0.36	0.05	4.60	3	Limited CA applicability
H7	Robust A/C	278	0.59	0.04	3.80	3	
S5	Residential Cool Color Roofing	144	0.30	0.04	3.70	3	
L13	High Quality Residential Compact Fluorescent Portable Plug-In Fixtures	216	0.46	0.03	3.10	3	
S1	High Performance Windows (U<0.25)	144	0.30	0.03	2.70	3	
D2	Advanced Air-Conditioning Compressors	200	0.42	0.03	2.40	3	
W3	Residential Heat Pump Water Heaters	158	0.33	0.02	2.20	3	
R1	Solid State Refrigeration (Cool Chips TM)	171	0.36	0	0	3	
D3	Advanced HVAC Blower Motors	112	0.24	0.04	3.80	4	
D1	Advanced Appliance & Pump Motors; CW Example	58	0.12	0	0.20	4	Low savings
P1b	Residential Micro-CHP Using Sterling Engines	201	0.42	0.06	5.50	2	Probability of success
L3	General Service Halogen IR Lamp	74	0.16	0.03	2.40	2	Probability of success
H13	Micro Channel Heat Exchangers	132	0.28	0.02	1.60	2	Probability of success
H10a	Ground-Coupled Heat Pumps	15	0.03	0	0	2	Probability of success

13 Ibid. The measures and the values assigned were taken from Appendix B, Table B-13. However, the measures selected for inclusion in Table 3 are a subset of those in Table B-13, selected especially for the purposes of the present study.

14 Savings potential are nationwide.

Table L–6 (cont'd.): Emerging Technologies Meriting Detailed Consideration – Residential

ACEEE Code	Measure Name	Savings Potential (TBTU)[15]	Percent Saved	CSE $/kWh	CSE ($/MM Btu)	Likelihood of Success Rating	Deselection Criteria
CA3	Integrated Whole House Ventilation	74[16]	0	0.22	21.70	4	Cost-effectiveness
H1b	Advanced Rooftop Packaged Air Conditioner-Residential	81	0.17	0.06	6.00	3	Low savings
D4	High Efficiency Pool And Domestic Water Pump Systems	19	0.04	0.03	3.40	3	Low savings
H8	Residential Gas Absorption Chiller Heat Pumps	41	0.09	0.07	6.60	2	Probability of success
W4	Integrated Home Comfort Systems	43	0.09	0.04	3.80	2	Probability of success
H5	Residential HVAC for Hot-Dry Climates	11	0.02	0.04	4.40	4	Low savings
S3b	Electro Chromic Glazing for Residential Windows	3	0.01	0.05	4.60	3	Limited CA applicability
H2a	Cromer Cycle Air Conditioner-Residential	21	0.04	0.03	3.10	3	Low savings
H4	CAC Dehumidifiers/Free-Standing Dehumidifiers	5	1	5	440	3	Limited ca applicability
W1	Residential Condensing Water Heaters	217	0.46	N/A	6.40	2	Probability of success
W2	Instant Gas High-Modulating Water Heaters	127	0.27	N/A	8.30	2	Probability of success
P1a	Residential Micro-CHP Using Fuel Cells	171	0.36	0.18	17.40	2	Probability of success
S4	Attic Foil Radiant Barriers	27	0.06	0.16	16.20	2	Limited ca applicability
H14	Solid State Refrigeration for Heat Pumps And Power Generation	106	0.22	0.16	15.60	2	Probability of success
L11a	Residential LED Lighting	229	0.48	0.11	11.30	2	Probability of success
S2a	Active Window Insulation-Residential	41	0.09	0.73	72.20	1	Probability of success
L8	Universal Light Dimming Control Device	97	0.20	0.08	8.10	1	Probability of success

15 Savings potential are nationwide.

16 Sachs et al. 2004, op. cit. Reported in Appendix B as 9 TBTU for California only. Adjusted to nationwide based on 2003 population.

Selection Results—Residential

The effects of applying each of the detailed criteria outlined in Selection Criteria are described below. The criteria by which technologies were deselected are also indicated in Table L-6, above.

Limited Applicability in California

Of the 37 candidate residential technologies, only four measures were eliminated because of lack of widespread applicability in California:

- H4—CAC dehumidifiers/free-standing dehumidifiers,
- H9—Advanced cold-climate heat pump,
- S3b—Electrochromic glazing for residential windows, and
- S4—Attic foil radiant barriers.

These measures are only applicable for colder climates zones found in limited areas in California.

Likelihood of Success

Of the 33 remaining measures, 20 had a good likelihood of success with success ratings of 3 or 4 per ACEEE 2004 specifically for California. The 13 technologies deselected due to lower probability of success ratings are as follows.

- P1b—Residential micro-CHP using Sterling Engines (2)
- L3—General service halogen IR lamp (2)
- H13—Micro channel heat exchangers (2)
- H10a—Ground-coupled heat pumps (2)
- H14—Solid state refrigeration for heat pumps and power generation (2)
- H8—Residential gas absorption chiller heat pumps (2)
- W4—Integrated home comfort systems (2)
- W1—Residential condensing water heaters (2)
- W2—Instant gas high-modulating water heaters (2)
- P1a—Residential micro-CHP using fuel cells (2)
- L11a—Residential LED lighting (2)
- S2a—Active window insulation-residential (1)
- L8—Universal light dimming device (1)

Cost-Effectiveness

Because the remaining measures are capable of saving electricity at low cost of saved energy, only one of the 20 remaining measures failed the cost-effectiveness test. CA3—Integrated whole house ventilation is reportedly too costly both in terms of cost per saved kWh and cost per saved MMBtu.

Total Saved Energy

Of the 19 remaining measures, 13 had total energy savings nationwide of over 112 TBTU. The selection of measures was cut off at this point because the remaining measures saved considerably less than 100 TBtus of energy (the next best measure saved 82 TBtus.

The selected residential emerging technologies with the greatest potential are listed in Table L-7 and described in the following paragraphs. The savings potential in Table L-7 has been adjusted to California based on weather-adjustments in the ACEEE 2004 report, or through population adjustments.[17]

[17] National estimates were adjusted to California based on the ratios of 2003 population, where California population was 35.5 million and US population was 290.8 million.

Table L-7: Selected Measures – Residential (in order of California Savings Potential)[18]

ACEEE #	NAME	Savings Potential (TBTU)	Percent Saved	CSE $/kWh	CSE ($/MM Btu)	Likelihood of Success Rating
A1	1 Watt Standby Power For Home Appliances	60.6	1.05	0.02	1.90	4
L16	Airtight Compact Fluorescent Down Lights	47.9	0.83	-0.01	-1.2	4
H12	Aerosol-Based Duct Sealing	38.9	0.93	0.03	2.50	3
H11	Leakproof Duct Fittings[19]	26.3	1.03	0	0.40	4
L13	High Quality Residential Compact Fluorescent Portable Plug-In Fixtures	26.4	0.46	0.03	3.10	3
R1	Solid State Refrigeration (Cool Chips TM)	20.9	0.36	0	0	3
W3	Residential Heat Pump Water Heaters	19.3	0.33	0.02	2.20	3
S5	Residential Cool Color Roofing	4.4	0.30	0.04	3.70	3
S1	High Performance Windows (U<0.25)	12.7	0.30	0.03	2.70	3
A2	1 kWh/Day Refrigerator	17.1	0.30	0.04	3.90	4
D3	Advanced HVAC Blower Motors	13.7	0.24	0.04	3.80	4
H7	Robust A/C	8.5	0.59	0.04	3.80	3
D2	Advanced A/C Compressors	6.0	0.42	0.03	2.40	3

Description of the Selected Measures

The following paragraphs describe the selected measures in descending order of total California energy savings potential. In addition to the description, for each of the measures the status of the technology is described and the energy saving potential is discussed. The text of these measure descriptions are all quoted directly from ACEEE 2004.

---

18 Sachs et al. 2004, op. cit. Based on Table B-13.

19 Leakproof duct fittings apply to both commercial and residential applications. Therefore, the reported savings must be divided between these categories.

A1: 1-Watt Standby Power for Home Appliances:[20] **497 TBTU**

Standby power is the electricity consumed by end-use electrical equipment that is switched off or is not performing its main function. A wide variety of consumer electronics, small household appliances, and office equipment use standby power.

Status: Recent trends toward the incorporation of digital displays and other electronic components into white goods (i.e., major appliances), as well as the ongoing growth in the use of digital technology and devices, add to the list of products that consume standby power. The most common sources of standby power consumption include products with remote controls, low-voltage power supplies, rechargeable devices, and continuous digital displays.

Savings: Although the amount of standby power consumed by an individual product is relatively small, typically ranging from 0.5 to 30 Watts, the cumulative total is significant given the large number of products involved: an estimated 50 to 70 Watts per U.S. house, or 5% of average residential electricity consumption (ETA 2003b).[21]

H11 Leak Proof Duct Fittings:[22] **489 TBTU**[23]

The majority of duct leakage in residential and small commercial HVAC systems is due to improperly sealed connections between ductwork and fittings. Even when duct connections are initially well sealed, leakage may increase over time.[24] Although the use of mastics and mechanical fasteners is becoming more widespread, a low-cost, Leakproof system will help to transform the market. The benefit of any duct remediation technology is greatest in climates with high cooling loads and attic ducts. Available round-section spiral sheet metal systems from Lindal and others are targeted to commercial applications in the United States. They are used for residences in Sweden, but cost about twice as much as conventional residential systems in the United States.[25]

Status: In California, the installation of tight duct systems has increased significantly over the past three years as the Title 24 code has provided a credit for “tight” duct systems leaking less than 6% of system airflow. One approach to reducing duct leakage is the use of mastic, mechanical fasteners, and UL-18 1-approved duct tapes. An alternative approach is through

20 Sachs et al. 2004, op. cit. Page 40.

21 Meier, Alan. Presentation at the California Energy Commission Public Interest Energy Research Workshop on Standyby Power. Berkeley, CA. 2002.

22 Sachs et al. 2004, op. cit. Page 88.

23 Leakproof duct fittings apply to both commercial and residential applications. Therefore, the reported savings must be divided between these categories.

24 Walker, I., M. Sherman, M. Modera, and J. Siegel. *Leakage Diagnostics, Sealant Longevity, Sizing and Technology Transfer in Residential Thermal Distribution Systems.* LBL-41118. Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division, Energy Performance of Buildings Group. 1998.

25 Spartz, Philip. California Energy Commission. Personal communication. 2004.

the use of long-lasting leakproof duct connections that can be reliably field installed with a minimum of skill. Proctor Engineering Group has developed the Snap Duct system of fittings with support from DOE's Small Technology Transfer program. The system consists of mechanically fastened fittings (couplings, boots, plenums, wyes) for flex and hard ducts that snap together to create a long-lasting seal. Testing of the fittings show that about 90% of the leakage within the duct system is eliminated.[26]

Savings: Various field studies indicate that mitigating residential duct leakage may reduce HVAC energy use by roughly 20%.[27,28] The California Title 24 energy code assumes typical new residential duct systems leak 22% of HVAC system airflow.[29] Typical new construction costs for manual duct sealing are estimated as $250 per house. The Snap Duct technology is still in the prototype stage, but indications are that the system will be less expensive than current manual duct sealing techniques. Although the fitting cost will be more than standard fittings, labor savings is expected to more than offset the incremental cost. Duct pressurization testing is still necessary to insure proper installation.[30]

H12 Aerosol-Based Duct Sealing:[31] 433 TBTU

Approximately 20%[32,33] of energy use in ducted residential space conditioning systems is associated with duct losses, with about half due to conduction and half due to leakage.[34] Sealing ducts not only reduces annual heating and cooling energy use, but also significantly reduces air conditioning peak demand for systems with attic ducts. Although new homes can achieve leakage levels on the order of 5–10% (of HVAC airflow) through the use of improved materials and diagnostic testing, fixing existing home duct leakage is often problematic and expensive as ducts are often in hard or impossible to access locations such as small attics, crawl spaces, and duct chases. Manual duct sealing has been performed for many years, but it is messy, labor-intensive, and not always effective at eliminating a majority of the leakage.

---

26 Proctor, John. Proctor Engineer Group. Personal communication to Marc Hoeschele. October 30, 2003.
27 Sachs et al. 2004, op. cit. Page 88, reference to Hammurlund 1992.
28 Proctor Engineering Group. *Performance of Residential High SEER Air Conditioning Units at High Ambient Temperature.* Prepared for Pacific Gas & Electric. 1993.
29 California Energy Commission. *Residential Manual for Compliance with California 1998 Energy Efficiency Standards.* Publication 400-98-002. 1999.
30 Sachs et al. 2004, op. cit. Page 42.
31 Ibid. Page 90.
32 Proctor 1993, op. cit.
33 Sachs et al. 2004, op. cit. Page 88, reference to Hammurlund 1992.
34 Jump, D., I.S. Walker, and M.P. Modera. "Field Measurements of Efficiency and Duct Retrofit Effectiveness in Residential Forced Air Distribution Systems." In *Proceedings of the 1996 ACEEE Summer Study on Energy Efficiency in Buildings.* 1.147-I.156. American Council for an Energy Efficient Economy. 1996.

Status: An aerosol duct sealing technology (Aeroseal) developed at Lawrence Berkeley National Laboratory can seal holes in ducts up to ¼" in diameter from the inside by spraying atomized latex aerosol into a sealed duct system. By pressurizing the duct system while spraying the atomized aerosol, the material collects around small leaks in ductwork and seals them in a process similar to that used by canned flat tire sealers. A computer monitors and controls the atomization and duct pressurization process that typically lasts 40–90 minutes.

Savings: A number of large-scale utility demonstration projects have documented the performance of the Aeroseal technology. The Sacramento Municipal Utility District (SMIJD)[35] found an average 81% reduction in leakage for a sample of 121 houses that underwent the Aeroseal process. A 1996 Florida study of 47 houses found an average 80% reduction in leakage.[36] The average cost per house for the Sacramento study was slightly over $1,000, although other remediation work occurred at many of the sites. A better mature market cost estimate for Aeroseal remediation is in the range of $500 to $900 per site.[37] In 2001, Aeroseal was acquired by the Carrier Corporation, which greatly increased the visibility and marketing of the technology. There are close to 80 Aeroseal franchises nationwide, which performed about 3,000 sealing jobs during 2002. The hottest markets for Aeroseal are Sacramento, Phoenix, southern California, and parts of Washington and Illinois. Aeroseal projects 10,000 jobs per year by 2007. Some utilities are continuing rebate programs to partially offset some of the cost of performing Aeroseal remediation. In the Sacramento area, where about 100 jobs a month were completed in 2000,[38] SMUD is currently offering a $300 rebate to residential customers.[39]

L16 Airtight Compact Fluorescent Down Lights:[40] 393 TBTU

Increasingly, recessed down lights have become the lighting fixture of choice for residential construction. Because only a very small part of the fixture is visible, the fixtures can be made inexpensively without sacrificing aesthetics. It is estimated that 21.7 million were manufactured in 2001 alone with approximately 350 million currently installed.[41] However, there are two energy-related problems associated with recessed down lights. First, they rely on low efficiency incandescent lamps, and second they add envelope leakage and potentially

---

35 Kallett, R., E. Hamzawi, C. Sherman, and J. Erickson. "SMUD's New Residential Duct-Improvement Program Using an Aerosol-Based Duct Sealant." In *Proceedings of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings.* 2-163-2.174. American Council for an Energy Efficient Economy. 2000.

36 Modera, M., D. Dickerhoff, O. Nilssen, H. Duquette, and J. Geyselaers. "Residential Field Testing of an Aerosol-Based Technology for Sealing Ductwork." In *Proceedings of the 1996 ACEEE Summer Study on Energy Efficiency in Buildings.* 1.169-1.176. American Council for an Energy Efficient Economy. 1996.

37 Bourne, D., and J. Stein. *Aeroseal: Sealing Ducts from the Inside Out.* ER-99-16. E-Source. 1999.

38 Kallet et al. 2000, op. cit.

39 Sachs et al. 2004, op. cit. Page 215.

40 bid. Page 136.

41 Gordon, K.L., and J.J. McCullough. "Recessed Lighting in the Limelight." Home Energy. 21(1):12-13. 2003.

an insulation void to the area in which they are located. In 60 new California homes, Davis Energy Group found an average of 12 recessed lights per house, leaking 104 cfm, or 6% of total measured house leakage.[42]

Status: To improve on current practice, manufacturers are now beginning to produce air tight recessed down light fixtures that use compact fluorescent lamps (CFLs). One problem discovered during extensive testing completed at Pacific Northwestern National Laboratories relates to problems with heat build-up in the remote ballast. Since the ballast is in the attic and surrounded by insulation, the heat being generated by the ballast is not adequately removed and thus the ballast overheats. Research completed by LBNL under the California Energy Commission's PIER program developed an advanced CFL downright. LBNL, in a partnership with NRDC, CEC, SMUD, and Lithonia Lighting, has installed these units in about fifty new homes in the Sacramento area.

Savings: Replacing a 75-Watt incandescent bulb with a 28-Watt CFL will reduce lighting energy use by 63%. The configuration of the advanced CFL down light is such that two cans share single electronic ballast. With higher light output, six CFL down lights can replace eight standard down lights at an equivalent installed cost.[43]

H7 Robust Air Conditioning:[44] 278 TBTU

Residential air conditioners and heat pumps generally do not achieve the efficiency in the field implied by their SEER ratings.[45] Shortfalls arise from deficiencies in the national rating method, and from poor installation and maintenance. These factors include low charge (combined with low proportion with thermostatic expansion valves [TXVs]), incorrect airflow, leaky ducts, and over sizing. "Robust" units could largely compensate for charge losses and low airflow (25% cumulative). A new specification to achieve the equipment-related goals is within reach of existing designs. The "robust" air conditioner would be characterized by the highest SEER levels readily attained without modulating compressors (SEER 14), very good high-temperature performance (EER 12), an adaptive refrigerant metering device (TXV or better), and a fan assembly that adapts to the static pressure of the house's duct system. It would include a thermostat equipped with alarm functions, such as "check filter" and "call for service."[46]

---

42 Davis Energy Group. *Residential Construction Quality Assessment Project: Phase II Final Report.* CEC 400-98-004. Prepared for the California Energy Commission. 2002.

43 Siminovitch, M. Lawrence Berkeley National Laboratory. Personal communication with Marc Hoeschele. January 22, 2004.

44 Sachs et al. 2004, op. cit. Page 78.

45 Neal, C.L. "Field Adjusted SEER [SEERFA]." In *Proceedings of the 1998 ACEEE Summer Study on Energy Efficiency in Buildings.* 1.197-1.209. American Council for an Energy Efficient Economy. 1998.

46 Sachs, H.M. and S. Smith. *Saving Energy with Efficient Residential Furnace Handlers: A Status Report and Program Recommendations.* American Council for an Energy Efficient Economy. 2003.

Status: The robust air conditioner concept has been circulated among market transformation groups and selected manufacturers. No insurmountable obstacles or barriers have been suggested. Proposals in review now (by PIER and others) would lead to prototype development and field tests. After that, any of several market transformation mechanisms could be used to pull robust units into the market. For example, it might be attractive to some production builders, as a "hassle-avoidance" measure, or for federal procurement for military base housing and similar applications.

Savings: From Neal,[47] the field-adjusted SEER is 25% lower than the rated value, bringing SEER 12 down to SEERFA (field-adjusted) 11.1. By correcting these problems, the robust unit at SEER 14 delivers SEERFA=13.9, for a saving of 19% through better air conditioning performance. This includes compensation for the 60% market penetration of TXVs among current SEER 13 and 14 units.[48]

L13 High Quality Residential Compact Fluorescent Portable Plug-In Fixtures:[49] **216 TBTU**

Residential portable fixtures include table lamps, desk lamps, floor lamps (torchieres), and other plug-in fixtures typically found in living rooms, home offices, and family rooms. Together they consume roughly 20% of total annual household lighting energy.[50] Although energy-efficient compact fluorescents (CFLs) are available for use with these fixtures, most users still prefer lower cost incandescent lamps. However, many manufacturers have now developed residential portable fixtures designed specifically for pin-based CFLs. When used, these CFL-dedicated fixtures guarantee energy savings, since they are incompatible with incandescents.

Status: Depending on the region of the country, CFL residential portable fixtures can be purchased in furniture stores, lighting specialty stores, home improvement stores, hardware stores, department stores, and national discount stores[51] but availability is limited in home improvement stores and large discount stores. Additionally, a recent study in California

---

47 Neal 1998, op. cit.

48 Sachs et al. 2004, op. cit. Page 82.

49 Ibid. Page 78.

50 Calwell, C., C. Granda, L. Gordon, and M. Ton. *Lighting the Way to Energy Savings: How Can We Transform Residential Lighting Markets, Volume 2: Background and Reference.* http://www.ceel.org/resid/rs-lt/rs-lt-pubs/ltwy_vol2.pdf. National Resources Defense Council. 1999.

51 Regional Economic Research, Inc. *Residential Energy Efficient Lighting Consumer Research.* Report #00-051. http://www.nwalliance.org/resources/reports/00051.pdf. Prepared for Northwest Energy Efficiency Alliance. 2000.

showed that many retailers are not very knowledgeable about fluorescent lighting fixtures.[52] Replacement bulbs are not widely stocked or readily available, either. Currently, several initiatives are underway to encourage lighting manufacturers and designers to create better portable CFL fixtures. The Consortium for Energy Efficiency (CEE), the American Lighting Association (ALA), and the U.S. Department of Energy (DOE) have partnered to sponsor Lighting for Tomorrow, a national competition for lighting fixture designs. The sponsors have selected several portable CFL fixtures as finalists and honorable mentions based on paper designs. Some of the portable fixtures are estimated to cost less than $100 retail. Manufacturers and lighting designers who made the final round were due to submit their prototypes in January 2004. The California Energy Commission (CEC) also recently started the ENERGY STAR Residential Fixture Advancement Project, which reimburses manufacturers for 50% of their cost to design higher-end table or floor lamps. Program managers estimated that products would be out in the market by mid-2004.

Savings: Energy savings from portable CFL fixtures could be more than 70% over traditional incandescent fixtures. A 27-Watt CFL fixture is equivalent to a typical 100-Watt incandescent table lamp.[53] However, the incremental retail cost of the fixture is high, almost $40 (including replacement bulbs). For cost as well as aesthetic reasons, consumers have been slow in accepting CFL table lamps. CFL floor lamps are growing in popularity, however, as a replacement for halogen torchieres, which have been shown to be unsafe.[54]

D2 Advanced Air-Conditioning Compressors:[55] 200 TBTU

In the United States, almost all residential and light commercial central air conditioners and heat pumps use single-speed reciprocating or scroll hermetic compressors. Compressor peak load efficiencies have improved by 50% since the mid-1960s, with signs of less improvement recently.[56] In larger commercial packaged units, the norm has been to use two compressors of different sizes and to give three operation stages. Modulating compressors are more common in Asia for "mini-split" systems in which a single compressor supports multiple, independently controlled evaporators. Modulating compressors give designers many alternatives for designing products that match varying sensible and latent loads well, particularly when coupled with modulating air handlers (treated in D-3, Advanced HVAC fan motors). Recently, U.S. attention has turned to multi-stage and modulating compressors to improve part-load performance of systems, the subject of this write-up.

---

52 Heschong Mahone Group. *Lighting Efficiency Technology Report, Volume III: Market Barriers Report.* http://www.energy.ea.gov/efficiency/lighting/lighting_reports.html. Prepared for the California Energy Commission. 1999.

53 ENERGYGuide. "ENERGY STAR Lights®." Spring Product Catalog. 2003.

54 Calwell 1999, op. cit.

55 Sachs et al. 2004, op. cit. Page 56.

56 U.S. Department of Energy. *Technical Support Document for Energy Efficiency Standards for Residential Central Air Conditioners.* 2001.

Status: Bristol introduced the "TS" reciprocating compressor several years ago. It reduces capacity to 40% by idling one of its two pistons, yielding roughly 50% reduction in system capacity. Copeland has introduced the two-stage "UltraTech" compressor for U.S.-style residential split systems. It reduces capacity to 67% by using alternate bypass ports to introduce refrigerant. Several manufacturers now offer two-speed residential air conditioners with very high SEER levels; not all indicate the compressor source. With the current SEER rating method, products can be designed that use the first stage of the compressor for almost all of the test cycle, giving very high SEER values. This design approach does not improve high temperature performance, typically measured with EER. Thus, we expect modulating technology to dominate the market for SEER>14, unless stringent EER requirements are applied, as this approach seems more compact and less expensive than alternative approaches to raise SEER.

Savings: Using the appropriate mark-ups, the data in the air conditioner Technical Support Document, or TSD,[57] suggest that the retail price of the compressor for a SEER 13 air conditioner itself would be $77 more than for a SEER 10 unit. This value is used for the incremental cost. The two-stage could reasonably be more costly; we estimate $150 retail for a commodity unit with only the two-stage compressor added (based on "hints" from a manufacturer about OEM costs).

R1 Solid State Refrigeration (Cool Chips TM):[58] 171 TBTU

Cool Chips™ are thin, efficient, and small thermoelectric cooling devices. Thermoelectric cooling uses an electric current to move high-energy electrons (and their associated heat) across a junction between two semi-conductors. Conventional thermoelectric cooling efficiencies are limited to about 10%. Cool Chips use nanotechnology manufacturing to replace the electron transfer junction with a 2 to 10 nanometer gap. This gap enables the electrons to move in one direction only through electron tunneling, thereby preventing heat migration back to the heat source. The result is a cooling coefficient of performance (COP) that is twice that of conventional mechanical cooling systems. Cool Chips also offer reduced operation and maintenance costs (no moving parts), improved environmental performance (no refrigerants and less material), quieter operation, and lower space requirements (as an example, a one-square-inch Cool Chip panel could satisfy the requirements of an average refrigerator[59]).

Status: The Cool Chips technology is being developed by Cool Chips PLC. Lab-scale production of Cool Chips prototypes is currently under way. The Cool Chips goal is greater

57 U.S. DOE 2001, op. cit.

58 Sachs et al. 2004, op. cit. Page 164.

59 Criscione, P. "A New Reality for Refrigeration." ET Currents. 19:6-7. 2002.

efficiency than conventional compressors, with simpler processes that yield competitive products. In December 2002, Cool Chips announced a research agreement with SRI International for prototype characterization and fabrication. The goal of this research is to help develop a manufacturing process for production devices (Cool Chips PLC 2003). Boeing's Phantom Works conducted an independent evaluation and determined that the operating principles of the technology are sound and that the measured physical data comply with the theory.[60]

Savings: There is no prototype demonstration experience from which to obtain measure cost estimates and, consequently, performance assumptions are based on observations emerging from lab scale work. Laboratory results show efficiencies of 50–55% of the theoretical maximum Carnot efficiency, but the developers project that this will ultimately rise to 70 to 80%, approximately 50% better than conventional refrigeration devices now in use (Cool Chips PLC 2003). The company claimed that product costs would be lower compared to conventional compressor technology used in residential refrigerators, saving $20–30 per refrigerator.[61]

W3 Residential Heat Pump Water Heaters:[62] 158 TBTU

The typical U.S. house today uses an insulated storage tank and heats water with a gas flame or electric resistance element. The former suffers large standby losses through the flue, and the latter has inherent inefficiencies of electricity generation. The heat pump water heater uses a vapor-compression refrigeration cycle, like a refrigerator or air conditioner, and the COP largely compensates for primary electricity conversion losses. HPWHs are commonly installed in basements, where they take heat from the air at a relatively low temperature and reject the heat at a higher temperature to the water tank; placement for slab-on-grade houses varies with climate. In the process, most units also cool and dehumidify the basement, which can be valuable. Efforts to commercialize the technology have waxed and waned for decades. Current U.S. annual sales are estimated as a few thousand units per year.[63]

Status: Within the past few years, several manufacturers abandoned the market, and the only large-scale utility program for residential HPWHs in the continental United States was suspended after 4,000 installations, largely because utility funding was disrupted.[64] However, two new residential products have been introduced, and there is substantial interest now. The "Watter$aver" from ECR International is designed to "drop in" to the same space

---

60 Boeing. "Boeing Completes Evaluation of Borealis Cool Chips™ Technology." http://www.boeing.com/news/releases/2001/q4/nr_011130a.html. 2001.

61 Cool Chips PLC. *Cool Chips PLC Business Plan.* 2003.

62 Sachs et al. 2004, op. cit. Page 50.

63 Sachs, H.M. *Toward Market Transformation: Commercial Heat Pump Water Heaters for the New York Energy $mart[SM] Program.* American Council for an Energy Efficiency Economy. 2002.

64 U.S. Department of Energy. *In Hot Water, a Newsletter.* 2(2):1. 2002.

as an existing 50-gallon resistance water heater and can be installed by a single trade. Its certified EF is 2.4,[65] compared with 0.95 for the best resistance units. NYSERDA offers $300 incentives for this unit. The alternative, an add-on unit, is exemplified by the Nyle Specialties Nyletherm 110 heat pump water heater. It is a wall-hung, 7,000 Btuh auxiliary unit designed to supplement an existing water heater by replacing the primary resistance element. Its power requirement, 7.25 amps at 120 v., can be met by a conventional wall socket. The unit is new, and there are no independent performance data yet. In the commercial sector, HPWHs have not established a big market. However, DOE recently selected United Technologies Corp. to develop systems with higher water-delivery temperatures and wider operating range for commercial uses.[66]

Savings: The incremental cost of an integrated heat pump water heater today is in the range of $900–$1,000.[67] At average electricity prices ($0.078/kWh), this would be a four-year simple payback. The add-on HPWH will likely have similar costs and benefits, but certified ratings are not yet available. In a mature, competitive market, the purchase price (without installation) will be about the same as that of the separate technologies, approximately equal to resistance water heater plus a room air conditioner, or about $500–600. Installation should be the same cost as for a resistance water heater, unless a condensate pump and installation are required ($100).

S5 Residential Cool Color Roofing:[68] 144 TBTU

Light color roofing material has been used widely in cooling-dominated climates to reduce the summer contribution of solar-driven roof gains. Typically, these lighter colored roofing materials are used on commercial or industrial buildings with flat roofs not visible from the ground. These reflective surfaces have not found popularity in the residential sector due primarily to aesthetic issues associated with having a shiny white roof surface. New “cool” color technology research has developed products that reflect heat regardless of color. These products came from military research in the early 1980s where the goal was to find pigments that would confuse infrared sensors. The cool colors achieve high infrared reflectance (~65%) by adding metallic elements to yield a product with a traditional appearance that has an improvement in total solar reflectance (TSR) of 150 to 500%.

---

65 Gas Appliance Manufacturers Association. *Consumers’ Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment.* http://www.gamanet.org/consumer/certification/cerdir.htm. 2003.

66 U.S. Department of Energy. *ENERGY STAR® Labeling Potential for Water Heaters.* http://www.energystar.gov/ia/partners/gen_res/prod_development/new-specs/downloads/water_heaters/WH_Paper.pdf. 2003.

67 Johnson, Russ. Johnson Research, LLC. Personal communication with Harvey Sachs. 2003.

68 Sachs et al. 2004, op. cit. Page 182.

Status: Although cool colors have only had limited success in the residential market (less than 1% market share), significant research continues at national laboratories and major roofing manufacturers. Much work is being done to incorporate the technology into darker roofing materials since this combination promises the greatest benefit. The status of these technologies varies from development to commercialized. Metal roof manufacturers currently offer cool roofs using these pigments and work with the color manufacturers to incorporate the new, more efficient products when they become available. The Cool Metal Roofing Coalition is a consortium of manufacturers that has been encouraging the use of cool colors in the building industry .[69] Clay tile cool roofs are in the prototype phase, and the asphalt shingles and cedar shakes are also under development. Oak Ridge National Laboratory is currently working with the California Energy Commission and the Sacramento Municipal Utility District on a demonstration program for two products. Four houses will be built in Sacramento, California, two with metal roofs and two with tile roofs. Each pair of houses will consist of one base case and one cool roof.

Savings: The current ENERGY STAR Cool Roof simulation model available online at the ORNL website estimates 60% roof cooling load reduction using cool color roofing.[70] Savings will vary depending on the product, the climate, house insulation characteristics, and amount of cooling energy use. Reduction in cooling peak demand and improved duct efficiencies (for attic-ducted systems) are also significant in cooling dominated climates. Depending on the product, the climate, and the house insulation characteristics, the savings and paybacks can vary widely—indeed, there will be no cost differential for some categories.[71] Peak demand benefits and improved duct efficiencies are also significant in cooling-dominated climates where attic ducts are common.

<u>S1 High Performance Windows (U<0.25):[72] 144 TBTU</u>

In most homes, windows are the weak link in terms of energy efficiency and comfort[73] and can account for as much as 25% of the heat loss of homes built to current code. Over the past 10–15 years or so, new windows has improved significantly by adopting low emissivity glazing, inert gas fills, insulating spacers, and better design of window frames. Indeed, the small incremental cost of low-e coatings and gas fill have made double pane, low-e gas filled windows commonplace both for new construction and the replacement market, with Canadian Energy Ratings (ERs) ranging from -11 to +15.[74] ER accounts for solar gain and infiltration losses, as well as the transmission losses. Canada's R-2000 standard requires

---

69 CMRC Cool Metal Roofing. http://coolmetalroofing.org.
70 Sachs et al. 2004, op. cit. Page 183.
71 Scruton, C. Personal communication with E. Stubee. 2003.
72 Sachs et al. 2004, op. cit. Page 170.
73 Natural Resources Canada. *Standards for Window Energy Performance.* Natural Resources Canada, Office of Energy Efficiency. 2002.
74 Natural Resources Canada. *Consumer's Guide to Buying Energy Efficient Windows and Doors.* 1994.

minimum ER in Toronto of-13.[75] To qualify for ENERGY STAR in the U.S, a window must have a U-value no higher than 0.35 Btu/hr-ft^2-°F (that is, an R-value no lower than 2.86 hr-ft^2-°F/Btu). High insulation technology (HIT) windows, also known as "superwindows," are now available in the market offering energy and comfort performance improvements that exceed these requirements.

Status: HIT windows embody incremental design and performance improvements beyond today's energy-efficient windows. For example, using low-e films suspended between two panes of glass to create two or more spaces (interpane air space) can achieve performance superior to triple pane windows. These multi-air space windows have the same weight as a double pane window. Alternative HIT window strategies include vacuum windows and aerogels. Due to their high cost, HIT windows are currently best for heating-dominated climates above 5,500 heating degree days/year. HIT window sales currently amount to less than 1% of the North American market. Nevertheless, there are a significant number of HIT products available with a thermal performance greater than R-4.[76] The National Fenestration Rating Council May 2003 Certified Products Directory[77] lists approximately 360 manufacturers that offer roughly 3,800 window products rated at greater than R-4 and some 80 products beyond R-6. The HIT window products include fixed and operable windows with wood, fiberglass, plastic, and vinyl frames (no aluminum windows). They are available in two- to four-pane units as well as a few double pane units with interpane air spaces. In general, HIT windows rated at R-4 and beyond can replace double pane, low-e, aluminum, thermally broken frame (R-2) windows for both new construction and replacement applications.

Savings: While energy savings vary by climate, there are performance results from demonstrations and studies in many areas of North America. A 2000 study by LBNL and NFRC showed modeled seasonal heating energy savings of 14–16% and fuel cost savings of $50–$100/year for a typical 2,000 ft^2 house located in a northern state.[78] Costs of HIT windows are dropping continuously thanks to increased demand and improved technology.[79]

A2 1 kWh/day Refrigerator:[80] 140 TBTU

Under current U.S. appliance efficiency standards, the maximum annual energy use of 20 ft^3 U.S. refrigerators is 496 kWh/yr, or 1.36 kWh/day, with energy use scaled by formula for larger and smaller units. In 2004, ENERGY STAR will require 15% better performance,

---

75 Natural Resources Canada 2002, op. cit.

76 Arasteh, D. Lawrence Berkeley National Laboratory. E-mail correspondence to G. Todesco. July 2003.

77 National Fenestration Rating Council. "We Are Changing the Way America Shops for Windows, Doors, and Skylights." http://www.nfrc.org. 2002.

78 Arasteh 2003, op. cit.

79 Reilly, S. *High Performance Glazing in Commercial Buildings.* ER-01-16. E-Source, Inc. 2001.

80 Sachs et al. 2004, op. cit. Page 42.

about 422 kWh/yr (1.16 kWh/day). Reaching the metaphoric “magic mile” of 1 kWh/day (365 kWh/yr) means improving the baseline efficiency by 26%. Two pathways for achieving the goal are continued incremental design changes (e.g., thicker walls) or very large changes in key components. This might mean vacuum panel instead of foam insulation, or modulating linear compressors. Oak Ridge National Laboratory employed an incremental approach involving doubling door insulation thickness, substituting efficient DC motors for AC, improving compressor efficiency, and changing from (timed) automatic defrost to adaptive defrost, and achieved 1.16 kWh/day, with further improvement to 0.93 kWh/day by using vacuum panel insulation around the freezer compartment, although the latter showed payback longer than the expected life of the refrigerator.[81] Large changes are exemplified by the LG implementation of SunPower-developed free-piston linear compressors, which are inherently modulating output devices.

Status: The LG side-by-side unit, now being sold outside the United States, saves 30% relative to the U.S. minimum efficiency standard and will be marketed in the United States beginning in January 2004.[82] Because of the small number of moving parts, there is little reason to expect shorter life than conventional compressors.

Savings: In LG design work, direct substitution of the linear compressor for a reciprocating unit reduced energy use by 24% in a 24-ft^3 side-by-side refrigerator/freezer. Optimizing the design for the modulating linear compressor with HFC-1 34a led to a 47% reduction in energy use. This efficiency level is likely to require using separate evaporators for the freezer and refrigerator, which will directly improve efficiency and reduce frost control issues in the freezer section. The expected reduction for a smaller unit would be less, but a 40% reduction would still yield 300 kWh/yr, or 0.82 kWh/day. SunPower asserts that the technology will have rather consistent efficiency in sizes from 10W to 5 kW. Vineyard and Sand[83] estimated manufacturers’ cost of $53 to achieve 1.16 kWh/day, but much more ($134) to include vacuum panel insulation. Unger[84] suggested that the linear compressor (when mature) may be less expensive than the components it replaces. LG reports that its 2004 models that introduce the linear compressor to the U.S. market will reduce energy consumption 30% without split evaporators and show no significant price increase relative to its reciprocating compressor models

81 Vineyard, E.A., and J.R. Sand. “Experimental and Cost Analyses of a One Kilowatt-Hour/Day Domestic Refrigerator-Freezer.” *ASHRAE Transactions*. Symposia 103, Paper BN-97-7-2, 621-629. 1997.

82 Hollingsworth, D. LGE. Personal communication with Harvey Sachs. October 2003.

83 Vineyard 1997, op. cit.

84 Unger, R. “Development and Testing of a Linear Compressor Sized for the European Market.” http://www.sunpower.com/pdf/doc0074.pdf. Sunpower. 1999.

<u>D3 Advanced HVAC blower motors:[85] 112 TBTU</u>

Smaller HVAC systems typically use air conditioner fractional horsepower motors that directly drive the centrifugal fan, which is attached to the extended motor shaft. The market for conventional, baseline, residential split systems and furnaces is completely dominated by multi-tap permanent split capacitor (PSC) induction motors, which combine reasonable efficiency with the ability to select different speeds for heating, air-conditioning, and ventilating, or to match the external static pressure of a particular duct system. PSC motor efficiencies tend to run from about 35% (low speed) to 65% (high speed). In contrast, premium products (furnaces with AFUE greater than 91; air conditioners with SEER 14 or above) often use electronically commutated DC permanent magnet motors. These are continuously modulated and 10% (full load) to 100% more efficient (light load, as in ventilation/circulation) than PSC motors. Some units can be "tuned" to supply specified air flow or delivery, regardless of duct conditions.

Status: The DCPM is commercially available, with several hundred thousand units/year sold for HVAC applications. In general, these are "bundled" in premium models that combine high efficiency with other features, such as quiet starts and separate controls for temperature and humidity. DCPM are also becoming available for commercial terminal units and powered VAV boxes.

Savings: ACEEE estimates average national savings for residential air handlers as 700 kWh/yr, 500 in heating and 200 in air-conditioning.[86] One manufacturer estimated average savings twice as large,[87] but this estimate seems to ignore incremental gas needed in heating season to replace electricity no longer dissipated as heat. ACEEE estimates that the incremental OEM cost of the DCPM motor will be $35 (½ hp), or $80 consumer price (using DOE TSD assumptions on price multipliers[88]).

L.5 Selection Results—Commercial

Initial Screening Results—Commercial

Forty-two of the 77 technologies identified in Table L-2 and Table L-3 are applicable to the commercial sector and survived the initial screening procedure outlined in Selection Criteria. These measures are listed in Table L-8 and Table L-9. CSE refers to the cost of saved energy, either electrical (kWh) or heat energy (MMBtu). For the ACEEE-identified measures, the energy savings potential and the priority rating were assigned by ACEEE

85 Sachs et al. 2004, op. cit. Page 58.
86 Sachs and Smith 2003, op. cit.
87 General Electric. "Halogen Lamps." Product Catalog. http://www.gelighting.com. 2003.
88 Sachs and Smith 2003, op. cit.

specifically for California in Appendix B of ACEEE 2004. For the ETCC measures, the energy savings potential was obtained from the ETCC database where available. Success likelihood was also estimated based on the same source. Energy savings potential is nationwide.

Table L-8: Emerging Technologies Meriting Detailed Consideration – Commercial,[89] ACEEE Measures

ACEEE Code	Measure Name	Savings Potential (TBTU)	Percent Saved	CSE $/kWh	CSE ($/MMBtu)	Likelihood of Success Rating	Deselection Criteria
CA1	Variable Output (Stepped) Compact Florescent	98[90]	0	-0.01	-1.5	3	Not Widespread
CA2	Advanced HVAC Controls	98[91]	0	0.03	2.80	3	
CR1	Hotel Key Card System	15	0.03	0.01	1.30	2	Low success
H10a	Ground-Coupled Heat Pumps-Commercial	43	0.09	0.13	12.60	2	Low success
H11	Leakproof Duct Fittings	489	1.03	0	0.40	4	
H13	Micro-Channel Heat Exchangers	132	0.28	0.02	1.60	2	Low success
H14	Solid State Refrigeration for Heat Pumps And Power Generation	106	0.22	0.16	15.60	2	Low success High cost
H16	High-Efficiency Gas-Fired Rooftop Units	20	0.04	N/A	3.40	2	Low success
H17	Solar Pre-Heated Ventilation Air Systems (Solarwall tm)	7	0.02	N/A	2.4	3	Not Widespread
H18	CO2 Ventilation Control	163	0.34	0.03	2.70	4	

89 Sachs et al. 2004, op. cit. The measures and the values assigned were taken from Appendix B, Table B-13. However, the measures selected for inclusion in Table 3 are a subset of those in Table B-13, selected especially for the purposes of the present study. In addition, all non-duplicative ETCC measures were also included in the table.

90 Ibid. Savings potential reported in Appendix B as 12 TBTU for California. Adjusted to nationwide estimate using 2003 population.

91 Reported as 12 TBTU for California. Adjusted to nationwide.

Table L–8 (cont'd.): Emerging Technologies Meriting Detailed Consideration – Commercial, ACEEE Measures

ACEEE Code	Measure Name	Savings Potential (TBTU)	Percent Saved	CSE $/kWh	CSE ($/MMBtu)	Likelihood of Success Rating	Deselection Criteria
H19	Displacement Ventilation	11	0.02	0	0	3	
H1a	Advanced Rooftop Packaged Air Conditioners—Commercial	81	0.17	0.04	3.50	3	
H20	Advanced Condensing Boilers-Commercial	23	0.05	0.01	0.60	3	
H2b	Cromer Cycle Air Conditioner-Commercial	16	0.03	0.07	6.80	3	
H3	Commercial HVAC Heat Pipes	8	0.02	0.28	27.30	2	Low success
H6	UVHVAC Disinfecting	19	0.04	0.57	56.50	2	Low success
L 14	1-Lamp Fluorescent Fixtures W/High Performance Lamps	215	0.45	0.01	0.80	3	
L10	Hybrid Solar Lighting	270	0.57	0.27	26.30	2	Low success
L11b	Commercial LED Lighting	176	0.37	0.03	2.90	3	
L15	Scotopic Lighting	154	0.33	0	0	3	
L4	Cost-Effective Load Shed Ballast & Controller	1	0	0.43	42.90	3	High Cost
L5	Advanced Daylighting Controls	80	0.17	0.02	2.30	3	
L6	Low Wattage Ceramic Metal Halide Lamp	130	0.27	0.03	2.80	3	
L7	Hospitality Bathroom Lighting	28	0.06	0.04	4.00	3	
L8	Universal Light Dimming Control Device	97	0.20	0.08	8.10	1	Low success

Table L–8 (cont'd.): Emerging Technologies Meriting Detailed Consideration – Commercial, ACEEE Measures

ACEEE Code	Measure Name	Savings Potential (TBTU)	Percent Saved	CSE $/kWh	CSE ($/MMBtu)	Likelihood of Success Rating	Deselection Criteria
L9	Advanced High Intensity Discharge Lighting	97	0.21	0.05	4.90	2	Low success
O1	Networked Computer Power Management	286	0.60	0.02	1.70	3	
P2a	Commercial Micro-CHP Using Fuel Cells	767	1.62	0.07	7.40	2	Low success
P2b	Commercial Micro-CHP Using Micro-Turbines	692	1.46	0.05	5.30	2	Low success
R2	Modulating Compressor for packaged Refrigeration	45	0.09	0.02	2.20	4	
R3	Efficient Fan Options For Comm. Refrigeration	29	0.06	0.02	1.60	4	
S2b	Active Window Insulation, Commercial	93	0.20	0.02	1.80	2	
S3a	Electrochromic Glazing For Commercial	3	0.01	0.08	7.80	2	

Table L-9: Emerging Technologies Meriting Detailed Consideration – Commercial, ETCC Measures

ETCC Code	Measure Name	Savings Potential (TBTU)	Percent Saved	CSE $/kWh	CSE ($/MMBtu)	Likelihood of Success Rating	Deselection Criteria
ETCC 30	Anti-Sweat Heater					?	Not widespread
ETCC 31	Display Case Shields with Low Emissivity Coating					?	Not widespread
ETCC 36	Efficient Open Vertical Display Case:					?	Not widespread
ETCC 39	Refrigerated Display Cases Mechanical Sub-Cooling:					?	Not widespread
ETCC 41	High Speed Hand Dryer:					?	Not widespread
ETCC 68	Adsorption Space Conditioning -					Low success	Low success
ETCC 72	Professional Garment Cleaning System					?	Not widespread
ETCC 85	Dual Cool A/C					Low success	Low success
ETCC 171	Variable Reflector Geometry Lighting					Low success	Low success

Selection Results—Commercial

The effects of applying each of the detailed criteria out lined in Selection Criteria are described below. The criteria by which technologies were deselected are also indicated in the tables above.

<u>Likelihood of Success</u>

Of the 41 candidate commercial measures, 17 were eliminated on the basis of having a lower likelihood of success rating (less than 3 as assigned by ACEEE specifically, for California). Based on the information in the ETCC database, three of the ETCC technologies were also eliminated because, in Itron’s judgment, they would not be rated 3 or more under ACEEE criteria.

- Hotel key card system
- Ground-coupled heat pumps
- Microchannel heat exchangers
- Solid state refrigeration for heat pumps and power generation
- High-efficiency gas-fired roof top units

- Commercial HVAC heat pipes
- UVHVAC disinfection
- Hybrid solar lighting
- Universal light dimming control device
- Advanced HID lighting
- Commercial micro-CHP using fuel cells
- Commercial micro-CHP using micro-turbines
- Active window insulation, commercial
- Electrochromic glazing for commercial
- Adsorption space conditioning
- Dual cool air conditioners
- Variable reflector geometry lighting

Widespread Applicability

Of the remaining 24 commercial technology measures, nine were eliminated because of lack of widespread applicability:

- Variable output (stepped) compact florescent
- Solar pre-heated ventilation air systems
- Anti-sweat heater
- Display case shields with low emissivity coating
- Efficient open vertical display case
- A high efficiency heat exchanger within the display case
- Refrigerated display cases mechanical sub-cooling
- High speed hand dryer
- Professional garment cleaning system

These technologies were not considered by Itron to have sufficiently wide commercial applicability to include in the forecast.

Cost-Effectiveness

Of the remaining 15 measures, only one was eliminated because it was not cost-effective. Despite its technology description, "Cost-effective load shed ballast & controller" did not pass the test of saving electricity at less than 10 cents per kWh or heat at less than $6 per MMBTU.

Total Saved Energy

Of the 14 remaining measures, 10 had total energy savings in California of between 1,161 and 80 TBTU. The remaining four technologies were eliminated because their total energy savings were markedly lower:

- Efficient fan options for commercial refrigeration 29 TBTU
- Hospitality bathroom lighting 28 TBTU
- Advanced condensing boilers—commercial 23 TBTU
- Cromer Cycle air conditioner—commercial 16 TBTU
- Displacement ventilation 11 TBTU

The 10 selected commercial emerging technologies with the greatest potential are listed in Table L-10 and described in the following paragraphs.

Table L-10: Selected Measures – Commercial (in order of California Savings Potential)[92]

ACEEE #	NAME	Savings Potential (TBTU)	Percent Saved	CSE $/kWh	CSE ($/MM Btu)	Likelihood of Success Rating
CA2	Advanced HVAC Controls	12	0	0.03	2.80	3
H11	Leakproof Duct Fittings	489[93]	1.03	0	0.40	4
O1	Networked Computer Power Management	286	0.60	0.02	1.70	3
L 14	1-Lamp Fluorescent Fixtures w/High Performance Lamps	215	0.45	0.01	0.80	3
L11b	Commercial LED Lighting	176	0.37	0.03	2.90	3
H18	CO2 Ventilation Control	163	0.34	0.03	2.70	4
L6	Low Wattage Ceramic Metal Halide Lamp	130	0.27	0.03	2.80	3
H1a	Advanced Rooftop Packaged Air Conditioners –Commercial	81	0.17	0.04	3.50	3
L5	Advanced Daylighting Controls	80	0.17	0.02	2.30	3

Description of the Selected Measures

The following paragraphs describe the selected measures in descending order of total California energy saving potential. In addition to the description, for each of the measures the status of the technology is described and the energy saving potential is discussed. The texts of these measure descriptions are all quoted directly from ACEEE 2004 except for the ETCC measures; those descriptions were obtained from the ETCC database.

92 Sachs et al. 2004, op. cit. Based on Table B-13.

93 Leakproof duct fittings apply to both commercial and residential applications. Therefore, the reported savings must be divided between these categories.

<u>Advanced Controls: 1,161 TBTU</u>

Advanced controls for packaged HVAC units for light commercial applications. Packaged units, typified by rooftop units (RTUs), are rated by refrigeration efficiency only, but also provide ventilation and economizer services, the latter being the ability to bring in cooler outside air when available to avoid use of the refrigeration cycle. In hot-dry climates with large daily temperature cycles, economizers alone can save almost half of the energy use of RTUs but are often absent or not operating. Advanced controls would optimize use of ventilation for savings and indoor environmental quality (IEQ) and give key fault diagnostics—but look and work much like thermostats.

Status: Fully optioned units from major manufacturers combine an impressive array of characteristics. As one example, consider the Lennox L Series, which offers SEER up to 13.25 and EER up to 12.2, integrated DDC control with humidity control (hot gas reheat) and demand control (C02) options, multi-stage cooling, heat recovery wheel, and premium fan motors.[94] On the other hand, neither the CEE High Efficiency Commercial Air Conditioner program[95] nor the FEIVIP procurement (PNIL 2004) includes controls or non-refrigeration aspects of performance.

Savings: With very conservative assumptions, Itron computed potential California savings of 1,740 GWH in 2020, at a cost of saved energy of $0.03/kWh. Demand savings would be real, but depend on the ability of CO2 or equivalent monitors to estimate occupancy (and thus ventilation requirements) at peak times.

<u>Leakproof Duct Fittings:[96] 489 TBTU</u>

The majority of duct leakage in residential and small commercial HVAC systems is due to improperly sealed connections between ductwork and fittings. Even when duct connections are initially well sealed, leakage may increase over time.[97]

Status: Although the use of mastics and mechanical fasteners is becoming more widespread, a low cost, leakproof system will help to transform the market. The benefit of any duct remediation technology is greatest in climates with high cooling loads and attic ducts. Available round-section spiral sheet metal systems from Lindab and others are targeted to commercial applications in the United States. They are used for residences in Sweden, but cost about twice as much as conventional residential systems in the United States.[98] In

94 Lennox. LG/LC/LH Models L Series® Brochure. 76M73. January 2004.
95 Consortium for Energy Efficiency. "CEE Super-Efficient High Efficiency Commercial Air Conditioning and Heat Pumps Initiative (HECAC)." http://www.cee1.org/com/hecac/hecac-tiers.pdf. 2004.
96 Sachs et al. 2004, op. cit. Page 88.
97 Walker et al. 1998, op. cit.
98 Spartz 2004, op. cit.

California, the installation of tight duct systems has increased significantly over the past three years as the Title 24 code has provided a credit for "tight" duct systems leaking less than 6% of system airflow. One approach to reducing duct leakage is the use of mastic, mechanical fasteners, and UL-18 1-approved duct tapes. An alternative approach is through the use of long-lasting leakproof duct connections that can be reliably field installed with a minimum of skill. Proctor Engineering Group has developed the Snap Duct system of fittings with support from DOE's Small Technology Transfer program. The system consists of mechanically fastened fittings (couplings, boots, plenums, wyes) for flex and hard ducts that snap together to create a long-lasting seal. Testing of the fittings show that about 90% of the leakage within the duct system is eliminated.[99]

Savings[100]: Various field studies indicate that mitigating residential duct leakage may reduce HVAC energy use by roughly 20%.[101,102] The California Title 24 energy code assumes typical new residential duct systems leak 22% of HYAC system airflow.[103] Typical new construction costs for manual duct sealing are estimated as $250 per house. The Snap Duct technology is still in the prototype stage, but indications are that the system will be less expensive than current manual duct sealing techniques. Although the fitting cost will be more than standard fittings, labor savings is expected to more than offset the incremental cost. Duct pressurization testing is still necessary to insure proper installation.

Networked Computer Power Management:[104] 286 TBTU

Computer networks consume a considerable and increasing amount of energy. Approximately 74 Terawatt-hours of power are used by office equipment and networks.[105] A large fraction of this energy is consumed while the user is not present, even though ENERGY STAR desktop computers with "sleep" capabilities have been available for years. In corporate, institutional, and government offices, the network software may not support use of low-power states when the computer is unused for long periods. Conceptually and pragmatically, the problem has at least two dimensions, notably the monitor and the central processor unit (CPU). The potential power savings are about 30 to 50 Watts for CRT monitors and about half that for LCD screens. The Pentium 4 processors in current CPUs draw about 55 Watts while working and 2 Watts while in sleep mode. Control of networked CRT and LCD monitors is no longer considered an emerging technology, with tools

99 Proctor 2003, op. cit.

100 The savings indicated for leakproof duct fittings apply to both commercial and residential applications and thus must be divided between these categories.

101 Sachs et al. 2004, op. cit. Page 88, reference to Hammurlund 1992.

102 Proctor 1993, op. cit.

103 California Energy Commission Residential Manual 1999, op. cit.

104 Sachs et al. 2004, op. cit. Page 138.

105 Roberson, J., et al. *Energy Use and Power Levels in New Monitors and Personal Computers.* LGNL-48581. Lawrence Berkeley National Laboratory. 2002.

incorporated in network management packages from vendors such as Computer Associates, CSC, and others.

Status: Many large organizations have implemented the feature on their own, and in addition, ENERGY STAR distributes monitor software (EZ Save) for free. Korn estimated that at least 30% of large networks have monitor controls now.[106] The current "frontier" is CPU power management. Commercial products are available from Verdiem (Surveyor) 1 e (NightWatchman) and others, but their market penetration is considered low (Korn 2003).[107] Surveyor software is readily available at this time and has been extensively tested in a number of different environments.[108] The cost of installation is dependent upon the size of the network, but is approximately $15 per computer.[109] Incremental savings for CPU management (beyond monitor management) are estimated at 100-400 kWh/year[110] and 200 kWh/year.[111]

One-Lamp Fluorescent Fixtures with High Performance Lamps:[112] 215 TBTU

One-lamp fixtures for fluorescent lamps can reduce lighting electricity consumption for most commercial buildings, especially for those with small or oddly dimensioned offices, spaces with some daylighting, and offices where computer-oriented tasks predominate. In many commercial buildings, general lighting levels are set around 50-foot-candles, typically more light than needed to perform tasks using desktop computers. The Illuminating Engineering Society of North America (IESNA) has recommended that decreasing ambient lighting levels to about 30-foot-candles would reduce excess lighting and improve worker comfort and productivity.[113] One way that high energy savings and 30-foot-candles can be attained is by using one-lamp fixtures with super T8 lamps and high-output electronic ballasts (ballast factors of 1.18 to 1.26). Using one-lamp indirect T5 fixtures is also an option.

Status: Despite the IESNA recommendation and the potential energy savings for one-lamp lighting design, installing one-lamp fixtures is still not common. Some major utilities do recognize the energy savings potential and currently offer financial incentives for one-lamp lighting system designs. National Grid currently offers $10 per fixture and an additional $5 for using Super T8 lamps on new construction projects. However, the number of proposals

---

106 Korn, D. The Cadmus Group. Personal communication with Harvey Sachs. 2003.
107 Sachs et al. 2004, op. cit.
108 Thatham, C. Verdiem. Personal communication with Hugh Dwiggins. August 21, 2003.
109 Ibid.
110 Ibid.
111 Degens, P. Northwest Energy Efficiency Alliance. Personal Communication with Hugh Dwiggins. September 25, 2003.
112 Sachs et al. 2004, op. cit. Page 132.
113 Illuminating Engineering Society of North America, The. *The IESNA Lighting Handbook: Reference & Application.* Ninth Edition. 2000.

for one-lamp fixture designs has generally been low (less than 5% of total number of proposals in the last year).[114] The utility has received proposals to replace many two-lamp fixtures in school classrooms, but has not seen many for offices. Xcel, Pacific Gas & Electric, and Portland General Electric (for existing buildings) are also offering financial incentives for lighting designs that reduce energy consumption, for which one-lamp fixtures would qualify.[115,116,117]

Savings: Energy savings can add up to 204 kWh/yr per unit or 72% by using two one-lamp fixtures with super T8 lamps instead of two two-lamp fixtures with standard T8 lamps. When replacing a T12 system, savings will be greater. T8 and T12 fluorescent lamps comprise more than 50% of total lighting energy use in commercial buildings.[118] We estimate that the feasible application for this technology is 50% of T8 and T12 use in the commercial sector.

Commercial LED Lighting:[119] **176 TBTU**

Light emitting diodes (LEDs) are solid-state devices that convert electricity to light, potentially with very high efficiency and long life. They are generally monochromatic, so early applications have been for (red) exit signs and for traffic signals. Recently, lighting manufacturers have been able to produce "cool" white LED lighting indirectly, using ultraviolet LEDs to excite phosphors that emit a white-appearing light.

Status: Red and green LED traffic signals are now mainstream. White LED products are entering niche markets including retail displays, building exterior illumination, task lighting, elevators, kitchens (under-cabinet), and backlighting for liquid crystal displays. LumiLeds has released a warm white, incandescent-equivalent LED lamp with average light output of 22 lumens and 50,000 hour life at 70% of initial brightness.[120] For comparison, a typical 60-Watt incandescent bulb has an output of around 800 lumens and lasts about 1,000 hours. GE has announced white LED lighting products with an efficacy of 30 lumens/Watt and 50,000

---

114 Hagspiel, A. National Grid. Personal communication with Marycel Tuazon. July 2003.

115 Portland General Electric. "Lighting Rebates – Existing Buildings." http://www.portlandgeneral.com/business/energy_efficiency/programs/pdfs/existlight.pdf. 2003.

116 Savings by Design. "Savings by Design 2003 Participant Handbook: Policies and Procedures for Participation in the Statewide Savings by Design Program." http://www.savingsbydesign.com/pdfs/2003SBDParticipantHandbook.pdf. 2003.

117 Xcel Energy. "Xcel Energy New Construction Lighting Rebate Application." http://wwwxcelenergy.com/docs/retail/busmrkts/BusinessLightingNewConstructionRebateMN.pdf. 2003.

118 U.S. Department of Energy. *U.S. Lighting Market Characterization, Volume 1: National Lighting Inventory and Energy Consumption Estimate.* Prepared by Navigant Consulting for the U.S. DOE, Office of Energy Efficiency and Renewable Energy, Building Technologies Program. 2002.

119 Sachs et al. 2004, op. cit. Page 126.

120 LumiLeds. "Lumileds to Ship Warm White, Incandescent-Equivalent LED in August." Press Release. http://www.lumileds.com. 2003.

hour life.[121] For comparison, current CFLs generally exceed 70 lumen/Watt,[122] with life expectancy of several thousand hours. Technical Consumer Products, mc, a lighting manufacturer, recently released an $89, 5-Watt LED desk lamp.[123]

Savings: When compared to a typical 60-Watt incandescent lamp, the LED desk lamp offers over 90% in energy savings.[124] In California, the PIER Lighting program expected to have LED fixture prototypes ready in the fall of 2003 that could be used for residential porches, commercial entry ways, and other exterior illumination needs (Porter 2003). PIER is also working on low profile fixtures for elevators, kitchen cabinets, and similar applications. The products are expected to reach marketable stage towards the end of 2004. Much current research is focused on improving the efficacy and light quality of white LEDs.

Currently, white LEDs are estimated to cost about $200/lumen,[125,126] however, this number could continue to go down if the design of LED systems components also improves.[127] There are also other technical challenges related to semiconductors used in LEDs.[128] Currently, thermal management is a key issue that needs to be resolved for LED systems. Although they do not radiate as much as heat as other lighting sources, LEDs still need an appropriate heat sink so that light output and life span do not decrease.

CO2 ventilation controls:[129] 163 TBTU

Since 1916, CO_2 level controls have been recommended to ensure sufficient ventilation in buildings, but it was not until the late 1990s that an accurate, reliable, and affordable CO_2 sensor was developed for integration with zoned commercial HVAC systems. By 2000, some manufacturers' controller product lines were 100% compatible with demand-controlled ventilation (DCV). Using CO_2 to trigger ventilation in areas of commercial buildings where significant occupancy fluctuations occur can result in significant fan energy and ventilation load savings over standard "cubic feet in/occupant" (or per ft^2) sizing rules. The standard

121 Talbot, D. "LEDs vs the Lightbulb." *Technology Review: MIT's Magazine of Innovation.* 106 (4):30-36. 2003.

122 IESNA 2002, op. cit.

123 Technical Consumer Products, Inc. "GALAXe LED Desk Lamp." Specification Sheet. http://www.tcpi.com/pdf/Galaxe%/20spec%20sheet.pdf. 2003.

124 David, S. Technical Consumer Products, Inc. Personal communication with Marycel Tuazon. August 2003.

125 Craford, M.G. *Visible LEDs: The Trend toward High Power Emitters and Remaining Challenges for Solid State Lighting.* Presented to Lawrence Berkeley National Laboratory. http://ncem.lbl.gov/team/presentations/Craford/sld001.htm. 2002.

126 Ton, M., S. Foster, and C. Calwell. *LED Lighting Technologies and Potential for Near-Term Applications.* Market Research Report #E03-114. Ecos Consulting. Prepared for the Northwest Energy Efficiency Alliance. http://www.nwalliance.org/resources/reports/114ES.pdf. 2003.

127 Ibid.

128 Simmons, J. Sandia National Laboratory. Personal communication with Marycel Tuazon. August 2003.

129 Sachs et al. 2004, op. cit. Page 102.

method involves estimating the number of occupants, usually the maximum, and constantly supplying an amount of ventilation air sufficient for maximum occupation, regardless of the actual occupation at any given time. DCV only operates when CO_2 levels indicate ventilation is needed, adapting to the occupancy of critical areas, such as conference rooms, boardrooms, cafeterias, and other spaces with changing occupancy. ASHRAE 62-2000 allows this method of ventilation control.

Status: Major manufacturers of commercial HVAC control systems supply CO_2 controls as an option to their standard product line. There has recently been an upsurge in adoption of this technology partly due to the increased interest in indoor air quality and a resulting increase in fan energy use. Once design engineers are educated on the potential benefits of this technology, market penetration should increase rapidly.

Savings: A DCV system can save 100% of the energy used for ventilation of an underused space anytime that space is not being used and will always be saving energy anytime the space has less than the design occupancy present. One manufacturer estimated that converting critical spaces to DCV could save 20–30% (Shaw 2003) of the overall ventilation air energy use. The cost for adding this functionality is approximately $575 per zone (CEC 2002).

Low wattage ceramic metal halide lamp:[130] **130 TBTU**

Advances in metal halide (MH) lamp technology have led to the production of ceramic metal halide (CMH) lamps that use ceramic rather than quartz arc tubes typical of most MH lamps. Ceramic arc tubes can tolerate a higher temperature than quartz, resulting in improved color rendering, color temperature and the warm tones desired in retail and other color-sensitive applications. Furthermore, CMH lamps can provide the concentrated beams required for accent lighting both in retail and other architectural applications. CMH lamps represent an attractive alternative to the halogen PAR lamps commonly used in these applications because they have a much longer life and use just half of the energy.

Status: All major lamp manufacturers currently offer CMH lamps in the 39–400W range. CMH lamps are most common in wattages of 39–150W. A 39W CMH lamp produces 2,200–2,400 lumens, a higher output than both the 100W halogen-infrared PAR lamps (2,070 lumens) and the 100W halogen PAR lamps (1,400 lumens) typically used in retail and other commercial applications. Unlike halogen sources, CMH lamps require ballast to operate.

Savings: CMH lamp systems use less than half the energy of HJR PAR lamps to produce a similar light output. In addition to energy savings, CMHs last three to four times as long as halogen-JR PAR lamps (9,000–12,000 hours versus 3,000 hours) and can reduce the number

[130] Sachs et al. 2004, op. cit. Page 116.

of fixtures required to illuminate a space. In a typical retail application, replacement of each 100W halogen-JR PAR lamp with a 39W ceramic metal halide (lamp plus ballast uses 44W) saves roughly 225 kWh per year. For retrofits, current costs are approximately $175 per fixture including lamp, fixture, and ballast costs. However, in many cases—particularly where halogen PAR lamps have not been upgraded to halogen-JR—fewer than one-to-one fixture replacements are required, reducing the overall retrofit project costs. For new construction and remodeling projects, the current incremental cost relative to halogen-JR lamps is approximately $140.[131]

Advanced rooftop packaged air conditioners:[132] **81 TBTU**

Packaged rooftop units (RTUs) are ubiquitous, accounting for almost half (44%) of the air-conditioned commercial floor space in California (AEC undated). They are typically small (mode = 5 tons) commodity products. They are rated only on refrigeration efficiency, i.e., steady state EER for larger units or seasonal efficiency (SEER) for units up to 65,000 Btu per hour. On the other hand, conventional applications rely on the packaged unit to provide outdoor air to meet ventilation requirements and often to implement and control an economizer cycle that uses cool outside air instead of mechanical refrigeration when cost-effective. In some cases (particularly cold climates and humid climates), energy or enthalpy recovery ventilation (ER V/HR V) would also improve efficiency. Thus, a product rated on one parameter is expected to provide multiple services, generally relying on third-party components (economizers, heat recovery, controls) with field integration. This measure explores an alternative, an advanced RTU designed, installed, operated, and maintained to efficiently provide the full range of required services.

Status: FEMP sponsored a federal procurement for advanced units with minimum life-cycle costs (FEMP Unitary Air Conditioner Procurement). The winning products included mid-efficiency entries by Lennox International, with capacities from 90,000 to 120,000 Btuh and EERs and ILPVs of 11.0/11.8 to 11.3/12.0, and high-efficiency units from Global Energy Group, with capacities of 88,000 and 115,000 Btuh and EERs/IPLVs of 13.5/13.9 and 13.4/1 4.0, respectively. Our analysis begins with the Global Energy unit, because of its advanced specifications. The 10-ton (120,000 Btuh) unit includes powered exhaust and an optional economizer with differential controller.

Savings: Our baseline model is an ASHRAE 90.1-1999 ten-ton rooftop unit, with EER of 10.3. According to LBNL,[133] the cost of this unit is $4,855, but this seems to be for a 7.5-ton

---

[131] Thorne, J. and S. Nadel. *Commercial Lighting Retrofits: A Briefing Paper for Program Implementers.* American Council for an Energy Efficient Economy. 2003.

[132] Sachs et al. 2004, op. cit. Page 62.

[133] Lawrence Berkeley National Laboratory, Environmental Energy Technologies. *Average Values: Manufacturer Price, Customer Equipment Price, Installation Cost, and Total Installed Cost.* Presentation slide. 2003.

unit. The GEG 115,000 Btu unit proxy for advanced units has a federal price only $800 higher.[134]

Advanced daylighting controls:[135] **80 TBTU**

In most office spaces, lighting has traditionally been designed to provide equal amount of light for all occupant spaces. However, lighting may not be needed in all spaces; part-time occupancy and daylight may eliminate lighting needs. Individual workers needs and expectations also vary. New lighting control products allow individuals more flexibility in setting light levels for their spaces. Most allow workers to change lighting levels using their computers or remote control devices. Four models of advanced daylighting controls are currently available in North America. ADCs have been installed in large offices around the country. LRC has installed the self-commissioning photosensor and control device in private offices in Connecticut and plans to monitor the sites for six months. LRC also monitored Ergolights in New York.[136]

Status: In a study done in offices at the National Center for Atmospheric Research (NCAR), most workers preferred the model used with desktop computers, such as Ledalite's Ergolight. Ledalite has seen increases in the number of units sold in the last few years. The company now has more than 10,000 Ergolights in various locations. The World Resources Institute installed Ergolight in 140 individual workstations in Washington, D.C. with positive results.[137] BC Hydro also installed 195 Ergolight systems at one of their facilities. The British Columbia utility company is now seeing monthly savings of 65—80% (Campbell 2002). At its facility in Tewskbury, Massachusetts, Raytheon Company replaced 697 fixtures (combination of two-lamp and four-lamp T12s) with 503 Ergolights and has seen similar savings. Raytheon has since added more units and now has about 3,000 of the fixtures. Ledalite will be releasing a new version of the Ergolight in the near future.

Savings: ADCs cost $125–$400 per unit, depending on available features. Fully integrated systems with occupancy sensors, such as Ergolight, cost around $400 or $2–$3/ft^2. As the volume of sales increase, these prices will likely come down. Standard T8 lamps cost around $1 .75/ft^2 to install. For this analysis, we estimated that the incremental cost for the user is about 500/ft^2 over a standard T8 fixture. Compared to using standard T8 lamps, we compute energy savings of 46%.

---

134 Frankenfield, G. Global Energy Group. Personal communication. October 30, 2003.

135 Sachs et al. 2004, op. cit. Page 114.

136 Stubee, E. Science Applications International Corporation (SAIC). Comments in review of draft document. 2004.

137 Krepchin, I. and J. Stein. *New Dimming Controls: Taking It Personally.* E Source, Inc. 2000.

Appendix M

ASSET Documentation

The attached User's Guide provides documentation on Itron's ASSET model used in this analysis.

ASSET

User's Guide

Assessment of Energy Technologies

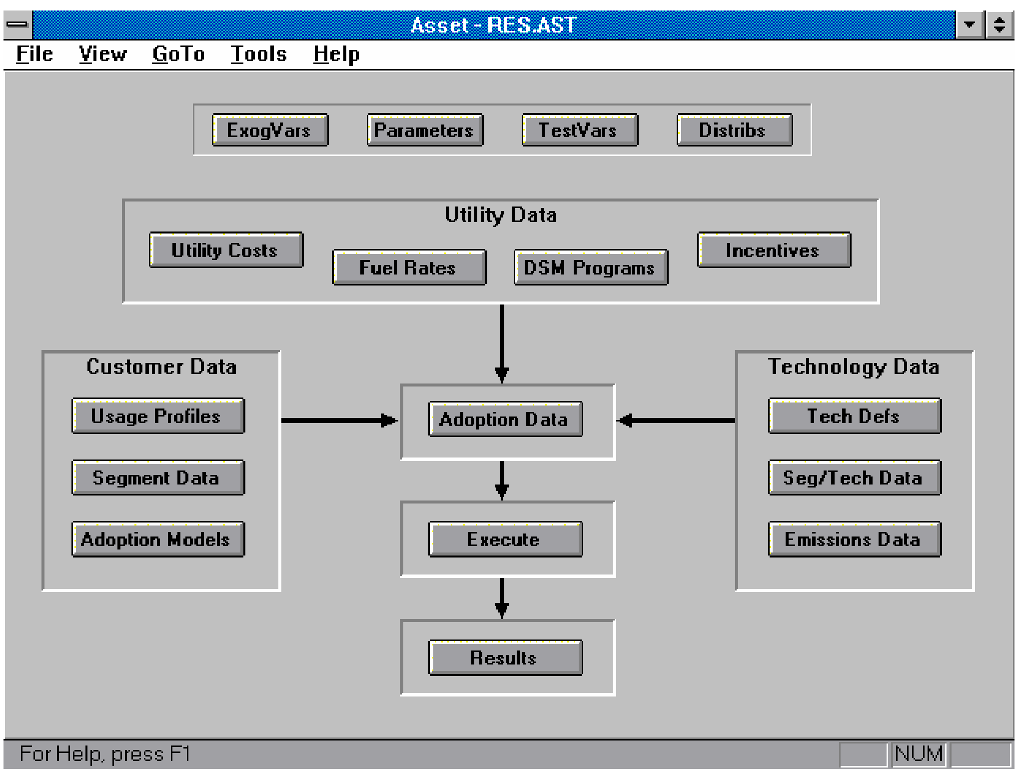


Table of Contents

1

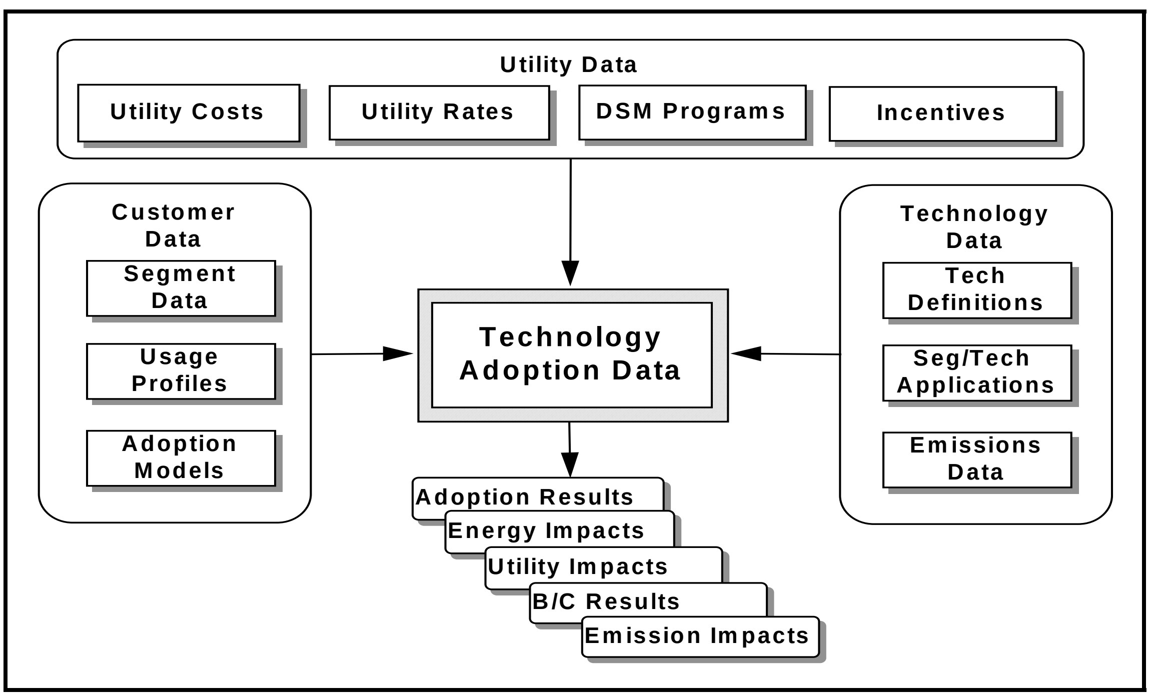
Overview of ASSET

ASSET provides a framework for tracking and modeling customer adoption of specific technologies, as well as participation in utility programs. This User's Guide documents the structure of ASSET. It contains instructions for program installation and discussions of program use. It contains detailed descriptions of the inputs required by the program and the outputs that are available. Details of the program logic are contained in Appendices.

1.1 ASSET Framework

ASSET stands for Assessment of End-Use Technologies. As depicted in Figure 1-1, the program models technology adoption outcomes by combining data about: (a) customer characteristics by segment, (b) utility costs, rates, and programs, (c) end-use technology data, and (d) models of customer behavior related to technology adoption.

Figure 1-1: Data Flows in ASSET Title



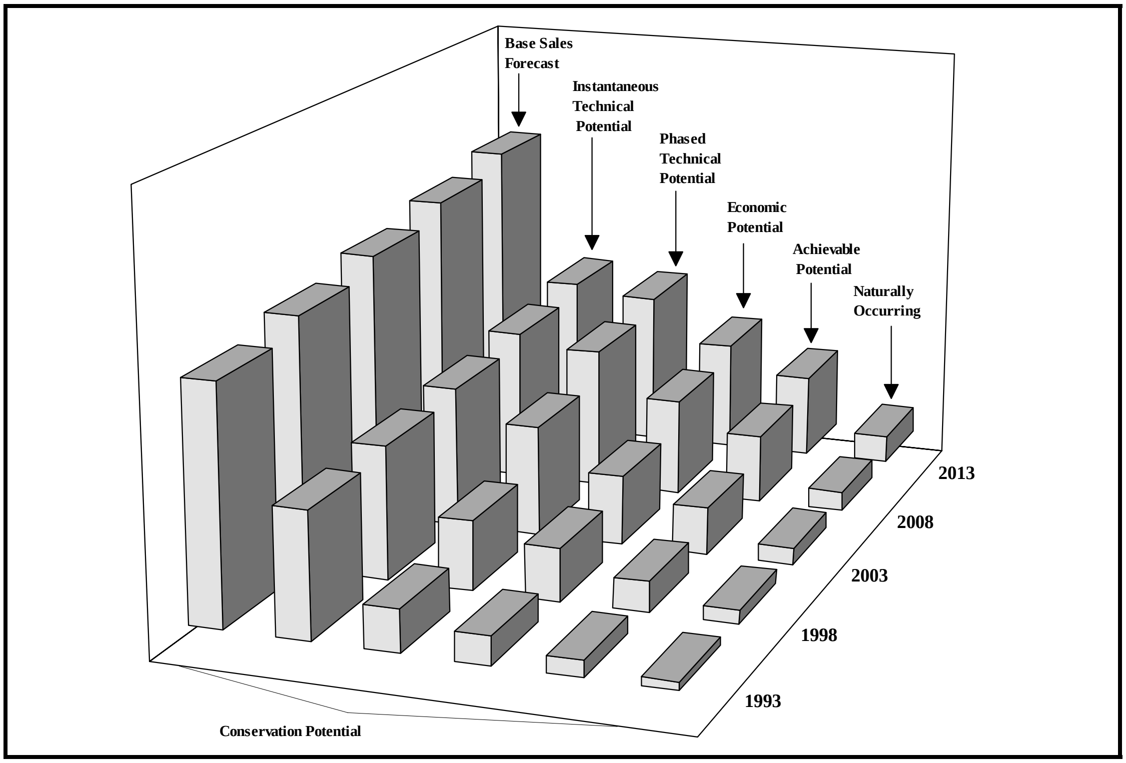
ASSET combines the above data elements to produce alternative projections of technology adoption and energy impacts. In each run, gross energy impacts are computed for electricity and natural gas. As the simulation proceeds, purchases of efficient equipment and installation of devices generate gross energy impacts. Net program impacts are computed as the difference between gross impacts with utility programs and gross impacts without programs.

1.2 ASSET Results

ASSET provides results on the costs, energy impacts, and emission impacts associated with alternative adoption scenarios. In addition to estimating adoption levels based on customer behavior, ASSET can execute runs that simulate technical potential and economic potential. As depicted in Figure 1-2, the four run options can be interpreted as follows:

- ***Technical potential***, in which the most efficient technology option is selected subject to applicability, feasibility, and technology availability.
- ***Economic potential***, in which the most efficient technology option that is cost effective is selected subject to applicability, feasibility, and technology availability.
- ***Achievable potential***, based on a market simulation with utility programs.
- ***Naturally occurring***, based on a market simulation without utility programs.

Figure 1-2: ASSET Results -- DSM Potential Scenario



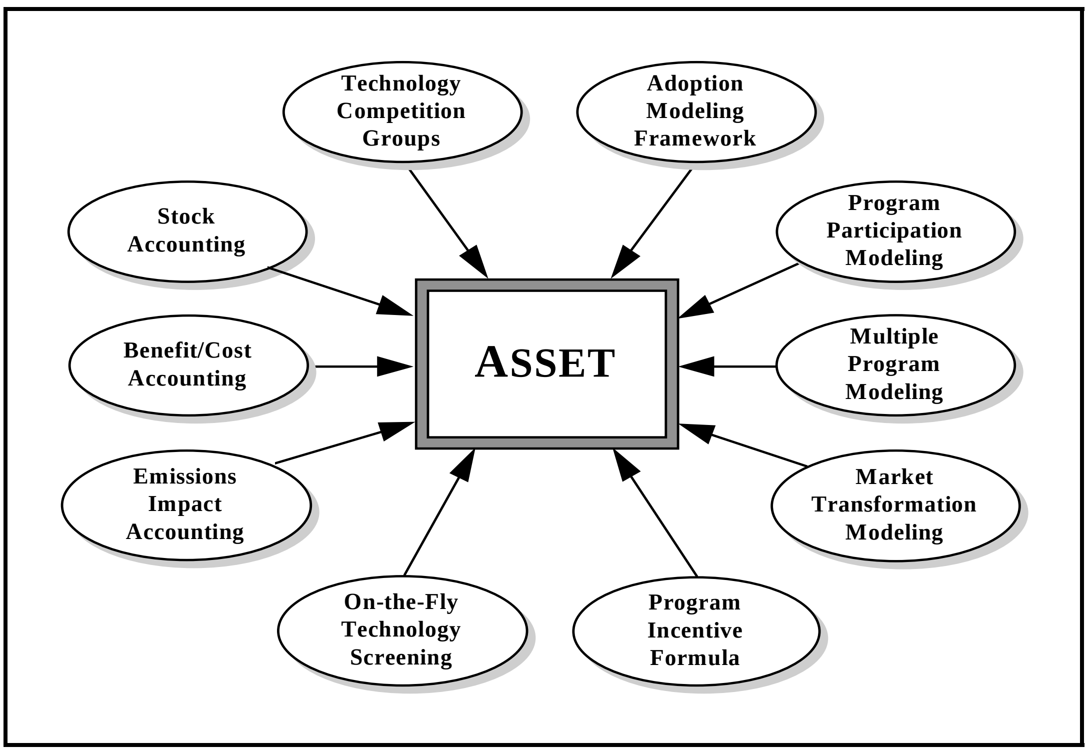
Results available from ASSET include the following:

- Technology adoption levels by segment, technology and decision type.
- Energy impacts from technology adoption.
- Cost impacts from technology adoption.
- Emission impacts from technology adoption
- Gross and net impacts of utility programs
- Benefit/cost test results for utility programs
- Market results for equipment efficiency and measure saturation.

1.3 Key Features of the ASSET Framework

The program contains a set of proven algorithms for tracking equipment stocks through time and for computing energy impacts of technology adoption. Also, the program contains a complete benefit/cost accounting procedure that generates results for the standard tests of cost effectiveness. With the exception of this core accounting engine, all data, model equations, and model parameters are user inputs. Some of the key features of the modeling framework are shown in Figure 1-3 and are described below.

Figure 1-3: ASSET Model Features



- ***Adoption Modeling Framework.*** ASSET provides a generalized adoption modeling framework, rather than a specific adoption model. The framework allows use of a variety of modeling approaches, such as payback requirements curves, diffusion models, adoption process models, and probability share models. All parameters and equations in these models are user inputs.

- ***Competition Groups***. In the case of equipment efficiency, and for some devices, the list of options is mutually exclusive, implying that only one of the options can be selected and installed. In this case, these technologies are grouped by the user into a Competition Group, and technology shares are computed for members of each group as the simulation proceeds. In this way, there is no need to pre-allocate the market among the competing options.
- ***Program Participation Modeling.*** In addition to modeling technology adoption, the ASSET framework allows modeling of program participation. Technologies can be purchased through programs or outside of programs, depending on program awareness, program availability, costs of participation, and other factors.
- ***Multiple Program Modeling.*** For each technology and decision type, ASSET allows modeling of a single program or multiple programs. This allows modeling of program choice, as well as participation and technology adoption.
- ***Market Transformation Modeling.*** In addition to direct impacts of program incentives, ASSET has the capability to model market transformation effects through endogenous changes in technology awareness and technology availability.
- ***Incentive Formula.*** In ASSET, when programs are applied to an individual technology, incentives are established according to an incentive formula for that technology. This formula can specify rebates, loan amounts, and shared savings rules as a function of technology costs, energy savings, and other factors.
- ***On-The-Fly Screening***. For each technology covered by a utility program, ASSET allows application of cost-effectiveness tests or other screening criteria. A separate screening rule can be applied to each technology in selected test years.
- ***Stock Accounting***. At the core of ASSET is a set of well-tested stock accounting routines. These routines have their genesis in the end-use modeling area, and have been refined over the last two decades. Separate accounts are maintained for each segment, building vintage, and technology option, and all accounting is performed by equipment vintage.
- ***Benefit/Cost Accounting.*** Each adoption actions spawns a stream of costs and benefits over time. These streams are accumulated as the simulation proceeds, and at the conclusion of the run, long-run benefit/cost tests are performed from the perspective of a test year.
- ***Emissions Impact Accounting.*** In addition to accounting for energy impact of technology adoption, ASSET also tracks the corresponding emission impacts, including both point-of-use emissions and generation-level emissions.

1.4 Types of Decisions Modeled in ASSET

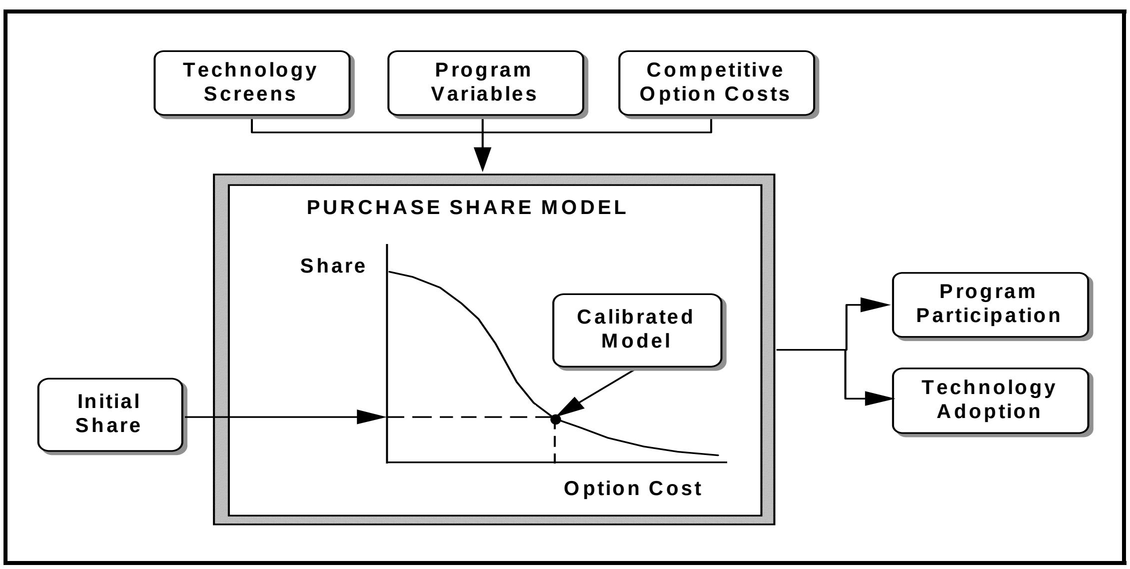
Technology adoption is modeled according to the type of decision. The decision types are broken into two broad categories.

- ***Event-Driven Decisions.*** The key factor defining event-driven decisions is that the size of the market is defined by a physical process, such as construction of a new home or physical decay of an existing piece of equipment. In these cases, purchase decisions will be made, and the number of purchase decisions can be computed outside of the technology adoption modeling framework. In ASSET, the two types of event-driven decisions are *new construction* (labeled NEW) and *replacement on burnout* (labeled ROB).

- ***Discretionary Decisions***. For these decisions, there is no physical process that gives the number of purchase decisions that will be made. In these cases, a large number of customers might be situated to enter the market, but they are not compelled to do so by a physical event. This situation applies to most retrofit actions, including prefailure equipment conversions, thermal shell retrofit decisions, and application of controls and other devices that alter equipment operation. In ASSET, the two types of discretionary decisions are equipment *conversion* (labeled CON) and device acquisition (labeled ACQ).

The modeling framework for a new construction model is depicted in Figure 1-4.

Figure 1-4: Depiction of New Construction Model

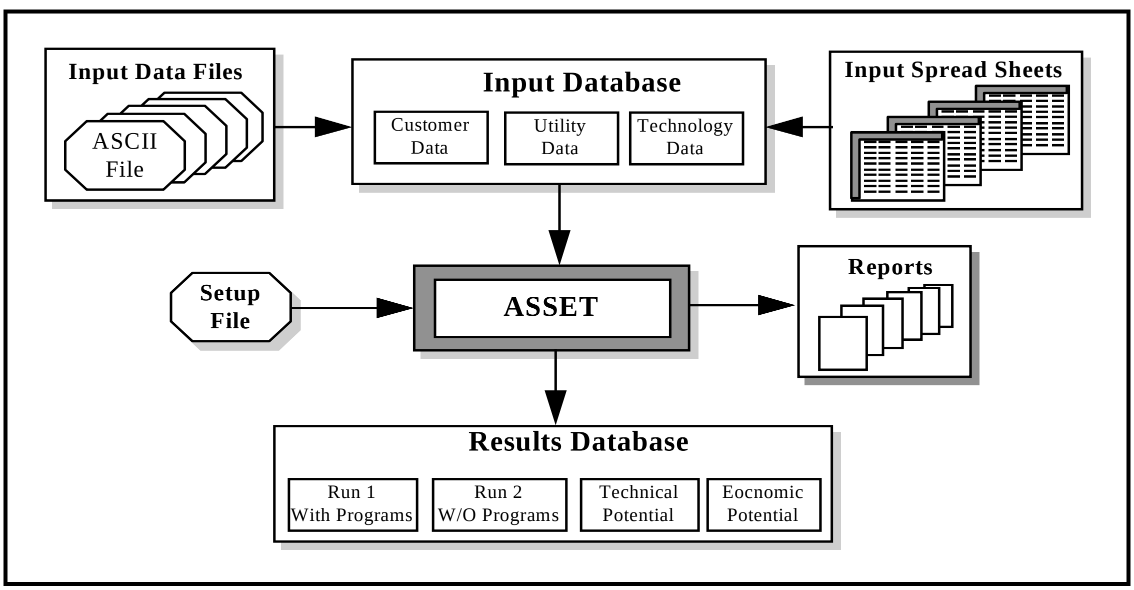


1.5 ASSET Program Structure

ASSET provides an interactive environment for viewing, editing, and saving input files and input databases. Once these items have been retrieved or created, the result is an ASSET database. As depicted in Figure 1-5, key elements are as follows:

- ***Input Spreadsheets.*** Most of the inputs to ASSET are maintained in Microsoft Excel spread sheets. These spreadsheets are combined into a Microsoft ACCESS database, which serves data to ASSET.
- ***Input Files.*** Some of the inputs to ASSET are maintained in external ASCII input files. These files are not rectangular in nature and, therefore, are not treated as databases. These input files can be edited within the program or they can be created and edited in a text editor.
- ***Input Database.*** ASSET inputs are combined and stored in an input database that contains a set of relational data tables. These tables are rectangular in appearance, and contain a number of records each of which has the same format.
- ***Batch Execution.*** Upon execution, a simulation is executed for all technologies and segments in the workspace or for a selected segment.
- ***Results Database***. When ASSET is executed, it creates a results database that contains tables with different types of results for each of the model runs. In addition, a series of pre defined reports is available, including CEC forms.

Figure 1-5: Depiction of ASSET Program Structure



ASSET is a Windows™ program. It is written in the latest and most advanced development environment based on Version 8 of the Microsoft C/C++ compiler and using the C++

language. The interface is developed using Visual C++ and the Microsoft Foundation Class Library. Some of the key programming features are as follows.

- ***Equation Processor.*** Most data inputs in ASSET can be entered as either numbers or expressions. Expressions can involve parameters, variables, and keywords combined using standard algebraic forms.
- ***Parametric Capabilities***. In addition to variables, ASSET provides an area for defining parameters. These parameters are defined separately at the "top" of the program and can be used throughout the detailed input files. This allows parametric simulations and scenarios to be executed without laborious editing of the input databases.
- ***Database Features.*** ASSET databases are retrieved and created in Microsoft ACCESS format using the Open Database Connectivity (ODBC) protocols. This protocol supports all of the common databases, which provides maximum flexibility and portability into the future.
- ***Interactive Review.*** ASSET combines a variety of data elements from the input database and supporting files to model technology adoption. Within the user interface, it is possible to view the individual inputs in tables and graphs and to see how these inputs are combined into modeling elements and adoption model results.

1.6 Relationship Between ASSET and End-Use Models

End-use models are used for forecasting energy consumption levels for all end uses and fuels. The focus in these models is fairly broad, involving customer growth, fuel choice, behavioral trends, and efficiency trends. ASSET focuses more narrowly on issues relating to equipment efficiency and measure saturation levels for a list of specific technologies. Whereas the end-use models focus on market size and energy sales, ASSET focuses on energy, cost, and emission impacts from technology adoption.

End-use models can provide market size data to ASSET, such as new construction levels, end-use shares in new construction, and overall end-use saturation levels and fuel shares. In return, the detailed technology adoption results with and without programs can be returned from ASSET to end-use models as an alternative to the more aggregate efficiency models embedded in the end-use framework.

1.7 User's Guide Organization

The remainder of this User's Guide is organized as follows.

- Section 2 provides installation instructions and an overview of program usage.
- Section 3 provides an overview of ASSET modeling concepts.
- Section 4 describes the Setup file and Modeling Data.
- Section 5 describes the Customer Data section of the input database.
- Section 6 describes the Utility Data section of the input database.
- Section 7 describes the Technology Data section of the input database.
- Section 8 describes the Technology Adoption Data section of the input database.
- Section 9 describes the Results Database and reports.
- Section 10 describes the Cost/Benefit Accounting algorithms.

2

Installation and Execution

2.1 Installing ASSET

In order to run ASSET in the recommended configuration, you must have the following software installed on your system:

- Microsoft Windows 3.1 or greater.
- Microsoft Excel 4 or 5.
- Microsoft ACCESS 2.0 or greater.
- Microsoft ODBC Desktop Drivers, Version 2.0 or greater.

To install ASSET:

1. Start Microsoft Windows™.
2. Insert the disk labeled ASSET Setup Disk 1 in your 3.5" drive.
3. From the File menu in Program Manager or File Manager, choose Run.
4. Type ***a:setup***.
5. Press the Enter key.
6. Follow the installation instructions on the screen.

2.2 Configuration

ASSET comes with sample input and output files. These files include:

1. ASCII input files with varying extensions.
2. Excel 5 spread sheets (.XLS files),
3. Microsoft ACCESS input databases (.MDB files), and
4. ASCII output files (.CSV files)

As part of the installation process, these files are installed under the ASSET directory. Assuming that you have selected C:\ASSET as the directory for installation, your system will be configured as shown below.

- ***Project Directory.*** For organizing and keeping track of separate projects, we find it useful to create a separate project directory for each effort. The project directory for the sample data is C:\ASSET\TESTPROJ\.

- ***Subdirectories by File Type.*** Because ASSET involves a number of input files and output files, it is useful to organize these files by file type. It is recommended that separate subdirectories be created for each of the following file types and with the following subdirectory names.

  \TESTPROJ\INPUTTXT\ -- contains ASCII input files.
  \INPUTXLS\ -- contains Microsoft Excel input spread sheets.
  \INPUTMDB\ -- contains Microsoft AXCESS input database file.
  \OUTPUTS\ -- contains ASCII output files and post processing files.

By using this configuration consistently, internal references to file names and directories are easy to maintain, and it is relatively simple to find a specific type of information. Further details on this configuration are as follows.

- ***C:\ASSET\\.*** This directory contains executable files (.EXE), supporting dynamic link libraries (.DLL), and other supporting files.

- ***C:\ASSET\TESTPROJ\\.*** This directory contains subdirectories for all of the project files, and also contains any ASSET Project Setup (.AST) files that are relevant to the project. The example file is titled SAMPLE.AST.

- ***C:\ASSET\TESTPROJ\INPUTTXT\\.*** This directory contains example input files. Extensions are as follows:

  -- *.TST files are ASCII files for program eligibility test variables.
  -- *.UTD files are ASCII files for utility data.
  -- *.MOD files are ASCII files for adoption models.
  -- *.DST files are ASCII files with data for distributions.
  -- *.RAT files are ASCII files for utility rate schedules.

- ***C:\ASSET\ TESTPROJ\INPUTMDB\\.*** This directory contains input databases in Microsoft ACCESS format (.MDB). The example database is titled SAMPLE.MDB.

- ***C:\ASSET\ TESTPROJ\INPUTXLS.*** This directory contains examples of Microsoft Excel spreadsheet files (.XLS) containing input data for ASSET. Typically, two types of spreadsheets are included in this directory:

  -- **Time Series Spreadsheets.** These spreadsheets contain data for time series variables that are linked into the program as exogenous variables. For the example files, a separate spread sheet file is used for segment drivers

(SEGDRIVE.XLS), price and cost drivers (PRICE.XLS) and other miscellaneous drivers (OTHER.XLS).

-- **Import Spreadsheet for Technology Data.** Because Excel has strong data entry features, data manipulation capabilities, and data documentation features, we find it most productive to maintain the three technology database tables in Excel. In the example data, these data tables are contained in TECHDATA.XLS.

- ***C:\ASSET\OUTPUTS.*** This directory contains examples of ASSET output files and postprocessing files. The output files themselves are in comma separated variable (.CSV) format. Postprocessing of these files results in output databases (.MDB) and spreadsheets (.XLS).

2.3 Executing ASSET

The Installation program installs the ASSET icon in a program group titled ASSET. You can move the ASSET icon to another group using standard Windows procedures.

To execute the program, click on the ASSET icon. This will bring up the ASSET main menu. To execute the example database, you must retrieve the ASSET project setup file (SAMPLE.AST), execute a model simulation, and review the results.

1. Use *File➔Open* to activate the ASSET project setup file, SAMPLE.AST.
2. Use the ASSET navigation buttons to examine input values, as desired.
3. Select the *Execute* button on the Main Menu.
4. Select specific segments or press the ALL button (an X appears by all selections).
4. Select the *Go* button on the Execute Menu.
5. Select the *Results* button to examine model results.

2.4 Navigation in ASSET

There are three ways to navigate in ASSET. The first involves the buttons on the main menu. By pressing any of these buttons, you will go to the part of the program that is indicated.

The second is the GoTo menu. From most areas of the program, you can press this button, or press Alt-G, and this will cause the GoTo drop down menu to be presented.

The third uses the buttons on the custom navigation bar. This bar appears at the top of all screens other than the Top Menu. The buttons are clustered in the same groupings as on the Top Menu. Two letter abbreviations are used, as follows:

Top -- Transfers control to the Top Menu.

EX -- Transfers control to Exogenous Variable screen.
PM -- Transfers control to Parameters screen.
TV -- Transfers control to program eligibility Test Variable screen.
DS -- Transfers control to the Distributions screen.

UP -- Transfers control to Usage Profiles screen
SD -- Transfers control to Segment Data screen.
AM -- Transfers control to Adoption Models screen.

UD -- Transfers control to Utility Data screen.
ER -- Transfers control to Energy Rates screen.
PD -- Transfers control to the Program Data screen.
IR -- Transfers control to the Incentive Rule screen.

TD -- Transfers control to the Technology Data screen.
ST -- Transfers control to the Segment/Technology data screen.
ED -- Transfers control to the Emissions Data screen.

AD -- Transfers control to the Adoption Data screen.
GO -- Transfers control to the Execution screen.
RR -- Transfers control to the Review Results screen.

2.5 Using the ASSET Project Setup File (.AST)

Project Setup Files are opened and saved using the *File* menu. Each Project Setup File contains a list of parameters and file names that define a modeling problem. The types of information in the Setup File are as follows:

- Time period definitions for the simulation.
- Switches for simulation options.
- Input database directory and name.
- Utility Data File directory and name.
- Output database directory and name.
- Output file options and file names.

To configure your own project within ASSET open a file and select *File→Edit*. This will bring up a dialog box containing the Project Setup information. Make desired changes and save using *File→Save* or *File→Save As*. Alternatively, you can edit the ASCII Setup File externally using a text editor. More information about the Project Setup File is contained in Section 4.

2.6 ASSET Input Files

The Setup program installs example input files in the \ASSET\TESTPROJ\ directory. ASSET has two direct input files that are identified in the Project Setup (.AST) file. These are:

-- Utility Data, which is an ASCII file with a .UTD extension.
-- Input Database, which is a Microsoft ACCESS file with a .MDB extension.

The Utility Data file is treated as a stand alone ASCII file because it contains a variety of inputs that are not repeated. As a result, it does not fit naturally into the database framework. All remaining inputs are contained in database tables or are contained in files that are referenced in the database tables. As presented on the ASSET Main Menu, the database tables are grouped into five input areas.

- ***Modeling Data and Parameters.*** These input tables include Exogenous Variables, Parameters, Test Variables for program eligibility, and Distributions. These tables are discussed in detail in Section 4. As shown in Figure 2-1:

  -- The Exogenous Variable table contains references to spreadsheet ranges,
  -- The Parameter table contains parameter values,
  -- The Test Variable table contains references to ASCII files, and
  -- The Distribution table contains references to ASCII files.

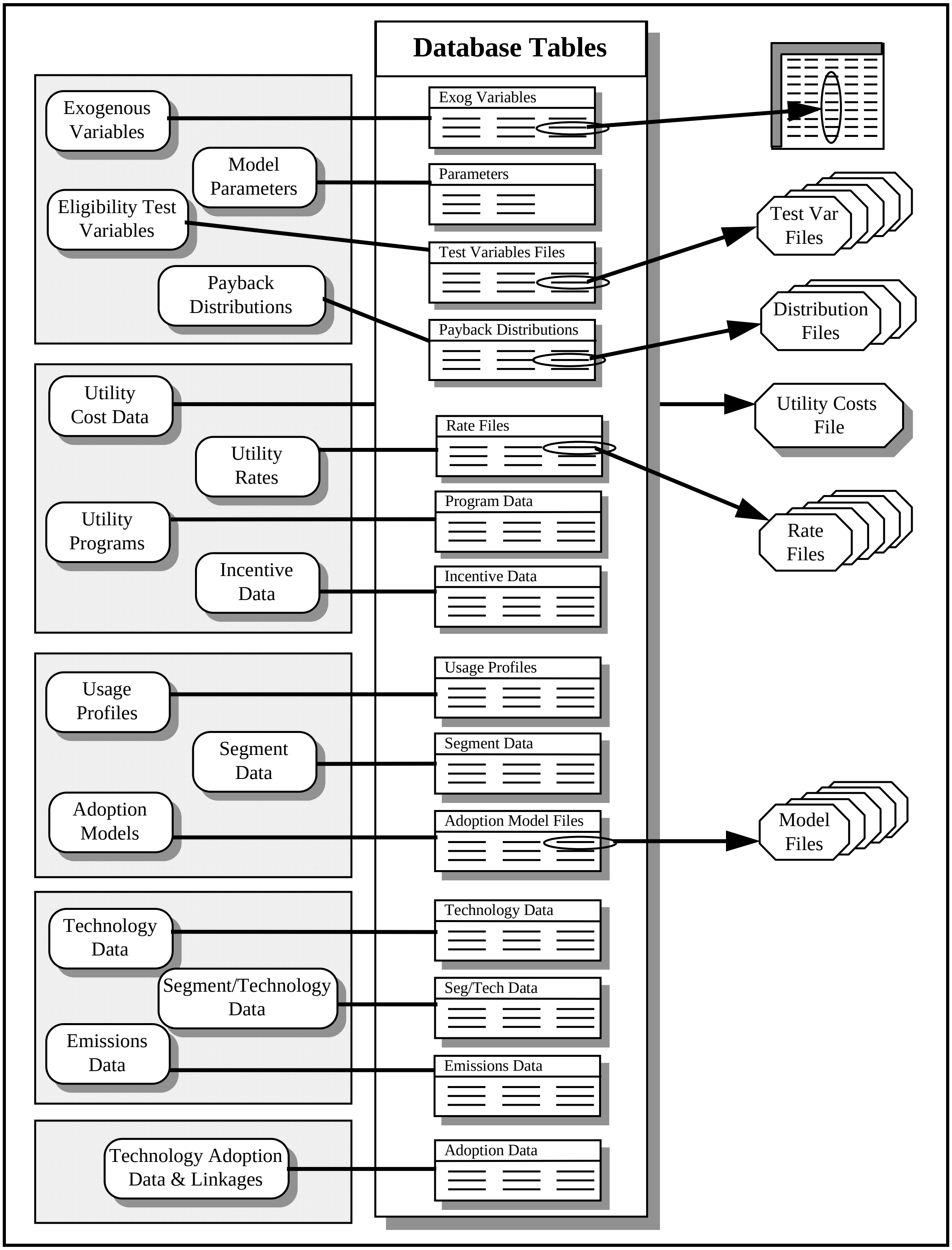
- ***Utility Data.*** Other than the Utility Data file, which is not included as a database table, this section contains three input tables, containing Energy Rates, Program Data, and Incentive Data. These tables are discussed in detail in Section 6. As shown in Figure 2-1:

  -- The Utility Data file is an external ASCII file,
  -- The Energy Rate table contains references to ASCII files,
  -- The Utility Program table contains data values, and
  -- The Incentive Data table contains data values.

- ***Customer Data.*** The Customer Data section contains three tables, the Usage Profiles table, the Segment Data table, and the Adoption Model table. These tables are discussed in detail in Section 5. As shown in Figure 2-1:

  -- The Usage Profile table contains data values,
  -- The Segment Data table contains data values, and
  -- The Adoption Models table contains references to ASCII files.

Figure 2-1: Depiction of ASSET Input Database



- ***Technology Data.*** The Technology Data section contains three tables, including the Technology Definitions table, the Segment/Technology Data table, and the Emissions Data table. These tables are discussed in detail in Section 7. As shown in Figure 2-1:

  -- The Technology Definitions table contains data values,
  -- The Segment/Technology Data table contains data values, and
  -- The Emissions Data table contains data values.

- ***Technology Adoption Data.*** The Technology Adoption Data table contains one record for each adoption action. As discussed in Section 8, the fields in this table include data values and expressions, as well as numerous linkages to data records in other tables.

2.7 Creating New Input Databases

ASSET input databases must contain 14 relational data tables with record definitions as indicated in Sections 4 through 8. The manual process of creating a new database from scratch is not recommended. The best way to start a new database is by making a copy of an existing database and editing the copy. With this approach, the structure of database tables and the associated data fields are defined appropriately.

To create a new database, identify an existing ASSET input database (.MDB) and make a copy under a new name. This can be done using File Manager or DOS copy commands. From this point, you can proceed to alter records, import data tables, or edit data fields in Microsoft Access. Also, you can alter records or edit data fields directly in the ASSET interface. More information is provided below about the best way to formulate a new problem.

2.8 ASSET Output Files

Upon execution, ASSET creates a set of output files, as controlled by the options that are set in the Program Setup file. Section 9 provides record definitions for each file. Generally speaking, these tables are designed to provide data for each model run at varying levels of detail, including the following:

-- By Technology,
-- By Segment/Technology,
-- By Segment/Technology/Decision Type,
-- By Segment/Product Class,
-- By Segment/End-Use, and

-- By Utility Program.

There are a total of 11 output files available, and each output file is written in comma separated variable (.CSV) format. These results are easily imported into Microsoft ACCESS. or Excel spreadsheets for post processing and report preparation.

2.9 Recommended Configuration and Approach to Data Entry

The configuration and approach discussed below has proven to be convenient and efficient. It involves the use of text editors, Excel, and Microsoft ACCESS as programs for creating and managing project files. The discussion appears in six parts.

ASCII Input Files -- create and manage in a text editor.
Time Series Spreadsheets -- create and manage in Excel.
Input Database -- create and manage in Microsoft Access.
Technology Data Spreadsheets -- create and manage in Excel.
Technology Data Spreadsheets -- Import into Input Database using Microsoft Access.
Postprocessing Outputs.

The recommended approach is not mandatory. Within the ASCII\EXCEL\ACCESS environment, there is a tremendous amount of flexibility, and individual users will settle on their own approach for managing model inputs. However, we believe that the approach outlined here is well balanced and makes maximum use of the strengths of the programs involved.

ASCII Input Files. The Utility Data file and all ASCII files that are linked into ASSET through references in data tables should be edited using a text editor (such as Dos Edit, Notepad, or Brief) . These files include the following:

- *.TST files, which contain equations for testing program eligibility.
- *.UTD file, which contains a variety of utility data and parameters.
- *.MOD files, which contain equations and parameters for adoption models.
- *.DST files, which contain distributions for payback requirements.
- *.RAT files, which contain data for energy rates.

To create a new file, either start from scratch, or open an existing file, edit the contents, and save under the new name. To include this new file in the model run, add a record to the input database table that identifies the directory and name of the file. This action links the file into the project, making it available for assignment to a modeling task.

You can also edit data and text in ASCII files directly in the ASSET interface. In the interface, you can view each file as though it were a record in a database. When you move to the next record, you will view the next file. When you make a change to a file, this change is saved to that file as soon as you move to a different record or move to another screen. That is, changes to these files are made directly by ASSET without any conscious action by the user, such as invoking *File➔Save* or *File➔Save As*. As a result, although you can edit existing files that have been linked into the project, you cannot create a new file under a new name by this method.

Time-Series Spreadsheets. It is recommended that time series data, such as segment data, program variables, and variables used to drive rates and costs over time, be placed in one or more Excel workbooks organized by topic. Once the data are entered, it is important to add a range name for each variable. In this way, the series can be linked into the model with reference to this range name.

Input Database. With the exception of the three technology tables, which are discussed below, it is recommended that the remaining input databases be maintained directly in Microsoft Access. If you want to keep the original file intact, remember to make a copy into the desired directory before you begin the file editing process. There is no *File➔Save As* operation in Access. This is a database program, and changes to any record are installed into the database as soon as you leave that record.

You can also edit data and text fields directly in the ASSET interface. When you make a change to a record, this change is installed in the input database as soon as you leave that record or move to another screen. Currently, it is not possible to insert or add records to the database within the ASSET interface. This must be done directly in Microsoft Access, or in the source files that are imported into the Microsoft Access database.

Technology Data Spreadsheet. As noted above, it is recommended that the three detailed data inputs be prepared and maintained in Microsoft Excel. These data tables include the following.

- -- Technology Definitions
- -- Segment/Technology Data
- -- Technology Adoption Data

By using Excel spreadsheets, these database tables can be edited and manipulated using the powerful editing capabilities and standardized interface of Excel. Also, side computations can be included outside of the database columns, or in the case of Excel 5, on separate worksheets. This provides internal documentation of input values that are computed from other data.

Each of these spreadsheets should be maintained in database format. In Excel, a spreadsheet is in database format if field names are entered in the top row of the sheet followed by adjacent rows with data. The field names must be identical to those used in the corresponding database table in Microsoft Access. Rules to remember are:

- -- Variable names are case insensitive.
- -- The order of the variable columns in Excel does not matter.
- -- Extra columns and blank columns can be included, as desired.

In an Excel spreadsheet in database format, each row beyond the first row is treated as a record. As will be discussed below, it is a simple matter to import the spread sheet tables into the Microsoft Access database that serves as the main input file for ASSET.

It is important to remember that ASSET does not directly read the Excel data files (with the exception of exogenous variable date). That is, the actual model inputs are contained in the Microsoft ACCESS database, referred to here as the Input Database. If Excel spreadsheets are used to maintain the technology data, then it is important to insure that any experimental changes made directly to the input database are also installed in the Excel files, if they are to be maintained as permanent changes. Otherwise, the next time the Excel files are imported into the database, any intermediate changes will be written over.

Importing Excel Data Into the Input Database. Once the input database has been edited and the technology data tables have been prepared in Excel spreadsheets, these tables can be quickly imported into the Input Database using Microsoft ACCESS. The manual process for importing a data table is as follows.

1. Execute Microsoft ACCESS.
2. *File*➔*Open* to open the Input Database (.MDB).
4. Open the table to be imported.
5. *Edit*➔*Select All* or press Alt-A.
6. *Edit*➔*Delete* or press Delete key.
7. Close the table.
8. *File*➔*Import.*
9. Select Excel 4 or Excel 5 format, as appropriate.
10. Select the directory and file name to be imported.
11. In the Import Dialog
    -- Check "First row contains field names."

- -- Select Append.
- -- For Excel 5, select the sheet name.
- -- Press OK

Because it would be tedious to import each table in the Input Database manually, macros in Microsoft ACCESS have been created to automate the process. The macro name is ImportAll, and it is part of the example Input Database. The contents of this macro can be examined by selecting the macro and pressing the Design button.

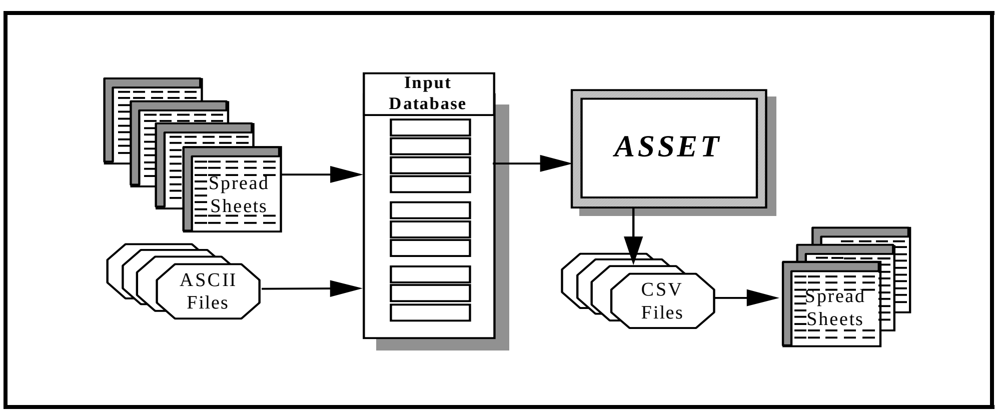
In the example database, the ImportAll macro imports database tables from the Excel 5 spreadsheet in C:\ASSET\TESTPROJ\INPUTMDB\SAMPLE.XLS. If this spreadsheet is located elsewhere in the installation process, these macros will need to be edited before they are executed.

As discussed above, if you keep your input data in Excel spreadsheets, it is important to understand that each time the import macros are executed, all data in the Input Database are replaced. As a result, any editing done in Microsoft ACCESS or in the ASSET interface will be lost. If the Excel approach is used, it is recommended that all changes be made directly to the input spreadsheets followed by execution of the import macro.

Post Processing of Output Files. Upon execution, ASSET creates 11 output files. As discussed in Section 9, each file contains specific model results at a specific level of aggregation. Post processing files can be established in Microsoft Access using import macros and database queries. Alternatively, post processing files can be established in Microsoft Excel. Sample post processing files are included in the directory C:\ASSET\TESTPROJ\OUTPUTS\.

A summary of the ASSET file configuration is provided in Figure 2-2.

Figure 2-2: Summary of ASSET Configuration



2.10 Modeling Summary And Checklist

The following tables provide a set of checklists for setting up projects and modeling problems of specific types.

- ***Creating a New Project.*** Table 2-1 provides a list of actions to take in setting up a new project. Following the recommended configuration, the actions are broken into six steps (1) setting up the new project, (2) creating ASCII files, (3) creating Excel files for time-series data, (4) modifying the Input Database, (5) modifying the Technology Data spreadsheet, and (6) importing the Technology Data spreadsheet into the Input Database. To create a new project execute each of these steps in the order indicated.

- ***Equipment Groups -- NEW and ROB Decisions.*** The normal method for dealing with equipment groups involves use of a competition group for new construction and an identical competition group for replacement decisions. Table 2-2 provides an overview of the steps and inputs to focus on for this type of modeling problem.

- ***Devices -- NEW and RET Decisions.*** The normal method for dealing with devices involves simple competition groups with a single device option in each group. Usually, each device has a retrofit adoption record , and in some cases, a new construction record is also be included. Table 2-3 provides an overview of the steps and inputs to focus on for this type of modeling problem.

- ***Equipment Systems -- NEW and CON Decisions.*** The normal method for dealing with equipment systems involves a competition group for new construction and a set of competition groups for conversions with appropriate base technologies in each conversion group. Table 2-4 provides an overview of the steps and inputs to focus on for this type of modeling problem.

- ***Load Management Measures.*** The normal method for dealing with load management measures or similar services is to label the product as a device with a one year life. Set up two competition groups, one for recruitment of new participants using a retrofit (RET) model and one for retention of existing participants using a replacement (ROB) model. Table 2-5 provides an overview of the steps and inputs to focus on for this type of modeling problem.

The checklists for the modeling problem focus on the data elements that are most important or that have a special interpretation for each problem. In these checklists, it is assumed that all background information is installed and ready for use, such as segment data, program definitions, and utility data.

Table 2-1: General Actions for Updating or Creating a Project

1. Initial Setup to Create a New Project
A. Create a Project Directory (e.g., C:\ASSET\NEWPROJ)
B. Create Project Subdirectories (e.g., C:\ASSET\INPUTXLS)
C. Copy a Project Setup File (.AST) into the Project Directory and edit.
D. Copy an existing Input Database (.MDB file) to the INPUTMDB subdirectory.

2. Create or Modify ASCII Files in INPUTTXT Subdirectory
A. Create or copy Distribution Files (.DST). Edit as needed.
B. Create or copy Eligibility Test Variable Files (.TST). Edit as needed.
C. Create or copy Rate Files (.RAT). Edit as needed.
D. Create or copy Adoption Model Files (.MOD). Edit as needed.
E. Create or copy Utility Cost File (.UTD). Edit if necessary.

3. In Excel, Create or Modify Spreadsheets in INPUTXLS Subdirectory
A. Add segment forecast data to Excel sheet and name range.
B. Add price and cost drivers to Excel sheet and name range.
C. Add other exogenous variables to Excel sheet and name range.

4. In Microsoft Access, Modify Input Database in INPUTMDB Directory
A. Add records to Exogenous Variable Table to include data from Step 3.
B. Add records to Distribution Table to include files created in Step 2.A.
C. Add records to Test Variable Table to include files created in Step 2.B.
D. Add records to Usage Profiles Table, as needed, and enter data values.
E. Add records to Segment Data as needed, and link to forecast data from Step 3.A.
F. Add records to Adoption Model Table to include files created in Step 2.D.
G. Add records to Rate Table to include files created in Step 2.C.
H. Add records to Utility Program Table, as needed, and enter data values.
I. Add records to Incentive Table, as needed, and enter data values.
J. Add records to Emissions Data Table, as needed, and enter data values.

5. In Excel, Modify Technology Data Spreadsheets in .XLS Directory.
A. For each technology, create a row in the Technology Definitions sheet.
B. For each segment/technology, create a row in the Segment/Technology sheet.
C. For each competition group:
   1. Create adjacent rows in the Technology Adoption sheet.
   2. Enter data values and references to each data row.

6. In Microsoft Access, Execute Import Macro
A. Open Input Database (.MDB) from Step 4.
B. Modify Import Macro to import Excel tables from Step 5.
C. Execute Import Macros.
D. Examine any error messages and repeat necessary steps.

Table 2-2: Input Checklist for Equipment Groups -- NEW and ROB

The normal method for dealing with equipment groups involves a competition group for new construction and a replacement competition group. The following assumes that data for the segment, utility rates, and programs exist and do not require modification.

Decision Model (.MOD) Files -- Step 2.D

Create or modify MULS model for NEW (new construction) actions.
Create or modify MULS model for ROB (replacement) groups.

Usage Profiles in Input.MDB -- Step 4.D

If the Usage Profiles table does not contain profiles that apply to the new seg/tech combinations, add new records. Using Type 1 profiles, enter energy intensities in annual KWh and KBtu. Energy multipliers should sum to 1.0 for each profile.

Incentives & Program Costs Table in Input.MDB-- Step 4.I

If the Incentive Table does not contain information appropriate for the options in the group, add a record for each incentive rule that is required. Code the incentive level and variable program costs to depend on KW, KWh, or incremental cost.

Technology Definitions in Import.XLS -- Step 5.A.

Add Technology records of type E (Equipment) for all options in the group.
Set the automatic replacement fractions to:
- -- 0 if there is an ROB model.
- -- 1 if there is no ROB model.

Assign a legal availability variable to any option eliminated by standards.
Assign a market availability variable to any emerging technologies in the group.
Assign a substitute technology if base option becomes unavailable.

Segment/Technology Data in Import.XLS -- Step 5.B.

Add Segment/Technology records for each relevant combination.
- -- Enter base shares. (Sum ≤ 1 or 100%)
- -- Enter existing and new intensities to kWh levels (per home, per ksf, etc.)
- -- Enter the density in technology units per segment unit (e.g. fixtures per ksf)

Technology Adoption Records in Import.XLS -- Step 5.A.

Add Technology adoption records for each option in NEW group and ROB group.
Enter applicability fraction for the group on base technology record.
Set control shares for NEW actions as a fraction of the applicable market.
Set control shares for ROB actions (retention) to the fraction of replacements.
Enter expressions for technology screens (feasibility, awareness, willingness).
Assign appropriate program, incentive rule, eligibility test, and model.
Enter model parameters for each technology.

Table 2-3: Input Checklist for Devices -- NEW and RET

The normal method for dealing with devices involves simple competition groups with a single device option in each group. Usually, each device has a retrofit adoption record , and in some cases, a new construction record is also be included. The following assumes that data for the segment, utility rates, and programs exist and do not require modification.

Decision Model (.MOD) Files -- Step 2.D

Create or modify BPEN model for NEW (new construction) actions.
Create or modify BRET model for RET (retrofit) groups.

Usage Profiles in Input.MDB -- Step 4.D

If the Usage Profiles table does not contain profiles that apply to the new segment/device combinations, add new records. Usually energy intensities will be entered in KWh and KBtu, implying energy-based (Type = 1) profiles. If so, make sure that energy multipliers sum to 1.0 or 100% for each profile.

Incentives & Program Costs Table in Input.MDB-- Step 4.I

If the Incentive Table does not contain information appropriate for the devices, add a record for each incentive rule that is required. Code the incentive level and variable program costs to depend on KW, KWh, or incremental cost.

Technology Definitions in Import.XLS -- Step 5.A.

Add Technology records of type D (Device) for each device to be covered.
Enter an automatic replacement fractions ($0 \leq$ Fraction ≤ 1.0).
Assign a market availability variable to any emerging device.

Segment/Technology Data in Import.XLS -- Step 5.B.

Add a Segment/Technology record for each device.
-- Enter base shares as fractions of total segment size.
-- Enter existing and new intensities as -kWh impacts (per home, per ksf, etc.)

Technology Adoption Records in Import.XLS -- Step 5.A.

Add Technology Adoption records for each device in NEW and RET groups.
Enter applicability fraction for the device on each record.
Set control shares for NEW and RET actions as a fraction of the applicable market.
Enter expressions for technology screens (feasibility, awareness, willingness).
Assign appropriate program, incentive rule, eligibility test, and model.
Enter model parameters for each technology.

Table 2-4: Input Checklist for Equipment Systems -- NEW and CON

The normal method for dealing with equipment systems involves a competition group for new construction and a set of competition groups for conversions with appropriate base technologies in each conversion group. The following assumes that data for the segment, utility rates, and programs exist and do not require modification.

Decision Model (.MOD) Files -- Step 2.D

Create or modify MULS model for NEW (new construction) actions.
Create or modify MCON model for CON (conversion) groups.

Usage Profiles in Input.MDB -- Step 4.D

If the Usage Profiles table does not contain profiles that apply to the new segment/technology combinations, add new records.

Incentives & Program Costs Table in Input.MDB-- Step 4.I

If the Incentive Table does not contain information appropriate for the technologies in the group, add a record for each incentive rule that is required.

Technology Definitions in Import.XLS -- Step 5.A.

Add Technology records of type E (Equipment) for all options in the group.
Set the automatic replacement fractions to 1 or include replacement (ROB) group.
Assign a legal availability variable to any option eliminated by standards.
Assign a market availability variable to any emerging technologies in the group.
Assign a substitute technology if base option becomes unavailable.

Segment/Technology Data in Import.XLS -- Step 5.B.

Add Segment/Technology records for each relevant combination.

- -- Enter base shares. (Sum ≤ 1 or 100%)
- -- Enter existing and new intensities to kWh levels (per home, per ksf, etc.)
- -- Enter the density in technology units per segment unit (e.g. fixtures per ksf)

Technology Adoption Records in Import.XLS -- Step 5.A.

Add Technology adoption records for each option in NEW group and CON group.
Enter applicability fraction for the NEW group on base technology record.
Set applicability fraction to 1.0 for the CON group on base technology record.
Set control shares for NEW actions as a fraction of the applicable market.
Set control shares for CON actions to the fraction switching from the base option.
Enter expressions for technology screens (feasibility, awareness, willingness).
Assign appropriate program, incentive rule, eligibility test, and model.
Enter model parameters for each technology.

Table 2-5: Input Summary for Load Management Measures

The normal method for dealing with load management measures or similar services is to label the product as a device with a one year life. Set up two competition groups, one for recruitment of new participants using a retrofit (RET) model and one for retention of existing participants using a replacement (ROB) model. The following assumes that data for the segments, programs exist and do not require modification.

Utility Rates (.RAT) File -- Step 2.C

To use rates to compute bill savings create a rate file that either

(a) Sets the fixed charge to give the average monthly bill credit or

(b) Sets the energy and demand amounts to give monthly bill savings.

Otherwise use the incentive rule, below, to capture bill reductions.

Decision Model (.MOD) Files -- Step 2.D

Create BRET model for RET actions (recruitment) from nonparticipant population.

Create BPEN model for ROB actions (retention) for existing participants.

Usage Profiles -- Step 4.D

Set the profile type to be load based (Type=2).

Set the energy multipliers to an "hours" value so that -KW × HOURS = Energy.

Set the peak demand multipliers and system peak multipliers to apply to -KW.

Incentives & Program Costs -- Step 4.I

Define two incentive rules, one for RET actions and one for ROB actions

To use the incentive rule to capture bill reductions:

Set the incentives to give the annual bill savings and

Set utility rates to zero to avoid double counting savings

Program costs for recruitment rule equal to the cost of LM hardware.

Program costs for retention rule equal to ongoing annual maintenance cost, if any.

Technology Definitions -- Step 5.A

Set the technology type to D for Device

Set the minimum life to 0, the maximum life to 1, and the autorep fraction to 0.

Segment/Technology Data -- Step 5.B

Set the base share to the fraction of the segment that participates in the base year.

Set the existing and new intensity fields to a negative KW value.

Set the density to the inverse of the typical customer size.

Technology Adoption Records -- Step 5.C

Enter applicability fraction to end-use share for RET, 1.0 for ROB.

Set control shares to recruitment fraction for RET, retention fraction for ROB.

Assign appropriate program, incentive rule, eligibility rule, and model.

3

Methods and Concepts

The purpose of this section is to describe the framework used for estimating technology adoption levels and program impacts. The framework has the following key features and capabilities.

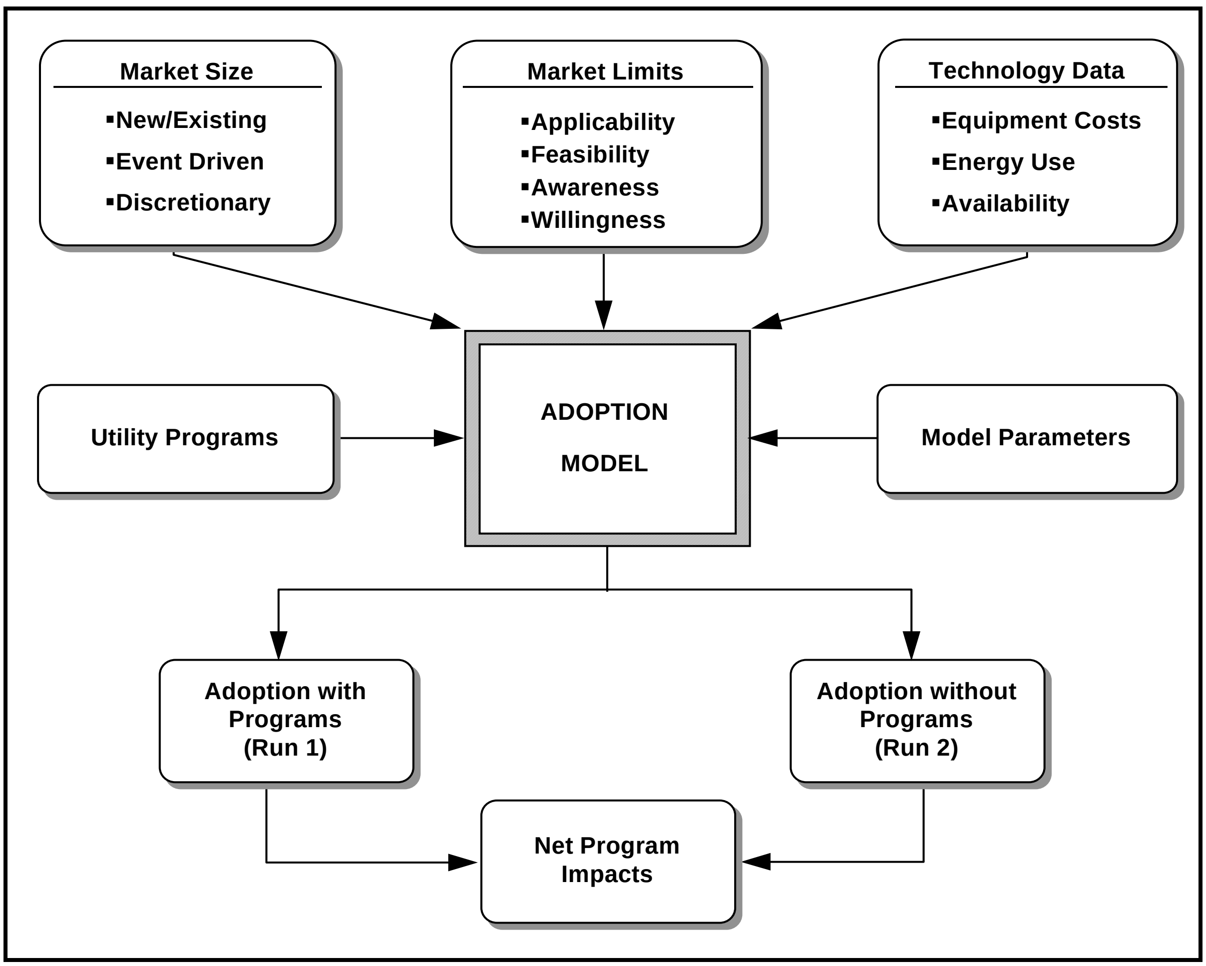
- ***Segmentation.*** Customer segmentation provides the foundation for modeling technology decisions based on customer characteristics and attitudes.
- ***Stock Accounting.*** Equipment inventory data provide a starting point for defining market size and the applicability of technology options. Stock accounting algorithms are used to track equipment inventory levels through time.
- ***Adoption Barriers.*** Physical barriers to adoption (technology applicability and feasibility), and market barriers to adoption (customer awareness, customer willingness, and supply-side availability) are modeled to impose realistic limits on market potential estimates.
- ***Adoption Models.*** A variety of adoption models are available to estimate market adoption rates based on technology and customer characteristics. Specific modeling frameworks are provided for four different types of decisions: new construction, replacement at time of burnout, equipment conversions, and retrofit actions.
- ***Net Program Impacts.*** Two adoption model runs are executed, one with programs and incentives and one without. The results are compared to derive net program impacts.
- ***Technical and Economic Potential.*** In addition to the two adoption model runs, technical potential and economic potential runs can be executed to develop estimates of impacts in absence of market barriers to adoption.

The framework is based on a series of database tables and input files that describe customer characteristics, technology trends, program characteristics, and adoption behavior. These databases are described in detail in Sections 4 through 10. The remainder of this section provides an overview of the ASSET model structure, data requirements, and impact accounting conventions that are used.

3.1 Adoption Modeling Framework

The structure of the adoption modeling framework is depicted in Figure 3-1. As indicated, adoption rates depend on a variety of input data and parameters, including data about market size, market screens and other limiting factors, and technology cost and efficiency data. Given these factors, market impact estimates are developed using adoption criteria for estimating technical and economic potential, and using models of adoption behavior for estimating adoption rates with and without utility programs and incentives. The role of each type of data in the adoption modeling process is discussed below.

Figure 3-1: Adoption Model Framework



3.2 Market Size and Decision Types

Market size is a measure of the size of the customer base available for technology adoption in a particular analysis year. Market size is measured in units of homes, floor area, production capacity, or mWh, depending on the application. The appropriate measure of market size depends on the technology being applied and on the decision state being modeled. Conceptually, it is useful to split decisions into those that are event-driven versus those that are discretionary.

Event-Driven Decisions. The key factor defining event-driven decisions is that the size of the market is defined by a physical process, such as construction of a new home or physical decay of an existing piece of equipment. In these cases, purchase decisions must be made, and the number of purchase decisions can be computed from external assumptions or internal stock accounting algorithms.

- For new construction decisions, market size is limited by the amount of new construction or new manufacturing capacity. End-use saturations, fuel shares, and product class shares in new construction further limit the size of the applicable market for competing efficiency options.

- For replacement decisions, the size of the market is determined at the competition-group level. The amount of replacement activity is computed using vintage-based stock accounting algorithms applied to all technology options in the group.

In the case of replacement, there is usually a significant amount of inertia, and equipment is most often replaced with a similar technology. Conversions across fuel types or between technology classes is rare at the time of replacement. On the other hand, in new construction decisions, the full spectrum of product classes and efficiency options is available. In either case, however, an equipment purchase is dictated by an event -- construction or renovation of a facility or physical decay of equipment.

In event-driven decisions, ASSET allows modeling of the shares of competing equipment efficiency options given the predetermined or internally calculated estimates of market size for the competition group as a whole.

Discretionary Decisions. For these decisions, there is not a physical process that gives the number of purchase decisions that will be made. In any year, a large number of customers might be situated to enter the market, but they are not compelled to do so by a physical event. This situation applies to most retrofit actions, including prefailure equipment conversions, thermal shell retrofit decisions, and acquisition of controls and other devices.

Because the timing of these actions is not event driven, this adds an additional dimension to the modeling problem. It is necessary to model the fraction of the market that is taking a retrofit action in any year, as well as the degree of action or the efficiency of purchased equipment. Further, it is necessary to impose limits so that retrofit activity does not eventually lead to a 100% or greater saturation of efficient equipment.

In any case, market size for discretionary decisions is defined by the fraction of the market that has the equipment or physical configuration that makes the retrofit action applicable. For example, market size for 4-foot fluorescent lighting upgrades is defined by the number of 4-foot fixtures with inefficient lamp/ballast combinations. Similarly, the market size for application of an ASD is defined by the number of motors in a certain size and usage category that have duty cycles for which an ASD would be beneficial.

3.3 Market Screens and Adoption Limits

The ASSET framework includes a set of market screens that are used to limit the application of DSM technologies to reasonable levels. These market screens fall into five groups: applicability, feasibility, awareness, willingness, and availability. Each of these groups is discussed below.

Applicable Market. Applicability limits reduce the market to those situations where a qualifying end use or technology is present. The applicable market is computed by multiplying total market size by the applicability fraction for a competition group.

Feasible Market. The feasible market is further limited by physical and practical barriers to technology adoption, such as technology size, noise or vibration limitations, room for additional insulation, and lighting-level requirements. The feasible market is computed by multiplying the feasibility fraction by the applicable market size.

Aware Market. Technology awareness applies primarily to new technologies or to technologies that have a small market share. Customers are in the aware market when they have been exposed to a technology option and have formed an opinion about the operating characteristics of that option. Technology awareness levels can be altered through information programs, and increased awareness can lead to increased adoption rates. The aware market is computed by multiplying the awareness fraction by the feasible market size.

Willing Market. This term gives the fraction of the aware market that accepts the technology as being valid and useful, without major non-cost barriers. The types of factors that limit willingness to adopt include concerns about safety, reliability, and aesthetics. These types of concerns typically outweigh economic considerations, and therefore act as non-cost barriers to adoption. The willing market is defined by multiplying the aware market by the willingness fraction.

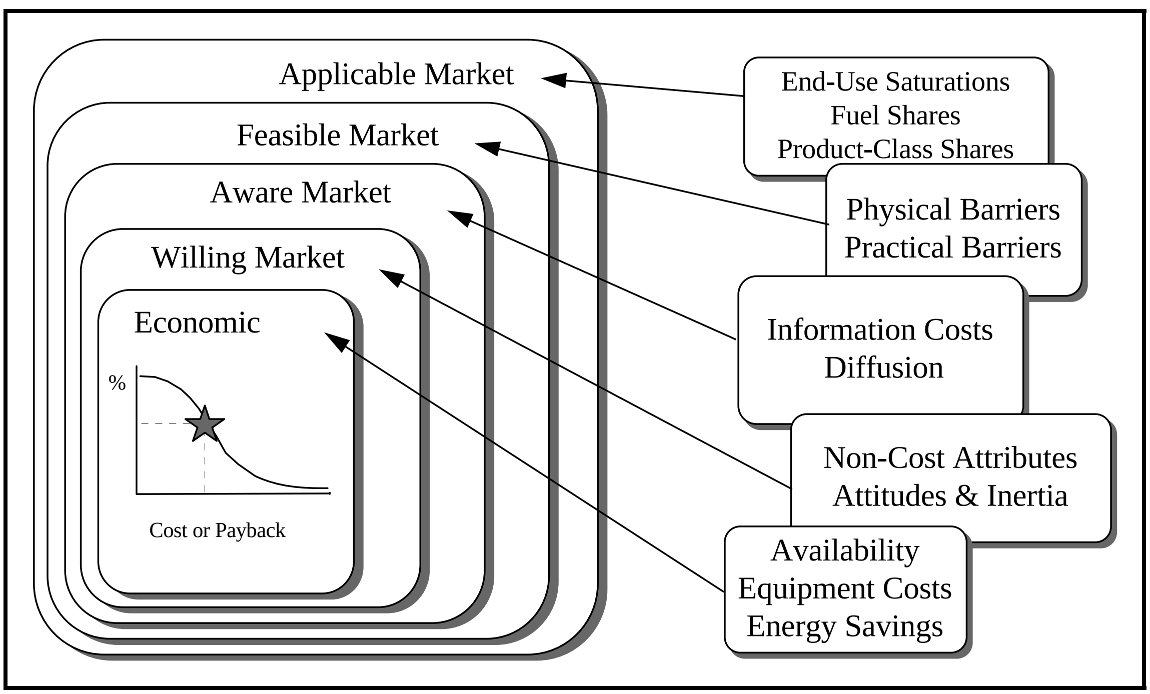
Technology Availability. Technology availability covers two types of issues.

- ***Market Availability*** captures supply-side limitations of technology markets. Availability limitations are especially important for new technologies which have not reached full-scale production. From a modeling perspective, an extreme example is a future efficiency option that is assumed to become available during the forecast period but that is not currently on the market.
- ***Legal Availability*** captures limitations imposed by efficiency standards. These standards eliminate the low end of the efficiency spectrum, effectively removing low-end design options from the market.

In either case, technology availability limits the market share, and this limitation is factored into the computation of market share when decision models are applied.

The screening process is depicted in Figure 3-2. Beyond the application of the series of market screens, technology adoption rates are computed using adoption models. These models give market shares or adoption rates within the willing market subject to technology availability. The adoption rates are based on equipment costs, operating costs, and other factors included in the adoption models.

Figure 3-2: Role of Market Screens



3.4 Technology Data

Models of technology adoption and market potential can be developed for a broad range of conservation measures, load management actions, and load building technologies. In the modeling process, these measures fall into four broad categories.

- ***Equipment****.* This category refers to appliances and major types of equipment, such as chillers, motors, refrigerators, and lighting systems. Decisions about equipment type and efficiency level are made when new equipment is purchased, when existing equipment is replaced, or when existing systems are converted to new systems. Equipment efficiency standards limit the range of efficiency options that are available at the time of purchase. DSM programs target the high end of the remaining part of the efficiency spectrum, thereby altering the efficiency level of purchased equipment.

- ***Devices and Controls****.* This category covers controls, equipment features, and add-on devices that alter the level or pattern of usage. Examples are time clocks, energy management systems, adjustable speed drives, occupancy sensors, and water heater blankets. These types of items alter the timing or usage level of equipment, but do not alter the efficiency of the equipment itself. DSM programs often provide direct incentives for installation of devices and controls.

- ***Thermal Efficiency****.* This category covers levels of ceiling, wall, and foundation insulation, as well as window efficiency and infiltration levels. Thermal efficiency is of primary importance for estimation of heating loads, although cooling loads and fan energy are also impacted. Thermal efficiency levels in new construction are prescribed by state standards, and utility DSM programs provide incentives for builders to take actions beyond the requirements of standards.

- ***Load Management Measures.*** Load management measures include load management rates and equipment cycling strategies. These actions may or may not involve installation of control devices. DSM programs provide direct incentives in the form of bill credits or incentive rates that make adoption of load management strategies attractive to customers.

Competition Groups. For modeling purposes, it is important to group mutually-exclusive options into competition groups. This will be the case for most equipment efficiency options. For example, if there are low, medium, and high-efficiency chillers, only one of these options can be selected in a new construction or replacement decision. As a result, these options should be placed in a single competition group. Given these groups, adoption models compute a share of the group total for each option.

In contrast, most add-on devices can be treated on a stand-alone basis. For example, ASD's can be treated as a single option. In this case, rather than modeling shares of purchases, the adoption rate gives the penetration in new construction or the acquisition rate in existing applications.

Technology Costs and Other Data. Several types of technology data are required to execute technology adoption models and to estimate potentials. For technical and economic potential, the key inputs are technology costs, energy requirements, and technology life times. For achievable and market potential, additional information about decision-maker behavior is required.

Regarding technology costs, a variety of cost figures can be developed from data about competing equipment options and about energy-saving measures and devices. The appropriate figure of merit for modeling purposes will depend on the type of action being modeled.

- In event-driven decisions, such as new construction or replacement on burnout, it is natural to model these decisions on the basis of life-cycle cost or on the basis of levelized costs for the competing options.

- For discretionary decisions, the incentive to take an action is based on the expected savings that would accrue over time. In this case, models based on payback or return on investment are appealing.

Details about alternative cost variables are provided in Section 3.10.

3.5 Utility Programs and Cost Effectiveness Screening

In the ASSET framework, each technology option can be assigned up to two programs, along with incentive formulas and screening variables used to establish eligibility of the technology under the program. If a technology passes the eligibility test, it will be included in the program with the designated incentive. For example, rebates for lighting system conversions are normally covered under a C&I lighting program. If this program is active, then incentives would be available to conversion actions that satisfy the eligibility screening rule. Modeling concepts used in this process are described below.

Program Periods. For purposes of cost-effectiveness screening, the user defines a set of program periods. The number of periods is not constrained, allowing use of year-by-year testing. Typically, the expected planning cycle is used to define these periods.

Variables for Cost Effectiveness Screening. The program constructs a set of cost and benefit variables for each technology based on data provided in the input tables. Variables include technology-level resource costs, the incremental value of avoided energy costs, the levelized value of resource costs, and the first-year incremental avoided costs. These variables are available for construction of cost-effectiveness screening rules.

Program Eligibility Test Variables. Program eligibility is determined by eligibility test variables. For each technology adoption action and program, the test variable provides a screening rule that is evaluated at the beginning of each program period. The screening rules can have fixed values (1.0 implies that a technology passes the screen and 0.0 implies that it fails) or they can have expressions based on the cost and benefit variables constructed from technology and avoided cost data. If the rules are defined based on costs and benefits, they can be used to implement on-the-fly cost effectiveness screening.

The screening rules are evaluated in the first year of each program period. In the specification of the screening rules, a separate column is provided for each of the two adoption model runs. The only differences between the first and second runs are those implied by the differences in the eligibility screening rules and any differences coded by the user into expressions used in the model.

An example of the specification for a screening rule follows in Table 3-1. In the column for Run 1, this screening rule implies that a technology is included in the first program period (93-95), but is subject to screening in subsequent program periods based on the technology benefit/cost ratio. In the second run, the technology is excluded from programs beyond the first program period.

Table 3-1: Example of Program Eligibility Variable

	Period Begins	Period Ends	Run 1 Eligibility Formula	Run 2 Eligibility Formula
1	1993	1995	1.0	1.0
2	1996	1998	BCRatio > 1.0	0.0
3	1999	2001	BCRatio > 1.0	0.0
4	2002	2014	BCRatio > 1.0	0.0

Screening Logic. Screening rules are assigned at the most detailed level (technology adoption by segment, technology, and decision type). Within a segment, the screening test is applied to each individual combination of technology, program, and eligibility variable. If an equipment option is assigned the same program and eligibility variable for new construction and conversion decisions, then the screening test will be evaluated jointly for these decisions. If more than one competition group has the same technology covered by the same program and eligibility variable, then the screening test will be evaluated once for these decisions.

3.6 Adoption Models by Decision State

To understand the following discussions, it is important to understand the relationship among modeling concepts and stock accounting activities. The term saturation is used to define the fraction of the customer base that has a specific type of equipment or device. Base-year shares give the initial saturation levels, and saturation levels change gradually over time as equipment decays and as adoption decisions are made.

In contrast, adoption rates and penetration rates refer to flows rather than stocks. These flows are related to the amount of new construction, the level of equipment decay, and the level of conversion and acquisition activity. Reflecting these four types of flow decisions, four types of modeling frameworks are provided, and adoption rates have a different meaning for each decision state.

- ***New Construction (NEW).*** For new construction decisions, adoption models give the fraction of new construction that adopts an option. The adoption rate is the same as the market penetration in new construction. Average saturation levels in the overall stock change as the new units are included in the overall totals.

- ***Replacement On Burnout (ROB).*** For replacement decisions, the total decay of all options in a competition group defines market size. In this case, the adoption models give the share of total group replacements for an option. Average saturation levels are impacted if the shares in replacement differ from the shares of total decay in the group.

- ***Equipment Conversion (CON).*** For equipment conversion decisions, existing saturation levels define the size of the conversion market. In this case, the adoption models give the fraction of customers with a specific type of equipment who convert to an alternative option. Saturation levels change because the stock of the base option declines and the stock of the target option increases.

- ***Device Acquisition (ACQ).*** For acquisition decisions, saturation levels are modeled relative to the fraction of customers who qualify for the specific device. In this sense, saturation levels define the fraction of the applicable market that already has a measure installed. The adoption rate is an acquisition rate, giving the fraction of the applicable market that installs a device. Device saturation levels change as a direct result of device acquisition.

These distinctions are related to the distinction between event-driven and discretionary decisions. In particular, new construction and ROB decisions are treated with event-driven models, and equipment conversion and device acquisition actions are treated with models that account for the discretionary nature of the decisions. Differences in terminology across the four types of models are outlined in the Table 3-2.

In what follows, each of the modeling frameworks is described in more detail.

Table 3-2: Modeling Concepts by Decision State

Decision State	New Construction	Replacement On Burnout	Equipment Conversion	Device Acquisition
Market Size	New units (homes, square footage, or capacity)	Amount of equipment decaying in the competition group less auto replacement.	Total amount of base-option equipment in the competition group.	Existing units (homes, square footage, or capacity)
Applicable Market	Fraction of new units with the qualifying equipment or configuration	Fraction of decaying units that are replaced (usually 1.0)	Max cumulative conversion from the base option to other options in the comp group (usually 1.0).	Fraction of existing units with the qualifying equipment or configuration.
Screens	Feasible, Aware Willing, Available for an Option	Feasible, Aware Willing, Available for an Option	Feasible, Aware Willing, Available for an Option	Feasible, Aware Willing, Available for an Option
Adoption Rate	Fraction of applicable units in which an option is installed.	Fraction of applicable decaying units in a competition group that are replaced with an option	Fraction of base option equipment that is converted to an alternative option.	Fraction of the applicable market that adds a device.

.1 New Construction Model (NEW)

The new construction model is depicted in Figure 3-3. As indicated in the figure, market size is defined by the number of new units in each year. The applicability fraction gives the fraction of the new market that qualifies for an equipment group or a device. For example:

- The fraction of new construction that has systems with chillers would be used to define the applicable market for modeling chiller efficiency or other measures related to chillers in new construction.

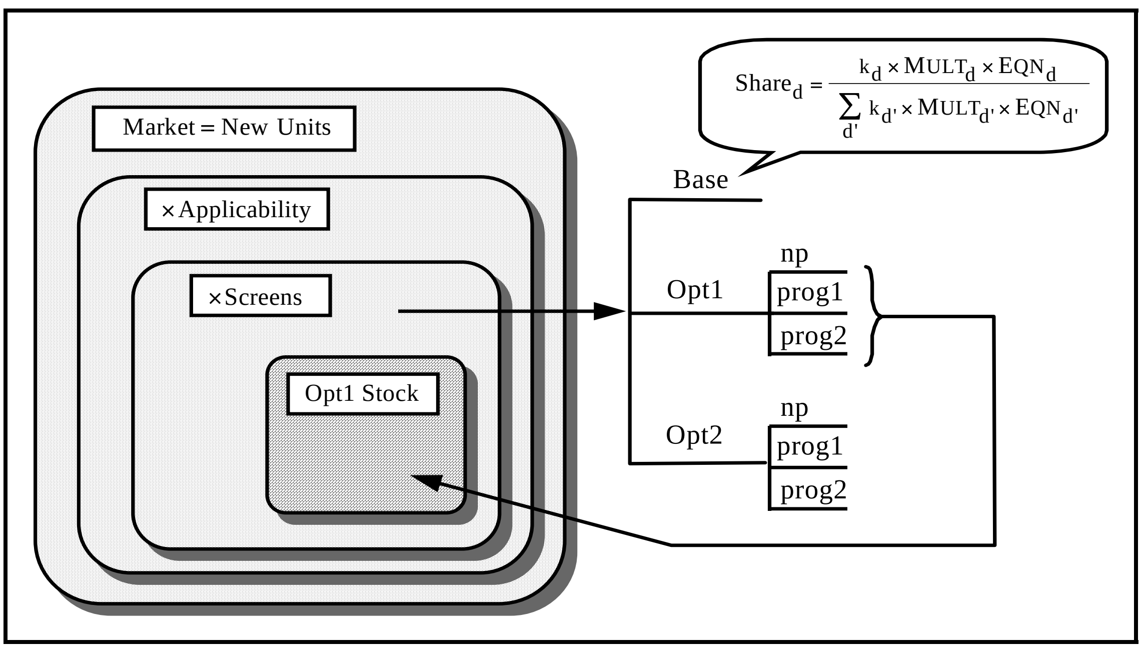
- Similarly, the fraction of the market with four-foot fluorescent systems would be used to define the applicable market for modeling four-foot system efficiency or for modeling the adoption rate for controls and devices that go with four-foot systems.

- Finally, the fraction of new homes with central air conditioning systems would define the applicable market for central air conditioner efficiency decisions.

Once the applicable market is defined, the remaining screens apply to the individual technology options. These screens are feasibility, technology awareness, willingness, and technology availability. The screens for an option are used to segment the market into a screened segment, where the option is not in the choice set, and an unscreened segment, where the option is in the choice set.

Finally the shares for all options are computed based on the economic and other features. Binomial logit models can be used for two-option groups or for device adoption equations, and either multinomial or nested logits are used for larger competition groups. As depicted in the figure, program participation can be modeled, as well as market shares. At the participation level, np stands for nonparticipant purchases of an option, prog1 for purchases through the first program that applies to the option, and prog2 for the second program. If there are no programs defined for the option, or if the option does not satisfy the screening test for program eligibility, then only the np branch is relevant.

Figure 3-3: Depiction of New Construction Model



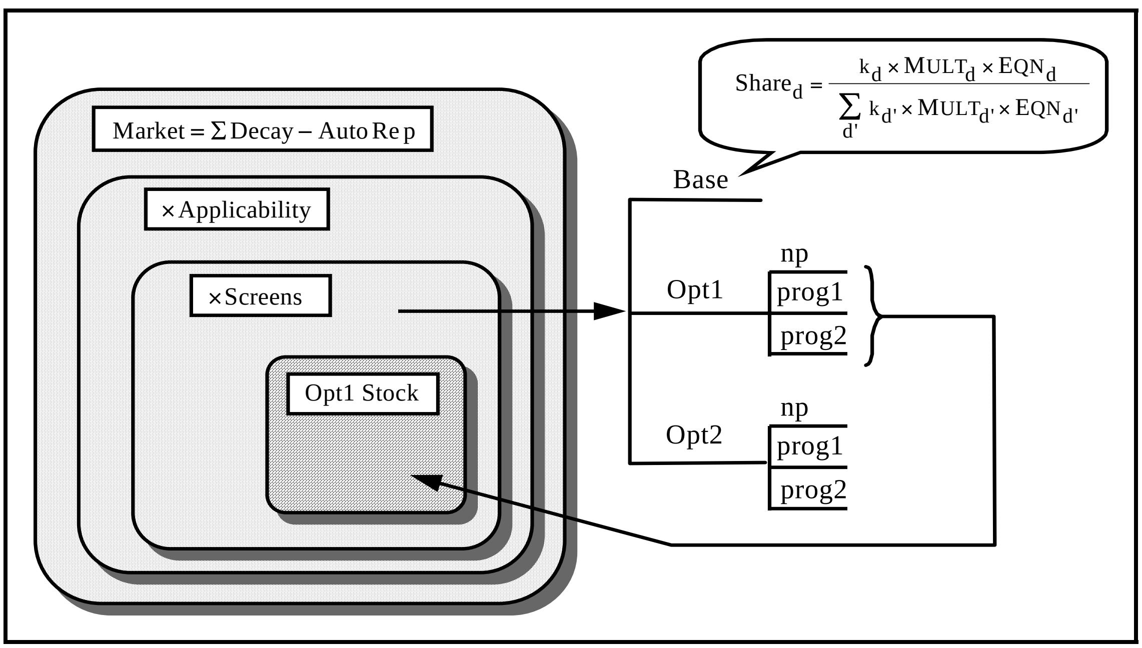
.2 Replace On Burnout Model (ROB)

The replacement model is depicted in Figure 3-4. As indicated in the figure, market size is defined by total decay less the amount that is reserved for automatic replacement, as indicated by AutoRep parameter values. In the case of competition groups, all members of the group contribute to the total market size. The applicability fraction is usually set to 1.0 for replacement groups, indicating that all decayed equipment is replaced with one of the competing options. If this fraction is set to less than 1.0, then the competition group saturation will decline over time, reflecting incomplete replacement.

Once the applicable market is defined, the remaining screens apply to the individual technology options. As with the new construction model, these screens include feasibility, technology awareness, willingness, and technology availability. The screens for an option are used to segment the market into a screened segment, where the option is not in the choice set, and an unscreened segment, where the option is in the choice set.

Finally the shares for all options are computed based on the economic and other features of the competing options. Binomial models are used for two-option groups and either multinomial or nested models are used for larger competition groups. As depicted in the figure, program participation can be modeled, as well as market shares. If there are no programs defined for the option, or if the option does not satisfy the screening test for program eligibility, then only the nonparticipant (np) branch is relevant.

Figure 3-4: Depiction of Replacement Model



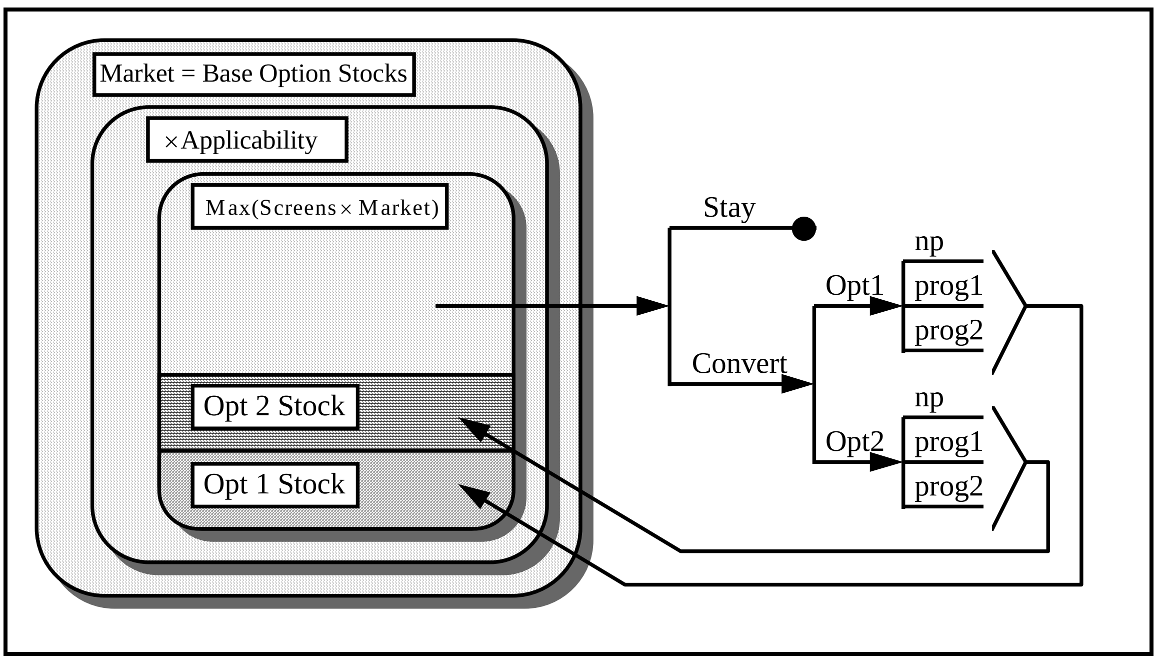
.3 Equipment Conversion Model (CON)

The equipment conversion model is depicted in Figure 3-5. For each conversion group, a base technology is defined, and conversion occurs when customers switch from this base option to one of the alternative options in the group. As indicated in the figure, market size is defined by the total amount of the base option that is initially in the stock. Applicability is usually set to 1.0, indicating that the conversion action is applicable to 100% of the initial equipment stock.

In the equipment conversion model, conversion potential is limited by the remaining technology level screens and an additional screen for market potential. The market potential screen for each option is part of the decision model used to compute the rate of conversion activity. The product of the earlier screens (feasibility, availability, awareness, and willingness) and the market potential screen gives the combined screen value for each technology.

As indicated in the figure, there is an additional modeling step in the equipment conversion model. This step involves the decision to convert versus keeping the initial base equipment. In this upper level decision, the individual technology screens are combined to find the least restrictive value, and this maximum fraction is used for accounting purposes to cap cumulative conversion activity from the base system.

Figure 3-5: Depiction of Equipment Conversion



The technology-specific screens are also applied separately to each option to determine the mix of conversions to the competing alternatives. For example, if the awareness level for an option increases during the forecast, this will lead to an increase in this option's share of total conversion activity.

Finally, the shares for all options are computed based on the economic and other features of the competing options. As depicted in the figure, program participation can be modeled, as well as market shares. If there are no programs defined for an option, or if the option does not satisfy the screening test for program eligibility, then only the nonparticipant (np) branch is relevant.

In the model, as conversions occur, the stocks of the conversion alternatives build over time. As these stocks build, they take increasing shares of the maximum potential box. Total conversion activity is capped so that this maximum potential is not exceeded for the group as a whole.

.4 Device Acquisition Model (ACQ)

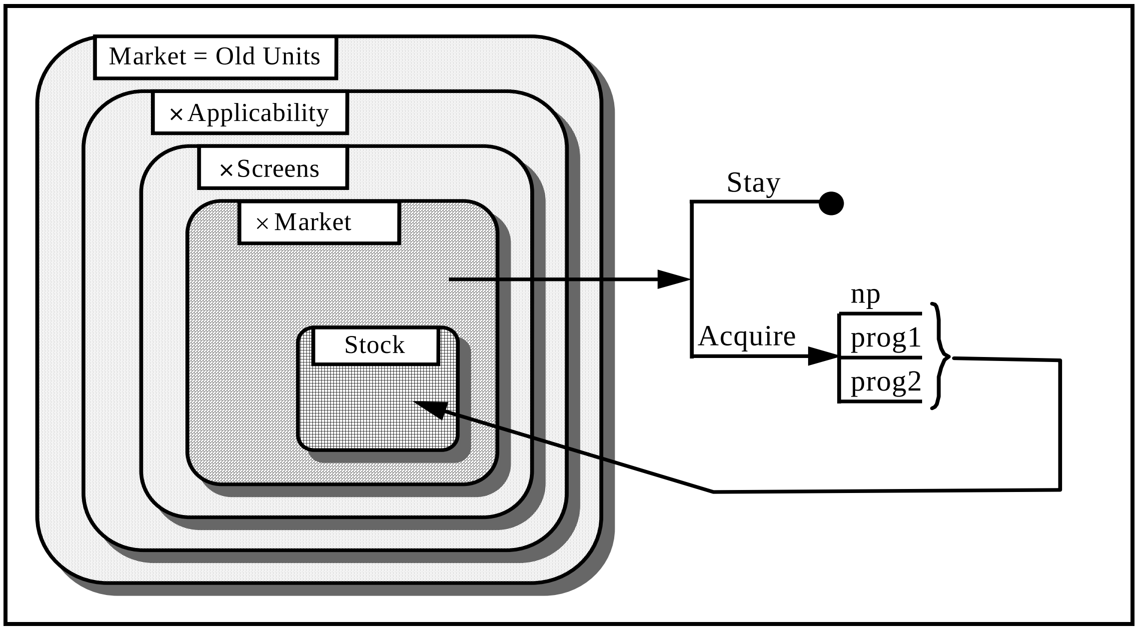
The device acquisition model is depicted in Figure 3-6. This model deals strictly with existing customer units, and as indicated in the figure, market size is defined by the total existing market. (Installation of devices in new construction is covered in the new construction model.)

The applicability fraction gives the fraction of the total market to which the device applies. For example, for installation of ASDs, the applicability fraction gives an estimate of the fraction of motors where application of an ASD is beneficial. This would exclude, for example, most motors with constant loads or with intermittent loads. As another example, for water heater blankets, the applicability fraction gives the share of homes with electric water heaters.

In the device acquisition model, total potential is limited by the technology level screens and an additional screen for market potential. The market potential fraction for a device is part of the decision model used to compute the rate of acquisition activity. The product of the earlier screens (feasibility, availability, awareness, and willingness) and the market potential fraction gives the overall market limit on the device saturation level.

As indicated in the figure, with the addition of the market potential fraction, the acquisition decision appears as a binomial model. For customers who have the qualifying equipment but who do not have the device, the two options are to stay in the current state or to acquire the device. The acquisition rate is modeled to depend on the economic and other features of the device.

Figure 3-6: Depiction of Device Acquisition Model



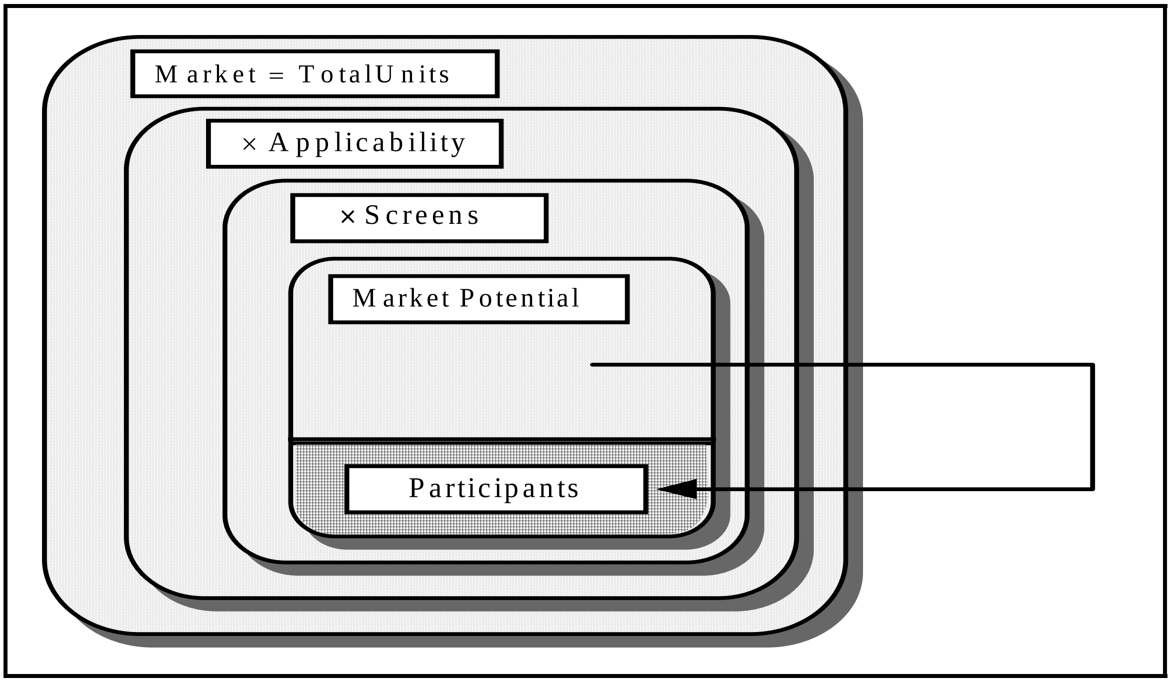
As depicted in the figure, program participation can be modeled, as well as the acquisition rate. If there are no programs defined for a device, or if the device does not satisfy the screening test for program eligibility, then only the nonparticipant (np) branch is relevant.

.5 Load Management Model (LMAN)

The load management decision model is depicted in Figure 3-7. As indicated in the figure, market size is defined by the total market, including both new and existing units. The applicability fraction is based on the fraction of the total market that has the required equipment, size, or flexibility to be in the program. For example, if the program requires a controllable load of 50 kW or more, then the applicability fraction gives the fraction of a segment that is large enough to meet this criterion through actions that can typically be taken by customers in that segment.

Remaining screens are used to limit the market based on program awareness, willingness, and feasibility issues, if there are any. In the load management model, total potential is limited by these screens and an additional screen for market potential. The market potential screen is part of the decision model that is used to compute the rate of gain in program participation. The product of the earlier screens (applicability, feasibility, awareness, and willingness) and the market potential fraction gives the combined market limit for the program.

Figure 3-7: Depiction of Load Management Model



As indicated in the figure, with the addition of the market potential screen, the participation model appears as a binomial model. For the fraction of the applicable and willing market that finds the economics of the program satisfactory, but who are not yet on the program, the two options are to stay on the standard rate schedule or to participate in the program. The rate at which customers join the program is modeled to depend on the economic and other features of the program and of the customer.

3.7 Adoption-Rate Models

Technology adoption models comprise the core of the modeling framework. In ASSET, these models are probability models which give adoption rates and market shares as functions of technology option characteristics and customer characteristics. A wide variety of model specifications are available in the ASSET framework. Three types of share systems are commonly used. These are binary logit systems, multinomial logic systems, and nested logit systems.

- ***Binary Logit Systems.*** In its simplest form, a binary logit system gives the share for an option as a function of the characteristics of that option and a single competing option.

- ***Multinomial Logit Systems***. The multinomial logit is a generalization of the binary logit, and applies to situations where there are more than two outcomes. This type of model can be used to compute purchase probabilities or shares for a group of competing options.

- ***Nested Logit Systems.*** These models are similar to multinomial logits, but additional structure is imposed about the substitution patterns among the competing options. Generally speaking, options that are more closely substitutable with each other are placed in closely competing groups. With this approach, the share for an option can be expressed as the product of two probabilities. The first gives the probability of the group and the second gives the probability of the specific option within the group.

The detailed specification for each of these systems is presented in Section 3.11.

3.8 Impact Accounting Logic

For purposes of long-run impact accounting, a test year is identified as part of the program setup. All cost/benefit computations are accumulated beginning in this test year, and all present values are discounted to this test year.

Each time ASSET is executed, a set of separate model runs is completed, and a separate set of gross impacts is maintained for each model run. The typical approach has programs active in the first run, and inactive in the second run. As a result, we refer to Run 1 as the Program Run, and Run 2 as the No-Program Run. Despite this terminology, gross impacts are computed for both runs, and programs may be active in both runs.

Gross Technology and Program Impacts

For each run, impact accounts are maintained for each technology, competition group, and program. For equipment options, all impacts are measured relative to the base technology in a competition group. For devices, impacts are entered directly and there are no base technologies. In all cases, two types of impacts are maintained.

- ***Initial Impacts.*** The first is a set of initial impacts for one-time events, such as equipment unit purchases and installation costs.

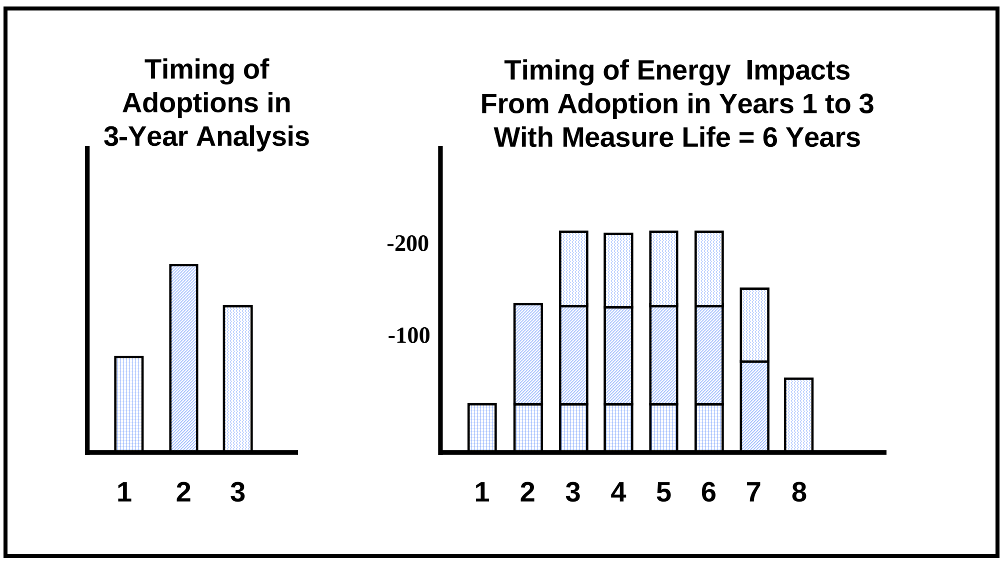
- ***Cumulative Impacts.*** The second is a set of cumulative impacts for recurring events, such as kWh impacts, bill savings, and avoided costs, all of which last through the measure life.

In ASSET, gross energy impacts are adjusted for measure interactions, rebound effects, measure retention rates, and performance degradation rates. Rebound effects and measure interactions result in an immediate adjustment to energy impacts, and this adjustment lasts through the full measure life. In contrast, incomplete measure retention and performance compound over time, implying increasing adjustments as the measure life proceeds.

The accounting for all impacts begins in the test year. This process is depicted in Figure 3-8. In the figure, the test year is assumed to be the first year that is displayed, and the simulation extends for three years. In each of the three years, there is some level of adoption for the DSM technology, with the highest adoption level in the second year and lower levels in the first and third years.

As shown in the right-hand side of the figure, each of the adoption events spawns a stream of annual impacts. In the example, the measure life is assumed to be 6 years, and persistence is assumed to be 100%, so that initial energy impacts remain unchanged over the measure life. In this case, gross energy impacts build over the first three years, and decay over time into future years after the end of the simulation. Because of the 6-year measure life, gross impacts from the third year of adoptions last through year 8. Cumulative energy impacts from technology adoption that occurred during the three-year simulation period are zero beyond year 8.

Figure 3-8: Example of Technology Adoption and Cumulative kWh Impacts



Gross Technology Impacts. For equipment groups, gross technology impacts give the results of all equipment purchases above the baseline option in the group. For devices, gross technology impacts record the result of all device adoption actions.

- ***Gross Technology Costs.*** These costs include the costs of equipment purchase and installation. For equipment competition groups, the gross cost impact for an option is the incremental cost of that option above the baseline option. For a device, gross costs are all expenditures on that device.

- ***Gross Energy and Peak Impacts.*** These impacts include annual electricity and gas energy impacts and electric peak reductions from measure adoption. For equipment competition groups, the gross energy impact for an option is the incremental reduction in energy use relative to the baseline option. For a device, gross energy impacts are computed directly using the impact values for that device.

- ***Accumulation of Gross Impacts.*** Because an action in one year can spawn savings in several years to come, the gross energy savings are accumulated in the accounts in the year they are expected to be realized.

- ***Time Profile of Gross Impacts.*** Energy savings are assigned to future years out to the average measure life. In each year, these impacts are reduced for interaction effects, rebound effects, incomplete measure retention and performance degradation.

Gross Program Impacts. For each technology adoption decision, gross program data are tracked. These data relate to equipment and device purchases by all participants in the program. No effort is made to sort out free-rider effects, free-driver effects, or net program impacts at this point.

As with gross technology impacts, all gross program results are adjusted for measure interactions, rebound effects and measure persistence. Items tracked for each technology in the accounts for gross program data include the following.

- ***Units Purchased***. The number of technology units purchased by program participants is assigned to the year of purchase. These purchase volumes are also accumulated through the mean measure life, with adjustments for measure retention.

- ***Gross Incentive Payments***. Incentive payments from the utility to program participants are recorded in the expected year of incidence. In the year of participation, all rebate payments and loan amounts are recorded directly in that year. The stream of annual rebates spawned by participation, if any, is assigned to future years, with adjustment for measure retention.

- ***Gross Loan Payments.*** For programs that involve loans or shared savings, participation implies a stream of payments from the customer to the utility. These payments are recorded through the life of the loan. No adjustments are made for measure persistence.

- ***Gross Program Costs.*** For each program the variable costs caused by program participation are recorded in the expected year of incidence. Initial variable costs are recorded in the year of participation, and on-going annual costs, if any, are accumulated in future years through the mean measure life, with adjustment for measure retention.

Net Technology and Program Impacts

At the conclusion of a model execution, the data base of ASSET results contains gross impacts from each of the model runs. This includes the following:

- Program Run (Run 1)
- No-Program Run (Run 2)
- Technical Potential Run
- Economic Potential Run

Net impacts and net benefit/cost accounting are performed by comparing the gross impacts from the first two runs.

Net Adoption Impacts. This process is depicted for annual adoption impacts in Figure 3-9. The example depicts technology adoption levels for a three-year simulation. Note that the impacts continue beyond the end of the simulation period, through the full measure life of adoption actions that occurred during the runs. However, any dynamic effects of programs on technology adoption levels after the end of the simulation period (three years in the example) are not included in the analysis. Thus, to account fully for dynamic "end effects," it is necessary to allow the simulation to continue beyond the end of the program period.

Also, it should be recognized that net adoption impacts can be negative in some years. This is especially likely for aggressive retrofit programs which cause large amounts of adoption early in the simulation in Run 1. In this case, annual adoption levels in the later years in Run 2 may exceed adoption levels in these years in Run 1, reflecting the small remaining market in the program case.

Net Energy Impacts. Cumulative net energy impacts are depicted in Figure 3-10. In the example, the three-year simulation spawns impact streams lasting through year 8, reflecting a 6-year measure life. The net impact in each year is computed as the difference between the cumulative gross impacts in each year.

As mentioned above, any dynamic effects of programs on technology adoption after the end of the simulation period are not represented in the cumulative gross energy impacts. For example, if programs in the three-year simulation cause an increase in technology awareness or availability that will last beyond the three-year program, this would result in additional net impact streams beginning in year 4 and extending beyond year 8. If these dynamic end effects are modeled, it is important to extend the simulation period beyond the three-year program period.

Net Technology-Level Impacts. Net technology impacts come from the difference in gross adoption rates between Run 1 and Run 2. All impacts are computed as values in Run 1 minus values in Run 2. As a result, cost impacts will typically be positive, indicating higher gross equipment costs and program costs in the first run. Energy and utility bill impacts will typically be negative, indicating lower energy usage levels in the first run.

Because both sets of gross impacts are adjusted for interactions, rebound effects, and measure persistence, the net impacts are already also for these factors. For purposes of cost/benefit accounting, net impacts are provided for the following items.

- ***Net Technology Impacts***. Net impacts include annual differences in units purchased (equipment and device flows), as well as cumulative differences in equipment and device stocks. If Run 1 has additional purchases of DSM equipment and devices, the net technology impacts will be positive, indicating higher gross adoption levels with programs.

- ***Net Energy and Demand Impacts.*** Net energy and demand impacts are the difference between gross energy impacts in Run 1 and Run 2. If Run 1 has additional purchases of DSM equipment, then the gross energy impacts will be larger in Run 1, implying a negative result. For example, if the Run 1 gross impact in a year is -100 GWh, and the Run 2 gross impact is -40 GWh, then the net impact is -60 GWh.

- ***Net Equipment Cost Impacts.*** Cost impacts include the change in gross spending on equipment and labor costs associated with different levels of technology adoption. If Run 1 has higher levels of DSM measure adoption, the net cost impacts will be positive, indicating greater gross spending on DSM in Run 1.

- ***Net Utility Bill Impacts.*** Operating cost impacts include changes in maintenance costs and utility bills. If Run 1 has higher levels of DSM measure adoption, the net bill impacts will be negative, indicating higher levels of gross bill savings in Run 1. For example, if gross bill impacts are -$15 million in Run 1 and are -$5 million in Run 2, then the net bill impact is -$10 million.

- ***Other Annual Impacts.*** Other annual impacts include the net difference in equipment maintenance costs and changes in the value of service. These net impacts can be either positive or negative, depending on the technology data.

Figure 3-9: Depiction of Annual Adoption Impacts

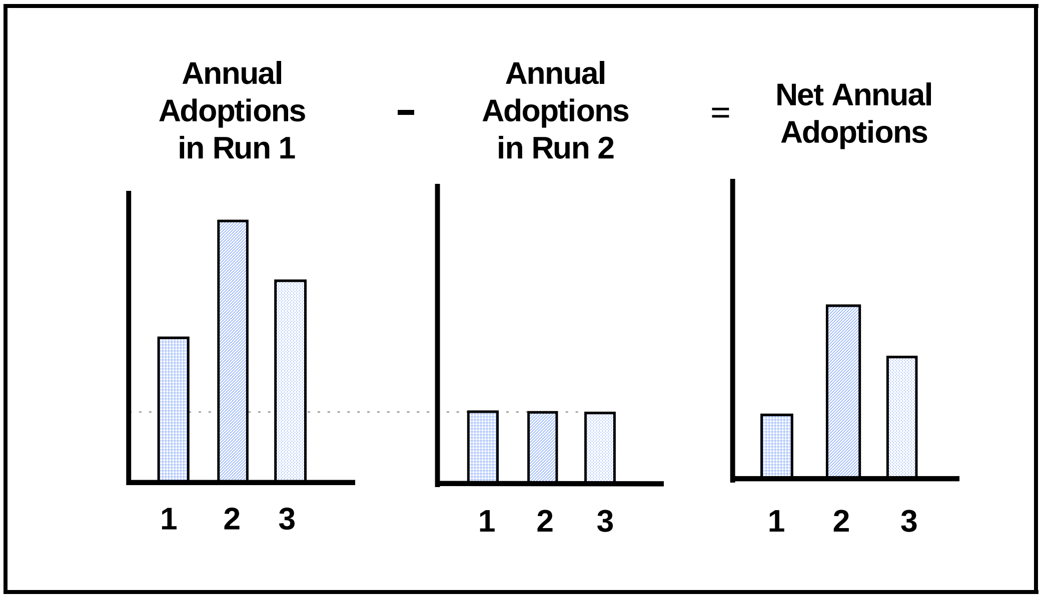
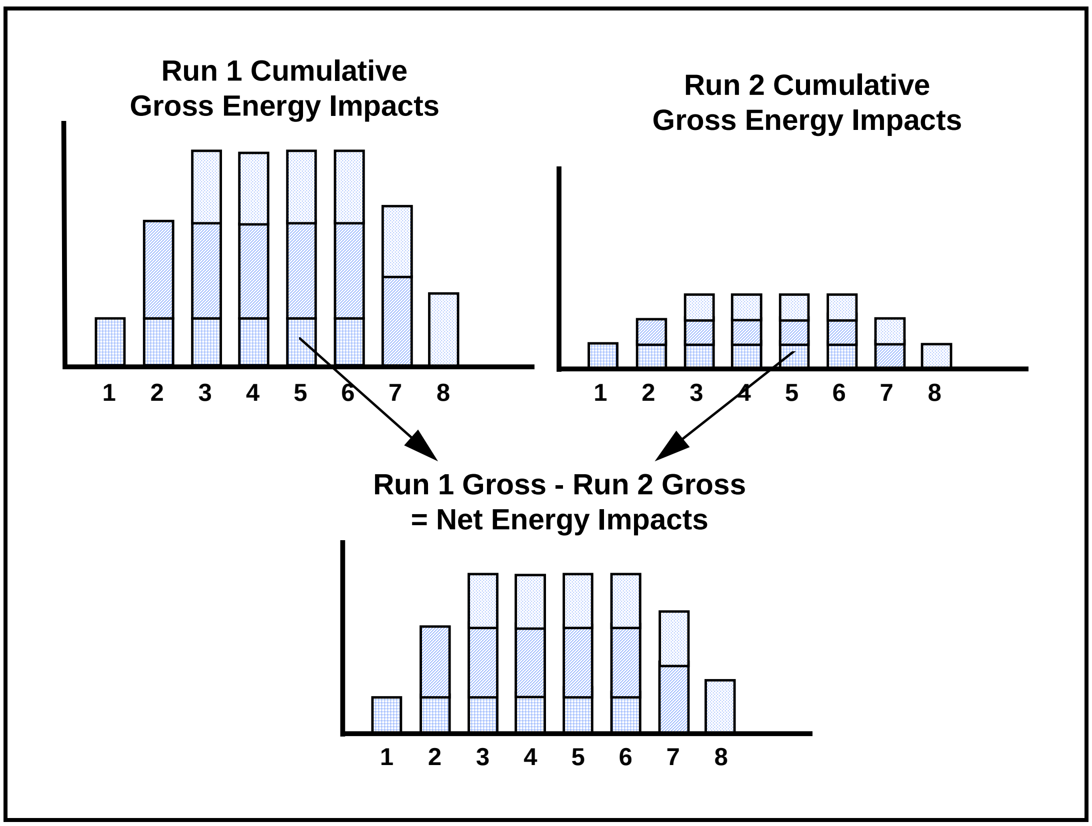


Figure 3-10: Depiction of Cumulative Gross and Net Energy Impacts



- ***Net Avoided Cost Impacts.*** Gross avoided costs are computed for both runs. Assuming Run 1 has higher levels of DSM measure adoption, the net avoided cost impact will be positive, indicating higher levels of gross avoided costs in Run 1. For example, if gross avoided costs are $10 million in Run 1 and $4 million in Run 2, then the net avoided cost impact is $6 million.

Net Program Impacts. Net program impacts are computed as the difference between gross technology impacts under Run 1 and gross technology impacts under Run 2. Any differences between these two sets of impacts are caused by differences in program eligibility and user-coded differences in model equations. The interpretation of these differences as net program impacts is correct only if the second run sets program eligibility values to zero beyond some point in the simulation.

3.9 Stock Accounting Logic

Stock accounting refers to algorithms that track the quantity and quality of capital equipment through time. The algorithms typically involve data about initial equipment stocks, an initial vintage distribution, and parameters that determine the rate of decay of these stocks over time.

Model Inputs. For each market segment, DSM measure saturation levels are entered for the base year. For equipment, these saturation levels imply option shares and overall density levels for competition groups. For devices, these saturation levels give the fraction of the market that has each individual device installed. In addition to saturation levels, four parameters are used to describe the vintage distribution. These parameters also play a key role in computing the size of replacement markets.

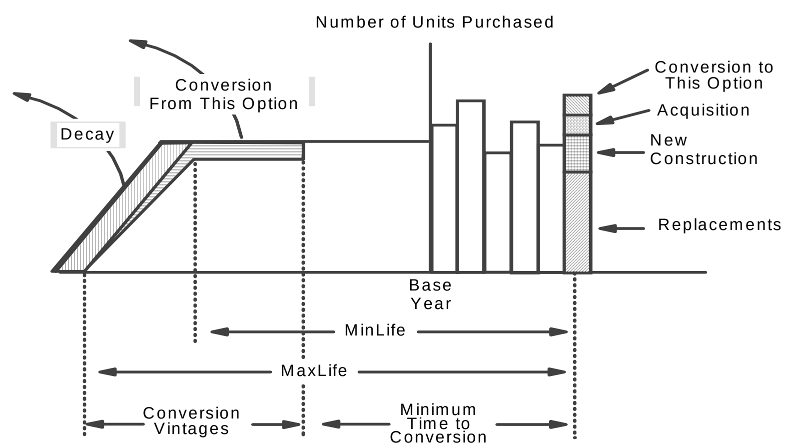
- ***Minimum and Maximum Life***. Separate parameters are entered for the minimum and maximum life of a measure. These values are entered in years and they determine the expected life of an equipment option or device. By the end of the maximum life, all equipment of a given vintage has been removed from the installed stock because of physical deterioration or economic obsolescence.

- ***Minimum Time to Conversion.*** A third parameter gives the minimum life before conversion is allowed. For example, a value of 10 indicates that converted equipment should be removed from vintages that are 10 years old or older at the time of conversion.

- ***First Year Available.*** A fourth parameter gives the first year that the technology was available. This is used mainly for relatively new technologies to prevent replacement activity before the first generation of equipment reaches the minimum life value.

Forecast Logic. These inputs are used to convert the base-year saturation into an annual vintage representation. This allows application of an annual decay algorithm to the constructed base-year data and to the succeeding annual forecast results. The stock accounting algorithm is depicted in Figure 3-11.

Figure 3-11: Depiction of Equipment Stock Accounting



In the figure, the X axis represents time and the Y axis represents the number of units in the stock. The shaded parts of the example show changes that would occur in the sixth forecast year.

- ***Historical Stock.*** To the left of the base year, it is assumed that unit purchases are uniformly distributed. As a result the number of units is level until the minimum life is reached. At this point the number of surviving units falls linearly until the maximum life is reached. If the "first year available" is less than the maximum life, this distribution is truncated.

- ***Decay.*** The shaded area on the far left indicates the number of units that decay in year 6. These units are removed from the stock in vintages that are greater than the minimum life through the maximum life, measured from the perspective of the current year.

- ***Conversions.*** The shaded area labeled "Conversions From This Option", indicates the level of prefailure conversion activity. This activity is positive if the technology is the base technology in a conversion group. In this case, the number of units converted is determined by the model assigned to the conversion group, and the units are removed from vintages that are older than the minimum time to conversion. These are labeled as the Conversion Vintages.

- ***Purchases.*** Purchases in year 6 are indicated by the shaded bar at the right. The number of units purchased is broken into parts indicating purchases to replace units that decayed, units purchased for new construction, first-time acquisition purchases in existing buildings, and units purchases as part of conversion.

3.10 Measure Cost Data

As discussed in Section 2.4, a variety of cost figures can be developed from data about competing equipment options and about energy-saving measures and devices. The appropriate figure of merit for modeling purposes will depend on the type of action being modeled. Alternative cost variables that are computed by ASSET for use in the adoption models are discussed below.

Life-Cycle Cost. Life-cycle cost (LCC) is computed from input data on equipment cost and installation cost less any rebate amount (FirstCost - Rebate), operating cost (OpCost) and maintenance cost (Maint). Operating cost is computed from the energy-use profile and energy rates. The intent of a life-cycle-cost calculation is to discount future O&M costs to a present value, and this computation depends on the life of the equipment item and a discount rate. Formally, life-cycle cost is defined as follows:

$$\text{LCC} = \text{FirstCost} + \sum_{t=1}^{\text{Life}} \frac{\text{OpCost}^t + \text{Maint}^t}{(1+r)^t}$$

Levelized Cost. Levelized cost (LevCost) depends on the same factors as life-cycle cost. However, instead of computing a combined value on a first-cost equivalent basis, the installed equipment cost is annualized and added to annual O&M expenses. In the simplest case, annual O&M costs are constant, and the capitalized first cost is added to these annual costs, giving the following.

$$\text{LevCost} = \text{FirstCost} \times \left[\frac{r}{1-(1+r)^{-\text{Life}}} \right] + \text{OpCost} + \text{Maint}$$

Levelized cost is a preferred approach when competing options have significantly different expected life times. With this approach, annualized costs can be compared directly across options, whereas life-cycle costs would not be directly comparable for options with different life times. This distinction is less important when life times are relatively long or when discount rates are high.

Simple Payback. The most commonly used criterion for retrofit investments is the simple payback on an action. The payback gives the number of years that it will take to recover an up-front investment. Whereas both life-cycle cost and levelized cost can be computed separately for each option, computing a payback implicitly requires comparison of two options.

For modeling of a retrofit action, such as adding a measure or device, the investment is the cost of the additional equipment, and the savings are the energy savings from the action. For modeling decisions among competing options, a base option is identified. The payback value for a more efficient option is then given by the ratio of (a) the incremental cost of that option relative to the base option to (b) the annual O&M savings that accrue from adoption of that option relative to the base option. Formally,

$$\text{Payback} = \frac{\Delta\text{First Cost}}{\text{O\&M Savings}}$$

where ΔFirst Cost is the incremental investment amount including equipment and installation costs. Utility incentive programs reduce the payback period by reducing the incremental first cost to the customer.

Return on Investment (ROI). Whereas the simple payback is computed with savings under current conditions, the return on investment allows for changes in operating costs over time. The ROI is computed to be the discount rate that equates the present value of savings to the investment cost. Equivalently, this rate sets the present value of the investment (the change in life-cycle cost) to zero. Formally, the ROI is the value of the discount rate r such that:

$$\Delta\text{FirstCost} + \sum_{t=1}^{\text{Life}} \frac{\Delta\text{O\&M Cost}^{t}}{(1+r)^{t}} = 0$$

There is an inverse relationship between simple payback and ROI. In the case where O&M costs are constant and the investment has an infinite life, this inverse relationship is exact. In this case, a four-year payback requirement implies the same decisions as a required ROI of 25%, and a 10-year payback requirement implies the same decisions as a required ROI of 10%.

Computation of Operating Costs. Operating costs for a technology are computed from data on energy-use patterns and rates. Input data required by ASSET are as follows:

- An annual kWh level or impact,

- Usage profiles giving the fraction of sales by season and time-of-use period,
- Peak factors by season and time-of-use period, and
- Utility rates by season and time-of-use period.

For some rates, such as simple energy charges or energy charges by time of use, the bill for a specific piece of equipment can be computed separately based solely on the energy use data for that piece of equipment. For other rates, such as fixed block rates and load-factor block rates, a separate bill for a specific piece of equipment cannot be computed directly, since the bill can only be computed on a whole-premise basis. The correct approach in these cases is to compute the incremental change in the whole-premise bill from an incremental action or an incremental piece of equipment. This computation requires information about whole-premise energy-use patterns as well as the incremental effect of the action being considered.

Rebates. Up-front rebates are treated as offsets to first cost of equipment purchases and retrofit actions. In the equations above, the variable for initial installed cost (FirstCost) is computed from data on the equipment cost (EqCost), installation costs (InstallCost), rebate amounts, and program participation costs (PartCost), which account for the time and inconvenience associated with program participation. Thus, the total up-front cost of a technology is computed as follows:

- For Nonparticipants: FirstCost = EqCost + InstallCost

- For Participants: FirstCost = EqCost + InstallCost - Rebate + PartCost

Rebate amounts can be entered in several forms, based on kWh savings, kW savings, or as a fraction of measure cost or incremental cost.

Finance Incentives. The impact of financing incentives on costs depends on the terms of the loan. The loan amount can be expressed as a percentage of the total cost of the incentive technology or as a percentage of the incremental cost above the base technology. The loan payments will depend on the term of the loan and the loan amount. In the equations above, the loan amounts are subtracted from FirstCost and the annual loan payments are added to operating costs.

3.11 Adoption-Rate Model Specifications

As discussed in Section 2.7, ASSET allows a wide variety of model specifications. Because the equations for adoption-rate models are specified by the user, there is no prescribed functional form. Three types of systems that are commonly used are binomial logit systems, multinomial logit systems, and nested logit systems, each of which is discussed below.

.1 Binary Logit Systems

In its simplest form, a binary logit system gives the share for an option as a function of the characteristics of that option and a single competing option. The shares for the two options are given as follows:

$$\text{SHARE}_1^t = \frac{e^{a_1 + bX_1^t + c_1Z^t}}{e^{a_1 + bX_1^t + c_1Z^t} + e^{a_2 + bX_2^t + c_2Z^t}}$$

$$\text{SHARE}_2^t = \frac{e^{a_2 + bX_2^t + c_2Z^t}}{e^{a_1 + bX_1^t + c_1Zt} + e^{a_2 + bX_2^t + c_2Z^t}}$$

In these equations, the parameters give the share sensitivities with respect to the driving variables. Specific meanings of these parameters are as follows:

- ***Constant Term***. The option specific constants (a_1 and a_2) represent the average influence of all excluded factors. For example, if the explanatory variables relate to cost characteristics of an option, then the constant term will capture the positive or negative impacts of non-cost characteristics.

- ***Option Characteristics***. The X variables represent characteristics of the options, which can include cost and non-cost attributes. The slope coefficients determine the sensitivity of the share results to the value of each attribute. For example, if the X variables include first cost, rebate amount and operating cost, then the corresponding slope coefficients (the b's) give the sensitivity of the option share with respect to these cost variables.

- ***Buyer Characteristics***. The Z variables represent buyer characteristics. Since buyer characteristics may be positively correlated with some options and negatively correlated with other options, the slope coefficients (c_1 and c_2) have option subscripts.

Binomial systems can be rewritten to specify the share of an option with respect to the relative attractiveness of that option. For example, the share for the second option can be rewritten as follows.

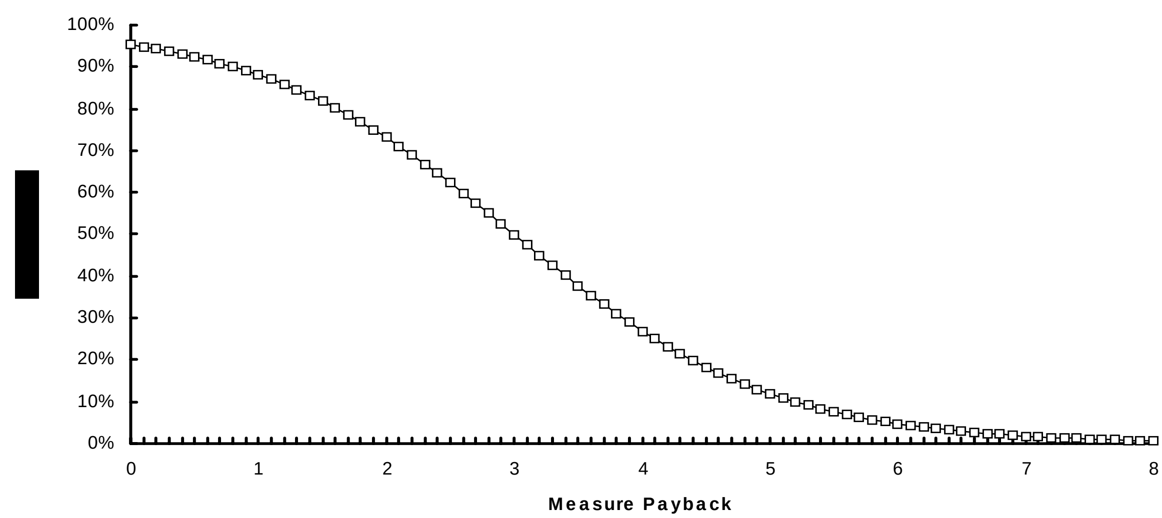
$$\text{SHARE}_2^t = \frac{e^{a+b\left(X_2^t - X_1^t\right)+cZ^t}}{1 + e^{a+b\left(X_2^t - X_1^t\right)+cZ^t}}$$

where $a = a_2 - a_1$ and $c = c_2 - c_1$. In this form, the X variables enter as incremental cost or incremental savings for the second option relative to the base option. A simple form of this type of binary system uses measure payback as the X variable, giving the following.

$$\text{SHARE}_2^t = \frac{e^{a + b \times PB^t}}{1 + e^{a + b \times PB^t}}$$

An example of a binary logit curve with a constant term of 3.0 and a slope of -1 is depicted in Figure 3-12.

Figure 3-12: Example of Binary Logit Curve using Payback



.2 Multinomial Logit Systems

The multinomial logit is a generalization of the binary logit, and applies to situations where there are more than two outcomes. This type of model can be used to compute purchase probabilities or shares for a group of competing options. Each option has an "attractiveness" equation that includes cost and non-cost attributes of the option. If the cost attributes are expressed in levels, combined variables (such as life-cycle cost) can be used, or the separate cost elements can be included separately. Alternatively, incremental return variables like incremental cost and simple payback can be used, where all incremental values are defined relative to the base option for the group.

The form of the multinomial logit gives the share of an option as the attractiveness function for that option divided by the sum of the attractiveness functions. Since exponentiation is used, each share numerator is positive regardless of the values of the driving variables. The shares necessarily sum to 1.0 by construction. Formally:

$$\text{SHARE}_i^t = \frac{e^{a_i + b X_i^t + c_i Z^t}}{\sum_j e^{a_j + b X_j^t + c_j Z^t}}$$

In this equation, the parameters give the share sensitivities with respect to the driving variables. Specific meanings of these parameters are as follows:

- ***Constant Term***. The option specific constants (the a's) represent the average influence of all excluded factors. For example, if the explanatory variables relate to cost characteristics of an option, then the constant term will capture the positive or negative impacts of non-cost characteristics.

- ***Option Characteristics***. The X variables represent characteristics of the options, which can include cost and non-cost attributes. The slope coefficients determine the sensitivity of the share results to the value of each attribute. For example, if the X variables include first cost, rebate amount and operating cost, then the corresponding slope coefficients (the b's) give the sensitivity of the option share to these cost variables.

- ***Buyer Characteristics***. The Z variables represent buyer characteristics. Since buyer characteristics may be positively correlated with some options and negatively correlated with other options, the slope coefficients (the c's) have option subscripts.

The main application of these types of systems in ASSET is for multi-option competition groups where design options are used to represent competing efficiency levels.

.3 Nested Logit Systems

These models are similar to multinomial logits, but additional structure is imposed about the substitution patterns among the competing options. Generally speaking, options that are more closely substitutable with each other are placed in closely competing groups. With this approach, the share for an option can be expressed as the product of two probabilities. The first gives the probability of the group and the second gives the probability of the specific option within the group. Formally the share for option i in group g can be expressed as follows:

$$\mathrm{SHARE}_{ig} = \frac{\mathrm{Sum}_g{}^{\lambda_g}}{\sum_{g'} \mathrm{Sum}_{g'}{}^{\lambda_{g'}}} \times \frac{e^{V_{ig}/\lambda_g}}{\sum_{j \in g} e^{V_{jg}/\lambda_g}}$$

where SUM_g is the denominator of the right-hand term. This sum for the options in a group provides a measure of the attractiveness of the group relative to other groups.

This form has two potential applications within the ASSET framework. The first is for estimating results when both product classes and design options are DSM targets. The second application occurs when program participation is modeled in addition to option choice. In this case, alternative purchase methods (participate vs. don't participate) are structured to occur in the lower level of the nested structure.

4

Setup and Modeling Data

ASSET inputs appear in three main input groups, containing: Utility Data, Customer Data, and Technology Data. In addition to these three main input groups, a Setup file is used to describe file locations and key run parameters, and four auxiliary data tables are used to provide time-series variables, parameters, program eligibility test variables, and distributions.

The four sets of data inputs are as follows:

- ***Exogenous Variables.*** This data table defines a list of time-series variables that will be available for a model run. For each variable, a reference is provided to a spread sheet containing the data.

- ***Parameters.*** This data table contains a set of parameter names and values. These parameter names can be used in any model input that allows an expression.

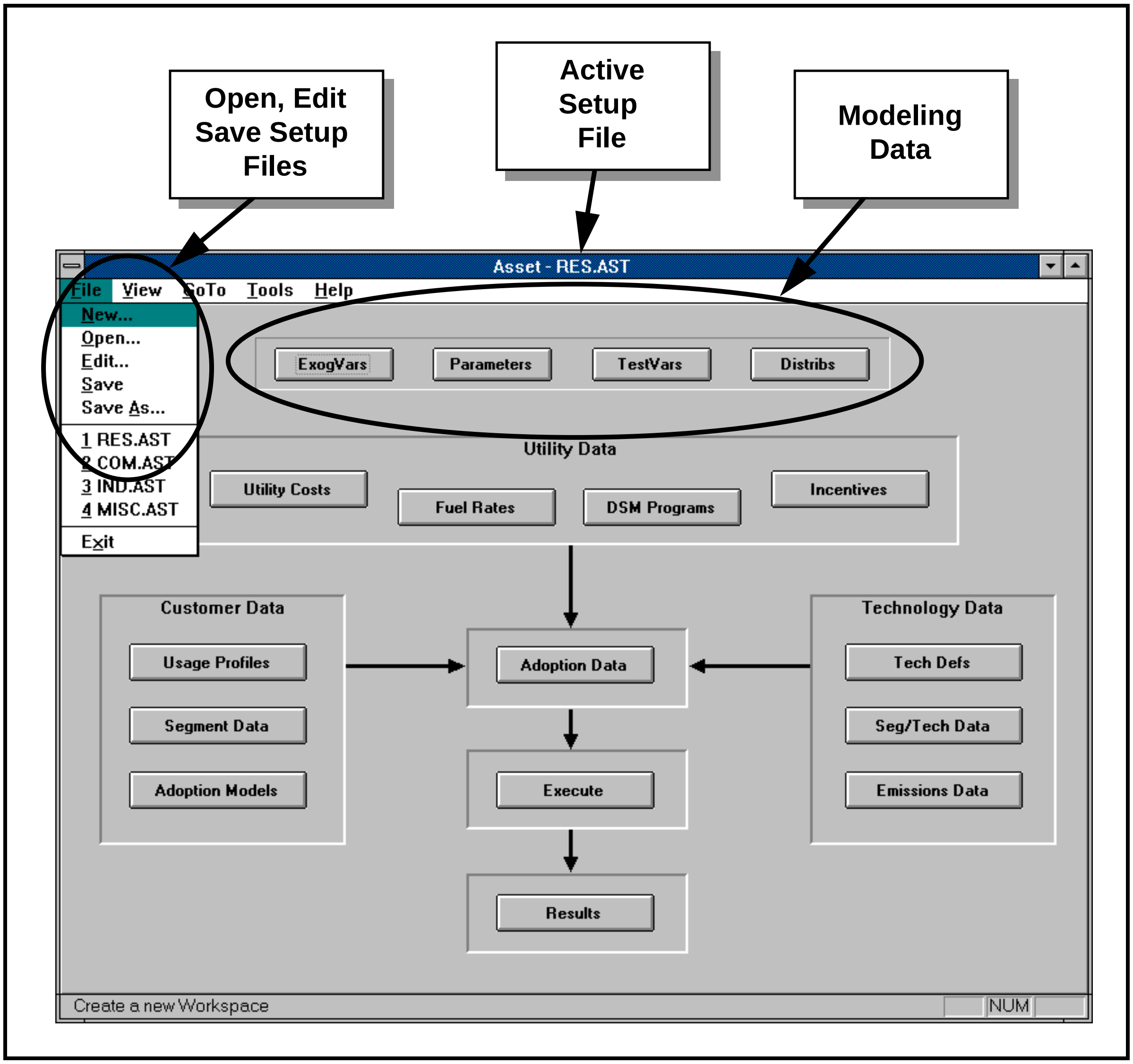
- ***Program Eligibility Test Variables.*** This data table defines the list of variables that can be used to test program eligibility. For each test variable, a reference is provided to an ASCII file that contains the formulas for the test variable.

- ***Distributions.*** This data table defines names for payback requirement distributions that are available for adoption modeling. For each distribution, a reference is provided to an ASCII file that contains the distribution values.

As shown in Figure 4-1, the Setup File is accessed from the top screen through the File menu, and the Modeling Data tables are accessed through navigation buttons or through the View menu.

The remainder of this section contains detailed descriptions of the contents of the Setup File and the Modeling Data tables and supporting external files.

Figure 4-1: Location of Setup and Modeling Data



4.1 Setup File

The Setup File is an ASCII text file that contains a variety of parameters and identifiers that define the dimensions of the model run. The Setup File is accessed through the File Menu.

- ***File Open*** is used to open a Setup file and read the model databases.
- ***File Save*** is used to save a Setup file that has been modified.
- ***File Save As*** is used to save a Setup file under a different file name.
- ***File Edit*** is used to edit the Setup file.

An example of the ASSET Setup File is provided in Figure 4-2. As shown in the figure, the Setup File contains the following fields.

- ***Internal File Version.*** This input is used by the program to support version upgrades. Do not edit this field.

- ***Simulation Years.*** The first set of inputs defines the time boundaries for the market simulation. Variables include the following:

  -- ***Start Year*** is the base year for the simulation (Year 0). Base-year equipment shares apply to equipment stocks in this year. Adoption models are calibrated to adoption shares that apply to the first simulation year (Year 1), which is the year after the base year.

  -- ***End Year*** is the last year of the simulation. Adoption models are executed from Year 1 through the End Year. Model inputs and exogenous variables should be available through the End Year.

  -- ***Reference Year*** is the year that is used as the base for all impact accounting. Program and technology impacts are calculated beginning in this year. All present value calculations are from the perspective of this year.

  -- ***Last Tracking Year*** is the last year of the impact accounting. Program and technology impacts are computed from the Reference year through the Last Tracking Year.

- ***Forecast Switches.*** Y/N switches are available for selecting alternative forecasting logic. Switches available are as follows:

  -- ***Compute Trailing Effects*** controls impact accounting for the Auto Replacement model. When this switch is set to "Y," impacts from measure auto-replacement are computed. When this switch is set to "N," impacts from measure adoption are included in the program impact streams only through the first measure life.

  -- ***Compute Hvac Interacions*** controls the HVAC Interactions computations. When this switch is set to "Y," HVAC interactions are included in the economic calculations and the impact streams for each measure.

- ***Program Period Test Years.*** As the simulation proceeds, program eligibility screening is performed at specified test years. At each specified test year, eligibility variables are evaluated based on the costs and benefits in that year. Technologies that pass the eligibility screens are included in the appropriate program until the next test year. There are four fields available for specifying test years.

- ***File Locations.*** As discussed in Section 2, ASSET works with an input database, a Utility Data file, and multiple output tables. The locations of these files are entered here. For each file, the full path is required. For the output directory, the full path to the directory must be provided, including a trailing back-slash.

  -- Input Database (ACCESS database with .MDB extension)

  -- Utility Data File (ASCII input file with .UTD extension)

  -- Output Directory (Drive:\Directory\Subdirectory\)

- ***Output Result Options.*** A variety of output results are available from ASSET. These outputs are written in the form of comma seperated values (.CSV) text files. This section of the setup file contains a set of Y/N flags and file names for the creation of these output files. For each file, ASSET will use the output directory specified above. For example, an output directory of "C:\ASSET\RESULTS\" and a result base filename of "PROGCOST" will be combined into the text file "C:\ASSET\RESULTS\PROGCOST.CSV".

Figure 4-2: Layout for Setup File

```
      "1.12"              ;Internal File Version -- For program use only

; Simulation Years
      1993                ;Start Year
      2015                ;End Year
      1996                ;Reference Year
      2025                ;Last Tracking Year

; Forecast Switches
      "N"                 ;Compute Trailing Effects ?
      "Y"                 ;Compute Hvac Interactions ?

; Program Period Test Years
      1994                ;Program Period 1 Test Year
      1996                ;Program Period 2 Test Year
      2000                ;Program Period 3 Test Year
      2005                ;Program Period 4 Test Year

"C:\ASSET\SAMPLE.MDB"     ; Input Database
"C:\ASSET\SAMPLE.UTD"     ; Utility Costs File
"C:\ASSET\OUTPUTS\"       ; Output Directory

; Output Tables
      "Y"    "Stock"      ;Segment/Technology Measure Stocks & Adoptions
      "Y"    "SgTch"      ;Segment/Technology Impacts
      "Y"    "Mod"        ;Detailed Model Results -- Adoptions
      "Y"    "Imp"        ;Detailed Impact Results -- Energy Impacts
      "Y"    "FrstYr"     ;Detailed Impact Results -- First Year Impacts
      "Y"    "PrdCls"     ;Segment/Product Class Results
      "Y"    "EndUse"     ;Segment/End Use Results
      "Y"    "Prog" ;Program Energy Impacts & Costs
      "Y"    "BenCst"     ;Program Cost/Ben Results
      "Y"    "PrgSum"     ;Program Summary Results
      "Y"    "PrgTch"     ;Program/Technology Energy Impacts
```

4.2 Exogenous Variable Table

This data table identifies the list of time-series variables that will be available for a model run. For each variable, a reference is provided to a spreadsheet range that contains the data values. The table has the following fields.

- ***Variable Name [S].*** The variable name is a 16-character string that identifies a specific time-series variable. This name can be used in other parts of the program wherever an expression is allowed.
- ***Path/Filename [S].*** This 132-character string must contain a valid directory, path, and filename that identifies an existing Excel spreadsheet.
- ***Range Name [S].*** This 32-character string must contain a valid range name that exists on the spreadsheet that is referenced in the path/filename. For Excel version 5 files, local range names may be specified in the form: *SheetName!RangeName*.
- ***Start Year [I].*** This integer value identifies the year of the first data value in the range name. The full year (e.g. 1980) must be entered.

The layout for the exogenous variable table is shown in Table 4-1.

Table 4-1: Exogenous Variable Table

	Field	**Example Data**
☑	Variable Name [S]	SFElecWHShare
	Path\Filename [S]	C:\Reeps\Res.XLS
	Range Name [S]	SF!EWH_Share
	Start Year [I]	1980
☑ Keyword in Table		

4.3 Parameter Table

This data table contains a set of parameter names and values. The parameters names can be used in any model input that allows an expression. The parameter concept is useful for specifying constants that appear in many places in the inputs. By using a parameter, consistency can be maintained throughout the model input tables. Also, the parameter feature can be used to provide scenario capabilities. This is done by using parameters as binary switches that are referenced in input expressions.

The number of parameters in the data table is not limited. The parameter table has two fields.

- ***Parameter Name [S].*** The parameter name is a uniue 16-character string that identifies a specific parameter. This name can be used in other parts of the program wherever an expression is allowed.

- ***Parameter Value [N].*** This is a floating point number that gives the parameter value.

Table 4-2: Parameter Table

	Field	**Example Data**
☑	Parameter Name [S]	ProgEff
	Parameter Value [N]	.035
☑ Keyword in Table		

4.4 Test Variables for Program Eligibility

This data table defines the list of variables that can be used to test a technology for program eligibility. For each test variable, a file name is entered, providing a reference to the ASCII file that contains the equations for that test variable. The data table contains the following fields.

- ***Test Variable Name [S].*** This name is a 16-character string that identifies a specific test variable. This name is used in the Technology Adoption table, in the fields for assignment of test variables.
- ***Path/Filename [S].*** This 255-character string must contain a valid directory, path, and filename that identifies an existing ASCII file that contains test variable data. The file extension for these variables is .TST.

Table 4-3: Test Variable Table

	Field	Example Data
☑	Test Variable Name [S]	ResAppRebate
	Path\Filename [S]	C:\Reeps\Restest1.TST
☑ Keyword in Table		

Each test variable file is an ASCII file that contains equations and equation assignments. Each variable contains separate assignments for Run 1 and Run 2, allowing a technology to pass eligibility screens in the first run, but to be excluded in the second run. In addition to exogenous variables and parameters, the following specially constructed variables may be used in the equations for test variables.

- -- Run1: A binary variable that set to 1.0 during Run1 and 0.0 otherwise.
- -- Run2: A binary variable that set to 1.0 during Run2 and 0.0 otherwise.
- -- TrCost: Contains total resource cost per segment unit.
- -- TrBen: Contains total resource benefits per segment unit.
- -- TrLevCost: Contains levelized total resource cost per segment unit.
- -- FyAvoidCost: Contains first-year avoided cost per segment unit.
- -- ERimCost: Contains value of electric rate impact costs per segment unit.
- -- ERimBen: Contains value of electric rate impact benefits per segment unit.
- -- EUtilCost: Contains value of electric utility costs per segment unit.
- -- EUtilBen: Contains value of electric utility benefits per segment unit.

Further details about the cost and benefit variables are provided below.

- ***TrcCost.*** This variable contains the technology-level resource cost value. This value includes incremental equipment and installation costs, variable program costs, the present value of incremental maintenance costs, and the present value of additional fuel, energy, and capacity costs, if any. All present values are computed using the TRC discount rate from the Utility Data file.

- ***TrcBen.*** This variable contains the technology-level total resource benefit value. This value includes the present value of incremental avoided costs related to fuel, energy, and capacity savings, as well as the present value of incremental maintenance cost savings, if any. All present values are computed using the TRC discount rate from the Utility Data file.

- ***TrcLevCost.*** This variable contains the levelized value of the resource cost stream. This stream includes incremental equipment and installation costs, variable program costs, any incremental maintenance costs, and additional fuel, energy, and capacity costs, if any. The stream is levelized using the TRC discount rate from the Utility Data file.

- ***FyAvoidCost.*** This variable contains the first-year avoided cost for a technology, including any incremental fuel, energy, and capacity savings in the first year of the measure life.

- ***ERimCost.*** This variable contains costs included in the Electric Rate Impact Measure (RIM), including variable program costs, incentive payments, and revenue losses. For measures that increase energy use, incremental energy, generation and T&D costs are also included here.

- ***ERimBen.*** This variable contains benefits included in the Electric Rate Impact Measure (RIM), including avoided energy, generation, and T&D cost savings and finance payment receipts, if any. For measures that increase utility revenue, revenue gains are also included here.

- ***EUtilCost.*** This variable contains costs included in the Utility Cost test, including variable program costs and incentive payments. For measures that increase energy use, incremental energy, generation and T&D costs are also included here.

- ***EUtilBen.*** This variable contains benefits included in the Utility Cost test, including avoided energy, generation, and T&D cost savings and finance payment receipts, if any.

An example of a test variable file is shown in Figure 4-3. In the column for Run 1, this screening rule implies that a technology is included in the first program period, but is subject to screening in subsequent program periods based on the technology benefit/cost ratio. In the second run, the technology is excluded from programs beyond the first program period. The definition of the program periods is provided in the Setup File.

Figure 4-3: File Layout for Eligibility Test Variables

```
; Program Eligibility Test Variable

     1          ;Number of Equations

     "BCRatio = TrcBen/TrcCost;"

; Test Expressions
;
;    Run 1              Run 2
     1.0                1.0          ; Program Period 1
   "BCRatio"            0.0          ; Program Period 2
   "BCRatio"            0.0          ; Program Period 3
   "BCRatio"            0.0          ; Program Period 4
```

The equation processing capability allows significant modeling flexibility. For example, the following logic creates a variable that evaluates to 1.0 if the TRC benefit/cost ratio is greater than 1.0 and the electric RIM ratio is greater than .75.

> "TrcRatio = TrcBen/TrcCost;"
> "RimRatio = ERimBen/ERimCost;"
> "TestVar = (RimRatio>.75) × (TrcRatio > 1.0)

By including thest three equations in the file for an eligibility test variable and assigning the TestVar variable to be used as the test variable for Run1, a technology would be included in a program only if it passes this compound screening criterion.

4.5 Distrubutions

This data table defines names for payback requirement distributions. For each distribution, a fiel name is entered, providing a reference to the ASCII file that contains data for that distribution. The data table contains the following fields.

- ***Distribution Name [S].*** The distribution name is a 16-character string that identifies a specific distribution. This name can be used in other parts of the program wherever a distribution is allowed.

- ***Path/Filename [S].*** This 255-character string must contain a valid directory, path, and filename that identifies an existing ASCII file that contains distribution data. The file extension for distribution files is .DST.

Table 4-4: Distribution Table

	Field	**Example Data**
☑	Variable Name [S]	Res_App_Dist
	Path\Filename [S]	C:\Asset\Dist\ResApp.DST
☑ Keyword in Table		

The distribution file is an ASCII file that contains the number of distribution categories, and values and percentages for each category. The only application of distributions in ASSET is in computing market potential by applying a payback requirements distribution to a payback value. An example of the format for a distribution file is provided in Figure 4-4.

Figure 4-4: Layout for Distribution Files

```
 11                        ; Number of Categories

  0.0         100.0        : Category 1
  1.0          93.0        : Category 2
  2.0          47.0        : Category 3
  3.0          16.0        : Category 4
  4.0           6.0        : Category 5
  5.0           3.0        : Category 6
  6.0           1.5        : Category 7
  7.0           1.0        : Category 8
  8.0            .6        : Category 9
  9.0            .2        : Category 10
 10.0            .0        : Category 11
```

Distributions are passed into decision model on the Technology Adoption record for a technology. Values are referenced through the keyword, PBREQ. When used in an adoption model, this keyword applies the distribution to the simple payback value for the active technology. For example, suppose that a technology has a payback of 3.5 years. Then, using the data in Figure 4-4, the PBREQ keyword would evaluate to:

PBREQ = FRACTION OF DISTRIBUTION BEYOND 3.5 YEARS = .11

This indicates that 11% of the decision makers will accept a payback of 3.5 years or more. This value is half way between the distribution values at 3 years (16%) and at 4 years (6%).

5

Customer Data and Adoption Models

ASSET input files and databases are segmented into four main input areas: (a) Customer Data, (b) Utility Data, (c) Technology Data, and (d) Adoption Data. This section covers inputs in the Customer Data section. These inputs are entered in three parts.

- ***Usage Profiles.*** The usage profiles table provides data about energy usage profiles by time of use and season. Each profile is identified by a Profile Name. The multipliers in this table are used to compute energy use by season and period, average customer peak demand in each season and period, and contribution to system peak in each season and period.

- ***Segment Data.*** This table contains segment definitions and provides data and forecasts of segment size and segment growth. Typically, segments are defined by housing type for the residential sector, building type for the commercial sector, and industry group for the industrial sector. Each segment is identified by a Segment Name.

- ***Adoption Models***. For each adoption model, this table provides a Model Name and a file reference. Each adoption model is stored in a separate ASCII file. These models define the structure of technology competition and provide equations for modeling option shares and program participation rates.

The following sections provide detailed descriptions of the input fields on each of these data tables. In the section on adoption models, a discussion is also provided about the modeling framework, the types of algebraic expressions that can be used in models, reserved words available in each type of model, and the syntax of expressions in each model.

5.1 Usage Profiles

Usage Profiles. This input section contains a database of energy and demand profiles. The data are provided by season and time-of-use period. In other sections of the program, usage profiles are referenced by name, and the same profile can be applied to several different technologies, different segments, and decision states.

The Usage Profiles table is part of the input database. The table contains one record for each profile. The record layout is depicted in Table 5-1. Individual data elements are as follows:

- ***Profile Name[S].*** The profile name is a 16-character string used to identify the profile data. This string must be unique within the database. The profile name is used in other sections of the program to apply the profile data to a specific task.

- ***Type[I].*** This integer is set to indicate an energy-based profile (Type = 1) or a load-based profile (Type = 2). When an energy-based profile is assigned, it is expected that the corresponding intensity data on the Segment/Technology record represents annual kWh and annual kBtu values. When a load-based profile is assigned, it is expected that the corresponding intensity data represent hourly loads in kW and kBtu/h. Details about the computations used for each profile type are provided below.

Table 5-1: Layout for Usage Profiles

	Variable	**Example Data**
1	**Profile ID**	
☑	Profile Name[S]	CAC
	Type [I] 1 (energy based), 2 (load based), or 3 (HVAC interaction)	1
2	**Profile Data**	
	$Energy_{s1,t1}$, $Energy_{s1,t2}$, $Energy_{s1,t3}$, $Energy_{s2,t1}$, $Energy_{s2,t2}$, $Energy_{s2,t3}$ [N]	.282, .217, .298 .072, .055, .076
	$Demand_{s1,t1}$, $Demand_{s1,t2}$, $Demand_{s1,t3}$, $Demand_{s2,t1}$, $Demand_{s2,t2}$, $Demand_{s2,t3}$ [N]	4.19, 2.21, 2.05 4.19, 2.21, 2.05
	$SysDemand_{s1,t1}$, $SysDemand_{s1,t2}$, $SysDemand_{s1,t3}$, $SysDemand_{s2,t1}$, $SysDemand_{s2,t2}$, $SysDemand_{s2,t3}$ [N]	.800, .899, .890 .800, .899, .890
☑ Key Field in Table		

- ***Energy[N].*** The energy multipliers are used to convert intensity values into annual energy use in each season and time-of-use period. If the profile type is energy-based (Type = 1), then the energy multipliers are fractions of annual use. In this case,

$$\text{kWh}_{s,t} = \text{kWh} \times \text{ENERGY}_{s,t}$$

where kWh is the energy-based annual intensity and $\text{ENERGY}_{s,t}$ is the fraction of annual energy that is used in a season (s) and period (t). In this case, the energy multipliers should sum to one across seasons and periods.

If the profile type is load-based (Type = 2), then the energy multipliers are full load hours. In this case,

$$\text{kWh}_{s,t} = \text{kW} \times \text{ENERGY}_{s,t}$$

where kW is the load-based intensity and $\text{ENERGY}_{s,t}$ is the full-load hours of use in each season (s) and period (t).

- ***Demand[N].*** Within each season and time-of-use period, the peak demand multipliers are used to compute hourly loads at the time of customer peak within each period. If the profile type is energy-based (Type = 1), then the peak multipliers are inverse load factors, giving the ratio of load at the time of customer peak in a season and period to the average hourly load in that season and period. In this case, the demand multipliers are used as follows:

$$\text{PEAKKW}_{s,t} = \frac{\text{kWh}_{s,t}}{\text{HOURS}_{s,t}} \times \text{DEMAND}_{s,t}$$

where $\text{kWh}_{s,t}$ is energy consumption in the season and period, $\text{HOURS}_{s,t}$ is the number of hours in the season and period, and $\text{DEMAND}_{s,t}$ is the inverse load factor used as the demand multiplier. For example, if the average cooling load in the summer on-peak period is 1.25 Watts/SqFt, and the cooling load at the time of customer peak averages 2.50 Watts/SqFt in the summer months, then the peak factor is 2.0.

If the profile type is load-based (Type = 2), then the demand multipliers are used as fractions that convert the load-based intensity value to a set of customer peak demand values by season and period. That is:

$$\text{PEAKKW}_{s,t} = \text{kW} \times \text{DEMAND}_{s,t}$$

where kW is the load-based intensity and $\text{DEMAND}_{s,t}$ is the demand multiplier for the season (s) and period (t). For example, if the intensity value that is input is 2.5

kW per thousand square feet and the customer peak averages 2.5 Watts/SqFt in the summer months, then the demand multiplier for the summer on-peak period is 1.0.

- ***SysDemand[N].*** Within each season and time-of-use period, the system peak multiplier is used to compute load at the time of system peak within each season and period. If the profile type is energy based (Type = 1), then the peak multipliers are applied to the customer peak demand values. This provides an adjustment for coincidence between the customer load at the time of system peak and the average customer peak demand in the season and period. In this case, the customer contribution to system peak is computed as follows:

$$\text{SysPeakKW}_{s,t} = \frac{\text{kWh}_{s,t}}{\text{Hours}_{s,t}} \times \text{Demand}_{s,t} \times \text{SysDemand}_{s,t}$$

where $\text{kWh}_{s,t}$ is energy consumption in the season and period, $\text{Hours}_{s,t}$ is the number of hours in the season and period, $\text{Demand}_{s,t}$ is the inverse load factor used as the demand multiplier, and $\text{SysDemand}_{s,t}$ is the system demand multiplier.

If the profile type is load-based (Type = 2), then the system demand multipliers are applied directly to the load-based intensity value. That is:

$$\text{SysPeakKW}_{s,t} = \text{kW} \times \text{SysDemand}_{s,t}$$

where kW is the load-based intensity and $\text{SysDemand}_{s,t}$ is the system demand multiplier for the season (s) and period (t). For example, if the intensity value that is input is 2.5 kW per thousand square feet and the customer demand at time of system peak is 2.0 Watts per square foot, then the system demand multiplier is .80.

5.2 Segment Data

This table defines market segments and provides a variety of data about each segment, including data about total segment size and new construction levels. Also, links are provided to electric and gas Usage Profiles for the segment and to electric and gas rates for the segment. In other sections of the program, segment names are used to link the segment data to technology data and adoption models.

The Segment Data table is part of the input database. The table contains one record for each segment. The record layout is depicted in Table 5-2. Individual data elements are as follows:

- ***Segment Name [S].*** The segment name is a 16-character string used to identify segment. This string must be unique within the table. The segment name is used in other sections of the program, providing a link to the data for that segment.

- ***Area [S].*** The area identifier is a 16-character string used to identify a planning area, climate zone, or other geographic indicator.

- ***Sector [S].*** The sector identifier is a 16-character string used to identify the analysis sector. Typical values are RES for residential, COM for commercial, IND for industrial, AG for agriculture, etc.

- ***Size Units [S]***. These units provide an 16-character label for the size measure used for a segment. Typically, segment size is measured in number of homes for residential, thousands of square feet for commercial, and millions of dollars of output for industrial. The label entered here is for identification purposes only.

- ***Typical Size [N].*** This floating point number gives the typical size of a customer in terms of the size units for the segment. Examples would be 1.0 home per customer for residential, 25 ksf per customer for commercial, and $150 million per customer for industrial.

- ***Total Units [E].*** This expression is evaluated each year to determine the total number of units in place for a segment in that year.

- ***New Units [E].*** This expression is evaluated each year to determine the total number of newly constructed units for a segment in that year.

- ***Electric Sales [N].*** This number gives a typical value for total annual electric consumption for a segment in MWh per year per segment unit. For example, for households, this would be entered in MWh per home. For commercial buildings, it would be entered as MWh per thousand square feet (or, equivalently, kWh per square foot).

Table 5-2 Layout for Customer Segment Data

	Variable	Example Data
1	***Segment ID***	
☑	Segment[S] (e.g. Smo, Lgo, Rst, SF)	SF
☑	Area[S] (e.g. PA1, CA1, All)	All
	Sector[S] (e.g. Res, Com, Ind, Agr, Oth)	Res
2	***Customer Segment Data***	
	Size Units[S] (e.g. homes, ksf, $M, gWh)	Homes
	Typical Size[N] (e.g. 1.0, ksf, $M, gWh)	1.0
	Discount Rate[E] (Variable or expression)	11%
	Total Units[E] (Variable or expression)	sfTotal
	New Units[E] (Variable or expression)	sfNew
	Electric Sales[N] (Typical Annual Sales in mWh)	9.0
⇦	Electric Profile[S] (Usage profile label)	sfElec
⇦	Electric Rate[S] (Rate label)	resElec
	Gas Sales[N] (Typical gas use in mmBtu)	10.0
⇦	Gas Profile[S] (Usage profile label)	sfGas
⇦	Gas Rate[S] (Rate Label)	resGas
	Electric Heating Average Share[E]	
	Electric Heating New Share[E]	
	Gas Heating Average Share[E]	
	Gas Heating New Share[E]	
	Electric Heating Efficiency[E]	
	Gas Heating Efficiency[E]	
	Electric Cooling Average Share[E]	
	Electric Cooling New Share[E]	
	Gas Cooling Average Share[E]	
	Gas Cooling New Share[E]	
	Electric Cooling Efficiency[E]	
	Gas Cooling Efficiency[E]	
☑ Key Field in Table, ⇦ Reference to another record		

- ***Electric Profile [S].*** This 16-character string identifies the electric usage profile for the segment. The profile that is assigned should be an energy-based profile (Type 1) that reflects the typical electricity usage pattern at the whole-building level.

- ***Electric Rate [S].*** This 16-character string identifies the rate that would be used to compute whole-customer bills based on the electric profile.

- ***Gas Sales [N].*** This number gives a typical value for annual natural gas consumption in a segment. Data are entered in million British Thermal Units (mmBtu per year) per segment unit (e.g., per thousand square feet).

- ***Gas Profile [S].*** This 16-character string identifies the gas usage profile for the segment. The profile that is assigned should be an energy-based profile (Type 1) that reflects the typical gas usage pattern at the whole-building level.

- ***Gas Rate [S].*** This 16-character string identifies the rate that would be used to compute whole-customer gas bills based on the gas profile.

- ***Electric Heating Average Share [E].*** This expression gives the fraction of existing space that is heated with electricity. The value should be entered as a decimal fraction (e.g., fifty percent should be entered as .50). This value is used in the computation of measure interactions with electric heating system energy use.

- ***Electric Heating New Share [E].*** This expression gives the fraction of new space that is heated with electricity. The value should be entered as a decimal fraction (e.g., fifty percent should be entered as .50). This value is used in the computation of HVAC interactions in new construction.

- ***Gas Heating Average Share [E].*** This expression gives the fraction of existing space that is heated with natural gas. The value should be entered as a decimal fraction (e.g., eighty percent should be entered as .80). This value is used in the computation of measure interactions with gas heating system energy use.

- ***Gas Heating New Share [E].*** This expression gives the fraction of existing space that is heated with electricity. The value should be entered as a decimal fraction (e.g., fifty percent should be entered as .50). This value is used in the computation of HVAC interactions in new construction.

- ***Electric Heating Efficiency [E].*** This expression gives the mechanical efficiency of electric heating equipment. It is entered as an average coefficient of performance (COP) value, such as 1.0 for electric resistance systems. This value is used in the computation of measure interactions with electric heating systems.

- ***Gas Heating Efficiency [E].*** This expression gives the mechanical efficiency of gas heating equipment. It is entered as an average coefficient of performance

(COP) value, such as .75. This value is used in the computation of measure interactions with gas heating systems.

- ***Electric Cooling Average Share [E].*** This expression gives the fraction of existing space that is cooled with electricity. The value should be entered as a decimal fraction (e.g., ninety percent should be entered as .90). This value is used in the computation of measure interactions with electric cooling systems.

- ***Electric Cooling New Share [E].*** This expression gives the fraction of new space that is cooled with electricity. The value should be entered as a decimal fraction (e.g., ninety percent should be entered as .90). This value is used in the computation of HVAC interactions in new construction.

- ***Gas Cooling Average Share [E].*** This expression gives the fraction of existing space that is cooled with natural gas. The value should be entered as a decimal fraction (e.g., five percent should be entered as .05). This value is used in the computation of measure interactions with gas cooling equipment.

- ***Gas Cooling New Share [E].*** This expression gives the fraction of existing space that is cooled with electricity. The value should be entered as a decimal fraction (e.g., three percent should be entered as .03). This value is used in the computation of HVAC interactions in new construction.

- ***Electric Cooling Efficiency [E].*** This expression gives the mechanical efficiency of electric cooling equipment. It is entered as an average coefficient of performance (COP) value, such as 2.5. This value is used in the computation of measure interactions with electric heating systems.

- ***Gas Heating Efficiency [E].*** This expression gives the mechanical efficiency of gas cooling equipment. It is entered as an average coefficient of performance (COP) value, such as .60. This value is used in the computation of measure interactions with gas cooling systems.

5.3 Adoption Models

This database table provides links to the models that are used to determine technology adoption rates. The Adoption Models table provides a reference name and a full path and file name for each model file. The models themselves, which are discussed below, are contained in external ASCII text files. As discussed in Section 8, models are assigned to competition groups in the Technology Adoption Data table using the model names entered here.

The Adoption Models table contains one record for each model. The record layout is depicted in Table 5-3. Individual data elements are as follows:

- ***Model Name [S].*** The variable name is a 16-character string that identifies a specific model. This name is used on the Technology Adoption records to assign a model to a competition group.

- ***Path/Filename [S].*** This 255-character string must contain a valid directory, path, and filename. The filename must identify an existing ASCII file that contains a valid model format and has an .MOD extension.

Table 5-3 Layout for Adoption Models Table

	Field	**Example Data**
☑	Model Name [S]	ResNLogitRef
	Path\Filename [S]	C:\ASSET\Models\ResRef.MOD
☑ Key Field in Table		

Each adoption model file contains a complete set of model equations for computing technology adoption rates and program participation levels. Five types of models are supported in the code.

- ***Multinomial Share (MULS).*** This framework uses a nested specification to model equipment option shares and program participation rates. It can be used to implement nested or multinomial logit models or other comparable share systems. This framework is designed to be used for modeling the following:

  -- equipment decisions in new construction

  -- equipment decisions at time of replacement.

  The equations for option shares and program participation are calibrated to initial shares, if control values are available.

- ***Multinomial Conversion (MCON).*** This framework uses a nested specification to model the rate of conversion, the fraction that goes to each conversion option, and program participation for each conversion option. This framework is designed to be used for modeling the following:

  -- Prefailure equipment conversion decisions, and

  -- Equipment acquisition decisions.

  The conversion rate equations, option share equations, and participation rate equations are calibrated to initial rates and shares, if control values are available.

- ***Binary Penetration (BPEN).*** This framework uses a nested binary specification to model device penetration levels. It can be implemented as a one-level binary logit, a binary nested logit, or other comparable binary share systems. This framework is designed to be used for modeling the following:

  -- Device penetration levels in new construction,

  -- Device replacement rates at the time of failure or burnout, and

  -- Load management program retention rates.

  The share models and participation equations are calibrated to initial rates, if control values are available.

- ***Binary Retrofit (BRET).*** This framework uses a nested specification to model the probability of adding a device or of taking a retrofit action, as well as program participation at the time of retrofit. This framework is designed to be used for modeling the following:

  -- Device acquisition, and

  -- Load management program participation gains.

  The retrofit rate equations and participation rate equations are calibrated to initial rates and shares, if control values are available.

- ***Potential/Diffusion (PD).*** With this two-step approach, market potential is estimated in a first step, based on the economics of a technology option, and diffusion toward this potential is modeled in a second step. This model applies separately to each measure, and can be used to model the following:

  -- Equipment decisions in new construction,

  -- Equipment replacement decisions,

  -- Equipment conversion decisions, and

  -- Device acquisition decisions.

  Unlike the other models, PD models are not calibrated, and when a technology is eligible for an incentive, the program participation rate is assumed to be 100% for all purchases of technologies covered by a program.

The intended use of the models is depicted in Table 5-4. This table shows the modeling frameworks that are available for each type of decision. Separate columns are provided for equipment and devices. Equipment decisions are always modeled using share systems that apply to equipment competition groups, where each group has a base technology. In contrast, devices are modeled individually using binary models. Finally, load management decisions also use binary models.

Each model is contained in a separate file, and each file contains ASCII text that defines the model structure and its equations. Models are attached to competition groups on the Technology Adoption records, which are discussed in Section 8.

The following subsections provide a description of the structure and the allowable syntax for the input files containing each type of adoption model, as well as the mathematical logic used in each modeling framework.

Table 5-4: Modeling Framework by Decision Type and Measure Type

Decision Type	**Modeling Framework**	**Equipment**	**Devices**
Replace on Burnout	PD -- Potential/Diffusion	✓	✓
	MULS -- Multinomial Share	✓	
	BPEN -- Binary Penetration		✓
Equipment Conversion	PD -- Potential/Diffusion	✓	
	MCON -- Multinomial Conversion	✓	
Device Acquisition	PD -- Potential/Diffusion		✓
	BRET -- Binary Retrofit		✓
New Construction	PD -- Potential/Diffusion	✓	✓
	MULS -- Multinomial Share	✓	
	BPEN -- Binary Penetration		✓
			Load Mgmt
Load Management	BRET -- Participant Gain		✓
	BPEN -- Participant Retention		✓

.1 Equation Syntax

Each of the adoption models allows the user to enter algebraic equations. Each equation is of the general form:

"Y = F(Variables);"

The left-hand side provides the name of the "local variable" that will be created when the right-hand expression is evaluated. The right-hand expression can contain the following functions and operators:

- Standard Functions
  - -- Log(x)
  - -- Exp(x)
  - -- Min(x1, x2, x3, etc.)
  - -- Max(x1, x2, x3, etc.)

- Specialized Functions
  - -- Trend(year1, value1, year2, value2)
  - -- Logit(year1, value1, year2, value2)
  - -- LL(T,R,P)

- Operators
  - -- Arithmetic (+, -, *, /)
  - -- Powers (**)
  - -- Logical (=, >, <, >=, <=)
  - -- Logical And (&) and Or (|)

The specialized functions operate as follows:

- ***Trend.*** The trend function provides linear interpolation capabilities. Outside the year range (year1 to year2) this function evaluates to zero. Within the year range, the result is between value1 and value2, depending on the year in which it is evaluated.

- ***Logit.*** The logit function provides S-curve modeling capabilities. The function solves for the unique binary logit that goes through Value1 in Year1 and Value2 in Year2. The parameters of this binary logit are used to compute a value for the year in which the function is evaluated. The numerical values for Value1 and Value2 must be greater than 0.0 and less than 1.0.

- ***LL.*** This function evaluates a Lawrence-Lawton diffusion curve. For a given time from introduction (T), and given a value for the diffusion rate parameter (r) and the prior adoption fraction (p), this function is evaluated as follows:

$$LL(T,r,p) = \frac{1+p}{\left(1 + \frac{1}{p} \times e^{-r \times T}\right)} - p$$

.2 Variables Available in Model Equations

As indicated above, model equations can be constructed using basic functions and operators and variables that have numerical values in each year of the simulation. ASSET provides access to global variables, such as exogenous variables defined by the user, and also provides a set of variables computed internally, and made available through reserved words, such as *Payback*, which indicates the simple payback on a measure. The following variables are available in the model equations:

- -- Years (Year, BaseYear)
- -- Exogenous Variables
- -- Global Parameters
- -- Run Logical Variables (Run1, Run2, EconRun, TechRun)
- -- Cost Variables (Cost, EqCost, OpCost, IncCost, Savings)
- -- Program Variables (Rebate, FinAmt, Points, FinPmt)
- -- Combined Cost Variables (Payback, Lcc, LevCost
- -- Inclusive Term (Sum)
- -- Program Eligibility (ProgElig)
- -- Payback Requirements Distribution (PBReq)
- -- Local Parameters (B1 to B5)

- ***Years (Year, BaseYear).*** These two variables give the numerical value of the current simulation year (*Year*) and the value of the base year. For example, if the base year is 1995 and the current simulation year is 2000, the expression

  "Time = Year-BaseYear"

  will evaluate to 5. The year variable is often used in logical expressions as a binary toggle, as in (*Year>2002*).

- ***Exogenous Variables.*** These variables are identified by using the variable name assigned in the Exogenous Variable Table, as discussed in Section 4.B.

- ***Global Parameters.*** Global parameters are included in equations using the name assigned in the Global Parameters Table, as discussed in Section 4.C.

- ***Run Logical Variables (Run1, Run2).*** These logical variables evaluate to 1.0 when true and to 0.0 when false. They can be used as multipliers to "toggle" between specifications or parameter values in the two model runs.

- ***Cost Variables (Cost, EqCost, OpCost, IncCost, IncEqCost, Savings).*** Four basic cost variables are constructed by the program based on inputs in the Technology Data Table and the Adoption Data Table. Variable values are context sensitive. For example, when equations are evaluated that apply to the third option in a competition group, the term *COST* will contain the value for option 3 in the year of evaluation. All cost variables are computed in real dollars per unit of size for the segment (that is, per home, per thousand square foot, etc.). Key words are as follows:

  -- ***COST*** -- Installed cost, including equipment and labor costs.
  -- ***EQCOST*** -- Equipment cost
  -- ***OPCOST*** -- Operating cost, including energy bills and maintenance
  -- ***INCCOST*** -- Incremental cost of measure, including equipment and labor
  -- ***INCEQCOST*** -- Incremental equipment cost
  -- ***SAVINGS*** -- Gross bill savings and maintenance cost savings for the measure.

  Note that for equipment options in a competition group, the *COST* is the full cost of a specific option, and *INCCOST* is the incremental cost of an option above the cost of the base option in the group. For devices, the term *COST* and *INCCOST* have the same value.

- ***Program Variables (Rebate, FinAmt, Points, FinPmt).*** To allow inclusion of variables related to utility programs, four program variables are computed. All program variables are computed in real dollars per unit of size for the segment (that is, per home, per thousand square foot, etc.). Key words are as follows:

  -- ***REBATE*** -- Initial rebate amount
  -- ***FINAMT*** -- Total amount financed
  -- ***POINTS*** -- Points charged on loan
  -- ***FINPMT*** -- Annual payment for loan.

  Separate values are computed for each program assigned to an option. The active value at the time an equation is evaluated is determined by the context of the evaluation. For example, if an equation is being evaluated that relates to participation in the first program for the second technology option, the term *REBATE* will contain the initial rebate amount in the year of evaluation for that program applied to that option.

- ***Combined Cost Variables (Payback, Lcc, LevCost).*** In addition to the direct cost variables discussed above, three additional variables are computed that indicate the attractiveness of an individual option or group of options. All combined cost variables are computed in real dollars per unit of size for the segment (that is, per home, per square foot, etc.). Key words are as follows:

-- ***PAYBACK*** -- Simple payback on a measure
-- ***LCC*** -- Live cycle cost
-- ***LEVCOST*** -- Levelized cost.

The life-cycle costs and levelized costs are computed for one complete measure life. For life-cycle cost, present values are computed using the discount rate that is assigned on the Technology Adoption record for a measure. This discount rate is also used to compute the capitalization factor used in the levelized cost computation. In these computations, all capital outlays are assumed to occur at the beginning of a year, and operating costs are assumed to occur at the midpoint of each year.

The combined cost variables are computed both with and without program factors. The active value at the time of evaluation is determined by the context of the evaluation. Further, these cost variables can be used at two different analysis levels. The first and most detailed level involves a specific technology and program participation state. The second is more aggregate and applies at the technology option level.

When evaluated in the context of a participation equation for a specific program, these values are computed to include the incentives available in that program. The payback variable is adjusted for initial rebate amounts, and the life-cycle and levelized cost variables are adjusted to include rebate and financing effects.

When evaluated at the technology option level, these variables are computed as the weighted average of the values in each participation state, where participation shares are used as the weights. For example, if nonparticipants purchase 10% of an option in a year, and participants in the first program purchase 90% of that option, the ***PAYBACK*** for the option is computed from the ***PAYBACK*** without incentives (10% weight) and the ***PAYBACK*** with program-1 incentives (90% weight).

- ***Inclusive Term (Sum).*** For execution of "Nested Logit" systems, ASSET automatically computes inclusive terms that can be used at the upper levels of the system. This value is context sensitive. For example, if the keyword *Sum* appears in an equation that is evaluated for technology option 3 in a system, the value of *Sum* will be the equations assigned to the three participation branches for that option (NP+P1+P2).

- ***Program Eligibility (ProgElig).*** The value of this variable is determined by the product of the program availability and the program eligibility variables. It is referenced through the reserved word *ProgElig*. Typically, if the program is active and the technology is eligible for incentives under the program, then this variable has a value of 1.0.

- ***Payback Requirements Share (PBReq).*** On the Technology Adoption records, a distribution name can be passed to the adoption model. This distribution can be used to evaluate market potential, through the keyword, *PBREQ*. As described in Section 4.5, this keyword returns the interpolated value of the cumulative distribution for a given payback value. This result represents the fraction of the population that is willing to accept a payback that is as long or longer than the given value.

  Payback has different values depending on the level at which it applies. As a result, *PBREQ* also has different values, depending upon the context in which it is used. When evaluated in the context of a participation equation for a specific program, the distribution is applied to the payback including adjustment for incentives available in that program. When evaluated on the nonparticipant branch, the distribution is applied to the normal payback based on equipment cost and savings, without the influence of incentives. When evaluated at the technology option level, the distribution is applied to the weighted average of the payback values in each participation state, where participation and nonparticipant shares are used as the weights.

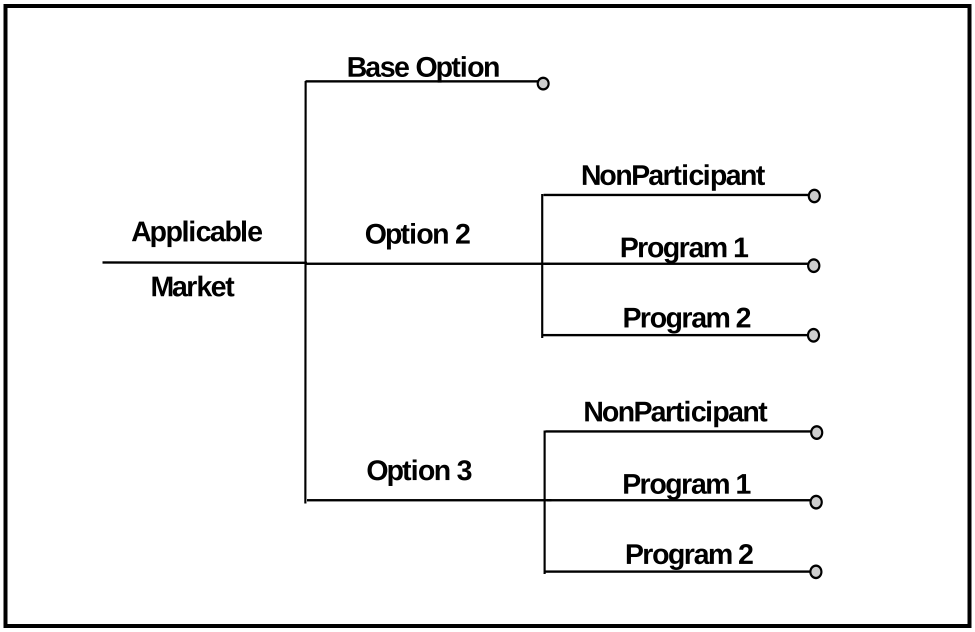
- ***Local Parameters (B1 to B5).*** On the Technology Adoption records, a set of five parameters can be passed to the adoption model. These parameters are referenced within the model using the reserved words *B1, B2, B3, B4,* and *B5*.

.3 Multinomial Share Model (MULS)

Multinomial share models are intended to be used for modeling of equipment competition groups with two or more options. This type of model should be used for event-driven decisions, including new construction decisions and equipment replacement decisions.

The structure of the problem addressed by multinomial share models is depicted in Figure 5-2. In the variable assignment portion of the input file for this type of model, a variable is required for each of the labeled branches.

Figure 5-1: Structure of Multinomial Share Model



Examples of input files for a MULS model are presented in Table 5-5 and Table 5-6. As seen in the examples, these files have three areas: (a) a header area, which defines the model type and the model structure, (b) an equation area, where model parameters and variables are combined into the model equations, and (c) a variable assignment area, where variables are assigned to specific modeling tasks.

- ***Model Type.*** The model type determines the structure of the model equation assignment table. For multinomial share models, the model type must be MULS.
- ***Number of Options.*** This input value gives the number of equipment options in the competition group. In the bottom part of the file, there will be one set of variable assignments required for each equipment option.
- ***Program Flags.*** For each equipment option, the program flags indicate the number of programs that apply to that option. This may be 0, 1, or 2. This flag

determines the number of participation variables that are expected in variable assignment area for each option.

-- If the program flag is 0, there are no participation variables.

-- If the program flag is 1, there are two variables, the first applying to nonparticipation (NP) and the second applying to participation in the first program (P1).

-- If the program flag is 2, there are three variables, the first applying to nonparticipation (NP) and the remaining two applying to participation in the two programs (P1 and P2).

- ***Number of Equations.*** This integer value defines the number of equations that are contained in the equation block. If there are no equations, enter 0.

- ***Equations.*** The equations are algebraic expressions. The equation syntax and special functions are defined above in Section 5.3.1. Variables available in the modeling framework are discussed above in Section 5.3.2.

- ***Variable Assignment.*** Two types of variable assignments are required. First, one share variable is required for each option in the competition group. Second, for any option that is covered by programs, participation variables are required. If there is one program, a nonparticipation variable (NP) and a program participation variable (P1) are required. If there are two programs, two participation variables (P1 and P2) are required.

-- ***Option Share Variable.*** This variable is used in the upper level share system. The share for an option is given by the ratio of the value of this variable to the sum of the values of variables assigned to all of the options in the competition group.

If the term *SUM* is used in an equation referenced by the option share variable, it is interpreted as the sum of the variables assigned to participation modeling (NP + P1 + P2). If cost terms are used in an equation that defines the option share variable, they are assigned the weighted average of the cost values outside of programs and within programs, where participation shares are used as the weights.

-- ***Participation Variables.*** The variables assigned to nonparticipation (NP) and participation (P1 and P2) are evaluated, and the share of each participation state is determined by the ratio of the corresponding variable to the sum of the variables.

In the first example, there are three technology options in the competition group, and the second and third options are covered by rebate programs. The decision model is a nested logit, with an inclusive term from the participation model coded using the reserved word *SUM*.

Table 5-5: Multinomial Share Model (MULS) -- Example 1

```
"MULS"                 ; Model Type
3                      ; Number of Options
0                      ; Program Flag for Option 1
1                      ; Program Flag for Option 2
1                      ; Program Flag for Option 3

; Model Equations
10                     ; Number of Equations

"A = -10;"
"B = A/Discount;"
"Lam = 1.2;"
"Opt1Eqn   = Exp(0.0  +  A * Cost  +  B * OpCost);"
"Opt2Eqn   = Sum ** Lam;"
        "npEqn2   = Exp((0.0 + A * Cost  +  B * OpCost)/Lam);"
        "pEqn2    = Exp((0.0 + A * (Cost-Rebate)  +  B * OpCost)/Lam);"
"Opt3Eqn   =  Sum ** Lam;"
        "npEqn3   = Exp((0.0 + A * Cost  +  B * OpCost)/Lam);"
        "pEqn3    = Exp((0.0 + A * (Cost-Rebate)  +  B * OpCost)/Lam);"

; Equation Assignments
Opt1Eqn                      ; Option 1
Opt2 Eqn                     ; Option 2
        npEqn2               ; Option 2 -- NP
        pEqn2                ; Option 2 -- P1
Opt3Eqn                      ; Option 3
        npEqn3               ; Option 3 -- NP
        pEqn3                ; Option 3 -- P1
```

In the second example, there are two technology options, and the second option is covered by two programs. The first is a standard rebate program, and the second is based on financing. The coefficient on the finance amount is constrained to be the same as the cost parameter and the coefficient on annual payments is constrained to be the same as the operating cost parameter. In this example, instead of directly coding the parameter values in the equation section, the equations assign parameters based on data elements (B1 and B2) passed into the model on Technology Adoption records.

Table 5-6 Multinomial Share Model (MULS) -- Example 2

```
"MULS"                  ; Model Type
2                       ; Number of Options
0                       ; Program Flag for Option 1
2                       ; Program Flag for Option 2

; Model Equations
8                       ; Number of Equations

"A = B1;"
"B = A/Discount;"
"Lam = B2;"
"Opt1Eqn   = Exp(0.0  +  A * Cost  +  B * OpCost);"
"Opt2Eqn   = Sum**Lam;"
        "npEqn2 = Exp((A * Cost  +  B * OpCost)/Lam);"
        "p1Eqn2 = Exp((A * (Cost-Rebate)  +  B * OpCost)/Lam);"
        "p2Eqn2 = Exp((A * (Cost-FinAmt) +  B * (OpCost+FinPmt))/Lam);"

; Equation Assignments
Opt1Eqn                         ; Option 1
Opt2Eqn                         ; Option 2
        npEqn2                  ; Option 2 -- NP
        p1Eqn2                  ; Option 2 -- P1
        p2Eqn2                  ; Option 2 -- P2
```

ASSET Logic for MULS Models. In ASSET, the values of the assigned variables are combined with information about market size and screening ratios to determine the market share and technology adoption rate in a particular year. MULS models apply to equipment competition groups in new construction and replacement decisions. In both cases, market size is given internally by the level of new construction or by the amount of equipment decay for the group.

In ASSET, the market share for a technology in a year is simulated internally based on the value of the variables assigned to the following:

- The values of the variables assigned to each option (OPTVAR)
- Values of variables assigned to participation decisions (NPVAR, P1VAR, P2VAR)
- Market size (denoted below by MARKET),
- The applicability fraction (denoted below by APP), and
- The product of awareness, willingness, and availability screens (SCREEMULT).

Given these data, adoptions for a given technology are computed as follows:

$$\mathrm{ADOPT}_{i,t} = \mathrm{MARKET}_t \times \mathrm{APP}_t \times \mathrm{PEN}_{i,t}$$

where the annual penetration (PEN) is the fraction of total equipment purchases accruing to the equipment option. Formally, the annual penetration for equipment option i is defined as follows:

$$\mathrm{PEN}_{i,t} = \frac{k_i \times \mathrm{SCRNMULT}_i \times \mathrm{OPTVAR}_i(*)}{\sum_{j=1}^{N} k_j \times \mathrm{SCRNMULT}_j \times \mathrm{OPTVAR}_j(*)}$$

In this expression, the k terms are calibration constants. These constants are computed in the first simulation year to adjust the computed share of the applicable market to equal the control value that is entered on the technology adoption record for the technology. If no control value is entered for a technology, the corresponding calibration constant is set to 1.0.

The SCRNMULT variables are computed to reflect the value of the market screening variables (feasibility, awareness, willingness, and availability). If any of these values are zero, then the SCRNMULT variable is also zero. If all screen values are one, then the SCRNMULT value is one. For intermediate values, this variable is constructed to approximate the result of segmentation into two states, a state where the option is available and a state where it is not.

For each option, the fraction of equipment purchases in each program state is computed using the participation variables. In the case of two programs, the three shares are computed as follows.

$$\text{NPSHARE}_{i,t} = \frac{kNP_i \times \text{NPVAR}_i(*)}{\text{SUM}_{i,t}}$$

$$\text{P2SHARE}_{i,t} = \frac{kP1_i \times \text{P2MULT} \times \text{P1VAR}_i(*)}{\text{SUM}_{i,t}}$$

$$\text{P2SHARE}_{i,t} = \frac{kP2_i \times \text{P2MULT} \times \text{P2VAR}_i(*)}{\text{SUM}_{i,t}}$$

where the SUM term is the sum of the three numerator expressions. That is,

$$\text{SUM}_{i,t} = kNP_i \times \text{NPVAR}_i(*) + kP1_i \times \text{P1MULT} \times \text{P1VAR}_i(*) +$$

$$kP2_i \times \text{P2MULT} \times \text{P2VAR}_i(*)$$

In these expressions, the k terms (kNP, kP1 and kP2) are calibration constants. These constants are computed in the first simulation year to adjust the computed participation shares to equal the control values that are entered on the technology adoption record for the option. If no control values are entered for a technology, the corresponding calibration constant is set to 1.0.

The program multiplier variables (P1MULT and P2 MULT) are computed to reflect the value of program availability and program eligibility variables. If either of these values is zero, then the program multiplier variable is also zero. If both variables have a value of one, then the program multiplier value is one. For intermediate values, the program multipliers are constructed to approximate the result of segmentation into two states, a state where the program is available and a state where it is not.

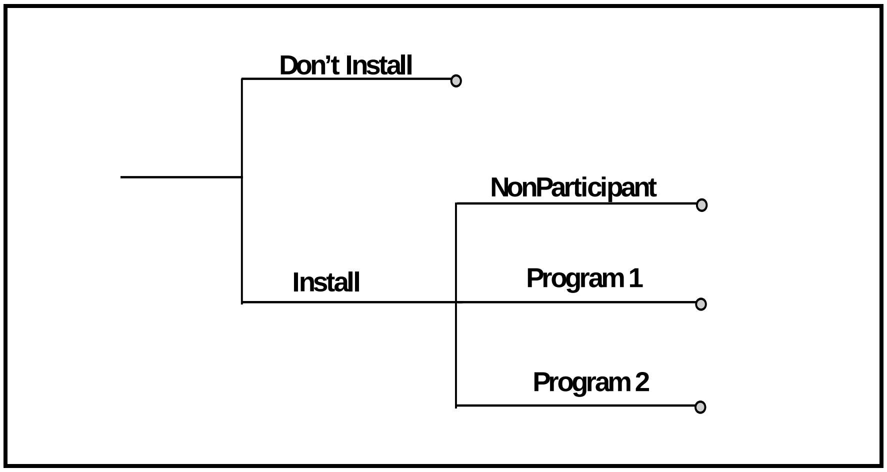
.4 Binary Penetration Model (BPEN)

Binary penetration models are a special case of multinomial share models, where there are only two options. These models are intended to be used for modeling of device purchase decisions, device replacement decisions, and load management retention modeling. In these three cases, the interpretation of the two options is as follows:

- New construction: don't install device vs. install device.
- Replacement on burnout: don't replace device vs. replace device.
- Load management retention: don't stay in program vs. stay in program.

The structure of the problem addressed by binary penetration models is depicted in Figure 5-2. In the variable assignment portion of the input file for this model, a variable is required for each of the labeled branches.

Figure 5-2: Structure of Binary Penetration Model



Examples of input files for a BPEN model are presented in Table 5-5 and Table 5-6. As seen in the examples, these files have three areas: (a) a header area which defines the model type and the model structure, (b) an equation area, where model parameters and variables are combined into the model equations, and (c) a variable assignment area, where variables are assigned to specific modeling tasks.

- ***Model Type.*** The model type determines the structure of the model equation assignment table. For binary penetration models, the model type must be BPEN.

- ***Program Flags.*** The program flag applies to the second option and indicates the number of programs that apply to that option. This may be 0, 1, or 2. This flag determines the number of participation variables that are expected in variable assignment area for each option. See the discussion of MULS models for more details.

- ***Number of Equations.*** This integer value defines the number of equations that are contained in the equation block. If there are no equations, enter 0.

- ***Equations.*** The equations are algebraic expressions. The equation syntax and special functions are defined above in Section 5.3.1. Variables available in the modeling framework are discussed above in Section 5.3.2.

- ***Variable Assignment.*** Two types of variable assignments are required. First, one share variable is required for each of the two decision options. Next, if the second option is covered by programs, participation variables are required. If there is one program, a nonparticipation variable (NP) and a program participation variable (P1) are required. If there are two programs, two participation variables (P1 and P2) are required.

  -- ***Binary Share Variables.*** These variables are used to determine the fraction or decision makers who do install or replace a device versus the fraction who do not. These fractions are given by the ratio of each variable value to the sum of the two values.

  If the term *SUM* is used in an equation referenced by the binary share model, it is interpreted as the sum of the variables assigned at the participation modeling level (NP + P1 + P2). If cost terms are used in equations referenced by the binary share model, they are assigned the weighted average of the cost values outside of programs and within programs, where participation shares are used as the weights.

  -- ***Participation Variables.*** The variables assigned to nonparticipation (NP) and participation (P1 and P2) are evaluated, and the share of each participation state is determined by the ratio of the corresponding variable to the sum of the variables.

In the example, the decision to install or replace is modeled as a function of the Payback on the device involved. There is one program, and a participation share of 1.0 is imposed for all decision makers who install the device.

Table 5-7: Binary Penetration Model (BPEN)

```
"BPEN"              ;Model Type
1                   ;Program flag

; Model Equations
8                   ; Number of Equations

"Alpha  =  B1;"
"Beta  =  B2;"
"ProgEff  =  B3;"
"ProgImp = ProgElig*ProgEff;"

"BaseEqn = 1.0;"
"OptEqn  = exp(alpha + Beta * (PayBack+ProgImp));"

"NPEqn   = 0%;"
"PEqn    = 100%;"

; Equation Assignments
"BaseEqn"                  ; Don't Install/Replace Equation

"OptEqn"                   ; Install/Replace Equation
      "NPEqn"              ; NP Equation
      "PEqn"               ; P Equation
```

ASSET Logic for BPEN Models. In ASSET, the values of the assigned variables are combined with information about market size and screening ratios to determine the penetration rate in a particular year. BPEN models apply to devices in single-item competition groups. In the case of new construction, market size is defined as the applicable fraction of total new construction. In replacement decisions, market size is defined by the amount of the device stock that decays. In load management retention models, a one-year life is recommended, so that market size will be the number of participants from the preceding year.

In ASSET, the binary share for a technology in a year is simulated internally based on the value of the variables assigned to the following:

- -- The values of the variables assigned to the purchase options (NOVAR and YESVAR),
- -- Values of variables assigned to participation decisions (NPVAR, P1VAR, P2VAR)
- -- Market size (denoted below by MARKET),
- -- The applicability fraction (denoted below by APP), and
- -- The product of awareness, willingness, and availability screens (SCREEMULT).

Given these data, adoptions for the covered technology are computed as follows:

$$\text{ADOPT}_t = \text{MARKET}_t \times \text{APP}_t \times \text{PEN}_t$$

where the annual penetration (PEN) is the fraction of applicable market that installs or replaces the technology. Formally, the annual penetration defined as follows:

$$\text{PEN}_t = \frac{k_{yes} \times \text{SCRNMULT}_t \times \text{YESVAR}(*)}{k_{no} \times \text{NOVAR}(*) + k_{yes} \times \text{SCRNMULT}_t \times \text{YESVAR}(*)}$$

In this expression, the k terms are calibration constants. These constants are computed in the first simulation year to adjust the computed adoption fraction to equal the control value that is entered on the technology adoption record for the measure. If no control value is entered for a technology, the corresponding calibration constant is set to 1.0.

The SCRNMULT variable for the technology is computed to reflect the value of the market screening variables (feasibility, awareness, willingness, and availability). If any of these values is zero, then the SCRNMULT variable is also zero. If all screen values are one, then the SCRNMULT value is one. For intermediate values, this variable is constructed to approximate the result of segmentation into two states, a state where the option is available and a state where it is not.

The fraction of device purchases in each program state is computed using the participation variables. In the case of two programs, the three shares are computed as follows.

$$\text{NPSHARE}_t = \frac{kNP \times \text{NPVAR}(*)}{\text{SUM}_t}$$

$$\text{P1SHARE}_t = \frac{kP1 \times \text{P1MULT} \times \text{P1VAR}(*)}{\text{SUM}_t}$$

$$\text{P2SHARE}_t = \frac{\text{kP2} \times \text{P2MULT} \times \text{P2VAR}(*)}{\text{SUM}_t}$$

where the SUM term is the sum of the three numerator expressions. That is,

$$\text{SUM}_t = \text{kNP} \times \text{NPVAR}(*) + \text{kP1} \times \text{P1MULT} \times \text{P1VAR}(*) +$$

$$\text{kP2} \times \text{P2MULT} \times \text{P2VAR}(*)$$

In these expressions, the k terms (kNP, kP1 and kP2) are calibration constants. These constants are computed in the first simulation year to adjust the computed participation shares to equal the control values that are entered on the technology adoption record for the option. If no control values are entered for a technology, the corresponding calibration constant is set to 1.0.

The program multiplier variables (P1MULT and P2 MULT) are computed to reflect the value of program availability and program eligibility variables. If either of these values is zero, then the program multiplier variable is also zero. If both variables have a value of one, then the program multiplier value is one. For intermediate values, the program multipliers are constructed to approximate the result of segmentation into two states, a state where the program is available and a state where it is not.

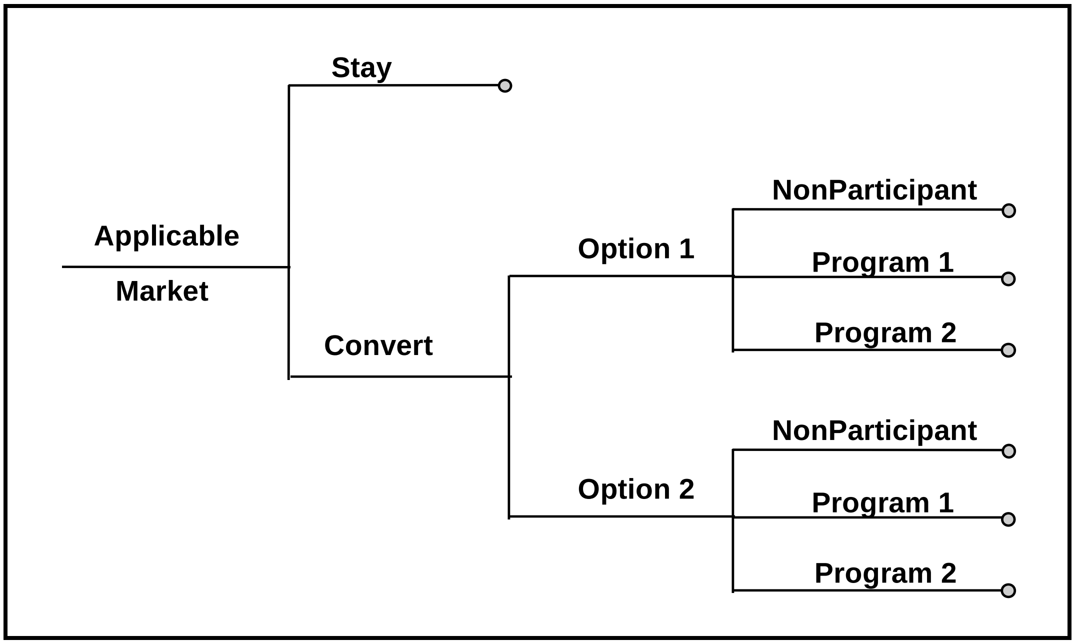
If, in any year, the participation equations all evaluate to zero, then the NP variable is set to one. This will occur whenever the NP variable evaluates to zero and the program variables also evaluate to zero because of the program multiplier variables. For example, in Table 5-7, the NP variable is zero by definition. If the program is not available or the technology is not eligible for the program according to the test variable used for screening, then the numerator of the P1 share equation will also evaluate to zero. In this case, all purchases will be assigned to the NP branch.

.5 Multinomial Conversion Model (MCON)

Multinomial conversion models are intended to be used for modeling of equipment conversion groups. In these groups, there is a base option and one or more conversion options. The conversion rate gives the overall rate of conversion from the base option, and the conversion shares give the share of conversions that go to each conversion option.

The structure of the problem addressed by binary penetration models is depicted in Figure 5-2. In the variable assignment portion of the input file for this model, a variable is required for each of the labeled branches.

Figure 5-3: Structure of Multinomial Conversion Model



Examples of input files for a MCON model are presented in Table 5-8. As seen in the example, these files have three areas: (a) a header area, which defines the model type and the model structure, (b) an equation area, where model parameters and variables are combined into the model equations, and (c) a variable assignment area, where variables are assigned to specific modeling tasks.

- ***Model Type.*** The model type determines the structure of the variable assignment area of the input file. For multinomial conversion models, the model type must be MCON.

- ***Number of Options.*** This input value gives the number of equipment conversion options in the competition group, not counting the base option. In the equation assignment area, there will be one set of variables assigned to model conversion shares and program participation levels for each option, with additional variables assigned to model the overall conversion rate.

- ***Program Flags.*** For each conversion option, the program flags indicate the number of programs that apply to that option. This may be 0, 1, or 2. This flag determines the number of participation variables that are expected in variable assignment area for each option.

  -- If the program flag is 0, there are no participation variables.

  -- If the program flag is 1, there are two variables, the first applying to non participation (NP) and the second applying to participation in the first program (P1).

  -- If the program flag is 2, there are three variables, the first applying to non participation (NP) and the remaining two applying to participation in the two programs (P1 and P2).

- ***Number of Equations.*** This integer value defines the number of equations that are contained in the equation block. If there are no equations, enter 0.

- ***Equations.*** Equations are algebraic expressions. The equation syntax and special functions are defined above in Section 5.3.1. Keyword variables available in the modeling framework are discussed above in Section 5.3.2.

- ***Variable Assignment.*** Four types of variable assignments are required. These occur in the following order:

  -- ***Market Potential.*** One market potential variable is assigned to each conversion option (excluding the base option). These variables are combined with screening factors to identify the option with the largest conversion potential.

  -- ***Group Conversion Variables***. The overall conversion rate for the group of conversion options is determined by a two equation system. The first equation (*STAY*) gives the probability of remaining with the base option and the second equation (*CONVERT*) gives the probability of conversion. Aggregate variables are available in these equations that describe the overall attractiveness of conversion, including:

  - An inclusive term giving the sum of the option share equations (***CONVSUM***),
  - The average cost of conversion (***COST***),
  - The average savings from conversion (***SAVINGS***), and
  - The average simple payback from conversion (***PAYBACK***).

These aggregate variables are computed as weighted averages across the conversion options and participation states, where shares of total conversions and participation states are used as weights.

-- ***Option Share Variables.*** For each conversion option, this variable determines the share of total conversion activity that goes to that option. The share of conversions for an option is given by the ratio of this variable value to the sum of the values for all conversion options in the conversion group.

If the term ***SUM*** is used in an equation that defines the option-share variable, it is interpreted as the sum of the variables from the participation level. If cost terms are used in an equation that defines the option-share variable, they are assigned the weighted average of the cost values outside of programs and within programs, where participation shares are used as the weights.

-- ***Participation Equations.*** The variables assigned to nonparticipation (NP) and participation (P1 and P2) are evaluated, and the share of each participation state is determined by the ratio of the corresponding variable to the sum of the variables.

In the example, there are two conversion options in the conversion group. Both options are covered by rebate programs. Market potential for each option is defined by the payback requirements distribution. For each conversion option, this distribution is passed into the model on the Technology Adoption record, and the value of the distribution is accessed for a given payback through the keywork *PBREQ*.

In the example, the conversation rate is assigned a variable that depends on PAYBACK. In the context of overall conversion, the PAYBACK variable is computed to be the weighted average of the payback values for the two options, where shares of conversion activity are used as weights.

The conversion shares for the two options are determined by the relative life-cycle cost of the options. In the context of the option equations, life-cycle cost is computed as the weighted average with and without program incentives, where participation shares are used as weights. However, in the example, participation shares are set to 1.0 for the first program and 0.0 for nonparticipants, indicating that customers are assumed to participate in utility programs if a conversion action is taken. (Note: In the special case that program eligibility is zero, the cost variables for an option are set to equal costs without programs, regardless of the value of the participation equations.)

Table 5-8 Example of Multinomial Conversion Model (MCON) -- Example 1

```
"MCON"              ; Model Type
2                   ; Number of Options
1                   ; Program Flag for Option 1
1                   ; Program Flag for Option 2

; Model Equations
5                   ; Number of Equations

"Beta   = 0.8;"

"Econ  = PBReq;"

"Stay   = 1.0;"
"Conv   = exp(0.0 - Beta * PayBack);"

"OptEqn = LCC**-5.0;"

; Equation Assignments
"MktPot"                ; Market Potential -- Option 1
"MktPot"                ; Market Potential -- Option 2

"Stay"                  ; Stay Variable
"Conv"                  ; Total Conversion Variable

"OptEqn"                ;Option 1
        "0%"            ; NP - Option 1
        "100%"          ; P1 - Option 1

"OptEqn"                ;Option 21
        "0%"            ; NP - Option 1
        "100%"          ; P1 - Option 1
```

ASSET Logic for MCON Models. In ASSET, the values of the assigned variables are combined with information about market size and screening ratios to determine the conversion rate and the market share for specific conversion options. In equipment conversion groups, market size is defined in terms of the stock of the base technology. ASSET keeps track of total conversion activity since the beginning of the simulation, and defines the size of the remaining conversion market based on cumulative conversion activity.

In ASSET, the conversion rate and the conversion shares for each technology are simulated internally based on the value of the variables assigned to the following:

- -- Variables assigned to estimate market potential for each option (MKTPOT),
- -- The variable assigned to the total conversion rate (CONVVAR),
- -- The variable assigned to nonconversion (STAYVAR),
- -- The variables assigned to each conversion option (OPTVAR)
- -- Variables assigned to model participation for an option (NPVAR, P1VAR, P2VAR),
- -- The stock of the base technology (BASE),
- -- The cumulative amount of conversion in previous years (CUMCONV),
- -- The applicability fraction (denoted below by APP), and
- -- The product of the feasibility awareness, willingness, and availability screens (denoted below by SCREENS).

Given these data, conversions to a given equipment option are computed as follows:

$$\mathrm{ADOPT}_{i,t} = \left(\left(\mathrm{BASE}_t + \mathrm{CUMCONV}_t\right) \times \mathrm{APP}_t \times \mathrm{MAXPOT}_t - \mathrm{CUMCONV}_t\right) \times \mathrm{CONV}_{i,t}$$

In this expression, the term BASE + CUMCONV is provided by stock accounting algorithms in ASSET. It represents the total size of the conversion market, including the amount of the base technology stock and cumulative conversions that have occurred since the beginning of the simulation.

Typically, the applicability fraction (APP) is set to 1.0 for conversion groups, indicating that conversion is applicable by definition within the competition group. The term MAXPOT gives the maximum across all conversion options of the conversion potentials, defined to include the market potential variables and the technology screens (feasibility, awareness, willingness, and availability). Formally, this is defined as follows:

$$\mathrm{MAXPOT} = \underset{i}{\mathrm{Max}}\left(\mathrm{SCREENS}_{i,t} \times \mathrm{MKTPOT}_{i,t}\right)$$

In total, the terms in parentheses define the remaining economic potential for the conversion group. The remaining factor is the conversion rate. This can be written as the following compound ratio, which gives the fraction of remaining potential that converts to a specific conversion option.

$$\mathrm{CONV}_{i,t} = \frac{k_c \times \mathrm{CONVVAR}_i^t}{k_c \times \mathrm{CONVVAR}_i^t + k_s \times \mathrm{STAYVAR}_i^t} \times \frac{k_i \times \mathrm{SCRNMULT}_i \times \mathrm{OPTVAR}_i}{\sum_{j=1}^{N} k_j \times \mathrm{SCRNMULT}_j \times \mathrm{OPTVAR}_j}$$

The left-hand ratio in this expression gives the overall conversion rate. The right-hand ratio gives the fraction of total conversions that go to option i. In the left-hand ratio, the k_c and k_s terms are calibration constants for the overall conversion rate. These constants are computed in the first simulation year to adjust the computed conversion rate to agree with the sum of the control values that are entered on the technology adoption records for the conversion options. If no control values are entered, the corresponding calibration constants are set to 1.0. The two variables, CONVAR and STAYVAR represent the variables assigned to model total conversions and the fraction of the market that does not convert.

In the right-hand ratio, the k factors are calibration constants for the individual options. These constants are computed by ASSET in the first simulation year to adjust the computed conversion share for an option to agree with the control share that is entered on the Technology Adoption record for that option. If no control value is entered for an option, the corresponding calibration constant is set to 1.0.

The SCRNMULT variables in the right-hand ratio are computed to reflect the value of the market screening variables (feasibility, awareness, willingness, and availability) for an option. If any of these values is zero, then the SCRNMULT variable is also zero. If all screen values are one, then the SCRNMULT value is one. For intermediate values, this variable is constructed to approximate the result of segmentation into two states, a state where the option is available and a state where it is not.

The fraction of device purchases in each program state is computed using the participation variables. In the case of two programs, the three shares are computed as follows:

$$\mathrm{NPSHARE}_t = \frac{\mathrm{kNP} \times \mathrm{NPVAR}(*)}{\mathrm{SUM}_t}$$

$$\mathrm{P1SHARE}_t = \frac{\mathrm{kP1} \times \mathrm{P1MULT} \times \mathrm{P1VAR}(*)}{\mathrm{SUM}_t}$$

$$\mathrm{P2SHARE}_t = \frac{\mathrm{kP2} \times \mathrm{P2MULT} \times \mathrm{P2VAR}(*)}{\mathrm{SUM}_t}$$

where the SUM term is the sum of the three numerator expressions. That is,

$$\mathrm{SUM}_t = \mathrm{kNP} \times \mathrm{NPVAR}(*) + \mathrm{kP1} \times \mathrm{P1MULT} \times \mathrm{P1VAR}(*) + \mathrm{kP2} \times \mathrm{P2MULT} \times \mathrm{P2VAR}(*)$$

In these expressions, the k terms (kNP, kP1 and kP2) are calibration constants. These constants are computed in the first simulation year to adjust the computed participation shares to equal the control values that are entered on the technology adoption record for the option. If no control values are entered for a technology, the corresponding calibration constant is set to 1.0.

The program multiplier variables (P1MULT and P2 MULT) are computed to reflect the value of program availability and program eligibility variables. If either of these values is zero, then the program multiplier variable is also zero. If both variables have a value of one, then the program multiplier value is one. For intermediate values, the program multipliers are constructed to approximate the result of segmentation into two states, a state where the program is available and a state where it is not.

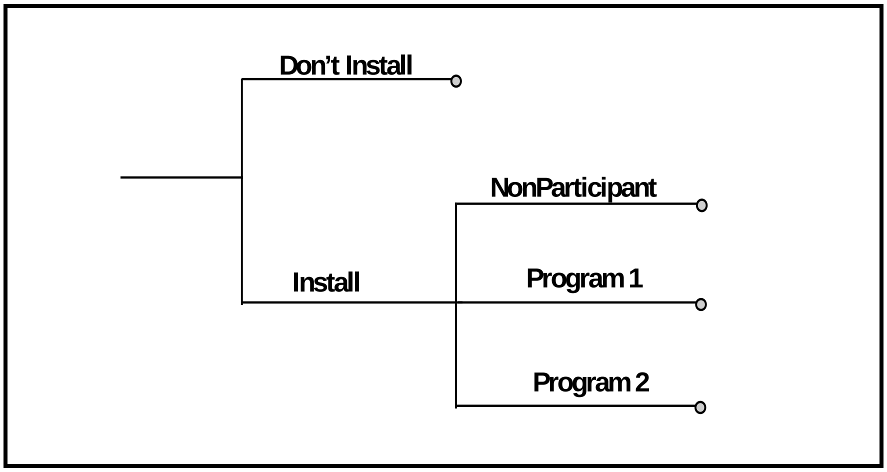
If, in any year, the participation equations all evaluate to zero, then the NP variable is set to one. This will occur whenever the NP variable evaluates to zero and the program variables also evaluate to zero because of the program multiplier variables. For example, in Table 5-7, the NP variable is zero by definition. If the program is not available or the technology is not eligible for the program according to the test variable used for screening, then the numerator of the P1 share equation will also evaluate to zero. In this case, all purchases will be assigned to the NP branch.

.6 5.C.5 Binary Retrofit Model (BRET)

Binary retrofit models are intended to be used for modeling of device acquisition and modeling of gains in load management program participation levels. In the case of device acquisition, the first option is to not acquire and the second option is to acquire. In the case of load management participation, the first option is not to join and the second option is to join.

The structure of the problem addressed by binary retrofit models is depicted in Figure 5-2. In the variable assignment portion of the input file for this model, a variable is required for each of the labeled branches.

Figure 5-4: Structure of Binary Penetration Model



Examples of input files for a BRET model are presented in Table 5-8. As seen in the example, these files have three areas: (a) a header area, which defines the model type and the model structure, (b) an equation area, where model parameters and variables are combined into the model equations, and (c) a variable assignment area, where variables are assigned to specific modeling tasks.

- ***Model Type.*** The model type determines the structure of the variable assignment area of the input file. For binary retrofit models, the model type must be BRET.

- ***Program Flags.*** The program flag applies for the second option (acquire or join), and it gives the number of programs that apply to that option. This may be 0, 1, or 2. This flag determines the number of participation variables that are expected in variable assignment area for each option. See the discussion of MULS models for more details.

- ***Number of Equations.*** This integer value defines the number of equations that are contained in the equation block. If there are no equations, enter 0.

- ***Equations.*** Equations are algebraic expressions. The equation syntax and special functions are defined above in Section 5.3.1. Keyword variables available in the modeling framework are discussed above in Section 5.3.2.

- ***Variable Assignment.*** Three types of variable assignments are required. These occur in the following order:

  -- ***Market Potential.*** This variable is intended to give an estimate of the fraction of the market for which the device meets an economic potential screen. This screen is combined with other screening factors to identify the remaining potential for the device.

  -- ***Retrofit Rate Variables***. The acquisition or retrofit rate is determined by a two equation system. The first equation (*STAYEQN*) determines the fraction of remaining potential that does not acquire the device, and the second equation (*ACQEQN*) gives the probability of acquisition. Aggregate variables are available in these equations that describe the overall attractiveness of the retrofit action, including:

  If the term ***SUM*** is used in an equation that defines the option-share variable, it is interpreted as the sum of the variables from the participation level. If cost terms are used in an equation that defines the option-share variable, they are assigned the weighted average of the cost values outside of programs and within programs, where participation shares are used as the weights.

  -- ***Participation Equations.*** The variables assigned to nonparticipation (NP) and participation (P1 and P2) are evaluated, and the share of each participation state is determined by the ratio of the corresponding variable to the sum of the variables.

In the example, market potential for the device is defined by the payback requirements distribution. This distribution is passed into the model on the Technology Adoption record, and the value of the distribution is accessed for a given payback through the keywork *PBREQ*. In addition, the acquisition rate is modeled to depend on the payback value and on a program effect that is active as long as the device is covered by the program (ProgElig = 1). There is one program, and a participation share of 1.0 is imposed for all retrofit actions. (Note: In the special case that program eligibility is zero, the cost variables for an option are set to equal costs without programs, regardless of the value of the participation equations.)

Table 5-9: Binary Penetration Model (BPEN)

```
; Model Equations
8                        ; Number of Equations

"MPoten = PBReq;"

"Alpha  =  B1;"
"Beta  =  B2;"
"ProgImp = ProgElig*ProgEff;"

"StayEqn = 1.0;"
"AcqEqn  = exp(alpha + Beta * (PayBack+ProgImp));"

"NPEqn   = 0%;"
"PEqn    = 100%;"

; Equation Assignments
"MPoten"                        ; Market Potential

"StayEqn"                       ; Don't Acquire
"AcqEqn"                        ; Acquire
        "NPEqn"                 ; NP Equation
        "PEqn"                  ; P Equation
```

ASSET Logic for BPEN Models. In ASSET, the values of the assigned variables are combined with information about market size, market potential, and screening ratios to determine the penetration rate in a particular year. BRET models apply to devices in single-item competition groups. In these models, market size is defined based on the total existing stock, and the remaining market is defined by subtracting the existing saturation level from the existing market.

In ASSET, the retrofit rate share for a technology in a year is simulated internally based on the value of the variables assigned to the following:

- -- Market size (denoted below by MARKET),
- -- The applicability fraction (denoted below by APP),
- -- The product of awareness, willingness, and availability screens (SCREEMULT),

- -- Variables assigned to estimate market potential for the device (MARKETPOT),
- -- The variable assigned to non conversion (STAYVAR),
- -- The variable assigned to the retrofit or acquisition rate (ACQVAR),
- -- Variables assigned to model participation for an option (NPVAR, P1VAR, P2VAR), and
- -- The saturation level for the measure in the existing stock (SAT).

Given these data, adoptions for the covered technology are computed as follows:

$$\text{ADOPT}_t = \text{MARKET}_t \times \left(\text{APP}_t \times \text{SCREENMULT}_t \times \text{MKTPOT}_t - \text{SAT}_t \right) \times \text{PEN}_t$$

where the annual penetration (PEN) is the fraction of remaining potential that installs or replaces the technology. Formally, the annual penetration is defined as follows:

$$\text{PEN}_t = \frac{k_{yes} \times \text{SCRNMULT}_t \times \text{YESVAR}(*)}{k_{no} \times \text{NOVAR}(*) + k_{yes} \times \text{SCRNMULT}_t \times \text{YESVAR}(*)}$$

In this expression, the k terms are calibration constants. These constants are computed in the first simulation year to adjust the computed adoption fraction to equal the control value that is entered on the technology adoption record for the measure. If no control value is entered for a technology, the corresponding calibration constant is set to 1.0. (Note: The control rate is entered in terms of a share of the applicable market. ASSET converts this conversion rate to be a share of remaining potential in the first year for purposes of calibration.)

The SCRNMULT variable for the technology is computed to reflect the value of the market screening variables (feasibility, awareness, willingness, and availability). If any of these values are zero, then the SCRNMULT variable is also zero. If all screen values are one, then the SCRNMULT value is one. For intermediate values, this variable is constructed to approximate the result of segmentation into two states, a state where the option is available and a state where it is not.

The fraction of device purchases in each program state is computed using the participation variables. In the case of two programs, the three shares are computed as follows:

$$\text{NPSHARE}_t = \frac{\text{kNP} \times \text{NPVAR}(*)}{\text{SUM}_t}$$

$$\text{P1SHARE}_t = \frac{\text{kP1} \times \text{P1MULT} \times \text{P1VAR}(*)}{\text{SUM}_t}$$

$$\text{P2SHARE}_t = \frac{\text{kP2} \times \text{P2MULT} \times \text{P2VAR}(*)}{\text{SUM}_t}$$

where the SUM term is the sum of the three numerator expressions. That is,

$$\text{SUM}_t = \text{kNP} \times \text{NPVAR}(*) + \text{kP1} \times \text{P1MULT} \times \text{P1VAR}(*) +$$
$$\text{kP2} \times \text{P2MULT} \times \text{P2VAR}(*)$$

In these expressions, the k terms (kNP, kP1 and kP2) are calibration constants. These constants are computed in the first simulation year to adjust the computed participation shares to equal the control values that are entered on the technology adoption record for the option. If no control values are entered for a technology, the corresponding calibration constant is set to 1.0.

The program multiplier variables (P1MULT and P2 MULT) are computed to reflect the value of program availability and program eligibility variables. If either of these values is zero, then the program multiplier variable is also zero. If both variables have a value of one, then the program multiplier value is one. For intermediate values, the program multipliers are constructed to approximate the result of segmentation into two states, a state where the program is available and a state where it is not.

If, in any year, the participation equations all evaluate to zero, then the NP variable is set to one. This will occur whenever the NP variable evaluates to zero and the program variables also evaluate to zero because of the program multiplier variables. For example, in Table 5-7, the NP variable is zero by definition. If the program is not available, or the technology is not eligible for the program according to the test variable used for screening, then the numerator of the P1 share equation will also evaluate to zero. In this case, all purchases will be assigned to the NP branch.

.7 Potential/Diffusion Model (PD)

An example of an input file for a PD model is presented in Table 5-10. As seen in the example, the file has three areas: (a) a header area, which defines the model type, (b) an equation area, where model parameters and variables are combined into the model equations, and (c) a variable assignment area, where variables are assigned to specific modeling tasks.

- ***Model Type.*** The model type determines the structure of the variable assignment area. For potential/diffusion models, the model type must be PD.
- ***Number of Equations.*** This integer value defines the number of equations that are contained in the equation block.
- ***Equations.*** The equations are algebraic expressions. The equation syntax and special functions are defined above in Section 5.3.1. Variables available in the PD framework are discussed above in Section 5.3.2.
- ***Variable Assignment.*** Four variable assignments are required. The variables that are assigned can be exogenous variable names, parameter names, numerical values, or local variables created in the equation section of the file.
  - -- ***Market Fraction.*** These fractions are used to pre-allocate the willing market between mutually exclusive options. Since PD models are applied separately to each measure, these fractions must be used when there are mutually exclusive options to prevent option shares from rising above 100%.
  - -- ***Market Potential.*** This variable is evaluated to give the fraction of the willing market for which the option has acceptable economics. This fraction is used to represent market potential.
  - -- ***Program Effect.*** This effect augments the diffusion rate in each year to capture any non-cost impacts or information oriented impacts of utility programs on the rate of technology adoption.
  - -- ***Diffusion Rate.*** The value of this variable defines the diffusion rate in a given year. Usually, the variable assigned here will be linked to a time-driven diffusion function, such as the Lawrence Lawton function.

In the example data in Table 5-10, the pre-allocated market fraction is determined by the fifth parameter (*B5*). Next, the example file uses a payback requirements distribution to determine market potential. As discussed above, the *PRREQ* keyword returns a fraction indicating the percentage of customers in the payback requirements distribution for whom the measure payback is acceptable. The program effect is computed as the product of the third parameter (*B3*) and the program eligibility variable. With this approach, if the technology is eligible for the program incentive in Run1 but not eligible in Run2, then the program effect will only be active in Run1.

Table 5-10: Example of Potential/Diffusion Model (PD)

```
"PD"                    ; Model Type

;Model Equations
8                       ;Number of Equations

"R      = B1;"
"P      = B2;"

"mFrac  = B5;"
"Poten  = PBREQ;"

"ProgEff= B3 * ProgElig;"
"Mature = B4
"T      = Year - BaseYear + Mature - 1;"
"Diff   = LL(T, R, P);"

;Equation Assignments
"mFrac"                       ; Pre-Allocated Market Fraction
"Poten"                       ; Potential
"ProgEff"                     ; Program Effect
"Diff"                        ; Diffusion
```

The diffusion rate is computed using a time-driven Lawrence-Lawton diffusion function (*LL*). This function has three parameters. As described in Section 5.3.1, the first is a time index (T), the second is a diffusion rate parameter (r) , and the third is the initial condition parameter (p). The time index is computed in the local equation list to include technology maturity relative to the current forecast year. Maturity in the base year is passed in as a parameter (*B4*). The diffusion rate parameter (r) is set to the first parameter (*B1*). The initial condition parameter (p) is set to the second parameter (*B2*).

ASSET Logic for PD Models. In ASSET, the values of the four assigned variables are combined with information about market size and screening ratios to determine the market share and technology adoption rate in a particular year. The application of these concepts is different in the event-driven models (new construction and replacement) than it is in the discretionary models (retrofit and conversion).

- In the event-driven models, the cumulative diffusion rate is computed based on the diffusion rate and the program effect, and this share is applied to the applicable market that remains after application of screening variables (feasibility, awareness, willingness, and availability), the market fraction, and the market potential fraction.

- In the discretionary models, adoption levels are computed as the difference between a target stock and the stock in place. The target stock is computed by applying the cumulative diffusion fraction, the market potential fraction, and the market fraction to the relevant market.

These two distinct uses of the model are described more fully below. In ASSET, the market share for a technology in a year is simulated internally based on the value of the variables assigned to the following:

-- The value of the pre-allocated market fraction (denoted below by MKTFRAC),
-- The value of the market potential equation (denoted below by MKTPOTEN),
-- The value of the program effect (denoted PROGEFF), and
-- The value of the diffusion equation (denoted DIFF).

These four values are combined with data for:

-- Market size (denoted below by MARKET),
-- The applicability fraction (denoted below by APP), and
-- The product of the awareness, willingness, and availability screens (denoted below by SCREENS).

PD Models for Event Driven Decisions. Given these data, adoptions for event-driven decisions (new construction and replacement decisions) are computed as follows:

$$\text{ADOPT}_t = \text{MARKET}_t \times \text{APP}_t \times \text{PEN}_t$$

where the annual penetration (PEN) is the fraction of total purchases accruing to the measure or technology. Formally, the annual penetration is defined as follows:

$$\text{PEN}_t = \text{SCREENS}_t \times \text{MKTFRAC}_t \times \text{MKTPOTEN}_t \times \text{CUMDIFF}_t$$

The final element of this annual penetration expression is the cumulative diffusion term. The value of this term is computed by a dynamic simulation based on the value of the diffusion equation and the value of the program effect in each year. In particular, in year t, the share fraction is computed as follows:

$$\text{CUMDIFF}_t = \text{CUMDIFF}_{t-1} + \left(\frac{\text{DIFF}_t - \text{DIFF}_{t-1}}{1 - \text{DIFF}_{t-1}} + \text{PROGEFF}_t \right) * \left(1 - \text{CUMDIFF}_{t-1}\right)$$

In the case of the example shown in Table 5-10, the diffusion effect is computed using a Lawrence Lawton diffusion function, the program effect is a parameter value, which depends on whether the technology qualifies for the program.

PD Models for Discretionary Decisions. For retrofit and conversion models, adoption levels are computed as the difference between the target stock and the stock in place. That is:

$$\text{ADOPT}_t = \text{MARKET}_t \times \text{APP}_t \times \text{SHARE}_t - \text{STOCK}_{t-1}$$

In this expression, the target share (denoted SHARE) is computed based on values of the technology screens (awareness, willingness, and availability), the value of the pre-allocated market fraction (denoted below by MKTFRAC), the value of the market potential equation (denoted below by MKTPOTEN), and the cumulative diffusion rate (CUMDIFF). That is:

$$\text{SHARE}_t = \text{SCREENS}_t \times \text{MKTFRAC}_t \times \text{MKTPOTEN}_t \times \text{CUMDIFF}_t$$

The cumulative diffusion rate is simulated the same way for discretionary decisions as it is for event-driven decisions, based on the value of the diffusion function and the value of the program effect.

6

Utility Data

ASSET inputs files and databases are segmented into four main input areas: (a) Customer Data, (b) Utility Data, (c) Technology Data, and (d) Adoption Data. This section describes inputs in the Utility Data section. The Utility Data section contains the following elements.

- **Utility Cost File.** Inputs in this file include avoided costs, T&D loss factors, and a variety of data required for benefit/cost calculations.
- **Fuel Rate Table and Input Files.** This data table defines a list of fuel and electricity rates that will be available for a model run. For each rate, a reference is provided to an ASCII input file that contains the data values and time-series expressions for the rate elements.
- **DSM Programs Database.** This database contains information about utility incentive programs, including program definitions, program start and end dates, program availability variables, and fixed program costs.
- **DSM Incentives Database.** This database contains information about different types of incentives, including rebates, financing, and shared savings programs. For each incentive, the database identifies the type of incentive and the incentive rule. Also, this database contains expressions for variable program costs.

Each input type is described in detail below.

6.1 Utility Cost File

A single Utility Cost file is used by ASSET. This file is an ASCII that is not included in or accessed through tables in the input database. The path and file name are identified directly in the Setup File. The Utility Cost file contains a variety of input variables related to utility costs and cost/benefit accounting. As shown in Table 6-1, the inputs are partitioned into seven input areas.

1. Inflation and Discount Rates
2. Time-Of-Use Period Definitions
3. Electric Avoided Cost Data
4. Gas Avoided Cost Data
5. Electric T&D Loss Factors
6. Electric Generation Heat Rates
7. System Data for Rate Impacts

Discount Rates. The first section of the Utility Cost file contains discount rates. The discount rates are used to compute present values from the perspective of the Reference Year. Expressions may be entered, implying that the discount rates may vary over time. In ASSET, the value of the discount rate expression in year t is used as the cumulative discount rate for the period between the reference year and year t. Also, mid-year accounting is used for monthly cash flow variables. Reflecting these two conventions, present values in the reference year are computed as follows:

$$PV = \sum_{t=1}^{N} \frac{X_t}{\left(1 + dr_t\right)^{t-.5}}$$

The variables included in this portion of the file are as follows.

- ***Inflation Rate[E].*** This variable is not used in this version of ASSET. All cost and price inputs should be entered in real dollars with reference to a common base year.
- ***Participant Discount Rate[E].*** This discount rate is used to compute present values for the participant test.
- ***Utility Discount Rate[E].*** This discount rate is used to compute present values for the utility cost test.
- ***Discount Rate for RIM Test[E].*** This discount rate is used to compute present values for the rate impact measure.

Table 6-1: Utility Cost File

	Variable	Example Data
1	**Discount Rates**	
	Inflation Rate [E]	Not Used
	Participant Discount Rate [E]	11.0
	Utility Discount Rate E]	11.0
	Discount Rate for RIM Test [E]	11.0
	Discount Rate for TRC Test [E]	11.0
	Social Discount Rate [E]	11.0
2	**Time-Of-Use Period Definitions (Separate data by season)**	
	Months in Season [N]	4
	Peak Hours in Season [N]	540
	Partial Hours in Season [N]	810
	Off Peak Hours in Season [N]	1674
3	**Electric Avoided Cost Data (Separate data by season)**	
	Peak Capacity Cost [E] ($/kW)	5.0 * GenMult
	Partial Capacity Cost[E] ($/kW)	1.2 * GenMult
	Off-Peak Capacity Cost[E] ($/kW)	0.0
	Peak Energy Cost [E] (cents/kWh)	3.5 * ElecMult
	Partial Energy Cost[E] (cents/kWh)	2.2 * ElecMult
	Off-Peak Energy Cost[E] (cents/kWh)	1.3 * ElecMult
	Transmission Cost [E] ($/peak kW)	0.0
	Distribution Cost [E] ($/peak kW)	0.0
	Peak Externality Value [E] (cents/kWh)	.51
	Partial Externality Value [E] (cents/kWh)	.45
	Off-Peak Externality [E] (cents/kWh)	.39
4	**Gas Avoided Cost Data (Separate data by Season)**	
	Peak Energy Cost [E] ($/mmBtu)	2.50
	Partial Energy Cost [E] ($/mmBtu)	2.50
	Off-Peak Energy Cost [E] ($/mmBtu)	2.50
5	**T&D Loss Factors (Separate data by Season)**	
	Peak period demand [E]	9.0%
	Partial period demand [E]	6.5%
	Off-peak period demand [E]	6.2%
	Peak period energy [E]	7.0%
	Partial period energy [E]	6.5%
	Off-Peak period energy [E]	6.2%

Table 6-2: Utility Cost File (Continued)

6	**Electric Generation Heat Rates (Separate data by Season)**	
	Peak Heat Rate [E]	10.5
	Partial Heat Rate[E]	10.5
	Off-Peak Heat Rate [E]	10.5
7	**System Data for Rate Impacts (Separate data each Sector)**	
	Number of Sectors [N] (Must be 1)	1
	Sector Reference [S]	Total
	Sales Forecast [E] (GWh)	Sales
	Revenue Requirements Forecast Per kWh [E] (cents/kWh)	AvgPrice
	Customer Forecast [E] (Thousands)	TotCust

- ***Discount Rate for TRC Test[E].*** This discount rate is used to compute present values for the total resource cost test. It is also used to construct cost variables for technology-level resource cost tests.
- ***Social Discount Rate[E].*** This discount rate is used to compute present values for the societal test.

Time-of-Use Period Definitions. The second section of the Utility Cost file contains a set of definitions for time-of-use periods. ASSET is configured to have 2 seasons with 3 time-of-use periods in each season. For each season, data entered here include the number of months in the season, and the number of hours in each time-of-use period in that season. These data are used to convert data for energy use by season and period into average loads.

Electric Avoided Cost Data. The third section of the Utility Cost file contains avoided cost data for electricity generation, including capacity costs, energy costs, and T&D facility costs. Separate cost expressions are entered for each season. The variables included in this portion of the file are as follows.

- ***Electric Capacity Cost [E].*** The capacity cost represents the incremental cost of additional capacity in each time-of-use period. The expressions entered here are evaluated in each analysis year. The resulting values are expected to be in $ per kW at the point of generation.

- ***Electric Energy Cost [E].*** The energy cost represents the incremental cost of energy in each time-of-use period. The expressions entered here are evaluated in each analysis year. The resulting values are expected to be in cents per kWh generated.

- ***Transmission Cost [E].*** The cost of transmission capacity represents the incremental cost of additional transmission capacity in the peak period. The cost expression is evaluated in each analysis year, and the resulting value is expected to be in $ per kW at the customer level in the peak season and period.

- ***Distribution Cost [E].*** The avoided cost of distribution facilities represents the incremental cost of additional distribution facilities in the peak period. The cost expression is evaluated in each analysis year, and the resulting value is expected to be in $ per kW at the customer level in the peak season and period.

- ***Externality Value [E].*** These represent the value of generation externalities in each time-of-use period. The expressions entered here are evaluated in each analysis year. The resulting values are expected to be in cents per kWh generated.

Gas Avoided Cost Data. The fourth section of the Utility Cost file contains avoided cost data for natural gas. These costs represent the incremental cost of natural gas in each time-of-use period. Separate cost expressions are entered for each season and time-of-use period, and these expressions are evaluated in each analysis year. The resulting value is expected to be in $ per million Btu consumed.

T&D Loss Factors. The fifth section of the Utility Cost file contains transmission and distribution loss factors. Separate sets of loss factors are entered for each season. The loss factors are used to adjust energy amounts from the customer level to the generation level. In ASSET, this transformation is made as follows.

$$\text{GENLEVEL} = \frac{\text{CUSTLEVEL}}{1 - \text{LOSSFACTOR}}$$

The variables in this portion of the file are as follows.

- ***Demand Loss Factors [E]*** These factors represent the T&D loss rates at the time of system peak within each time-of-use period. The percentage value is used to inflate electricity customer loads at the time of peak to generation levels at the time of peak. The loss factors are entered as fractions (e.g., for eight percent enter .08 or 8%).

- ***Energy Loss Factors [E].*** These factors represent the average T&D line loss rates within each time-of-use period. The percentage value is used to inflate electricity consumption levels within a time-of-use period to electricity generation requirements for that period. The loss factors are entered as fractions (e.g., for six percent enter .06 or 6%).

Electric Generation Heat Rates. The sixth section of the Utility Cost file contains data on heat rates in electric generation. These values are used to compute generation level energy input requirements. The data are entered in Btu per Watthour. A typical value is 10.5 Btu/Watthour. Separate values are entered for each season and period.

System Data for Rate Impacts. The final section of the Utility Cost file contains data required to compute rate impacts. These data are used to translate utility costs and revenue losses into corresponding rate increases or to translate utility cost savings and revenue gains into corresponding rate decreases. In the current version, data are entered for the electric utility as a whole, and these data are used to compute overall rate impacts. The data fields are as follows.

- ***Sector Reference[S].*** This field is not currently used, since the rate impact variables are applied for the service territory as a whole.
- ***Sales Forecast[E].*** The sales data should represent a total sales forecast without utility programs. Data are entered in GWh. In ASSET, this forecast is discounted using the RIM discount rate, giving the present value of electricity sales. This present value is used in the denominator of the life-cycle RIM computation.
- ***Revenue Requirements Forecast[E].*** This input is reserved for future use in alternative computations of RIM impacts.
- ***Customer Forecast[E].*** This input is reserved for future use in computation of cost impacts on a per customer basis.

6.2 Fuel Rate Table and Rate Files

Each utility rate is stored in a separate ASCII input file. The input database contains a simple table that defines the list of rates available in the model and that provides the name of the ASCII file that defines the rate element values for each rate. The Rate Table has two fields.

- ***Rate Name [S].*** The rate name is a 16-character string that identifies a specific rate file. This name is used to apply the rate to a specific segment and technology on the Segment/Technology records, which are discussed in Section 7.B.

- ***Path/Filename [S].*** This 256-character string must contain a valid directory, path, and filename that identifies an existing ASCII file. The file must contain valid rate data, and must have a .RAT extension.

Table 6-3 Layout for Rate Table

	Field	Example Data
☑	Rate Name [S]	GSD
	Rate File Path\Filename [S]	C:\Asset\Rates\Gsd.RAT
☑ Key Field in Table		

ASCII Rate Files. Each rate file contains a fuel-type identifier. The remaining inputs provide expressions for rate elements, and separate expressions are allowed for each season. In this version of ASSET, all rates must use a time-of-use format. An example of this format is provided in Figure 6-1. Data elements for the TOU format are as follows.

- ***Fuel [S].*** This field contains a string that has the characters ***Elec*** or ***Gas.***

- ***Fixed Charge [E].*** The fixed charge is the monthly customer charge that is independent of consumption or demand. In each year, the expression value is interpreted as $ per month.

- ***Energy Charge[E].*** The energy charge for a time-of-use period is used to compute energy bills based on kWh consumption in that time-of-use period. The expression value is expected to be in cents per kWh for electricity and $ per million Btu for natural gas.

- ***Peak Charge[E].*** The peak charge for a time-of-use period is used to compute demand charges based on maximum kW in that time-of-use period. These terms apply only to electric rates, and the expression value is expected to be in $ per kW.

Figure 6-1: Example of TOU Rate Format

```
"Elec"    ;Fuel

;Fixed Monthly Charges
"35*GSD"      ;Summer
"35*GSD"      ;Winter

;Energy Charges
;Peak       Partial     Off
"7.5*GSD"   "7.5*GSD"   "7.5*GSD"     ;Summer
"7.5*GSD"   "7.5*GSD"   "7.5*GSD"     ;Winter

;Demand Charges
;Peak       Partial     Off
"8.21*GSD"  "0.0"       "0.0"         ;Summer
"8.21*GSD"  "0.0"       "0.0"         ;Winter
```

6.3 Utility Program Data

The Utility Program table is part of the input database. For each program, the table contains one record containing identifying information, data about program availability, and fixed program costs. Variable program costs are included with the incentive data, as discussed in Section 6.4. The record layout is depicted in Table 6-4.

Table 6-4 Layout for Utility Program Table

	Field	**Example Data**
1	**Program Identification**	GSD
☑	-- Program Name [S]	RHRebate
	-- Start Date [I]	1992
	-- End Date [I]	2000
	-- Description [S]	Res Hardware Reb
	-- Program Avail[E]	100%
2	**Fixed Program Costs**	
	-- Initial Program Costs [E] ($000)	250
	-- Annual Administrative Costs [E] ($000)	100
☑ Key Field in Table		

Program Identification. The program identification section of this table contains the program name and data about program availability. Individual fields in the table are as follows.

- ***Program Name [S].*** The program name is a 16-character string. This name is a key field in the table, and it is used to link the program data to other records. As discussed in Section 8, this name is used in the Technology Adoption records to indicate when a program applies to a specific technology within a competition group.

- ***Start Date [I].*** This integer value gives the initial year of the program. The value must give the full 4-character value of the year (e.g., 1996).

- ***End Date [I].*** This integer value gives the final year of the program. The value must give the full 4-character value of the year (e.g., 2002).

- ***Description [S].*** This 64-character string contains descriptive information about the program. It is used for identifying purposes only.

- ***Program Avail [E].*** This expression is used to provide a program availability profile. This expression is evaluated each year, and the resulting value is used as a program availability multiplier in the program participation models. The expression should be specified so that data values are bounded between zero and one in all simulation years.

Fixed Program Costs. The program cost fields give program costs that are independent of participation levels. The two fields in the table are as follows.

- ***Initial Program Cost [E].*** This cost expression is intended to give the initial setup costs of the program. These cost values are used in the appropriate cost tests for the program, and they are included in the first year of program availability. If this year is before the reference year, the value determined here does not enter the cost-effectiveness tests. The expression is expected to contain real dollar values in thousands of dollars.

- ***Annual Administrative Costs [E].*** This cost expression applies to annual administrative costs. These cost values are used in all program cost-effectiveness tests, other than the participant test. The expression is expected to contain data values in thousands of real dollars.

6.4 Incentive Data

The final data table in the Utility Data section contains a database of incentive formulas and variable cost formulas. For each incentive, the table contains one record. The first field in the record gives incentive identifier, and remaining fields contain expressions for variable program cost elements. The record layout is depicted in Table 6-5.

Table 6-5 Incentive Data

	Variable	Example Data
1	**Incentive ID**	
☑	Incentive Name [S]	Rebate
2	**Incentive Data**	
	Initial Rebate Formula [E] ($/unit)	.5 * IncCost
	Annual Rebate Formula [E] ($/unit)	0.0
	Annual Rebate Term [I] (years)	0.0
	Finance Amount [E] ($/unit)	0.0
	Finance Term [I] (years)	0
	Interest Rate [E] (%)	0.0
	Points [E] (%)	0.0
	Shared Savings Amount[E] ($/unit)	0.0
	Shared Savings Term [I] (years)	0
	Shared Savings Payment [E] ($/unit)	0.0
3	**Variable Program Costs**	
	Initial Variable Cost [E] ($/unit)	$1.15
	Annual Variable Cost [E] ($/unit)	0.0
☑ Key Field in Table		

Incentive Identification. The identification section of this table contains a single field which gives the incentive name. The incentive name is a 16-character string. This name is the key field in this table, and it is used to link the data about incentive levels and variable program costs to other records. As discussed in Section 8, this name is used in the Technology Adoption records to assign the incentives and variable program costs to an individual technology within a competition group.

Incentive Data. The incentive data section of the table contains expressions that give both the type of incentive and a set of formulas that determine the terms and amount of the incentive. In the expressions, several reserved variables are available, including the following:

- -- COST gives the full cost of an option (equipment + installation) per segment unit.
- -- INCCOST gives the incremental cost of a measure per segment unit.
- -- EQCOST gives the equipment cost for an option per segment unit.
- -- INCEQCOST gives the incremental equipment cost of a measure per segment unit.
- -- KW gives the system coincident peak kW savings at the customer meter.
- -- kWh gives the annual kWh impact of a measure.
- -- kBtu gives the annual kBtu impact of a measure.
- -- TECHDENS which gives the technology density per segment unit.

All of these variables are computed by the program in terms of segment units, i.e., $/home, $/ksf, $/$mill. It is possible to express incentives in terms of technology units by multiplying by the measure density (TECHDENS). This value, which is entered on the Seg/Tech table, gives the number of technology units per segment unit. Examples are:

- -- For commercial lighting, fixtures per thousand square feet
- -- For commercial cooling, tons of capacity per thousand square feeet
- -- For manufacturing, horsepower per million dollars of output.

For example, if a commercial air conditioning incentive is $50 per ton of capacity, then enter technology density as tons per thousand square feet of floor space (e.g., 2 tons/ksf), and express the incentive as 50*TECHDENS. This expression will convert the incentive to be $100 per thousand square feet.

The incentive fields are in three parts. The first part is for rebate-type incentives. The second part is for inputs that relate to utility financing. The third part is for shared savings incentives. The specific definitions of each data field are as follows.

- ***Initial Rebate Formula [E].*** This expression gives the initial rebate value, if any, in real dollars. Arguments in the expression can include exogenous variables, parameters, and reserved variables (COST, INCCOST, KW, KWH, KBTU). Because the cost and energy impact variables are measured relative to segment units (homes, ksf, $million), the rebate amounts will also be computed as dollars per segment unit. Examples of valid expressions follow:
  - -- Half of incremental cost: .5 * INCCOST
  - -- Two hundred dollars per KW: 200 * KW
  - -- Three cents per KWH: .03 * KWH

-- Fifty dollars per ton: 50/TECHDENS

- ***Annual Rebate Formula [E].*** This expression gives the annual rebate value, if any, in real dollars. Arguments in the expression can include exogenous variables, parameters, and reserved variables (IC, KW, KWH, KBTU).

- ***Annual Rebate Term [I].*** This integer value gives the number of years that the annual rebate continues. This value can be different from the measure life for the technology to which the incentive is assigned.

- ***Finance Amount [E].*** To activate financing, an expression is entered in this field. The expression gives the finance amount in real dollars. Arguments in the expression can include exogenous variables, parameters, and reserved variables (IC, KW, KWH, KBTU). Because the cost and energy impact variables are measured relative to segment units ($/home, $/ksf, $/$million), the finance amount will also be computed in dollars per segment unit.

- ***Finance Term [I].*** This integer value gives the term in years of the financing arrangement. In the program an annual payment is computed that amortizes the finance amount over the term of the loan. This value can be different from the measure life to which the incentive is assigned.

- ***Interest Rate [E].*** This expression is evaluated to give the real interest rate on a financing incentive. This interest rate is combined with the loan amount and term to compute the annual payment. The annual payment is computed as follows:

$$\text{PAYMENT} = \text{FINAMT} \times \frac{\text{INT}}{1-(1+\text{INT})^{-\text{TERM}}}$$

- ***Points [E].*** This expression is evaluated to give the number of up-front points charged on the finance amount. For example, if this expression evaluates to .015, then the financing charge is computed as 1.5% of the finance amount.

- ***Shared Savings Amount [E].*** To activate shared savings, an expression is entered in this field. The expression gives the loan amount in real dollars. Arguments in the expression can include exogenous variables, parameters, and reserved variables (IC, KW, KWH, KBTU). Because the cost and energy impact variables are in measured relative to segment units ($/home, $/ksf, $/$million), the loan amount will also be computed in dollars per segment unit.

- ***Shared Savings Term [I].*** This integer value gives the term in years of the shared savings repayment period. This value can be different from the measure life of the technology to which the incentive is assigned.

- ***Shared Savings Payment [E].*** This expression gives the annual payment amount. This amount will be paid each year over the term of the shared-savings agreement. Arguments in the expression can include exogenous variables, parameters, and reserved variables (IC, KW, KWH, KBTU). Because the cost and energy impact variables are measured in segment units ($/home, $/ksf, $/$million), the payment amounts will also be computed in dollars per segment unit.

Variable Program Costs. This part of the table contains expressions that give the incremental or variable program costs caused by changes in the level of program participation. Like the incentive expressions, these expressions can include parameters, exogenous variables, and reserved variables including the following:

-- COST gives the full cost of an option (equipment + installation) per segment unit.
-- INCCOST gives the incremental cost of a measure per segment unit.
-- EQCOST gives the equipment cost for an option per segment unit.
-- INCEQCOST gives the incremental equipment cost of a measure per segment unit.
-- KW gives the system coincident peak kW savings at the customer meter.
-- kWh gives the annual kWh impact of a measure.
-- kBtu gives the annual kBtu impact of a measure.
-- TECHDENS gives the technology density per segment unit.

These variables are available to compute variable program costs as described below.

- ***Initial Variable Cost [E].*** This expression gives the incremental program cost of participation in the year of participation. The expression should be specified in real dollars. Arguments in the expression can include exogenous variables, parameters, and reserved variables. Because the cost and energy impact variables are measured in segment units (homes, ksf, $million), the variable cost amounts will also be computed as dollars per segment unit. In the program, these cost amounts are multiplied by the participation level, which is also measured in segment units.

- ***Annual Variable Cost[E].*** This expression gives the on-going annual variable costs associated with participation, if any, in real dollars. Arguments in the expression can include exogenous variables, parameters, and reserved variables. If costs of this type are entered, they will be included as program costs through the end of the measure life, independent of the life of the program itself.

7

Technology Data

ASSET inputs files and databases are segmented into four main input areas: (a) Customer Data, (b) Utility Data, (c) Technology Data, and (d) Adoption Data. This section describes inputs in the Technology Data section. This section contains three database tables, as follows.

- **Technology Definitions Table.** This table contains one row for each technology. Inputs include technology identification and data for efficiency values, market availability, and other factors. Details about this data table are provided in Section 7.1.

- **Segment/Technology Data Table.** This table contains data about technology operation within a segment. Information provided in the Seg/Tech table includes measure installation and maintenance costs, measure life, base-year saturation levels, and links to usage profiles, energy rate files, and emission profiles. Details about this data table are provided in Section 7.2.

- **Emissions Data Table.** This database contains information about emission factors for end-use technologies. These factors give emissions levels in pounds per MWh for for electricity and pounds per million Btu for natural gas. Each profile provides emission factors by season and period for each of several emission categories. Details about this data table are provided in Section 7.3.

7.1 Technology Definitions Table

This table contains one record for each technology in the database. Technologies are identified to be equipment options, devices that alter energy use, or load management options. The technology definitions table contains several identifiers, allowing later aggregation by end-use, fuel, and product class. Technology data include information about equipment efficiency levels, measure availability, and parameters for computing automatic replacement levels. As shown in Table 7-1, the fields can be partitioned into two input areas: (1) Technology Identification Data and (2) Technology Data.

Technology Identification Data. The first section of the Technology Definitions table contains fields that identify and name the technology option. The variables included in this portion of the file are as follows.

- ***Technology Name [S].*** This 16-character string provides a unique technology identifier. This name is a key word used to link the technology data to other records. References to this name are contained in the Segment/Technology table, discussed below in Section 7.2 and the Technology Adoption table, discussed in Section 8.

- ***Technology Type [S].*** This field indicates the technology type, which takes one of two values:

  -- Equipment is indicated by an 1. Equipment options must appear in competition groups with a base technology. For these groups, energy impacts are computed as the difference in energy use between the each equipment option and the base option.

  -- Device is indicated by a 2. Devices do not appear in multiple-option competition groups. For devices , there is no base technology, and energy data are entered in terms of the device impact. In addition to conservation measures, load management programs are treated as devices.

- ***Alternative Name [S].*** This 16-character string provides an alternative identifier that can be used as a label to indicate the California Conservation Inventory identifier or any other alternative technology identifier.

- ***Technology Definition [S].*** The technology definition is a 96-character text string used to identify the technology.

- ***End-use Label [S].*** The end-use label identifies the end-use category for the measure or device. These labels are used to group results for reporting purposes. The end-use label is also included in the results databases, allowing post-processing by end use.

Table 7-1: Technology Definitions

	Variable	**Example Data**
1	**Technology ID**	
☑	Technology Name[S]	ResCoolSeer10
	Technology Type [I] (Equip = 1, Device = 2)	E
	Alternative Name [S]	RHE-33-09902
	Technology Definition[S]	CAC Seer 10
	End-use Label[S]	Cool
	Fuel Label[S]	Elec
	Product Class Label[S]	CAC
	Design Option or Measure Label[S]	Seer10
2	**Technology Data**	
	Efficiency 1 Value[N]	10.0
	Efficiency 2 Value[N]	0.0
	Legal Availability[E]	Seer10Avail
	Market Availability[E]	CONST
	First Year Available[I]	1970
	Default Minimum Life[I]	10
	Default Maximum Life[I]	20
	Automatic Replacement Fraction [N]	0.0
⇦	Substitute Technology[S]	ResCoolSeer12
☑ Keyword in Table; ⇦ Reference to another record		

- ***Fuel Label [S].*** The fuel label is a 16-character text string that indicates whether the primary fuel is electricity (*Elec*) or natural gas (*Gas*). The fuel label is also included in the results databases, allowing post processing by fuel.

- ***Product Class Label [S].*** This 16-character text string identifies the product class to which the technology belongs. This usually applies to equipment. These labels can be used to group results for reporting purposes. The product-class label is also included in the results databases, allowing post-processing by product class.

- ***Design Option or Device Label [S].*** This 16-character text string provides the most detailed label, and identifies the specific option within a product class. For equipment classes, the design option usually identifies a specific efficiency level.

Technology Data. This part of the technology definitions table contains data values and expressions that are used in the modeling process. The specific fields are as follows.

- ***Efficiency Values [N].*** Each technology can be assigned two numerical efficiency values. These values are intended to give the efficiency level for the design options within a product class. At the conclusion of the run, average efficiency values are computed for the equipment stock in each product class and for the annual purchases of design options in each product class.

- ***Legal Availability [E].*** This expression is evaluated in each analysis year to give the legal availability multiplier. Typically, this value will be a one, indicating that the option is available, or a zero, indicating that it is not. When legal availability is set to zero, energy impacts resulting from equipment purchases in subsequent years are measured with respect to the substitute technology for the base option, rather than the from the base option itself.

- ***Market Availability [E].*** This expression is evaluated in each analysis year to give the market availability multiplier. This value is one if the option is a mature product that is fully available to all consumers, and is a fraction less than one if the option is less than fully available. Typically, this expression is used to "phase in" a new design option that becomes available during the analysis period.

- ***First Year Available [I].*** This integer value indicates the first year that a technology option is available. If the option was first introduced in the distant past, the base-year stock is spread across vintages assuming constant annual shipments. If the option was first introduced in the recent past, the base-year stock is spread across vintages to the first year available, but not beyond. In this case, there will be lower levels of decay in the early analysis years.

- ***Default Minimum Life [I].*** The default minimum life is used in the stock vintaging and decay algorithms when segment specific values are not entered on the Segment/Technology record, described in Section 7.2.

- ***Default Maximum Life [I].*** The default maximum life is used in the stock vintaging and decay algorithms when segment specific values are not entered on the Segment/Technology record, described in Section 7.2.

- ***Automatic Replacement Fraction [N].*** This fraction is used to compute the fraction of the technology that is automatically replaced in kind at time of burnout. When the technology stock decays, the fraction that is not automatically replaced will contribute to the market size for replacement competition groups. The full cost of all automatic replacements is assumed to be paid by the customer without utility incentives.

- ***Substitute Technology [S].*** When present, the substitute technology name should represent a valid design option. The substitute technology is used when the automatic replacement fraction for a decaying technology is positive and the decaying technology is no longer available in the analysis year. If the substitute technology is also not available, then the substitute technology for the substitute technology will be used. If there is no substitute available in this cascade, the decaying technology will not be replaced. Also, when the base technology is taken off the market by a legal availability variable, savings estimates are measured relative to the substitute technology for purchases in all subsequent years.

7.2 Segment/Technology Data Table

This table contains one record for each segment/technology (Seg/Tech) combination that is to be active in the analysis. Segments are defined in the Customer Segment table, discussed in Section 5.1. Technologies are defined in the Technology Definitions table, discussed in Section 7.1 above. Information provided in the Seg/Tech table includes measure installation and maintenance costs, measure life, base-year saturation levels, and links to usage profiles, energy rate files, and emission profiles.

As shown in Table 7-2, the inputs can be partitioned into two input areas.

1 Segment/Technology References

2 Segment/Technology Data

Segment/Technology References. The first section of the Seg/Tech table provides references that identify the segment and the technology. The three references included in this portion of the file are as follows.

- ***Segment Name Reference [S].*** This 16-character string must contain a reference to a valid Segment Name in the Customer Segment table, which is discussed in Section 5.1.

- ***Area Reference [S].*** This 16-character string must contain a reference to a valid Area Name that appears in combination with the Segment Name in the Customer Segment table, as discussed in Section 5.1.

- ***Technology Name [S].*** This 16-character string must contain a reference to a valid Technology Name in the Technology Definitions table, which is discussed above in Section 7.1.

Segment/Technology Data. This part of the Seg/Tech table contains data values and expressions that are used in the modeling process. The specific fields are as follows.

- ***Equipment Cost [E].*** This expression gives the equipment cost in real dollars per unit ($/home, $/thousand square feet, $/million $ of output). To input costs in technology units, the measure density can be included in the expression by using the keyword *TECHDENS*. For example, if the conditional density for a chiller is 2 tons per thousand square feet and the cost of a chiller is $300 per ton, then the equipment cost can be entered as follows: 300*TECHDENS. This will result in a value of $600 per thousand square feet.

Table 7-2: Segment/Technology Data

	Variable	Example Data
1	**Technology ID**	
⇦	Segment Name Reference[S]	SingleFamily
⇦	Area Name Reference[S]	All
⇦	Technology Name Reference[S]	ResCoolSeer10
2	**Technology Data**	
	Equipment Cost[E]	2200
	Labor Cost[E]	200
	O&M Cost[E]	20
	Value of Service[E]	0
	Minimum Life[I]	12
	Maximum Life[I]	20
	Minimum Conversion Life[I]	10
	Base Share[E]	45.0%
	Conditional Density[N]	1.0
	Existing Electricity Intensity or Savings[E] (kWh)	1600
	New Electricity Intensity or Savings [E] (kWh)	1400
⇦	Electricity Usage Profile Reference [S]	ResCool
⇦	Electric Rate Reference [S]	ER
⇦	Electric Emissions Profile Reference [S]	ElecGen
	Existing Gas Intensity or Savings[E] (kBtu)	0
	New Intensity or Savings[E] (kBtu)	0
⇦	Gas Profile Reference [S]	n.a.
⇦	Gas Rate Reference [S]	n.a.
⇦	Gas Emissions Profile Reference [S]	n.a.
⇦	Heating Interaction Profile Reference [S]	n.a.
⇦	Cooling Interaction Profile Reference [S]	n.a.
⇦ Reference to object name in another table		

- ***Labor Cost [E].*** This expression gives the one-time measure installation cost in real dollars per unit ($/home, $/thousand square feet, $/million $ of output). As with equipment costs, labor costs can be expressed in technology units through use of the keyword for technology density (*TECHDENS*).

- ***O&M Cost [E].*** This expression gives the annual measure maintenance cost in real dollars per unit ($/home, $/thousand square feet, $/million $ of output). As with equipment costs, O&M costs can be expressed in technology units through use of the keyword for technology density (*TECHDENS*).

- ***Value of Service [E].*** This expression gives the annual value of service provided by a measure per segment unit ($/home, $/thousand square feet, $/million $ of output). This can be a positive number if the measure has positive non-cost attributes, or negative if the measure has negative non-cost attributes. As with equipment costs, these values can be expressed in technology units through use of the keyword for technology density (*TECHDENS).*

- ***Minimum Life [I].*** The minimum life is used in the stock vintaging and decay algorithms. If a value is entered here, it will over ride the default value entered in the Technology Definition table, as discussed in Section 7.1.

- ***Maximum Life [I].*** The maximum life is used in the stock vintaging and decay algorithms. If a value is entered here, it will over ride the default value entered in the Technology Definition table, as discussed in Section 7.1.

- ***Minimum Conversion Life [I].*** This integer value is used in the stock vintaging algorithms in the case of equipment conversion models. With these models, when there is conversion away from the base technology, the conversion amounts are removed from stock beyond the minimum conversion age, if sufficient stock is available in these older vintages.

- ***Base Share [E].*** The base share is used to initialize the stock accounts. It should give the fraction of the segment (homes, square footage, output) which has the technology in place in the base year. For devices that depend on the presence of a specific type of equipment, the compound saturation level should be entered here. For example, if the electric water heater share is 50%, and 20% of these units have tank wrap, then the base share for the measure -- tank wrap on electric water heaters -- is 10% of all homes.

- ***Technology Density [N].*** This floating point number is used as a ratio or multiplier to go between segment units (homes, square feet, $ million) and technology units (appliances, tons, fixtures).

  -- The technology density can be greater than one, (e.g. 1.75 televisions per home).

-- For lighting, the density can give the number of fixtures per unit (e.g. 10 high-use fixtures per home or 12.5 four-lamp fixtures per thousand square feet).

-- For cooling, the density could be the number of pieces of equipment or tons per unit (e.g. 1 central air unit per home or 2 tons per thousand square feet).

-- For motors, the density could give motor density per unit of output (e.g. 25 horsepower per million dollars of output).

This density ratio can be used in input expressions for measure costs and energy intensity values by using the keyword *TECHDENS* in the appropriate expressions.

- ***Existing Electricity Intensity or Savings [E].*** This expression provides the basis for computing annual energy and peak demand impacts. The interpretation of this field depends on the nature of the technology involved. Usage depends on the type of measure involved (equipment versus device) and the type of usage profild that is assigned (energy based versus load based).

-- Equipment measures appear in competition groups, and each group has a base technology. For each measure, energy impacts are computed by subtracting the energy for the base technology from energy for the measure. If an energy-based usage profile is assigned, then the intensity should be entered as an annual kWh value, giving energy consumption per segment unit. If a load-based profile is assigned, then the intensity should be entered in kW for each measure in the group. In either case, these values should be entered as positive numbers (such as 2000 kWh per home or 1500 kWh per thousand square feet).

-- Devices appear as single-items, and do not appear in competition groups with a base option. For each measure, energy impacts are entered directly. If an energy-based profile is assigned, then the intensity should be entered as the annual kWh impact for the device. If a load-based profile is assigned, then the intensity should be entered as a kW impact for the device. Since the entries are impacts, they should be entered as negative numbers when the impact implies a reduction in electricity use (e.g., -150 kWh per home) and positive numbers when the impact implies an increase.

-- Load management measures are treated as devices. These measures should be assigned a load-based usage profile. Intensities should be entered as a kW impact for these measures. As with other devices, the impacts should be entered as negative values if the kW impact is a reduction in loads.

The measure density can be used in this expression, through use of the keyword, *TECHDENS*. For example, for commercial lighting, assume that the density is 12.5 four-lamp fixtures per thousand square feet, operating hours are 3000 hours per year, and the connected load 174 Watts per fixture. In this case, the the electricity intensity could be entered as 3000 * .174 * TECHDENS, which would give a value 6,525 kWh per thousand square feet.

- ***New Electricity Intensity or Savings [E].*** This expression provides the basis for computing annual energy and peak demand impacts in new construction. It is interpreted the same as the existing electric intensity, discussed above. The main case in which new intensities will differ from existing intensities is in the case of space conditioning. Since newer units are sometimes built under strict thermal efficiency standards, they may tend to have higher levels of insulation and better thermal integrity, resulting in lower kWh levels and impacts for HVAC equipment and devices.

- ***Electricity Usage Profile Reference [S].*** This 16-character string must contain a reference to a valid Usage Profile Name in the Usage Profiles table, which was discussed in Section 5.2.

- ***Electric Rate [R].*** This 16-character string must contain a reference to a valid Rate Name in the Fuel Rate table, which was discussed in Section 5.2.

- ***Electric Emissions Profile [R].*** This 16-character string must contain a reference to a valid Emissions Profile Name in the Emissions Data table, which is discussed below in Section 7.3.

- ***Existing Gas Intensity or Savings [E].*** This expression provides the basis for computing natural gas consumption impacts. As with electric intensities, the interpretation of this field depends on the nature of the technology involved. Typically, gas usage profiles will be energy based rather than load based. In this case, the only distinction is between equipment and devices.

  -- For equipment, usage levels should be positive numbers, such as 20,000 kBtu per home or 12,000 kBtu per thousand square feet.

  -- Devices should have negative numbers, such as -1,000 kBtu per home.

  As with the electric intensity, the measure density can be used in this expression, through use of the keyword, *TECHDENS*. If load-based usage profiles are assigned to a natural gas impact, then the levels and impacts should be entered in kBtu/h (thousand Btu per hour) per segment unit.

- ***New Gas Intensity or Savings [E].*** This expression provides the basis for computing natural gas consumption impacts in new construction. It is interpreted the same as the existing gas intensity, discussed above. The main case in which new intensities will differ from existing intensities is in the case of space heating. Since newer units are sometimes built under strict thermal efficiency standards, they may tend to have higher levels of insulation and better thermal integrity, resulting in lower kBtu levels and impacts for gas heating equipment and devices.

- ***Gas Usage Profile Reference [S].*** This 16-character string must contain a reference to a valid Usage Profile Name in the Usage Profiles table, which was discussed in Section 5.2.

- ***Gas Rate [S].*** This 16-character string must contain a reference to a valid Rate Name in the Fuel Rate table, which was discussed in Section 6.2.

- ***Gas Emissions Profile [S].*** This 16-character string must contain a reference to a valid Emissions Profile Name in the Emissions Data table, which is discussed below in Section 7.3.

- ***Heating Interaction Profile [S].*** For measures that are inside conditioned space and that have significant interactions with heating equipment, a heating interaction profile should be entered in this field. In this case, the 16-character string must contain a reference to a valid profile name in the Usage Profiles table, which was discussed in Section 5.2. The referenced profile should be Type 1 (energy based).

- ***Cooling Interaction Profile [S].*** For measures that are inside conditioned space and that have significant interactions with cooling equipment, a cooling interaction profile should be entered in this field. In this case, the 16-character string must contain a reference to a valid profile name in the Usage Profiles table, which was discussed in Section 5.2. The referenced profile should be Type 1 (energy based).

7.3 Emissions Data Table

This table contains one record for each emission profile. On each record, emission factors are for each emission category by season and time-of-use period. Fields on this table are as follows.

Emission Profile Identification. The first field of the Emissions Data Table contains the Emissions Profile Name. This 16-character string provides a unique profile identifier. This name is the reference used to link the emissions data to segment/technology records, as discussed above in Section 7.2.

Emission Profile Data. On each record, emission values are provided by season and time-of-use period for each of six emission categories. All data values are entered in pounds per thousand kWh (lbs/MWh) for electric profiles and pounds per million Btu (lbs/mmBtu) for gas profiles.

- ***CO2 multipliers [E].*** These expressions are used as multipliers that give pounds of carbon dioxide per MWh or per mmBtu.

- ***CO multipliers [E].*** These expressions are used as multipliers that give pounds of carbon monoxide per MWh or per mmBtu.

- ***NOX multipliers [E].*** These expressions are used as multipliers that give pounds of nitrous oxide per MWh or per mmBtu.

- ***SOX multipliers [E].*** These expressions are used as multipliers that give pounds of sulfur dioxide per MWh or per mmBtu.

- ***PM10 multipliers [E].*** These expressions are used as multipliers that give pounds of particulate matter of ten microns or greater per MWh or per mmBtu.

- ***ROG multipliers [E].*** These expressions are used as multipliers that give pounds of raw organic material per MWh or per mmBtu.

Table 7-3: Emission Data Table

	Variable	**Example Data**
1	**Profile ID**	
☑	Profile Name [S]	GasFurnace
2	**Profile Data**	
	CO2 multipliers by season & period [E] (lbs/gWh or lbs/bBtu)	120
	CO multipliers by season & period [E] (lbs/gWh or lbs/bBtu)	5.10
	NOX multipliers by season & period [E] (lbs/gWh or lbs/bBtu)	2.53
	SOX multipliers by season & period [E] (lbs/gWh or lbs/bBtu)	4.32
	PM10 multipliers by season & period [E] (lbs/gWh or lbs/bBtu)	1.85
	ROG multipliers by season & period [E] (lbs/gWh or lbs/bBtu)	2.56
☑ Key Field in Table		

8

Technology Adoption Data

ASSET inputs files and databases are segmented into four main input areas: (a) Customer Data, (b) Utility Data, (c) Technology Data, and (d) Adoption Data. This section describes inputs in the Adoption Data area. This area contains one database table. Data in this table provide inputs to the adoption models and a variety of references to model inputs from other data tables. Included in the table are data for the following:

- Competition group ID,
- Links to Segment, Area, and Technology,
- Identification of decision type,
- Screening fractions (applicability, feasibility, awareness, and willingness),
- First-year adoption rates,
- Links to utility programs,
- Links to incentive data,
- Links to program eligibility rules,
- Impact multipliers (interactions, rebound, retention, and performance),
- Discount rate for adoption decisions,
- Links to an adoption model, and
- Distributions and parameters passed to the adoption model.

Each input type is described in detail below.

Technology Adoption ID

The Technology Adoption table contains one record for each adoption action. The first section of each record contains information that identifies which segments and technologies are involved, what type of decision is being modeled, and how measures are grouped into Competition Groups. Fields in the first part of the record are as follows.

- ***Competition Group ID [S].*** This 16-character string provides a unique competition group name. This name is a key field, and this key field binds technology options together for modeling purposes. For equipment groups, the first technology in the group is treated as the base technology, and all incremental costs and energy impacts are computed relative to this technology, or relative to its substitute technology if it is not legally available.

- ***Segment Name Reference [R].*** This 16-character string must contain a reference to a valid Segment Name in the Customer Segment table, which is discussed in Section 5.1.

- ***Area Reference [R].*** This 16-character string must contain a reference to a valid Area Name that appears in combination with the Segment Name in the Customer Segment table, which is discussed in Section 5.1.

- ***Technology Name [R].*** This 16-character string must contain a reference to a valid Technology Name in the Technology Definitions table, which is discussed above in Section 7.1.

- ***Decision Type [S].*** The decision type determines the structure of the modeling problem. In particular, the decision type determines the method used to compute market size for the competition group. Options are:

  -- NEW indicates new construction, and in this case, market size is based on the amount of new construction that occurs each year.

  -- ROB indicates replacement on burnout, and in this case, market size is based on the quantity of equipment in the competition group that is subject to replacement.

  -- CON indicates conversion before burnout, and in this case, market size is computed from the total competition group saturation, less saturation of options other than the base option.

  -- RET indicates a device acquisition or retrofit action, and in this case, market size is computed as the fraction of the applicable market that does not yet have the device.

- ***Tech Order [I].*** This entry indicates the order of the option in the competition group. In equipment groups, the first option should be the base option. Generally, options should be numbered from least efficient to most efficient. This ordering is important for computations related to economic and technical potential.

Table 8-1: Technology Definitions

	Variable	Example Data
1	**Technology ID**	
☑	Competition Group ID [S]	R3
⇦	Segment Reference [S]	SF
⇦	Area Reference [S]	1
⇦	Technology Name [S]	RC106
	Decision Type [S] (New, Rob, Ret, Con)	New
	Tech Order [I]	1
2	**Technology Data**	
	Decision Specific Cost [E]	0
	Measure Share [E]	20.0
	Percent Applicable [E]	100.0
	Percent Feasible [E]	100.0
	Percent Aware of Technology [E]	100.0
	Percent Willing [E]	100.0
⇦	Program 1 Reference [S]	R_REB
	Program 1 Participation Fraction [N]	75%
	Program 1 Participation Cost [E]	$10.0
⇦	Program 1 Incentive Name [S]	$10.0
⇦	Program 1 Eligibility Rule [S]	ResTRC
⇦	Repeat Program Fields for Program 2	
	Interaction Multiplie [E]	1.0
	Rebound Multiplier [N]	.96
	Retention Rate [N]	1.00
	Performance Rate [N]	1.00
⇦	Adoption Model Reference [S]	M_R_CAC
	Discount Rate [E]	.25
⇦	Distribution Reference [S]	Res_App_Dist
	Parameter 1 [E]	.66
	Parameter 2 [E]	.4 - .1*(Year>1999)
	Continue for Remaining Parameters	
☑ Key Field in Table; ⇦ Reference to another record		

Technology Adoption Data.

The second section of each record contains data and references required to execute the adoption models. In the user interface, these data are broken into several sections, and the data for all options in a competition group are presented in that section. Data items include the following.

- ***Decision Specific Cost[E].*** Measure cost data are entered for each technology within each segment in the Segment/Technology Data section, discussed in Section 7.B. The expression entered here gives any additional costs related to the specific decision type. These costs are entered in real dollars per unit ($/home, $/thousand square feet, $/million $ of output). To input costs in technology units, the measure density can be included in the expression by using the keyword *TechDens*. For a given decision state, the expression value is added to the Seg/Tech cost value.

- ***Measure Share [E].*** This share determines the adoption rate in the first year. This is a key input, since all decision models are calibrated to the adoption rates implied by the values entered here. The measure share is interpreted as the fraction of the applicable market that adopts an option. For example, if a competition group is applicable to 60% of the market, and a measure in the group has a measure share of 10%, this implies an overall adoption rate of 6%. The interpretation of the measure share depends on the type of decision that is being modeled.

  New Construction. In new construction, the measure share gives each measure's share of the applicable new construction market. Market size is the amount of new construction for which the competition group is applicable.

  -- Example for an equipment option. Suppose that the applicability factor for a competition group is 60%. If the group has three technology options, and these have measure shares of 50%, 40%, and 10%, then the first option will be installed in 30% of new construction (computed as a measure share of 50% times a group applicability of 60%).

  -- Example for a device. Suppose that the device applicability is set to 30%. Then a measure share of 50% implies that the device will be installed in 15% of new construction.

  Replacement. In replacement, the measure share gives each measure's share of the applicable replacement market for a competition group. Market size is the total decay for the competition group, reduced by the applicability rate for the group if replacement is not complete.

  -- Example for an equipment option. The total number of replacements for the competition group is determined by stock accounting. Usually, the applicability rate is set to 1.0, indicating that all decaying units will be replaced. If a technology option in the replacement group has a measure share of 40%, this implies that this option will get 40% of replacements under conditions in the first year.

-- Example for a device. Normally, device replacement is not modeled, and automatic replacement rates are set to either zero or one. Suppose, however, that a replacement model is entered for a device. The total amount of device decay is determined by stock accounting. Some fraction of the decayed stock may be automatically replaced. If the applicability factor is set to one, the remaining amount of decay is subject to the replacement model. If the measure share is set to 50%, this implies that one half of the remaining decayed amounts will be replaced.

Conversions.--In conversions, the measure share for a technology gives the fraction of the base technology market that converts to that technology under conditions in the first year. For example, suppose that the base technology has a 20% share in a segment. If the measure share in a conversion group is 5%, this implies that conversion from the base technology to the designated technology will occur in 1% of the customer base. The sum of the measure shares for a conversion group give the total rate of conversion away from the base technology.

Device Acquisitions. In the case of device acquisitions, the measure share applies to the applicable market. For example, suppose that one half of a segment has equipment that qualifies for a device, implying an applicability rate of 50%. If the measure share in an acquisition decision is 10%, this implies that 5% of the total market adds the device.

- ***Percent Applicable [E].*** This fraction gives the share of new or existing units to which a competition group applies. The fraction is entered for the first measure in the competition group. This fraction limits the size of the market for the group as a whole, as opposed to subsequent screens which are specific to the individual measures. As discussed in Section 3.6, the interpretation of the applicability factor differs significantly across the different decision models.

-- ***New Construction.*** In new construction, applicability represents the share of the new units that qualify for the equipment group or device. Typically, this will be an end-use or product class share in new construction.

-- ***Replace on Burnout***. In equipment replacement groups, the applicability factor gives the fraction of group decay that will be replaced. Usually, this is 1.0, indicating that all units will be replaced with one of the options in the group. If the fraction is less than 1.0, then replacement will be incomplete, and the overall saturation for technologies in the group will decline through time.

- -- ***Equipment Conversion.*** In equipment conversion groups, the applicability factor places an upper bound on the cumulative conversion from the base option to other options in the competition group. Usually, this limit is 1.0, since the options in the conversion group are all close substitutes for the base technology.

- -- ***Device Acquisition.*** In device acquisition measures, the applicability factor gives the fraction of existing units in the segment with the qualifying equipment or configuration. Usually, this factor will be an end-use or product class share.

- ***Percent Feasible [E].*** The feasibility expression gives the share of the applicable market for which an individual measure is feasible, given limitations on size, space, required level of service, or other configuration issues. The fraction effectively divides the applicable market into a segment where the measure is feasible, and a segment where it is not. Separate feasibility factors are entered for each technology in a competition group.

- ***Percent Aware of Technology [E].*** This expression gives the share of decision makers within the feasible market who have been exposed to a technology and have formed an opinion about the operating characteristics of that option. The expression value may change over time due to market diffusion processes, information programs, and other factors. Separate awareness expressions are entered for each technology in a competition group.

- ***Percent Willing [E].*** This fraction gives the share of aware decision makers who accept the technology as being valid and useful, without major non-cost barriers. The types of factors that limit willingness to adopt include concerns about safety, reliability, and aesthetics. These types of concerns typically outweigh economic considerations, and therefore act as non-cost barriers to adoption. For a measure with positive bill savings, the willingness factor is sometimes interpreted as the long-run market potential for the measure if its incremental cost is set to zero. Separate willingness expressions are entered for each technology in a competition group.

- ***Program 1 Reference [S].*** This 16-character string identifies the first utility program that applies to a measure, and it must contain a reference to a valid Program Name in the Utility Program table, which is discussed in Section 6.3.

- ***Program 1 Participation Fraction [N].*** This fraction gives the share of buyers for a measure who participate in the first program assigned to that measure. If all buyers of a measure participate, this share should be set to 100%.

- ***Program 1 Participation Cost [E].*** If there are customer costs associated with program participation, they are entered here. This cost is included in the following cost variables available in decision models: life-cycle cost (*LCC*), levelized cost (*LevCost*), and simple payback (*PayBack*). These costs are also included in the calculations related to the participant cost test.

- ***Program 1 Eligibility Rule [S].*** This 16-character string identifies the eligibility test variable that will be used to determine if the measure is eligible for incentives in the first program. It must contain the name of a valid Eligibility Test Variable, as discussed in Section 4.3.

- ***Program 1 Incentive Rule [S].*** This 16-character string identifies incentive variable that will be used to compute rebates, financing amounts and payments, and shared savings variables. The incentive rule also contains data for variable program costs. The string must contain the Incentive Name, as discussed in Section 6.4.

- ***Program 2 Data.*** The fields described above for program 1 are repeated in the database for program 2. Each field is defined in the same way, except the data apply to the second program. The fields are:

  -- Program 2 Reference [S]
  -- Program 2 Participation Fraction [N]
  -- Program 2 Participation Cost [E]
  -- Program 2 Eligibility Rule [S]
  -- Program 2 Incentive Data [S]

- ***Interaction Multiplier [E].*** The interaction multiplier is used to adjust measure impacts for interactions with other measures. For example, if interactions are expected to reduce the measure impact by 10% on average, then a multiplier value of .90 should be entered.

- ***Rebound Multiplier [N].*** This numerical value gives the rebound multiplier for each measure. For example, if the rebound effect is estimated to be 5%, then a multiplier value of .95 should be entered.

- ***Retention Rate [N].*** This fraction gives the annual retention rate for a measure. It is applied to reduce the size of measure impacts during the measure life. For example, if 3% of measures are removed each year, this rate should be set to .97. In computations involving multiple measure lifetimes, the retention rate continues to be applied geometrically through all measure lives.

- ***Performance Rate [N].*** This fraction gives the annual performance rate for a measure. It is applied to reduce the size of measure impacts during the measure life. For example, if the performance of a measure declines by 2% each year relative to the base option, then the performance rate should be set to .98. In computations involving multiple measure lifetimes, the performance rate is reset to 1.0 at the beginning of each measure life.

- ***Adoption Model Reference [S].*** This 16-character string identifies the adoption model to be applied to a competition group. The reference entered for the first technology in the group is used for all members of the group. This reference must be to a valid Model Name in the Adoption Model section, which is discussed in Section 5.3. Also, for each competition group, the model must be conformable with the number of options and programs specified on the technology adoption records.

- ***Discount Rate [E].*** This discount rate is used to compute present values, life-cycle costs, and levelized costs for a technology option. It should reflect the discount factor used by decision makers for investments in energy equipment. The discount rate should be entered as a fraction. For example .25 should be entered to imply a 25% discount rate.

- ***Distribution Reference [S].*** This entry allows provides a reference to a distribution, and must contain a valid Distribution Name, as discussed in Section 4.3. This distribution is passed into the Potential/Diffusion adoption model where it is used to compute market potential based on the measure payback.

- ***Parameter 1 to 5 [E].*** These values or expression are passed into the adoption model, and can be invoked through use of the key words *B1 through B5.*

9

Model Results and Outputs

The key model outputs are technology adoption results, technology impacts, program impacts, and benefit/cost statistics. When ASSET is executed, it creates eleven output files. Each file is in comma-separated-variables (CSV) format, and each file contains a type of result aggregated to a specified level. Of course, the contents of each table depends on segment and technology coverage of the input database used in the model run. The output files are as follows.

1. Segment/Technology Stocks & Adoptions
2. Segment/Technology Energy Impacts
3. Detailed Model Results -- Adoptions (on line)
4. Detailed Impact Results -- Energy Impacts (on line)
5. Detailed Impact Results -- First Year Impacts
6. Segment/Product Class Table (on line)
7. Segment/End-Use Table (on line)
8. Program Energy Impacts & Costs (on line)
9. Program Cost/Benefit Impacts (on line)
10. Program Summary File (on line)
11. Program/Technology Energy and Cost Impacts

Many of the results can be reviewed interactively. These are indicated in the above list by the paranthetical expression (on line). As directed by the user, ASSET will retrieve necessary records from the result files and present a graph and table containing the requested data. In addition to these review capabilities, the detailed components for each technology can be viewed interactively from the Technology Adoptions screen. This review provides access to detailed cost data, energy impacts, calibration factors and other detailed items that are not available in the final database tables.

This section describes ASSET results in three parts.

Results Database Contents
Detailed Model Data Review
Interactive Results Review

9.1 Results Database Contents

Model Results are contained in a series of output files. Each file has a specified layout in terms of the data topics that are covered and the years for which results are presented. The main categories of data are as follows:

- ***Technology Adoption Data***. These results provide detail about adoption model results and the implications of these results for equipment and device stocks over time. The key results are the number of units purchased, market shares, and equipment stocks.

- ***Technology Adoption Impacts***. These data summarize the energy and cost impacts associated with technology adoption decisions. Gross impacts are available from each model run, and net impacts compare Run 1 with Run 2.

- ***DSM Program Data***. For DSM programs, the data tables summarize participation levels, technology adoption levels within programs, gross program costs and gross program benefits.

- ***DSM Program Impacts.*** In addition to the gross program data, net impacts are saved, including net energy impacts, net cost impacts, and net benefit impacts. Both incremental and cumulative impacts are included.

- ***Benefit/Cost Data.*** Results from the benefit/cost tests are available at several levels. Test results for individual technologies and segments are included with the technology adoption impact tables. Cumulative benefit and cost streams are included in the program impact tables. Finally, net present values are provided as of the Reference Year in a separate table.

The model results are stored in a set of results data bases, allowing development of user-defined reports as well as direct links to the end-use models.

.1 Segment/Technology Stocks & Adoptions

This table presents technology stock results and adoption levels for each combination of segment and technology that is active in the model execution. Results are available for each run, as well as net results if both Run1 and Run2 are included. The database includes end-use and product class labels, allowing aggregation of results to higher levels. The two concepts included in the table are total technology stocks and annual technology purchases. The results are stored in segment units (homes, ksf, $m), but the technology density value is included, allowing conversion to technology units.

Table 9-1: Segment/Technology Stocks and Adoptions

	Variable	**Example Data**
1	**Segment/Technology ID**	
	Run [S] (Run1, Run2, Net, Econ, Tech)	Run1
⇦	Segment Name [S]	SF
⇦	Area [S]	All
⇦	Technology Name[S]	SEER12
	End Use Label [S]	Cool
	Product Class Label [S]	CAC
	Concept [S] ➔Stock (Total stock in place) Adopt (Annual purchases)	Stock
	Density [N]	1
2	**Technology Data (One Record for Each Concept)**	
	Year 1 Value [N]	15,809
	Year 2 Value [N]	24,132
	....	
	Year N Value [N]	119,056

⇦ Reference to Key Field in Input Table

.2 Segment/Technology Energy Impacts

This table presents energy impacts for each combination of segment and technology that is active in the model execution. Results are available for each run, as well as net results if both Run1 and Run2 are included. The database includes end-use and product class labels, allowing aggregation of results to higher levels. The three concepts included in the table are:

-- Cumulative electricity impacts, measured in GWh,
-- Cumulative system peak impacts, measured in MW, and
-- Cumulative gas consumption impacts, measured in GBtu.

Table 9-2: Segment/Technology Energy Impacts

	Variable	**Example Data**
1	**Segment/Technology ID**	
	Run [S] (Run1, Run2, Net, Econ, Tech)	Run1
⇦	Segment Name [S]	SF
⇦	Technology Name[S]	SEER12
	Concept [S] ➔GWh (Cumulative GWh Impact) MW (Cumulative MW Impact) GBtu (Cumulative GBtu Impact)	GWh
2	**Technology Data (One Record for Each Concept)**	
	Year 1 Value [N]	2.5
	Year 2 Value [N]	5.3
	....	
	Year N Value [N]	32.5
⇦ Reference to Key Field in Input Table		

.3 Detailed Results -- Measure Adoptions

This table presents technology adoption results by segment, technology, and decision type. Results are available for each run, as well as net results if both Run1 and Run2 are included. The database includes end-use and product class labels, allowing aggregation of results to higher levels. Concepts included are as follows.

- Share. This value reports the gross annual penetration rate as a fraction of the total segment size. Depending on the decision type, this share is a fraction of total segment units or of new construction. Specifically.
  - -- New construction (NEW) -- Fraction of new segment units
  - -- Replacement (ROB) -- Fraction of existing segment units
  - -- Retrofit (RET) -- Fraction of existing segment units.
  - -- Conversion (CON) -- Fraction of existing segment units.
- Adoptions. This value reports the volume of measure adoptions, measured in segment units (homes, ksf, $m). The technology density value is included in the table, allowing conversion from segment units to technology units.

Table 9-3: Detailed Results -- Measure Adoptions

	Variable	Example Data
1	**Segment/Technology Adoption ID**	
	Run [S] (Run1, Run2, Net, Econ, Tech)	Run1
⇦	Segment Name [S]	SF
⇦	Area [S]	Area3
⇦	Decision Type [S] (New, Rob, Con, Ret, All)	New
⇦	Competition Group [S]	NewCool
⇦	Technology Name[S]	SEER12
	End Use Label [S]	Cool
	Product Class Label [S]	CAC
	Concept [S] ➔Share (gross penetration rate) Adopt (annual purchases in segment units)	Share
	Density [N]	1
2	**Technology Data (One Record for Each Concept)**	
	Year 1 Value [N]	35.3%
	Year 2 Value [N]	38.5%
	....	
	Year N Value [N]	37.8%

⇦ Reference to Key Field in Input Table

.4 Detailed Results -- Energy Impacts

This table presents cumulative technology adoption impacts by segment, technology, and decision type. Gross adoption impacts are available for each run, as well as net results if both Run1 and Run2 are included. The database includes end-use and product class labels, allowing aggregation of results to higher levels. Concepts included are as follows.

-- Cumulative electricity impacts, measured in GWh,
-- Cumulative system peak impacts, measured in MW, and
-- Cumulative gas consumption impacts, measured in GBtu.

Table 9-4: Detailed Results -- Energy Impacts

	Variable	**Example Data**
1	**Segment/Technology Adoption ID**	
	Run [S] (Run1, Run2, Net, Econ, Tech)	Run1
⇦	Segment Name [S]	SF
⇦	Area [S]	Area3
⇦	Decision Type [S] (New, Rob, Con, Ret, All)	New
⇦	Competition Group [S]	NewCool
⇦	Technology Name[S]	SEER12
	End Use Label [S]	Cool
	Product Class Label [S]	CAC
	Concept [S] ➔GWh (Cumulative GWh Impact) MW (Cumulative MW Impact) GBtu (Cumulative GBtu Impact)	GWh
	Density [N]	1
2	**Technology Data (One Record for Each Concept)**	
	Year 1 Value [N]	1.12
	Year 2 Value [N]	2.39
	....	
	Year N Value [N]	19.15
⇦ Reference to Key Field in Input Table		

.5 Detailed Results -- First Year Impacts

This table presents first-year technology adoption impacts by segment, technology, and decision type. Gross adoption impacts are available for each run, as well as net results if both Run1 and Run2 are included. The database includes end-use and product class labels, allowing aggregation of results to higher levels. Concepts included are as follows.

-- Installed equipment cost in dollars,
-- First-year electricity impacts, measured in GWh,
-- First-year system peak impacts, measured in MW, and
-- First-year gas consumption impacts, measured in GBtu.

Table 9-5: Detailed Results -- First-Year Impacts

	Variable	Example Data
1	**Segment/Technology Adoption ID**	
	Run [S] (Run1, Run2, Net, Econ, Tech)	Run1
⇦	Segment Name [S]	SF
⇦	Area [S]	Area3
⇦	Decision Type [S] (New, Rob, Con, Ret, All)	New
⇦	Competition Group [S]	NewCool
⇦	Technology Name[S]	SEER12
	End Use Label [S]	Cool
	Product Class Label [S]	CAC
	Concept [S] ➔Cost GWh (First Year GWh Impact) MW (First Year MW Impact) GBtu (First Year GBtu Impact)	GWh
	Density [N]	1
2	**Technology Data (One Record for Each Concept)**	
	Year 1 Value [N]	1.12
	Year 2 Value [N]	1.27
	....	
	Year N Value [N]	1.04

⇦ Reference to Key Field in Input Table

.6 Segment/Product Class Results

This table provides a summary of results by segment, product class, and decision type. Results are available for each run, as well as net results if both Run1 and Run2 are included. Concepts included are

-- Product class efficiency (primary and secondary) for new equipment purhases
-- Cumulative energy impacts (GWh, MW, and GBtu)

The cumulative energy impacts are for all equipment and device purchases, whether these purchases occur through programs or not.

Table 9-6: Segment/Product Class Results

	Variable	**Example Data**
1	**Segment/Product Class ID**	
	Run [S] (Run1, Run2, Net, Econ, Tech)	Run1
⇦	Segment Name [S] (Segment Name or All)	SF
⇦	Area [S] (Area Name or All)	All
	End Use Label [S]	Cool
	Product Class Label [S]	CAC
	Decision Type [S] (New, Rob, Con, Ret, All)	New
	Concept [S] ➔Eff1 (Purchase efficiency, first element) Eff2 (Purchase efficiency, second element) GWh (Cumulative GWh Impact) MW (Cumulative MW Impact) GBtu (Cumulative GBtu Impact)	Eff1
2	**Product Class Data (One Record for each Concept)**	
	Year 1 Value [N]	11.92
	Year 2 Value [N]	11.98
	....	
	Year N Value [N]	13.42

⇦ Reference to Key Field in Input Table

.7 Segment/End-Use Results

This table provides a summary of results by segment, end use, and decision type. Results are available for each run, as well as Net results if both Run1 and Run2 are included. Concepts included are

-- Cumulative energy impacts (GWh, MW, and GBtu)
-- Installed equipment cost
-- Incentive payments (Run1, Run2, and Net only)

The cumulative energy impacts and equipment costs are for all equipment and device purchases, whether these purchases occur through programs or not.

Table 9-7: Segment/End Use Results

	Variable	**Example Data**
1	**Segment/End-Use ID**	
	Run [S] (Run1, Run2, Net, Econ, Tech)	Run1
⇦	Segment Name [S]	SF
⇦	Area [S]	All
	End Use Label [S]	CAC
	Fuel Label [S]	CAC
	Decision Type [S] (New, Rob, Con, Ret, All)	New
	Concept [S] ➔GWh (GWh Impact) MW (MW Impact) GBtu (GBtu Impact) Cost Incent (Run1, Run2 and Net only)	Eff1
2	**End-Use Data**	
	Year 1 Value [N]	11.92
	Year 2 Value [N]	11.98
	....	
	Year N Value [N]	13.42
⇦ Reference to Key Field in Input Table		

.8 Program Energy Impacts & Costs

This table provides a summary of gross and net impact results by program. Gross program impacts are computed for all program participants in Run 1. Net impacts are based on the difference between technology adoption levels in Run 1 and Run 2, including both program participants and non participants. If there are multiple programs, then the net technology impacts are allocated between the programs based on cumulative participation levels.

- -- Cumulative energy impacts (GWh, MW, GBtu)
- -- First-year energy impacts (GWh, MW, GBtu)
- -- Avoided costs (electric and gas)
- -- Utility bill impacts (electric and gas)
- -- Costs (Equipment, participation, maintenance, and value impacts)
- -- Utility costs (Incentive payments and program costs)

Table 9-8: Program Components Table

	Variable	Example Data
1	**Program & Concept ID**	
⇦	Program Name [S]	ResAppReb
	Concept [S] ➔GWh: Gross or Net GWh Impact MW: Gross or Net MW Impact GBtu: Gross or Net GBtu Impact Inc GWh: Gross First Year GWh Impact Inc MW: Gross First Year MW Impact Inc GBtu: Gross First Year GBtu Impact E AvCost: Gross or Net Avoided Elec Cost G AvCost: Gross or Net Avoided Gas Cost EBill: Gross or Net Electric Bill Impact GBill: Gross or Net Gas Bill Impact Cost: Gross or Net Installed Cost Impact Part Cost: Gross or Net Participant Cost Maint: Gross or Net O&M Cost Impact Val Srvc: Gross or Net Value Impact Incent: Gross Incentive Payments Prog Cost: Gross Program Costs	Gross GWh
2	**Program Impact Data**	
	Year 1 Value [N]	5.1
	Year 2 Value [N]	10.4
	....	
	Year N Value [N]	146.3
⇦ Reference to Key Field in Input Table		

.9 Program Cost/Benefit Results

This table provides data for program costs and benefits associated with the following tests.

Participant Cost Test,
Electric Utility Cost Test,
Electric Rate Impact Measure,
Total Resource Cost Test,
Societal Cost test.

Participant costs give the gross costs and benefits for participants. The remaining data are net (Run1 - Run2), with the exception of gross program costs which are included to rereflecting the definitions of the appropriate tests. All impacts represent cumulative adoption effects beginning in the Reference Year.

Table 9-9: Program Components Table

	Variable	**Example Data**
1	**Program & Concept ID**	
⇦	Program Name [S]	ResAppReb
	Concept [S] ➔Part Ben: Part Cost: Rim Ben: Rim Cost: Util Ben: Util Cost: TRC Ben: TRC Cost: Soc Ben: Soc Cost:	Part Ben.
2	**Program Impact Data**	
	Present Value [N]	458.2
	Year 1 Value [N]	5.1
	Year 2 Value [N]	10.4
	....	
	Year N Value [N]	146.3
⇦ Reference to Key Field in Input Table		

.10 Program Summary Table

This table provides the results for a full set of cost tests, including the Participant Test, the Utility Cost Test, the Ratepayer Impact Measure, the Total Resource Cost Test, and the Societal Cost Test. In addition to net present values and benefit/cost ratios, levelized cost values are presented for the Utiltiy Cost Test and TRC, and a Life-Cycle RIM statistic is presented. All computations are made from the perspective of the Reference Year.

Table 9-10: Program Summary Table

	Variable		Example Data
	Program & Concept ID		
⇦	Program Name [S]		ResAppReb
2	**Technology Data**		
	NPVPart:	Net Present Value of Participant Impacts ($k)	22584.5
	BCRPart:	Benefit/Cost Ratio for Participant Impacts	1.649
	NPVUtil:	Net Present Value of Utility Impacts ($k)	29349.2
	BCRUtil:	Benefit/Cost Ratio for Utility Impacts	1.344
	LevUtil:	Levelized Utility Cost ($/MWh)	22.54
	NPVRim:	Net Present Value of Electric RIM Impacts ($k)	-11387.2
	BCRRim:	Benefit/Cost Ratio for Electric RIM Impacts	.464
	LCRim:	Life Cycle Electric Rate Impact ($/MWh)	1.56
	NPVTrc:	Net Present Value of TRC Impacts ($k)	32187.5
	BCRTrc:	Benefit/Cost Ratio for TRC Impacts	1.583
	LevTrc:	Levelized TRC Cost ($/MWh)	2.679
	NPVSoc:	Net Present Value of Societal Impacts ($k)	33289.5
	BCRSoc:	Benefit/Cost Ratio for Soc Impacts	1.632
⇦ Reference to Key Field in Input Table			

.11 Program/Technology Energy and Cost Impacts

This table provides a summary of gross and net impact results by program and technology. Gross program impacts are computed for all program participants in Run 1. Net impacts are based on the difference between technology adoption levels in Run 1 and Run 2. If there are multiple programs for a technology, then the net impacts are allocated between the programs based on cumulative participation levels. Data are presented for the following topics.

- -- Cumulative energy impacts (gross and net GWh, MW, GBtu)
- -- First-year energy impacts (GWh, MW, GBtu)
- -- Avoided costs (gross and net electric and gas)
- -- Utility bill impacts (gross and net electric and gas)
- -- Costs (gross and net equipment, participation, maintenance, and value impacts)
- -- Utility costs (gross incentive payments and program costs)

Table 9-11: Program/Technology Energy and Cost Impacts

	Variable	**Example Data**
1	**Program & Concept ID**	
⇦	Program Name [S]	ResAppReb
⇦	Technology Name [S]	SEER12
	Concept [S] ➔GWh: Gross or Net GWh Impact MW: Gross or Net MW Impact GBtu: Gross or Net GBtu Impact Inc GWh: Gross First Year GWh Impact Inc MW: Gross First Year MW Impact Inc GBtu: Gross First Year GBtu Impact E AvCost: Gross or Net Avoided Elec Cost G AvCost: Gross or Net Avoided Gas Cost EBill: Gross or Net Electric Bill Impact GBill: Gross or Net Gas Bill Impact Cost: Gross or Net Installed Cost Impact Part Cost: Gross or Net Participant Cost Maint: Gross or Net O&M Cost Impact Val Srvc: Gross or Net Value Impact Incent: Gross Incentive Payments Prog Cost: Gross Program Costs	Gross GWh
2	**Program Impact Data**	
	Present Value [N]	458.2
	Year 1 Value [N]	5.1
	Year 2 Value [N]	10.4
	....	
	Year N Value [N]	146.3
⇦ Reference to Key Field in Input Table		

9.2 Detailed Model Data Review

In addition to the results database, more detailed results for model components are available interactively through the input side of the ASSET interface. In the Technology Adoption section of the ASSET, models, programs, and incentive rules are applied to individual technology adoption decisions. The ***Review Economics*** button provides a set of tables that contain detailed cost and energy impact data for an individual year. The *Review Models* button provides access to time series data about option shares.

In this part of the program, technology data are grouped according to the competition group that is assigned. This is true for the input data that are presented for a group, and it is also true for the detailed review tables. For example, if a competition group includes four technologies, then the data for all four technologies will be presented on the review tables.

Review Economics. Data in this area present detailed cost and market share values for a single year. Results are computed and presented for the first simulation year on the way into the review screens. This ***Next Year*** button advances the simulation year one step each time it is pressed. It is not possible to step backward once a year is passed.

Radio buttons at the top allow selection of the presentation mode. As a default, all results are presented in segment units (homes, ksf, $m). The other options are technology units and customer units. To convert to technology units, ASSET multiplies all results by the technology density. For example, if lighting density is expressed in fixtures per thousand square feet, then the technology data will give the number of fixtures. To convert to customer units, ASSET divides by typical customer size. For example, if the customer size is 20,000 square feet, then the results will give adoptions in equivalent terms.

In the Review Economics section, data for the competition group are organized by topic. The full set of details available are summarized in Table 9-12. As indicated in the table, the topic areas are:

- ***Cost.*** This review topic provides data on the energy use and cost levels associated with each technology.

- ***Incremental Cost.*** This review topic provides data on incremental energy use impacts and cost impacts for each technology relative to the base technology. Also shown are resource costs and benefits and simple payback values.

- ***Program Data.*** This topic includes data about program availability, incentive amounts, customer cost values revised by incentives. The first program button provides these data under Program 1 and the second under Program 2.

- ***Market Data.*** This topic presents adoption model results, including the market size for each option, the value of adoption screens, the decision share for each option, and the calibration constants for each option. The specific topics presented depend on the type of model. For example, for a replacement group, total group decay is presented, whereas total new units are presented for new construction groups.

Table 9-12: Economic Review Topics and Variables

Cost	**Incremental Cost**	**Program Data**	**Model Impacts**
Cost	IncCost	Prog. Avail	Share
KWh	DeltaKWh	Part. Cost	Non-Part (%)
Peak KW	DeltaKW	Rebate	Prog. 1 (%)
Elec Bill	DeltaEBill	AnnRebate	Prog. 2 (%)
KBtu	DeltaKBtu	FinanceAmt	KWh Impact
Gas Bill	DeltaGBill	FinancePmt	KW Impact
OpCost	DeltaOpCost	SharedAmt	KBtu Impact
MaintCost	DeltaMaint	SharedPmt	
ValSrvc	DeltaValSrvc	PVPayments	
PVOpCost	Savings	LCC	
PVMaint	Payback	LevCost	
LCC	Res. Benefit	IncCost	
LevCost	Res. Cost	Payback	
Market New Construction	**Market Replace on Burnout**	**Market Equipment Conversion**	**Market Device Acquisition**
New Con.	Group Decay	Base Stock	Existing Con.
Applicability	Applicability	Cum. Conv.	Applicability
App. Market	App. Market	Applicability	App. Market
Screens	Screens	App. Market	Screens
AppShare	Share	Screens	Econ. Pot.
Purchases	Purchases	Econ. Pot.	Retrofit Pot.
Stock	Stock	Conv. Pot	Share
kTech	kTech	Share	Purchases
		Purchases	Stock
		Stock	kRetrofit
		kStay	
		kConv	
		kTech	

Review Models. The Review Models option is the second way to examine detailed model results. Unlike the Review Economics option, which presents data for one year at a time, the Review Models option provides access to time series data about model results. The topics that can be reviewed include:

- -- Adoption Shares,
- -- Measure Stocks, and
- -- Program Participation Fractions

Data values can be reviewed for Run1 or for Run2. In addition to review of data values, the graph option will plot the selected topic, giving a visual comparison of the Run1 and Run2 outcomes.

9.3 Interactive Results Review

When ASSET is executed, it writes results files in CSV (comma separated variable) format. To save these files, the appropriate flags must be set to Y in the Setup File. Aslo, in this file, the user provides a directory/pathname for storing result files, as well as an 8-character external file name for each file. All selected files are saved with a .CSV extension. These files can be imported as database tables into Microsoft ACCESS or they can be imported into Excel for further processing.

Within ASSET, it is possible to review results interactively in the Review Results module. This part of program allows review of seven of the results files that have been saved as part of the current run. The Review Results menu presents buttons that provide access to these output files. These buttons appear in three groups. The following list presents the three button groups, the button text within each group and output file type that is accessed by each button.

- Detailed Results
  - -- Adoptions (Detailed Results -- Adoptions File)
  - -- Impacts (Detailed Results -- Energy Impacts File)
- Segment Data
  - -- By Product Class (Segment/Product Class File)
  - -- By End Use (Segment/End Use File)
- Program
  - -- Components (Program Energy Impacts & Costs File)
  - -- Benefits & Costs (Program Cost/Benefit Results File)
  - -- Summary (Program Summary File)

When one of these buttons is pressed, the appropiate output file is imported and the user is provided with a dialog-box interface to retrieve specific records from the database. Note, results will only be available if the corresponding CSV file has been saved by setting the save indicator to Y in the Setup File.

10

Cost/Benefit Accounting

Standard procedures for cost-benefit analysis of DSM programs have been established by the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC), as documented in the *Standard Practices Manual Economic Analysis of Demand-Side Management Programs*, December 1987. ASSET follows these procedures to provide the five standard benefit-cost tests.

The approach uses some generalizations of the standard formulas, reflecting the fact that ASSET includes treatment of some concepts and situations not covered in the Manual. For example, if data are entered in the value-of-service fields for a technology, then these value impacts are included in participant benefits or costs in the Participant Test and the Total Resource Cost Test. Also, in ASSET, many items may be either positive or negative. For example, if a technology has reduced maintenance costs, this is treated in ASSET as a participant benefit. In the Manual, it appears that this should be treated as a negative cost, although this specific case is not treated explicitly in the Manual.

An additional complication in ASSET occurs because of the treatment of multiple programs for a given measure. If more than one program is assigned to a technology adoption decision, then net program effects in each year must be allocated between the two programs. The comparison of Run1 (with both programs) and Run2 results (without either program) gives the net impact of the two programs combined. In ASSET, allocation fractions are computed based on cumulative data for gross program participation. These allocation ratios are applied to all net technology impacts to allocate these impacts to the programs.

10.1 Participant Test

The participants test is the measure of the quantifiable benefits and costs to the customers who participate in utility programs. In ASSET, gross participant benefits (PartBen) are defined to include the following items:

- ☺ Incentive receipts, including rebates and financing amounts net of points.
- ☺ Electric bill savings
- ☺ Gas bill savings
- ☺ Maintenance cost savings
- ☺ Increases in the value of service
- ☺ Reductions in equipment and installation cost

Given this list, the present value of participant benefits is computed as follows.

$$\mathrm{PVBEN}_{\mathrm{Part}} = \sum_{t=1}^{N}\sum_{b} \frac{\mathrm{PARTBEN}_{b}^{t}}{(1+d)^{t-k}}$$

where d is the participant discount rate and where k = 1 for up-front benefits k = .5 for benefits that accrue on a monthly basis throughout each year.

Items included in gross participant costs (PARTCOST) include the following

- ☹ Incremental measure costs, including installation
- ☹ Customer payments associated with financing
- ☹ Customer costs associated with program participation
- ☹ Maintenance cost increases
- ☹ Reductions in the value of service to the customer
- ☹ Electric bill increases
- ☹ Gas bill increases

The present value of participant costs is computed as follows:

$$\mathrm{PVCOST}_{\mathrm{Part}} = \sum_{t=1}^{N}\sum_{c} \frac{\mathrm{PARTCOST}_{c}^{t}}{(1+d)^{t-k}}$$

where the inner summation is over cost items (c), d is the participant discount rate, and where k = 1 for up-front costs and k = .5 for costs that accrue on a monthly basis throughout each year.

10.2 Ratepayer Impact Measure

The Ratepayer Impact Measure (RIM) test measures the pressures placed on utility rates due to changes in utility revenues and operating costs caused by the program. Generally speaking, items that reduce revenues or that increase revenue requirements will cause rate increases, and these items are treated as costs. Items that increase revenues or that reduce revenue requirements will cause rate decreases, and these items are treated as benefits.

For conservation programs, rates will go up if the sum of program implementation costs and the revenue loss from the program is greater than avoided cost savings. This test indicates the direction and magnitude of the expected change in customer rate levels, and therefore, in non participant customer bills.

In ASSET, the following items are included in the list of potential benefits for the electric utility RIM test.

- ☺ Net avoided electric supply costs
- ☺ Net revenue gain from increased sales or bills
- ☺ Gross financing payments from customers

Given this list, the present value of RIM benefits is computed as follows.

$$\mathrm{PVBEN}_{\mathrm{Rim}} = \sum_{t=1}^{N} \sum_{b} \frac{\mathrm{RIMBEN}_b^t}{(1+d)^{t-k}}$$

where d is the RIM discount rate, and where k = 1 for up-front benefits and k = .5 for benefits that accrue on a monthly basis throughout each year.

Items included in costs for the Ratepayer Impact Measure (RIMCOST) include the following

- ☹ Gross program costs
- ☹ Gross incentive payments, including rebates and finance amounts
- ☹ Net increase in electric supply costs
- ☹ Net revenue loss from decreased sales or bills

The present value of RIM costs is computed as follows.

$$\mathrm{PVCOST}_{\mathrm{Rim}} = \sum_{t=1}^{N} \sum_{c} \frac{\mathrm{RIMCOST}_c^t}{(1+d)^{t-k}}$$

where the inner summation is over cost items (c), d is the RIM discount rate, and where k = 1 for up-front costs and k = .5 for costs that accrue on a monthly basis throughout each year.

For the RIM test, results may be expressed as a life-cycle revenue impact. This term is interpreted as the one time change in rates needed to bring total revenues in line with revenue requirements over the life of the program. It is calculated as the ratio of the net present value of the program to the discounted stream of system energy sales ($/kWh or $/kW).

10.3 Total Resource Cost Test

The total resource cost test (TRC) measures the net costs of a demand-side management program as a resource option based on the total costs of the program, including both the participant costs and the utility costs. The test is applicable to conservation, load management, and fuel substitution programs. For fuel substitution programs, the test measures the net effect of the impacts from the alternate fuel not chosen versus the impacts from the fuel that is chosen as a result of the program. TRC test results for fuel substitution programs should be viewed as a measure of the economic efficiency implications for the total energy supply system (gas and electric).

The total resource cost test is based on changes in equipment, labor and materials costs (economic resources) summed across the utility and program participants. As a result, any payments from the utility to customers or from customers to utilities do not factor in this test. Items that reduce use of economic resources are treated as a benefit. Anything that increases use of economic resources is treated as a cost. Also, any positive change in the value of energy services is treated as a benefit, and any loss in the value of energy services is treated as a cost.

In ASSET, gross participant benefits (TRCBEN) are defined to include the following items:

- ☺ Net avoided electric supply costs
- ☺ Net avoided gas supply costs
- ☺ Net maintenance cost savings
- ☺ Net increases in the value of service
- ☺ Net reductions in equipment and installation cost

Given this list, the present value of TRC benefits is computed as follows.

$$\mathrm{PVBEN}_{\mathrm{Trc}} = \sum_{t=1}^{N} \sum_{b} \frac{\mathrm{TRCBEN}_b^t}{(1+d)^{t-k}}$$

where d is the TRC discount rate and where k = 1 for up-front benefits k = .5 for benefits that accrue on a monthly basis throughout each year.

Items included in TRC costs (TRCCOST) include the following.

- Net incremental measure costs, including equipment and installation
- Gross program costs
- Gross customer costs associated with program participation
- Net maintenance cost increases
- Net reductions in the value of service to the customer
- Net increase in electric supply costs
- Net increase in gas supply costs

The present value of TRC costs is computed as follows:

$$PVCOST_{Trc} = \sum_{t=1}^{N} \sum_{c} \frac{TRCCOST_c^t}{(1+d)^{t-k}}$$

where the inner summation is over cost items (c), d is the TRC discount rate, and where k = 1 for up-front costs and k = .5 for costs that accrue on a monthly basis throughout each year.

10.4 Societal Test

The societal test is a variant on the TRC test. As it is usually defined, the societal test differs from the TRC test in that it includes the effects of externalities, excludes tax credit benefits, and uses a different (societal) discount rate.

In Version 1.0 of ASSET, the only addition to costs and benefits for the Societal tests is the inclusion of the net impacts of programs on electric generation externalities. In each year, the changes in electricity consumption in each season and time-of-use period are translated into an externality value, based on parameters in the Utility Cost file, as discussed in Section 6.A. These parameters convert the generation level impacts into dollar values. If the net dollar impacts are negative, impling reduced emission levels, these reductions are treated as a benefit. If these net dollar impacts are positive, implying increased emission levels, these increases are treated as a cost.

With the inclusion of the net externality impacts, along with other elements of the TRC variables, present values of the cost and benefit streams are computed using the Societal Discount Rate from the Utility Cost file.

10.5 Utility Cost Test

Variables for the electric utility cost test are based on net technology impacts and gross program costs from the perspective of the electric utility. Variables for the utility cost test are similar to the RIM variables, except revenue gains and losses are excluded from the costs and benefits.

In ASSET, the following items are included in the list of potential benefits for the electric utility cost test.

- ☺ Net avoided electric supply costs
- ☺ Gross financing payments from customers

Given this list, the present value of Utility Benefits is computed as follows.

$$\text{PVBEN}_{\text{Util}} = \sum_{t=1}^{N} \sum_{b} \frac{\text{UTILBEN}_b^t}{(1+d)^{t-k}}$$

where d is the Utility Cost Test discount rate, and where k = 1 for up-front benefits and k = .5 for benefits that accrue on a monthly basis throughout each year.

Items included in list of potential costs for the Utility Cost Test are as follows.

- ☹ Gross program costs
- ☹ Gross incentive payments, including rebates and finance amounts
- ☹ Net increase in electric supply costs

The present value of Utility Costs is computed as follows.

$$\text{PVCOST}_{\text{Util}} = \sum_{t=1}^{N} \sum_{c} \frac{\text{UTILCOST}_c^t}{(1+d)^{t-k}}$$

where the inner summation is over cost items (c), d is the RIM discount rate, and where k = 1 for up-front costs and k = .5 for costs that accrue on a monthly basis throughout each year.

10.6 Present Value of Sales

For computing levelized cost ratios and life-cycle RIM ratios, present value sums are also accumulated for net electricity savings and for gross electricity sales. For computing levelized TRC ratios, the present value of net program savings is computed as follows:

$$\text{PvNetKwh} = \frac{\sum_{t=1}^{N} \text{NetKwh}_t}{\left(1 + \text{Disc}_{trc}\right)^{(t-.5)}}$$

where NETKWH is the net program impact, p indicates the program and N is the number of years in the simulation plus the additional period required to account for continuing impacts spawned by adoption decisions made during the simulation period.

For computing life-cycle RIM ratios, the present value of total utility sales over the simulation period is computed as follows:

$$\text{PvTotKwh} = \frac{\sum_{t=1}^{T} \text{TotKwh}_t}{\left(1 + \text{Disc}_{rim}\right)^{(t-.5)}}$$

where T is the number of years in the simulation period.

10.7 Cost Test Results

The variables constructed for cost tests are applied to create ratios and differences as follows:

- ***Participant Test***. For the participant test, a net present value and a benefit cost ratio are computed as follows:

  $NPVPART = PVBEN_{Part} - PVCOST_{Part}$
  $BCRPART = PVBEN_{Part} / PVCOST_{Part}$

- ***Utility Cost Test***. For the utility cost test for each program, a net present value, a benefit cost ratio, and a levelized cost are computed as follows:

  $NPVUTIL = PVBEN_{Util} - PVCOST_{Util}$
  $BCRUTIL = PVBEN_{Util} / PVCOST_{Util}$
  $LEVUTIL = PVCOST_{Util} / PVNETKWH$

- ***Ratepayer Impact Measure Test***. For the rate impact cost test for each program, a net present value, a benefit cost ratio, and a life cycle cost are computed as follows:

  $NPVRIM = PVBEN_{Rim} - PVCOST_{Rim}$
  $BCRRIM = PVBEN_{Rim} / PVCOST_{Rim}$
  $LIFECYCRIM = NPVRIM / PVTOTKWH$

- ***Total Resource Cost Test***. For the total resource cost test for each program, a net present value, a benefit cost ratio, and a levelized cost are computed as follows:

  $NPVTRC = PVBEN_{Trc} - PVCOST_{Trc}$
  $BCRTRC = PVBEN_{Trc} / PVCOST_{Trc}$
  $LEVCOST = PVCOST_{Trc} / PVNETKWH$

- ***Societal Cost Test***. For the societal cost test for each program, a net present value and a benefit cost ratio are computed as follows:

  $NPVSOC = PVBEN_{Soc} - PVSOCCOST_{Soc}$
  $BCRSOC = PVBEN_{Soc} / PVSOCCOST_{Soc}$

Appendix N

DSM ASSYST Methodology and User Guide

The attached provides documentation on DSM ASSYST™, KEMA's model used to develop market potential estimates.

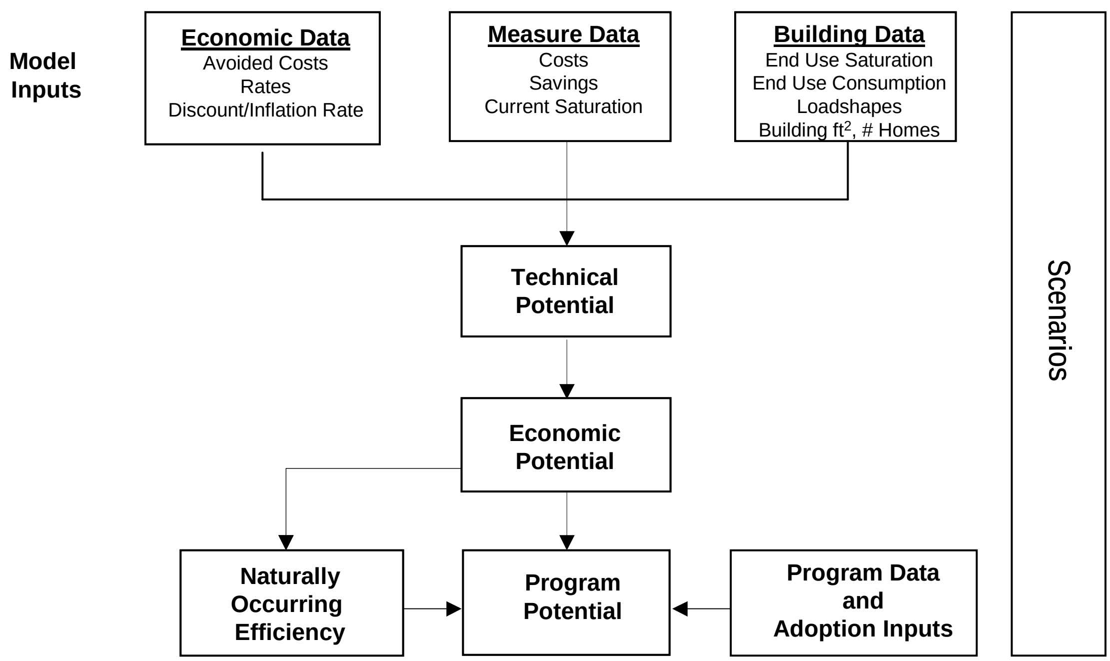
A DSM ASSYST Methodology and User Guide

In this appendix we present and discuss our basic methodology for conducting market potential studies. We also include a User Guide for DSM ASSYST™, our model used to develop market potential estimates.

A.1 DSM Forecasting Method

The crux of any DSM forecasting process involves carrying out a number of systematic analytical steps that are necessary to produce accurate estimates of energy efficiency (EE) effects on system load. A simplified overview of these basic analytical steps is shown in Figure A-1.

Figure A-1
Simplified Conceptual Overview of Modeling Process



Developing a DSM forecast is viewed by KEMA as a five-step process. The steps include:

Step 1: Develop Initial Input Data

- Develop list of EE measure opportunities to include in scope
- Gather and develop technical data (costs and savings) on efficient measure opportunities
- Gather, analyze, and develop information on building characteristics, including total square footage and households, electricity consumption and intensity by end use, end-use consumption load patterns by time of day and year (i.e., load shapes), market shares of key electric consuming equipment, and market shares of EE technologies and practices.

Step 2: Estimate Technical Potential and Develop Supply Curves

- Match and integrate data on efficient measures to data on existing building characteristics to produce estimates of technical potential and EE supply curves.

Step 3: Estimate Economic Potential

- Gather economic input data such as current and forecasted retail electric prices and current and forecasted costs of electricity generation, along with estimates of other potential benefits of reducing supply, such as the value of reducing environmental impacts associated with electricity production
- Match and integrate measure and building data with economic assumptions to produce indicators of costs from different viewpoints (e.g., utility, societal, and consumer)
- Estimate total economic potential using supply curve approach

Step 4: Estimate Achievable Program and Naturally Occurring Potentials

- Gather and develop estimates of program costs (e.g., for administration and marketing) and historic program savings
- Develop estimates of customer adoption of EE measures as a function of the economic attractiveness of the measures, barriers to their adoption, and the effects of program intervention
- Estimate achievable program and naturally occurring potentials; calibrate achievable and naturally occurring potential to recent program and market data
- Develop alternative economic estimates associated with alternative future scenarios

Step 5: Scenario Analyses and Resource Planning Inputs

- Recalculate potentials under alternate economic scenarios and deliver data in format required for resource planning.

Provided below is additional discussion of KEMA's modeling approaches for technical, economic, and achievable DSM forecasts.

A.1.1 Estimate Technical Potential and Develop Energy-Efficiency Supply Curves

Technical potential refers to the amount of energy savings or peak demand reduction that would occur with the *complete* penetration of all measures analyzed in applications where they were deemed *technically* feasible from an *engineering* perspective. Total technical potential is developed from estimates of the technical potential of individual measures as they are applied to discrete market segments (commercial building types, residential dwelling types, etc.).

Core Equation

The core equation used to calculate the energy technical potential for each individual efficiency measure, by market segment, is shown below (using a commercial example):[1]

[1] Note that stock turnover is not accounted for in our estimates of technical and economic potential, stock turnover *is accounted for* in our estimates of achievable potential. Our definition of technical potential assumes instantaneous replacement of standard-efficiency with high-efficiency measures.

Technical Potential of Efficient Measure	=	Total Square Feet	×	Base Case Equipment EUI	×	Applicability Factor	×	Not Complete Factor	×	Feasibility Factor	×	Savings Factor

where:

- **Square feet** is the total floor space for all buildings in the market segment. For the residential analysis, the **number of dwelling units** is substituted for square feet.
- **Base-case equipment EUI** is the energy used per square foot by each base-case technology in each market segment. This is the consumption of the energy-using equipment that the efficient technology replaces or affects. For example, if the efficient measure were a CFL, the base EUI would be the annual kWh per square foot of an equivalent incandescent lamp. For the residential analysis, unit energy consumption (UECs), energy used per dwelling, are substituted for EUIs.
- **Applicability factor** is the fraction of the floor space (or dwelling units) that is applicable for the efficient technology in a given market segment; for the example above, the percentage of floor space lit by incandescent bulbs.
- **Not complete factor** is the fraction of applicable floor space (or dwelling units) that has not yet been converted to the efficient measure; that is, (1 minus the fraction of floor space that already has the EE measure installed).
- **Feasibility factor** is the fraction of the applicable floor space (or dwelling units) that is technically feasible for conversion to the efficient technology from an *engineering* perspective.
- **Savings factor** is the reduction in energy consumption resulting from application of the efficient technology.

Technical potential for peak demand reduction is calculated analogously.

An example of the core equation is shown in Table A-1 for the case of a prototypical 75-Watt incandescent lamp, which is replaced by an 18-Watt CFL in the office segment of a large utility service territory.

Table A-1
Example of Technical Potential Calculation—Replace 75-W Incandescent with 18-W CFL in the Office Segment of a Utility Service Territory

Technical Potential of Efficient Measure	=	Total # of Dwellings	×	Base Case Equipment UEC	×	Applicability Factor	×	Not Complete Factor	×	Feasibility Factor	×	Savings Factor
7.7 million kWh		471 million		11.4		0.011		0.20		0.90		0.72

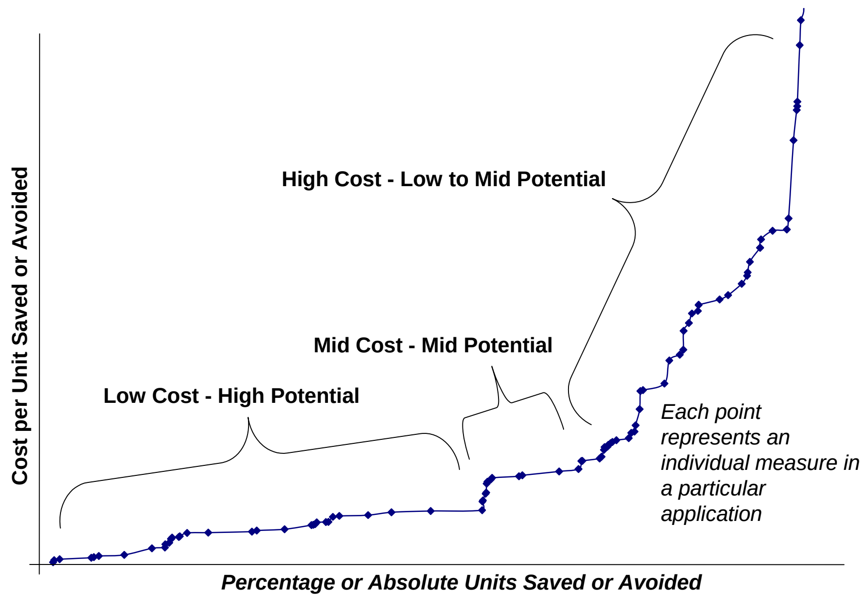
Technical EE potential is calculated in two steps. In the first step, all measures are treated *independently*; that is, the savings of each measure are not marginalized or otherwise adjusted for overlap between competing or synergistic measures. By treating measures independently, their relative economics are analyzed without making assumptions about the order or combinations in which they might be implemented in customer buildings. However, the total technical potential across measures cannot be estimated by summing the individual measure potentials directly. The cumulative savings cannot be estimated by adding the savings from the individual savings estimates because some savings would be double counted. For example, the savings from a measure that reduces heat gain into a building, such as window film, are partially dependent on other measures that affect the efficiency of the system being used to cool the building, such as a high-efficiency chiller; the more efficient the chiller, the less energy saved from the application of the window film.

Use of Supply Curves

In the second step, cumulative technical potential is estimated using an EE supply curve approach.[2] This method eliminates the double-counting problem. In Figure A-2, we present a generic example of a supply curve. As shown in the figure, a supply curve typically consists of two axes—one that captures the cost per unit of saving a resource or mitigating an impact (e.g., $/kWh saved or $/ton of carbon avoided) and the other that shows the amount of savings or mitigation that could be achieved at each level of cost. The curve is typically built up across individual measures that are applied to specific base-case practices or technologies by market segment. Savings or mitigation measures are sorted on a least-cost basis, and total savings or impacts mitigated are calculated incrementally with respect to measures that precede them. Supply curves typically, but not always, end up reflecting diminishing returns, i.e., as costs increase rapidly and savings decrease significantly at the end of the curve.

[2] This section describes conservation supply curves as they have been defined and implemented in numerous studies. Readers should note that Stoft 1995 describes several technical errors in the definition and implementation of conservation supply curves in the original and subsequent conservation supply curve studies. Stoft concludes that conservation supply curves are not "true" supply curves in the standard economic sense but can still be useful (albeit with his recommended improvements) for their intended purpose (demonstration of cost-effective conservation opportunities).

Figure A-2
Generic Illustration of EE Supply Curve



As noted above, the cost dimension of most EE supply curves is usually represented in dollars per unit of energy savings. Costs are usually annualized (often referred to as “levelized”) in supply curves. For example, EE supply curves usually present levelized costs per kWh or kW saved by multiplying the initial investment in an efficient technology or program by the "capital recovery rate" (CRR):

$$\text{CRR} = \frac{d}{1 - (1 + d)^{-n}}$$

where *d* is the real discount rate and *n* is the number of years over which the investment is written off (i.e., amortized).

Thus,

Levelized Cost per kWh Saved = Initial Cost x CRR/Annual Energy Savings

Levelized Cost per kW Saved = Initial Cost x CRR/Peak Demand Savings

The levelized cost per kWh and kW saved are useful because they allow simple comparison of the characteristics of EE with the characteristics of energy supply technologies. However, the levelized cost per kW saved is a biased indicator of cost-effectiveness because all of the efficiency measure costs are arbitrarily allocated to peak savings.

Returning to the issue of EE supply curves, Table A-2 shows a simplified numeric example of a supply curve calculation for several EE measures applied to commercial lighting for a hypothetical population of buildings. What is important to note is that in an EE supply curve, the measures are sorted by relative cost—from least to most expensive. In addition, the energy consumption of the system being affected by the efficiency measures goes down as each measure is applied. As a result, the savings attributable to each subsequent measure decrease if the measures are interactive. For example, the occupancy sensor measure shown in Table 1-2 would save more at less cost per unit saved if it were applied to the base-case consumption before the T8 lamp and electronic ballast combination. Because the T8 electronic ballast combination is more cost-effective, however, it is applied first, reducing the energy savings potential for the occupancy sensor. Thus, in a typical EE supply curve, the base-case end-use consumption is reduced with each unit of EE that is acquired. Notice in Table 1-2 that the total end-use GWh consumption is recalculated after each measure is implemented, thus reducing the base energy available to be saved by the next measure.

Table A-2 shows an example that would represent measures for one base-case technology in one market segment. These calculations are performed for all of the base-case technologies, market segments, and measure combinations in the scope of a study. The results are then ordered by levelized cost and the individual measure savings are summed to produce the EE potential for the entire sector.

In the next subsection, we discuss how economic potential is estimated as a subset of the technical potential.

Table A-2
Sample Technical Potential Supply Curve Calculation for Commercial Lighting
(*Note: Data are illustrative only*)

Measure	Total End Use Consumption of Population (GWh)	Applicable, Not Complete and Feasible (1000s of ft^2)	Average kWh/ft^2 of population	Savings %	GWh Savings	Levelized Cost ($/kWh saved)
Base Case: T12 lamps with Magnetic Ballast	425	100,000	4.3	N/A	N/A	N/A
1. T8 w. Elec. Ballast	425	100,000	4.3	21%	89	$0.04
2. Occupancy Sensors	336	40,000	3.4	10%	13	$0.11
3. Perimeter Dimming	322	10,000	3.2	45%	14	$0.25
With all measures	309		3.1	27%	116	

A.1.2 Estimation of Economic Potential

Economic potential is typically used to refer to the *technical potential* of those energy conservation measures that are cost effective when compared to either supply-side alternatives or the price of energy. Economic potential takes into account the fact that many EE measures cost more to purchase initially than do their standard-efficiency counterparts. The incremental costs of each efficiency measure are compared to the savings delivered by the measure to produce estimates of energy savings per unit of additional cost. These estimates of EE resource costs can then be compared to estimates of other resources such as building and operating new power plants.

Cost Effectiveness Tests

To estimate economic potential, it is necessary to develop a method by which it can be determined that a measure or program is *economic*. There is a large body of literature that debates the merits of different approaches to calculating whether a public purpose investment in EE is cost effective (Chamberlin and Herman 1993, RER 2000, Ruff 1988, Stoft 1995, and Sutherland 2000). We usually adopt the cost-effectiveness criteria used by the CPUC in its decisions regarding the cost-effectiveness of EE programs funded under the State's public goods charge. The CPUC uses the total resource cost (TRC) test, as defined in the California Standard Practice Manual (CASPM 2001), to assess cost effectiveness. The TRC is a form of societal benefit-cost test. Other tests that have been used in analyses of program cost-effectiveness by EE analysts include the utility cost, ratepayer impact measure (RIM), and participant tests. These tests are discussed in detail the CASPM.

Before discussing the TRC test and how it is often used in our DSM forecasts, we present below a brief introduction to the basic tests as described in the CASPM:[3]

- **Total Resource Cost Test—**The TRC test measures the net costs of a demand-side management program as a resource option based on the total costs of the program, including both the participants' and the utility's costs. The test is applicable to conservation, load management, and fuel substitution programs. For fuel substitution programs, the test measures the net effect of the impacts from the fuel not chosen versus the impacts from the fuel that is chosen as a result of the program. TRC test results for fuel substitution programs should be viewed as a measure of the economic efficiency implications of the total energy supply system (gas and electric). A variant on the TRC test is the societal test. The societal test differs from the TRC test in that it includes the effects of externalities (e.g. environmental, national security), excludes tax credit benefits, and uses a different (societal) discount rate.
- **Participant Test—**The participant test is the measure of the quantifiable benefits and costs to the customer due to participation in a program. Since many customers do not base their decision to participate in a program entirely on quantifiable variables, this test cannot be a complete measure of the benefits and costs of a program to a customer.
- **Utility (Program Administrator) Test—**The program administrator cost test measures the net costs of a demand-side management program as a resource option based on the costs incurred by the program administrator (including incentive costs)

[3] These definitions are direct excerpts from the California Standard Practice Manual, October 2001.

and excluding any net costs incurred by the participant. The benefits are similar to the TRC benefits. Costs are defined more narrowly.

- **Ratepayer Impact Measure Test—**The ratepayer impact measure (RIM) test measures what happens to customer bills or rates due to changes in utility revenues and operating costs caused by the program. Rates will go down if the change in revenues from the program is greater than the change in utility costs. Conversely, rates or bills will go up if revenues collected after program implementation are less than the total costs incurred by the utility in implementing the program. This test indicates the direction and magnitude of the expected change in customer bills or rate levels.

The key benefits and costs of the various cost-effectiveness tests are summarized in Table A-3.

Table A-3
Summary of Benefits and Costs of California Standard Practice Manual Tests

Test	Benefits	Costs
TRC Test	Generation, transmission and distribution savings Participants avoided equipment costs (fuel switching only)	Generation costs Program costs paid by the administrator Participant measure costs
Participant Test	Bill reductions Incentives Participants avoided equipment costs (fuel switching only)	Bill increases Participant measure costs
Utility (Program Administrator) Test	Generation, transmission and distribution savings	Generation costs Program costs paid by the administrator Incentives
Ratepayer Impact Measure Test	Generation, transmission and distribution savings Revenue gain	Generation costs Revenue loss Program costs paid by the administrator Incentives

Generation, transmission and distribution savings (hereafter, energy benefits) are defined as the economic value of the energy and demand savings stimulated by the interventions being assessed. These benefits are typically measured as induced changes in energy consumption, valued using some mix of avoided costs. Statewide values of avoided costs are prescribed for use in implementing the test. Electricity benefits are valued using three types of avoided electricity costs: avoided distribution costs, avoided transmission costs, and avoided electricity generation costs.

Participant costs are comprised primarily of incremental measure costs. Incremental measure costs are essentially the costs of obtaining EE. In the case of an add-on device (say, an adjustable-speed drive or ceiling insulation), the incremental cost is simply the installed cost of the measure itself. In the case of equipment that is available in various levels of efficiency (e.g., a central air conditioner), the incremental cost is the excess of the cost of the high-efficiency unit over the cost of the base (reference) unit.

Administrative costs encompass the real resource costs of program administration, including the costs of administrative personnel, program promotions, overhead, measurement and evaluation, and shareholder incentives. In this context, administrative costs are not defined to include the costs of various incentives (e.g., customer rebates and salesperson incentives) that may be offered to encourage certain types of behavior. The exclusion of these incentive costs reflects the fact that they are essentially transfer payments. That is, from a societal perspective they involve offsetting costs (to the program administrator) and benefits (to the recipient).

Use of the Total Resource Cost to Estimate Economic Potential

We often use the TRC test in two ways in our model. First, we develop an estimate of economic potential by calculating the TRC of individual measures and applying the methodology described below. Second, we develop estimates of whether different program scenarios are cost effective.

Economic potential can be defined either inclusively or exclusively of the costs of programs that are designed to increase the adoption rate of EE measures. *In many of our projects, we define economic potential to* ***exclude*** *program costs*. We do so primarily because program costs are dependent on a number of factors that vary significantly as a function of program delivery strategy. There is no single estimate of program costs that would accurately represent such costs across the wide range of program types and funding levels possible. Once an assumption is made about program costs, one must also link those assumptions to expectations about market response to the types of interventions assumed. Because of this, we believe it is more appropriate to factor program costs into our analysis of *program potential*. Thus, our definition of *economic potential* is that portion of the technical potential that passes our economic screening test (described below) exclusive of program costs. Economic potential, like technical potential, is a theoretical quantity that will exceed the amount of potential we estimate to be achievable through current or more aggressive program activities.

As implied in Table A-3 and defined in the CASPM 2001, the TRC focuses on resource savings and counts benefits as utility-avoided supply costs and costs as participant costs and utility program costs. It ignores any impact on rates. It also treats financial incentives and rebates as transfer payments; i.e., the TRC is not affected by incentives. The somewhat simplified benefit and cost formulas for the TRC are presented in Equations A-1 and A-2 below.

$$\text{Benefits} = \sum_{t=1}^{N} \frac{\text{Avoided Costs of Supply}_{p,t}}{(1+d)^{t-1}}$$ **Equation A-1**

$$\text{Costs} = \sum_{t=1}^{N} \frac{\text{Program Cost}_t + \text{Participant Cost}_t}{(1+d)^{t-1}}$$ **Equation A-2**

where

d = the discount rate
p = the costing period
t = time (in years)
n = 20 years

A nominal discount rate is used for the analysis. Also, we use a *normalized* measure life of 20 years to capture the benefit of long-lived measures. Measures with measure lives shorter than 20 years are "re-installed" in our analysis as many times as necessary to reach the normalized 20-year life of the analysis.

The avoided costs of supply are calculated by multiplying measure energy savings and peak demand impacts by per-unit avoided costs by costing period. Energy savings are allocated to costing periods and peak impacts estimated using load shape factors.

As noted previously, in the *measure-level* TRC calculation used to estimate economic potential, program costs are excluded from Equation A-2. Using the supply curve methodology discussed previously, measures are ordered by TRC (highest to lowest) and then the *economic* potential is calculated by summing the energy savings for all of the technologies for which the marginal TRC test is greater than 1.0. In the example in Table A-4, the economic potential would include the savings for measures 1 and 2, but exclude saving for measure 3 because the TRC is less than 1.0 for measure 3. The supply curve methodology, when combined with estimates of the TRC for individual measures, produces estimates of the economic potential of efficiency improvements. By definition and intent, this estimate of economic potential is a theoretical quantity that will exceed the amount of potential we estimate to be achievable through program activities in the final steps of our analyses.

Table A-4
Sample Use of Supply Curve Framework to Estimate Economic Potential
(*Note: Data are illustrative only*)

Measure	Total End Use Consumption of Population (GWh)	Applicable, Not Complete and Feasible Sq.Feet (000s)	Average kWh/ft^2 of population	Savings %	GWh Savings	Total Resource Cost Test	Savings Included in Economic Potential?
Base Case: T12 lamps with Magnetic Ballast	425	100,000	4.3	N/A	N/A	N/A	N/A
1. T8 w. Elec. Ballast	425	100,000	4.3	21%	89	2.5	Yes
2. Occupancy Sensors	336	40,000	3.4	10%	13	1.3	Yes
3. Perimeter Dimming	322	10,000	3.2	45%	14	0.8	No
Technical Potential with all measures				27%	116		
Economic Potential with measures for which TRC Ratio > 1.0				24%	102		

A.1.3 Estimation of Program and Naturally occurring Potentials

In this section we present the method we employ to estimate the fraction of the market that adopts each EE measure in the presence and absence of EE programs. We define:

- **Program potential** as the amount of savings that would occur in response to one or more specific market interventions
- **Naturally occurring potential** as the amount of savings estimated to occur as a result of normal market forces, that is, in the absence of any utility or governmental intervention.

Our estimates of program potential are typically the most important results of the modeling process. Estimating technical and economic potentials are necessary steps in the process from which important information can be obtained; however, the end goal of the process is better understanding how much of the remaining potential can be captured in programs, whether it would be cost-effective to increase program spending, and how program costs may be expected to change in response to measure adoption over time.

Adoption Method Overview

We use a method of estimating adoption of EE measures that applies equally to be our program and naturally occurring analyses. Whether as a result of natural market forces or aided by a program intervention, the rate at which measures are adopted is modeled in our method as a function of the following factors:

- The availability of the adoption opportunity as a function of capital equipment turnover rates and changes in building stock over time
- Customer awareness of the efficiency measure
- The cost-effectiveness of the efficiency measure
- Market barriers associated with the efficiency measure.

The method we employ is executed in the measure penetration module of KEMA's DSM ASSYST™ model.

In many of our projects, only measures that pass the measure-level TRC test are put into the penetration module for estimation of customer adoption.

Availability

A crucial part of the model is a stock accounting algorithm that handles capital turnover and stock decay over a period of up to 20 years. In the first step of our achievable potential method, we calculate the number of customers for whom each measure will apply. The input to this calculation is the total floor space available for the measure from the technical potential analysis, i.e., the total floor space multiplied by the applicability, not complete, and feasibility factors described previously. We call this the *eligible* stock. The stock algorithm keeps track of the amount of floor space available for each efficiency measure in each year based on the total eligible stock and whether the application is new construction, retrofit, or replace-on-burnout.[4]

Retrofit measures are available for implementation by the entire eligible stock. The eligible stock is reduced over time as a function of adoptions[5] and building decay.[6] Replace-on-burnout measures are available only on an annual basis, approximated as equal to the inverse of the service life.[7] The annual portion of the eligible market that does not accept the replace-on-burnout measure does not have an opportunity again until the end of the service life.

New construction applications are available for implementation in the first year. Those customers that do not accept the measure are given subsequent opportunities corresponding to whether the measure is a replacement or retrofit-type measure.

Awareness

In our modeling framework, customers cannot adopt an efficient measure merely because there is stock available for conversion. Before they can make the adoption choice, they must be aware and informed about the efficiency measure. Thus, in the second stage of the process, the model calculates the portion of the available market that is *informed*. An initial user-specified parameter sets the initial level of awareness for all measures. Incremental awareness occurs in the model as a function of the amount of money spent on awareness/information building and how well those information-building resources are directed to target markets. User-defined program characteristics determine how well information-building money is targeted. Well-targeted programs are those for which most of the money is spent informing only those customers that are in a position to implement a particular group of measures. Untargeted programs are those in which advertising cannot be well focused on the portion of the market that is available to implement particular measures. The penetration module in DSM ASSYST has a target effectiveness parameter that is used to adjust for differences in program advertising efficiency associated with alternative program types.

The model also controls for information retention. An information decay parameter in the model is used to control for the percentage of customers that will retain program information from one year to the next. Information retention is based on the characteristics of the target audience and the temporal effectiveness of the marketing techniques employed.

[4] Replace-on-burnout measures are defined as the efficiency opportunities that are available only when the base equipment turns over at the end of its service life. For example, a high-efficiency chiller measure is usually only considered at the end of the life of an existing chiller. By contrast, retrofit measures are defined to be constantly available, for example, application of a window film to existing glazing.

[5] That is, each square foot that adopts the retrofit measure is removed from the eligible stock for retrofit in the subsequent year.

[6] Buildings do not last forever. An input to the model is the rate of decay of the existing floor space. Floor space typically decays at a very slow rate.

[7] For example, a base-case technology with a service life of 15 years is only available for replacement to a high-efficiency alternative each year at the rate of 1/15 times the total eligible stock. For example, the fraction of the market that does not adopt the high-efficiency measure in year t will not be available to adopt the efficient alternative again until year $t + 15$.

Adoption

The portion of the total market this is available and informed can now face the choice of whether or not to adopt a particular measure. Only those customers for whom a measure is available for implementation (stage 1) and, of those customers, only those who have been informed about the program/measure (stage 2), are in a position to make the implementation decision.

In the third stage of our penetration process, the model calculates the fraction of the market that adopts each efficiency measure as a function of the participant test. The participant test is a benefit-cost ratio that is generally calculated as follows:

$$\text{Benefits} = \sum_{t=1}^{N} \frac{\text{Customer Bill Savings (\$)}_t}{(1+d)^{t-1}} \qquad \textbf{Eqn. A-3}$$

$$\text{Costs} = \sum_{t=1}^{N} \frac{\text{Participant Costs (\$)}_t}{(1+d)^{t-1}} \qquad \textbf{Eqn. A-4}$$

where

d = the discount rate
t = time (in years)
n = 20 years

We use a *normalized* measure life of 20 years in order to capture the benefits associated with long-lived measures. Measures with lives shorter than 20 years are “re-installed” in our analysis as many times as necessary to reach the normalized 20-year life of the analysis.

The bill reductions are calculated by multiplying measure energy savings and customer peak demand impacts by retail energy and demand rates.

The model uses measure implementation curves to estimate the percentage of the informed market that will accept each measure based on the participant’s benefit-cost ratio. The model provides enough flexibility so that each measure in each market segment can have a separate implementation rate curve. The functional form used for the implementation curves is:

$$y = \frac{a}{\left(1 + e^{-\ln\frac{x}{4}}\right) \times \left(1 + e^{-c\ln(bx)}\right)}$$

where:

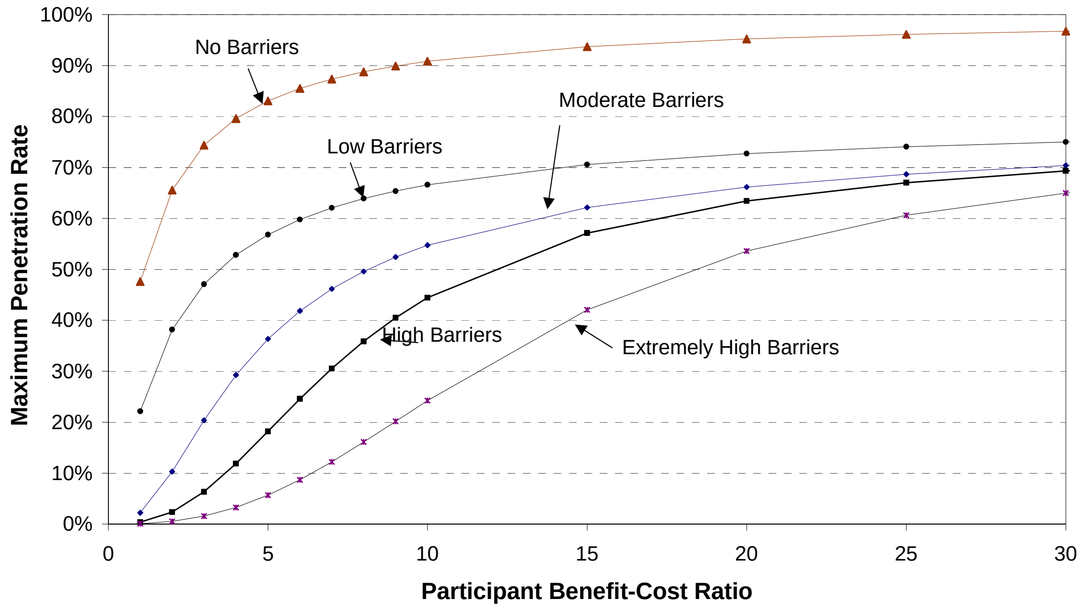
y = the fraction of the market that installs a measure in a given year from the pool of informed applicable customers;
x = the customer’s benefit-cost ratio for the measure;
a = the maximum annual acceptance rate for the technology;

b = the inflection point of the curve. It is generally 1 over the benefit-cost ratio that will give a value of 1/2 the maximum value; and

c = the parameter that determines the general shape (slope) of the curve.

The primary curves utilized in our model are shown in Figure A-3. These curves produce base year program results that are calibrated to actual measure implementation results associated with major IOU commercial efficiency programs over the past several years. Different curves are used to reflect different levels of market barriers for different efficiency measures. A list of market barriers is shown in Table A-5. It is the existence of these barriers that necessitates program interventions to increase the adoption of EE measures.

Figure A-3
Primary Measure Implementation Curves Used in Adoption Model



Note that for the moderate, high barrier, and extremely high curves, the participant benefit-cost ratios have to be very high before significant adoption occurs. This is because the participant benefit-cost ratios are based on a 15-percent discount rate. This discount rate reflects likely adoption if there were no market barriers or market failures, as reflected in the no-barriers curve in the figure. Experience has shown, however, that actual adoption behavior correlates with implicit discount rates several times those that would be expected in a perfect market.[8]

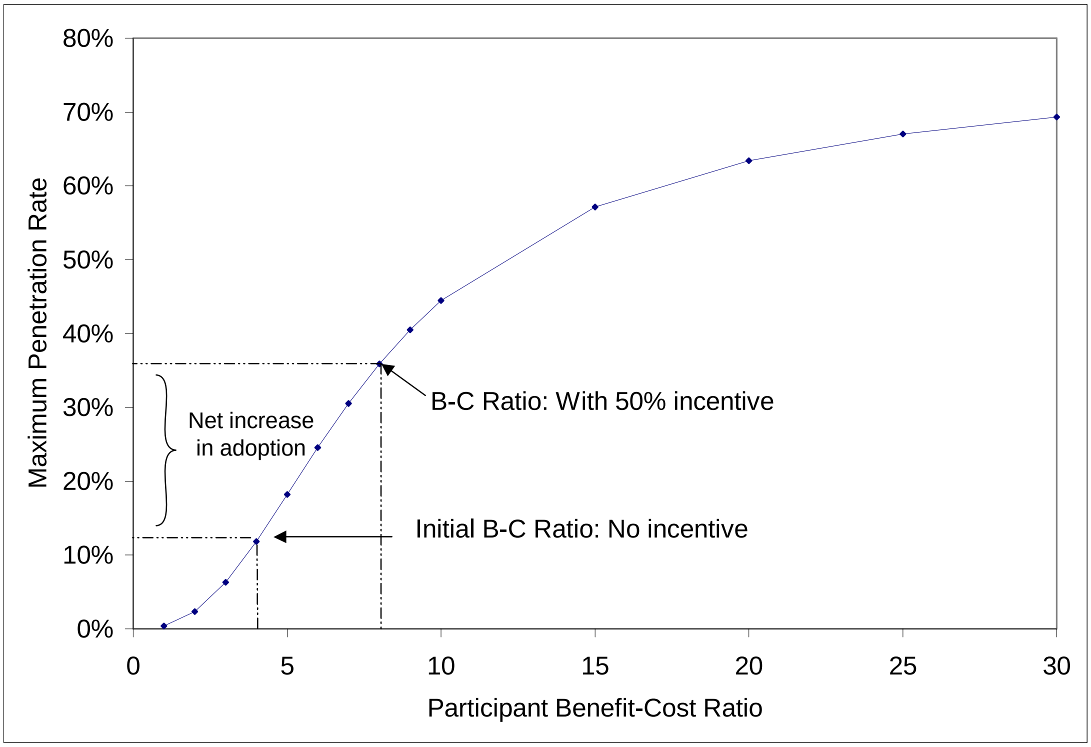
[8] For some, it is easier to consider adoption as a function of simple payback. However, the relationship between payback and the participant benefit-cost ratio varies depending on measure life and discount rate. For a long-lived measure of 15 years with a 15-percent discount rate, the equivalent payback at which half of the market would adopt a measure is roughly 6 months, based on the high barrier curve in Figure A-3. At a 1-year payback, one-quarter of the market would adopt the measure. Adoption reaches near its maximum at a 3-month payback. The curves reflect the real-world observation that implicit discount rates can average up to 100 percent or more.

The model estimates adoption under both naturally occurring and program intervention situations. There are only two differences between the naturally occurring and program analyses. First, in any program intervention case in which measure incentives are provided, the participant benefit-cost ratios are adjusted based on the incentives. Thus, if an incentive that pays 50 percent of the incremental measure cost is applied in the program analysis, the participant benefit-cost ratio for that measure will double (since the costs have been halved). The effect on the amount of adoption estimated will depend on where the pre- and post-incentive benefit-cost ratios fall on the curve. This effect is illustrated in Figure A-4.

Table A-5
Summary Description of Market Barriers from Eto, Prahl, Schlegel 1997

Barrier	Description
Information or Search Costs	The costs of identifying energy-efficient products or services or of learning about energy-efficient practices, including the value of time spent finding out about or locating a product or service or hiring someone else to do so.
Performance Uncertainties	The difficulties consumers face in evaluating claims about future benefits. Closely related to high search costs, in that acquiring the information needed to evaluate claims regarding future performance is rarely costless.
Asymmetric Information and Opportunism	The tendency of sellers of energy-efficient products or services to have more and better information about their offerings than do consumers, which, combined with potential incentives to mislead, can lead to sub-optimal purchasing behavior.
Hassle or Transaction Costs	The indirect costs of acquiring EE, including the time, materials and labor involved in obtaining or contracting for an energy-efficient product or service. (Distinct from search costs in that it refers to what happens once a product has been located.)
Hidden Costs	Unexpected costs associated with reliance on or operation of energy-efficient products or services - for example, extra operating and maintenance costs.
Access to Financing	The difficulties associated with the lending industry's historic inability to account for the unique features of loans for energy savings products (i.e., that future reductions in utility bills increase the borrower's ability to repay a loan) in underwriting procedures.
Bounded Rationality	The behavior of an individual during the decision-making process that either seems or actually is inconsistent with the individual's goals.
Organization Practices or Customs	Organizational behavior or systems of practice that discourage or inhibit cost-effective EE decisions, for example, procurement rules that make it difficult to act on EE decisions based on economic merit.
Misplaced or Split incentives	Cases in which the incentives of an agent charged with purchasing EE are not aligned with those of the persons who would benefit from the purchase.
Product or Service Unavailability	The failure of manufacturers, distributors or vendors to make a product or service available in a given area or market. May result from collusion, bounded rationality, or supply constraints.
Externalities	Costs that are associated with transactions, but which are not reflected in the price paid in the transaction.
Non-externality Pricing	Factors other than externalities that move prices away from marginal cost. An example arises when utility commodity prices are set using ratemaking practices based on average (rather than marginal) costs.
Inseparability of Product Features	The difficulties consumers sometimes face in acquiring desirable EE features in products without also acquiring (and paying for) additional undesired features that increase the total cost of the product beyond what the consumer is willing to pay.
Irreversibility	The difficulty of reversing a purchase decision in light of new information that may become available, which may deter the initial purchase, for example, if energy prices decline, one cannot resell insulation that has been blown into a wall.

Figure A-4
Illustration of Effect of Incentives on Adoption Level as Characterized in Implementation Curves



In many of our projects achievable potential EE forecasts are developed for several scenarios, ranging from base levels of program intervention, through moderate levels, up to an aggressive EE acquisition scenario. Uncertainty in rates and avoided costs are often characterized in alternate scenarios. The final results produced are annual streams of achievable program impacts (energy and demand by time-of-use period) and all societal and participant costs (program costs plus end-user costs).

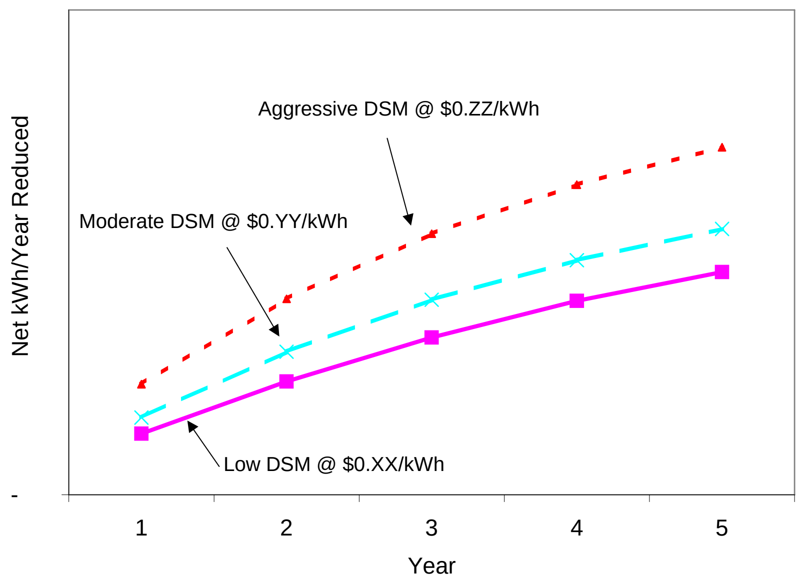
A.1.4 Scenario Analyses

Achievable potential forecasts can be developed for multiple scenarios. For example, program savings can be modeled under low levels of program intervention, through moderate levels, up to an aggressive DSM acquisition scenario. Uncertainty in rates and avoided costs can be characterized in alternate scenarios as well. The final results produced will be annual streams of achievable DSM program impacts (energy and demand by time-of-use period) and all societal and participant costs. An example of the types of outputs that have been produced for similar studies in the past is shown in Table A-6 and Figure A-5.

Table A-6
Example Format of DSM ASSYST Achievable Potential Outputs

DSM ASSYST Program Output	2006	2007	2008	etc.
Annual Energy Savings (kWh)				
Summer Period Energy Savings (kWh)				
Non Summer Period Energy Savings (kWh)				
Net Annual Energy Savings (kWh)				
Summer Period Net Energy Savings (kWh)				
Non Summer Period Net Energy Savings (kWh)				
Peak Demand Savings (kW)				
Net Peak Demand Savings (kW)				
Annual Program Costs				
Supplemental Customer Costs				

Figure A-5
Example of DSM Scenario Outputs



A.1.5 Measure "Bundles" for Complex End Uses

Although potential can be estimated through measure-specific analyses for many sectors and end uses, there are some cases where the measure-specific approach becomes problematic because of the complexity or heterogeneity of the base-case energy systems being addressed. Two key examples are industrial processes and some aspects of residential and commercial new construction.

In the industrial case, there may be dozens or even hundreds of individual measures that can be applied to industrial processes throughout the population of industrial facilities in a service territory; however, analyzing each of these opportunities, though possible, is impractical within a resource and time-constrained study such as this one.

In the case of new construction, the problem is sometimes that an equipment substitution paradigm does not fit the real-world circumstances in which efficiency levels are improved. For example, in commercial lighting, virtually all new buildings tend to have electronic ballasts and T-8 lamps, as well as CFLs, and other high-efficiency components. These high-efficiency components are generally needed to meet Title 24 efficiency requirements; however, the overall lighting system efficiency can often be increased by using these same components in smarter designs configurations or by combining with other features such as daylighting.

For both of these situations, our approach on recent related work has been to bundle multiple individual efficiency measures into somewhat simplified efficiency levels. For example, lighting levels for commercial new construction might be set at 10- and 20-percent improvement over Title 24 standards (as they are often specified in the Savings by Design program planning documents). Similarly, for industrial compressed air systems, we have bundled savings opportunities into three levels where both savings and costs increase with each level. We then estimate an incremental cost for achieving each of the efficiency levels. An example of these results developed in a recent study for industrial motors, compressed air, and processes in California is shown in Table A-7.

Once the levels efficiency are specified in terms of costs and savings, they are run through the modeling system as if they were individual measures. Thus, cost-effectiveness indicators are calculated for each level, those that pass the TRC are included in the achievable potential forecasting, and adoption is modeled using the same process as described above. Although we recommend using this approach for complex end uses in the proposed study because it creates a manageable forecasting process, care must be taken in developing the levels and recognizing that this approach results in some aggregation bias.

Table A-7
Example of Industrial Efficiency Levels Developed for a Recent California Potential Study

DSM ASSYST ADDITIVE SUPPLY ANALYSIS			Year	2011			
		Vintage: Existing			Levelized	Levelized	Total
		Sector: Industrial Scenario: Base			Cost per	Cost per	Resource
End	Measure		GWH	MW	KWh Saved	KW Saved	Cost Test
Use	Number	Measure	Savings	Savings	$/kWH	$/kW	TRC
Motors	101	Replace 1-5 HP Motor	248.7	34.1	$0.10	$698	0.8
Motors	102	Add 1-5 HP VSD	447.1	61.3	$0.14	$1,019	0.6
Motors	103	Motor Practices Level 1	607.0	83.2	$0.06	$440	1.3
Motors	104	Motor Practices Level 2	539.1	73.9	$0.24	$1,764	0.3
Motors	121	Replace 21-50 HP Motor	78.1	10.7	$0.09	$661	0.9
Motors	122	Add 21-50 HP VSD	319.0	43.7	$0.04	$278	2.1
Motors	123	Motor Practices Level 1	404.3	55.4	$0.03	$211	2.7
Motors	124	Motor Practices Level 2	361.9	49.6	$0.12	$840	0.7
Motors	151	Replace 201-500 HP Motor	143.5	19.7	$0.03	$201	2.8
Motors	152	Add 201-500 HP VSD	516.6	70.8	$0.01	$106	5.4
Motors	153	Motor Practices Level 1	598.6	82.0	$0.02	$152	3.7
Motors	154	Motor Practices Level 2	554.9	76.0	$0.08	$586	1.0
Compressed Air	202	CAS Level 1	433.9	59.5	$0.02	$168	3.4
Compressed Air	203	CAS Level 2	453.6	62.2	$0.05	$362	1.6
Compressed Air	204	CAS Level 3	325.5	44.6	$0.13	$936	0.6
Other Process	301	Process Level 1	1,031.8	141.4	$0.03	$190	3.0
Other Process	302	Process Level 2	1,219.7	167.1	$0.05	$345	1.7
Other Process	303	Process Level 3	767.3	105.1	$0.25	$1,831	0.3

A.2 DSM ASSYST™ USER GUIDE

DSM ASSYST™ (Demand-Side Management Technology Assessment System) is a tool developed to assess the technical, economic and market potential of DSM technologies in the Residential, Commercial and Industrial sectors. Based on user specified information about base technologies, conservation technologies, load shapes, utility avoided costs, utility service rates, and economic parameters, DSM ASSYST yields numeric data for a variety of criteria. The user can then evaluate and compare technologies. DSM ASSYST allows the user to analyze each DSM technology in multiple combinations of building types, market segments, end uses, and vintages both individually and compared to other DSM technology options.

The current version of DSM ASSYST uses a combination of Microsoft Excel spreadsheets and Visual Basic (VB) programming software. All input and output data are stored in spreadsheets. The VB modules read input data from various spreadsheets, perform the various analyses, and store output results into spreadsheets.

A.2.1 Getting Around in Excel

DSM ASSYST was written for use by trained analysts. The user should be familiar with basic spreadsheet operations in Excel for Windows and with movement within spreadsheets, copy commands, delete commands, transferring data between spreadsheet files, and running macros.

DSM ASSYST is <u>not</u> protected against accidental user error. As spreadsheets are extremely susceptible to the accidental overwriting of data and/or formulas, it is recommended that a copy of the model is preserved for reference.

A.2.2 Pre-Analysis Instructions

Preliminaries

The following spreadsheet files are discussed in this manual.

DSM ASSYST.XLS: This is the actual DSM ASSYST spreadsheet model. ASSYST is used for the Basic Analysis, Supply Analysis and to produce input for the Market Potential Analysis.

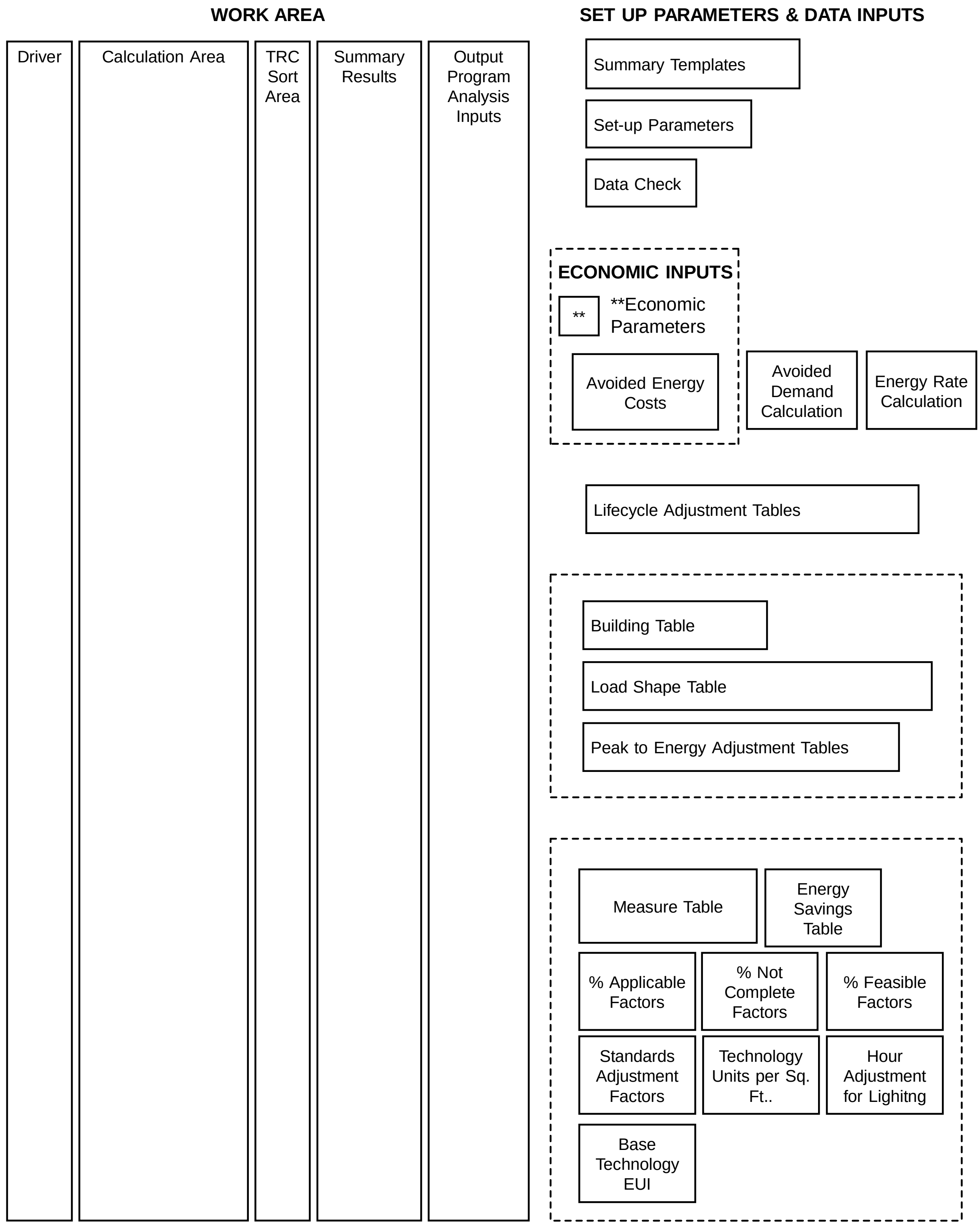
See Figure A-6 for an overview of the ASSYST model layout.

The ASSYST work area consists of the Driver area (Columns A through E), the Calculation area (Columns F through BT), the TRC Sort area (Column BU through BY), the Summary Results area (Columns CA through CV), and the ASSYST output that are inputs for the Market Potential Analysis (Column CX through DS). The work area expands or contracts to the number of rows necessary to perform and report the analysis. The number of rows are governed by the number of rows in the Driver.

The other portion of ASSYST consists of set up parameters and data inputs. This area occupies Columns EU through HH. All data and formulas in this section of the model are spatially relative and therefore it is imperative that no rows or columns are added or deleted from the model.

ASSYST is completely macro driven and will automatically import Drivers, Economic Inputs, Building Based Inputs and Technology Based Inputs and will automatically name and output results. Users have full access to all algorithms and intermediary results in ASSYST for analytic inquiry and quality control purposes, yet never need to work within the ASSYST directly. **Do <u>not</u> save ASSYST.**

Figure A-6
Overview of Technical Potential Spreadsheet



BATCHXYZ.XLS: The BATCHXYZ file is the main file that guides the DSM ASSYST analytic process. BATCHXYZ first translates user defined characteristics into the names of files that are needed to perform each DSM ASSYST analytic run. These characteristics may take the form of market segments, end uses, sectors, vintages, and types of analysis. BATCHXYZ then works in conjunction with DSM ASSYST macros to guide DSM ASSYST through the analytic process. The BATCHXYZ spreadsheet automatically names input and output files that will be called upon by the DSM ASSYST Macro.

Figure A-7 is the Map of the BATCHXYZ File. Columns A through J are for the user to specify characteristics. Column A is for the type of analysis (BASIC or SUPPLY). Column B is for Sector (RES, COM, or IND). Column C is for Vintage (EXISTING or NEW). Column D is for End Use. End Use names can reflect how the end uses are defined (e.g. ALL, CONDITIONING, COOLING, HEATING, LIGHTING, REFRIGERATION, HVAC, etc.) Column E is for Segment (0 through 9). Column G is for identifying the input Batch # (1 through 9). Column H is for identifying the output Batch # (1 through 9). Separating the input and output Batch numbers allows use of the same input files for economic sensitivity analysis while maintaining means of labeling output files differently. Column I is for the utility building data file name. Column J is for the utility economic data file name. These two files usually have a three letter utility name abbreviation plus a number. The number is useful in identifying different building sectors or sets of economic input data such as alternative avoided costs. Shaded Columns K through U are the names of files that DSM ASSYST will import, create and/or use in the analytic process.

Figure A-7
Map of the BATCHXYZ File

INPUT AREA	FILE NAMES CREATED FROM INPUTS
Column A-J	Column K-U

ASSYST will run all rows of run characteristics defined in the BATCHXYZ starting with Row 5 until it reaches a row in Column A with no data. Each row of characteristics is used for a separate run of ASSYST.

M_*.XLS Technology Input Files: These files contain sets of tables with technology based input data which are loaded into ASSYST. Names for the M_ files are derived in the BATCHXYZ. M_B*.XLS files contain data for the Basic Analysis and M_S*.XLS files contain data for the Supply Analysis.

D_*.XLS Drivers: The first five columns of the work area within ASSYST contain information that informs the model of technologies being analyzed, end uses, building types and segment context. This information is used to operate the lookup tables and thereby specify which parameters are to be used in the analysis. Names for the D_ files are derived in the BATCHXYZ. D_B*.XLS files are used for the Basic Analysis and D_S*.XLS files are used for the Supply Analysis.

BLD_*.XLS Building Files: These files contain the Building Tables, Load Shape Tables, and Peak to Load Shape Tables. Names for the BLD_ files are derived in the BATCHXYZ.

ECO_*.XLS Economic Parameters Files: These files contain utility specific economic parameters including discount rates, inflation rates, technology implementation rates, avoided cost tables, and customer rates.

B_*.XLS Basic Output Files: These files contain the results from the Basic Analysis. Names for the B_ files are derived in the BATCHXYZ.

S_*.XLS Supply Output Files: These files contain the results from the Supply Analysis. Names for the S_ files are derived in the BATCHXYZ.

POSTBAT.XLS: This file is used to control post ASSYST processing of Supply Output and the Market Potential Analysis. The file contains the names of Supply Output files and Program Input and Output files. Supply Output file names are listed in Column A and the Program Input names are listed in Column D. The Supply Output File names can be found in BATCHXYZ and can be copied.

POSTBAT works similar to BATCHXYZ. It starts running at Row 6 and continues until it encounters a row without data. Post Supply Analysis and Program Analysis are completely independent and are run by separate macros.

POSTBAT will automatically name Program Output file based on the names of Program Input files by changing the first letter "P" (P_*.XLS) to an "O" (e.g. O_*.XLS). The algorithm to create the output name is located in the shaded Column F.

PENWORK.XLS: This file is used for the final portion of the market potential analysis.

IB_*.XLS: These files are produced in Basic ASSYST and are inputs for the P_*.XLS Program Input Files.

IS_*.XLS : These files are produced in Supply ASSYST and are inputs for the P_*.XLS Program Input Files.

P_*.XLS Program Input Files: These files are produced in ASSYST and are inputs for the final portion of the Market Potential Analysis.

O_*.XLS Program Output Files: These files are output from PENWORK and contain the results of the Market Potential Analysis.

TR_*.XLS TRC Files: These files contain the TRC Sort resulting from the Basic Analysis. These files are used to establish the Driver order used in the Supply Analysis.

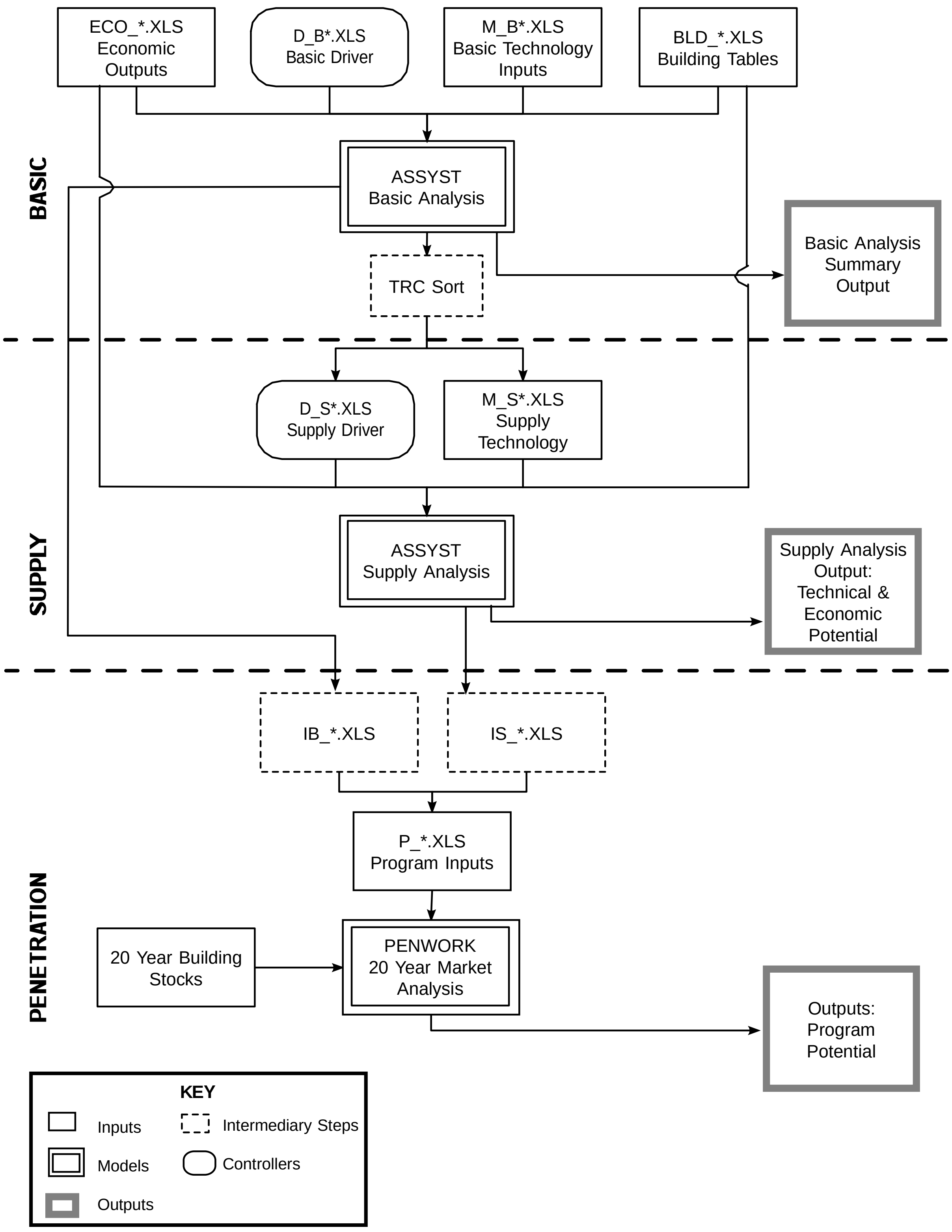
Installation Procedure

1. Load Microsoft Excel for Windows on your computer and make sure it is running properly.
2. On your hard drive or network, set up a system of sub directories. Although sub directories are not necessarily needed, we recommend them for file management purposes. We recommend:
   - One sub directory that contains the ASSYST, BATCHXYZ, ASMACH, PENWORK, and POSTBAT files.
   - Residential, Commercial, Industrial data contained in separate sub directories.
   - Batch numbers assigned to different runs to help distinguish them. We advise keeping different batches in different sub directories.
   - Use other sub directories as desired.
3. Load DSM ASSYST files on your hard drive or network using sub directories as appropriate.

A.2.3 Methodology and Operation

For a flow chart of the DSM ASSYST Analytic Flow, see Figure A-8.

Figure A-8
DSM ASSYST Analytic Flow



Basic Analysis

In the Basic Analysis each technology is assessed individually by comparing it to a base case. Comparisons are made at a high degree of segmentation. The segmentation may include, but is not limited to sector, building type, end use, vintage and geographic area.

Four types of information, contained within four spreadsheet files, are automatically brought into the ASSYST model. These files must be prepared by the user prior to running ASSYST. These files are the appropriate versions of:

ECO_*.XLS economic parameters file containing utility rates paid by customers, avoided costs and other utility specific economic parameters,

BLD_*.XLS building file containing square footage or number of households and load shape data,

M_B*.XLS measure file containing technology based inputs for the Basic Analysis, and

D_B*.XLS driver file containing information that drives the analysis process.

Preparation of the input files is discussed in later sections.

Outputs of the Basic Analysis include a B_*.XLS Summary Basic Output spreadsheet file that contains an assessment of how much energy and demand each technology will save relative to the base case within each segment. In addition, the summary contains cost data, savings fractions, before and after EUIs or UECs, service life, the levelized costs of implementing the technology, and results of economic tests including the TRC test, participant test and customer payback.

DSM ASSYST also produces a TR_*.XLS file that contains all the measures that were assessed in the Basic Analysis sorted in the highest to lowest TRC order within each segmentation. This file serves as a guide for the implementation or stacking order that will be used in the Supply Analysis. This will be discussed in more detail in the next section.

Finally, the Basic ASSYST produces measure level information that can be screened and combined into program inputs. The Basic ASSYST output containing this information is found in IB_*.XLS files. Use of the IB_*XLS files will be discussed in more detail in Section 5.3.

Supply Analysis

In the Supply Analysis each technology, within each market segment, is stacked, or implemented, such that all energy savings are realized from preceding technologies prior to the implementation of all subsequent technologies. The stacking order generally follows the TRC sort order, highest to lowest, resulting from the Basic Analysis.

Three types of input changes are required when moving from the Basic Analysis to the Supply Analysis.

1. For the Supply Drivers, D_S*.XLS, technologies must be listed in the order that they will be implemented within each market segment. Although the TRC sort provided in TR_*.XLS files is a useful guide, the user must make sure that the order is logical. Some measures may need to appear in a different order and other measures may need to be eliminated from the analysis. For example, if a SEER 12 air conditioner has a higher TRC than a SEER 11 unit, the SEER 12 unit will be implemented first leaving no savings potential for the SEER 11 unit. Thus, the SEER 11 unit should be excluded from the Supply Driver.

2. Once the Supply stacking order is established, energy savings must concur. In the Basic Analysis the energy savings matrixes found in the M_B*.XLS files are developed assuming that each technology will be compared against a base case technology. In the Supply Analysis, after each technology is implemented, it becomes the base case for the next technology in the stacking order. Some technologies do not affect the percent energy savings of other technologies. For example, a 10% savings fraction from insulation is not affected by a higher efficiency water heater. The amount of energy savings will be reduced because there is less energy available to save, but the 10% savings fraction will still be relevant. However, if a high efficiency water heater with a savings fraction of 15% is implemented followed by a super high efficiency water heater with a savings fraction of 25%, the change in savings must be recalculated. This is because the high efficiency model becomes the base case for the super high efficiency model. The formula for converting the energy savings is:

$$\text{New Savings Fraction} = 1- ((1\text{-Saving Fraction(higher)})/(1\text{-Saving Fraction(lower)}))$$

$$= 1- ((1 - .25)/(1 - .15))$$

Hence, the savings fraction for the super efficient water heater in the M_S*.XLS file should be reduced from 25% to 11.8%

1. <u>All costs in the M_S*.XLS technology input files need to be incremental</u>. In the example above, if the base case cost is $200, the high efficiency model cost is $300 and the super high efficiency model cost is $450, then in the M_S*.XLS technology input file cost should be calculated as follows.

Technology	Actual Cost	Base Cost	Incremental Cost	Cost used for Supply Analysis
Base Heater	$200	$200	$0	$0
High Eff. Heater	$300	$200	$100	$100
Super Eff. Heater	$450	$300	$150	$150

Note: In the Supply Analysis, for all measures, the "Initial Cost" and "Replace Cost " (Column K and L in the M_*.XLS files) should both equal 1 for "full".

Output from the Supply Analysis is the full technical and economic potential plus energy and demand supply curves.

Finally, the Supply ASSYST model produces measure-level information that can be screened and combined into program inputs. The Supply ASSYST output containing this information is found in IS_*.XLS files. Use of the IS_*XLS files is discussed in more detail in Section 5.3 below.

Market Potential Analysis

The Market (or Program) Potential Analysis module of ASSYST is a separate input-output model designed to calculate the costs and net energy and demand savings from DSM programs under a variety of marketing scenarios. The program module evaluates each DSM measure in each market segment. Using a stock accounting algorithm over a period of 20 years, the market module first calculates the number of customers for whom the measure will apply. Second, the model calculates the number of informed customers based on the amount of money spent on advertising. Third, the model calculates the number of customers who will implement the technology based on their Benefit/Cost ratio. Finally, the model compares the number of customers that implement the technology due to the program with those who would take the technology anyway (naturally occurring). Per unit energy and demand savings are applied to the net number of customers (total minus naturally occurring) over the twenty year period. After completing the analysis, the results are automatically summed across measures to provide program level costs and savings for 20 years, and formatted for input into Integrated Resource Planning models.

Using The Market Potential Module:

1. Screen measure level outputs from the ASSYST Program Analysis Input files (IB_*.XLS or IS_*.XLS). Determine which measures in which segment are appropriate for DSM programs. The macro "program building" (ctrl "p") will automatically copy the desired block of measure data, from Row 6 until the first blank Row, Columns A through U. It will then place the data in a user defined Program Input file (P_*.XLS), appending it to the existing measure data, or starting at Row 23. Use an existing Program Input file (P_.XLS) as a template and remove the unwanted data (from col. A to U, at Row 23). A separate Program Input file (P_*.XLS) should be made for each separate program.

   The choice of whether to take energy savings and demand savings data from the basic output (IB_*.XLS) or the supply output (IS_*.XLS) is left to the discretion of the analyst. The basic output may tend to overestimate program savings potential because it does not account for measure interaction. The supply output may tend to underestimate program potential due to the supply stacking methodology that assumes full implementation of each applicable measure prior to adding subsequent measures within a segment. This results in reduced energy savings potential for the subsequent measures. The analyst may also choose some value between the extremes.

2. For each measure, set the technology/market segment specific parameters. See Figure A-9 Map of Program Input File for parameter locations.

   Incentive: The incentive can be set at a specific level (e.g., $10, "10") or as a percent of some other value(e.g. 30% of the customer cost , "=L23/K23*.3"). The units are $/sq. ft. or $/household.

   Technology Acceptance Curve Parameters:

   MAX: This parameter determines the highest possible annual acceptance rate for the technology.

   MID: This parameter determines the inflexion point of the curve. It is generally one over the Benefit/Cost ratio that will give the value of 1/2 the maximum value.

   FIT: This parameter determines the general shape of the curve.

3. Set the program specific parameters.

   Administration Budgets: This is the amount of money spent each year on administration. These costs have no impact on the number of customers who will participate but should reflect the actual cost of administration to enable accurate cost analysis.

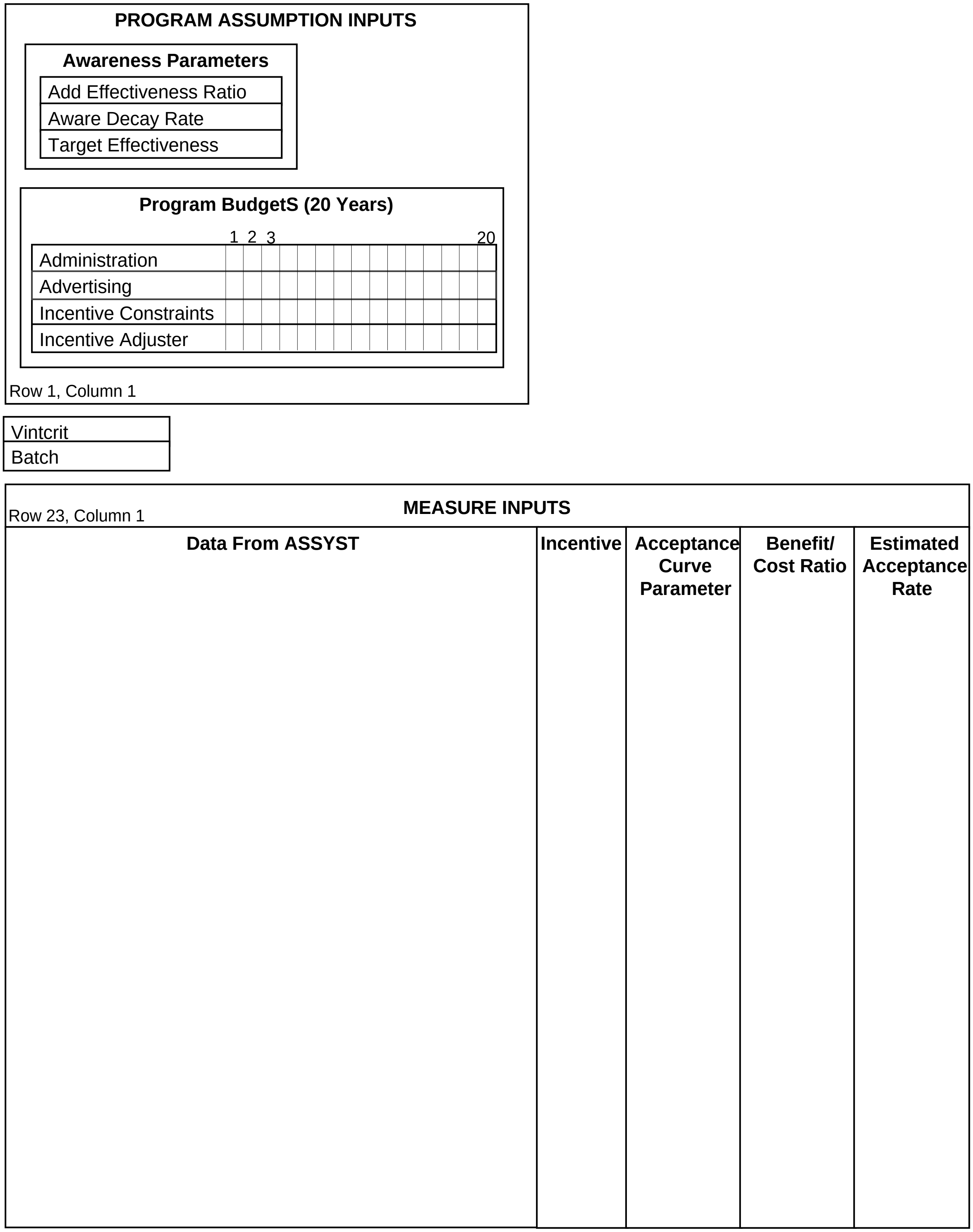
   Advertising Budgets: This is the amount of money spent each year on advertising. The advertising budget affects the number of new customers who are informed about the program each year.

   Advertising Effective Ratio: This coefficient represents an estimate of the amount of advertising budget required to inform one household or one square foot of commercial space about the program. The units are $/sq ft or $/household, depending on the sector being modeled.

   Awareness Decay Rate: This parameter represents an estimate of the rate of annual decay in customers' awareness of the measures.

   Target Effectiveness: This parameter controls how effectively advertising dollars are being directed toward eligible customers. The value should be set between "0" and "1". A value of "0" means that the money spent on advertising is not targeted and is informing all the applicable building stock at the same rate independent of whether the stock is eligible for measure implementation. A value of "1" indicates that all money spent on advertising is directed toward customers who have building stock that is eligible for measure implementation.

Figure A-9
Map of Program Input File



Incentive Constraint: This parameter adjusts the number of households or square feet that can receive incentives. The default value for this parameter is "1". The parameter is input for each year and can be used when incentive payments are expected to exceed the program budget. A value of ".5" means that half the households or square footage will be able to receive the incentive. Determining a set of values for this parameter may require an iterative process.

Incentive Adjuster: This parameter will adjust the incentive amount. The default value for this parameter is "1". The incentive for each measure is set at the measure-level as discussed above in Section 5.3.2. This parameter is input for each year and can be used to model changes in incentive level over time. A value of "2" will double the incentive, a value of "0" can be used to turn the incentive off.

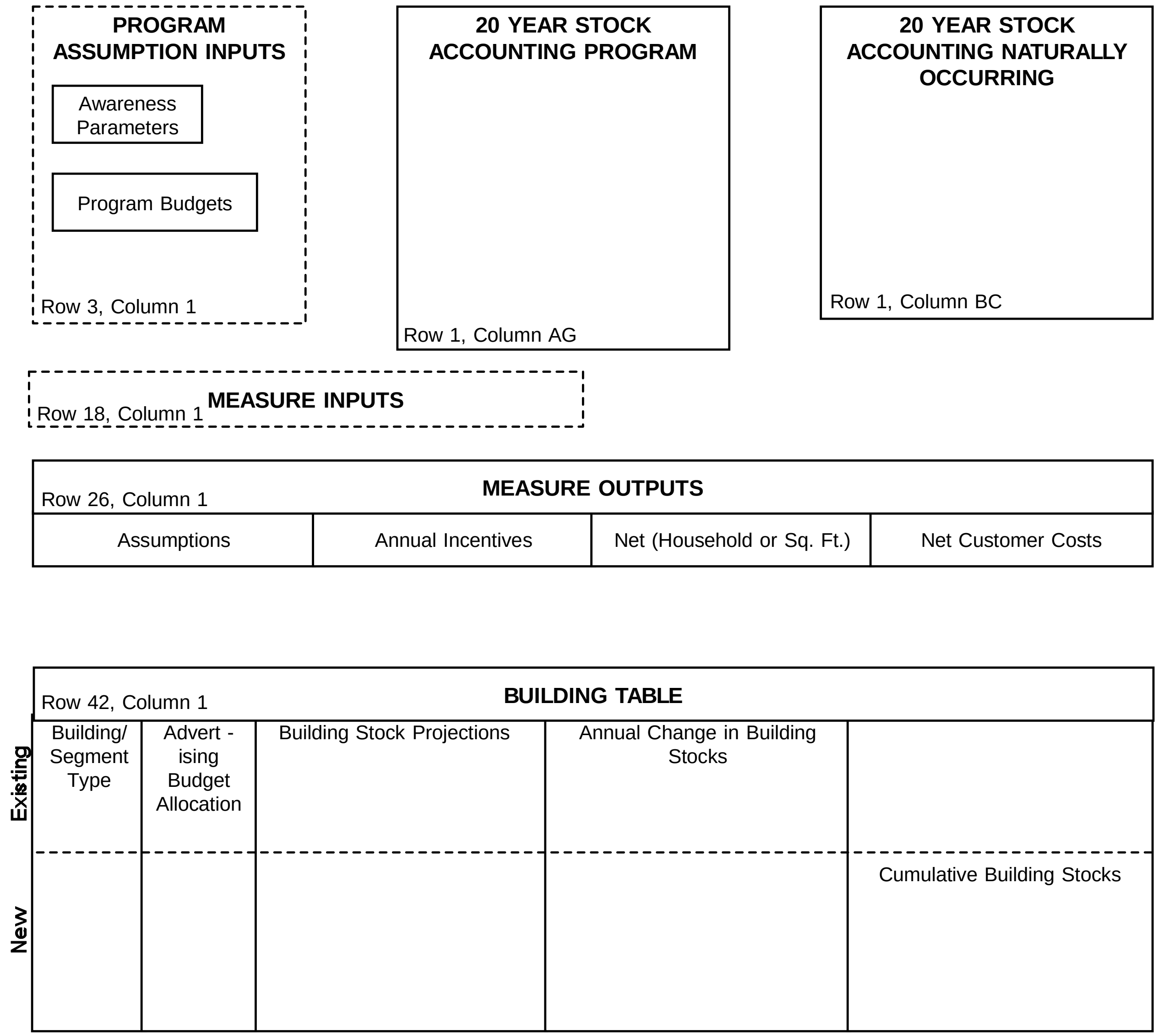
Vintcrit: This parameter tells the model which segment code is the start of new construction buildings.

Batch: This parameter is for the user to keep track of their model run.

4. Update the building table in PENWORK.XLS. This table contains the number of households and/or square footage values from the starting year through the following 20 years. The values for existing buildings are the cumulative and decayed existing building stock. The values for new buildings are the number of new buildings for each year. Buildings should appear listed by ascending Segment code number. The Segment code will be calculated automatically based on the Segment/Section and the building number. Column E contains the Advertising Budget Allocation which restricts the amount of total advertising budget for specific building types. For example, setting the values to 0.95 for single-family homes and 0.05 for multi-family homes will result in the advertising budget split such that 95% of the advertising budget will be used to inform single-family customers and 5% will be used to inform multi-family customers. The default Advertising Budget Allocation values should be the portion of square footage or households of each building type relative to the total for the segment. See Figure A-10 Map of PENWORK for an overview of the PENWORK module.

5. Enter the names of the Program Input files P_*.XLS into the POSTBAT.XLS spreadsheet Column D. Copy down the formula in Column F that creates the O_*.XLS name.
6. Run ASMAC2B.XLM: "pen_run" macro.
7. Review results in O_*.XLS files.

Figure A-10
Map of PENWORK



A.2.4 Preparing for Analysis

1. Compile all necessary input data. This includes the preparation of Economic Parameter Input Files (ECO_*.XLS), Building Input Files (BLD_*.XLS), Technology Input Files (M_*.XLS) and Drivers (D_*.XLS). **Note: All input tables that are brought into ASSYST function as lookup tables. Exact spatial relationships within these files must be maintained for ASSYST to work properly.**
2. Set up a BATCHXYZ file such that it contains the elements of the analysis that you are interested in running. The first analytic run should start on Row 5 and each subsequent

analytic run should be on succeeding row until all are entered. DSM ASSYST will evaluate each analytic segment from Row 5 until there is a blank Row.

3. Check the ASMACH .XLM macro file to make sure that all parts of the analysis that are engaged are pertinent to the analysis being performed. A more detailed description of ASMACH is found in Section 12.
4. If running Supply Curve Analysis on the back end of the Supply Output and/or if running the Market Analysis, set up the POSTBAT.XLS file as described in Section 4.
5. Make sure all input files are in the current sub-directory and are closed.
6. Make as much memory available to EXCEL as possible by entering expanded windows mode, close unnecessary applications or other methods available to you.

A.2.5 Simple Operations: Running DSM ASSYST Start to Finish

The following steps assume a first time run of the entire process. Excel must have access to the proper sub-directory at all times, that is, the directory where the files to be analyzed are located.

1. Open ASSYST3.XLS, BATCHXYZ.XLS, and ASMAC2B.XLM.
2. Set BATCHXYZ to run the Basic Analysis as described in Section 4. Confirm that Excel has access to the directory with the files that you intend to run.
3. Run the ASSYST macro by pressing (Ctrl "a"). Evaluate the Basic Output as desired.
4. Evaluate the results of the TRC Sort in the TR_*.XLS file. Build Drivers (D_S*.XLS) and Technology Input Files (M_S*.XLS) for the Supply Analysis.
5. Set BATCHXYZ to run the Supply Analysis.
6. Run the ASSYST macro by pressing (Ctrl "a"). Supply Outputs and Program Analysis Inputs will be generated.
7. Close ASSYST to make room on the system. **DO NOT SAVE ASSYST.**
8. Open the Program Analysis Input files (I_*.XLS) and a Program Input file (P_.XLS). Create Program Input files (P_.XLS) by combining the desired measures into programs. The macro (Ctrl "p") moves the block of data in (I_*.XLS) from row 6 until a blank row into a user defined Program Input file (P_.XLS). Set the technology and program parameters. Close these files after completing.
9. Open POSTBAT and place Supply Output file names in Column A and the Program Input names in Column D.
10. Close BATCHXYZ.
11. Run the Supply_Curve_Sort macro by pressing (Ctrl "c"). This will provide further evaluation of the Supply Output including supply curve sorts for both energy and demand. Evaluate further as desired.
12. Open PENWORK.

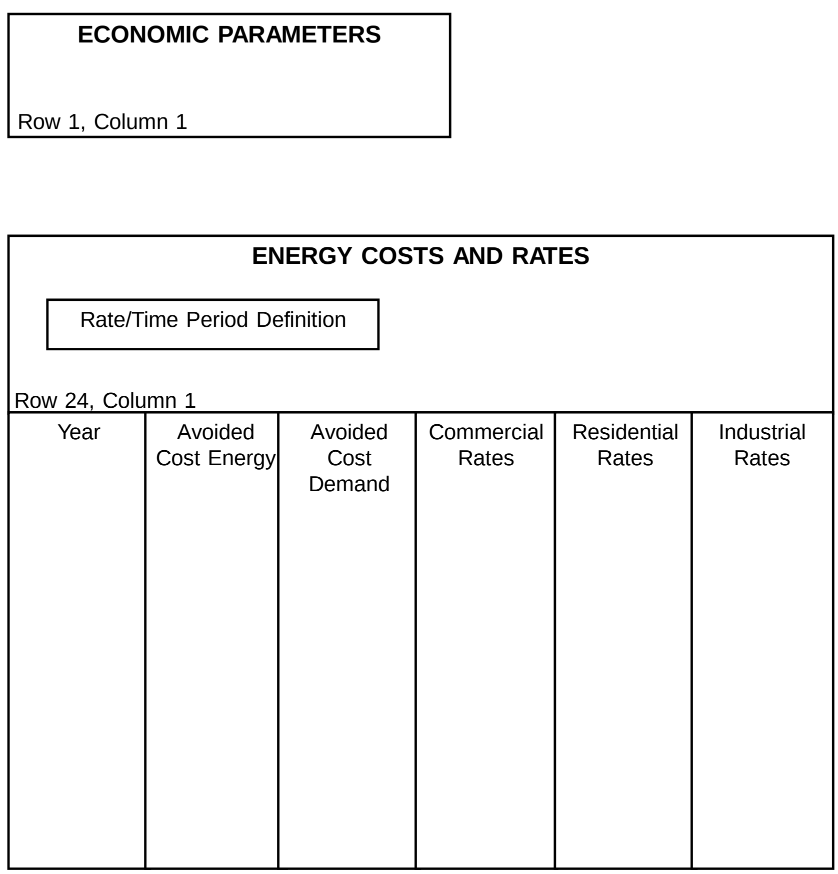
13. Run the Pen_Run macro by pressing (Ctrl "q"). This provides the Market Potential under each of the program scenarios specified by P_*.XLS. Summarize and evaluate further as desired.

Note: Basic and Supply Analysis can be run within the same BATCHXYZ run if Supply Technology Input Files and Drivers are already built and will not change due to changes in the Basic TRC sort.

A.2.6 Economic Parameter Inputs (ECO_*.XLS)

The following inputs are general economic parameters. These data and their locations are shown in Figure A-11 Map of Economic Parameter Inputs.

Figure A-11
Map of Economic Parameter Inputs



Economic Parameters

Utility Name: This cell is informational and used in the Data Check.

Sector: This cell is informational and used in the Data Check.

Batch #: This cell is informational and used in the Data Check.

Utility Discount Rate (UTIL_DISC_RATE): This is the discount rate that the utility uses to do net present value analysis when considering cost streams over the life of projects.

Customer Discount Rate (CUST_DISC_RATE): This is the discount rate that utility customers would use when calculating the net present value of savings from reduced energy bills resulting from energy conservation.

General Inflation Rate (INFLATION_RATE): Projected inflation rate.

Base Year (BASE_YEAR): This is the year to which all cost and benefits are normalized. It is also the first year for data in the Avoided Cost and Rate Tables. In the model delivered, the Base Year is 1992.

Start Year (START_YEAR): This is the first year of the analysis. Changing the Start Year changes the 20-year period over which the cost and benefit streams are calculated. The Start Year can not be earlier than the Base Year.

Difference: This is the calculated difference between the Start Year and the Base Year.

Utility Line Loss Rate: The percentage of energy lost through line losses.

Energy Costs and Rates Table

Type: Used to identify separate runs for sensitivity analysis.

Energy Units: Used to specify type of currency per kWh.

Demand Units: Used to specify type of currency per kW.

Rate/Time Period Data: Rate/Time period data is to identify what the five available rate/time periods are by name, by abbreviation and how many hours are in each. The Monthly Adjustment for Rates is the number of mouths the monthly demand change will be multiplied times.

Avoided Energy Costs by Rate/Time Period: Columns B through F contain projected avoided cost of energy by rate/time period over time. Entries should be made in nominal monetary units (e.g., dollars). DSM ASSYST will discount the values to the Base Year as part of the analysis.

Avoided Demand Costs by Rate/Time Period: Columns G through K contain projected avoided cost of demand by rate/time period over time. Entries should be made in nominal monetary units (e.g., dollars). DSM ASSYST will discount the values to the Base Year as part of the analysis.

Energy Rate Projections by Time Period: Columns L through P contain projected energy cost by rate/time period over time. Entries should be made in nominal monetary units (e.g., dollars). DSM ASSYST will discount the values to the Base Year as part of the analysis.

Monthly Demand Rate Projections by Time Period: Columns Q through U contain projected monthly demand charges by rate/time period over time. Entries should be made in nominal monetary units (e.g., dollars). DSM ASSYST will discount the values to the Base Year as part of the analysis.

A.2.7 Building Tables (BLD_*.XLS)

The following inputs are shown in Figure A-12 Map of Building Tables.

Building Table

The Building Table allows the user to specify up to 10 building segments and up to 14 different types of buildings in each segment. Building types are defined by row and segments are defined by column. Units used for the analysis of the residential sector are number of households. Units used for the analysis of the commercial or industrial sectors are square feet or square meters. The matrix bound by Columns D through M and Rows 8 through 21 contains values. The matrix bound by Columns N through W and Rows 8 through 21 contains definitions of those values. Typically, segments are used to define geographic differences and vintage differences. For example, Segments 1 - 4 may be used to define the number of existing households in four separate utility sub regions and Segment "0" can be used to define the total number of existing households in the utility. Segments 5 - 9 can be used in the same manner for the number of new households.

Header information at the top of the building table is particularly important for keeping track of which building table should be used in which analysis. The Batch # is a useful way to signify the difference between commercial and residential sectors.

Figure A-12
Map of Building Tables

BUILDING TABLE Row 1, Column 1	
Number of Households or Sq. Ft. by Building Type by Segment	Building Type Definitions by Segment

LOADSHAPES BY BUILDING TYPE Row 24, Column 1								
End Use 1	End Use 2	End Use 3	End Use 4	End Use 5	End Use 6	End Use 7	End Use 8	End Use 9

PEAK TO ENERGY RELATIONSHIP TABLE BY BUILDING TYPE Row 44, Column 1								
End Use 1	End Use 2	End Use 3	End Use 4	End Use 5	End Use 6	End Use 7	End Use 8	End Use 9

Load Shape Table

The Load Shape Table specifies what portion of energy is used in each rate time period, by building type and end use. The Proportional Energy Use must sum to 1 for each building type within each end use.

The end use order is typically, though users may specify whatever order they prefer:

Order	Commercial/Industrial	Residential
1	Lighting	Heating
2	Exterior Lighting	Air Conditioning
3	Cooling	Cooking
4	Heating	Refrigerator/Freezer
5	Ventilation	DHW
6	Refrigeration	Clothes washer
7	DHW	Misc.
8	Process	Lighting
9		Dishwasher

This order can change so long as there is consistency between the order and the numbering of end uses in the Technology Input Table (Section 10).

Peak-to-Energy Relationship Table

The Peak-to-Energy Relationship Table is comprised of factors that associate the average demand, as can be calculated from the load shape, to the actual demand for each market segment or building type, for each rate time period, for each end use, coincident with the utility's peak.

To calculate the values, average the demand for each market segment, for each rate-time period, for each end use. Next, divide the actual demand during the utility's peak time period for the end-use for the market segment by the average demand of the same end-use, market segment, and time period. For example, if average demand for high-rise office cooling during the hours that constitutes the summer peak rate-time period is 0.80 kW/Sq. Ft. and the actual demand for high-rise office cooling is 1.20 kW/Sq/ Ft., then the Peak-to-Energy factor is 1.20 divided by 0.80, or 1.5.

End uses are listed in the same order as in the Load Shape Table above.

Customer Coincident Peak-to-Energy Relationship Table

The Customer Coincident Peak-to-Energy Relationship Table is comprised of factors that associate the average demand, as can be calculated from the load shape, to the actual demand coincident with the customer's peak usage for each market segment or building type, for each rate time period, for each end use,.

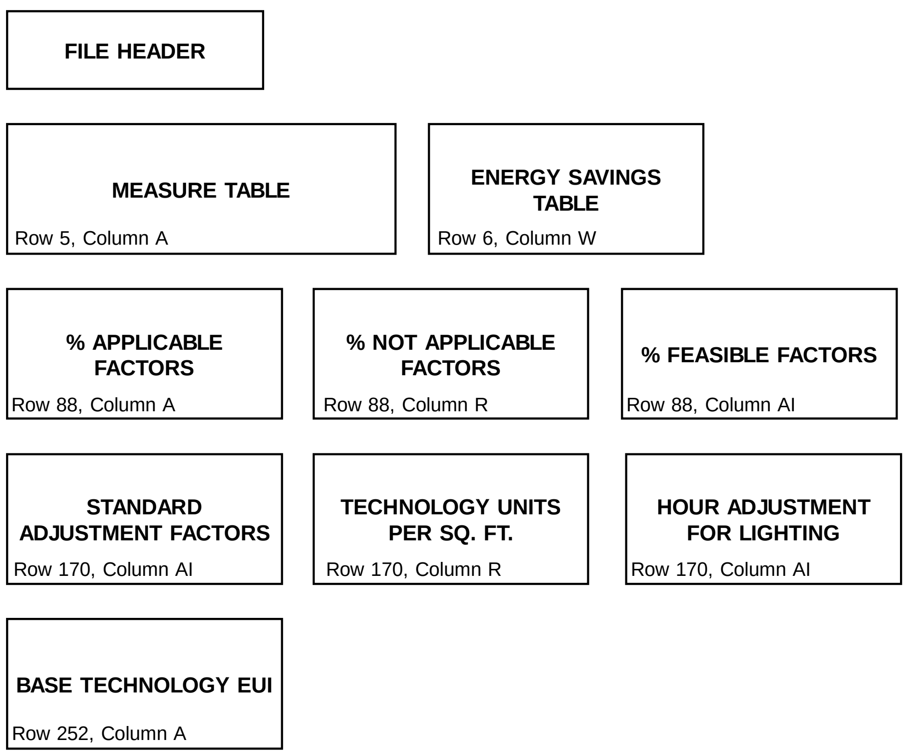
End uses are listed in the same order as in the Load Shape Table.

A.2.8 Technology-Based Inputs (M_*.XLS)

The following technology-based input tables operate as a set and are referenced by the same Measure Numbers. The Measure Numbers, including the Base Technology Measure Numbers, must all be in progressive sequential order for the "look-up" functions to operate properly.

See Figure A-13 for a Map of a DSM Technology Input file.

Figure A-13
Map of Measure Input File



Measure Input Table (M)

DSM Measure Input Tables contain the following data.

Measure Number: Contains the number by which the measure will be referred.

Measure: A brief description or title of the DSM technology.

Savings Units: The engineering units in which energy savings are associated.

Cost Units: The units by which the technology is priced.

Unit Equipment Cost: The cost of the DSM technology. This can either be wholesale or retail but the user should know which it is and it should be consistent in the application of costs. (For the Supply Analysis this should be entered as the incremental cost).

Unit Labor Cost: This is the cost of installing the technology. (For the Supply Analysis this should be entered as the incremental cost).

Incremental Lifetime O&M Cost: These values are used to account for the discrepancies between the O&M cost of the DSM technology relative to the base case technology. This value can be positive (if the measure costs more to operate and maintain than the base technology) or negative (if the measure costs less to operate and maintain than the base technology). Although O&M is generally accounted for on an annual basis, this value should reflect the discounted sum of the annual incremental O&M cost over the life of the technology.

Cost Multiplier: This factor allows the user to increase the cost of a measure without changing the cost in the cost fields. This factor can be used for scenario analysis. The default value should be "1".

Cost Units Per Savings Units: This factor reconciles the differences between cost units and savings units, should they be different thereby making them multiplicative. The default value for this factor is "1."

Service Life: This is the expected life of the measure. If the Service Life is less than 100, the model assumes that the units are years. If the Service Life is over 100, the model assumes that the units are hours. All measures are analyzed over a 20-year period.

Initial Cost (Full = 1, Incremental = 0): This is a toggle switch that tells ASSYST whether to consider the measure a retrofit or replace-on-burnout measure. The toggle should be set to "1" for retrofit measures and the full cost of the measure will be used. The toggle may be set to "0" if the measure is a replace-on-burnout measure and the user wants the initial cost to be the incremental cost between the measure and the base case. (This toggle must be set to "1" for the Supply Analysis.)

Replacement Cost (Full = 1, Incremental = 0): When a measure has a service life of less than 20 years and needs to be replaced one or more times over the 20-year period of analysis, this toggle switch tells DSM ASSYST whether to apply the full cost of replacing the measure or the incremental cost of replacing the measure. The toggle is usually set to the same value as it is in the Initial Cost. (This toggle must be set to "1" for the Supply Analysis.)

Full Unit Cost: This is the sum of the Unit Equipment Cost, the Unit Labor Cost, and the Incremental Lifetime O&M Cost and is automatically calculated.

Relative Energy Reduction Factors (by rate time period): These five columns allow the user to allocate each measure's incremental energy and demand savings to the appropriate rate time period thus affecting load shifting. The default value equals "1" indicating that energy savings resulting from the measure occur in the same pattern as base case energy use (e.g., a value of "1" would mean that a 20% energy savings would yield a savings of 20% of the base case energy for the time covered in the rate-time period). If the marginal savings are to occur in a different pattern than the base energy use pattern, then these factors allow the user to change the proportional savings. For example, if the energy savings in a particular rate-time period are 90% of what would be expected (e.g. 18% instead of 20%), then the factor should be "0.9". These factors are closely tied to the definition of energy savings found in the ENERGY_SAVINGS table (see Section 10.2) because they can potentially alter the weighted average savings for the measure.

End Use: This is a numerical value corresponding to the end use for each measure. Numbers should correspond to the end uses as numbered in the load shape portion of the Building Table and Peak-To-Energy Relationship Table.

Implementation Type 1= 1 time, 2= turnover: This informs PENWORK how to treat the implementation of the technology. Generally "1" is used for retrofit applications such as shell measures and "2" is used for replace-on-burnout applications.

Energy Saving (ENERGY_SAVINGS)

The Energy Savings table contains the estimated annual energy savings for each measure by market segment or building type. In the Basic Analysis the energy savings are in relation to the base case. In the Supply Analysis the energy savings are in relation to previous technologies in the stacking order. See Section 5.2 for more details.

Care must be taken in defining energy savings for measures whose energy savings patterns do not follow the base case energy usage (e.g., variable speed drives, occupancy sensors & load shifting strategies). The use of Relative Energy Reduction Factors (see Section 10.1) may produce an annual weighted average energy savings different from the energy savings value input. One possible approach may lie in setting the energy savings to the maximum savings level. This should only be done with awareness of how the energy savings were originally calculated. For example, a Variable Speed Drive may save 30% off peak and -5% on peak. The energy savings can be set at 30% with the awareness that the annual energy savings will actually be less. Documenting the approach is important for repeatability.

Applicable Factors (APPLICABLE)

The % Applicable Factors table contains the fraction of the floorspace or households that is applicable for conversion to the DSM technology for each market segment or building type. It generally corresponds to the saturation of the base case technology.

Not Complete Factors (NOT_COMPLETE)

The % Not Complete Factors table contains the fraction of the applicable floorspace or households that has not yet been converted to the particular energy-efficiency technology. The % Not Complete Factors are arranged by measure and market segment or building type.

Feasible Factors (FEASIBLE)

The % Feasible Factors table contains the fraction of the applicable floorspace or households that is technically feasible for conversion to the DSM technology from an engineering perspective. The % Feasible Factors are arranged by measure and market segment or building type.

Standards Adjustment Factors (EUI_ADJUST)

The Standards Adjustment Factors table allows the user to adjust EUIs or UECs to account for efficiency improvements due to existing or anticipated regulations. These factors can also be used to adjust base EUIs and UECs to account for changing market conditions that would result in higher base technology energy efficiencies. The Standards Adjustment Factors are arranged by measure and market segment or building type.

Technology Units per square foot (units_per)

The Technology Units per square foot table contains information about how many measure costing units are found in each square foot or household of each market segment or building type (e.g. tons/sq. ft.). The measure units are the same as those specified in Cost Units in the Measure Input Table.

Hour Adjustment for Lighting (LIGHT)

The Hour Adjustment for Lighting table gives estimates of the annual hours of operation for measures whose service lives are expressed in hours.

Base Technology EUIs (BASE_TECH_EUI)

The Base Technology EUIs table contains the energy consumption of each base technology by market segment or building type. Commercial units are kWh/ square foot. Residential units are UEC or kWh/ per household.

A.2.9 Drivers (D_*.XLS)

The first five columns of ASSYST's calculation area contain data that informs the model about which technologies are being analyzed, for what end uses, for which building types and in what segment (usually geographical) context. This information is used to operate the lookup tables and thereby specify which parameters are to be used in the analysis. Header material further directs ASSYST as to what type of analysis is being performed (BASIC, SUPPLY, PEN), what sector is being analyzed (COM, RES, IND) and what fuel type (ELEC, GAS) is being analyzed. Other information included in the header is the utility name, batch number and vintage. The Segment can be entered into the header and automatically be changed below. For data location, see Figure A-14 Map of Driver.

Figure A-14
Map of Driver

HEADER INFORMATION				
Building Segment	Building Number	End Use	Base Number	Measure Number
Column A	Column B	Column C	Column D	Column E

Column A specifies the building Segment. ASSYST is set up to handle 10 segments. The segment can be specified in the header and all cells in this column will change automatically, or each line can be changed manually.

Column B specifies the Building Type. Building Type numbers should correspond to those established in the Building Table.

Column C specifies the End Use. End Use is associated with the Measure and is read into the driver from the Measure Input Table.

Column D specifies the Base Number. Each DSM technology has a base case technology against which it is compared.

Column E specifies the Measure Number. The Measure number is the identifier by which the DSM technology or system is referred. Base case technologies also have a Measure Number. Measure numbers generally appear in sequential order in the Basic Analysis and must appear in stacking order in the Supply Analysis.

When constructing a Basic Driver (D_B*.XLS), start with a base case, then list all the measures (technologies) related to that base case, then list the next base case and its corresponding measures until you have listed all of the possible technologies to be analyzed for a building type. Do the same for the next building type until you have a full set of relevant measures and base cases for all building types.

When constructing a Supply Driver (D_S*.XLS), under each base case list relevant measure numbers in the Supply stacking order. See Section 5.2 for more detail.

A.2.10 The Macro ASMAC2B.XLM

There is seldom a reason for the user to open the macro file or edit DSM ASSYST macros. If there is a reason to adapt the macros, it should be done by someone familiar with Excel macros.

The primary macro for running DSM ASSYST is the ASSYST macro found in Column A. Sometimes a user may choose to disable part of the ASSYST macro when it is not relevant to the analysis being performed. This can be done by removing the "=" sign before the run statement. The "=" can be replaced when the user wants to re-enable the macro.

Do **NOT** save ASMAC2B.XLM when exiting.

DSM ASSYST Macros:

ASSYST (a) = Runs ASSYST. Reads the BATCHXYZ and directs other macros to perform their functions.

pen_run (q) = Runs the market potential analysis, for each program, in batch mode from POSTBAT.

Supply_Curve_Sort (c) = Aggregates supply analysis results in the supply output files and creates energy and demand supply curves. Runs in batch mode from POSTBAT.

program_building (p) = Copies measure data from an I_*.XLS file and places it in a user defined P_*.XLS file. This macro must be executed from within an I_*.XLS file.

Selected Sub-routine Macros

Output_Summary (o) = Takes summary data and places them in new file.

TRC_Sort (t) = Sorts data in from the Basic Analysis in order of highest to lowest TRC within each segment.

Output_ANNTP = Creates I_*.XLS files from ASSYST data.

Appendix O

Residential New Construction Methodology and ASSET Inputs

As part of the New Construction Potential study, Itron was charged with estimating the potential energy savings from constructing low-rise residential buildings in California that are higher than code (i.e., ENERGY STAR® Homes). The first and most important part of the study was to find the costs and savings for low-rise buildings to reach 15% and 25% above the 2001 Standards. This information was then used to create packages of high efficiency measures. The RFP for this study stated the contractor:

> *"shall utilize existing databases of buildings characteristics for the residential … new construction markets. These databases have been developed for the Residential Market Share Tracking Study …"*

These pre-existing databases were originally suggested because of the availability of the data, because the data had been analyzed previously, and building prototypes had been developed. However, the data consisted of on-site surveys of homes built under the 1998 Standards. Due to the age of the data, the project advisory committee agreed to await the completion of the 2003 Statewide Residential New Construction (RNC) Baseline Study, which consisted of more current data from homes built under the 2001 Standards. While developing new prototypes, and therefore new savings and cost estimates, was beyond the scope of work, the project advisory committee and managers felt that it was important to utilize the most recent data.

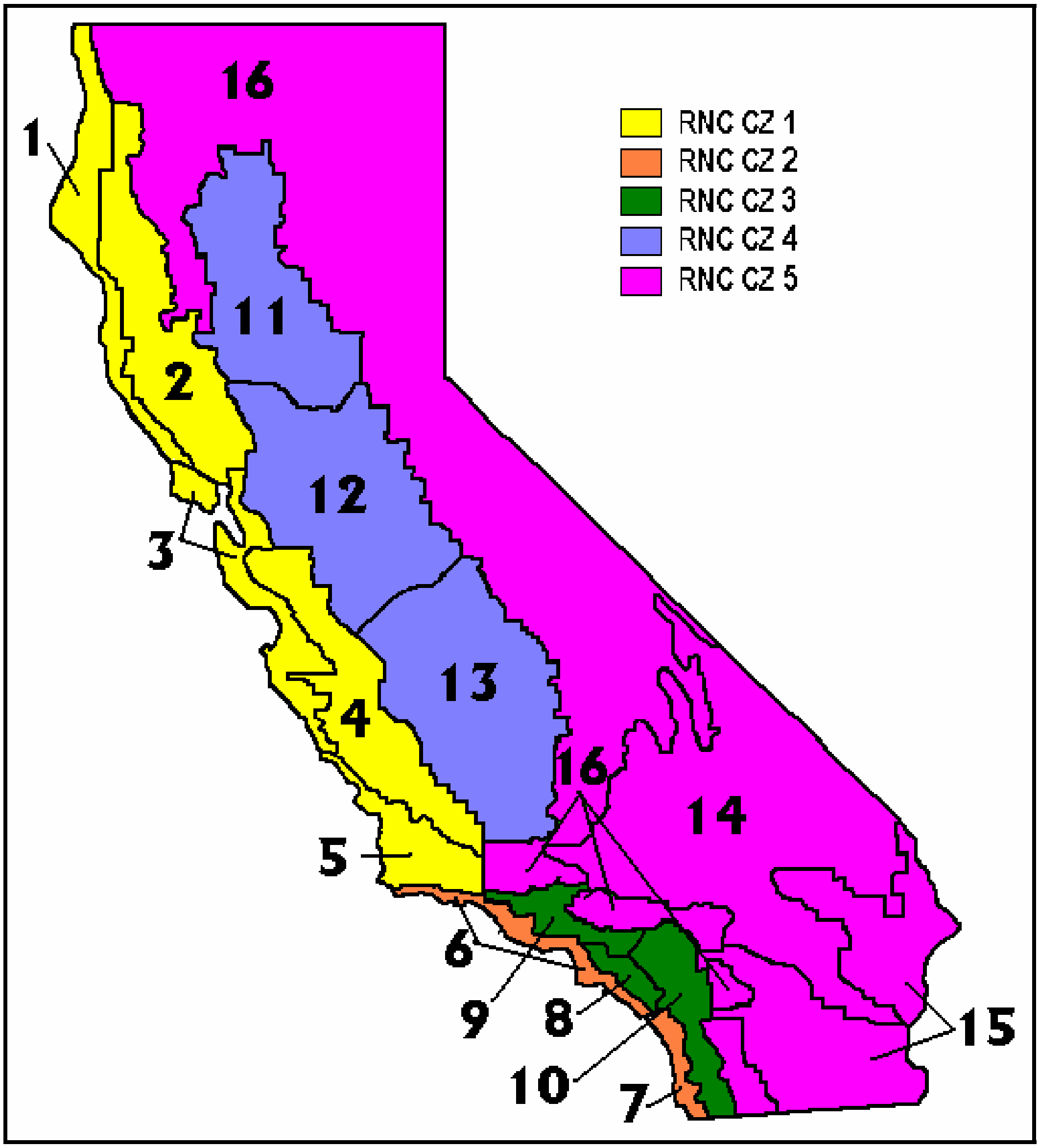
As the study progressed, time became a more pressing issue. This interim report was designed to include the cost and savings results most important to the program managers in helping design the 2006-2008 programs for the IOUs. This report summarizes the work completed to date on the residential portions of Tasks 3 and 4.

The remainder of this appendix summarizes the prototypes used as the baseline, the incremental measure cost of high efficiency measures, the bundles of measures included in the packages, and the proposed least-cost packages to reach the base and high activity levels presented in Table O-1.

O.1 Objectives

The objectives of the New Construction Potential Study included finding the saving potential for residential buildings that would approximate the building of ENERGY STAR homes under the new standards (reaching 10 and 15% above the 2005 codes), by Title 24 climate zone (as shown in Figure O-1). Further, unlike previous studies, the savings were to be calculated using "real" homes not "typical" homes, which are usually a box with windows spread evenly over each wall.

Figure O-1: California Energy Commission (CEC) Climate Zones



Source: California Energy Commission.

Table O-1: Measure Bundle Efficiency Levels

Scenario	Description	2004-2005 Level of Efficiency	2006-2013 Level of Efficiency
1	Code level	2001 Code	2005 Code
2	Base activity level	2001 Code +15%	2005 Code + 10%
3	High activity level	2001 Code + 25%	2005 Code + 15%

O.2 Single Family Detached Homes

A single family detached home is defined as a dwelling that has no walls or ceilings adjoining with any other dwellings.

Base Case Prototypes

The first step was to develop base case one-story and two-story homes for each RMST climate zone. These base case (prototype) homes were developed by first finding homes that matched closely with the average building shell characteristics (such as floor area and glazing area) of each CEC climate zone.[1,2] Once the best matching site was selected for each climate zone and story, the efficiency of the measures installed (HVAC, water heating, wall/roof insulations, window types) were adjusted. The first adjustment was made so that the measures in the prototypes more accurately reflect the average building practices in each climate zone found in the 2003 Statewide RNC Baseline Study.[3]

After the preliminary prototypes were developed, each was run under the 2001 Standards using MICROPAS 6.0. Next, the % compliance margin for each prototype was compared to the average % compliance margin found in each CEC climate zone during the 2003 study (baseline). This was done because it is important that each prototype not only reflects the average building characteristics of its respective CEC climate zone, but also closely matches the average compliance margin of homes. In cases where the % compliance margins of the prototype were not close to the baseline compliance margins, the efficiencies of the measures in the prototype were adjusted slightly and then reanalyzed using MICROPAS.[4] Table O-2 presents the building characteristics and the compliance margins of the 32 single family detached prototypes used in the analysis and approved by the New Construction Residential Advisory Group on September 2, 2004.

---

1 Since the goal was to develop baseline building characteristics, the ENERGY STAR homes that were surveyed were not included in the analysis.

2 The average building characteristics were drawn from the 2003 Statewide RNC Baseline Study.

3 The baseline results were taken from the averages of the sites surveyed in the 2003 Statewide RNC Baseline Study.

4 The compliance margin of each climate zone by story.

Table O-2: Single Family Detached Prototypes (base case)

		CEC CZ 1	CEC CZ 2	CEC CZ 3	CEC CZ 4	CEC CZ 5	CEC CZ 6	CEC CZ 7	CEC CZ 8	CEC CZ 9	CEC CZ 10	CEC CZ 11	CEC CZ 12	CEC CZ 13	CEC CZ 14	CEC CZ 15	CEC CZ 16
1-Story	Sq Ft	2,400	2,400	2,400	2,400	2,400	2,450	2,450	2,150	2,150	2,150	1,800	1,800	1,800	2,000	2,000	2,000
	Glazing % Area	17.1%	17.1%	17.1%	17.1%	17.1%	16.9%	16.9%	14.1%	14.1%	14.1%	14.3%	14.3%	14.3%	15.5%	15.5%	15.5%
	Glazing Area	410	410	410	410	410	414	414	303	303	303	257	257	257	310	310	310
	Type of Window	2VL	2VL	2VL	2VL	2VL	2VC	2VC	2VL	2VL	2VL	2VL	2VL	2VL	2VL	2VL	2VL
	Glazing U-factor	0.37	0.37	0.37	0.37	0.37	0.60	0.60	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
	Glazing SHGC	0.41	0.41	0.41	0.41	0.41	0.65	0.65	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
	Wall Area	2,560	2,560	2,560	2,560	2,560	2,214	2,214	2,580	2,580	2,580	2,080	2,080	2,080	1,989	1,989	1,989
	Wall	19	13	13	13	19	13	13	13	13	13	19	13	13	13	19	19
	Roof Area	2,400	2,400	2,400	2,400	2,400	2,450	2,450	2,150	2,150	2,150	1,800	1,800	1,800	2,000	2,000	2,000
	Roof	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
	Radiant Barrier	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
	TXV	No	No	No	No	No	No	No	No	Yes	No	Yes	No	No	No	No	Yes
	Tight Ducts	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
	Infiltration Testing	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
	Duct Design	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
	Duct R-value	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
	SEER	10.0	10.5	10.5	10.0	10.5	10.0	10.0	10.5	10.5	10.5	12.0	11.0	10.5	11.0	11.0	12.0
	AFUE	92%	92%	86%	80%	86%	80%	80%	80%	80%	80%	86%	80%	80%	80%	80%	86%
	EF	0.62	0.62	0.62	0.62	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.62
	Standard	29.59	36.46	22.95	28.62	24.49	17.96	16.28	22.69	26.89	32.69	41.03	38.47	42.60	44.52	51.18	51.55
	Margin	2.28	3.49	3.53	3.33	4.46	3.90	2.10	2.50	3.70	1.64	4.85	0.24	-3.44	-0.92	-5.16	0.54
	% Compliance Margin	**7.7%**	**9.6%**	**15.4%**	**11.6%**	**18.2%**	**21.7%**	**12.9%**	**11.0%**	**13.8%**	**5.0%**	**11.8%**	**0.6%**	**-8.1%**	**-2.1%**	**-10.1%**	**1.0%**
2-Story	Sq Ft	2,450	2,450	2,450	2,450	2,450	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,800	2,800	2,800
	Glazing % Area	18.3%	18.3%	18.3%	18.3%	18.3%	16.2%	16.2%	15.9%	15.9%	15.9%	16.2%	16.2%	16.2%	14.6%	14.6%	14.6%
	Glazing Area	447	447	447	447	447	470	470	461	461	461	470	470	470	409	409	409
	Type of Window	2VL	2VL	2VL	2VL	2VL	2VL	2VL	2VL	2VL	2VL	2VL	2VL	2VL	2VL	2VL	2VL
	Glazing U-factor	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
	Glazing SHGC	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
	Wall Area	3,313	3,313	3,313	3,313	3,313	3,114	3,114	3,834	3,834	3,834	3,456	3,456	3,456	4,060	4,060	4,060
	Wall	19	13	13	13	19	13	13	13	13	13	19	13	13	13	19	19
	Roof Area	1,558	1,558	1,558	1,558	1,558	1,500	1,500	2,010	2,010	2,010	1,720	1,720	1,720	2,086	2,086	2,086
	Roof	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
	Radiant Barrier	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
	TXV	No	No	No	No	No	No	No	No	Yes	No	Yes	Yes	Yes	No	No	Yes
	Tight Ducts	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
	Infiltration Testing	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
	Duct Design	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
	Duct R-value	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
	SEER	10.0	10.5	10.5	10.0	10.5	10.0	10.0	10.5	10.5	10.5	12.0	11.0	10.5	11.0	11.0	12.0
	AFUE	92%	92%	86%	80%	86%	82%	80%	80%	80%	80%	86%	80%	80%	80%	80%	86%
	EF	0.62	0.62	0.62	0.62	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.62
	Standard	32.38	41.05	26.08	32.11	28.46	16.25	14.84	21.17	25.41	31.18	36.29	34.05	37.08	44.43	49.29	54.53
	Margin	2.52	4.96	4.33	4.46	5.71	2.14	2.80	2.85	3.80	2.28	2.80	-1.16	-2.58	-1.82	-6.21	-0.19
	% Compliance Margin	**7.8%**	**12.1%**	**16.6%**	**13.9%**	**20.1%**	**13.2%**	**18.9%**	**13.5%**	**15.0%**	**7.3%**	**7.7%**	**-3.4%**	**-7.0%**	**-4.1%**	**-12.6%**	**-0.3%**

Incremental Costs

Table O-3 presents the incremental cost for each high efficiency measure included in the analysis. These costs were originally taken from the incremental costs study conducted by Itron in 2003. However, due to changes in the window industry, the incremental costs of high efficiency windows were decreased. In addition, a few measures were added because the previous list of measures did not enable all of the prototypes to reach the desired targets. In June 2005, after a re-examination of the market, the costs of roof insulation and radiant barriers were decreased to better reflect current pricing. Note that there are two costs given for each of the central air conditioning units due to the change in the federal minimum efficiencies beginning in 2006. (For example, from 2003 to 2005 the incremental cost for moving from a 10 SEER unit to a 14 SEER unit is $900; however, beginning in 2006, the incremental cost to move from a 13 SEER to a 14 SEER is $350.)

Table O-3: Summary of Proposed Incremental Measure Costs (2003 – 2005)

Measure	Efficiency	Total Cost	
Central Air Conditioner	12 SEER	$400 / N/A	Per Unit
	14 SEER	$900 / $350	Per Unit
	15 SEER	$1,200 / $600	Per Unit
Furnace	92% AFUE	$700	Per Unit
Water Heater	0.63 EF	$50	Per Unit
Radiant Barrier	Yes	$0.12	Per Sq. Ft. (Roof)
Roof Insulation	R-38	$0.08	Per Sq. Ft. (Roof)
	R-49	$0.20	Per Sq. Ft. (Roof)
Wall Insulation	R-19	$0.06	Per Sq. Ft. (Wall)
Insulation Credit	Yes	$50	Per House
House Wrap	Yes	$0.25	Per Sq. Ft. (Wall)
Windows	2-Pane Vinyl Low-E	$0.50	Per Sq. Ft. (Glazing)
	2-Pane Vinyl Spectral Low-E	$0.75	Per Sq. Ft. (Glazing)
Duct Insulation	R-8.0	$350	Per House
HERS Certified Sealed Ducts	Yes	$163	Per House
ACCA Duct Design	Yes	$131	Per House
Infiltration Testing	Yes	$150 + cost of House Wrap	Per House
TXV	Yes	$0	Per Unit

Developing the Packages

After the prototypes were finalized, the prototype homes were used as the base cases to which the high efficiency packages were added. The packages were designed according to common builder practices found in the 2003 Statewide RNC Baseline Study. From these commonly found efficiency measures, 70 combinations of measures were constructed. These 70 packages were then added to each base case home and simulated using MICROPAS. The least-cost packages that reached a compliance margin of at least 15% and 25% above the 2001 Standards and 10% and 15% above the 2005 Standards were used to calculate energy savings per year for each prototype.

Least-Cost Package Results

Lastly, the savings in therms and watts per year were calculated for the least-cost package of each CEC climate zone. Energy savings per year were derived by subtracting the proposed energy usage of the upgraded home per year from the base case proposed energy usage per year (for space heating, cooling, and water heating). The following presents the cost and savings for reaching the targets under the 2001 Standards and the 2005 Standards separately.

<u>2001 Standards</u>

Table O-4 and Table O-5 present the measures included in the least-cost package that upgraded each prototype to 15% and 25% above the 2001 Standards, respectively. The tables also present the incremental cost of each package (*Cost*), the compliance margin of the base case prototype (*Base Compliance*), and the compliance margin reached by adding the package to the base case prototype (*Package Compliance*). For convenience, the measures that were upgraded for each prototype to reach its target are highlighted.

As shown in Table O-4, six of the base case prototypes were already at least 15% better than the 2001 Standards. (Note that these six prototypes have a $0 cost and their baseline and package compliance margins are equal.) Each of these six base case prototypes is along the coast of California, which has a mild climate and is relatively unaffected by the changes to the 2001 Standards. On the other hand, the 2003 RNC Baseline Study shows that homes in the inland regions of California are, on average, noncompliant. This is reflected in the small or negative base compliance margins of the base case prototypes in CEC Climate Zones 12-16. As shown, the one-story base case prototype in CEC Climate Zone 13 had a -8.1% compliance margin and would have to install several high efficiency measures including spectral low-E windows, a 12 SEER air conditioner with a TXV, and a 0.63 EF 50-gallon gas water heater. Additionally, a HERS rater would verify that they installed 8.0 duct insulation and tight ducts. To reach 15% above the 2001 Standards would cost approximately $1,000 more than building the typical home in this climate zone.

Table O-5 provides the same results for the base case homes to reach 25% above the 2001 Standards. The base case prototype in CEC Climate Zone 1 could not be upgraded to 25% above the 2001 Standards with the high efficiency measures currently included the packages. CEC Climate Zone 1 has no cooling in the Title 24 model and therefore has to achieve 25% using just water heating and space heating. This is difficult since most high efficiency measures are designed to reduce the peak cooling load.

Table O-4: Least-Cost Package by CEC Climate Zone – 15% Above 2001 Standards – Single Family Detached Homes

CEC_CZ	Story	FlArea	Base Compliance	Package Compliance	Cost	Window Type	Wall	Roof	Radiant Barrier	TXV	Tight Ducts	Infiltration Testing	House Wrap	SEER	AFUE	EF	Duct Design	Duct Insulation
01	1	2,400	7.7%	16.2%	$513	2VL	19	30	Yes	No	Yes	No	No	10	92%	0.63	No	Yes
02	1	2,400	10.4%	16.5%	$592	2VL	13	38	No	Yes	No	No	No	12	92%	0.63	No	No
03	1	2,400	15.4%	15.4%	$0	2VL	13	30	No	No	No	No	No	10.5	86%	0.62	No	No
04	1	2,400	11.6%	16.0%	$400	2VL	13	30	No	Yes	No	No	No	12	80%	0.63	No	No
05	1	2,400	16.8%	16.8%	$0	2VL	19	30	No	No	No	No	No	10.5	86%	0.60	No	No
06	1	2,450	21.7%	21.7%	$0	2VC	13	30	No	No	No	No	No	10	80%	0.60	No	No
07	1	2,450	12.9%	21.0%	$207	2VL	13	30	No	No	No	No	No	10	80%	0.60	No	No
08	1	2,150	11.9%	19.9%	$450	2VL	13	30	No	Yes	No	No	No	12	80%	0.63	No	No
09	1	2,150	13.8%	16.8%	$76	2VS	13	30	No	Yes	No	No	No	10.5	80%	0.60	No	No
10	1	2,150	6.9%	17.8%	$450	2VL	13	30	No	Yes	No	No	No	12	80%	0.63	No	No
11	1	1,800	11.8%	15.8%	$194	2VL	19	38	No	Yes	No	No	No	12	86%	0.63	No	No
12	1	1,800	0.6%	15.2%	$827	2VS	13	30	No	Yes	Yes	No	No	12	80%	0.63	No	Yes
13	1	1,800	-8.1%	15.9%	$1,027	2VS	13	30	No	Yes	Yes	No	No	12	80%	0.63	No	Yes
14	1	2,000	-2.1%	17.1%	$763	2VL	13	30	No	Yes	Yes	No	No	12	80%	0.63	No	Yes
15	1	2,000	-10.1%	18.9%	$763	2VL	19	30	No	Yes	Yes	No	No	12	80%	0.63	No	Yes
16	1	2,000	1.0%	15.1%	$513	2VL	19	30	No	Yes	Yes	No	No	12	86%	0.63	No	Yes
01	2	2,450	7.8%	15.7%	$513	2VL	19	30	Yes	No	Yes	No	No	10	92%	0.63	No	Yes
02	2	2,450	12.1%	17.4%	$600	2VL	13	30	No	Yes	No	No	No	12	92%	0.63	No	No
03	2	2,450	16.6%	16.6%	$0	2VL	13	30	No	No	No	No	No	10.5	86%	0.62	No	No
04	2	2,450	13.9%	15.4%	$112	2VS	13	30	No	No	No	No	No	10	80%	0.62	No	No
05	2	2,450	19.2%	19.2%	$0	2VL	19	30	No	No	No	No	No	10.5	86%	0.60	No	No
06	2	2,900	13.2%	15.9%	$650	2VL	13	30	No	Yes	No	No	No	12	82%	0.63	No	No
07	2	2,900	18.9%	18.9%	$0	2VL	13	30	No	No	No	No	No	10	80%	0.60	No	No
08	2	2,900	13.5%	19.5%	$650	2VL	13	30	No	Yes	No	No	No	12	80%	0.63	No	No
09	2	2,900	15.0%	15.6%	$115	2VS	13	30	No	Yes	No	No	No	10.5	80%	0.60	No	No
10	2	2,900	7.3%	16.0%	$650	2VL	13	30	No	Yes	No	No	No	12	80%	0.63	No	No
11	2	2,900	7.7%	18.6%	$563	2VL	19	30	No	Yes	Yes	No	No	12	86%	0.63	No	Yes
12	2	2,900	-3.4%	17.0%	$1,812	2VS	13	30	No	Yes	Yes	No	No	12	92%	0.63	Yes	Yes
13	2	2,900	-9.4%	15.9%	$1,831	2VS	13	49	Yes	Yes	Yes	No	No	12	80%	0.63	No	Yes
14	2	2,800	-4.1%	15.9%	$965	2VS	13	30	No	Yes	Yes	No	No	12	80%	0.63	No	Yes
15	2	2,800	-12.6%	16.4%	$863	2VL	19	30	No	Yes	Yes	No	No	12	80%	0.63	No	Yes
16	2	2,800	-0.3%	15.0%	$930	2VL	19	38	Yes	Yes	Yes	No	No	12	86%	0.63	No	Yes

Table O-5: Least-Cost Package by CEC Climate Zone – 25% Above 2001 Standards – Single Family Detached Homes

CEC_CZ	Story	FlArea	Base Compliance	Package Compliance	Cost	Window Type	Wall	Roof	Radiant Barrier	TXV	Tight Ducts	Infiltration Testing	House Wrap	SEER	AFUE	EF	Duct Design	Duct Insulation
01	1	2,400	7.7%	19.8%	$2,067	2VS	19	49	Yes	No	Yes	Yes	Yes	10	92%	0.63	Yes	Yes
02	1	2,400	10.4%	25.2%	$1,208	2VS	13	38	No	Yes	Yes	No	No	12	92%	0.63	No	Yes
03	1	2,400	15.4%	25.3%	$1,703	2VL	13	30	No	Yes	Yes	Yes	Yes	12	86%	0.63	No	Yes
04	1	2,400	11.6%	25.5%	$1,393	2VL	13	38	Yes	Yes	Yes	No	No	12	80%	0.63	No	Yes
05	1	2,400	16.8%	25.8%	$1,155	2VL	19	38	No	Yes	Yes	No	No	12	86%	0.63	No	Yes
06	1	2,450	21.7%	26.0%	$450	2VC	13	30	No	Yes	No	No	No	12	80%	0.63	No	No
07	1	2,450	12.9%	25.4%	$657	2VL	13	30	No	Yes	No	No	No	12	80%	0.63	No	No
08	1	2,150	11.9%	25.3%	$1,135	2VL	13	38	No	Yes	Yes	No	No	12	80%	0.63	No	Yes
09	1	2,150	13.8%	25.9%	$963	2VL	13	30	No	Yes	Yes	No	No	12	80%	0.63	No	Yes
10	1	2,150	6.9%	25.1%	$963	2VL	13	30	No	Yes	Yes	No	No	12	80%	0.63	No	Yes
11	1	1,800	11.8%	25.4%	$771	2VS	19	38	No	Yes	Yes	No	No	12	86%	0.63	No	Yes
12	1	1,800	0.6%	25.6%	$2,170	2VL	13	49	Yes	Yes	Yes	No	No	12	92%	0.63	Yes	Yes
13	1	1,800	-8.1%	25.2%	$2,370	2VL	13	49	Yes	Yes	Yes	No	No	12	92%	0.63	Yes	Yes
14	1	2,000	-2.1%	25.3%	$1,832	2VS	13	38	No	Yes	Yes	No	No	12	92%	0.63	Yes	Yes
15	1	2,000	-10.1%	25.2%	$1,163	2VL	19	38	Yes	Yes	Yes	No	No	12	80%	0.63	No	Yes
16	1	2,000	1.0%	26.6%	$2,401	2VL	19	49	Yes	Yes	Yes	Yes	Yes	12	92%	0.63	Yes	Yes
01	2	2,450	7.8%	22.4%	$1,934	2VL	19	49	Yes	No	Yes	Yes	Yes	10	92%	0.63	Yes	Yes
02	2	2,450	12.1%	25.1%	$1,349	2VS	13	38	No	Yes	Yes	No	No	12	92%	0.63	No	Yes
03	2	2,450	16.6%	25.9%	$1,838	2VL	13	38	No	Yes	Yes	No	No	12	92%	0.63	Yes	Yes
04	2	2,450	13.9%	25.0%	$1,238	2VL	13	38	No	Yes	Yes	No	No	12	80%	0.63	No	Yes
05	2	2,450	19.2%	26.8%	$1,163	2VL	19	30	No	Yes	Yes	No	No	12	86%	0.63	No	Yes
06	2	2,900	13.2%	23.5%	$2,092	2VL	13	30	No	Yes	Yes	Yes	Yes	12	82%	0.63	No	Yes
07	2	2,900	18.9%	25.1%	$1,163	2VL	13	30	No	Yes	Yes	No	No	12	80%	0.63	No	Yes
08	2	2,900	13.5%	25.0%	$1,278	2VS	13	30	No	Yes	Yes	No	No	12	80%	0.63	No	Yes
09	2	2,900	15.0%	25.2%	$1,163	2VL	13	30	No	Yes	Yes	No	No	12	80%	0.63	No	Yes
10	2	2,900	7.3%	25.4%	$1,278	2VS	13	30	No	Yes	Yes	No	No	12	80%	0.63	No	Yes
11	2	2,900	7.7%	26.2%	$1,625	2VS	19	38	Yes	Yes	Yes	No	No	12	92%	0.63	Yes	Yes
12	2	2,900	-3.4%	27.6%	$3,366	2VL	19	49	Yes	Yes	Yes	No	Yes	12	92%	0.63	Yes	Yes
13	2	2,900	-9.4%	26.9%	$3,666	2VL	19	49	Yes	Yes	Yes	No	Yes	12	92%	0.63	Yes	Yes
14	2	2,800	-4.1%	25.4%	$2,214	2VS	13	38	Yes	Yes	Yes	No	No	12	92%	0.63	Yes	Yes
15	2	2,800	-12.6%	26.4%	$2,214	2VS	19	38	Yes	Yes	Yes	No	No	12	92%	0.63	Yes	Yes
16	2	2,800	-0.3%	25.8%	$2,946	2VL	19	49	Yes	Yes	Yes	Yes	Yes	12	92%	0.63	Yes	Yes

Table O-6 and Table O-7 summarize the cost and savings results arising from upgrades to the base case home with the least-cost package for each to reach 15% and 25% above the 2001 Standards. As shown, it would cost approximately $763 to upgrade the base case prototype in CEC Climate Zone 14 from -2.1% to 17.1% and would result in a savings of 67 therms and 1,015kWh per year.

Table O-6: Energy Savings and Costs by CEC Climate Zone – 15% Above 2001 Standards – Single Family Detached Homes

CEC_CZ	Story	FlArea	Base Compliance	Package Compliance	Cost	Space Heat Savings (Therms)	Space Cool Savings (kWh)	DHW Savings (Therms)
01	1	2,400	7.7%	16.2%	$513	57	0	4
02	1	2,400	10.4%	16.5%	$592	11	382	4
03	1	2,400	15.4%	15.4%	$0	0	0	0
04	1	2,400	11.6%	16.0%	$400	0	256	4
05	1	2,400	16.8%	16.8%	$0	0	0	0
06	1	2,450	21.7%	21.7%	$0	0	0	0
07	1	2,450	12.9%	21.0%	$207	-12	433	0
08	1	2,150	11.9%	19.9%	$450	7	206	11
09	1	2,150	13.8%	16.8%	$76	1	164	0
10	1	2,150	6.9%	17.8%	$450	10	549	11
11	1	1,800	11.8%	15.8%	$194	7	113	11
12	1	1,800	0.6%	15.2%	$827	37	521	11
13	1	1,800	-8.1%	15.9%	$1,027	23	1,462	11
14	1	2,000	-2.1%	17.1%	$763	56	1,015	11
15	1	2,000	-10.1%	18.9%	$763	5	2,747	11
16	1	2,000	1.0%	15.1%	$513	140	12	3
01	2	2,450	7.8%	15.7%	$513	59	0	4
02	2	2,450	12.1%	17.4%	$600	-10	589	4
03	2	2,450	16.6%	16.6%	$0	0	0	0
04	2	2,450	13.9%	15.4%	$112	-14	256	0
05	2	2,450	19.2%	19.2%	$0	0	0	0
06	2	2,900	13.2%	15.9%	$650	0	14	11
07	2	2,900	18.9%	18.9%	$0	0	0	0
08	2	2,900	13.5%	19.5%	$650	0	252	11
09	2	2,900	15.0%	15.6%	$115	-10	150	0
10	2	2,900	7.3%	16.0%	$650	0	661	11
11	2	2,900	7.7%	18.6%	$563	51	513	11
12	2	2,900	-3.4%	17.0%	$1,812	107	819	11
13	2	2,900	-9.4%	15.9%	$1,831	43	2,129	11
14	2	2,800	-4.1%	15.9%	$965	71	1,623	11
15	2	2,800	-12.6%	16.4%	$863	-11	3,917	11
16	2	2,800	-0.3%	15.0%	$930	220	104	4

Table O-7: Energy Savings and Costs by CEC Climate Zone – 25% Above 2001 Standards – Single Family Detached Homes

CEC_CZ	Story	FlArea	Base Compliance	Package Compliance	Cost	Space Heat Savings (Therms)	Space Cool Savings (kWh)	DHW Savings (Therms)
01	1	2,400	7.7%	19.8%	$2,067	82	0	4
02	1	2,400	10.4%	25.2%	$1,208	54	706	4
03	1	2,400	15.4%	25.3%	$1,703	49	14	4
04	1	2,400	11.6%	25.5%	$1,393	43	479	4
05	1	2,400	16.8%	25.8%	$1,155	40	16	11
06	1	2,450	21.7%	26.0%	$450	0	72	12
07	1	2,450	12.9%	25.4%	$657	-12	493	12
08	1	2,150	11.9%	25.3%	$1,135	21	328	11
09	1	2,150	13.8%	25.9%	$963	23	351	11
10	1	2,150	6.9%	25.1%	$963	29	857	11
11	1	1,800	11.8%	25.4%	$771	34	545	11
12	1	1,800	0.6%	25.6%	$2,170	94	669	11
13	1	1,800	-8.1%	25.2%	$2,370	66	1,745	11
14	1	2,000	-2.1%	25.3%	$1,832	87	1,425	11
15	1	2,000	-10.1%	25.2%	$1,163	3	3,402	11
16	1	2,000	1.0%	26.6%	$2,401	255	51	3
01	2	2,450	7.8%	22.4%	$1,934	112	0	4
02	2	2,450	12.1%	25.1%	$1,349	54	716	4
03	2	2,450	16.6%	25.9%	$1,838	50	50	4
04	2	2,450	13.9%	25.0%	$1,238	42	410	4
05	2	2,450	19.2%	26.8%	$1,163	39	19	12
06	2	2,900	13.2%	23.5%	$2,092	35	23	11
07	2	2,900	18.9%	25.1%	$1,163	7	79	11
08	2	2,900	13.5%	25.0%	$1,278	10	490	11
09	2	2,900	15.0%	25.2%	$1,163	21	417	11
10	2	2,900	7.3%	25.4%	$1,278	18	1,315	11
11	2	2,900	7.7%	26.2%	$1,625	67	1,137	11
12	2	2,900	-3.4%	27.6%	$3,366	190	1,026	11
13	2	2,900	-9.4%	26.9%	$3,666	141	2,330	11
14	2	2,800	-4.1%	25.4%	$2,214	143	2,080	11
15	2	2,800	-12.6%	26.4%	$2,214	-4	5,192	11
16	2	2,800	-0.3%	25.8%	$2,946	382	134	4

Figure O-2 to Figure O-5 illustrate the data presented in the tables above by end use, number of stories, and CEC climate zone. The solid bars illustrate the therms/kWh savings and the thinner striped bars illustrate the total cost of the package. Since many measures lead to both space heating and cooling savings, it is impossible to separate the costs associated with the energy savings by end-use. The text above the bars is the % compliance margin of the base case prototype.

For example, Figure O-2 shows that the one-story prototype in CEC Climate Zone 14 had a base compliance of -2.1%. To reach at least 15% above the 2001 Standards would cost approximately $750 and result in a savings of just over 50 therms. However, upgrading the prototype to 25% above the 2001 Standards would cost an additional $1,100 and only result in an additional savings of 30 therms. Please note that this does not reflect the cooling savings associated with the cost.

Figure O-2: Gas Savings of Least-Cost Package by CEC Climate Zone – 2001 Standards – One-Story Single Family Detached Homes

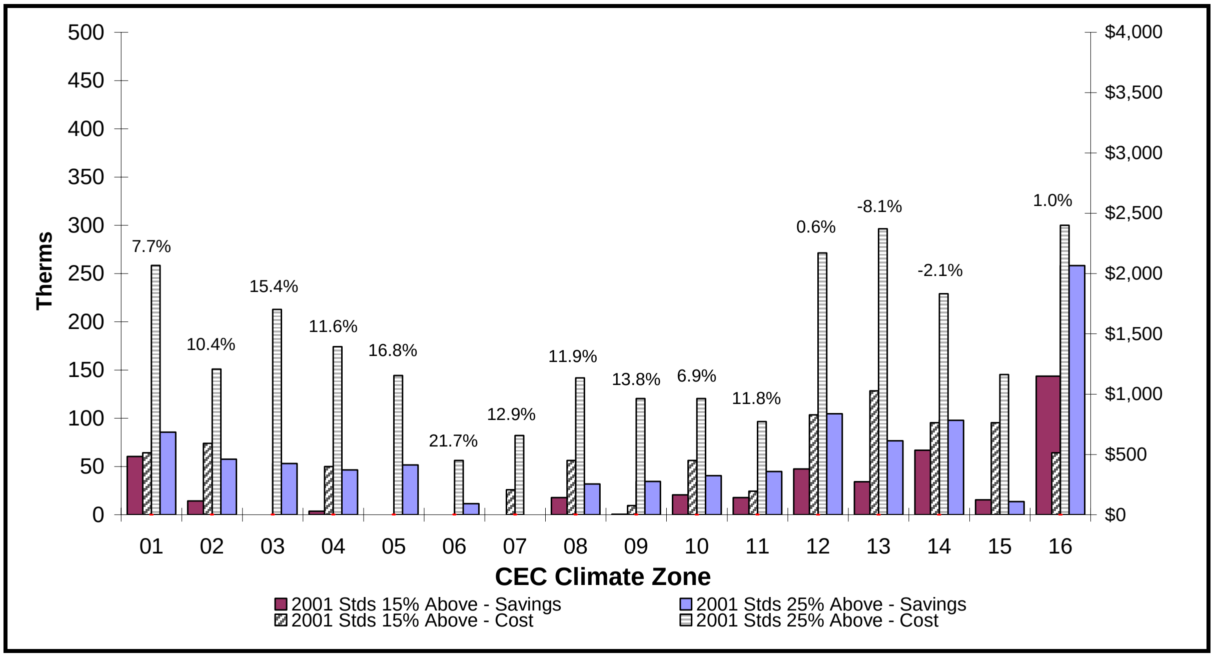


Figure O-3: Electric Savings of Least-Cost Package by CEC Climate Zone – 2001 Standards – One-Story Single Family Detached Homes

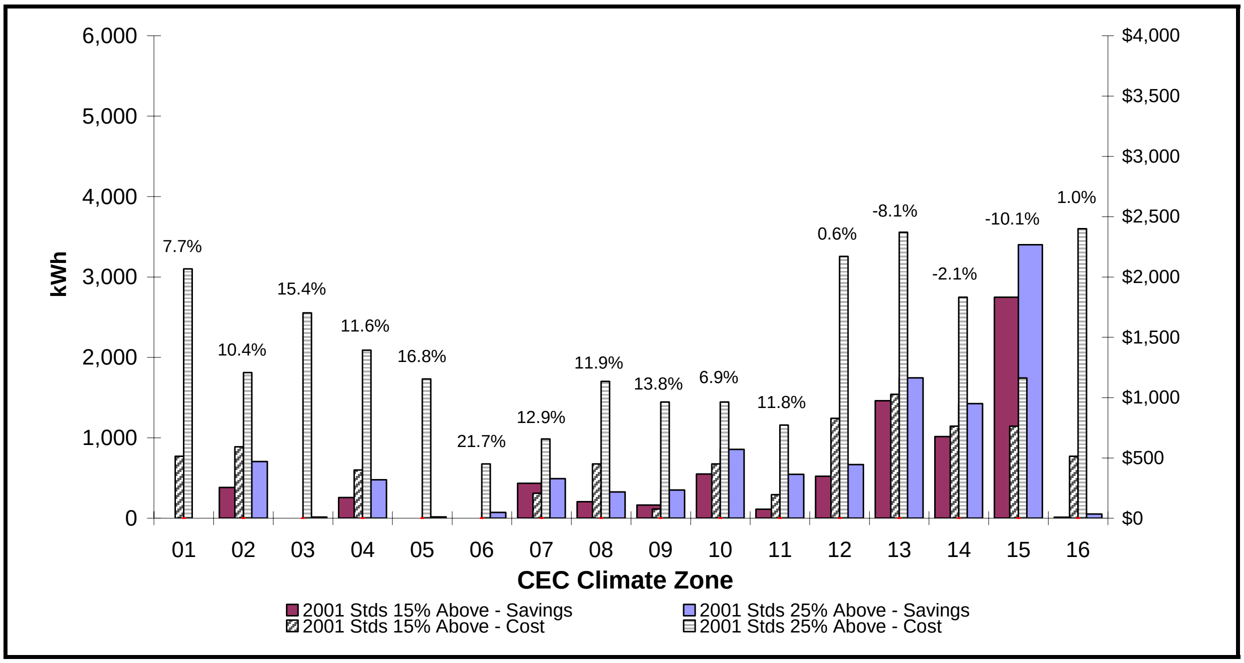


Figure O-4: Gas Savings of Least-Cost Package by CEC Climate Zone – 2001 Standards – Two-Story Single Family Detached Homes

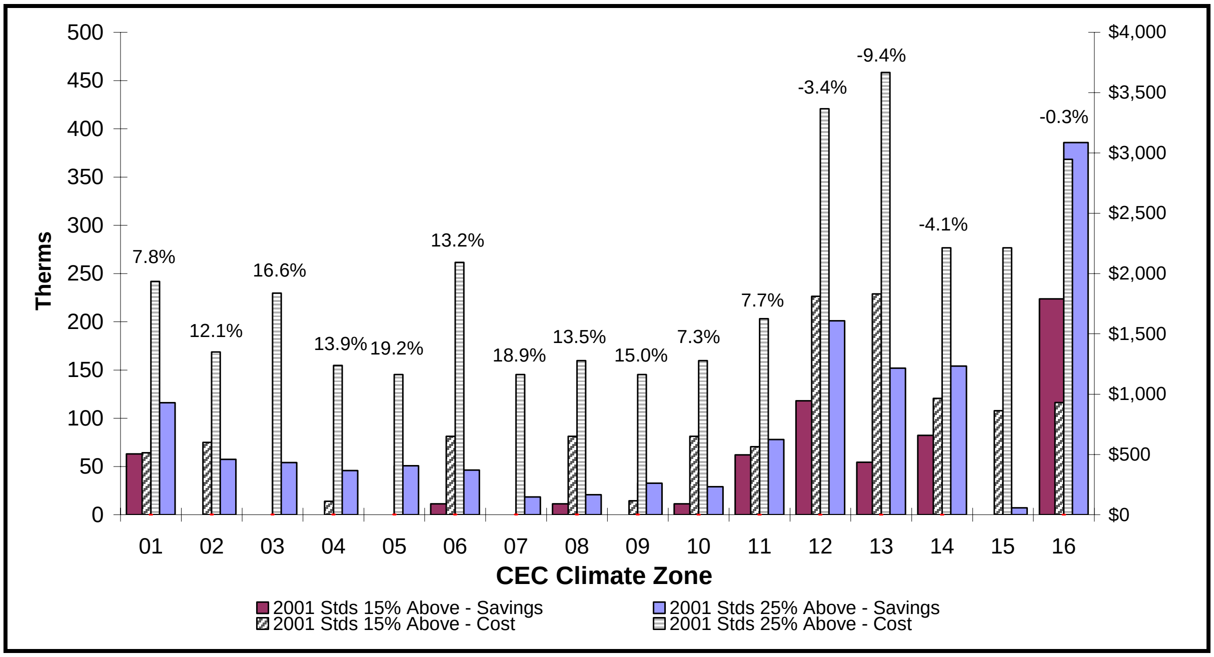
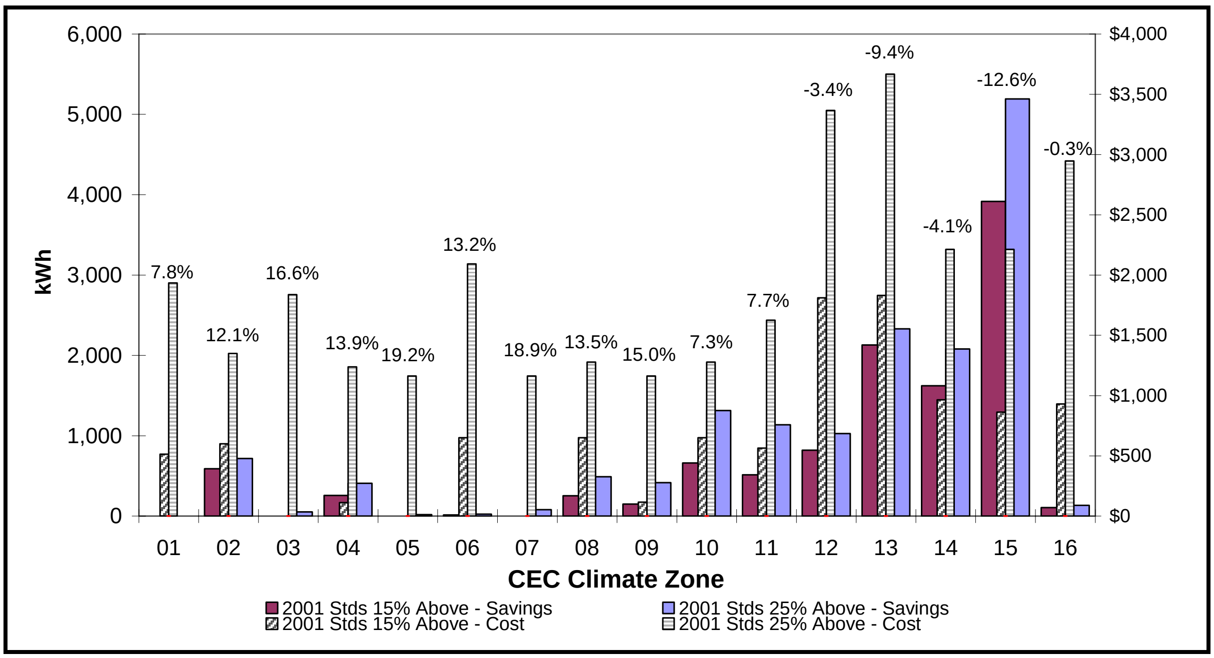


Figure O-5: Electric Savings of Least-Cost Package by CEC Climate Zone – 2001 Standards – Two-Story Single Family Detached Homes



2005 Standards

The 2001 base case prototypes were developed using the average building characteristics of newly constructed single family detached homes. However, because the 2005 Standards have not taken affect, it is impossible to know how builders will reach the new Standards. Therefore, each of the packages was added to the prototypes and run under the 2005 Standards.[5] The least-cost package that caused each prototype to just comply with the 2005 Standards was chosen as the 2005 base case prototype. Table O-8 presents the % compliance margin, the measures installed, and the cost of the package relative to the 2001 base case prototypes. Of the 32 single family detached prototypes, nine have the same 2005 base case as the 2001 base case. Each of these nine is along the coast, which is not surprising given that the 2005 Standards, like the 2001 Standards, were developed to be more stringent in the inland regions.

[5] Beginning in 2006, the federal appliance standards will require the minimum efficiency of all air conditioners manufactured to be 13 SEER. Therefore, each of the 70 packages were modified when used to upgrade the homes when analyzed under 2005 to include at least a 13 SEER A/C. The packages that included a 14 or 15 SEER A/C were not changed.

Table O-8: 2005 Standards Base Case Prototypes – Single Family Detached Homes

CEC_ CZ	Story	FlArea	Base Compliance	Cost Above 01 Baseline	Window Type	Wall	Roof	Insulation Certification	Radiant Barrier	TXV	Tight Ducts	Infiltration Testing	House Wrap	SEER	AFUE	EF	Duct Design	Duct Insulation
01	1	2,400	2.8%	$0	2VL	19	30	No	Yes	Yes	No	No	No	13	92%	0.62	No	No
02	1	2,400	2.6%	$343	2VS	13	38	No	No	Yes	No	No	No	13	92%	0.63	No	No
03	1	2,400	3.7%	$0	2VL	13	30	No	No	Yes	No	No	No	13	86%	0.62	No	No
04	1	2,400	0.1%	$240	2VL	13	38	No	No	Yes	No	No	No	13	80%	0.63	No	No
05	1	2,400	10.9%	$0	2VL	19	30	No	No	Yes	No	No	No	13	86%	0.60	No	No
06	1	2,450	13.5%	$0	2VL	13	30	No	No	Yes	No	No	No	13	80%	0.60	No	No
07	1	2,450	4.1%	$50	2VC	13	30	No	No	Yes	No	No	No	13	80%	0.63	No	No
08	1	2,150	0.1%	$76	2VS	13	30	No	No	Yes	No	No	No	13	80%	0.60	No	No
09	1	2,150	2.3%	$341	2VS	13	38	No	No	Yes	No	No	No	13	80%	0.63	No	No
10	1	2,150	2.3%	$563	2VL	13	30	No	No	Yes	Yes	No	No	13	80%	0.63	No	Yes
11	1	1,800	4.9%	$563	2VL	19	30	No	No	Yes	Yes	No	No	13	86%	0.63	No	Yes
12	1	1,800	0.9%	$1,031	2VL	13	38	No	Yes	Yes	Yes	No	No	13	80%	0.63	No	Yes
13	1	1,800	2.4%	$1,095	2VS	13	38	No	Yes	Yes	Yes	No	No	13	80%	0.63	No	Yes
14	1	2,000	1.5%	$841	2VS	13	38	No	No	Yes	Yes	No	No	13	80%	0.63	No	Yes
15	1	2,000	1.5%	$641	2VS	19	30	No	No	Yes	Yes	No	No	13	80%	0.63	No	Yes
16	1	2,000	-1.5%	$469	2VL	19	30	No	No	Yes	No	No	No	13	92%	0.63	No	No
01	2	2,450	-1.8%	$467	2VL	19	49	No	Yes	Yes	No	No	No	14	92%	0.63	No	No
02	2	2,450	1.5%	$0	2VL	13	30	No	No	Yes	No	No	No	13	92%	0.62	No	No
03	2	2,450	8.7%	$0	2VL	13	30	No	No	Yes	No	No	No	13	86%	0.62	No	No
04	2	2,450	2.5%	$0	2VL	13	30	No	No	Yes	No	No	No	13	80%	0.62	No	No
05	2	2,450	21.0%	$0	2VL	19	30	No	No	Yes	No	No	No	13	86%	0.60	No	No
06	2	2,900	4.3%	$0	2VL	13	30	No	No	Yes	No	No	No	13	82%	0.60	No	No
07	2	2,900	7.4%	$0	2VL	13	30	No	No	Yes	No	No	No	13	80%	0.60	No	No
08	2	2,900	2.5%	$115	2VS	13	30	No	No	Yes	No	No	No	13	80%	0.60	No	No
09	2	2,900	0.1%	$165	2VS	13	30	No	No	Yes	No	No	No	13	80%	0.63	No	No
10	2	2,900	3.6%	$563	2VL	13	30	No	No	Yes	Yes	No	No	13	80%	0.63	No	Yes
11	2	2,900	3.2%	$563	2VL	19	30	No	No	Yes	Yes	No	No	13	86%	0.63	No	Yes
12	2	2,900	0.4%	$1,684	2VS	13	38	No	No	Yes	Yes	No	No	13	92%	0.63	Yes	Yes
13	2	2,900	0.9%	$1,959	2VS	13	38	No	Yes	Yes	Yes	No	No	13	92%	0.63	Yes	Yes
14	2	2,800	2.4%	$874	2VS	13	38	No	No	Yes	Yes	No	No	13	80%	0.63	No	Yes
15	2	2,800	1.6%	$874	2VS	19	38	No	No	Yes	Yes	No	No	13	80%	0.63	No	Yes
16	2	2,800	-4.3%	$469	2VL	19	30	No	No	Yes	No	No	No	13	92%	0.63	No	No

Table O-9 and Table O-10 present the measures included in the least-cost package that upgraded each prototype to 10% and 15% above the 2005 Standards, respectively. The tables also present the incremental cost of each package (*Cost*), the compliance margin of the base case prototype (*Base Compliance*), and the compliance margin reached by adding the package to the base case prototype (*Package Compliance*). For convenience, the measures that were upgraded for each prototype to reach its target are highlighted in yellow meaning the measure was added, and green meaning that the base case prototype actually had a higher efficiency version of the measure installed (therefore decreasing the cost).

As shown in Table O-9, two of the base case prototypes were already at least 10% better than the 2005 Standards. Table O-10 provides the same results for the base case homes to reach 15% above the 2005 Standards. While it is possible for each of the prototypes to reach 15% better than the 2005 Standards, the number of high efficiency measures and the cost of those measures varies dramatically between the coast and inland regions. The prototypes in the inland regions need nearly every high efficiency measure in the list while some coastal prototypes need to install just one or two high efficiency measures.

Table O-9: Least-Cost Package by CEC Climate Zone – 10% Above 2005 Standards – Single Family Detached Homes

CEC_CZ	Story	FlArea	Base Compliance	Package Compliance	Cost	Window Type	Wall	Roof	Insulation Certification	Radiant Barrier	TXV	Tight Ducts	Infiltration Testing	House Wrap	SEER	AFUE	EF	Duct Design	Duct Insulation
01	1	2,400	2.8%	6.2%	$993	2VL	19	49	No	Yes	Yes	Yes	No	No	13	92%	0.63	No	Yes
02	1	2,400	2.6%	11.4%	$273	2VS	13	30	No	No	Yes	Yes	No	No	13	92%	0.63	No	Yes
03	1	2,400	3.7%	14.0%	$513	2VL	13	30	No	No	Yes	Yes	No	No	13	86%	0.63	No	Yes
04	1	2,400	0.1%	10.3%	$465	2VL	13	38	No	No	Yes	Yes	No	No	13	80%	0.63	No	Yes
05	1	2,400	10.9%	10.9%	$0	2VL	19	30	No	No	Yes	No	No	No	13	86%	0.60	No	No
06	1	2,450	13.5%	13.5%	$0	2VC	13	30	No	No	Yes	No	No	No	13	80%	0.60	No	No
07	1	2,450	4.1%	15.1%	$157	2VL	13	30	No	No	Yes	No	No	No	13	80%	0.60	No	No
08	1	2,150	0.1%	12.5%	$735	2VS	13	38	No	No	Yes	Yes	No	No	13	80%	0.63	No	Yes
09	1	2,150	2.3%	11.5%	$470	2VS	13	38	No	No	Yes	Yes	No	No	13	80%	0.63	No	Yes
10	1	2,150	2.3%	13.2%	$506	2VS	13	38	No	Yes	Yes	Yes	No	No	13	80%	0.63	No	Yes
11	1	1,800	4.9%	11.2%	$208	2VS	19	38	No	No	Yes	Yes	No	No	13	86%	0.63	No	Yes
12	1	1,800	0.9%	10.4%	$1,004	2VS	13	49	No	Yes	Yes	Yes	No	No	13	92%	0.63	Yes	Yes
13	1	1,800	2.4%	10.2%	$1,445	2VL	13	49	Yes	Yes	Yes	Yes	No	Yes	13	92%	0.63	Yes	Yes
14	1	2,000	1.5%	11.3%	$1,271	2VS	13	49	No	Yes	Yes	Yes	No	No	13	92%	0.63	Yes	Yes
15	1	2,000	1.5%	10.9%	$400	2VS	19	38	No	Yes	Yes	Yes	No	No	13	80%	0.63	No	Yes
16	1	2,000	-1.5%	11.3%	$44	2VL	19	30	No	No	Yes	Yes	No	No	13	86%	0.63	No	Yes
01	2	2,450	-1.8%	16.1%	$539	2VL	19	49	Yes	Yes	Yes	Yes	No	No	15	92%	0.63	Yes	Yes
02	2	2,450	1.5%	13.9%	$513	2VL	13	30	No	No	Yes	Yes	No	No	13	92%	0.63	No	Yes
03	2	2,450	8.7%	10.4%	$125	2VL	13	38	No	No	Yes	No	No	No	13	86%	0.63	No	No
04	2	2,450	2.5%	13.1%	$513	2VL	13	30	No	No	Yes	Yes	No	No	13	80%	0.63	No	Yes
05	2	2,450	21.0%	21.0%	$0	2VL	19	30	No	No	Yes	No	No	No	13	86%	0.60	No	No
06	2	2,900	4.3%	13.9%	$563	2VL	13	30	No	No	Yes	Yes	No	No	13	82%	0.63	No	Yes
07	2	2,900	7.4%	10.0%	$167	2VS	13	30	No	No	Yes	No	No	No	13	80%	0.63	No	No
08	2	2,900	2.5%	11.5%	$563	2VS	13	30	No	No	Yes	Yes	No	No	13	80%	0.63	No	Yes
09	2	2,900	0.1%	10.4%	$513	2VS	13	30	No	No	Yes	Yes	No	No	13	80%	0.63	No	Yes
10	2	2,900	3.6%	13.1%	$517	2VS	13	38	No	Yes	Yes	Yes	No	No	13	80%	0.63	No	Yes
11	2	2,900	3.2%	11.9%	$461	2VS	19	38	No	Yes	Yes	Yes	No	No	13	86%	0.63	No	Yes
12	2	2,900	0.4%	18.9%	$1,382	2VL	19	49	Yes	Yes	Yes	Yes	No	Yes	13	92%	0.63	Yes	Yes
13	2	2,900	0.9%	13.4%	$1,107	2VL	19	49	Yes	Yes	Yes	Yes	No	Yes	13	92%	0.63	Yes	Yes
14	2	2,800	2.4%	11.2%	$1,290	2VS	13	49	No	Yes	Yes	Yes	No	No	13	92%	0.63	Yes	Yes
15	2	2,800	1.6%	10.2%	$2,980	2VS	19	49	No	Yes	Yes	Yes	Yes	Yes	14	92%	0.63	Yes	Yes
16	2	2,800	-4.3%	10.2%	$211	2VL	19	38	No	No	Yes	Yes	No	No	13	86%	0.63	No	Yes

Note: Yellow highlighting indicates a more efficient measure is needed compared to the baseline home and green highlighting indicates a less efficient measure is needed.

Table O-10: Least-Cost Package by CEC Climate Zone – 15% Above 2005 Standards – Single Family Detached Homes

CEC_CZ	Story	FlArea	Base Compliance	Package Compliance	Cost	Window Type	Wall	Roof	Insulation Certification	Radiant Barrier	TXV	Tight Ducts	Infiltratio n Testing	House Wrap	SEER	AFUE	EF	Duct Design	Duct Insulation
01	1	2,400	2.8%	13.4%	$1,174	2VL	19	49	Yes	Yes	Yes	Yes	No	No	13	92%	0.63	Yes	Yes
02	1	2,400	2.6%	17.2%	$753	2VS	13	38	No	Yes	Yes	Yes	No	No	13	92%	0.63	No	Yes
03	1	2,400	3.7%	15.5%	$705	2VL	13	38	No	No	Yes	Yes	No	No	13	86%	0.63	No	Yes
04	1	2,400	0.1%	15.7%	$1,144	2VS	13	49	No	Yes	Yes	Yes	No	No	13	80%	0.63	No	Yes
05	1	2,400	10.9%	15.7%	$519	2VL	19	30	No	No	Yes	No	No	No	13	92%	0.63	No	No
06	1	2,450	13.5%	16.4%	$207	2VL	13	30	No	No	Yes	No	No	No	13	80%	0.60	No	No
07	1	2,450	4.1%	15.1%	$157	2VL	13	30	No	No	Yes	No	No	No	13	80%	0.60	No	No
08	1	2,150	0.1%	15.7%	$993	2VS	13	38	No	Yes	Yes	Yes	No	No	13	80%	0.63	No	Yes
09	1	2,150	2.3%	15.4%	$728	2VS	13	38	No	Yes	Yes	Yes	No	No	13	80%	0.63	No	Yes
10	1	2,150	2.3%	15.8%	$1,114	2VS	13	49	No	Yes	Yes	Yes	No	No	14	80%	0.63	No	Yes
11	1	1,800	4.9%	16.8%	$640	2VS	19	49	No	Yes	Yes	Yes	No	No	13	86%	0.63	No	Yes
12	1	1,800	0.9%	15.6%	$1,509	2VL	13	49	Yes	Yes	Yes	Yes	No	Yes	13	92%	0.63	Yes	Yes
13	1	1,800	2.4%	17.7%	$1,570	2VL	19	49	Yes	Yes	Yes	Yes	No	Yes	13	92%	0.63	Yes	Yes
14	1	2,000	1.5%	20.6%	$1,861	2VL	19	49	Yes	Yes	Yes	Yes	No	Yes	13	92%	0.63	Yes	Yes
15	1	2,000	1.5%	17.7%	$2,769	2VS	19	49	Yes	Yes	Yes	Yes	Yes	Yes	15	92%	0.63	Yes	Yes
16	1	2,000	-1.5%	15.4%	$684	2VL	19	49	No	Yes	Yes	Yes	No	No	13	86%	0.63	No	Yes
01	2	2,450	-1.8%	16.1%	$539	2VL	19	49	Yes	Yes	Yes	Yes	No	No	15	92%	0.63	Yes	Yes
02	2	2,450	1.5%	16.2%	$625	2VS	13	30	No	No	Yes	Yes	No	No	13	92%	0.63	No	Yes
03	2	2,450	8.7%	18.8%	$513	2VL	13	30	No	No	Yes	Yes	No	No	13	86%	0.63	No	Yes
04	2	2,450	2.5%	16.6%	$749	2VS	13	38	No	No	Yes	Yes	No	No	13	80%	0.63	No	Yes
05	2	2,450	21.0%	21.0%	$0	2VL	19	30	No	No	Yes	No	No	No	13	86%	0.60	No	No
06	2	2,900	4.3%	15.3%	$1,043	2VL	13	49	No	Yes	Yes	Yes	No	No	13	82%	0.63	No	Yes
07	2	2,900	7.4%	16.7%	$683	2VL	13	38	No	No	Yes	Yes	No	No	13	80%	0.63	No	Yes
08	2	2,900	2.5%	16.7%	$965	2VS	13	38	No	Yes	Yes	Yes	No	No	13	80%	0.63	No	Yes
09	2	2,900	0.1%	16.1%	$915	2VS	13	38	No	Yes	Yes	Yes	No	No	13	80%	0.63	No	Yes
10	2	2,900	3.6%	15.5%	$1,349	2VS	13	38	No	Yes	Yes	Yes	No	No	13	92%	0.63	Yes	Yes
11	2	2,900	3.2%	15.4%	$1,682	2VS	19	49	No	Yes	Yes	Yes	Yes	Yes	13	86%	0.63	No	Yes
12	2	2,900	0.4%	18.9%	$1,382	2VL	19	49	Yes	Yes	Yes	Yes	No	Yes	13	92%	0.63	Yes	Yes
13	2	2,900	0.9%	19.1%	$2,275	2VS	19	49	Yes	Yes	Yes	Yes	Yes	Yes	15	92%	0.63	Yes	Yes
14	2	2,800	2.4%	15.3%	$2,253	2VL	13	49	Yes	Yes	Yes	Yes	No	Yes	13	92%	0.63	Yes	Yes
15	2	2,800	1.6%	14.4%	$3,405	2VS	19	49	Yes	Yes	Yes	Yes	Yes	Yes	15	92%	0.63	Yes	Yes
16	2	2,800	-4.3%	15.5%	$1,062	2VL	19	38	No	Yes	Yes	Yes	No	No	13	92%	0.63	Yes	Yes

Note: Yellow highlighting indicates a more efficient measure is needed compared to the baseline home and green highlighting indicates a less efficient measure is needed.

Table O-11 and Table O-12 summarize the cost and savings[6] that result from upgrading the base case home with the least-cost package for each to reach 10% and 15% above the 2005 Standards. As shown, it would cost just $157 to upgrade the one-story base case prototype in CEC Climate Zone 7 from 4.1% to 15.1% and would result in a savings of 273 kWh per year; however, installing this package of measures results in the prototype using more therms for both water heating and space heating. While installing a different package could result in positive gas savings, this was the least-cost package that brings this prototype to the goal.

Table O-11: Energy Savings and Costs by CEC Climate Zone – 10% Above 2005 Standards – Single Family Detached Homes

CEC_CZ	Story	FlArea	Base Compliance	Package Compliance	Cost	Space Heat Savings (Therms)	Space Cool Savings (kWh)	DHW Savings (Therms)
01	1	2,400	2.8%	6.2%	$993	25	0	0
02	1	2,400	2.6%	11.4%	$273	70	47	0
03	1	2,400	3.7%	14.0%	$513	60	0	4
04	1	2,400	0.1%	10.3%	$465	61	42	0
05	1	2,400	10.9%	10.9%	$0	0	0	0
06	1	2,450	13.5%	13.5%	$0	0	0	0
07	1	2,450	4.1%	15.1%	$157	-6	273	-12
08	1	2,150	0.1%	12.5%	$735	26	111	12
09	1	2,150	2.3%	11.5%	$470	25	137	0
10	1	2,150	2.3%	13.2%	$506	0	427	0
11	1	1,800	4.9%	11.2%	$208	0	257	0
12	1	1,800	0.9%	10.4%	$1,004	33	158	0
13	1	1,800	2.4%	10.2%	$1,445	73	0	0
14	1	2,000	1.5%	11.3%	$1,271	50	260	0
15	1	2,000	1.5%	10.9%	$400	3	743	0
16	1	2,000	-1.5%	11.3%	$44	140	2	0
01	2	2,450	-1.8%	16.1%	$539	149	0	0
02	2	2,450	1.5%	13.9%	$513	97	189	4
03	2	2,450	8.7%	10.4%	$125	7	10	4
04	2	2,450	2.5%	13.1%	$513	75	50	4
05	2	2,450	21.0%	21.0%	$0	0	0	0
06	2	2,900	4.3%	13.9%	$563	33	3	12
07	2	2,900	7.4%	10.0%	$167	-13	51	12
08	2	2,900	2.5%	11.5%	$563	36	68	12
09	2	2,900	0.1%	10.4%	$513	39	218	0
10	2	2,900	3.6%	13.1%	$517	-2	573	0
11	2	2,900	3.2%	11.9%	$461	-2	621	0
12	2	2,900	0.4%	18.9%	$1,382	147	315	0
13	2	2,900	0.9%	13.4%	$1,107	117	366	0
14	2	2,800	2.4%	11.2%	$1,290	81	296	0
15	2	2,800	1.6%	10.2%	$2,980	20	944	0
16	2	2,800	-4.3%	10.2%	$211	231	57	0

6 The method of estimating the compliance and energy savings from exceeding the 2005 Standards was calculated differently than it was under the 2001 Standards. The 2005 Standards use TDV for calculating compliance. However, since the TDV calculations weight the energy used across hours differently, it is not correct to use the TDV budgets to calculate energy savings. Therefore, the TDV budgets are used to determine the % compliance margins but the source energy budgets are used to calculate energy savings. Under the 2001 Standards, the source energy budgets are used to estimate both compliance and savings.

Table O-12: Energy Savings and Costs by CEC Climate Zone – 15% Above 2005 Standards – Single Family Detached Homes

CEC_CZ	Story	FlArea	Base Compliance	Package Compliance	Cost	Space Heat Savings (Therms)	Space Cool Savings (kWh)	DHW Savings (Therms)
01	1	2,400	2.8%	13.4%	$1,174	78	0	0
02	1	2,400	2.6%	17.2%	$753	85	206	0
03	1	2,400	3.7%	15.5%	$705	68	2	4
04	1	2,400	0.1%	15.7%	$1,144	58	242	0
05	1	2,400	10.9%	15.7%	$519	17	0	12
06	1	2,450	13.5%	16.4%	$207	-9	137	-12
07	1	2,450	4.1%	15.1%	$157	-6	273	-12
08	1	2,150	0.1%	15.7%	$993	28	172	12
09	1	2,150	2.3%	15.4%	$728	26	231	0
10	1	2,150	2.3%	15.8%	$1,114	3	523	0
11	1	1,800	4.9%	16.8%	$640	8	443	0
12	1	1,800	0.9%	15.6%	$1,509	84	107	0
13	1	1,800	2.4%	17.7%	$1,570	100	216	0
14	1	2,000	1.5%	20.6%	$1,861	144	299	0
15	1	2,000	1.5%	17.7%	$2,769	14	1,251	0
16	1	2,000	-1.5%	15.4%	$684	178	31	0
01	2	2,450	-1.8%	16.1%	$539	149	0	0
02	2	2,450	1.5%	16.2%	$625	83	369	4
03	2	2,450	8.7%	18.8%	$513	72	7	4
04	2	2,450	2.5%	16.6%	$749	68	220	4
05	2	2,450	21.0%	21.0%	$0	0	0	0
06	2	2,900	4.3%	15.3%	$1,043	38	9	12
07	2	2,900	7.4%	16.7%	$683	26	23	12
08	2	2,900	2.5%	16.7%	$965	41	198	12
09	2	2,900	0.1%	16.1%	$915	37	454	0
10	2	2,900	3.6%	15.5%	$1,349	30	573	0
11	2	2,900	3.2%	15.4%	$1,682	32	706	0
12	2	2,900	0.4%	18.9%	$1,382	147	315	0
13	2	2,900	0.9%	19.1%	$2,275	109	907	0
14	2	2,800	2.4%	15.3%	$2,253	167	216	0
15	2	2,800	1.6%	14.4%	$3,405	33	1,390	0
16	2	2,800	-4.3%	15.5%	$1,062	313	93	0

Figure O-6 to Figure O-9 illustrate the data presented in the tables above by end use, number of stories, and CEC climate zone. The solid bars illustrate the therms/kWh savings and the thinner striped bars illustrate the total cost of the package. Since many measures lead to both space heating and cooling savings, it is impossible to separate the costs associated with the energy savings by end use. The text above the bars is the % compliance margin of the base case prototype.

Figure O-6: Gas Savings of Least-Cost Package by CEC Climate Zone – 2005 Standards – One-Story Single Family Detached Homes

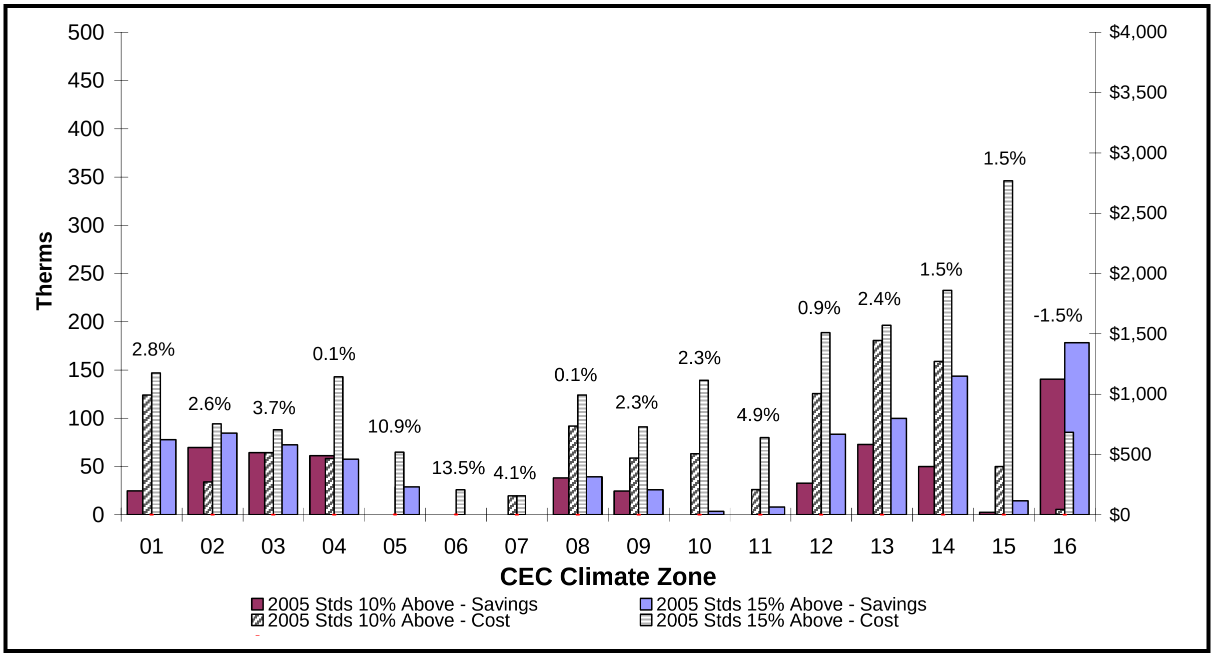


Figure O-7: Electric Savings of Least-Cost Package by CEC Climate Zone – 2005 Standards – One-Story Single Family Detached Homes

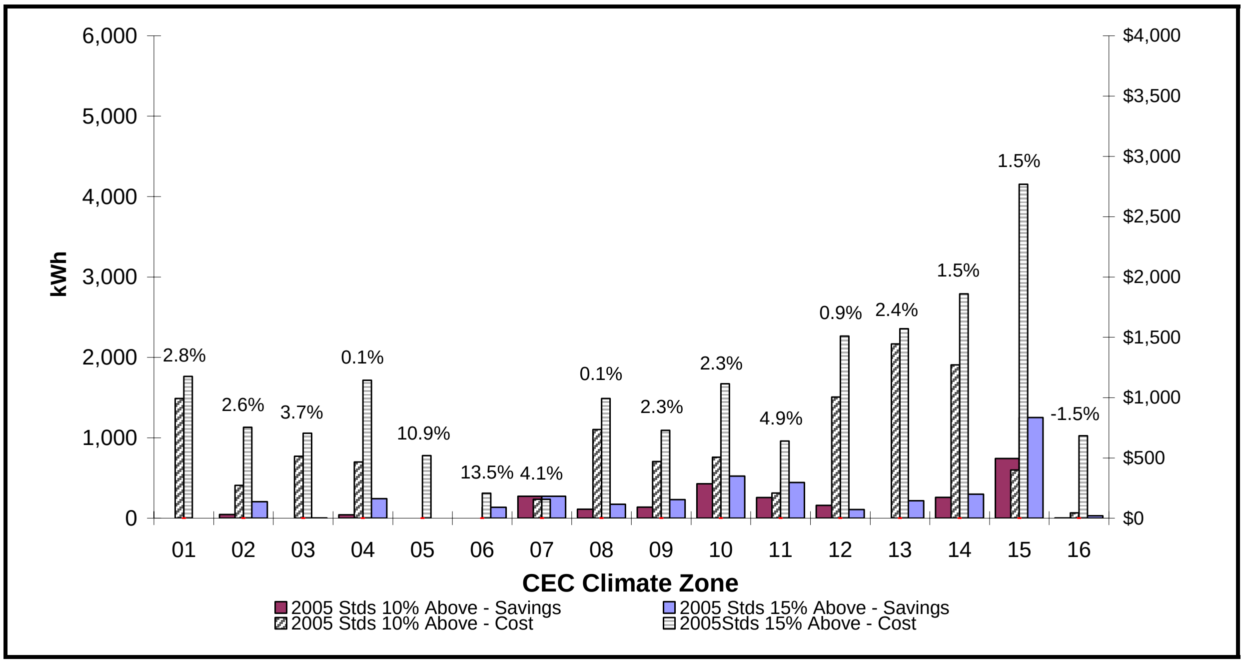


Figure O-8: Gas Savings of Least-Cost Package by CEC Climate Zone – 2005 Standards – Two-Story Single Family Detached Homes

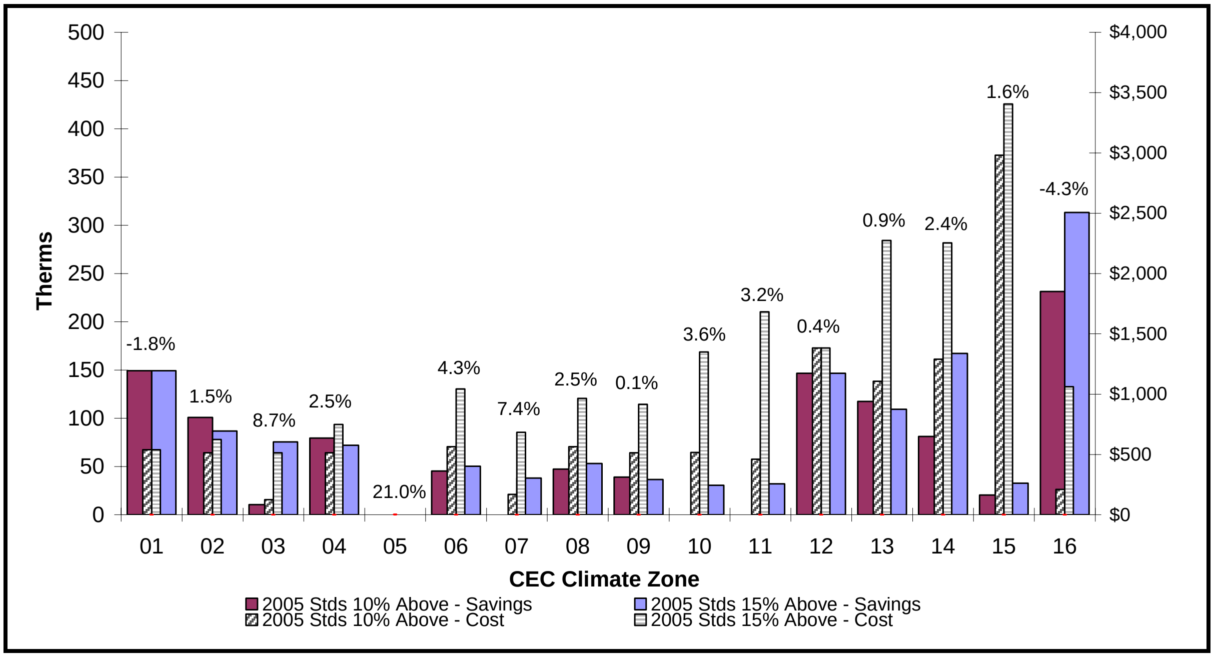
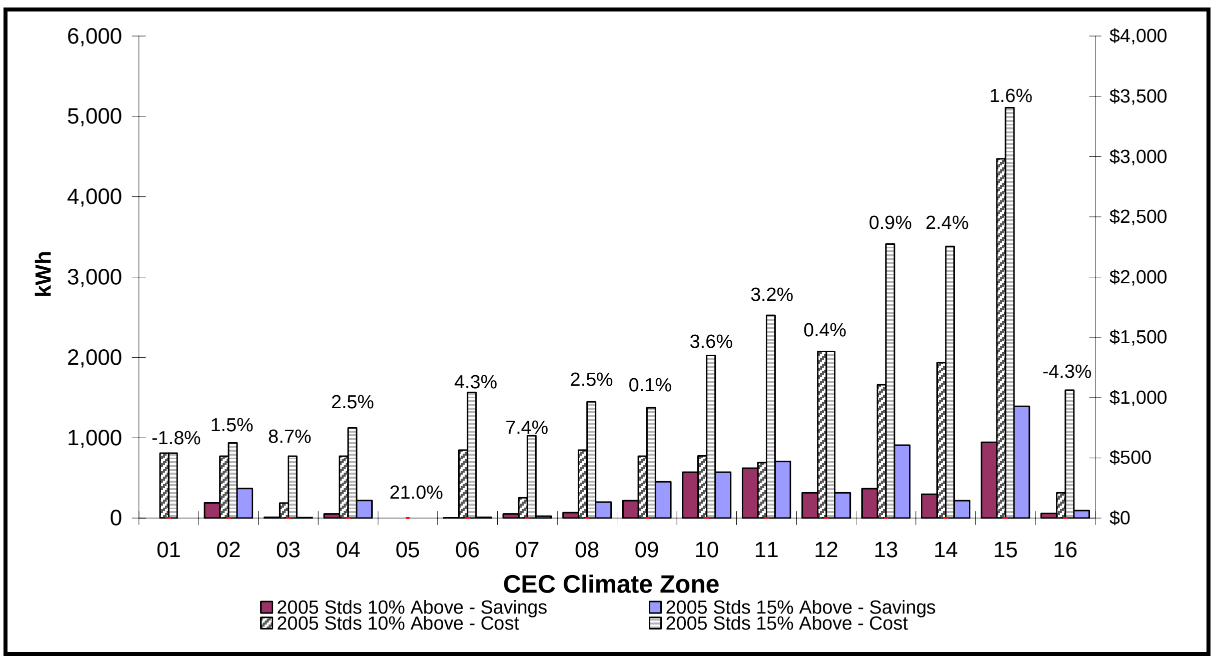


Figure O-9: Electric Savings of Least-Cost Package by CEC Climate Zone – 2005 Standards – Two-Story Single Family Detached Homes



O.3 Single Family Attached Buildings

A single family attached building is defined as a building with dwelling units that do not have floors or ceilings adjoining with any other dwelling units but share adjoining walls.

Base Case Prototypes

The first step was to develop a base case building for each RMST climate zone. These base case (prototype) buildings were developed by first finding buildings that matched closely the baseline average building shell characteristics (such as floor area and glazing area) of each CEC climate zone found during the RNC Baseline Study conducted in 2001. The adjustments were then made to the equipment efficiencies based on the expertise of the advisory group and using the 2001 RNC Baseline Study and the ENERGY STAR New Homes Evaluation conducted in 2004 by RLW.

Table O-13 presents the building characteristics and the compliance margins of the 16 single family attached prototypes used in the analysis and approved by the New Construction Residential Advisory Group on September 16, 2004.

Table O-13: Single Family Attached Prototypes (Base Case)

	CEC CZ 1	CEC CZ 2	CEC CZ 3	CEC CZ 4	CEC CZ 5	CEC CZ 6	CEC CZ 7	CEC CZ 8	CEC CZ 9	CEC CZ 10	CEC CZ 11	CEC CZ 12	CEC CZ 13	CEC CZ 14	CEC CZ 15	CEC CZ 16
Sq Ft	8,400	8,400	8,400	8,400	8,400	10,400	10,400	12,936	12,936	12,936	4,551	4,551	4,551	4,200	4,200	4,200
# Stories	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
# of Units	6	6	6	6	6	6	6	7	7	7	3	3	3	4	4	4
Glazing % Area	13.5%	13.5%	13.5%	13.5%	13.5%	13.5%	13.5%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%
Glazing Area	1134	1134	1134	1134	1134	1404	1404	1552	1552	1552	546	546	546	504	504	504
Type of Window	2VL	2VL	2VL	2VL	2VL	2VC	2VC	2VL	2VL	2VL	2VL	2VL	2VL	2VL	2VL	2VL
Glazing U-factor	0.37	0.37	0.37	0.37	0.37	0.60	0.60	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Glazing SHGC	0.41	0.41	0.41	0.41	0.41	0.65	0.65	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
Wall Area	8,060	8,060	8,060	8,060	8,060	7,480	7,480	9,168	9,168	9,168	3,520	3,520	3,520	3,740	3,740	3,740
Wall	19	19	19	19	19	13	13	13	13	13	13	13	13	19	19	19
Roof Area	4,200	4,200	4,200	4,200	4,200	5,200	5,200	6,468	6,468	6,468	4,551	4,551	4,551	4,200	4,200	4,200
Roof	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Radiant Barrier	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
TXV	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Tight Ducts	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Infiltration Testing	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Duct Design	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Duct R-value	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
SEER	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	11.0	11.0	11.0	11.0	11.0	11.0
AFUE	0.92	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
EF	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Standard	30.7	38.3	27.3	32.3	28.8	18.9	18.0	21.1	23.8	28.1	37.1	34.6	38.9	48.6	58.8	53.5
Margin	-0.12	-0.31	4.08	3.27	3.11	3.26	1.77	3.53	3.48	3.49	1.77	2.35	-0.15	-1.63	-7.04	0.75
% Compliance Margin	-0.4%	-0.8%	14.9%	10.1%	10.8%	17.2%	9.8%	16.8%	14.6%	12.4%	4.8%	6.8%	-0.4%	-3.4%	-12.0%	1.4%

Incremental Costs

Table O-14 presents the incremental cost for each measure included in the analysis. These costs were developed in the same manner as the incremental costs for the high efficiency measures installed in single detached homes. The New Construction Residential Advisory Group approved the final incremental costs on October 8, 2004. As with the single family detached residences, the incremental cost of the central air conditioning units changed due to the change in the federal minimum efficiency standards in 2006. The first cost given applied to the years from 2003 to 2005, and the second cost given applies to all years after 2005.

Table O-14: Summary of Proposed Incremental Measure Costs – Single Family Attached Buildings

Measure	Efficiency	Total Cost	
Central Air Conditioner	12 SEER	$200/N/A	Per Unit
	14 SEER	$400/$200	Per Unit
	15 SEER	$1,000/$500	Per Unit
Furnace	92% AFUE	$600	Per Unit
Water Heater	0.63 EF	$50	Per Unit
Radiant Barrier	Yes	$0.12	Per Sq. Ft. (Roof)
Roof Insulation	R-38	$0.08	Per Sq. Ft. (Roof)
	R-49	$0.20	Per Sq. Ft. (Roof)
Wall Insulation	R-19	$0.06	Per Sq. Ft. (Wall)
Insulation Credit	Yes	$25	Per House
House Wrap	Yes	$0.25	Per Sq. Ft. (Wall)
Windows	2-Pane Vinyl Low-E	$0.50	Per Sq. Ft. (Glazing)
	2-Pane Vinyl Spectral Low-E	$0.75	Per Sq. Ft. (Glazing)
Duct Insulation	R-8.0	$200	Per House
HERS Certified Sealed Ducts	Yes	$163	Per House
ACCA Duct Design	Yes	$131	Per House
Infiltration Testing	Yes	$150 + cost of House Wrap	Per House
TXV	Yes	$0	Per Unit

Developing the Packages

After the prototypes were finalized, the prototype buildings were used as the base cases to which the 70 high efficiency packages were added. The least-cost packages that reached a compliance margin of at least 15% and 25% above the 2001 Standards and 10% and 15% above the 2005 Standards were used to calculate energy savings per year for each prototype.

Least-Cost Package Results

Lastly, the savings in therms and watts per year were calculated for the least-cost package of each CEC climate zone. Energy savings per year were derived by subtracting the proposed energy usage of the upgraded unit per year from the base case proposed energy usage per year (for space heating, cooling, and water heating). The following presents the cost and savings for reaching the targets under the 2001 Standards and the 2005 Standards separately. All savings and costs presented are per unit.

2001 Standards

Table O-15 and Table O-16 present the measures included in the least-cost package that upgraded each prototype to 15% and 25% above the 2001 Standards, respectively. The tables also present the incremental cost of each package (*Cost*), the compliance margin of the base case prototype (*Base Compliance*), and the compliance margin reached by adding the package to the base case prototype (*Package Compliance*). For convenience, the measures that were upgraded for each prototype to reach its target are highlighted.

As shown in Table O-15, two of the base case prototypes already were at least 15% better than the 2001 Standards. (Note that these two prototypes have a $0 cost and their baseline and package compliance margins are equal.) Both of these base case prototypes are along the Southern coast of California, which has a mild climate and was not affected much by the changes to the 2001 Standards. Also shown is that the base case prototype in CEC Climate Zone 2 had a -0.8% compliance margin and would have to install several high efficiency measures, including a 12 SEER air conditioner with a TXV, roof insulation with a 38 R-value, a radiant barrier, and a 0.62 50-gallon gas water heater. Additional a HERS rater would have to verify that they installed 8.0 duct insulation and tight ducts. To reach 15% above the 2001 Standards would cost approximately $700 more than building the typical home in this climate zone.

Table O-16 provides the same results for the base case homes to reach 25% above the 2001 Standards. The base case prototype in CEC Climate Zone 1 could not be upgraded to 25% above the 2001 Standards given the current high efficiency measures in the packages. CEC Climate Zone 1 has no cooling in the Title 24 model and therefore has to achieve 25% using just the water heating and space heating budgets. This is difficult since most high efficiency measures are designed to reduce the peak cooling load.

Table O-15: Least-Cost Package by CEC Climate Zone – 15% Above 2001 Standards – Single Family Attached Buildings

CEC_CZ	# Units	FlArea	Base Compliance	Package Compliance	Cost	Window Type	Wall	Roof	Radiant Barrier	TXV	Tight Ducts	Infiltration Testing	House Wrap	SEER	AFUE	EF	Duct Design	Duct Insulation
01	6	8,400	-0.4%	15.1%	$1,080	2VL	19	49	Yes	No	Yes	Yes	Yes	10	92%	0.62	No	Yes
02	6	8,400	-0.8%	15.2%	$710	2VL	19	38	Yes	Yes	Yes	No	No	12	80%	0.62	No	Yes
03	6	8,400	14.9%	18.2%	$250	2VL	19	30	No	Yes	No	No	No	12	80%	0.62	No	No
04	6	8,400	10.1%	16.2%	$250	2VL	19	30	No	Yes	No	No	No	12	80%	0.62	No	No
05	6	8,400	10.8%	18.9%	$570	2VL	19	30	No	Yes	Yes	No	No	12	80%	0.62	No	Yes
06	6	10,400	17.2%	17.2%	$0	2VC	13	30	No	No	No	No	No	10	80%	0.60	No	No
07	6	10,400	9.8%	17.5%	$117	2VL	13	30	No	No	No	No	No	10	80%	0.60	No	No
08	7	12,936	16.8%	16.8%	$0	2VL	13	30	No	No	No	No	No	10	80%	0.60	No	No
09	7	12,936	14.6%	17.6%	$55	2VS	13	30	No	No	No	No	No	10	80%	0.60	No	No
10	7	12,936	12.4%	21.4%	$250	2VL	13	30	No	Yes	No	No	No	12	80%	0.62	No	No
11	3	4,551	4.8%	19.2%	$470	2VL	13	30	No	Yes	Yes	No	No	12	80%	0.62	No	Yes
12	3	4,551	6.8%	18.6%	$470	2VL	13	30	No	Yes	Yes	No	No	12	80%	0.62	No	Yes
13	3	4,551	-0.4%	17.0%	$470	2VL	13	30	No	Yes	Yes	No	No	12	80%	0.62	No	Yes
14	4	4,200	-3.4%	15.9%	$470	2VL	19	30	No	Yes	Yes	No	No	12	80%	0.62	No	Yes
15	4	4,200	-12.0%	15.9%	$470	2VL	19	30	No	Yes	Yes	No	No	12	80%	0.62	No	Yes
16	4	4,200	1.4%	15.3%	$470	2VL	19	30	No	Yes	Yes	No	No	12	80%	0.62	No	Yes

Table O-16: Least-Cost Package by CEC Climate Zone – 25% Above 2001 Standards – Single Family Attached Buildings

CEC_CZ	# Units	FlArea	Base Compliance	Package Compliance	Cost	Window Type	Wall	Roof	Radiant Barrier	TXV	Tight Ducts	Infiltration Testing	House Wrap	SEER	AFUE	EF	Duct Design	Duct Insulation
01	6	8,400	-0.4%	15.1%	$1,080	2VL	19	49	Yes	No	Yes	Yes	No	10	92%	0.62	No	Yes
02	6	8,400	-0.8%	25.2%	$2,059	2VS	19	49	Yes	Yes	Yes	Yes	Yes	12	92%	0.62	Yes	Yes
03	6	8,400	14.9%	26.1%	$1,056	2VL	19	30	No	Yes	Yes	Yes	Yes	12	80%	0.63	No	Yes
04	6	8,400	10.1%	26.1%	$1,280	2VL	19	49	Yes	Yes	Yes	Yes	Yes	12	80%	0.62	No	Yes
05	6	8,400	10.8%	25.6%	$1,686	2VL	19	49	Yes	Yes	Yes	No	Yes	10	92%	0.63	Yes	Yes
06	6	10,400	17.2%	25.1%	$756	2VL	13	38	No	Yes	Yes	No	No	12	80%	0.62	No	Yes
07	6	10,400	9.8%	25.0%	$1,119	2VS	13	38	Yes	Yes	Yes	No	No	14	80%	0.62	No	Yes
08	7	12,936	16.8%	25.4%	$570	2VL	13	30	No	Yes	Yes	No	No	12	80%	0.62	No	Yes
09	7	12,936	14.6%	25.7%	$379	2VS	13	38	No	Yes	No	No	No	12	80%	0.62	No	No
10	7	12,936	12.4%	26.5%	$570	2VL	13	30	No	Yes	Yes	No	No	12	80%	0.62	No	Yes
11	3	4,551	4.8%	25.5%	$1,001	2VS	13	49	Yes	Yes	Yes	No	No	12	80%	0.62	No	Yes
12	3	4,551	6.8%	25.2%	$1,255	2VL	13	49	Yes	Yes	Yes	No	No	14	80%	0.62	No	Yes
13	3	4,551	-0.4%	25.7%	$1,301	2VS	13	49	Yes	Yes	Yes	No	No	14	80%	0.62	No	Yes
14	4	4,200	-3.4%	25.7%	$1,221	2VS	19	49	Yes	Yes	Yes	Yes	Yes	12	80%	0.62	No	Yes
15	4	4,200	-12.0%	25.5%	$1,138	2VS	19	49	Yes	Yes	Yes	No	No	14	80%	0.62	No	Yes
16	4	4,200	1.4%	25.8%	$1,537	2VL	19	49	Yes	Yes	Yes	No	No	12	92%	0.62	Yes	Yes

Table O-17 and Table O-18 summarize the cost and savings results caused by upgrading the base case home with the least-cost package for each to reach 15% and 25% above the 2001 Standards. As shown, it would cost approximately $470 to upgrade the base case prototype in CEC Climate Zone 14 from -3.4% to 15.9%, and would result in a savings of 30 therms and 662 kWh per year.

Table O-17: Energy Savings and Costs by CEC Climate Zone – 15% Above 2001 Standards – Single Family Attached Buildings

CEC_CZ	# Units	FlArea	Base Compliance	Package Compliance	Cost	Space Heat Savings (Therms)	Space Cool Savings (kWh)	DHW Savings (Therms)
01	6	8,400	-0.4%	15.1%	$1,080	56	0	10
02	6	8,400	-0.8%	15.2%	$710	35	396	10
03	6	8,400	14.9%	18.2%	$250	0	22	10
04	6	8,400	10.1%	16.2%	$250	0	170	10
05	6	8,400	10.8%	18.9%	$570	19	36	10
06	6	10,400	17.2%	17.2%	$0	0	0	0
07	6	10,400	9.8%	17.5%	$117	0	239	0
08	7	12,936	16.8%	16.8%	$0	0	0	0
09	7	12,936	14.6%	17.6%	$55	-4	166	0
10	7	12,936	12.4%	21.4%	$250	0	352	11
11	3	4,551	4.8%	19.2%	$470	26	433	10
12	3	4,551	6.8%	18.6%	$470	28	230	10
13	3	4,551	-0.4%	17.0%	$470	18	721	10
14	4	4,200	-3.4%	15.9%	$470	20	662	10
15	4	4,200	-12.0%	15.9%	$470	2	1,571	10
16	4	4,200	1.4%	15.3%	$470	60	79	10

Table O-18: Energy Savings and Costs by CEC Climate Zone – 25% Above 2001 Standards – Single Family Attached Buildings

CEC_CZ	# Units	FlArea	Base Compliance	Package Compliance	Cost	Space Heat Savings (Therms)	Space Cool Savings (kWh)	DHW Savings (Therms)
01	6	8,400	-0.4%	15.1%	$1,080	56	0	10
02	6	8,400	-0.8%	25.2%	$2,059	76	521	10
03	6	8,400	14.9%	26.1%	$1,056	30	29	10
04	6	8,400	10.1%	26.1%	$1,280	33	278	10
05	6	8,400	10.8%	25.6%	$1,686	45	42	10
06	6	10,400	17.2%	25.1%	$756	-2	164	11
07	6	10,400	9.8%	25.0%	$1,119	1	354	11
08	7	12,936	16.8%	25.4%	$570	5	173	11
09	7	12,936	14.6%	25.7%	$379	-3	397	11
10	7	12,936	12.4%	26.5%	$570	9	522	11
11	3	4,551	4.8%	25.5%	$1,001	32	724	10
12	3	4,551	6.8%	25.2%	$1,255	40	451	10
13	3	4,551	-0.4%	25.7%	$1,301	21	1,194	10
14	4	4,200	-3.4%	25.7%	$1,221	34	1,017	10
15	4	4,200	-12.0%	25.5%	$1,138	2	2,143	10
16	4	4,200	1.4%	25.8%	$1,537	111	156	10

Figure O-10 and Figure O-11 illustrate the data presented in the tables above by end use and CEC climate zone. The solid bars illustrate the therms/kWh savings and the thinner striped bars illustrate the total cost of the package. Since many measures lead to both space heating and cooling savings, it is impossible to separate the costs associated with the energy savings by end use. The text above the bars is the % compliance margin of the base case prototype.

For example, Figure O-10 shows that the prototype in CEC Climate Zone 15 had a base compliance of -12.0%. To reach at least 15% above the 2001 Standards would cost $638 and result in a savings of just 12 therms. However, upgrading the prototype to 25% above the 2001 Standards would cost an additional $1,500 and only result in an additional savings of 3 therms. Note that this does not reflect the cooling savings associated with the cost.

Figure O-10: Gas Savings of Least-Cost Package by CEC Climate Zone – 2001 Standards – Single Family Attached Buildings

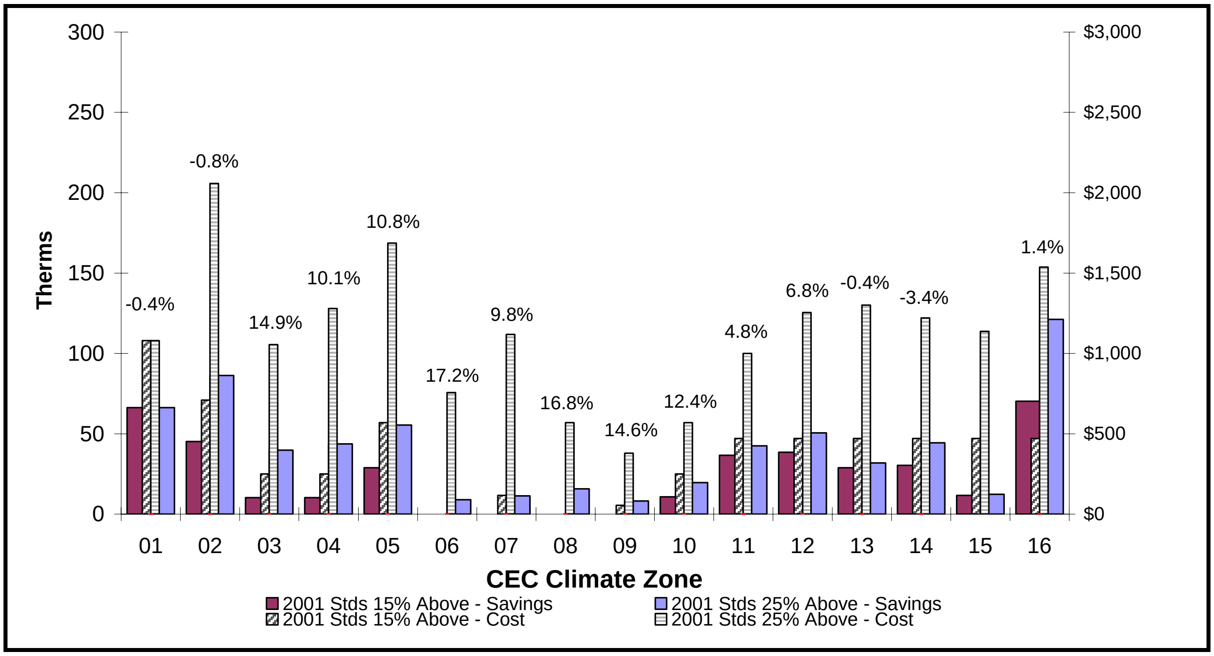
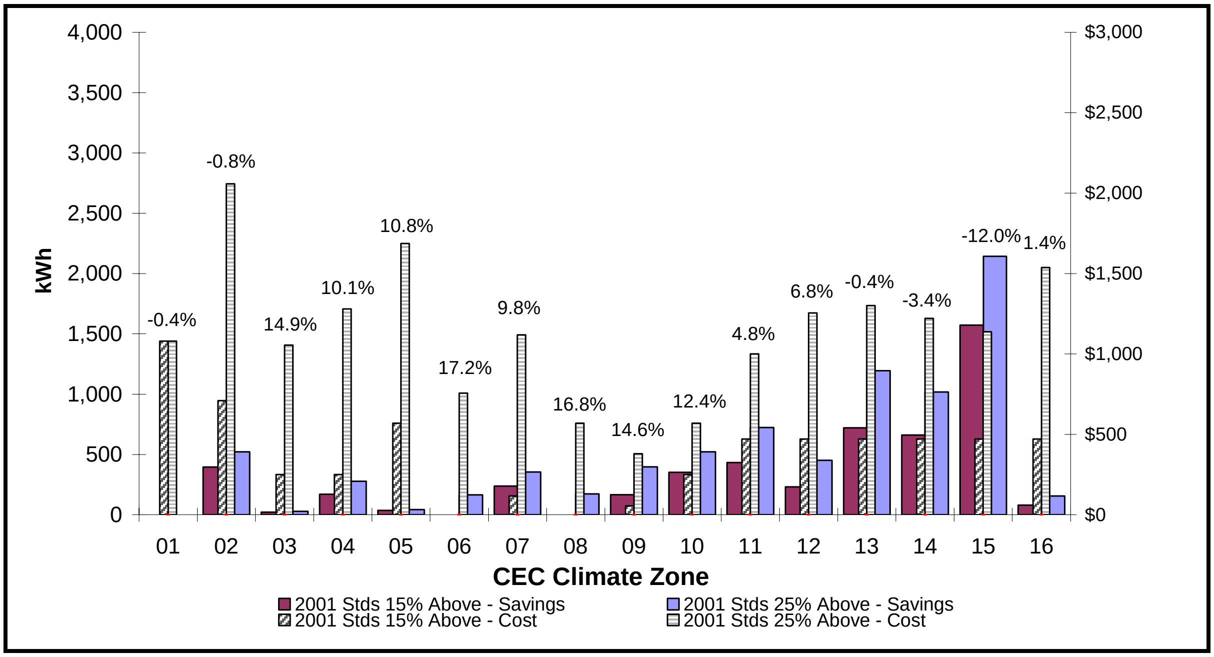


Figure O-11: Electric Savings of Least-Cost Package by CEC Climate Zone – 2001 Standards – Single Family Attached Buildings



2005 Standards

The 2005 base buildings were developed in the same way that the single family detached homes were—the least-cost package that caused each prototype to just comply with the 2005 Standards was chosen as the 2005 base case prototype. Table O-19 presents the % compliance margin, the measures installed, and the cost of the package relative to the 2001 base case prototypes. Of the 16 single family attached prototypes, two have the same 2005 base case as the 2001 base case. Both are along the coast, which is not surprising given that the 2005 Standards, like the 2001 Standards, were developed to be more stringent in the inland regions.

Table O-19: 2005 Standards Base Case Prototypes – Single Family Attached Buildings

RER _CZ	CEC_ CZ	Story	FlArea	Package	Base Compliance	Cost Above 01 Baseline	Window Type	Wall	Roof	Insulation Cert	Radiant Barrier	TXV	Tight Ducts	Infiltration Testing	House Wrap	SEER	AFUE	EF	Duct Design	Duct Insulation
1	01	2	8,400	49	-1.3%	$692	2VL	19	49	No	Yes	No	Yes	No	No	13	92%	0.62	No	Yes
1	02	2	8,400	44	2.3%	$417	2VS	19	30	No	No	Yes	Yes	No	No	13	80%	0.62	No	Yes
1	03	2	8,400	1	1.6%	$0	2VL	19	30	No	No	Yes	No	No	No	13	80%	0.60	No	No
1	04	2	8,400	43	4.4%	$370	2VL	19	30	No	No	Yes	Yes	No	No	13	80%	0.62	No	Yes
1	05	2	8,400	1	4.1%	$0	2VL	19	30	No	No	Yes	No	No	No	13	80%	0.60	No	No
2	06	2	10,400	3	1.6%	$50	2VC	13	30	No	No	Yes	No	No	No	13	80%	0.62	No	No
2	07	2	10,400	1	4.5%	$117	2VL	13	30	No	No	Yes	No	No	No	13	80%	0.60	No	No
3	08	2	12,936	7	0.9%	$198	2VS	13	38	No	No	Yes	No	No	No	13	80%	0.62	No	No
3	09	2	12,936	44	3.6%	$425	2VS	13	30	No	No	Yes	Yes	No	No	13	80%	0.62	No	Yes
3	10	2	12,936	55	1.9%	$662	2VL	13	38	No	No	Yes	Yes	No	No	14	80%	0.62	No	Yes
4	11	2	4,551	46	0.1%	$567	2VS	13	38	No	No	Yes	Yes	No	No	13	80%	0.62	No	Yes
4	12	2	4,551	46	1.4%	$567	2VS	13	38	No	No	Yes	Yes	No	No	13	80%	0.62	No	Yes
4	13	2	4,551	48	2.6%	$810	2VS	13	38	No	Yes	Yes	Yes	No	No	13	80%	0.62	No	Yes
5	14	2	4,200	47	0.5%	$643	2VL	19	38	No	Yes	Yes	Yes	No	No	13	80%	0.62	No	Yes
5	15	2	4,200	47	0.4%	$643	2VL	19	38	No	Yes	Yes	Yes	No	Yes	13	80%	0.62	No	Yes
5	16	2	4,200	43	6.2%	$370	2VL	19	30	No	No	Yes	Yes	No	No	13	80%	0.62	No	Yes

Table O-20 and Table O-21 present the measures included in the least-cost package that upgraded each prototype to 10% and 15% above the 2005 Standards, respectively. The tables also present the incremental cost of each package (*Cost*), the compliance margin of the base case prototype (*Base Compliance*), and the compliance margin reached by adding the package to the base case prototype (*Package Compliance*). For convenience, the measures that were upgraded for each prototype to reach its target are highlighted in yellow meaning the measure was added, and green meaning that the base case prototype actually had a higher efficiency version of the measure installed (therefore decreasing the cost).

As shown in Table O-20, three of the base case prototypes were already at least 10% better than the 2005 Standards. Table O-21 provides the same results for the base case homes to reach 15% above the 2005 Standards. While it is possible for each of the prototypes to reach 15% better than the 2005 Standards, the number of high efficiency measures and the cost of those measures varies dramatically between the coast and inland regions. The prototypes in the inland regions need nearly every high efficiency measure in list while some of the coastal prototypes need to install only one or two high efficiency measures.

Table O-20: Least-Cost Package by CEC Climate Zone – 10% Above 2005 Standards – Single Family Attached Buildings

CEC_CZ	# Units	FlArea	Base Compliance	Package Compliance	Cost	Window Type	Wall	Roof	Insulation Certification	Radiant Barrier	TXV	Tight Ducts	Infiltration Testing	House Wrap	SEER	AFUE	EF	Duct Design	Duct Insulation
01	6	8,400	-1.3%	5.6%	$58	2VL	19	49	No	Yes	No	Yes	No	No	13	92%	0.63	Yes	Yes
02	6	8,400	2.3%	10.4%	$871	2VS	19	38	No	Yes	Yes	Yes	No	No	13	92%	0.62	Yes	Yes
03	6	8,400	1.6%	12.5%	$370	2VL	19	30	No	No	Yes	Yes	No	No	13	80%	0.62	No	Yes
04	6	8,400	4.4%	10.3%	$271	2VS	19	49	No	Yes	Yes	Yes	No	No	13	80%	0.62	No	Yes
05	6	8,400	4.1%	15.1%	$370	2VL	19	30	No	No	Yes	Yes	No	No	13	80%	0.62	No	Yes
06	6	10,400	1.6%	11.9%	$117	2VL	13	30	No	No	Yes	No	No	No	13	80%	0.62	No	No
07	6	10,400	4.5%	10.2%	$109	2VS	13	30	No	No	Yes	No	No	No	13	80%	0.62	No	No
08	7	12,936	0.9%	10.0%	$612	2VS	13	38	No	Yes	Yes	Yes	No	No	14	80%	0.62	No	Yes
09	7	12,936	3.6%	10.0%	$385	2VS	13	38	No	Yes	Yes	Yes	No	No	14	80%	0.62	No	Yes
10	7	12,936	1.9%	10.9%	$736	2VS	13	49	No	Yes	Yes	Yes	Yes	Yes	14	80%	0.62	No	Yes
11	3	4,551	0.1%	10.4%	$1,265	2VS	13	49	No	Yes	Yes	Yes	No	No	14	92%	0.62	Yes	Yes
12	3	4,551	1.4%	10.3%	$977	2VS	13	49	No	Yes	Yes	Yes	Yes	Yes	14	80%	0.62	No	Yes
13	3	4,551	2.6%	9.0%	$1,095	2VL	13	49	Yes	Yes	Yes	Yes	No	Yes	13	92%	0.63	Yes	Yes
14	4	4,200	0.5%	9.5%	$1,053	2VL	19	49	Yes	Yes	Yes	Yes	No	Yes	13	92%	0.63	Yes	Yes
15	4	4,200	0.4%	7.0%	$678	2VS	19	49	No	Yes	Yes	Yes	Yes	Yes	14	80%	0.62	No	Yes
16	4	4,200	6.2%	10.6%	$210	2VL	19	38	No	Yes	Yes	Yes	No	No	13	80%	0.62	No	Yes

Note: Yellow highlighting indicates a more efficient measure is needed compared to the baseline home and green highlighting indicates a less efficient measure is needed.

Table O-21: Least-Cost Package by CEC Climate Zone – 15% Above 2005 Standards – Single Family Attached Buildings

CEC_CZ	# Units	FlArea	Base Compliance	Package Compliance	Cost	Window Type	Wall	Roof	Insulation Cert	Radiant Barrier	TXV	Tight Ducts	Infiltration Testing	House Wrap	SEER	AFUE	EF	Duct Design	Duct Insulation
01	6	8,400	-1.3%	8.4%	$394	2VL	19	49	Yes	Yes	No	Yes	No	Yes	13	92%	0.63	Yes	Yes
02	6	8,400	2.3%	16.3%	$1,269	2VL	19	49	Yes	Yes	Yes	Yes	No	Yes	13	92%	0.63	Yes	Yes
03	6	8,400	1.6%	15.1%	$794	2VL	19	49	No	Yes	Yes	Yes	No	No	14	80%	0.62	No	Yes
04	6	8,400	4.4%	15.4%	$1,203	2VS	19	49	No	Yes	Yes	Yes	No	No	14	92%	0.62	Yes	Yes
05	6	8,400	4.1%	15.1%	$370	2VL	19	30	No	No	Yes	Yes	No	No	13	80%	0.62	No	Yes
06	6	10,400	1.6%	15.7%	$437	2VL	13	30	No	No	Yes	Yes	No	No	13	80%	0.62	No	Yes
07	6	10,400	4.5%	15.7%	$602	2VS	13	38	No	Yes	Yes	Yes	No	No	13	80%	0.62	No	Yes
08	7	12,936	0.9%	18.9%	$2,011	2VS	19	49	No	Yes	Yes	Yes	Yes	Yes	14	92%	0.63	Yes	Yes
09	7	12,936	3.6%	16.6%	$1,403	2VL	19	49	No	Yes	Yes	Yes	No	Yes	13	92%	0.63	Yes	Yes
10	7	12,936	1.9%	15.5%	$1,166	2VL	19	49	No	Yes	Yes	Yes	No	Yes	13	92%	0.63	Yes	Yes
11	3	4,551	0.1%	19.7%	$1,408	2VL	19	49	No	Yes	Yes	Yes	No	Yes	13	92%	0.63	Yes	Yes
12	3	4,551	1.4%	15.7%	$1,338	2VL	13	49	Yes	Yes	Yes	Yes	No	Yes	13	92%	0.63	Yes	Yes
13	3	4,551	2.6%	15.2%	$1,166	2VL	19	49	No	Yes	Yes	Yes	No	Yes	13	92%	0.63	Yes	Yes
14	4	4,200	0.5%	14.2%	$1,735	2VS	19	49	Yes	Yes	Yes	Yes	Yes	Yes	15	92%	0.63	Yes	Yes
15	4	4,200	0.4%	10.4%	$1,735	2VS	19	49	Yes	Yes	Yes	Yes	Yes	Yes	15	92%	0.63	Yes	Yes
16	4	4,200	6.2%	15.6%	$815	2VL	19	38	No	No	Yes	Yes	No	No	13	92%	0.62	Yes	Yes

Note: Yellow highlighting indicates a more efficient measure is needed compared to the baseline home and green highlighting indicates a less efficient measure is needed.

Table O-22 and Table O-23 summarize the cost and savings[7] results caused by upgrading the base case home with the least-cost package for each to reach 10% and 15% above the 2005 Standards. As shown, it would cost just $117 to upgrade the base case prototype in CEC Climate Zone 6 from 1.6% to 11.9% and would result in a savings of 132 kWh per year.

Table O-22: Energy Savings and Costs by CEC Climate Zone – 10% Above 2005 Standards – Single Family Attached Buildings

CEC_CZ	# Units	FlArea	Base Compliance	Package Compliance	Cost	Space Heat Savings (Therms)	Space Cool Savings (kWh)	DHW Savings (Therms)
01	6	8,400	-1.3%	5.6%	$58	29	0	0
02	6	8,400	2.3%	10.4%	$871	34	60	0
03	6	8,400	1.6%	12.5%	$370	31	7	11
04	6	8,400	4.4%	10.3%	$271	0	114	0
05	6	8,400	4.1%	15.1%	$370	31	3	11
06	6	10,400	1.6%	11.9%	$117	-2	132	0
07	6	10,400	4.5%	10.2%	$109	-5	41	11
08	7	12,936	0.9%	10.0%	$612	13	92	0
09	7	12,936	3.6%	10.0%	$385	2	121	0
10	7	12,936	1.9%	10.9%	$736	13	191	0
11	3	4,551	0.1%	10.4%	$1,265	31	188	0
12	3	4,551	1.4%	10.3%	$977	17	132	0
13	3	4,551	2.6%	9.0%	$1,095	47	-10	0
14	4	4,200	0.5%	9.5%	$1,053	38	87	0
15	4	4,200	0.4%	7.0%	$678	1	318	0
16	4	4,200	6.2%	10.6%	$210	15	42	0

[7] The method of estimating the compliance and energy savings from exceeding the 2005 Standards was calculated differently than it was under the 2001 Standards. The 2005 Standards use TDV for calculating compliance. However, since the TDV calculations weight the energy used across hours differently, it is not correct to use the TDV budgets to calculate energy savings. Therefore, the TDV budgets are used to determine the % compliance margins but the source energy budgets are used to calculate energy savings. Under the 2001 Standards, the source energy budgets are used to estimate both compliance and energy savings.

Table O-23: Energy Savings and Costs by CEC Climate Zone – 15% Above 2005 Standards – Single Family Attached Buildings

CEC_CZ	# Units	FlArea	Base Compliance	Package Compliance	Cost	Space Heat Savings (Therms)	Space Cool Savings (kWh)	DHW Savings (Therms)
01	6	8,400	-1.3%	8.4%	$394	40	0	0
02	6	8,400	2.3%	16.3%	$1,269	73	31	0
03	6	8,400	1.6%	15.1%	$794	36	23	11
04	6	8,400	4.4%	15.4%	$1,203	19	133	0
05	6	8,400	4.1%	15.1%	$370	31	3	11
06	6	10,400	1.6%	15.7%	$437	9	136	0
07	6	10,400	4.5%	15.7%	$602	6	66	11
08	7	12,936	0.9%	18.9%	$2,011	32	154	0
09	7	12,936	3.6%	16.6%	$1,403	31	108	0
10	7	12,936	1.9%	15.5%	$1,166	43	164	0
11	3	4,551	0.1%	19.7%	$1,408	87	214	0
12	3	4,551	1.4%	15.7%	$1,338	73	28	0
13	3	4,551	2.6%	15.2%	$1,166	62	144	0
14	4	4,200	0.5%	14.2%	$1,735	34	258	0
15	4	4,200	0.4%	10.4%	$1,735	4	466	0
16	4	4,200	6.2%	15.6%	$815	51	21	0

Figure O-12 and Figure O-13 illustrate the data presented in the tables above by end use, number of stories, and CEC climate zone. The solid bars illustrate the therms/kWh savings and the thinner striped bars illustrate the total cost of the package. Since many measures lead to both space heating and cooling savings, it is impossible to separate the costs associated with the energy savings by end use. The text above the bars is the % compliance margin of the base case prototype.

Figure O-12: Gas Savings of Least-Cost Package by CEC Climate Zone – 2005 Standards – Single Family Attached Buildings

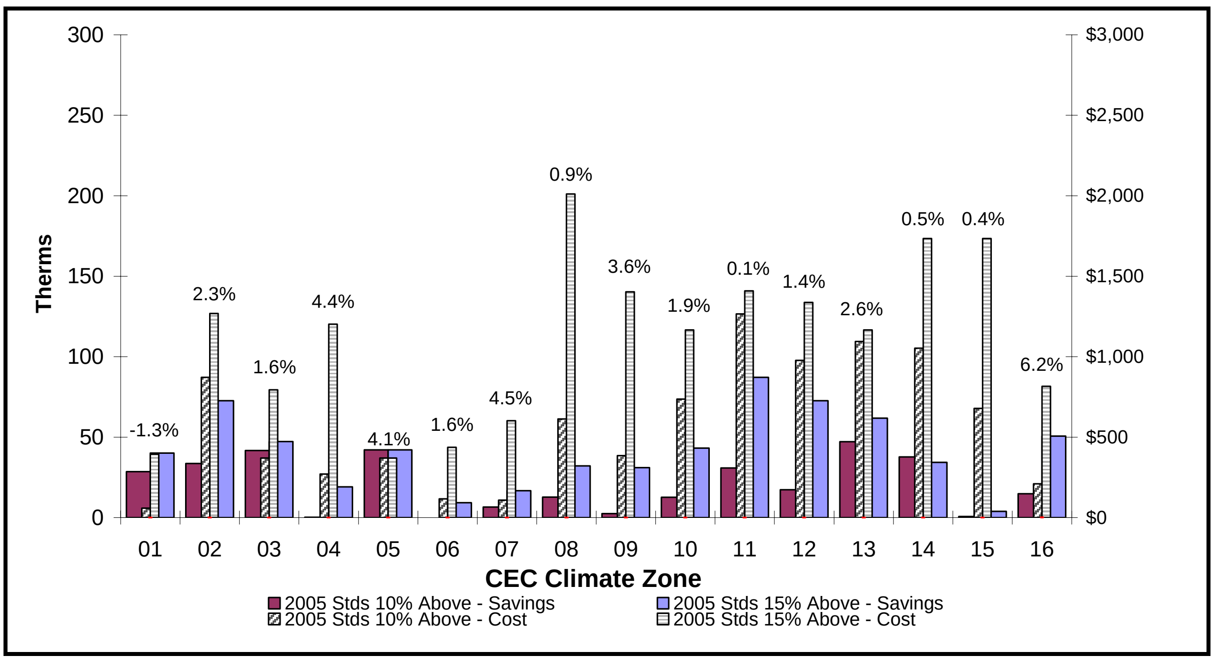
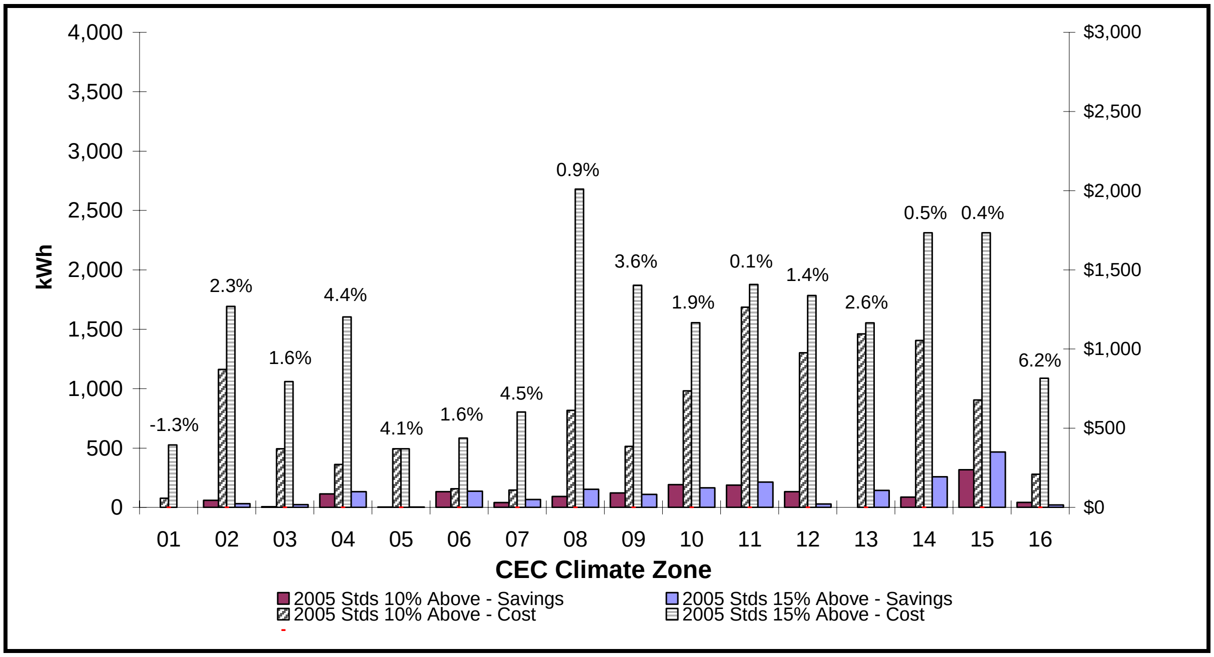


Figure O-13: Electric Savings of Least-Cost Package by CEC Climate Zone – 2005 Standards – Single Family Attached Buildings



O.4 Low-Rise Multifamily Buildings

A multifamily building is defined as a building with dwelling units that have adjoining floors and/or ceilings and possibly adjoining walls.

Base Case Prototypes

The first step was to develop a base case two-story and three-story building for each RMST climate zone. These base case (prototype) buildings were developed by first finding buildings that matched closely the baseline average building shell characteristics (such as floor area and glazing area) of each CEC climate zone found during the RNC Baseline Study conducted in 2001. Heating systems differ in multifamily units. Adjustments were then made to the equipment efficiencies based on the project team's expertise, and using the 2001 RNC Baseline Study and the ENERGY STAR New Homes Evaluation conducted in 2004 by RLW.

Table O-24 presents the building characterizes and the compliance margins of the 32 low-rise multifamily prototypes used in the analysis, which were approved by the New Construction Residential Advisory Group on December 3, 2004.

Table O-24: Low-Rise Multifamily Prototypes (base case)

2-Story	CEC CZ 1	CEC CZ 2	CEC CZ 3	CEC CZ 4	CEC CZ 5	CEC CZ 6	CEC CZ 7	CEC CZ 8	CEC CZ 9	CEC CZ 10	CEC CZ 11	CEC CZ 12	CEC CZ 13	CEC CZ 14	CEC CZ 15	CEC CZ 16
Sq Ft	10,800	10,800	10,800	10,800	10,800	12,000	12,000	8,400	8,400	8,400	13,936	13,936	13,936	13,936	13,936	13,936
# Stories	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
# of Units	12	12	12	12	12	8	8	8	8	8	12	12	12	12	12	12
Glazing % Area	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
Glazing Area	1,080	1,080	1,080	1,080	1,080	1,200	1,200	840	840	840	1,394	1,394	1,394	1,394	1,394	1,394
Type of Window	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC
Glazing U-factor	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Glazing SHGC	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Wall Area	9,240	9,240	9,240	9,240	9,240	7,480	7,480	5,720	5,720	5,720	8,184	8,184	8,184	8,184	8,184	8,184
Wall	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
Roof Area	5,400	5,400	5,400	5,400	5,400	6,000	6,000	4,200	4,200	4,200	6,968	6,968	6,968	6,968	6,968	6,968
Roof	30	30	30	30	30	19	19	19	19	19	19	19	19	30	30	30
Radiant Barrier	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
TXV	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Tight Ducts	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Infiltration Testing	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Duct Design	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Duct R-value	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
EER/SEER	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	12.0	12.0	12.0
Heating Type	Hydro	Hydro	Hydro	Hydro	Hydro	Heat Pump	Heat Pump	Hydro	Hydro	Hydro	Hydro	Hydro	Hydro	Hydro	Hydro	Hydro
Heating Efficiency	0.75	0.75	0.75	0.75	0.75	7.0	7.0	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
WH Type	Indiv Combo	Indiv Combo	Indiv Combo	Indiv Combo	Indiv Combo	Indiv Storage	Indiv Storage	Indiv Combo	Indiv Combo	Indiv Combo	Indiv Combo	Indiv Combo	Indiv Combo	Indiv Combo	Indiv Combo	Indiv Combo
Distrib Type	Std	Std	Std	Std	Std	Std	Std	Std	Std	Std	Std	Std	Std	Std	Std	Std
WH Efficiency	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.62	0.62	0.62	0.62	0.62	0.62
Standard	33.05	41.01	30.78	35.82	31.69	20.31	19.40	27.65	30.44	35.14	36.90	34.45	38.05	41.49	50.50	46.63
Margin	1.40	2.42	6.18	5.12	4.96	3.68	2.05	3.60	3.09	1.69	-2.46	-1.31	-4.16	-1.40	-5.74	-0.37
% Compliance Margin	4.2%	5.9%	20.1%	14.3%	15.7%	18.1%	10.6%	13.0%	10.2%	4.8%	-6.7%	-3.8%	-10.9%	-3.4%	-11.4%	-0.8%

Table O-24 (cont'd): Low-Rise Multifamily Prototypes (base case)

3-Story	**CEC CZ 1**	**CEC CZ 2**	**CEC CZ 3**	**CEC CZ 4**	**CEC CZ 5**	**CEC CZ 6**	**CEC CZ 7**	**CEC CZ 8**	**CEC CZ 9**	**CEC CZ 10**	**CEC CZ 11**	**CEC CZ 12**	**CEC CZ 13**	**CEC CZ 14**	**CEC CZ 15**	**CEC CZ 16**
Sq Ft	21,000	21,000	21,000	21,000	21,000	21,528	21,528	75,000	75,000	75,000	22,800	22,800	22,800	22,800	22,800	22,800
# Stories	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
# of Units	20	20	20	20	20	17	17	62	62	62	24	24	24	24	24	24
Glazing % Area	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%	9.0%
Glazing Area	1,890	1,890	1,890	1,890	1,890	1,938	1,938	6,750	6,750	6,750	2,052	2,052	2,052	2,052	2,052	2,052
Type of Window	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC	2VC
Glazing U-factor	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Glazing SHGC	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Wall Area	11,220	11,220	11,220	11,220	11,220	13,680	13,680	39,744	39,744	39,744	14,700	14,700	14,700	14,700	14,700	14,700
Wall	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
Roof Area	7,000	7,000	7,000	7,000	7,000	7,176	7,176	24,000	24,000	24,000	7,600	7,600	7,600	7,600	7,600	7,600
Roof	19	19	19	19	19	19	19	19	19	19	19	19	19	30	30	30
Radiant Barrier	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
TXV	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Tight Ducts	N/A	N/A	N/A	N/A	N/A	No	No	N/A	N/A	N/A	No	No	No	No	No	No
Infiltration Testing	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Duct Design	N/A	N/A	N/A	N/A	N/A	No	No	N/A	N/A	N/A	No	No	No	No	No	No
Duct R-value	N/A	N/A	N/A	N/A	N/A	4.2	4.2	N/A	N/A	N/A	4.2	4.2	4.2	4.2	4.2	4.2
EER/SEER	8.8	8.8	8.8	8.8	8.8	10.0	10.0	8.5	8.5	8.5	10.0	10.0	10.0	10.0	12.0	10.0
Heating Type	Electric	Electric	Electric	Electric	Electric	Hydro	Hydro	Room Heat	Room Heat	Room Heat	Heat Pump	Heat Pump	Heat Pump	Heat Pump	Heat Pump	Heat Pump
Heating Efficiency	3.4	3.4	3.4	3.4	3.4	0.75	0.75	6.8	6.8	6.8	7.0	7.0	7.0	7.0	7.0	7.0
WH Type	Central Storage	Central Storage	Central Storage	Central Storage	Central Storage	Indiv Combo	Indiv Combo	Central Storage	Central Storage	Central Storage	Central Storage	Central Storage	Central Storage	Central Storage	Central Storage	Central Storage
Distrib Type	Recirc/ Temp	Recirc/ Temp	Recirc/ Temp	Recirc/ Temp	Recirc/ Temp	Std	Std	Recirc/ Temp	Recirc/ Temp	Recirc/ Temp	Recirc/ Temp	Recirc/ Temp	Recirc/ Temp	Recirc/ Temp	Recirc/ Temp	Recirc/ Temp
WH Efficiency	0.76	0.76	0.76	0.76	0.76	0.60	0.60	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Standard	31.31	38.01	28.08	32.97	29.05	22.21	21.10	26.67	29.38	33.89	42.17	39.44	42.78	46.99	55.44	54.75
Margin	3.83	6.56	10.00	10.24	8.70	4.77	3.17	8.43	8.90	10.36	3.32	4.33	1.45	1.24	0.62	5.70
% Compliance Margin	12.2%	17.3%	35.6%	31.1%	29.9%	21.5%	15.0%	31.6%	30.3%	30.6%	7.9%	11.0%	3.4%	2.6%	1.1%	10.4%

Incremental Costs

Table O-25 presents the incremental cost for each measure included in the analysis. These costs were developed in the same manner as the incremental costs for the high efficiency measures installed in single family homes. The final incremental costs below were approved by the New Construction Residential Advisory Group on October 8, 2004. As with the single family buildings, the costs of the air conditioning units changed in 2006 to accommodate the changes in the federal standards.

Table O-25: Summary of Proposed Incremental Measure Costs – Low-Rise Multifamily Buildings

Measure	Efficiency	Total Cost	
Air Conditioner	12 SEER	$200 / N/A	per AC Unit
	14 SEER	$400 / $200	per AC Unit
Room Air Conditioner	9.8	$50 / N/A	per AC Unit
	10.8	$200 / $100	per AC Unit
Central Heat Pump Cooling	12 SEER	$300 / N/A	per HP Units
	14 SEER	$500 / $250	per HP Units
Room Heat Pump Cooling	9.5	$50 / N/A	per HP Units
	10.5	$200 / $100	per HP Units
Storage Water Heater	0.63 EF	$50	per Unit
Central Water Heater	95% AFUE	$1,261	per WH
Radiant Barrier	Yes	$0.12	Per Sq. Ft.
Roof Insulation	R-38	$0.08	Per Sq. Ft.
	R-49	$0.20	Per Sq. Ft.
Wall Insulation	R-19	$0.06	Per Sq. Ft.
Windows	2-Pane Vinyl Low-E	$0.50	Per Sq. Ft.
	2-Pane Vinyl Spectral Low-E	$0.25	Per Sq. Ft.
Duct Insulation	R-8.0	$150	per House
HERS Certified Sealed Ducts	Yes	$75	per House
ACCA Duct Design	Yes	$75	per House
Infiltration Testing	Yes	$1000	per House
TXV	Yes	$0	per AC Unit

Developing the Packages

After the prototypes were finalized, the prototype buildings were used as the base cases to which the 70 high efficiency packages were added. The least-cost packages that reached a compliance margin of at least 15% and 25% above the 2001 Standards and 10% and 15% above the 2005 Standards were used to calculate energy savings per year for each prototype.

Least-Cost Package Results

Lastly, the savings in therms and watts per year were calculated for the least-cost package of each CEC climate zone. Energy savings per year were derived by subtracting the proposed energy usage of the upgraded unit per year from the base case proposed energy usage per year (for space heating, cooling, and water heating). The following presents the cost and savings for reaching the targets under the 2001 Standards and the 2005 Standards separately. All savings and costs presented are per unit.

2001 Standards

Table O-26 and Table O-27 present the measures included in the least-cost package that upgraded each prototype to 15% and 25% above the 2001 Standards, respectively. The tables also present the incremental cost of each package (*Cost*), the compliance margin of the base case prototype (*Base Compliance*), and the compliance margin reached by adding the package to the base case prototype (*Package Compliance*). For convenience, the measures that were upgraded for each prototype to reach its target are highlighted.

As shown in Table O-26, 12 of the base case prototypes already were at least 15% better than the 2001 Standards. (Note that these prototypes have a $0 cost and their baseline and package compliance margins are equal.) Also shown is that the two-story base case prototype in CEC Climate Zone 12 had a -3.8% base compliance margin and would have to install several high efficiency measures including dual paned, vinyl, spectral low-E windows, R-30 roof insulation, a 12 SEER hydronic heating system, and a .63 EF water heater. To reach 15% above the 2001 Standards would cost approximately $337 more than building the typical home in this climate zone.

Table O-27 provides the same results for the base case homes to reach 25% above the 2001 Standards. Six of the prototypes, all of them three-story buildings, were at least 25% better than the 2001 Standards. The two-story prototype in CEC Climate Zone 12 would need, in addition to the measures needed to reach 15% above the standard, a radiant barrier, HERS-certified tight ducts, and duct insulation. These measures would cost $1,000 above the prototypical home.

Table O-26: Least Costs Package by CEC Climate Zone – 15% Above 2001 Standards – Low-Rise Multifamily Buildings

CEC_CZ	# Units	FlArea	Base Compliance	Package Compliance	Cost	Window Type	Wall	Roof	Radiant Barrier	TXV	Tight Ducts	Infiltration Testing	House Wrap	Cooling Eff	Heating Eff	Wh Eff	Duct Design	Duct Insulation
01	12	10,800	4.2%	15.0%	$356	2VL	13	38	No	No	Yes	No	No	10	75%	0.63	No	Yes
02	12	10,800	5.9%	15.2%	$68	2VS	13	30	No	No	No	No	No	10	75%	0.60	No	No
03	12	10,800	20.1%	20.1%	$0	2VC	13	30	No	No	No	No	No	10	75%	0.60	No	No
04	12	10,800	14.3%	21.5%	$45	2VL	13	30	No	No	No	No	No	10	75%	0.60	No	No
05	12	10,800	15.7%	15.7%	$0	2VC	13	30	No	No	No	No	No	10	75%	0.60	No	No
06	8	12,000	18.1%	18.1%	$0	2VC	13	19	No	No	No	No	No	10	7.0	0.60	No	No
07	8	12,000	10.6%	18.1%	$75	2VL	13	19	No	No	No	No	No	10	7.0	0.60	No	No
08	8	8,400	13.0%	19.2%	$53	2VL	13	19	No	No	No	No	No	10	75%	0.60	No	No
09	8	8,400	10.2%	19.5%	$53	2VL	13	19	No	No	No	No	No	10	75%	0.60	No	No
10	8	8,400	4.8%	15.9%	$53	2VL	13	19	No	No	No	No	No	10	75%	0.60	No	No
11	12	13,936	-6.7%	15.1%	$337	2VS	13	19	No	Yes	No	No	No	12	80%	0.63	No	No
12	12	13,936	-3.8%	15.7%	$337	2VS	13	19	No	Yes	No	No	No	12	80%	0.63	No	No
13	12	13,936	-10.9%	17.8%	$355	2VL	13	38	No	Yes	No	No	No	12	80%	0.63	No	No
14	12	13,936	-3.4%	16.1%	$184	2VS	13	38	No	Yes	No	No	No	12	80%	0.63	No	No
15	12	13,936	-11.4%	21.1%	$333	2VL	13	30	No	Yes	Yes	No	No	12	75%	0.63	No	Yes
16	12	13,936	-0.8%	15.1%	$333	2VL	13	30	No	Yes	Yes	No	No	12	75%	0.63	No	Yes
01	20	21,000	12.2%	18.1%	$47	2VL	13	19	No	No	N/A	No	No	8.8	3.4	0.76	N/A	N/A
02	20	21,000	17.3%	17.3%	$0	2VC	13	19	No	No	N/A	No	No	8.8	3.4	0.76	N/A	N/A
03	20	21,000	35.6%	35.6%	$0	2VC	13	19	No	No	N/A	No	No	8.8	3.4	0.76	N/A	N/A
04	20	21,000	31.1%	31.1%	$0	2VC	13	19	No	No	N/A	No	No	8.8	3.4	0.76	N/A	N/A
05	20	21,000	29.9%	29.9%	$0	2VC	13	19	No	No	N/A	No	No	8.8	3.4	0.76	N/A	N/A
06	17	21,528	21.5%	21.5%	$0	2VC	13	19	No	No	No	No	No	10	75%	0.60	No	No
07	17	21,528	15.0%	15.0%	$0	2VC	13	19	No	No	No	No	No	10	75%	0.60	No	No
08	62	75,000	31.6%	31.6%	$0	2VC	13	19	No	No	N/A	No	No	8.5	6.8	0.76	N/A	N/A
09	62	75,000	30.3%	30.3%	$0	2VC	13	19	No	No	N/A	No	No	8.5	6.8	0.76	N/A	N/A
10	62	75,000	30.6%	30.6%	$0	2VC	13	19	No	No	N/A	No	No	8.5	6.8	0.76	N/A	N/A
11	24	22,800	7.9%	18.2%	$43	2VL	13	19	No	No	No	No	No	10	7.0	0.76	No	No
12	24	22,800	11.0%	20.8%	$43	2VL	13	19	No	No	No	No	No	10	7.0	0.76	No	No
13	24	22,800	3.4%	15.7%	$64	2VS	13	19	No	No	No	No	No	10	7.0	0.76	No	No
14	24	22,800	2.6%	15.0%	$615	2VC	13	30	No	Yes	No	No	No	12	7.5	0.80	No	No
15	24	22,800	1.1%	19.1%	$358	2VL	13	30	No	Yes	No	No	No	12	7.5	0.80	No	No
16	24	22,800	10.4%	16.8%	$615	2VC	13	30	No	Yes	No	No	No	12	7.5	0.80	No	No

Note: The first 16 prototypes listed are two-story buildings, while the lower 16 , are three-story buildings.

Table O-27: Least-Cost Package by CEC Climate Zone – 25% above 2001 Standards – Low-Rise Multifamily Buildings

CEC_CZ	# Units	FlArea	Base Compliance	Package Compliance	Cost	Window Type	Wall	Roof	Radiant Barrier	TXV	Tight Ducts	Infiltration Testing	House Wrap	Cooling Eff	Heating Eff	Wh Eff	Duct Design	Duct Insulation
01	12	10,800	4.2%	26.4%	$1,608	2VS	19	49	Yes	No	Yes	Yes	No	10	80%	0.63	Yes	Yes
02	12	10,800	5.9%	25.3%	$556	2VL	13	38	No	Yes	Yes	No	No	12	75%	0.63	No	Yes
03	12	10,800	20.1%	26.8%	$295	2VL	13	30	No	Yes	No	No	No	12	80%	0.63	No	No
04	12	10,800	14.3%	27.4%	$295	2VL	13	30	No	Yes	No	No	No	12	80%	0.63	No	No
05	12	10,800	15.7%	25.2%	$520	2VL	13	30	No	Yes	Yes	No	No	12	75%	0.63	No	Yes
06	8	12,000	18.1%	25.4%	$425	2VL	13	19	No	Yes	No	No	No	12	7.5	0.63	No	No
07	8	12,000	10.6%	25.2%	$485	2VL	13	38	No	Yes	No	No	No	12	7.5	0.63	No	No
08	8	8,400	13.0%	25.5%	$303	2VL	13	19	No	Yes	No	No	No	12	80%	0.63	No	No
09	8	8,400	10.2%	26.8%	$303	2VL	13	19	No	Yes	No	No	No	12	80%	0.63	No	No
10	8	8,400	4.8%	25.8%	$329	2VS	13	19	No	Yes	No	No	No	12	80%	0.63	No	No
11	12	13,936	-6.7%	25.3%	$655	2VL	13	38	No	Yes	Yes	No	No	12	80%	0.63	Yes	Yes
12	12	13,936	-3.8%	25.2%	$678	2VS	13	38	Yes	Yes	Yes	No	No	12	75%	0.63	No	Yes
13	12	13,936	-10.9%	25.7%	$678	2VS	13	38	Yes	Yes	Yes	No	No	12	75%	0.63	No	Yes
14	12	13,936	-3.4%	25.1%	$524	2VL	13	38	Yes	Yes	Yes	No	No	12	80%	0.63	Yes	Yes
15	12	13,936	-11.4%	26.3%	$478	2VS	13	38	Yes	Yes	Yes	No	No	12	75%	0.63	No	Yes
16	12	13,936	-0.8%	25.4%	$1,519	2VL	13	49	Yes	Yes	Yes	Yes	Yes	12	75%	0.63	No	Yes
01	20	21,000	12.2%	28.3%	$1,500	2VL	13	49	Yes	No	N/A	No	Yes	8.8	3.4	0.80	N/A	N/A
02	20	21,000	17.3%	27.2%	$47	2VL	13	19	No	No	N/A	No	No	8.8	3.4	0.76	N/A	N/A
03	20	21,000	35.6%	35.6%	$0	2VC	13	19	No	No	N/A	No	No	8.8	3.4	0.76	N/A	N/A
04	20	21,000	31.1%	31.1%	$0	2VC	13	19	No	No	N/A	No	No	8.8	3.4	0.76	N/A	N/A
05	20	21,000	29.9%	29.9%	$0	2VC	13	19	No	No	N/A	No	No	8.8	3.4	0.76	N/A	N/A
06	17	21,528	21.5%	26.3%	$250	2VC	13	19	No	Yes	No	No	No	12	80%	0.63	No	No
07	17	21,528	15.0%	25.1%	$541	2VL	13	38	No	Yes	No	No	No	14	80%	0.63	No	No
08	62	75,000	31.6%	31.6%	$0	2VC	13	19	No	No	N/A	No	No	8.5	6.8	0.76	N/A	N/A
09	62	75,000	30.3%	30.3%	$0	2VC	13	19	No	No	N/A	No	No	8.5	6.8	0.76	N/A	N/A
10	62	75,000	30.6%	30.6%	$0	2VC	13	19	No	No	N/A	No	No	8.5	6.8	0.76	N/A	N/A
11	24	22,800	7.9%	27.0%	$658	2VL	13	19	No	Yes	No	No	No	12	7.5	0.80	No	No
12	24	22,800	11.0%	28.2%	$658	2VL	13	19	No	Yes	No	No	No	12	7.5	0.80	No	No
13	24	22,800	3.4%	25.1%	$658	2VL	13	19	No	Yes	No	No	No	12	7.5	0.80	No	No
14	24	22,800	2.6%	25.5%	$705	2VS	13	38	No	Yes	No	No	No	12	7.5	0.80	No	No
15	24	22,800	1.1%	29.9%	$583	2VL	13	30	No	Yes	Yes	No	No	12	7.0	0.80	No	Yes
16	24	22,800	10.4%	25.9%	$883	2VL	13	30	No	Yes	Yes	No	No	12	7.0	0.80	No	Yes

Note: The first 16 prototypes listed are two-story buildings, while the lower 16 prototypes are three-story buildings.

Table O-28 and Table O-29 summarize the cost and savings resulting from upgrading the base case homes with the least-cost package to reach 15% and 25% above the 2001 standards. As shown, it would cost approximately $903 to upgrade the two-story base case prototype in CEC Climate Zone 14 from -3.4% to 16.1%, resulting in a savings of 11 therms and 806 kWh per unit per year.

Table O-28: Energy Savings and Costs by CEC Climate Zone – 15% above 2001 Standards – Low-Rise Multifamily Buildings

CEC_CZ	# Units	FlArea	Base Compliance	Package Compliance	Cost	Space Heat Savings (Therms or *kWh*)	Space Cool Savings (kWh)	DHW Savings (Therms)
01	12	10,800	4.2%	15.0%	$356	22	0	10
02	12	10,800	5.9%	15.2%	$68	3	304	0
03	12	10,800	20.1%	20.1%	$0	0	0	0
04	12	10,800	14.3%	21.5%	$45	3	194	0
05	12	10,800	15.7%	15.7%	$0	0	0	0
06	8	12,000	18.1%	18.1%	$0	*0*	0	0
07	8	12,000	10.6%	18.1%	$75	*-1*	216	0
08	8	8,400	13.0%	19.2%	$53	0	179	0
09	8	8,400	10.2%	19.5%	$53	1	282	0
10	8	8,400	4.8%	15.9%	$53	1	389	0
11	12	13,936	-6.7%	15.1%	$337	5	829	3
12	12	13,936	-3.8%	15.7%	$337	7	668	3
13	12	13,936	-10.9%	17.8%	$355	12	1,090	3
14	12	13,936	-3.4%	16.1%	$184	8	806	3
15	12	13,936	-11.4%	21.1%	$333	1	1,821	3
16	12	13,936	-0.8%	15.1%	$333	66	161	3
01	20	21,000	12.2%	18.1%	$47	*190*	0	0
02	20	21,000	17.3%	17.3%	$0	*0*	0	0
03	20	21,000	35.6%	35.6%	$0	*0*	0	0
04	20	21,000	31.1%	31.1%	$0	*0*	0	0
05	20	21,000	29.9%	29.9%	$0	*0*	0	0
06	17	21,528	21.5%	21.5%	$0	0	0	0
07	17	21,528	15.0%	15.0%	$0	0	0	0
08	62	75,000	31.6%	31.6%	$0	*0*	0	0
09	62	75,000	30.3%	30.3%	$0	*0*	0	0
10	62	75,000	30.6%	30.6%	$0	*0*	0	0
11	24	22,800	7.9%	18.2%	$43	*29*	376	0
12	24	22,800	11.0%	20.8%	$43	*30*	330	0
13	24	22,800	3.4%	15.7%	$64	*-3*	491	0
14	24	22,800	2.6%	15.0%	$615	*66*	408	7
15	24	22,800	1.1%	19.1%	$358	*22*	836	7
16	24	22,800	10.4%	16.8%	$615	*59*	199	7

Note: The first 16 prototypes listed are two-story buildings, while the lower 16 prototypes are three-story buildings.

Table O-29: Energy Savings and Costs by CEC Climate Zone – 25% above 2001 Standards – Low-Rise Multifamily Buildings

CEC_CZ	# Units	FlArea	Base Compliance	Package Compliance	Cost	Space Heat Savings (Therms or *kWh*)	Space Cool Savings (kWh)	DHW Savings (Therms)
01	12	10,800	4.2%	26.4%	$1,608	56	0	10
02	12	10,800	5.9%	25.3%	$556	21	398	10
03	12	10,800	20.1%	26.8%	$295	3	57	10
04	12	10,800	14.3%	27.4%	$295	6	261	10
05	12	10,800	15.7%	25.2%	$520	10	72	10
06	8	12,000	18.1%	25.4%	$425	*-53*	167	10
07	8	12,000	10.6%	25.2%	$485	*31*	284	10
08	8	8,400	13.0%	25.5%	$303	1	250	10
09	8	8,400	10.2%	26.8%	$303	2	403	10
10	8	8,400	4.8%	25.8%	$329	1	655	10
11	12	13,936	-6.7%	25.3%	$655	29	1,019	3
12	12	13,936	-3.8%	25.2%	$678	24	866	3
13	12	13,936	-10.9%	25.7%	$678	14	1,410	3
14	12	13,936	-3.4%	25.1%	$524	28	1,035	3
15	12	13,936	-11.4%	26.3%	$478	0	2,124	3
16	12	13,936	-0.8%	25.4%	$1,519	119	190	3
01	20	21,000	12.2%	28.3%	$1,500	*448*	0	7
02	20	21,000	17.3%	27.2%	$47	*165*	223	0
03	20	21,000	35.6%	35.6%	$0	*0*	0	0
04	20	21,000	31.1%	31.1%	$0	*0*	0	0
05	20	21,000	29.9%	29.9%	$0	*0*	0	0
06	17	21,528	21.5%	26.3%	$250	1	25	10
07	17	21,528	15.0%	25.1%	$541	-1	170	10
08	62	75,000	31.6%	31.6%	$0	*0*	0	0
09	62	75,000	30.3%	30.3%	$0	*0*	0	0
10	62	75,000	30.6%	30.6%	$0	*0*	0	0
11	24	22,800	7.9%	27.0%	$658	*85*	598	7
12	24	22,800	11.0%	28.2%	$658	*90*	474	7
13	24	22,800	3.4%	25.1%	$658	*60*	736	7
14	24	22,800	2.6%	25.5%	$705	*76*	855	7
15	24	22,800	1.1%	29.9%	$583	*14*	1,399	7
16	24	22,800	10.4%	25.9%	$883	*467*	252	7

Note: The first 16 prototypes listed are two-story buildings, while the lower 16 prototypes are three-story buildings.

Figure O-14 and Figure O-15 illustrate the data presented in the previous tables by CEC climate zone and end use. The solid bars represent the therms/kWh savings and the thinner striped bars illustrate the total cost of the package. Since many measures lead to both space heating and cooling savings, it is impossible to separate the costs associated with the energy savings by end-use. The text above the bars is the % compliance margin of the base case prototype.

Figure O-14: Gas Savings of Least-Cost Package by CEC Climate Zone – 2001 Standards – Two-Story Low-Rise Multifamily Buildings

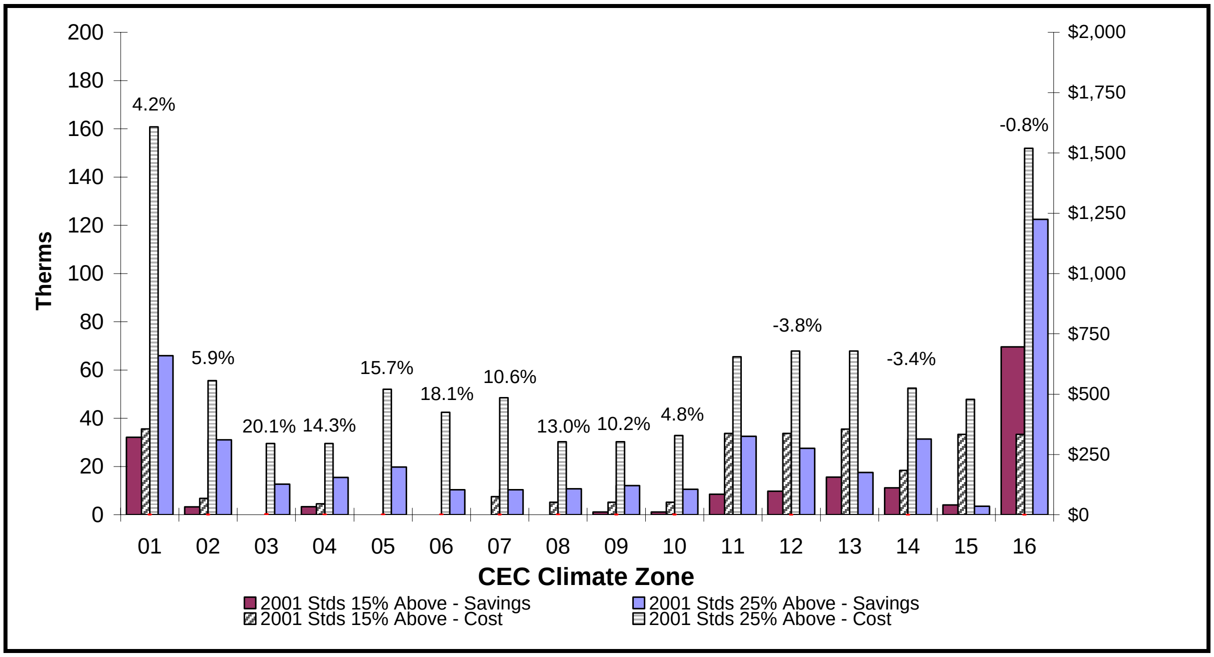


Figure O-15: Electric Savings of Least-Cost Package by CEC Climate Zone – 2001 Standards – Two-Story Low-Rise Multifamily Buildings

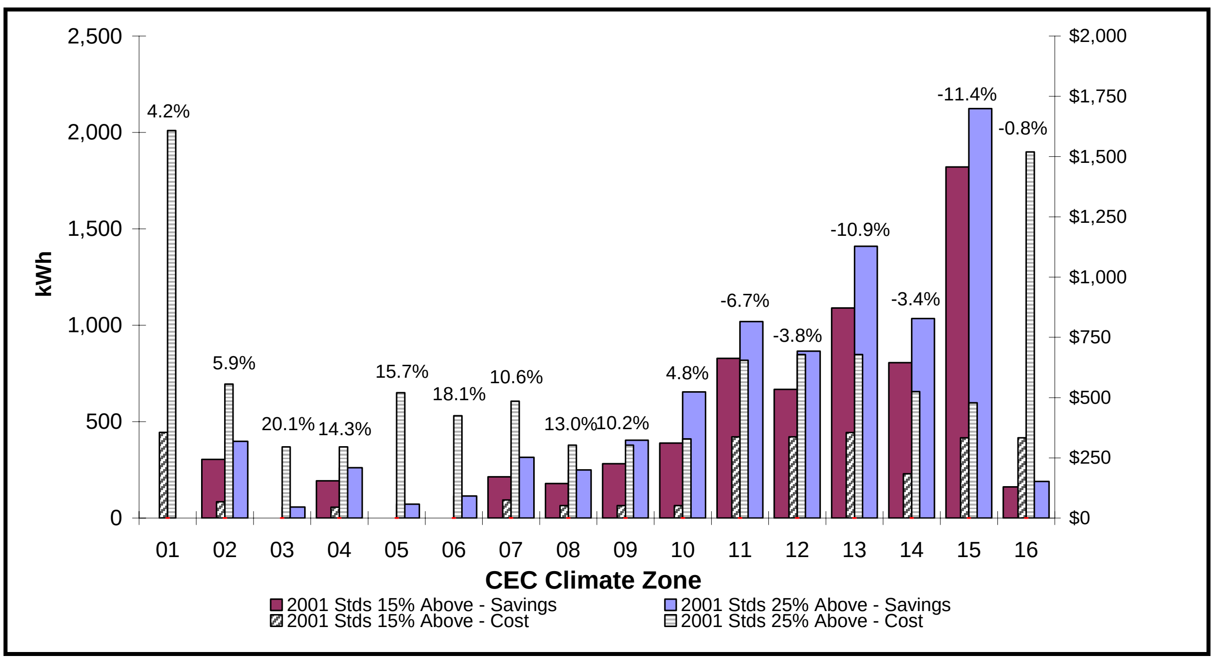


Figure O-16: Gas Savings of Least-Cost Package by CEC Climate Zone – 2001 Standards – Three-Story Low-Rise Multifamily Buildings

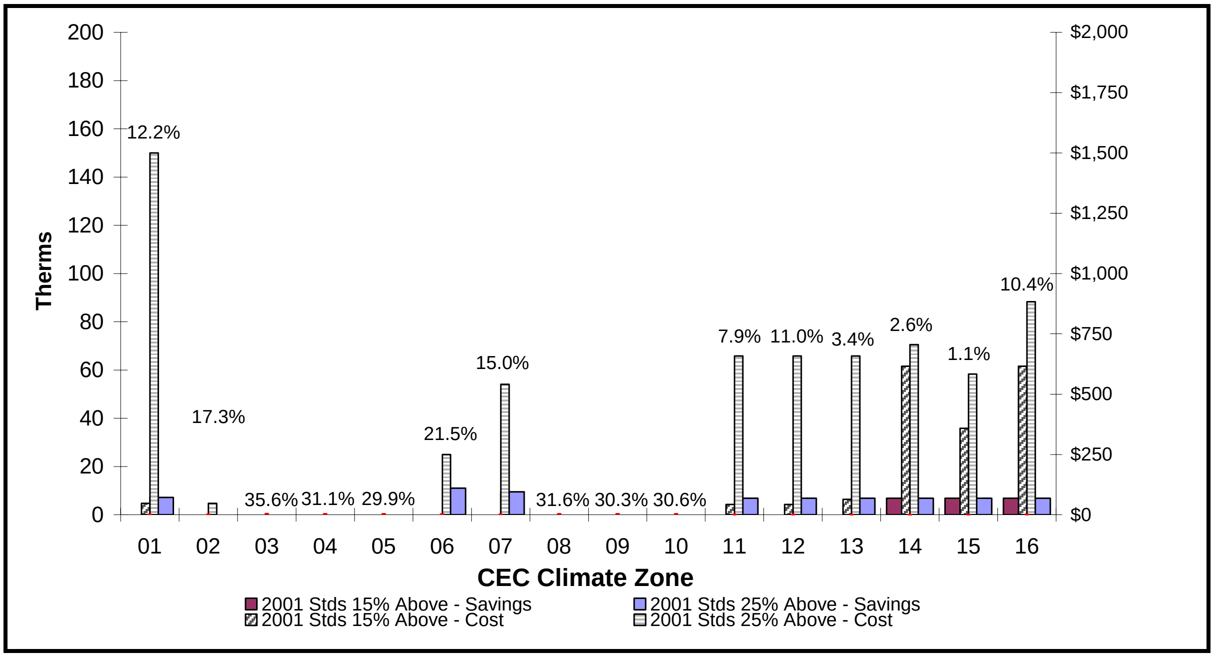
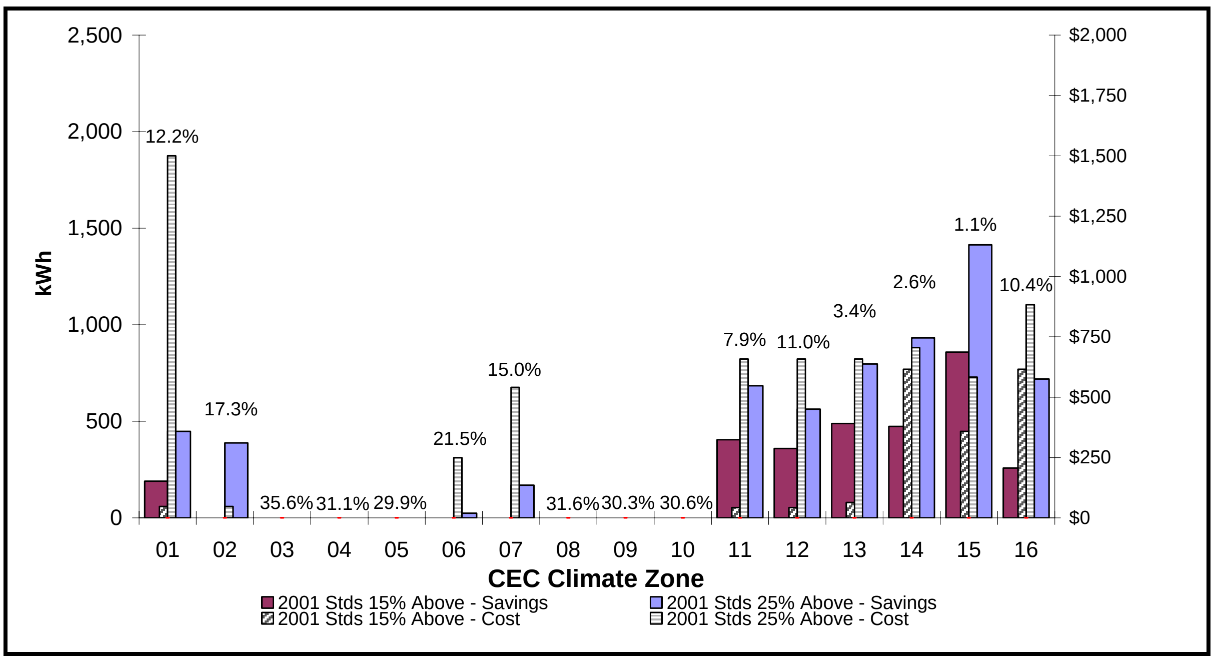


Figure O-17: Electric Savings of Least-Cost Package by CEC Climate Zone – 2001 Standards – Three-Story Low-Rise Multifamily Buildings



2005 Standards

The 2005 base multifamily buildings were developed in the same way that the single family homes were. The least-cost package that caused each prototype to just comply with the 2005

Standards was chosen as the 2005 base case prototype. Table O-30 presents the % compliance margin, the measures installed, and the cost of the package relative to the 2001 base case prototypes. Several of the coastal prototypes were able to comply with 2005 Standards with only one additional measure, such as low-E or spectral low-E windows, resulting in low costs above the 2001 baseline.

Table O-30: 2005 Standards Base Case Prototypes – Low-Rise Multifamily Building

CEC_ CZ	Story	FlArea	Base Compliance	Cost Above 01 Baseline	Window Type	Wall	Roof	Insulation Cert	Radiant Barrier	TXV	Tight Ducts	Infiltration Testing	House Wrap	Cooling Eff	Heatin g Eff	Wh Eff	Duct Design	Duct Insulation
01	2	10,800	0.1%	$302	2VL	13	49	No	Yes	No	No	No	No	13	80%	0.63	No	No
02	2	10,800	1.0%	$118	2VS	13	30	No	No	Yes	No	No	No	13	80%	0.63	No	No
03	2	10,800	7.2%	$45	2VL	13	30	No	No	Yes	No	No	No	13	75%	0.60	No	No
04	2	10,800	1.3%	$68	2VS	13	30	No	No	Yes	No	No	No	13	75%	0.60	No	No
05	2	10,800	8.3%	$45	2VL	13	30	No	No	Yes	No	No	No	13	75%	0.60	No	No
06	2	12,000	0.1%	$125	2VL	13	19	No	No	Yes	No	No	No	13	7.0	0.63	No	No
07	2	12,000	0.4%	$113	2VS	13	19	No	No	Yes	No	No	No	13	7.0	0.60	No	No
08	2	8,400	1.1%	$129	2VS	13	19	No	No	Yes	No	No	No	13	75%	0.63	No	No
09	2	8,400	0.3%	$155	2VL	13	38	No	No	Yes	No	No	No	13	75%	0.63	No	No
10	2	8,400	0.2%	$155	2VL	13	38	No	No	Yes	No	No	No	13	80%	0.63	No	No
11	2	13,936	1.0%	$391	2VL	13	38	No	No	Yes	Yes	No	No	13	75%	0.63	No	Yes
12	2	13,936	1.2%	$420	2VS	13	38	No	No	Yes	Yes	No	No	13	75%	0.63	No	Yes
13	2	13,936	2.2%	$391	2VL	13	38	No	No	Yes	Yes	No	No	13	75%	0.63	No	Yes
14	2	13,936	1.7%	$420	2VS	13	38	No	No	Yes	Yes	No	No	13	75%	0.63	No	Yes
15	2	13,936	3.4%	$437	2VS	13	30	No	No	Yes	Yes	No	No	13	80%	0.63	Yes	Yes
16	2	13,936	2.1%	$333	2VL	13	30	No	No	Yes	Yes	No	No	13	75%	0.63	No	Yes
01	3	21,000	-17.1%	$0	2VC	13	19	No	No	No	N/A	No	No	8.8	3.4	0.76	N/A	N/A
02	3	21,000	-0.5%	$386	2VS	13	19	No	No	No	N/A	No	No	9.7	3.4	0.80	N/A	N/A
03	3	21,000	6.8%	$47	2VL	13	19	No	No	No	N/A	No	No	8.8	3.4	0.76	N/A	N/A
04	3	21,000	2.5%	$47	2VL	13	19	No	No	No	N/A	No	No	8.8	3.4	0.76	N/A	N/A
05	3	21,000	-0.5%	$47	2VL	13	19	No	No	No	N/A	No	No	8.8	3.4	0.76	N/A	N/A
06	3	21,528	0.5%	$50	2VC	13	19	No	No	Yes	No	No	No	13	75%	0.63	No	No
07	3	21,528	3.1%	$57	2VL	13	19	No	No	Yes	No	No	No	13	75%	0.60	No	No
08	3	75,000	3.8%	$54	2VL	13	19	No	No	No	N/A	No	No	8.5	6.8	0.76	N/A	N/A
09	3	75,000	5.9%	$54	2VL	13	19	No	No	No	N/A	No	No	8.5	6.8	0.76	N/A	N/A
10	3	75,000	11.4%	$54	2VL	13	19	No	No	No	N/A	No	No	8.5	6.8	0.76	N/A	N/A
11	3	22,800	-0.8%	$711	2VS	13	38	No	No	Yes	Yes	No	No	13	7.5	0.80	Yes	Yes
12	3	22,800	-1.1%	$804	2VL	13	49	Yes	Yes	Yes	Yes	No	No	15	7.5	0.80	Yes	Yes
13	3	22,800	-0.5%	$687	2VS	13	38	No	Yes	Yes	Yes	No	No	13	7.0	0.80	No	Yes
14	3	22,800	0.0%	$762	2VS	13	38	No	Yes	Yes	Yes	No	No	13	7.5	0.80	Yes	Yes
15	3	22,800	0.4%	$711	2VS	13	38	No	No	Yes	Yes	No	No	13	7.5	0.80	Yes	Yes
16	3	22,800	4.7%	$804	2VL	13	49	Yes	Yes	Yes	Yes	No	No	15	7.5	0.80	Yes	Yes

Note: The first 16 prototypes listed are two-story buildings, while the lower 16 prototypes are three-story buildings.

Table O-31 and Table O-32 present the measures included in the least-cost package that upgraded each prototype to 10% and 15% above the 2005 Standards, respectively. The tables also present the incremental cost of each package (*Cost*), the compliance margin of the base case prototype (*Base Compliance*), and the compliance margin reached by adding the package to the base case prototype (*Package Compliance*). For convenience, the measures that were upgraded for each prototype to reach its target are highlighted in yellow meaning the measure was added, and green meaning that the base case prototype actually had a higher efficiency version of the measure installed (therefore decreasing the cost).

As shown in Table O-31, one of the base case prototypes was already at least 10% better than the 2005 Standards. The three-story unit for Climate Zone 1 was not able to reach 10% above compliance given the current packages. The package included in the table is for the second most compliant package. Table O-32 provides the same results for the base case homes to reach 15% above the 2005 Standards. Three of the three-story units were unable to reach 15% above compliance. Each of these has information on the most compliant package.

Table O-31: Least-Cost Package by CEC Climate Zone – 10% Above 2005 Standards – Low-Rise Multifamily Building

CEC_CZ	# Units	FlArea	Base Compliance	Package Compliance	Cost	Window Type	Wall	Roof	Insulation Cert	Radiant Barrier	TXV	Tight Ducts	Infiltration Testing	House Wrap	Cooling Eff	Heating Eff	Wh Eff	Duct Design	Duct Insulation
01	12	10,800	0.1%	12.3%	$325	2VL	13	49	Yes	Yes	No	Yes	No	No	13	80%	0.63	Yes	Yes
02	12	10,800	1.0%	10.4%	$300	2VS	13	30	No	No	Yes	Yes	No	No	13	80%	0.63	Yes	Yes
03	12	10,800	7.2%	12.4%	$50	2VL	13	30	No	No	Yes	No	No	No	13	80%	0.63	No	No
04	12	10,800	1.3%	11.3%	$311	2VS	13	38	No	No	Yes	Yes	No	No	13	75%	0.63	No	Yes
05	12	10,800	8.3%	13.4%	$50	2VL	13	30	No	No	Yes	No	No	No	13	80%	0.63	No	No
06	8	12,000	0.1%	10.7%	$285	2VL	13	38	No	No	Yes	Yes	No	No	13	7.0	0.63	No	Yes
07	8	12,000	0.4%	11.2%	$110	2VS	13	38	No	No	Yes	No	No	No	13	7.5	0.63	No	No
08	8	8,400	1.1%	10.9%	$267	2VS	13	38	No	No	Yes	Yes	No	No	13	75%	0.63	No	Yes
09	8	8,400	0.3%	11.7%	$314	2VS	13	38	No	Yes	Yes	Yes	No	No	13	75%	0.63	No	Yes
10	8	8,400	0.2%	10.8%	$251	2VS	13	38	No	No	Yes	Yes	No	No	13	75%	0.63	No	Yes
11	12	13,936	1.0%	10.1%	$174	2VS	13	38	No	Yes	Yes	Yes	No	No	13	80%	0.63	Yes	Yes
12	12	13,936	1.2%	12.3%	$510	2VL	13	49	Yes	Yes	Yes	Yes	No	No	15	80%	0.63	Yes	Yes
13	12	13,936	2.2%	12.0%	$174	2VS	13	38	No	Yes	Yes	Yes	No	No	13	80%	0.63	Yes	Yes
14	12	13,936	1.7%	10.1%	$214	2VS	13	49	No	Yes	Yes	Yes	No	No	13	80%	0.63	Yes	Yes
15	12	13,936	3.4%	10.2%	$386	2VS	13	49	No	Yes	Yes	Yes	No	No	14	80%	0.63	Yes	Yes
16	12	13,936	2.1%	8.9%	$261	2VL	13	49	No	Yes	Yes	Yes	No	No	13	80%	0.63	Yes	Yes
01	20	21,000	-17.1%	-10.6%	$1,000	2VL	13	49	Yes	Yes	No	N/A	No	Yes	8.8	3.4	0.80	N/A	N/A
02	20	21,000	-0.5%	12.3%	$1,077	2VL	19	49	Yes	Yes	Yes	N/A	No	Yes	9.7	3.4	0.80	N/A	N/A
03	20	21,000	6.8%	10.3%	$339	2VS	13	19	No	No	Yes	N/A	No	No	9.7	3.4	0.80	N/A	N/A
04	20	21,000	2.5%	10.7%	$343	2VS	13	38	No	No	Yes	N/A	No	No	9.7	3.4	0.80	N/A	N/A
05	20	21,000	-0.5%	10.5%	$1,137	2VL	13	49	Yes	Yes	Yes	N/A	No	Yes	9.7	3.4	0.80	N/A	N/A
06	17	21,528	0.5%	11.1%	$57	2VL	13	19	No	No	Yes	No	No	No	13	80%	0.63	No	No
07	17	21,528	3.1%	10.3%	$78	2VS	13	19	No	No	Yes	No	No	No	13	80%	0.63	No	No
08	62	75,000	3.8%	14.1%	$342	2VS	13	19	No	No	Yes	N/A	No	No	9.7	7.5	0.80	N/A	N/A
09	62	75,000	5.9%	10.5%	$27	2VS	13	19	No	No	No	N/A	No	No	8.5	6.8	0.76	N/A	N/A
10	62	75,000	11.4%	14.8%	$27	2VS	13	19	No	No	No	N/A	No	No	8.5	6.8	0.76	N/A	N/A
11	24	22,800	-0.8%	11.7%	$1,001	2VS	13	49	No	Yes	Yes	Yes	Yes	Yes	13	7.0	0.80	No	Yes
12	24	22,800	-1.1%	11.3%	$750	2VS	13	49	No	Yes	Yes	Yes	Yes	Yes	13	7.5	0.80	Yes	Yes
13	24	22,800	-0.5%	10.7%	$467	2VL	13	49	Yes	Yes	Yes	Yes	No	No	15	7.5	0.80	Yes	Yes
14	24	22,800	0.0%	11.1%	$1,017	2VL	13	49	No	Yes	Yes	Yes	Yes	Yes	13	7.5	0.80	Yes	Yes
15	24	22,800	0.4%	11.1%	$1,076	2VS	13	49	No	Yes	Yes	Yes	Yes	Yes	13	7.5	0.80	Yes	Yes
16	24	22,800	4.7%	11.8%	$550	2VL	13	49	No	Yes	Yes	Yes	Yes	Yes	13	7.0	0.80	No	Yes

Note: The first 16 prototypes listed are two-story buildings, while the lower 16 prototypes are three-story buildings. Yellow highlighting indicates a more efficient measure is needed compared to the baseline home and green highlighting indicates a less efficient measure is needed.

Table O-32: Least-Cost Package by CEC Climate Zone – 15% Above 2005 Standards – Low-Rise Multifamily Buildings

CEC_CZ	# Units	FlArea	Base Compliance	Package Compliance	Cost	Window Type	Wall	Roof	Insulation Cert	Radiant Barrier	TXV	Tight Ducts	Infiltration Testing	House Wrap	Cooling Eff	Heating Eff	Wh Eff	Duct Design	Duct Insulation
01	12	10,800	0.1%	15.1%	$1,325	2VL	13	49	Yes	Yes	No	Yes	No	Yes	13	80%	0.63	Yes	Yes
02	12	10,800	1.0%	19.8%	$747	2VL	13	49	Yes	Yes	Yes	Yes	No	No	15	80%	0.63	Yes	Yes
03	12	10,800	7.2%	15.6%	$311	2VL	13	38	No	No	Yes	Yes	No	No	13	75%	0.63	No	Yes
04	12	10,800	1.3%	15.7%	$494	2VS	13	49	No	Yes	Yes	Yes	No	No	13	80%	0.63	Yes	Yes
05	12	10,800	8.3%	15.6%	$275	2VL	13	30	No	No	Yes	Yes	No	No	13	75%	0.63	No	Yes
06	8	12,000	0.1%	20.6%	$915	2VL	13	49	Yes	Yes	Yes	Yes	No	No	15	7.5	0.63	Yes	Yes
07	8	12,000	0.4%	15.5%	$425	2VS	13	38	No	Yes	Yes	Yes	No	No	13	7.0	0.63	No	Yes
08	8	8,400	1.1%	15.5%	$468	2VS	13	49	No	Yes	Yes	Yes	No	No	13	80%	0.63	Yes	Yes
09	8	8,400	0.3%	15.4%	$452	2VS	13	49	No	Yes	Yes	Yes	No	No	13	80%	0.63	Yes	Yes
10	8	8,400	0.2%	16.6%	$389	2VS	13	38	No	Yes	Yes	Yes	No	No	13	80%	0.63	Yes	Yes
11	12	13,936	1.0%	16.1%	$1,239	2VL	13	49	Yes	Yes	Yes	Yes	No	Yes	13	80%	0.63	Yes	Yes
12	12	13,936	1.2%	18.9%	$1,251	2VL	19	49	Yes	Yes	Yes	Yes	No	Yes	13	80%	0.63	Yes	Yes
13	12	13,936	2.2%	16.0%	$539	2VL	13	49	Yes	Yes	Yes	Yes	No	No	15	80%	0.63	Yes	Yes
14	12	13,936	1.7%	15.2%	$1,214	2VS	13	49	No	Yes	Yes	Yes	Yes	Yes	13	80%	0.63	Yes	Yes
15	12	13,936	3.4%	15.6%	$1,223	2VL	19	49	Yes	Yes	Yes	Yes	No	Yes	13	80%	0.63	Yes	Yes
16	12	13,936	2.1%	16.1%	$586	2VL	13	49	Yes	Yes	Yes	Yes	No	No	15	80%	0.63	Yes	Yes
01	20	21,000	-17.1%	-6.9%	$1,034	2VL	19	49	Yes	Yes	No	N/A	No	Yes	8.8	3.4	0.80	N/A	N/A
02	20	21,000	-0.5%	14.1%	$1,301	2VS	19	49	Yes	Yes	Yes	N/A	Yes	Yes	11.2	3.4	0.80	N/A	N/A
03	20	21,000	6.8%	17.4%	$652	2VL	13	49	Yes	Yes	Yes	N/A	No	No	11.2	3.4	0.80	N/A	N/A
04	20	21,000	2.5%	16.6%	$629	2VL	13	49	Yes	Yes	Yes	N/A	No	No	11.2	3.4	0.80	N/A	N/A
05	20	21,000	-0.5%	12.6%	$1,171	2VL	19	49	Yes	Yes	Yes	N/A	No	Yes	9.7	3.4	0.80	N/A	N/A
06	17	21,528	0.5%	15.0%	$316	2VL	13	38	No	No	Yes	Yes	No	No	13	75%	0.63	No	Yes
07	17	21,528	3.1%	15.2%	$388	2VS	13	38	No	Yes	Yes	Yes	No	No	13	75%	0.63	No	Yes
08	62	75,000	3.8%	15.8%	$346	2VL	13	38	No	No	Yes	N/A	No	No	9.7	7.5	0.80	N/A	N/A
09	62	75,000	5.9%	16.5%	$342	2VS	13	19	No	No	Yes	N/A	No	No	9.7	7.5	0.80	N/A	N/A
10	62	75,000	11.4%	17.5%	$315	2VL	13	19	No	No	Yes	N/A	No	No	9.7	7.5	0.80	N/A	N/A
11	24	22,800	-0.8%	21.0%	$1,116	2VL	19	49	Yes	Yes	Yes	Yes	No	Yes	13	7.5	0.80	Yes	Yes
12	24	22,800	-1.1%	19.0%	$790	2VL	19	49	Yes	Yes	Yes	Yes	No	Yes	13	7.5	0.80	Yes	Yes
13	24	22,800	-0.5%	19.5%	$1,153	2VL	19	49	Yes	Yes	Yes	Yes	No	Yes	13	7.5	0.80	Yes	Yes
14	24	22,800	0.0%	18.8%	$1,078	2VL	19	49	Yes	Yes	Yes	Yes	No	Yes	13	7.5	0.80	Yes	Yes
15	24	22,800	0.4%	17.5%	$1,363	2VS	19	49	No	Yes	Yes	Yes	Yes	Yes	14	7.5	0.80	Yes	Yes
16	24	22,800	4.7%	20.1%	$687	2VL	19	49	Yes	Yes	Yes	Yes	No	Yes	13	7.5	0.80	Yes	Yes

Note: The first 16 prototypes listed are two-story buildings, while the lower 16 prototypes are three-story buildings. Yellow highlighting indicates a more efficient measure is needed compared to the baseline home and green highlighting indicates a less efficient measure is needed.

Table O-33 and Table O-34 summarize the cost and savings[8] results caused by upgrading the base case home with the least-cost package for each to reach 10% and 15% above the 2005 Standards. As shown, it would cost just $57 to upgrade the three-story base case prototype in CEC Climate Zone 6 from 0.5% to 11.1% and would result in a savings of 99 kWh per year. However, installing this package of measures results in the prototype using an additional therm for space heating.

Table O-33: Energy Savings and Costs by CEC Climate Zone – 10% Above 2005 Standards – Low-Rise Multifamily Buildings

CEC_CZ	# Units	FlArea	Base Compliance	Package Compliance	Cost	Space Heat Savings (Therms or *kWh*)	Space Cool Savings (kWh)	DHW Savings (Therms)
01	12	10,800	0.1%	12.3%	$325	32	0	0
02	12	10,800	1.0%	10.4%	$300	14	69	0
03	12	10,800	7.2%	12.4%	$50	3	0	11
04	12	10,800	1.3%	11.3%	$311	10	26	10
05	12	10,800	8.3%	13.4%	$50	2	0	10
06	8	12,000	0.1%	10.7%	$285	*148*	40	0
07	8	12,000	0.4%	11.2%	$110	*66*	45	11
08	8	8,400	1.1%	10.9%	$267	5	80	0
09	8	8,400	0.3%	11.7%	$314	1	137	0
10	8	8,400	0.2%	10.8%	$251	1	173	0
11	12	13,936	1.0%	10.1%	$174	3	188	0
12	12	13,936	1.2%	12.3%	$510	25	69	0
13	12	13,936	2.2%	12.0%	$174	1	254	0
14	12	13,936	1.7%	10.1%	$214	8	173	0
15	12	13,936	3.4%	10.2%	$386	1	286	0
16	12	13,936	2.1%	8.9%	$261	25	40	0
01	20	21,000	-17.1%	-10.6%	$1,000	*76*	0	5
02	20	21,000	-0.5%	12.3%	$1,077	*260*	15	5
03	20	21,000	6.8%	10.3%	$339	*-22*	11	5
04	20	21,000	2.5%	10.7%	$343	*30*	36	5
05	20	21,000	-0.5%	10.5%	$1,137	*116*	5	5
06	17	21,528	0.5%	11.1%	$57	-1	99	0
07	17	21,528	3.1%	10.3%	$78	-1	30	11
08	62	75,000	3.8%	14.1%	$342	*-19*	117	5
09	62	75,000	5.9%	10.5%	$27	*-24*	91	0
10	62	75,000	11.4%	14.8%	$27	*-31*	103	0
11	24	22,800	-0.8%	11.7%	$1,001	*371*	20	5
12	24	22,800	-1.1%	11.3%	$750	*300*	4	5
13	24	22,800	-0.5%	10.7%	$467	*195*	104	5
14	24	22,800	0.0%	11.1%	$1,017	*436*	-15	5
15	24	22,800	0.4%	11.1%	$1,076	*85*	242	5
16	24	22,800	4.7%	11.8%	$550	*377*	-16	5

Note: The first 16 prototypes listed are two-story buildings, while the lower 16 prototypes are three-story buildings.

[8] The method of estimating the compliance and energy savings from exceeding the 2005 Standards was calculated differently than it was under the 2001 Standards. The 2005 Standards use TDV for calculating compliance. However, since the TDV calculations weight the energy used across hours differently, it is not correct to use the TDV budgets to calculate energy savings. Therefore, the TDV budgets are used to determine the % compliance margins but the source energy budgets are used to calculate energy savings. Under the 2001 Standards, the source energy budgets are used to estimate both compliance and savings.

Table O-34: Energy Savings and Costs by CEC Climate Zone – 15% Above 2005 Standards – Low-Rise Multifamily Buildings

CEC_CZ	# Units	FlArea	Base Compliance	Package Compliance	Cost	Space Heat Savings (Therms or *kWh*)	Space Cool Savings (kWh)	DHW Savings (Therms)
01	12	10,800	0.1%	15.1%	$1,325	39	0	0
02	12	10,800	1.0%	19.8%	$747	36	113	0
03	12	10,800	7.2%	15.6%	$311	8	7	11
04	12	10,800	1.3%	15.7%	$494	14	55	10
05	12	10,800	8.3%	15.6%	$275	6	4	10
06	8	12,000	0.1%	20.6%	$915	*311*	65	0
07	8	12,000	0.4%	15.5%	$425	*119*	63	11
08	8	8,400	1.1%	15.5%	$468	7	120	0
09	8	8,400	0.3%	15.4%	$452	3	176	0
10	8	8,400	0.2%	16.6%	$389	2	259	0
11	12	13,936	1.0%	16.1%	$1,239	32	177	0
12	12	13,936	1.2%	18.9%	$1,251	41	96	0
13	12	13,936	2.2%	16.0%	$539	17	278	0
14	12	13,936	1.7%	15.2%	$1,214	27	212	0
15	12	13,936	3.4%	15.6%	$1,223	9	433	0
16	12	13,936	2.1%	16.1%	$586	58	58	0
01	20	21,000	-17.1%	-6.9%	$1,034	*152*	-1	5
02	20	21,000	-0.5%	14.1%	$1,301	*177*	76	5
03	20	21,000	6.8%	17.4%	$652	*92*	15	5
04	20	21,000	2.5%	16.6%	$629	*123*	47	5
05	20	21,000	-0.5%	12.6%	$1,171	*150*	6	5
06	17	21,528	0.5%	15.0%	$316	3	120	0
07	17	21,528	3.1%	15.2%	$388	2	59	11
08	62	75,000	3.8%	15.8%	$346	*30*	106	5
09	62	75,000	5.9%	16.5%	$342	*-22*	153	5
10	62	75,000	11.4%	17.5%	$315	*0*	98	5
11	24	22,800	-0.8%	21.0%	$1,116	*589*	84	5
12	24	22,800	-1.1%	19.0%	$790	*499*	11	5
13	24	22,800	-0.5%	19.5%	$1,153	*419*	148	5
14	24	22,800	0.0%	18.8%	$1,078	*623*	69	5
15	24	22,800	0.4%	17.5%	$1,363	*125*	428	5
16	24	22,800	4.7%	20.1%	$687	*787*	6	5

Note: The first 16 prototypes listed are two-story buildings, while the lower 16 prototypes are three-story buildings.

Figure O-18 to Figure O-19 illustrate the data presented in the tables above by end use, number of stories, and CEC climate zone. The solid bars illustrate the therms/kWh savings and the thinner striped bars illustrate the total cost of the package. Since many measures lead to both space heating and cooling savings, it is impossible to separate the costs associated with the energy savings by end use. The text above the bars is the % compliance margin of the base case prototype.

Figure O-18: Gas Savings of Least-Cost Package by CEC Climate Zone – 2005 Standards – Two-Story Low-Rise Multifamily Buildings

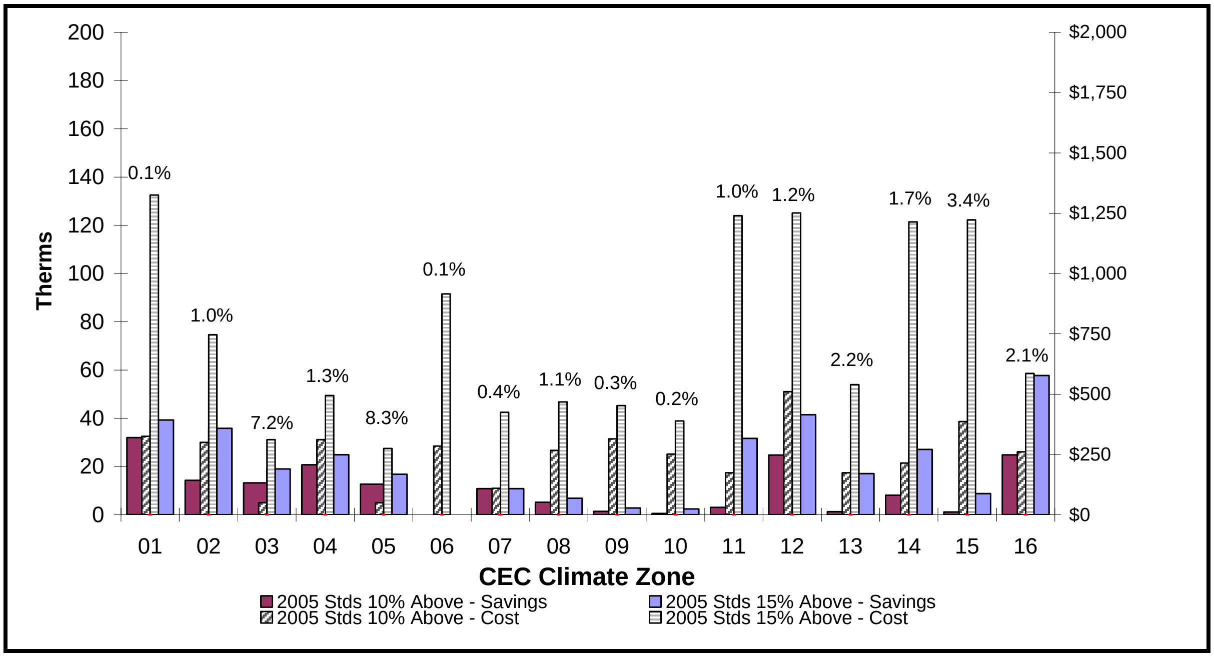


Figure O-19: Electric Savings of Least-Cost Package by CEC Climate Zone – 2005 Standards – Two-Story Low-Rise Multifamily Buildings

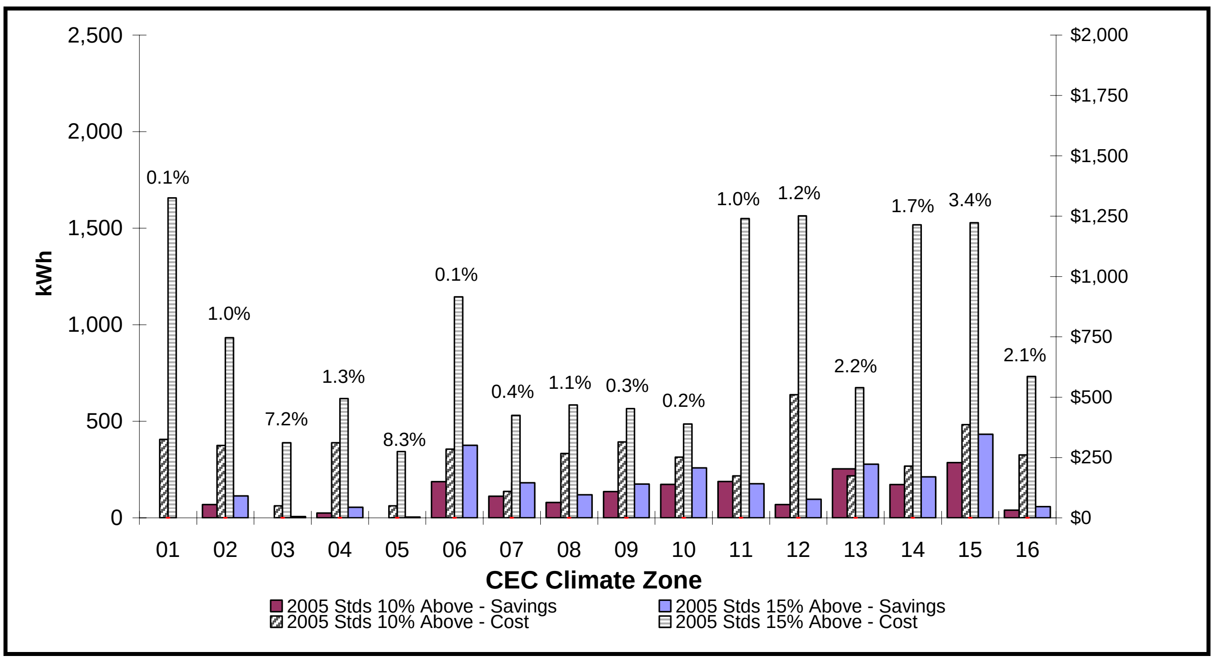


Figure O-20: Gas Savings of Least-Cost Package by CEC Climate Zone – 2005 Standards – Three-Story Low-Rise Multifamily Buildings

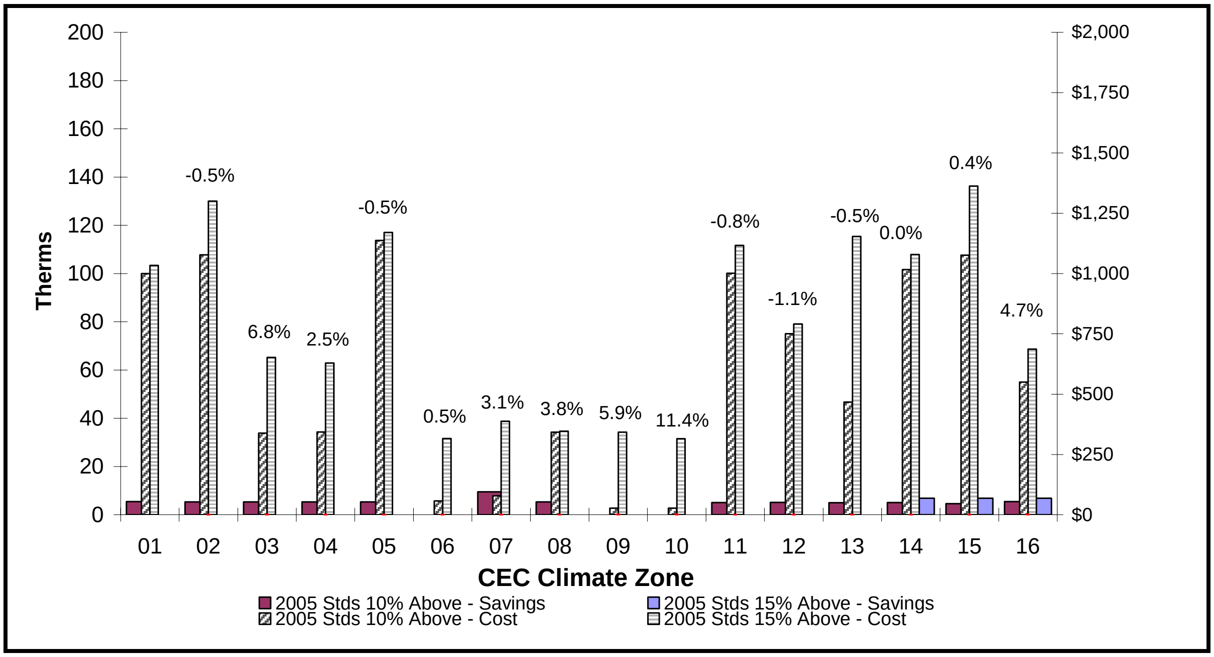
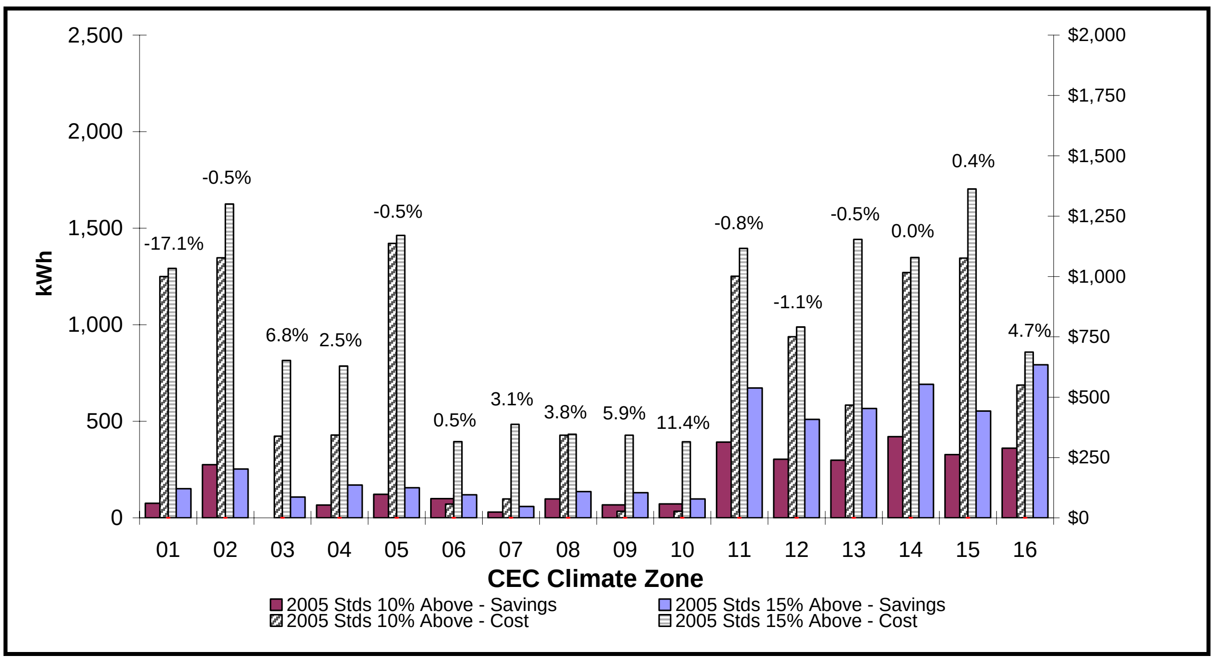


Figure O-21: Electric Savings of Least-Cost Package by CEC Climate Zone – 2005 Standards – Three-Story Low-Rise Multifamily Buildings



O.5 Development of ASSET Residential New Construction Model Inputs

Awareness

The residential new construction analysis used an awareness of 100% for all units built under the 2001 standards. Because of the change in Title 24 Standards in 2005, an awareness of 50% was used starting in 2006 for high efficiency units built under the 2005 standards, which was then increased each year.

Residential New Construction
Awareness

Segment	Area	Tech	Awareness	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1 Story SF	All	SF1_01_00	1	1.0	1.0	1.0	1.0											
1 Story SF	All	SF1_01_15	1	1.0	1.0	1.0	1.0											
1 Story SF	All	SF1_01_25	1	1.0	1.0	1.0	1.0											
1 Story SF	All	SF1_05_00	1					1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1 Story SF	All	SF1_05_10	Aware05					0.5	0.7	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1 Story SF	All	SF1_05_15	Aware05					0.5	0.7	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2 Story SF	All	SF2_01_00	1	1.0	1.0	1.0	1.0											
2 Story SF	All	SF2_01_15	1	1.0	1.0	1.0	1.0											
2 Story SF	All	SF2_01_25	1	1.0	1.0	1.0	1.0											
2 Story SF	All	SF2_05_00	1					1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2 Story SF	All	SF2_05_10	Aware05					0.5	0.7	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2 Story SF	All	SF2_05_15	Aware05					0.5	0.7	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0
SFA	All	SFA_01_00	1	1.0	1.0	1.0	1.0											
SFA	All	SFA_01_15	1	1.0	1.0	1.0	1.0											
SFA	All	SFA_01_25	1	1.0	1.0	1.0	1.0											
SFA	All	SFA_05_00	1					1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
SFA	All	SFA_05_10	Aware05					0.5	0.7	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0
SFA	All	SFA_05_15	Aware05					0.5	0.7	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2 Story MF	All	MFLR2_01_00	1	1.0	1.0	1.0	1.0											
2 Story MF	All	MFLR2_01_15	1	1.0	1.0	1.0	1.0											
2 Story MF	All	MFLR2_01_25	1	1.0	1.0	1.0	1.0											
2 Story MF	All	MFLR2_05_00	1					1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2 Story MF	All	MFLR2_05_10	Aware05					0.5	0.7	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2 Story MF	All	MFLR2_05_15	Aware05					0.5	0.7	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3 Story MF	All	MFLR3_01_00	1	1.0	1.0	1.0	1.0											
3 Story MF	All	MFLR3_01_15	1	1.0	1.0	1.0	1.0											
3 Story MF	All	MFLR3_01_25	1	1.0	1.0	1.0	1.0											
3 Story MF	All	MFLR3_05_00	1					1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3 Story MF	All	MFLR3_05_10	Aware05					0.5	0.7	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3 Story MF	All	MFLR3_05_15	Aware05					0.5	0.7	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Willingness, Feasibility, Technology Density, and Applicability

The willingness, feasibility, and applicability used in the residential new construction analysis are each 100%. These inputs are all 100% because anything is possible in residential new construction. The technology density used was also 1 since the analysis is done by residence.

New Construction Housing Starts

The following tables contain the housing stock by utility, climate zone, and building type. The housing stock forecast was provided courtesy of the CEC and is dated March 2004.

PG&E
Residential New Construction Housing Stock

Utility	Title 24 Climate Zone	Segment	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
PG&E	1	1 Story SF	87	127	119	113	122	124	125	125	107	107	109	110	111	112	114
PG&E	1	2 Story SF	348	508	477	454	488	496	499	502	426	429	435	439	444	449	455
PG&E	1	SFA	54	97	80	71	85	86	86	85	57	57	58	58	58	58	59
PG&E	1	2 Story MF	41	73	60	53	64	64	64	64	43	43	44	43	43	44	44
PG&E	1	3 Story MF	41	73	60	53	64	64	64	64	43	43	44	43	43	44	44
PG&E	2	1 Story SF	190	274	257	245	263	268	269	270	230	231	235	237	239	242	245
PG&E	2	2 Story SF	1,709	2,466	2,314	2,202	2,370	2,408	2,420	2,434	2,068	2,081	2,113	2,130	2,155	2,180	2,205
PG&E	2	SFA	212	375	311	275	328	331	331	329	220	220	224	223	224	225	226
PG&E	2	2 Story MF	159	281	233	206	246	249	248	247	165	165	168	167	168	169	170
PG&E	2	3 Story MF	159	281	233	206	246	249	248	247	165	165	168	167	168	169	170
PG&E	3a	1 Story SF	1,063	1,530	1,437	1,367	1,471	1,495	1,502	1,511	1,283	1,291	1,311	1,322	1,337	1,353	1,369
PG&E	3a	2 Story SF	1,771	2,551	2,394	2,278	2,452	2,491	2,504	2,518	2,139	2,152	2,186	2,203	2,229	2,255	2,281
PG&E	3a	SFA	859	1,391	1,154	1,020	1,217	1,229	1,227	1,221	816	817	832	826	830	835	839
PG&E	3a	2 Story MF	644	1,043	865	765	913	922	921	916	612	613	624	619	623	626	630
PG&E	3a	3 Story MF	644	1,043	865	765	913	922	921	916	612	613	624	619	623	626	630
PG&E	3b	1 Story SF	434	625	587	558	601	611	614	617	524	527	536	540	546	553	559
PG&E	3b	2 Story SF	723	1,042	978	930	1,001	1,018	1,023	1,029	874	879	893	900	910	921	932
PG&E	3b	SFA	351	568	471	417	497	502	501	499	333	334	340	337	339	341	343
PG&E	3b	2 Story MF	263	426	353	313	373	377	376	374	250	250	255	253	254	256	257
PG&E	3b	3 Story MF	263	426	353	313	373	377	376	374	250	250	255	253	254	256	257
PG&E	4	1 Story SF	1,281	1,800	1,690	1,608	1,731	1,758	1,767	1,777	1,510	1,519	1,543	1,555	1,573	1,592	1,610
PG&E	4	2 Story SF	1,281	1,800	1,690	1,608	1,731	1,758	1,767	1,777	1,510	1,519	1,543	1,555	1,573	1,592	1,610
PG&E	4	SFA	1,244	2,121	1,758	1,555	1,855	1,874	1,871	1,861	1,244	1,245	1,269	1,259	1,266	1,272	1,280
PG&E	4	2 Story MF	933	1,590	1,319	1,166	1,391	1,405	1,403	1,396	933	934	952	944	949	954	960
PG&E	4	3 Story MF	933	1,590	1,319	1,166	1,391	1,405	1,403	1,396	933	934	952	944	949	954	960
PG&E	5	1 Story SF	114	166	155	148	159	162	163	163	139	140	142	143	145	146	148
PG&E	5	2 Story SF	971	1,408	1,321	1,257	1,353	1,375	1,382	1,390	1,180	1,188	1,206	1,216	1,230	1,245	1,259
PG&E	5	SFA	74	131	109	96	115	116	116	115	77	77	78	78	78	79	79
PG&E	5	2 Story MF	56	98	82	72	86	87	87	86	58	58	59	58	59	59	59
PG&E	5	3 Story MF	56	98	82	72	86	87	87	86	58	58	59	58	59	59	59
PG&E	11	1 Story SF	5,030	7,205	6,763	6,434	6,926	7,038	7,072	7,113	6,042	6,080	6,174	6,223	6,296	6,370	6,445
PG&E	11	2 Story SF	2,347	3,363	3,156	3,002	3,232	3,284	3,300	3,320	2,820	2,837	2,881	2,904	2,938	2,973	3,007
PG&E	11	SFA	351	590	489	433	516	522	521	518	346	347	353	350	352	354	356
PG&E	11	2 Story MF	984	1,652	1,370	1,212	1,445	1,460	1,458	1,450	969	970	989	981	986	992	997
PG&E	11	3 Story MF	70	118	98	87	103	104	104	104	69	69	71	70	70	71	71

PG&E
Residential New Construction Housing Stock

Utility	Title 24 Climate Zone	Segment	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
PG&E	12	1 Story SF	9,515	12,507	11,795	11,230	12,033	12,217	12,288	12,359	10,622	10,686	10,848	10,948	11,081	11,216	11,353
PG&E	12	2 Story SF	15,435	20,289	19,134	18,218	19,521	19,818	19,934	20,050	17,231	17,335	17,598	17,759	17,976	18,195	18,417
PG&E	12	SFA	1,101	1,626	1,384	1,241	1,446	1,462	1,463	1,458	1,035	1,037	1,056	1,052	1,058	1,065	1,071
PG&E	12	2 Story MF	3,084	4,553	3,876	3,474	4,049	4,093	4,096	4,084	2,899	2,905	2,958	2,946	2,963	2,981	2,999
PG&E	12	3 Story MF	220	325	277	248	289	292	293	292	207	207	211	210	212	213	214
PG&E	13	1 Story SF	10,912	15,819	14,849	14,125	15,206	15,451	15,527	15,617	13,265	13,349	13,555	13,663	13,823	13,985	14,149
PG&E	13	2 Story SF	376	545	512	487	524	533	535	539	457	460	467	471	477	482	488
PG&E	13	SFA	533	909	753	666	795	803	802	797	533	533	544	539	542	545	548
PG&E	13	2 Story MF	1,492	2,544	2,109	1,865	2,225	2,248	2,244	2,232	1,492	1,494	1,522	1,510	1,518	1,526	1,535
PG&E	13	3 Story MF	107	182	151	133	159	161	160	159	107	107	109	108	108	109	110
PG&E	16	1 Story SF	606	869	816	776	835	849	853	858	729	733	745	751	759	768	777
PG&E	16	2 Story SF	303	435	408	388	418	424	427	429	364	367	372	375	380	384	389
PG&E	16	SFA	93	155	129	114	136	137	137	136	91	91	93	92	93	93	94
PG&E	16	2 Story MF	29	48	40	35	42	42	42	42	28	28	29	28	29	29	29
PG&E	16	3 Story MF	21	36	30	26	31	32	32	31	21	21	21	21	21	22	22

SCE/SoCalGas

Residential New Construction Housing Stock

Utility	Title 24 Climate Zone	Segment	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
SCE/SoCalGas	6	1 Story SF	495	586	688	715	798	818	836	852	780	794	818	817	829	841	853
SCE/SoCalGas	6	2 Story SF	4,645	5,495	6,449	6,701	7,480	7,667	7,839	7,984	7,312	7,440	7,665	7,660	7,772	7,885	8,000
SCE/SoCalGas	6	SFA	869	980	1,096	1,132	1,375	1,416	1,443	1,475	1,224	1,254	1,308	1,280	1,293	1,306	1,320
SCE/SoCalGas	6	2 Story MF	333	375	420	434	526	542	553	565	469	480	501	490	495	500	505
SCE/SoCalGas	6	3 Story MF	647	730	816	843	1,024	1,055	1,075	1,098	911	934	974	953	963	973	983
SCE/SoCalGas	8	1 Story SF	1,656	1,561	1,218	1,155	1,488	1,533	1,551	1,588	1,124	1,162	1,227	1,240	1,252	1,264	1,277
SCE/SoCalGas	8	2 Story SF	6,863	6,467	5,044	4,784	6,164	6,350	6,427	6,580	4,659	4,812	5,085	5,135	5,187	5,239	5,291
SCE/SoCalGas	8	SFA	1,354	1,984	2,038	1,920	1,502	1,420	1,822	1,875	1,897	1,939	1,369	1,414	1,492	6,594	6,662
SCE/SoCalGas	8	2 Story MF	812	1,190	1,223	1,152	901	852	1,093	1,125	1,138	1,164	822	848	895	847	855
SCE/SoCalGas	8	3 Story MF	542	794	815	768	601	568	729	750	759	776	548	566	597	2,638	2,665
SCE/SoCalGas	9	1 Story SF	2,332	2,176	1,443	1,828	2,588	2,706	2,772	2,861	2,416	2,500	2,639	2,478	2,514	2,551	2,588
SCE/SoCalGas	9	2 Story SF	6,995	6,529	4,330	5,484	7,765	8,119	8,315	8,583	7,247	7,500	7,918	7,434	7,542	7,652	7,764
SCE/SoCalGas	9	SFA	1,295	1,790	1,991	1,848	1,185	1,509	2,189	2,291	2,348	2,425	2,016	2,091	2,213	3,023	3,055
SCE/SoCalGas	9	2 Story MF	777	1,074	1,195	1,109	711	905	1,313	1,375	1,409	1,455	1,210	1,254	1,328	1,814	1,833
SCE/SoCalGas	9	3 Story MF	518	716	796	739	474	604	875	917	939	970	806	836	885	1,209	1,222
SCE/SoCalGas	10	1 Story SF	807	846	798	808	828	773	724	677	565	610	676	622	628	634	641
SCE/SoCalGas	10	2 Story SF	2,118	2,222	2,093	2,122	2,172	2,030	1,900	1,776	1,483	1,602	1,775	1,634	1,650	1,666	1,681
SCE/SoCalGas	10	SFA	899	1,329	1,248	1,264	1,295	1,205	1,123	1,044	858	932	1,041	950	958	967	976
SCE/SoCalGas	10	2 Story MF	539	797	749	758	777	723	674	626	515	559	624	570	575	580	585
SCE/SoCalGas	10	3 Story MF	359	532	499	505	518	482	449	417	343	373	416	380	383	387	390
SCE/SoCalGas	13	1 Story SF	1,912	2,262	2,654	2,758	3,079	3,155	3,226	3,286	3,010	3,062	3,155	3,153	3,199	3,245	3,293
SCE/SoCalGas	13	2 Story SF	66	78	92	95	106	109	111	113	104	106	109	109	110	112	114
SCE/SoCalGas	13	SFA	58	65	73	75	92	94	96	98	82	84	87	85	86	87	88
SCE/SoCalGas	13	2 Story MF	162	183	204	211	256	264	269	275	228	234	244	239	241	244	246
SCE/SoCalGas	13	3 Story MF	12	13	15	15	18	19	19	20	16	17	17	17	17	17	18
SCE/SoCalGas	14	1 Story SF	3,256	3,856	4,526	4,702	5,249	5,380	5,501	5,603	5,132	5,221	5,379	5,376	5,454	5,534	5,614
SCE/SoCalGas	14	2 Story SF	4,161	4,928	5,783	6,008	6,707	6,875	7,029	7,159	6,557	6,671	6,873	6,869	6,969	7,071	7,174
SCE/SoCalGas	14	SFA	637	715	800	826	1,004	1,034	1,054	1,077	893	915	955	935	944	954	964
SCE/SoCalGas	14	2 Story MF	196	220	246	254	309	318	324	331	275	282	294	288	290	293	296
SCE/SoCalGas	14	3 Story MF	147	165	185	191	232	239	243	248	206	211	220	216	218	220	222

SCE/SoCalGas
Residential New Construction Housing Stock

Utility	Title 24 Climate Zone	Segment	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
SCE/SoCalGas	15	1 Story SF	2,607	3,066	3,598	3,739	4,174	4,278	4,374	4,455	4,080	4,151	4,277	4,274	4,337	4,400	4,464
SCE/SoCalGas	15	2 Story SF	2,607	3,066	3,598	3,739	4,174	4,278	4,374	4,455	4,080	4,151	4,277	4,274	4,337	4,400	4,464
SCE/SoCalGas	15	SFA	367	415	464	479	582	599	611	624	518	531	554	542	547	553	559
SCE/SoCalGas	15	2 Story MF	113	128	143	147	179	184	188	192	159	163	170	167	168	170	172
SCE/SoCalGas	15	3 Story MF	85	96	107	111	134	138	141	144	120	122	128	125	126	128	129
SCE/SoCalGas	16	1 Story SF	3,482	4,137	4,855	5,044	5,631	5,771	5,901	6,010	5,504	5,600	5,770	5,766	5,850	5,936	6,022
SCE/SoCalGas	16	2 Story SF	1,741	2,068	2,427	2,522	2,815	2,886	2,951	3,005	2,752	2,800	2,885	2,883	2,925	2,968	3,011
SCE/SoCalGas	16	SFA	377	428	479	494	600	619	630	644	534	548	571	559	565	571	576
SCE/SoCalGas	16	2 Story MF	116	132	147	152	185	190	194	198	164	169	176	172	174	176	177
SCE/SoCalGas	16	3 Story MF	87	99	110	114	139	143	145	149	123	126	132	129	130	132	133

SDG&E

Residential New Construction Housing Stock

Utility	Title 24 Climate Zone	Segment	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
SDG&E	7	1 Story SF	672	704	664	673	689	644	603	563	470	508	563	518	523	528	533
SDG&E	7	2 Story SF	5,372	5,636	5,310	5,382	5,510	5,148	4,821	4,506	3,762	4,063	4,502	4,145	4,185	4,225	4,265
SDG&E	7	SFA	1,745	2,582	2,423	2,454	2,516	2,341	2,181	2,028	1,666	1,811	2,021	1,845	1,861	1,878	1,895
SDG&E	7	2 Story MF	668	989	928	940	964	897	835	777	638	694	774	707	713	719	726
SDG&E	7	3 Story MF	1,300	1,923	1,805	1,828	1,874	1,743	1,624	1,510	1,241	1,349	1,505	1,374	1,386	1,398	1,411
SDG&E	10	1 Story SF	807	846	798	808	828	773	724	677	565	610	676	622	628	634	641
SDG&E	10	2 Story SF	2,118	2,222	2,093	2,122	2,172	2,030	1,900	1,776	1,483	1,602	1,775	1,634	1,650	1,666	1,681
SDG&E	10	SFA	899	1,329	1,248	1,264	1,295	1,205	1,123	1,044	858	932	1,041	950	958	967	976
SDG&E	10	2 Story MF	539	797	749	758	777	723	674	626	515	559	624	570	575	580	585
SDG&E	10	3 Story MF	359	532	499	505	518	482	449	417	343	373	416	380	383	387	390
SDG&E	14	1 Story SF	214	224	212	214	220	205	192	180	150	162	179	165	167	168	170
SDG&E	14	2 Story SF	273	287	270	274	280	262	245	229	191	207	229	211	213	215	217
SDG&E	14	SFA	194	288	270	274	281	261	243	226	186	202	226	206	207	209	211
SDG&E	14	2 Story MF	60	89	83	84	86	80	75	70	57	62	69	63	64	64	65
SDG&E	14	3 Story MF	45	66	62	63	65	60	56	52	43	47	52	48	48	48	49

Energy Time-Of-Use Shares and Coincident Peak Factors

The following table lists the energy time-of-use shares associated with each segment for residential new construction units. The energy included in the data below include the electricity used for central air conditioners, room air conditioners, electric water heaters, and electric space heaters, where applicable.[9] The energy time-of-use shares change by Title 24 climate zone.

Table O-35: Energy Time-Of-Use Shares by Technology and Segment

Technology Name	Segment	Energy Time-Of-Use Share	Changes by
SF1_01_00	1 Story SF	SF1	T24 CZ
SF1_01_15	1 Story SF	SF1	T24 CZ
SF1_01_25	1 Story SF	SF1	T24 CZ
SF1_05_00	1 Story SF	SF1	T24 CZ
SF1_05_10	1 Story SF	SF1	T24 CZ
SF1_05_15	1 Story SF	SF1	T24 CZ
SF2_01_00	2 Story SF	SF2	T24 CZ
SF2_01_15	2 Story SF	SF2	T24 CZ
SF2_01_25	2 Story SF	SF2	T24 CZ
SF2_05_00	2 Story SF	SF2	T24 CZ
SF2_05_10	2 Story SF	SF2	T24 CZ
SF2_05_15	2 Story SF	SF2	T24 CZ
SFA_01_00	SFA	SF1	T24 CZ
SFA_01_15	SFA	SF1	T24 CZ
SFA_01_25	SFA	SF1	T24 CZ
SFA_05_00	SFA	SF1	T24 CZ
SFA_05_10	SFA	SF1	T24 CZ
SFA_05_15	SFA	SF1	T24 CZ
MFLR2_01_00	2 Story MF	MFLR2	T24 CZ
MFLR2_01_15	2 Story MF	MFLR2	T24 CZ
MFLR2_01_25	2 Story MF	MFLR2	T24 CZ
MFLR2_05_00	2 Story MF	MFLR2	T24 CZ
MFLR2_05_10	2 Story MF	MFLR2	T24 CZ
MFLR2_05_15	2 Story MF	MFLR2	T24 CZ
MFLR3_01_00	3 Story MF	MFLR3	T24 CZ
MFLR3_01_15	3 Story MF	MFLR3	T24 CZ
MFLR3_01_25	3 Story MF	MFLR3	T24 CZ
MFLR3_05_00	3 Story MF	MFLR3	T24 CZ
MFLR3_05_10	3 Story MF	MFLR3	T24 CZ
MFLR3_05_15	3 Story MF	MFLR3	T24 CZ

9 Each of the single family and attached single family time-of-use data include only central air conditioners. However, for multifamily dwellings, see Table O-24 for the type of equipment in each of the multifamily prototypes.

The following table lists the energy time-of-use shares for residential new construction end uses by Title 24 climate zone. The load shapes were determined using *SitePro*. The TOU periods are the same as those given in the previous section of the appendix. The summer peak coincidence factor is also included.

Table O-36: TOU Load Shapes and Summer Peak Factors

Energy Time-Of-Use Share	Region	Summer On Peak	Summer Partial Peak	Summer Off Peak	Winter Partial Peak	Winter Off Peak	Summer Peak Factor
MFLR2	T24 CZ 1	0%	0%	0%	0%	0%	0.0
MFLR2	T24 CZ 2	33%	19%	34%	10%	5%	2.5
MFLR2	T24 CZ 3	42%	11%	35%	4%	7%	5.0
MFLR2	T24 CZ 4	41%	17%	33%	5%	4%	2.0
MFLR2	T24 CZ 5	35%	18%	32%	8%	7%	5.0
MFLR2	T24 CZ 6	15%	8%	20%	12%	45%	3.2
MFLR2	T24 CZ 7	21%	11%	20%	9%	39%	2.6
MFLR2	T24 CZ 8	34%	21%	31%	9%	5%	2.1
MFLR2	T24 CZ 9	33%	18%	32%	11%	6%	2.2
MFLR2	T24 CZ 10	27%	20%	35%	12%	6%	1.9
MFLR2	T24 CZ 11	35%	22%	35%	5%	3%	2.0
MFLR2	T24 CZ 12	39%	19%	32%	6%	5%	2.3
MFLR2	T24 CZ 13	29%	22%	37%	8%	3%	1.8
MFLR2	T24 CZ 14	30%	23%	38%	7%	3%	1.8
MFLR2	T24 CZ 15	22%	19%	40%	12%	7%	1.5
MFLR2	T24 CZ 16	44%	21%	32%	2%	1%	2.4
MFLR3	T24 CZ 1	2%	4%	20%	24%	50%	0.0
MFLR3	T24 CZ 2	12%	8%	21%	19%	40%	2.3
MFLR3	T24 CZ 3	4%	2%	16%	21%	57%	5.0
MFLR3	T24 CZ 4	13%	7%	18%	16%	47%	1.9
MFLR3	T24 CZ 5	6%	4%	20%	15%	56%	4.7
MFLR3	T24 CZ 6	37%	21%	33%	5%	4%	3.2
MFLR3	T24 CZ 7	40%	21%	29%	6%	4%	2.7
MFLR3	T24 CZ 8	21%	12%	22%	11%	34%	2.2
MFLR3	T24 CZ 9	21%	12%	25%	11%	31%	2.2
MFLR3	T24 CZ 10	21%	15%	29%	11%	23%	1.9
MFLR3	T24 CZ 11	13%	9%	20%	17%	42%	2.0
MFLR3	T24 CZ 12	14%	7%	17%	18%	44%	2.4
MFLR3	T24 CZ 13	16%	12%	24%	15%	33%	1.8
MFLR3	T24 CZ 14	16%	13%	25%	12%	34%	1.8
MFLR3	T24 CZ 15	18%	16%	35%	11%	19%	1.5
MFLR3	T24 CZ 16	7%	5%	19%	21%	48%	2.4
SF1	T24 CZ 1	13%	11%	39%	8%	29%	0.0

Energy Time-Of-Use Share	Region	Summer On Peak	Summer Partial Peak	Summer Off Peak	Winter Partial Peak	Winter Off Peak	Summer Peak Factor
SF1	T24 CZ 2	32%	21%	39%	4%	3%	2.8
SF1	T24 CZ 3	16%	3%	76%	2%	3%	5.0
SF1	T24 CZ 4	45%	17%	36%	0%	2%	2.6
SF1	T24 CZ 5	52%	22%	23%	1%	2%	5.0
SF1	T24 CZ 6	41%	22%	35%	1%	1%	2.8
SF1	T24 CZ 7	44%	24%	30%	0%	1%	2.5
SF1	T24 CZ 8	38%	23%	37%	1%	1%	2.5
SF1	T24 CZ 9	36%	21%	39%	1%	3%	2.6
SF1	T24 CZ 10	29%	22%	41%	5%	3%	2.0
SF1	T24 CZ 11	34%	25%	40%	1%	1%	2.2
SF1	T24 CZ 12	41%	22%	33%	1%	2%	2.8
SF1	T24 CZ 13	28%	24%	42%	4%	2%	1.9
SF1	T24 CZ 14	29%	24%	43%	2%	2%	2.0
SF1	T24 CZ 15	22%	20%	43%	9%	6%	1.4
SF1	T24 CZ 16	43%	22%	34%	0%	0%	4.0
SF2	T24 CZ 1	13%	11%	40%	8%	29%	0.0
SF2	T24 CZ 2	32%	21%	39%	4%	4%	2.8
SF2	T24 CZ 3	20%	2%	72%	1%	4%	5.0
SF2	T24 CZ 4	45%	17%	36%	0%	2%	2.5
SF2	T24 CZ 5	53%	23%	22%	1%	1%	5.0
SF2	T24 CZ 6	40%	20%	40%	0%	0%	4.8
SF2	T24 CZ 7	48%	22%	29%	0%	0%	3.4
SF2	T24 CZ 8	38%	22%	33%	4%	3%	2.3
SF2	T24 CZ 9	35%	19%	34%	7%	5%	2.3
SF2	T24 CZ 10	29%	21%	35%	10%	5%	1.9
SF2	T24 CZ 11	36%	23%	36%	3%	2%	2.2
SF2	T24 CZ 12	41%	20%	32%	4%	4%	2.7
SF2	T24 CZ 13	31%	23%	37%	6%	3%	1.8
SF2	T24 CZ 14	31%	24%	38%	5%	2%	1.9
SF2	T24 CZ 15	23%	20%	41%	11%	6%	1.5
SF2	T24 CZ 16	46%	21%	32%	0%	0%	3.0

Appendix P

Commercial New Construction Methodology and ASSET Inputs

As part of the New Construction Potential study, Architectural Energy Corporation (AEC) was charged with estimating the potential energy savings from constructing commercial buildings in California that are higher than code (i.e., Savings by Design). The first and most important part of the study was to find the costs and savings for commercial buildings to reach 15% and 25% above the 2001 Standards. This information was then used to create packages of high efficiency measures.

The remainder of this appendix summarizes the prototypes used as the baseline, the incremental measure cost of high efficiency measures, the bundles of measures included in the packages, and the proposed least-cost packages to reach the base and high activity levels presented in Table P-1.

P.1 Objectives

The objectives of the New Construction Potential Study included finding the savings potential for commercial buildings that would approximate the building of Savings by Design buildings under the new standards (reaching 10 and 15% above the 2005 codes), by Title 24 climate zone.[1] Further, unlike the residential new construction analysis, the commercial new construction analysis conducted an individual building analysis on a large sample of buildings rather than defining a set of prototype models from a large sample of buildings. The analysis was conducted for 11 building types: colleges, grocery stores, health care buildings, lodging, large office buildings, retail, restaurants, schools, small office buildings, warehouses, and miscellaneous. The measure bundles were focused primarily on electricity saving measures, and were expanded to include gas measures in building types where gas was a major end use (primarily restaurants). Also unlike the residential analysis, incremental

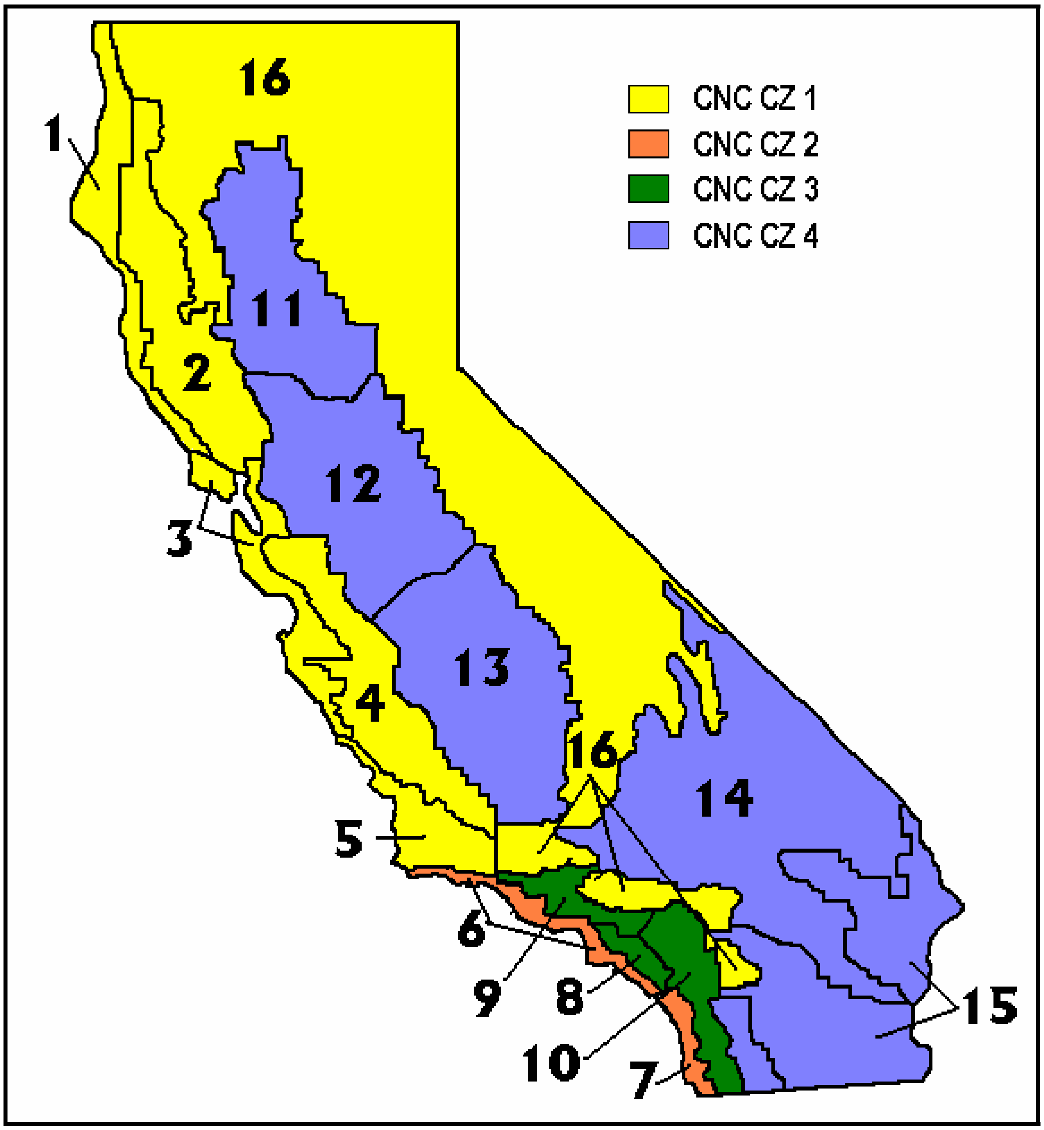
[1] While reviewing this section, please note that when developing the packages of measures, cost-effective measures were added first and then less cost-effective measures where added by building type and by region until each building reached the various levels above the Standards. Since the Standards are fuel neutral and, in general, electric measures are more cost-effective than gas measures, the packages assembled for many building types did not include many, if any, gas measures.

costs and savings were developed by region instead of by California Energy Commission (CEC) climate zones. Specifically, these inputs were developed by building type for each of the four climate regions shown in Figure P-1.

Table P-1: Measure Bundle Efficiency Levels

Scenario	Description	2004-2005 Level of Efficiency	2006-2013 Level of Efficiency
1	Code Level	2001 Code	2005 Code
2	Base Activity Level	2001 Code +15%	2005 Code + 10%
3	High Activity Level	2001 Code + 25%	2005 Code + 15%

Figure P-1: CEC Climate Zones



P.2 Commercial Buildings

Building Sample

The primary building characteristics dataset was the Nonresidential New Construction (NRNC) database. The California Statewide NRNC database is a collection of buildings statistically selected to represent the majority of statewide NRNC activity. The buildings in the database represent the building types considered by the CEC in their nonresidential sector forecasting models with the exception of refrigerated warehouses, which are not covered under Title 24. Most of the data come from on-site surveys conducted during impact evaluation studies of the PG&E, SCE, and SDG&E NRNC energy efficiency programs, starting with program year 1994 and continuing through program year (PY) 2003. The dataset contains nearly 1,900 buildings, including both program participants and nonparticipants. For this project, only nonparticipants were used, resulting in a final dataset of 996 buildings. Sample weights assigned to each building permit extrapolation of measure bundle impacts to the statewide level.

Load Impacts

The AEC ModelIT software was used to conduct the load impact analysis. ModelIT is a C++ application that reads data tables from the NRNC database and automatically creates a series of DOE-2 input files for each building in the database. ModelIT was programmed to create code-compliant versions of each building for each code scenario examined, and implemented the measure bundles defined in a series of parametric simulations. The simulations were run in a batch process and the resulting 8760 hourly end-use load profiles were combined into energy consumption and demand by costing period data, as required by ASSET.

Commercial Baseline

One issue of discussion during the development of the research plan was the manner in which the commercial baselines would be established. After further review and discussion with advisory committee members, it was decided to look at nonparticipant buildings studied under the BEA project (which looks at impacts of the PY2002 and PY2003 Savings by Design program) that were built under the AB 970 (2001) version of Title 24. This allowed the research team to gain an understanding of common practices relative to the code, especially in areas where the efficiency standards were tightened considerably. Due to limitations in the sample size and coverage across building types, only differences that are statistically significant from Title 24 are used; otherwise, the baseline is set at the minimum code compliant value.

Incremental Costs

Efficiency levels and incremental costs for building shell, lighting, mechanical equipment, refrigeration systems and food service equipment are described below. The Title 24 efficiency levels, Savings by Design incentive levels, and common practice baselines are shown in the tables. Common practices relative to 2001 code are designated “CP01.” Common practices extrapolated to the 2005 code are designated “CP05.” Resources for estimating incremental costs are primarily the 2005 Database for Energy Efficient Resources (DEER) measure cost study, supplemented by research conducted by AEC for measures not included in DEER.

Building Shell

Measure values for building envelope U-values are based on the *Advanced Buildings Guidelines* (ABG) taken from The New Buildings Institute’s *Energy Benchmark for High Performance Buildings* (E-Benchmark). For glazing, however, the ABG values are not as stringent as Title 24 in some instances. Therefore, measure values for glazing relative to solar heat gain are based on available high performance low-E glazing products. The shell measure efficiency and incremental costs are shown in Table P-2.

Lighting

Measure values for allowed lighting power densities (LPD) were primarily based on *Savings By Design* (SBD) values, *Advanced Buildings* guideline values, or common practice data adjusted for a change in source efficacy. In many space types, higher efficiency lighting sources or fixtures with improved optics were used to lower the LPD. For some spaces, the measure values were further reduced by the ratio of available higher efficacy light sources over common practice (e.g., using CFL high bays in place of metal halide lamps for commercial storage space). The lighting measure efficiency and incremental costs are shown in Table P-3.

Mechanical Equipment

Measure efficiency values for mechanical equipment typically was based on the most efficient of the values from several data sources, including SBD, ABG, common practice from BEA data, the Consortium for Energy Efficiency’s (CEE) Equipment Database Tier II criteria, and the U.S. DOE’s Federal Energy Management Program (FEMP) listings for “Best Available” efficiencies for various types of mechanical equipment. The mechanical equipment measure efficiency and incremental costs are shown in Table P-4.

Grocery Store Refrigeration

The grocery store refrigeration measures focused on display case measures and condenser measures. Since Title 24 does not address refrigeration, the characteristics of grocery stores in the BEA database were examined to determine common practice in grocery store refrigeration. Only measures not currently common practice are included. These measures were applied to grocery stores only. The measures considered in the analysis and their incremental costs are shown in Table P-5.

Food Service

The food service measures focus on griddles, fryers, ovens, food warmers and range tops. As with grocery store refrigeration, Title 24 does not address food service equipment. High efficiency versions of the common food service equipment used in the restaurants within the database are substituted for standard efficiency units. The measures considered in the analysis and their incremental costs are shown in Table P-6.

Table P-2: Shell Measure Efficiency Levels and Incremental Costs

Measure	Climate Zone	HE Measures	Title 24 - 2001	Common Practice 2001	Incremental Cost per SqFt over CP01	Title 24 - 2005	Common Practice 2005	Incremental Cost per SqFt over CP05
Roof U-value								
	CZ 1,16	0.039	0.057	0.057	$0.27	0.051	0.051	$0.20
	CZ 3-5	0.048	0.057	0.057	$0.10	0.051	0.051	$0.03
	CZ 6-9	0.048	0.078	0.078	$0.26	0.076	0.076	$0.24
	CZ 2, 10-13	0.048	0.057	0.057	$0.10	0.051	0.051	$0.03
	CZ 14,15	0.048	0.057	0.057	$0.10	0.051	0.051	$0.03
Wall U-value								
Wood frame	CZ 1,16	0.063	0.084	0.063	$0.00	0.102	0.063	$0.00
Wood frame	CZ 3-5	0.063	0.092	0.069	$0.03	0.110	0.069	$0.03
Wood frame	CZ 6-9	0.063	0.092	0.069	$0.03	0.110	0.069	$0.03
Wood frame	CZ 2, 10-13	0.063	0.084	0.063	$0.00	0.102	0.063	$0.00
Wood frame	CZ 14,15	0.063	0.084	0.063	$0.00	0.102	0.063	$0.00
Metal frame	CZ 1,16	0.077	0.182	0.152	$0.21	0.217	0.152	$0.18
Metal frame	CZ 3-5	0.077	0.189	0.189	$0.30	0.224	0.224	$0.34
Metal frame	CZ 6-9	0.077	0.189	0.189	$0.30	0.224	0.224	$0.34
Metal frame	CZ 2, 10-13	0.077	0.182	0.152	$0.21	0.217	0.152	$0.18
Metal frame	CZ 14,15	0.077	0.182	0.152	$0.21	0.217	0.152	$0.18
Mass HC 7 - 15	CZ 1,16	0.110	0.340	0.340	$0.59	0.330	0.330	$0.59
Mass HC 7 - 15	CZ 3-5	0.110	0.430	0.241	$0.24	0.430	0.241	$0.24
Mass HC 7 - 15	CZ 6-9	0.110	0.430	0.241	$0.24	0.430	0.241	$0.24
Mass HC 7 - 15	CZ 2, 10-13	0.110	0.430	0.241	$0.24	0.430	0.241	$0.24
Mass HC 7 - 15	CZ 14,15	0.142	0.430	0.241	$0.18	0.430	0.241	$0.18
Mass HC > 15	CZ 1,16	0.110	0.360	0.360	$0.59	0.360	0.360	$0.59
Mass HC > 15	CZ 3-5	0.110	0.650	0.385	$0.30	0.650	0.385	$0.30
Mass HC > 15	CZ 6-9	0.110	0.690	0.459	$0.36	0.690	0.459	$0.36
Mass HC > 15	CZ 2, 10-13	0.110	0.650	0.385	$0.30	0.650	0.385	$0.30
Mass HC > 15	CZ 14,15	0.142	0.400	0.400	$0.51	0.410	0.410	$0.51

Table P-2 (cont'd): Shell Measure Efficiency Levels and Incremental Costs

Window to Wall Area Ratio	Direction	Climate Zone	HE Measures	Title 24 - 2001	Common Practice 2001	Incremental Cost per SqFt over CP01	Title 24 - 2005	Common Practice 2005	Incremental Cost per SqFt over CP05
Window RSHG									
0-10% WWR	Non-north	CZ 1,16	0.23	0.49	0.47	$1.85	0.49	0.47	$1.85
		CZ 3-5	0.23	0.61	0.59	$1.87	0.61	0.59	$1.87
		CZ 6-9	0.23	0.61	0.59	$1.87	0.61	0.59	$1.87
		CZ 2, 10-13	0.23	0.47	0.45	$1.84	0.47	0.45	$1.84
		CZ 14,15	0.23	0.46	0.44	$1.84	0.46	0.44	$1.84
0-10% WWR	North	CZ 1,16	0.23	0.72	0.69	$1.88	0.72	0.69	$1.88
		CZ 3-5	0.23	0.61	0.59	$1.87	0.61	0.59	$1.87
		CZ 6-9	0.23	0.61	0.59	$1.87	0.61	0.59	$1.87
		CZ 2, 10-13	0.23	0.61	0.59	$1.87	0.61	0.59	$1.87
		CZ 14,15	0.23	0.61	0.59	$1.87	0.61	0.59	$1.87
11-20% WWR	Non-north	CZ 1,16	0.23	0.43	0.41	$1.83	0.43	0.41	$1.83
		CZ 3-5	0.23	0.55	0.53	$1.86	0.55	0.53	$1.86
		CZ 6-9	0.23	0.61	0.59	$1.87	0.61	0.59	$1.87
		CZ 2, 10-13	0.23	0.36	0.35	$1.78	0.36	0.35	$1.78
		CZ 14,15	0.23	0.36	0.35	$1.78	0.36	0.35	$1.78
11-20% WWR	North	CZ 1,16	0.23	0.49	0.47	$1.85	0.49	0.47	$1.85
		CZ 3-5	0.23	0.61	0.59	$1.87	0.61	0.59	$1.87
		CZ 6-9	0.23	0.61	0.59	$1.87	0.61	0.59	$1.87
		CZ 2, 10-13	0.23	0.51	0.49	$1.85	0.51	0.49	$1.85
		CZ 14,15	0.23	0.51	0.49	$1.85	0.51	0.49	$1.85
21-30% WWR	Non-north	CZ 1,16	0.23	0.43	0.41	$1.83	0.43	0.41	$1.83
		CZ 3-5	0.23	0.41	0.39	$1.82	0.41	0.39	$1.82
		CZ 6-9	0.23	0.39	0.37	$1.81	0.39	0.37	$1.81
		CZ 2, 10-13	0.23	0.36	0.35	$1.78	0.36	0.35	$1.78
		CZ 14,15	0.23	0.36	0.35	$1.78	0.36	0.35	$1.78
21-30% WWR	North	CZ 1,16	0.23	0.47	0.45	$1.84	0.47	0.45	$1.84
		CZ 3-5	0.23	0.61	0.59	$1.87	0.61	0.59	$1.87
		CZ 6-9	0.23	0.61	0.59	$1.87	0.61	0.59	$1.87
		CZ 2, 10-13	0.23	0.47	0.45	$1.84	0.47	0.45	$1.84
		CZ 14,15	0.23	0.47	0.45	$1.84	0.47	0.45	$1.84
31-40% WWR	Non-north	CZ 1,16	0.23	0.43	0.41	$1.83	0.43	0.41	$1.83
		CZ 3-5	0.23	0.41	0.39	$1.82	0.41	0.39	$1.82
		CZ 6-9	0.23	0.34	0.33	$1.75	0.34	0.33	$1.75
		CZ 2, 10-13	0.23	0.31	0.30	$1.69	0.31	0.30	$1.69
		CZ 14,15	0.23	0.31	0.30	$1.69	0.31	0.30	$1.69
31-40% WWR	North	CZ 1,16	0.23	0.47	0.45	$1.84	0.47	0.45	$1.84
		CZ 3-5	0.23	0.61	0.59	$1.87	0.61	0.59	$1.87
		CZ 6-9	0.23	0.61	0.59	$1.87	0.61	0.59	$1.87
		CZ 2, 10-13	0.23	0.47	0.45	$1.84	0.47	0.45	$1.84
		CZ 14,15	0.23	0.40	0.38	$1.81	0.40	0.38	$1.81

Table P-3: Lighting Measure Efficiency Levels and Incremental Costs

Primary Function	HE Measure	Title 24 - 2001	Common Practice 2001	Incremental Cost per SqFt over CP01	Title 24 - 2005	Common Practice 2005	Incremental Cost per SqFt over CP05
All Other	0.45	0.6	0.6	$0.11	0.6	0.6	$0.11
Auditorium	1.50	2.0	1.5	$0.00	1.5	1.5	$0.00
Auto Repair	0.70	1.2	1.2	$0.03	1.1	1.1	$0.02
Banks/Financial Institutions	1.10	1.4	1.4	$0.22	1.2	1.2	$0.07
Classrooms/Training	1.00	1.6	1.3	$0.08	1.2	1.2	$0.05
Commercial Storage	0.48	0.6	0.5	$0.00	0.6	0.5	$0.00
Conference Centers	1.12	1.5	1.5	$0.28	1.4	1.4	$0.21
Convention Centers	1.30	1.5	1.5	$0.08	1.4	1.4	$0.04
Corridors	0.45	0.6	0.6	$0.11	0.6	0.6	$0.11
Dining	0.82	1.1	1.4	$0.20	1.1	1.4	$0.20
Dressing Room (Gymnasium)	0.60	0.9	0.9	$0.10	0.8	0.8	$0.07
Electrical Rooms	0.52	0.7	0.7	$0.13	0.7	0.7	$0.13
General Commercial Work - High Bay	0.67	1.2	0.7	$0.00	1.1	0.7	$0.00
General Commercial Work - Low Bay	0.67	1.0	0.7	$0.00	1.0	0.7	$0.00
General Industrial Work - High Bay	0.67	1.2	0.7	$0.00	1.1	0.7	$0.00
General Industrial Work - Low Bay	0.67	1.0	0.7	$0.00	1.0	0.7	$0.00
Grocery Stores	1.30	1.6	1.6	$0.26	1.6	1.6	$0.26
Gymnasium/Exercise Center	0.90	1.0	1.6	$0.06	1.0	1.6	$0.06
Hotel Function Area	1.50	2.2	2.2	$0.26	1.5	1.5	$0.00
Hotel Lobby	1.10	1.7	1.7	$0.06	1.1	1.1	$0.00
Industrial Storage	0.54	0.6	0.6	$0.03	0.6	0.6	$0.03
Kitchen/ Food Preparation	1.27	1.7	1.5	$0.17	1.6	1.5	$0.17
Laundry	0.67	0.9	0.9	$0.17	0.9	0.9	$0.17
Lecture	1.20	1.6	1.6	$0.26	1.2	1.2	$0.00
Library - Reading Areas	0.89	1.2	1.2	$0.22	1.2	1.2	$0.22
Library - Stacks	1.12	1.5	1.5	$0.28	1.5	1.5	$0.28
Locker Room	0.60	0.8	0.8	$0.11	0.8	0.8	$0.11
Lounge/Recreation	0.99	1.1	1.1	$0.07	1.1	1.1	$0.07
Main Entry Lobby	1.20	1.5	1.2	$0.00	1.5	1.2	$0.00
Malls, Arcades, and Atria	0.89	1.2	1.2	$0.22	1.2	1.2	$0.22
Mechanical Rooms	0.52	0.7	0.7	$0.13	0.7	0.7	$0.13
Medical and Clinical Care	1.10	1.4	1.1	$0.00	1.2	1.1	$0.00
Meeting Centers	1.40	1.5	1.5	$0.24	1.4	1.4	$0.00
Motion Picture Theater	0.81	0.9	0.9	$0.06	0.9	0.9	$0.06
Multipurpose Centers	1.12	1.5	1.5	$0.28	1.4	1.4	$0.21
Museum Exhibit	2.00	2.0	2.0	$0.00	2.0	2.0	$0.00
Office	0.90	1.3	1.1	$0.08	1.2	1.1	$0.08
Performance Theater	1.26	1.4	1.4	$0.09	1.4	1.4	$0.09
Precision Commercial Work	0.96	1.5	1.0	$0.01	1.3	1.0	$0.01
Precision Industrial Work	0.96	1.5	1.0	$0.01	1.3	1.0	$0.01
Reception/Waiting	0.50	1.1	1.1	$0.06	1.1	1.1	$0.06
Religious Worship	1.40	2.1	1.4	$0.00	1.5	1.4	$0.00
Restrooms	0.45	0.6	0.6	$0.11	0.6	0.6	$0.11
Retail Sales	1.30	2.0	1.5	$0.06	1.7	1.5	$0.06
Stairs	0.45	0.6	0.6	$0.11	0.6	0.6	$0.11
Support Areas	0.45	0.6	0.6	$0.11	0.6	0.6	$0.11
Vocational Room	1.00	1.6	1.6	$0.16	1.2	1.2	$0.05
Wholesale Showrooms	1.30	2.0	2.0	$0.06	1.7	1.7	$0.03

Table P-4: Mechanical Measure Efficiency Levels and Incremental Costs

			Efficiency Units	HE Measure	Title 24 - 2001	Common Practice 2001	Incremental Cost per Ton Over CP01	Title 24 - 2005	Common Practice 2005	Incremental Cost per Ton Over CP05
Air Conditioner Cooling Efficiency										
Air cooled	< 65000	Single pkg	SEER	14.5	9.7	13.0	$176	13.0	13.0	$176
	< 65000	Split sys	SEER	14.5	10.0	13.0	$56	13.0	13.0	$56
	65 -135		EER	11.8	10.3	11.0	$149	11.0	11.0	$149
	135 - 240		EER	11.5	9.7	10.8	$110	10.8	10.8	$110
	240 - 760		EER	10.0	9.5	10.0	$0	10.0	10.0	$0
	>760		EER	10.0	9.2	10.0	$0	9.2	10.0	$0
Water and Evaporatively	< 65000		SEER	12.1	12.1	12.1	$0	12.1	12.1	$0
	65 -135		EER	14.0	11.5	14.0	$0	11.5	14.0	$0
	135 - 240		EER	14.0	11.0	14.0	$0	11.0	14.0	$0
	> 240		EER	14.0	11.0	14.0	$0	11.0	14.0	$0
Heat Pump Cooling Efficiency										
Air cooled	< 65000	Single pkg	SEER	14.0	9.7	13.0	$209	13.0	13.0	$209
	< 65000	Split sys	SEER	14.0	10.0	13.0	$68	13.0	13.0	$68
	65 -135		EER	11.5	10.1	11.0	$182	11.0	11.0	$182
	135 - 240		EER	10.8	9.3	10.8	$0	10.8	10.8	$0
	240 - 760		EER	10.0	9.0	10.0	$0	10.0	10.0	$0
	>760		EER	10.0	9.0	10.0	$0	9.0	10.0	$0
Water-Source	< 17		EER	14.0	11.2	14.0	$0	11.2	14.0	$0
	17 - 65		EER	14.0	12.0	14.0	$0	12.0	14.0	$0
	65 -135		EER	14.5	12.0	14.0	$36	12.0	14.0	$36
Heat Pump Heating Efficiency										
Air cooled	< 65000	Single pkg	HSPF	7.7	6.6	7.7	Covered in Cooling Costs	7.7	7.7	Covered in Cooling Costs
		Split sys	HSPF	8.5	6.8	8.0		7.9	8.0	
	65 -135		COP	3.4	3.2	3.4		3.4	3.4	
	> 135		COP	3.3	3.1	3.3		3.3	3.3	
Water-Source	all		COP	5.0	4.2	4.6		4.2	4.6	
Chiller										
Air Cooled	With Condenser Elecrically Operated	All capacities	COP	3.49	2.80	2.93	$32	2.80	2.93	$32
	Without Condenser Elecrically Operated	All capacities	COP	3.20	3.10	3.10	$40	3.10	3.10	$40
Water Cooled	Reciprocating			5.23	4.20	4.42	$13	4.20	4.42	$13
	Screw + scroll	< 150 t	COP	5.58	4.45	4.82	$33	4.45	4.82	$33
		150 - 300	COP	6.12	4.90	5.76	$7	4.90	5.76	$7
		> 300	COP	6.88	5.50	5.86	$8	5.50	5.86	$8
	Centrifugal	< 150 t	COP	6.27	5.00	5.76	$58	5.00	5.76	$58
		150 - 300	COP	6.89	5.55	5.96	$65	5.55	5.96	$65
		> 300	COP	7.64	6.10	6.28	$58	6.10	6.28	$58
Air Cooled	Single Effect	All	COP	0.60	0.60	0.60	$0	0.60	0.60	$0
Water Cooled Absorption	Single Effect	All Capacities	COP	0.7	0.7	0.7	$0	0.7	0.7	$0
Absorption	Fired	Capacities	COP	1.2	1.0	1.0	$53	1.0	1.0	$53
	Fired	Capacities	COP	1	1.0	1.0	$0	1.0	1.0	$0
Fan power										
	CV	> 25 hp	W/cfm	0.70	0.80	1.10	$0.60	0.80	1.10	$0.60
	VAV	> 25 hp	W/cfm	1.10	1.25	1.47	$0.60	1.25	1.47	$0.60

Table P-5: Grocery Store Refrigeration Measures and Measure Cost

Equipment	Base Efficiency Measure	HE Measure	Cost	Unit
Refrigerated Cases	Standard fan motor	ECM Evaporator fan motor	$76	per motor
	Standard dual-pane doors	Advanced Reach-in doors	$300	per door
	No Controls	Anti-sweat heater controls	$56	per LF
	Fixed suction pressure control	Floating suction pressure control	$25	per LF
Condenser	Fixed head pressure	Minimum condenser setpoint (floating head pressure)	$300	per ton
	Standard air cooled condenser	Oversized air cooled condenser	$350	per ton
	Standard water cooled condenser	Oversized water cooled condenser	$279	per ton

Table P-6: Food Service Equipment Measures and Measure Cost

Measure	Base	High Efficiency	Incremental Cost Per Unit	Unit
High efficiency gas griddle	25 kBtu/hour	20 kBtu/hour	$1,051	Lineal foot
High efficiency electric griddle	65% Efficiency	75 % Efficiency	$960	Lineal foot
High efficiency gas fryer - 30-50 lbs. cap	25 kBtu/hour	15 kBtu/hour	$65	Pound capacity
High efficiency electric fryer - 45-65 lbs. cap	2.8 kW/hour	2.4 kW/hour	$159	Pound capacity
High Efficiency Gas Pizza or Bake oven	40% Efficiency	50% Efficiency	$1,500	Deck
High Efficiency Electric Pizza or Bake oven	50% Efficiency	80% Efficiency	$2,000	Deck
High Efficiency Gas Range oven	40% Efficiency	50% Efficiency	$1,500	Deck
High Efficiency Electric Range oven	50% Efficiency	80% Efficiency	$2,000	Deck
High Efficiency Gas Convection, combi, or retherm oven	40% Efficiency	50% Efficiency	$1,000	Deck
High Efficiency Electric Convection, combi, or retherm oven	50% Efficiency	80% Efficiency	$1,000	Deck
High Efficiency Electric Food warmer			$1,044	Each
High Efficiency Gas Rangetop	30% Efficiency	60% Efficiency	$500	Burner

Integrated Design

Comprehensive integrated design strategies applied to commercial buildings can have significant impacts of measure bundle costs. Measures designed as "load avoidance" strategies, such as efficient lighting, high performance glazing, cool roofs, demand-controlled ventilation, etc., can reduce the peak cooling loads and size of the mechanical systems. The cost savings resulting from downsizing HVAC systems in response to these load avoidance strategies can partially or in some cases completely offset the incremental costs of the measures. To account for these interactions in the measure bundle analysis, the peak HVAC system loads associated with each bundle were calculated by DOE-2, and cost savings resulting from HVAC system downsizing was estimated. The marginal costs of the HVAC systems as a function of capacity was estimated from the 2005 R. S. Means "Costworks" database. They include material, labor, and contractor mark-up costs for reductions in the size of primary equipment (chillers, boilers, cooling towers, etc.), secondary distribution equipment (air handlers, unitary packaged equipment, terminal units, pumps, etc., etc.), and distribution systems (duct work, piping, etc.). Incremental design costs required to calculate equipment size reductions were deducted from the HVAC size reduction credits, as shown in Table P-7.

Table P-7: HVAC Downsizing Credits

HVAC System Type	System sizing credit per ton
Packaged rooftop or split system	$2,000
Built-up system with water-cooled chiller	$2,960
Built-up system with air-cooled chiller	$2,630

Based on interviews with design assistance providers at AEC, design assistance costs that vary by building size were used, as shown in Table P-8.

Table P-8: Design Assistance Cost Assumptions

Building Size (SF)	Design Assistance Cost ($/SF)
<10,000	$1.00
10,000 - 50,000	$0.50
50,000 -100,000	$0.40
100,000 - 500,000	$0.20
500,000 -1,000,000	$0.10

Developing the Packages

The shell, lighting, mechanical, refrigeration, and food service equipment measures were applied to the full set of 996 buildings. Measures were introduced into the dataset to meet the energy savings targets relative to 2001 and 2005 Title 24. Energy savings for the 2001 code bundles were evaluated using total source energy savings for electricity and natural gas. Energy savings for the 2005 code bundles were evaluated using the time-dependent valuation (TDV) multipliers for electricity and natural gas applied to the hourly DOE-2 outputs. The measures used in each package are shown in Table P-9.

Table P-9: Measure Bundle Packages

Measure type	15% above 2001	25% above 2001	10% above 2005	15% above 2005
Lighting - LPD	X	X	X	X
Mechanical - HVAC efficiency	X	X	X	X
Mechanical - fan power		X		X
Envelope - walls and roofs		X		X
Envelope - windows	X	X	X	X
Refrigeration – display case measures		X		X
Refrigeration – condenser measures	X	X	X	X
Food service	X	X	X	X

Least-Cost Package Results

The energy savings in kWh and therms per year were calculated for the measure bundles in each CEC climate zone. Energy savings per year were derived by subtracting the energy usage of the building with the measure bundle installed from the common practice baseline energy usage per year. The following presents the cost and savings for reaching the targets under the 2001 Standards and the 2005 Standards separately. As explained above, the results were aggregated into four climate regions.

- **CNC Climate Zone 1:** CEC Title 24 Climate Zones 1-5, 16
- **CNC Climate Zone 2:** CEC Title 24 Climate Zones 6-7
- **CNC Climate Zone 3:** CEC Title 24 Climate Zones 8-10
- **CNC Climate Zone 4:** CEC Title 24 Climate Zones 11-15

2001 Standards

The incremental cost of each measure bundle (*Cost*), the compliance margin of the base case prototype (*Base Compliance*), and the compliance margin reached by adding the package to the base case prototype (*Package Compliance)* relative to the 2001 Standards, along with the electricity and natural gas savings for each climate zone group are shown in Table P-10 to Table P-17. Compliance margins for this set of runs were evaluated on a source energy basis. Common practices in commercial new construction are generally more efficient than the Title 24 energy standards, thus the energy savings relative to the common practice baseline are lower than the savings relative to the code baseline. In some cases, common practice was more efficient that the measure package efficiency, resulting in negative base compliance. Gas savings relative to the common practice baseline is negative in some buildings, due to heating interactions with measure packages designed primarily to save electricity. Incremental costs were calculated to include the costs of the measures and the credits available from downsizing HVAC systems in response to reduced peak cooling loads. In some cases, the HVAC downsizing credit exceeded the measure costs, resulting in negative incremental costs.

Table P-10: Energy Savings and Costs by Building Type – 15% Above 2001 Standards – Climate Zones 1-5 and 16

Building Type	Base Compliance	Package Compliance	Cost ($/SF)	Electricity Savings (kWh/SF)	Gas Savings (therm/SF)
College	2.4%	15.9%	$0.40	2.46	0.0120
Schools	7.7%	18.6%	$1.28	0.95	-0.0109
Grocery Stores	-0.3%	12.5%	$3.37	9.74	-0.0272
Health Care	1.9%	7.6%	$0.77	1.09	-0.0100
Lodging	-4.2%	13.5%	$0.62	4.68	0.0869
Large Office	4.5%	15.8%	-$1.00	1.58	0.0027
Misc.	5.7%	12.2%	$0.68	1.50	-0.0213
Restaurants	-1.0%	11.7%	$7.19	5.83	0.3475
Retail	12.5%	18.1%	$1.13	1.54	-0.0228
Small Office	4.8%	12.9%	$0.40	1.35	-0.0110
Warehouse	1.7%	8.4%	$0.39	0.99	-0.0059
All	**4.2%**	**13.8%**	**$0.00**	**1.61**	**-0.0023**

Table P-11: Energy Savings and Costs by Building Type – 15% Above 2001 Standards – Climate Zones 6-7

Building Type	Base Compliance	Package Compliance	Cost ($/SF)	Electricity Savings (kWh/SF)	Gas Savings (therm/SF)
College	4.3%	16.8%	$0.44	1.96	-0.0057
Schools	6.8%	17.3%	$0.12	1.19	-0.0114
Grocery Stores	0.9%	15.3%	$3.37	8.14	-0.0410
Health Care	3.2%	10.4%	$0.74	2.11	-0.0023
Lodging	0.1%	1.4%	$1.17	1.00	0.0000
Large Office	8.2%	18.7%	-$0.07	1.36	-0.0001
Misc.	5.5%	8.1%	$0.93	1.00	-0.0227
Restaurants	0.1%	11.2%	$17.06	8.17	0.8877
Retail	6.3%	16.6%	$1.31	2.02	-0.0057
Small Office	-1.1%	10.0%	-$0.19	2.57	0.0023
Warehouse	24.1%	26.5%	$0.45	0.06	-0.0003
All	**4.5%**	**12.7%**	**$0.64**	**1.58**	**-0.0010**

Table P-12: Energy Savings and Costs by Building Type – 15% Above 2001 Standards – Climate Zones 8-10

Building Type	Base Compliance	Package Compliance	Cost ($/SF)	Electricity Savings (kWh/SF)	Gas Savings (therm/SF)
College	8.6%	15.8%	$1.39	1.24	-0.0119
Schools	7.5%	19.9%	$3.49	1.35	-0.0082
Grocery Stores	1.0%	18.3%	$3.46	10.09	-0.0307
Health Care	-2.9%	13.6%	$1.31	2.20	-0.0030
Lodging	-7.4%	6.5%	$0.65	3.98	-0.0023
Large Office	8.7%	15.8%	$1.12	0.92	-0.0037
Misc.	6.0%	11.1%	$1.30	1.00	-0.0021
Restaurants	-1.9%	12.5%	$12.95	7.64	0.9303
Retail	11.6%	17.5%	$1.29	1.38	-0.0072
Small Office	-0.4%	12.8%	$2.39	2.06	-0.0034
Warehouse	9.7%	14.5%	$0.35	0.20	-0.0008
All	**6.5%**	**14.3%**	**$1.42**	**1.10**	**0.0015**

Table P-13: Energy Savings and Costs by Building Type – 15% Above 2001 Standards – Climate Zones 11-15

Building Type	Base Compliance	Package Compliance	Cost ($/SF)	Electricity Savings (kWh/SF)	Gas Savings (therm/SF)
College	1.9%	16.1%	$0.59	2.44	-0.0110
Schools	0.6%	14.1%	$0.94	1.68	-0.0183
Grocery Stores	2.0%	14.9%	$3.27	9.29	-0.0656
Health Care	7.3%	11.8%	$1.36	1.01	-0.0425
Lodging	-6.2%	6.3%	$1.01	3.54	-0.0037
Large Office	5.6%	12.6%	$0.78	0.99	-0.0121
Misc.	5.9%	11.5%	$1.28	1.13	-0.0185
Restaurants	-1.0%	7.5%	$6.03	5.58	0.1604
Retail	11.9%	16.1%	$1.73	1.25	-0.0257
Small Office	6.3%	16.7%	$0.98	1.45	-0.0105
Warehouse	18.1%	21.1%	$0.26	0.14	-0.0010
All	**7.0%**	**14.6%**	**$0.82**	**1.03**	**-0.0119**

Table P-14: Energy Savings and Costs by Building Type – 25% Above 2001 Standards – Climate Zones 1-5 and 16

Building Type	Base Compliance	Package Compliance	Cost ($/SF)	Electricity Savings (kWh/SF)	Gas Savings (therm/SF)
College	2.4%	24.4%	$0.45	3.24	0.0992
Schools	7.7%	22.4%	$0.66	1.07	0.0062
Grocery Stores	-0.3%	22.6%	$4.96	16.42	0.0492
Health Care	1.9%	14.5%	-$1.24	1.97	0.0234
Lodging	-4.2%	19.1%	$0.88	5.68	0.1605
Large Office	4.5%	22.0%	-$2.06	2.12	0.0388
Misc.	5.7%	19.7%	$0.53	2.35	0.0429
Restaurants	-1.0%	12.8%	$6.94	6.54	0.3611
Retail	12.5%	23.8%	$0.12	2.50	0.0135
Small Office	4.8%	21.7%	-$0.27	2.21	0.0406
Warehouse	1.7%	13.5%	$0.31	1.50	0.0129
All	**4.2%**	**20.4%**	**-$0.66**	**2.31**	**0.0381**

Table P-15: Energy Savings and Costs by Building Type – 25% Above 2001 Standards – Climate Zones 6-7

Building Type	Base Compliance	Package Compliance	Cost ($/SF)	Electricity Savings (kWh/SF)	Gas Savings (therm/SF)
College	4.3%	24.3%	$0.63	2.64	0.0429
Schools	6.8%	22.7%	-$0.33	1.49	0.0144
Grocery Stores	0.9%	31.7%	$3.78	16.35	0.0162
Health Care	3.2%	19.9%	-$0.14	4.62	0.0254
Lodging	0.1%	1.6%	$1.17	1.08	0.0000
Large Office	8.2%	25.5%	-$2.16	1.87	0.0382
Misc.	5.5%	13.9%	$0.05	2.23	0.0306
Restaurants	0.1%	12.1%	$16.47	9.34	0.9094
Retail	6.3%	22.3%	-$0.05	2.95	0.0101
Small Office	-1.1%	16.9%	-$4.38	4.09	0.0108
Warehouse	24.1%	37.5%	$0.26	0.34	0.0001
All	**4.5%**	**19.0%**	**-$0.95**	**2.55**	**0.0234**

Table P-16: Energy Savings and Costs by Building Type – 25% Above 2001 Standards – Climate Zones 8-10

Building Type	Base Compliance	Package Compliance	Cost ($/SF)	Electricity Savings (kWh/SF)	Gas Savings (therm/SF)
College	8.6%	23.2%	-$0.43	2.09	0.0173
Schools	7.5%	25.9%	-$1.71	1.84	0.0037
Grocery Stores	1.0%	32.3%	$3.81	17.70	-0.0007
Health Care	-2.9%	27.2%	$0.07	3.89	0.0080
Lodging	-7.4%	11.8%	$0.77	5.39	0.0061
Large Office	8.7%	22.6%	-$1.64	1.62	0.0111
Misc.	6.0%	18.4%	$0.58	1.93	0.0465
Restaurants	-1.9%	14.1%	$13.85	9.48	0.9356
Retail	11.6%	23.5%	-$0.38	2.60	0.0041
Small Office	-0.4%	19.1%	$0.28	2.94	0.0061
Warehouse	9.7%	17.8%	$0.07	0.30	0.0030
All	**6.5%**	**20.6%**	**-$0.23**	**1.82**	**0.0203**

Table P-17: Energy Savings and Costs by Building Type – 25% Above 2001 Standards – Climate Zones 11-15

Building Type	Base Compliance	Package Compliance	Cost ($/SF)	Electricity Savings (kWh/SF)	Gas Savings (therm/SF)
College	1.9%	23.9%	$0.70	3.47	0.0150
Schools	0.6%	19.0%	$0.90	2.04	0.0015
Grocery Stores	2.0%	28.4%	$4.15	17.44	0.0309
Health Care	7.3%	24.6%	$0.31	1.89	0.0424
Lodging	-6.2%	10.6%	$0.87	4.68	0.0029
Large Office	5.6%	18.4%	-$0.06	1.47	0.0128
Misc.	5.9%	19.2%	$0.84	2.02	0.0235
Restaurants	-1.0%	8.9%	$5.73	6.72	0.1642
Retail	11.9%	22.1%	-$0.78	2.33	0.0116
Small Office	6.3%	22.1%	$0.42	1.98	0.0075
Warehouse	18.1%	25.1%	$0.26	0.29	0.0006
All	**7.0%**	**21.4%**	**$0.38**	**1.63**	**0.0092**

2005 Standards

The incremental cost of each measure bundles (*Cost*), the compliance margin of the base case prototype (*Base Compliance*), and the compliance margin reached by adding the package to the base case prototype (*Package Compliance)* relative to the 2005 Standards, along with the electricity and natural gas savings for each climate zone group are shown in Table P-18 to Table P-25. Compliance margins for this set of runs were evaluated on a TDV basis.

Table P-18: Energy Savings and Costs by Building Type – 10% Above 2005 Standards – Climate Zones 1-5 and 16

Building Type	Base Compliance	Package Compliance	Cost ($/SF)	Electricity Savings (kWh/SF)	Gas Savings (therm/SF)
College	-1.1%	12.2%	$0.37	2.18	0.0120
Schools	-1.9%	8.7%	$1.27	0.74	-0.0103
Grocery Stores	0.5%	9.0%	$1.66	6.02	-0.0331
Health Care	-0.3%	5.8%	$0.82	1.04	-0.0106
Lodging	-6.7%	13.8%	$0.62	4.55	0.0918
Large Office	1.8%	13.8%	-$1.02	1.53	0.0030
Misc.	1.6%	9.5%	$0.65	1.44	-0.0165
Restaurants	-2.2%	10.0%	$7.15	5.70	0.3489
Retail	4.9%	12.3%	$1.11	1.56	-0.0112
Small Office	2.0%	10.5%	$0.39	1.25	-0.0109
Warehouse	-0.1%	6.4%	$0.40	0.90	-0.0066
All	**1.2%**	**11.2%**	**-$0.03**	**1.49**	**-0.0010**

Table P-19: Energy Savings and Costs by Building Type – 10% Above 2005 Standards – Climate Zones 6-7

Building Type	Base Compliance	Package Compliance	Cost ($/SF)	Electricity Savings (kWh/SF)	Gas Savings (therm/SF)
College	-0.5%	12.1%	$0.43	1.72	-0.0056
Schools	-0.9%	10.6%	$0.19	1.02	-0.0107
Grocery Stores	0.2%	9.6%	$2.13	4.77	-0.0406
Health Care	1.5%	10.2%	$0.46	2.11	-0.0027
Lodging	0.1%	1.4%	$1.17	1.00	0.0000
Large Office	5.0%	15.6%	-$0.13	1.17	0.0000
Misc.	2.4%	5.5%	$0.95	0.98	-0.0206
Restaurants	-0.9%	8.8%	$17.03	8.13	0.8915
Retail	0.2%	11.8%	$1.28	1.99	-0.0048
Small Office	-3.6%	8.3%	-$0.42	2.56	0.0007
Warehouse	17.1%	18.4%	$0.46	0.02	-0.0003
All	**0.7%**	**9.4%**	**$0.58**	**1.49**	**-0.0007**

Table P-20: Energy Savings and Costs by Building Type – 10% Above 2005 Standards – Climate Zones 8-10

Building Type	Base Compliance	Package Compliance	Cost ($/SF)	Electricity Savings (kWh/SF)	Gas Savings (therm/SF)
College	2.3%	10.1%	$1.44	1.07	-0.0119
Schools	-0.7%	10.2%	$3.82	0.96	-0.0084
Grocery Stores	0.8%	11.7%	$1.95	5.91	-0.0443
Health Care	-6.2%	10.5%	$1.21	2.00	-0.0035
Lodging	-8.3%	5.5%	$0.64	3.52	-0.0011
Large Office	5.2%	12.5%	$1.14	0.83	-0.0047
Misc.	3.1%	8.4%	$1.30	0.95	-0.0037
Restaurants	-3.5%	9.7%	$12.97	7.42	0.9363
Retail	4.8%	11.2%	$1.30	1.27	-0.0055
Small Office	-4.0%	9.2%	$2.53	1.85	-0.0026
Warehouse	7.9%	12.5%	$0.35	0.18	-0.0008
All	**2.5%**	**10.1%**	**$1.47**	**0.96**	**0.0012**

Table P-21: Energy Savings and Costs by Building Type – 10% Above 2005 Standards – Climate Zones 11-15

Building Type	Base Compliance	Package Compliance	Cost ($/SF)	Electricity Savings (kWh/SF)	Gas Savings (therm/SF)
College	-4.4%	9.7%	$0.57	2.14	-0.0102
Schools	-7.4%	6.9%	$0.94	1.48	-0.0179
Grocery Stores	1.2%	9.4%	$1.90	5.75	-0.0844
Health Care	1.6%	7.6%	$1.36	0.95	-0.0418
Lodging	-7.6%	4.5%	$1.09	3.12	-0.0020
Large Office	3.4%	10.8%	$0.78	0.96	-0.0129
Misc.	2.4%	7.2%	$1.31	0.82	-0.0181
Restaurants	-2.7%	5.9%	$5.99	5.41	0.1681
Retail	5.7%	10.5%	$1.72	1.19	-0.0265
Small Office	1.0%	12.9%	$1.00	1.45	-0.0102
Warehouse	16.0%	17.8%	$0.26	0.08	-0.0011
All	**3.0%**	**10.3%**	**$0.80**	**0.86**	**-0.0123**

Table P-22: Energy Savings and Costs by Building Type – 15% Above 2005 Standards – Climate Zones 1-5 and 16

Building Type	Base Compliance	Package Compliance	Cost ($/SF)	Electricity Savings (kWh/SF)	Gas Savings (therm/SF)
College	-1.1%	19.4%	$0.49	2.88	0.0971
Schools	-1.9%	12.0%	$0.69	0.83	0.0072
Grocery Stores	0.5%	14.0%	$3.34	9.42	-0.0126
Health Care	-0.3%	12.1%	-$0.97	1.83	0.0237
Lodging	-6.7%	19.3%	$0.91	5.47	0.1634
Large Office	1.8%	19.2%	-$1.99	2.01	0.0386
Misc.	1.6%	16.3%	$0.52	2.18	0.0499
Restaurants	-2.2%	11.2%	$7.00	6.33	0.3601
Retail	4.9%	17.4%	$0.18	2.41	0.0090
Small Office	2.0%	18.1%	-$0.21	1.96	0.0420
Warehouse	-0.1%	11.4%	$0.32	1.37	0.0195
All	**1.2%**	**16.9%**	**-$0.63**	**2.08**	**0.0391**

Table P-23: Energy Savings and Costs by Building Type – 15% Above 2005 Standards – Climate Zones 6-7

Building Type	Base Compliance	Package Compliance	Cost ($/SF)	Electricity Savings (kWh/SF)	Gas Savings (therm/SF)
College	-0.5%	18.0%	$0.62	2.23	0.0419
Schools	-0.9%	14.7%	-$0.23	1.26	0.0127
Grocery Stores	0.2%	19.7%	$2.61	9.41	0.0046
Health Care	1.5%	18.3%	-$0.58	3.97	0.0228
Lodging	0.1%	1.6%	$1.17	1.08	0.0000
Large Office	5.0%	21.4%	-$2.04	1.62	0.0382
Misc.	2.4%	9.6%	$0.11	1.89	0.0287
Restaurants	-0.9%	9.9%	$16.49	9.34	0.9054
Retail	0.2%	17.2%	-$0.06	2.80	0.0109
Small Office	-3.6%	14.4%	-$4.30	3.85	0.0040
Warehouse	17.1%	30.2%	$0.27	0.29	0.0001
All	**0.7%**	**14.6%**	**-$0.91**	**2.28**	**0.0217**

Table P-24: Energy Savings and Costs by Building Type – 15% Above 2005 Standards – Climate Zones 8-10

Building Type	Base Compliance	Package Compliance	Cost ($/SF)	Electricity Savings (kWh/SF)	Gas Savings (therm/SF)
College	2.3%	18.1%	-$0.36	1.84	0.0213
Schools	-0.7%	16.3%	-$1.50	1.40	0.0042
Grocery Stores	0.8%	21.5%	$2.92	10.88	-0.0258
Health Care	-6.2%	22.7%	$0.24	3.45	0.0090
Lodging	-8.3%	10.4%	$0.76	4.74	0.0074
Large Office	5.2%	19.4%	-$1.64	1.46	0.0125
Misc.	3.1%	15.0%	$0.55	1.85	0.0460
Restaurants	-3.5%	11.7%	$13.75	9.15	0.9391
Retail	4.8%	17.4%	-$0.36	2.36	0.0039
Small Office	-4.0%	15.6%	$0.46	2.68	0.0065
Warehouse	7.9%	15.4%	$0.09	0.26	0.0029
All	**2.5%**	**16.2%**	**-$0.20**	**1.61**	**0.0203**

Table P-25: Energy Savings and Costs by Building Type – 15% Above 2005 Standards – Climate Zones 11-15

Building Type	Base Compliance	Package Compliance	Cost ($/SF)	Electricity Savings (kWh/SF)	Gas Savings (therm/SF)
College	-4.4%	17.3%	$0.69	3.07	0.0145
Schools	-7.4%	11.8%	$0.86	1.80	0.0023
Grocery Stores	1.2%	18.2%	$3.09	10.84	-0.0120
Health Care	1.6%	19.4%	$0.32	1.79	0.0427
Lodging	-7.6%	8.8%	$0.97	4.20	0.0044
Large Office	3.4%	16.8%	-$0.08	1.44	0.0131
Misc.	2.4%	15.1%	$0.86	1.67	0.0253
Restaurants	-2.7%	7.4%	$5.74	6.48	0.1698
Retail	5.7%	17.0%	-$0.80	2.26	0.0151
Small Office	1.0%	18.1%	$0.45	1.94	0.0079
Warehouse	16.0%	21.7%	$0.26	0.23	0.0006
All	**3.0%**	**16.6%**	**$0.36**	**1.39**	**0.0090**

P.3 Development of ASSET Commercial New Construction Model Inputs

Awareness

The analysis used the awareness of 100% for all units built under the 2001 standards. Because of the Standards change in 2005, an awareness of 80% was used starting in 2006 for high efficiency units built under the 2005 standards, which then increases by 5% each year. Awareness is defined such that the percent aware is the share of decision makers within the feasible market who have been exposed to a technology and have formed an opinion about the operating characteristics of that option.

Commercial New Construction
Awareness

Segment	Area	Tech	Awareness	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
COL	All	COL_01_00	1	1.00	1.00	1.00	1.00																														
COL	All	COL_01_15	1	1.00	1.00	1.00	1.00																														
COL	All	COL_01_25	1	1.00	1.00	1.00	1.00																														
COL	All	COL_05_00	1	1.00	1.00	1.00	1.00																														
COL	All	COL_05_10	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
COL	All	COL_05_15	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
GRC	All	GRC_01_00	1	1.00	1.00	1.00	1.00																														
GRC	All	GRC_01_15	1	1.00	1.00	1.00	1.00																														
GRC	All	GRC_01_25	1	1.00	1.00	1.00	1.00																														
GRC	All	GRC_05_00	1	1.00	1.00	1.00	1.00																														
GRC	All	GRC_05_10	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
GRC	All	GRC_05_15	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
HLT	All	HLT_01_00	1	1.00	1.00	1.00	1.00																														
HLT	All	HLT_01_15	1	1.00	1.00	1.00	1.00																														
HLT	All	HLT_01_25	1	1.00	1.00	1.00	1.00																														
HLT	All	HLT_05_00	1	1.00	1.00	1.00	1.00																														
HLT	All	HLT_05_10	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
HLT	All	HLT_05_15	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
LDG	All	LDG_01_00	1	1.00	1.00	1.00	1.00																														
LDG	All	LDG_01_15	1	1.00	1.00	1.00	1.00																														
LDG	All	LDG_01_25	1	1.00	1.00	1.00	1.00																														
LDG	All	LDG_05_00	1	1.00	1.00	1.00	1.00																														
LDG	All	LDG_05_10	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
LDG	All	LDG_05_15	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
MSC	All	MSC_01_00	1	1.00	1.00	1.00	1.00																														
MSC	All	MSC_01_15	1	1.00	1.00	1.00	1.00																														
MSC	All	MSC_01_25	1	1.00	1.00	1.00	1.00																														
MSC	All	MSC_05_00	1	1.00	1.00	1.00	1.00																														
MSC	All	MSC_05_10	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
MSC	All	MSC_05_15	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
LGO	All	LGO_01_00	1	1.00	1.00	1.00	1.00																														
LGO	All	LGO_01_15	1	1.00	1.00	1.00	1.00																														
LGO	All	LGO_01_25	1	1.00	1.00	1.00	1.00																														
LGO	All	LGO_05_00	1	1.00	1.00	1.00	1.00																														
LGO	All	LGO_05_10	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
LGO	All	LGO_05_15	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
SMO	All	SMO_01_00	1	1.00	1.00	1.00	1.00																														
SMO	All	SMO_01_15	1	1.00	1.00	1.00	1.00																														
SMO	All	SMO_01_25	1	1.00	1.00	1.00	1.00																														
SMO	All	SMO_05_00	1	1.00	1.00	1.00	1.00																														
SMO	All	SMO_05_10	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
SMO	All	SMO_05_15	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
RST	All	RST_01_00	1	1.00	1.00	1.00	1.00																														
RST	All	RST_01_15	1	1.00	1.00	1.00	1.00																														
RST	All	RST_01_25	1	1.00	1.00	1.00	1.00																														
RST	All	RST_05_00	1	1.00	1.00	1.00	1.00																														
RST	All	RST_05_10	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
RST	All	RST_05_15	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
RET	All	RET_01_00	1	1.00	1.00	1.00	1.00																														
RET	All	RET_01_15	1	1.00	1.00	1.00	1.00																														
RET	All	RET_01_25	1	1.00	1.00	1.00	1.00																														
RET	All	RET_05_00	1	1.00	1.00	1.00	1.00																														
RET	All	RET_05_10	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
RET	All	RET_05_15	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
SCH	All	SCH_01_00	1	1.00	1.00	1.00	1.00																														
SCH	All	SCH_01_15	1	1.00	1.00	1.00	1.00																														
SCH	All	SCH_01_25	1	1.00	1.00	1.00	1.00																														
SCH	All	SCH_05_00	1	1.00	1.00	1.00	1.00																														
SCH	All	SCH_05_10	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
SCH	All	SCH_05_15	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
WRH	All	WRH_01_00	1	1.00	1.00	1.00	1.00																														
WRH	All	WRH_01_15	1	1.00	1.00	1.00	1.00																														
WRH	All	WRH_01_25	1	1.00	1.00	1.00	1.00																														
WRH	All	WRH_05_00	1	1.00	1.00	1.00	1.00																														
WRH	All	WRH_05_10	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
WRH	All	WRH_05_15	Aware05					0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90

Willingness, Feasibility, Technology Density, and Applicability

The analysis used a willingness and feasibility factor of 100%. The technology density and applicability used were 1.

Commercial New Construction Floor Stock

The following tables contain the floorstock by utility, climate zone, and building type. The floorstock forecast was provided courtesy of the CEC and is dated March 2004.

PG&E Commercial New Construction
Floorstock

Utility	Title 24 Climate Zone	Segment	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
PG&E	1	COL	44,624	48,699	48,089	50,104	51,388	52,712	54,099	51,312	52,810	54,368	55,953	57,539	54,347	54,388	54,901
PG&E	1	GRC	51,991	52,897	55,815	60,132	61,127	62,040	62,892	61,976	62,595	63,160	63,546	63,817	62,998	63,015	63,188
PG&E	1	HLT	50,140	50,378	50,851	51,365	51,895	52,426	52,982	53,548	54,119	54,719	55,310	55,876	54,426	54,666	54,853
PG&E	1	LDG	60,589	60,425	61,176	61,659	62,061	62,347	62,540	62,245	61,893	61,514	61,070	60,568	61,638	61,488	61,362
PG&E	1	MSC	234,487	246,952	242,266	254,918	260,739	265,950	270,593	258,090	261,291	263,793	265,434	266,195	264,233	263,173	264,020
PG&E	1	LGO	183,545	201,164	193,502	197,883	200,881	203,550	205,956	190,097	191,818	193,332	194,390	195,096	195,115	193,308	193,843
PG&E	1	SMO	62,032	68,725	71,865	77,560	78,466	79,266	80,020	76,253	76,943	77,639	78,331	79,008	78,032	77,701	77,942
PG&E	1	RST	44,420	32,601	33,447	36,528	37,502	38,379	39,169	37,901	38,457	38,893	39,179	39,315	38,819	38,761	38,904
PG&E	1	RET	193,339	196,782	201,795	202,149	205,081	207,745	210,144	205,775	207,361	208,747	209,481	209,791	208,550	208,284	208,702
PG&E	1	SCH	70,408	72,766	69,697	71,438	73,325	75,324	77,470	79,731	82,106	84,616	87,177	89,789	83,482	84,483	85,276
PG&E	1	WRH	156,581	171,238	164,499	154,616	155,149	156,104	157,280	152,832	153,541	154,735	154,693	154,574	154,609	154,164	154,386
PG&E	2	COL	157,279	172,157	170,459	178,053	182,994	188,117	193,477	183,876	189,640	195,539	201,563	207,632	195,288	195,590	197,542
PG&E	2	GRC	183,243	186,996	197,845	213,691	217,674	221,405	224,922	222,092	224,780	227,163	228,916	230,285	226,360	226,599	227,350
PG&E	2	HLT	176,722	178,091	180,249	182,536	184,801	187,094	189,479	191,893	194,343	196,803	199,247	201,629	195,565	196,580	197,361
PG&E	2	LDG	213,548	213,608	216,850	219,118	221,002	222,500	223,662	223,057	222,257	221,243	220,000	218,563	221,463	221,097	220,771
PG&E	2	MSC	826,458	873,005	858,754	905,899	928,502	949,106	967,726	924,872	938,302	948,760	956,195	960,574	949,405	946,351	949,931
PG&E	2	LGO	646,909	711,139	685,901	703,215	715,346	726,415	736,565	681,218	688,822	695,337	700,267	704,010	701,036	695,115	697,431
PG&E	2	SMO	218,635	242,951	254,739	275,625	279,422	282,878	286,178	273,257	276,304	279,238	282,179	285,102	280,376	279,409	280,435
PG&E	2	RST	156,558	115,249	118,560	129,807	133,548	136,965	140,081	135,820	138,100	139,881	141,137	141,870	139,481	139,381	139,975
PG&E	2	RET	681,428	695,650	715,297	718,376	730,303	741,386	751,541	737,402	744,635	750,781	754,632	757,037	749,338	748,971	750,899
PG&E	2	SCH	248,155	257,238	247,054	253,867	261,113	268,810	277,058	285,719	294,845	304,330	314,046	324,006	300,001	303,824	306,842
PG&E	2	WRH	551,875	605,348	583,096	549,456	552,493	557,096	562,485	547,677	551,367	556,521	557,265	557,784	555,516	554,355	555,468
PG&E	3a	COL	407,248	442,824	435,709	452,156	462,045	472,456	483,348	457,066	469,223	481,763	494,573	507,428	482,234	482,048	486,211
PG&E	3a	GRC	474,476	480,995	505,711	542,657	549,611	556,061	561,906	552,060	556,169	559,675	561,690	562,787	559,048	558,571	559,657
PG&E	3a	HLT	457,591	458,089	460,734	463,540	466,609	469,888	473,361	476,992	480,859	484,876	488,890	492,756	482,956	484,555	485,815
PG&E	3a	LDG	552,947	549,447	554,289	556,439	558,012	558,810	558,757	554,457	549,927	545,091	539,811	534,140	547,030	545,076	543,513
PG&E	3a	MSC	2,139,975	2,245,557	2,195,057	2,300,482	2,344,394	2,383,690	2,417,597	2,298,976	2,321,622	2,337,520	2,346,207	2,347,525	2,344,908	2,332,793	2,338,429
PG&E	3a	LGO	1,675,062	1,829,203	1,753,230	1,785,777	1,806,194	1,824,398	1,840,103	1,693,318	1,704,339	1,713,146	1,718,238	1,720,513	1,731,610	1,713,527	1,716,896
PG&E	3a	SMO	566,119	624,923	651,138	699,935	705,518	710,450	714,936	679,241	683,653	687,976	692,379	696,753	692,490	688,749	690,333
PG&E	3a	RST	405,381	296,445	303,050	329,639	337,198	343,990	349,953	337,610	341,699	344,634	346,307	346,712	344,486	343,574	344,569
PG&E	3a	RET	1,764,443	1,789,364	1,828,368	1,824,278	1,843,959	1,861,997	1,877,519	1,832,977	1,842,436	1,849,747	1,851,633	1,850,104	1,850,736	1,846,272	1,848,488
PG&E	3a	SCH	642,557	661,672	631,494	644,683	659,291	675,118	692,152	710,219	729,528	749,796	770,571	791,832	740,683	748,772	755,197
PG&E	3a	WRH	1,428,987	1,557,085	1,490,450	1,395,316	1,395,000	1,399,151	1,405,214	1,361,373	1,364,235	1,371,136	1,367,357	1,363,155	1,372,078	1,366,556	1,367,420
PG&E	3b	COL	166,341	180,872	177,966	184,684	188,723	192,975	197,424	186,689	191,654	196,776	202,009	207,259	196,969	196,893	198,593
PG&E	3b	GRC	193,800	196,463	206,558	221,649	224,489	227,124	229,511	225,489	227,167	228,600	229,423	229,871	228,343	228,149	228,592
PG&E	3b	HLT	186,903	187,107	188,187	189,333	190,587	191,926	193,345	194,828	196,407	198,048	199,687	201,267	197,264	197,917	198,431
PG&E	3b	LDG	225,852	224,422	226,400	227,278	227,920	228,246	228,225	226,468	224,618	222,643	220,486	218,170	223,435	222,637	221,998
PG&E	3b	MSC	874,074	917,199	896,572	939,634	957,570	973,620	987,469	939,018	948,268	954,762	958,310	958,848	957,779	952,831	955,133
PG&E	3b	LGO	684,180	747,139	716,108	729,402	737,741	745,177	751,592	691,637	696,139	699,736	701,815	702,745	707,277	699,891	701,267
PG&E	3b	SMO	231,232	255,250	265,958	285,889	288,169	290,184	292,016	277,436	279,239	281,004	282,803	284,589	282,848	281,320	281,967
PG&E	3b	RST	165,578	121,083	123,781	134,641	137,729	140,503	142,939	137,897	139,567	140,766	141,449	141,615	140,705	140,333	140,739
PG&E	3b	RET	720,688	730,867	746,798	745,128	753,166	760,534	766,874	748,681	752,544	755,530	756,301	755,676	755,934	754,111	755,016
PG&E	3b	SCH	262,453	270,260	257,934	263,321	269,288	275,753	282,710	290,089	297,976	306,255	314,740	323,424	302,533	305,836	308,461
PG&E	3b	WRH	583,671	635,993	608,775	569,918	569,789	571,484	573,961	556,054	557,223	560,041	558,498	556,782	560,426	558,171	558,523

PG&E Commercial New Construction
Floorstock

Utility	Title 24 Climate Zone	Segment	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
PG&E	4	COL	278,278	303,471	299,339	311,189	318,483	326,264	334,382	316,719	325,482	334,365	343,434	352,553	334,489	334,507	337,472
PG&E	4	GRC	324,216	329,630	347,432	373,475	378,842	383,998	388,728	382,544	385,793	388,439	390,039	391,016	387,760	387,599	388,441
PG&E	4	HLT	312,678	313,932	316,532	319,024	321,629	324,490	327,473	330,526	333,554	336,525	339,487	342,359	334,987	336,240	337,192
PG&E	4	LDG	377,836	376,540	380,806	382,960	384,632	385,897	386,550	384,205	381,464	378,317	374,847	371,112	379,416	378,227	377,230
PG&E	4	MSC	1,462,273	1,538,899	1,508,040	1,583,270	1,615,969	1,646,101	1,672,502	1,593,052	1,610,421	1,622,342	1,629,215	1,631,025	1,626,426	1,618,747	1,623,029
PG&E	4	LGO	1,144,592	1,253,568	1,204,498	1,229,032	1,244,992	1,259,872	1,272,990	1,173,367	1,182,235	1,188,999	1,193,151	1,195,386	1,201,021	1,189,027	1,191,637
PG&E	4	SMO	386,836	428,265	447,343	481,719	486,307	490,615	494,595	470,673	474,224	477,486	480,791	484,093	480,310	477,930	479,139
PG&E	4	RST	277,002	203,156	208,200	226,869	232,428	237,548	242,099	233,943	237,023	239,191	240,477	240,890	238,937	238,410	239,155
PG&E	4	RET	1,205,667	1,226,265	1,256,119	1,255,530	1,271,023	1,285,837	1,298,874	1,270,143	1,278,028	1,283,806	1,285,781	1,285,424	1,283,676	1,281,143	1,282,976
PG&E	4	SCH	439,067	453,449	433,847	443,693	454,443	466,216	478,833	492,139	506,046	520,392	535,088	550,153	513,775	519,599	524,175
PG&E	4	WRH	976,446	1,067,083	1,023,964	960,304	961,560	966,210	972,131	943,349	946,318	951,629	949,498	947,099	951,671	948,261	949,079
PG&E	5	COL	62,982	69,399	69,149	72,647	75,264	77,999	80,865	77,454	80,493	83,768	87,141	90,585	83,384	83,804	84,862
PG&E	5	GRC	73,379	75,381	80,258	87,188	89,528	91,801	94,008	93,552	95,408	97,315	98,966	100,468	96,619	97,055	97,638
PG&E	5	HLT	70,767	71,791	73,120	74,476	76,008	77,575	79,195	80,831	82,489	84,309	86,139	87,966	83,488	84,204	84,766
PG&E	5	LDG	85,514	86,108	87,968	89,402	90,897	92,255	93,481	93,958	94,337	94,779	95,111	95,354	94,503	94,674	94,793
PG&E	5	MSC	330,951	351,920	348,364	369,614	381,887	393,527	404,470	389,585	398,263	406,441	413,386	419,076	405,203	405,326	407,949
PG&E	5	LGO	259,052	286,670	278,244	286,917	294,217	301,193	307,854	286,950	292,371	297,877	302,742	307,143	299,156	297,706	299,499
PG&E	5	SMO	87,551	97,937	103,338	112,457	114,924	117,289	119,610	115,104	117,277	119,623	121,993	124,383	119,665	119,674	120,436
PG&E	5	RST	62,693	46,458	48,095	52,963	54,927	56,790	58,548	57,211	58,617	59,924	61,017	61,894	59,535	59,700	60,114
PG&E	5	RET	272,875	280,426	290,169	293,103	300,369	307,400	314,113	310,617	316,061	321,628	326,245	330,277	319,824	320,775	322,468
PG&E	5	SCH	99,373	103,696	100,221	103,580	107,394	111,456	115,799	120,354	125,147	130,372	135,770	141,356	128,133	130,189	131,828
PG&E	5	WRH	220,996	244,024	236,540	224,183	227,237	230,988	235,096	230,699	234,028	238,409	240,919	243,348	237,083	237,414	238,533
PG&E	11	COL	112,631	124,796	125,011	132,056	137,066	142,281	147,725	141,672	147,366	153,097	158,982	164,948	152,298	153,060	154,959
PG&E	11	GRC	131,224	135,553	145,096	158,488	163,042	167,459	171,735	171,116	174,673	177,856	180,557	182,943	176,480	177,271	178,297
PG&E	11	HLT	126,555	129,097	132,192	135,381	138,419	141,508	144,673	147,848	151,021	154,086	157,155	160,178	152,493	153,797	154,788
PG&E	11	LDG	152,927	154,844	159,034	162,513	165,534	168,287	170,772	171,859	172,712	173,221	173,524	173,631	172,620	172,928	173,106
PG&E	11	LGO	463,267	515,501	503,028	521,552	535,807	549,421	562,389	524,859	535,272	544,411	552,332	559,281	546,424	543,763	546,914
PG&E	11	MSC	591,846	632,837	629,795	671,877	695,464	717,852	738,888	712,588	729,138	742,827	754,195	763,102	740,123	740,329	744,952
PG&E	11	RET	487,987	504,274	524,587	532,797	547,010	560,744	573,824	568,147	578,643	587,820	595,213	601,407	584,176	585,901	588,860
PG&E	11	RST	112,115	83,544	86,950	96,274	100,030	103,593	106,956	104,645	107,315	109,519	111,321	112,704	108,744	109,041	109,774
PG&E	11	SCH	177,710	186,471	181,185	188,285	195,578	203,313	211,542	220,139	229,119	238,273	247,702	257,398	234,029	237,777	240,716
PG&E	11	SMO	156,570	176,114	186,822	204,422	209,292	213,953	218,505	210,537	214,711	218,628	222,567	226,491	218,573	218,584	219,926
PG&E	11	WRH	395,211	438,814	427,633	407,515	413,827	421,357	429,474	421,970	428,457	435,725	439,541	443,116	433,047	433,643	435,588
PG&E	12	COL	423,705	465,313	462,202	484,191	499,844	516,287	533,473	509,404	527,791	546,767	566,255	586,001	544,948	546,861	553,104
PG&E	12	GRC	493,649	505,422	536,461	581,104	594,574	607,648	620,178	615,275	625,589	635,192	643,099	649,933	631,544	633,439	636,466
PG&E	12	HLT	476,082	481,352	488,750	496,382	504,781	513,480	522,451	531,611	540,879	550,299	559,747	569,057	545,674	549,545	552,534
PG&E	12	LDG	575,291	577,350	587,993	595,863	603,662	610,651	616,702	617,946	618,569	618,640	618,049	616,849	617,792	617,974	617,979
PG&E	12	LGO	1,742,750	1,922,096	1,859,836	1,912,298	1,953,955	1,993,650	2,030,929	1,887,217	1,917,073	1,944,299	1,967,273	1,986,927	1,955,620	1,943,068	1,952,377
PG&E	12	MSC	2,226,450	2,359,595	2,328,529	2,463,470	2,536,185	2,604,827	2,668,311	2,562,227	2,611,404	2,652,919	2,686,258	2,711,029	2,648,691	2,645,421	2,659,287
PG&E	12	RET	1,835,744	1,880,234	1,939,543	1,953,527	1,994,810	2,034,737	2,072,224	2,042,868	2,072,407	2,099,331	2,120,002	2,136,585	2,090,570	2,093,627	2,102,087
PG&E	12	RST	421,762	311,500	321,477	352,994	364,784	375,902	386,244	376,269	384,349	391,135	396,499	400,399	389,149	389,633	391,861
PG&E	12	SCH	668,522	695,274	669,893	690,359	713,226	737,750	763,930	791,545	820,587	850,966	882,255	914,443	837,288	849,514	859,176
PG&E	12	SMO	588,995	656,659	690,731	749,525	763,235	776,359	789,077	757,019	768,986	780,803	792,730	804,642	782,210	781,065	785,073
PG&E	12	WRH	1,486,732	1,636,160	1,581,078	1,494,173	1,509,123	1,528,952	1,550,939	1,517,261	1,534,518	1,556,142	1,565,537	1,574,234	1,549,772	1,549,577	1,554,963

PG&E Commercial New Construction
Floorstock

Utility	Title 24 Climate Zone	Segment	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
PG&E	13	COL	219,258	241,510	240,657	252,898	261,815	271,319	281,316	269,642	280,469	291,732	303,391	315,327	290,313	291,812	295,507
PG&E	13	GRC	255,454	262,328	279,321	303,516	311,434	319,331	327,039	325,683	332,439	338,912	344,563	349,728	336,394	337,953	339,998
PG&E	13	HLT	246,363	249,835	254,479	259,265	264,401	269,844	275,504	281,397	287,424	293,617	299,904	306,209	290,676	293,205	295,172
PG&E	13	LDG	297,702	299,660	306,153	311,225	316,194	320,910	325,205	327,097	328,709	330,080	331,141	331,926	329,026	329,663	330,091
PG&E	13	LGO	901,838	997,620	968,368	998,812	1,023,469	1,047,703	1,070,970	998,959	1,018,737	1,037,397	1,054,035	1,069,163	1,041,544	1,036,639	1,042,919
PG&E	13	MSC	1,152,143	1,224,694	1,212,404	1,286,695	1,328,437	1,368,889	1,407,081	1,356,262	1,387,706	1,415,487	1,439,256	1,458,802	1,410,766	1,411,380	1,420,566
PG&E	13	RET	949,960	975,893	1,009,870	1,020,346	1,044,868	1,069,295	1,092,746	1,081,350	1,101,282	1,120,116	1,135,865	1,149,694	1,113,509	1,116,969	1,122,906
PG&E	13	RST	218,253	161,677	167,385	184,372	191,072	197,544	203,678	199,170	204,244	208,693	212,438	215,454	207,280	207,880	209,332
PG&E	13	SCH	345,947	360,866	348,796	360,581	373,583	387,702	402,844	418,988	436,062	454,040	472,699	492,061	446,115	453,327	459,051
PG&E	13	SMO	304,793	340,824	359,646	391,484	399,777	407,992	416,104	400,712	408,641	416,604	424,733	432,977	416,629	416,716	419,383
PG&E	13	WRH	769,354	849,211	823,226	780,421	790,469	803,495	817,857	803,131	815,446	830,293	838,791	847,094	825,435	826,698	830,626

SCE/SoCalGas Commercial New Construction
Floorstock

Utility	Title 24 Climate Zone	Segment	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
SCE/SoCalGas	6	COL	288,391	276,537	274,312	272,278	270,108	254,711	255,206	269,946	275,439	280,281	286,191	260,120	271,197	273,862	274,515
SCE/SoCalGas	6	GRC	494,328	497,885	494,588	494,981	485,148	464,336	468,675	485,865	487,548	490,680	492,107	462,539	481,236	483,329	482,906
SCE/SoCalGas	6	HLT	422,628	427,465	399,679	416,908	435,508	397,865	457,188	473,309	616,288	629,505	684,768	579,240	573,383	592,749	612,656
SCE/SoCalGas	6	LDG	452,503	430,433	420,507	431,547	414,761	372,625	371,226	402,541	403,990	405,393	411,458	350,105	390,785	394,045	392,629
SCE/SoCalGas	6	LGO	2,613,245	2,543,231	2,477,654	2,461,436	2,384,437	2,428,807	2,552,442	2,555,451	2,644,366	2,714,518	2,816,175	2,801,949	2,680,817	2,702,213	2,726,673
SCE/SoCalGas	6	MSC	1,540,343	1,544,691	1,542,123	1,548,376	1,542,506	1,511,695	1,491,413	1,500,398	1,510,661	1,522,009	1,535,502	1,507,843	1,511,304	1,514,619	1,516,990
SCE/SoCalGas	6	RET	1,807,224	1,708,279	1,680,261	1,725,015	1,668,156	1,488,574	1,512,856	1,687,210	1,710,860	1,732,219	1,768,301	1,472,962	1,647,401	1,669,826	1,666,928
SCE/SoCalGas	6	RST	378,613	365,947	360,772	356,597	351,160	345,073	352,464	362,021	368,260	373,833	381,402	367,545	367,587	370,108	371,456
SCE/SoCalGas	6	SCH	895,446	828,622	823,330	798,488	757,195	730,029	692,483	664,117	594,547	515,289	485,200	470,702	570,390	550,041	531,028
SCE/SoCalGas	6	SMO	736,313	718,245	699,929	692,309	670,714	676,467	700,332	697,598	712,512	724,372	742,455	738,615	719,314	722,478	726,624
SCE/SoCalGas	6	WRH	2,330,829	2,197,066	2,106,271	2,030,084	1,943,887	1,868,906	1,863,405	1,853,477	1,840,167	1,823,517	1,821,880	1,717,312	1,819,960	1,812,719	1,805,926
SCE/SoCalGas	8	COL	347,740	333,262	330,380	327,703	324,547	305,534	305,610	322,697	328,687	333,598	339,762	308,025	323,063	325,972	326,518
SCE/SoCalGas	8	GRC	596,056	600,015	595,678	595,738	582,927	556,987	561,240	580,809	581,801	584,021	584,223	547,721	573,302	575,313	574,397
SCE/SoCalGas	8	HLT	509,602	515,150	481,370	501,773	523,283	477,252	547,484	565,800	735,428	749,255	812,947	685,915	682,805	705,358	728,618
SCE/SoCalGas	8	LDG	545,624	518,726	506,457	519,392	498,354	446,976	444,544	481,203	482,089	482,510	488,478	414,581	465,567	469,071	467,049
SCE/SoCalGas	8	LGO	3,151,029	3,064,917	2,984,071	2,962,483	2,865,009	2,913,435	3,056,555	3,054,819	3,155,574	3,230,896	3,343,324	3,317,965	3,193,189	3,215,961	3,242,818
SCE/SoCalGas	8	MSC	1,857,333	1,861,549	1,857,323	1,863,561	1,853,391	1,813,328	1,785,971	1,793,595	1,802,702	1,811,538	1,822,926	1,785,532	1,800,377	1,802,778	1,804,309
SCE/SoCalGas	8	RET	2,179,136	2,058,694	2,023,697	2,076,157	2,004,365	1,785,594	1,811,648	2,016,913	2,041,603	2,061,737	2,099,301	1,744,227	1,962,572	1,987,726	1,982,861
SCE/SoCalGas	8	RST	456,528	441,012	434,511	429,185	421,935	413,927	422,076	432,764	439,452	444,947	452,795	435,233	437,878	440,512	441,803
SCE/SoCalGas	8	SCH	1,079,722	998,595	991,614	961,027	909,804	875,695	829,250	793,894	709,485	613,311	576,022	557,388	679,892	654,999	631,850
SCE/SoCalGas	8	SMO	887,840	865,576	842,990	833,235	805,893	811,445	838,650	833,918	850,254	862,169	881,432	874,640	856,844	859,876	864,203
SCE/SoCalGas	8	WRH	2,810,494	2,647,743	2,536,780	2,443,326	2,335,669	2,241,815	2,231,432	2,215,671	2,195,908	2,170,402	2,162,910	2,033,577	2,168,317	2,157,797	2,148,152
SCE/SoCalGas	9	COL	213,655	204,702	202,880	201,087	199,371	188,022	188,422	199,346	203,455	207,139	211,626	192,467	200,409	202,407	202,917
SCE/SoCalGas	9	GRC	366,223	368,551	365,795	365,560	358,095	342,763	346,029	358,795	360,130	362,631	363,893	342,240	355,620	357,218	356,955
SCE/SoCalGas	9	HLT	313,105	316,424	295,600	307,901	321,455	293,695	337,548	349,523	455,224	465,229	506,357	428,589	423,745	438,111	452,876
SCE/SoCalGas	9	LDG	335,238	318,620	311,005	318,712	306,141	275,064	274,081	297,263	298,409	299,601	304,256	259,048	288,776	291,226	290,219
SCE/SoCalGas	9	LGO	1,936,027	1,882,584	1,832,461	1,817,853	1,759,990	1,792,892	1,884,503	1,887,115	1,953,275	2,006,135	2,082,443	2,073,206	1,981,113	1,997,214	2,015,564
SCE/SoCalGas	9	MSC	1,141,165	1,143,431	1,140,547	1,143,528	1,138,548	1,115,899	1,101,131	1,107,993	1,115,858	1,124,824	1,135,438	1,115,676	1,116,820	1,119,435	1,121,342
SCE/SoCalGas	9	RET	1,338,885	1,264,525	1,242,713	1,273,982	1,231,292	1,098,832	1,116,963	1,245,948	1,263,736	1,280,178	1,307,583	1,089,868	1,217,379	1,234,115	1,232,143
SCE/SoCalGas	9	RST	280,496	270,886	266,825	263,359	259,197	254,725	260,229	267,340	272,017	276,277	282,030	271,952	271,641	273,543	274,577
SCE/SoCalGas	9	SCH	663,393	613,374	608,931	589,710	558,897	538,892	511,270	490,428	439,166	380,819	358,785	348,280	421,458	406,489	392,499
SCE/SoCalGas	9	SMO	545,499	531,668	517,664	511,294	495,064	499,353	517,065	515,153	526,301	535,340	549,014	546,513	531,564	533,981	537,119
SCE/SoCalGas	9	WRH	1,726,798	1,626,340	1,557,788	1,499,286	1,434,813	1,379,585	1,375,778	1,368,731	1,359,250	1,347,651	1,347,203	1,270,666	1,344,880	1,339,730	1,334,896
SCE/SoCalGas	10	COL	257,519	251,845	254,579	257,562	260,331	249,864	254,719	274,086	284,368	294,344	305,591	282,315	282,571	287,212	289,400
SCE/SoCalGas	10	GRC	441,411	453,429	459,007	468,227	467,587	455,501	467,782	493,316	503,354	515,300	525,464	502,005	501,203	506,774	509,017
SCE/SoCalGas	10	HLT	377,387	389,297	370,926	394,375	419,744	390,294	456,316	480,567	636,267	661,091	731,185	628,664	599,015	622,798	646,503
SCE/SoCalGas	10	LDG	404,064	391,999	390,256	408,222	399,748	365,535	370,518	408,714	417,087	425,734	439,349	379,977	406,896	412,960	413,667
SCE/SoCalGas	10	LGO	2,333,503	2,316,144	2,299,413	2,328,398	2,298,129	2,382,591	2,547,576	2,594,639	2,730,093	2,850,720	3,007,068	3,041,025	2,795,187	2,836,455	2,876,758
SCE/SoCalGas	10	MSC	1,375,453	1,406,765	1,431,184	1,464,688	1,486,673	1,482,930	1,488,570	1,523,406	1,559,635	1,598,376	1,639,585	1,636,499	1,574,345	1,588,641	1,599,514
SCE/SoCalGas	10	RET	1,613,765	1,555,746	1,559,385	1,631,780	1,607,775	1,460,249	1,509,972	1,713,084	1,766,324	1,819,134	1,888,164	1,598,643	1,715,887	1,750,206	1,756,393
SCE/SoCalGas	10	RST	338,083	333,271	334,818	337,323	338,449	338,507	351,792	367,572	380,199	392,590	407,255	398,906	383,052	388,262	391,711
SCE/SoCalGas	10	SCH	799,591	754,634	764,100	755,331	729,787	716,138	691,163	674,301	613,822	541,144	518,089	510,865	591,564	574,964	558,408
SCE/SoCalGas	10	SMO	657,493	654,112	649,576	654,891	646,436	663,595	698,997	708,296	735,611	760,718	792,782	801,637	749,673	758,119	766,423
SCE/SoCalGas	10	WRH	2,081,319	2,000,888	1,954,747	1,920,360	1,873,526	1,833,344	1,859,853	1,881,900	1,899,823	1,915,013	1,945,375	1,863,841	1,894,301	1,900,042	1,903,066

Utility	Title 24 Climate Zone	Segment	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
SCE/SoCalGas	13	COL	48,203	46,825	47,054	47,324	47,523	45,355	45,986	49,224	50,821	52,294	53,986	49,603	50,319	51,041	51,344
SCE/SoCalGas	13	GRC	82,624	84,305	84,838	86,031	85,357	82,683	84,451	88,596	89,956	91,549	92,829	88,202	89,264	90,066	90,311
SCE/SoCalGas	13	HLT	70,640	72,381	68,558	72,461	76,623	70,846	82,381	86,306	113,710	117,450	129,171	110,456	106,579	110,612	114,663
SCE/SoCalGas	13	LDG	75,633	72,884	72,131	75,006	72,973	66,352	66,892	73,402	74,539	75,636	77,616	66,762	72,474	73,405	73,405
SCE/SoCalGas	13	LGO	436,788	430,636	425,001	427,813	419,518	432,489	459,928	465,978	487,905	506,462	531,230	534,308	497,635	503,920	510,243
SCE/SoCalGas	13	MSC	257,459	261,557	264,526	269,118	271,389	269,182	268,740	273,592	278,728	283,969	289,650	287,533	280,369	282,307	283,759
SCE/SoCalGas	13	RET	302,067	289,257	288,221	299,819	293,496	265,065	272,604	307,657	315,666	323,189	333,564	280,882	305,594	311,092	311,664
SCE/SoCalGas	13	RST	63,283	61,964	61,884	61,979	61,783	61,446	63,511	66,013	67,947	69,748	71,946	70,088	68,209	68,992	69,488
SCE/SoCalGas	13	SCH	149,668	140,308	141,229	138,782	133,221	129,994	124,779	121,099	109,698	96,140	91,526	89,759	105,500	102,287	99,152
SCE/SoCalGas	13	SMO	123,070	121,618	120,061	120,328	118,006	120,456	126,194	127,205	131,464	135,150	140,053	140,848	133,485	134,701	135,950
SCE/SoCalGas	13	WRH	389,584	372,021	361,296	352,841	342,008	332,789	335,769	337,975	339,524	340,223	343,671	327,477	337,440	337,718	337,676
SCE/SoCalGas	14	COL	137,862	133,858	134,415	135,103	135,735	129,564	131,390	140,686	145,282	149,673	154,699	142,303	144,005	146,108	147,012
SCE/SoCalGas	14	GRC	236,307	241,002	242,352	245,607	243,796	236,195	241,293	253,214	257,160	262,028	266,006	253,039	255,457	257,817	258,585
SCE/SoCalGas	14	HLT	202,032	206,915	195,846	206,868	218,852	202,383	235,379	246,671	325,064	336,162	370,148	316,883	305,051	316,663	328,329
SCE/SoCalGas	14	LDG	216,313	208,351	206,052	214,131	208,425	189,544	191,122	209,789	213,087	216,484	222,412	191,530	207,404	210,118	210,172
SCE/SoCalGas	14	LGO	1,249,228	1,231,052	1,214,072	1,221,353	1,198,227	1,235,467	1,314,102	1,331,803	1,394,785	1,449,581	1,522,269	1,532,851	1,424,232	1,442,587	1,461,051
SCE/SoCalGas	14	MSC	736,341	747,708	755,653	768,297	775,140	768,957	767,841	781,950	796,806	812,769	830,008	824,889	802,377	808,133	812,497
SCE/SoCalGas	14	RET	863,920	826,893	823,343	855,945	838,282	757,197	778,880	879,309	902,402	925,024	955,846	805,807	874,545	890,489	892,352
SCE/SoCalGas	14	RST	180,991	177,137	176,781	176,942	176,465	175,529	181,463	188,671	194,241	199,631	206,165	201,071	195,207	197,498	198,969
SCE/SoCalGas	14	SCH	428,057	401,095	403,439	396,206	380,506	371,346	356,519	346,112	313,597	275,170	262,272	257,505	301,863	292,753	283,860
SCE/SoCalGas	14	SMO	351,985	347,667	342,971	343,521	337,047	344,100	360,560	363,561	375,818	386,823	401,330	404,071	382,027	385,605	389,279
SCE/SoCalGas	14	WRH	1,114,223	1,063,490	1,032,091	1,007,319	976,842	950,661	959,357	965,961	970,606	973,778	984,808	939,483	965,665	966,717	966,843
SCE/SoCalGas	15	COL	64,882	63,674	64,566	65,511	66,390	63,879	65,275	70,388	73,174	75,887	78,929	73,044	72,783	74,034	74,642
SCE/SoCalGas	15	GRC	111,214	114,641	116,413	119,093	119,245	116,452	119,875	126,688	129,524	132,852	135,718	129,884	129,090	130,626	131,282
SCE/SoCalGas	15	HLT	95,083	98,426	94,074	100,309	107,044	99,781	116,937	123,414	163,725	170,440	188,852	162,655	154,337	160,570	166,763
SCE/SoCalGas	15	LDG	101,804	99,109	98,977	103,831	101,945	93,451	94,950	104,961	107,325	109,761	113,476	98,312	104,798	106,439	106,685
SCE/SoCalGas	15	LGO	587,928	585,592	583,176	592,225	586,075	609,125	652,847	666,325	702,511	734,960	776,673	786,809	720,021	731,217	742,032
SCE/SoCalGas	15	MSC	346,546	355,673	362,976	372,542	379,135	379,121	381,464	391,224	401,327	412,086	423,476	423,414	405,499	409,504	412,551
SCE/SoCalGas	15	RET	406,589	393,340	395,490	415,041	410,019	373,322	386,949	439,934	454,513	469,001	487,680	413,619	441,949	451,116	452,980
SCE/SoCalGas	15	RST	85,180	84,261	84,916	85,798	86,312	86,542	90,151	94,396	97,833	101,216	105,187	103,209	98,665	100,084	101,033
SCE/SoCalGas	15	SCH	201,457	190,794	193,791	192,118	186,112	183,085	177,119	173,166	157,950	139,515	133,813	132,177	152,290	148,152	143,983
SCE/SoCalGas	15	SMO	165,656	165,379	164,745	166,571	164,856	169,652	179,127	181,896	189,288	196,125	204,762	207,409	193,101	195,430	197,686
SCE/SoCalGas	15	WRH	524,390	505,885	495,762	488,442	477,791	468,707	476,610	483,288	488,865	493,720	502,456	482,234	487,862	489,738	490,813
SCE/SoCalGas	16	COL	89,748	87,297	87,814	88,432	88,994	85,070	86,392	92,628	95,775	98,785	102,215	94,125	94,987	96,419	97,051
SCE/SoCalGas	16	GRC	153,837	157,172	158,329	160,763	159,844	155,083	158,655	166,718	169,529	172,939	175,760	167,370	168,495	170,135	170,705
SCE/SoCalGas	16	HLT	131,523	134,942	127,946	135,406	143,489	132,882	154,766	162,410	214,294	221,868	244,570	209,598	201,251	208,998	216,763
SCE/SoCalGas	16	LDG	140,821	135,878	134,614	140,160	136,654	124,453	125,667	138,127	140,474	142,880	146,955	126,685	136,798	138,653	138,741
SCE/SoCalGas	16	LGO	813,252	802,843	793,153	799,439	785,615	811,194	864,048	876,870	919,490	956,728	1,005,818	1,013,886	939,473	952,044	964,573
SCE/SoCalGas	16	MSC	479,360	487,625	493,669	502,890	508,219	504,889	504,870	514,842	525,282	536,430	548,416	545,613	529,242	533,304	536,381
SCE/SoCalGas	16	RET	562,415	539,267	537,890	560,260	549,617	497,167	512,129	578,944	594,895	610,518	631,562	532,992	576,840	587,625	589,072
SCE/SoCalGas	16	RST	117,826	115,521	115,491	115,818	115,699	115,251	119,315	124,223	128,050	131,757	136,220	132,996	128,760	130,334	131,353
SCE/SoCalGas	16	SCH	278,666	261,578	263,567	259,337	249,477	243,821	234,418	227,883	206,734	181,613	173,293	170,324	199,044	193,148	187,359
SCE/SoCalGas	16	SMO	229,143	226,734	224,063	224,852	220,984	225,932	237,075	239,372	247,752	255,304	265,173	267,268	251,991	254,477	256,994
SCE/SoCalGas	16	WRH	725,363	693,566	674,265	659,342	640,464	624,193	630,796	635,997	639,857	642,696	650,698	621,410	636,909	637,928	638,249

SDG&E Commercial New Construction
Floorstock

Utility	Title 24 Climate Zone	Segment	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
SDG&E	7	COL	251,933	264,172	292,646	285,011	275,998	279,087	282,424	241,594	245,180	249,060	253,136	257,456	254,808	250,206	251,641
SDG&E	7	GRC	248,145	246,462	239,321	235,181	234,089	233,491	233,386	233,970	234,556	236,715	237,890	239,702	236,037	236,478	236,896
SDG&E	7	HLT	307,032	311,644	374,994	379,703	371,375	375,001	378,335	381,524	384,468	387,263	389,909	392,356	385,642	386,860	387,750
SDG&E	7	LDG	526,200	519,095	513,471	507,107	500,200	493,690	487,675	479,794	472,949	467,086	462,254	458,552	471,385	468,670	466,816
SDG&E	7	LGO	1,305,514	1,183,264	1,114,258	1,070,045	1,064,197	1,064,160	1,064,130	1,064,105	1,064,086	1,064,062	1,064,036	1,064,005	1,064,071	1,064,061	1,064,053
SDG&E	7	MSC	826,935	857,058	935,246	909,831	880,231	885,119	890,800	770,474	777,592	785,886	795,408	806,303	804,410	790,012	793,269
SDG&E	7	RET	1,031,984	1,047,981	1,011,003	982,338	970,099	960,867	954,692	952,604	950,767	956,943	958,001	962,055	955,844	956,036	956,608
SDG&E	7	RST	154,771	153,977	153,726	154,213	155,141	156,070	156,804	157,341	157,486	157,482	156,986	156,293	157,065	157,109	157,070
SDG&E	7	SCH	342,798	351,983	357,973	364,503	371,129	378,100	385,467	393,082	400,797	408,509	416,122	423,487	404,578	407,763	410,209
SDG&E	7	SMO	919,965	908,023	968,304	952,529	931,043	931,945	930,886	836,578	832,137	826,757	820,785	814,712	843,643	829,102	827,856
SDG&E	7	WRH	781,921	801,863	755,645	737,959	728,829	723,147	720,913	723,208	723,982	734,983	735,948	739,369	729,734	731,204	732,536
SDG&E	10	COL	207,815	217,939	241,455	235,183	227,776	230,351	233,127	199,439	202,411	205,629	209,011	212,599	210,369	206,577	207,766
SDG&E	10	GRC	204,690	203,329	197,458	194,064	193,189	192,717	192,648	193,146	193,641	195,437	196,423	197,938	194,872	195,243	195,592
SDG&E	10	HLT	253,265	257,103	309,399	313,320	306,488	309,517	312,297	314,953	317,402	319,732	321,943	323,995	318,387	319,402	320,144
SDG&E	10	LDG	434,053	428,248	423,653	418,450	412,806	407,479	402,552	396,077	390,448	385,636	381,678	378,658	389,175	386,945	385,423
SDG&E	10	LGO	1,076,895	976,180	919,348	882,970	878,262	878,331	878,387	878,433	878,468	878,513	878,563	878,620	878,497	878,516	878,530
SDG&E	10	MSC	682,124	707,064	771,650	750,766	726,439	730,556	735,312	636,037	641,950	648,845	656,760	665,818	664,120	652,255	654,958
SDG&E	10	RET	851,265	864,573	834,155	810,597	800,605	793,076	788,052	786,387	784,917	790,073	791,011	794,434	789,146	789,328	789,818
SDG&E	10	RST	127,668	127,030	126,836	127,252	128,035	128,817	129,434	129,887	130,014	130,021	129,622	129,062	129,673	129,713	129,684
SDG&E	10	SCH	282,768	290,382	295,356	300,777	306,286	312,075	318,185	324,494	330,882	337,274	343,588	349,702	334,021	336,660	338,688
SDG&E	10	SMO	758,863	749,110	798,925	785,999	768,373	769,205	768,401	690,606	686,980	682,588	677,714	672,763	696,509	684,527	683,513
SDG&E	10	WRH	644,993	661,528	623,465	608,942	601,489	596,867	595,079	597,018	597,691	606,817	607,664	610,547	602,469	603,701	604,815
SDG&E	14	COL	50,550	53,012	58,732	57,207	55,405	56,031	56,707	48,512	49,235	50,018	50,841	51,713	51,171	50,248	50,538
SDG&E	14	GRC	49,789	49,458	48,030	47,205	46,992	46,877	46,860	46,981	47,102	47,539	47,779	48,147	47,401	47,491	47,577
SDG&E	14	HLT	61,605	62,539	75,259	76,213	74,551	75,288	75,964	76,610	77,206	77,773	78,311	78,810	77,446	77,692	77,873
SDG&E	14	LDG	105,581	104,168	103,051	101,785	100,412	99,117	97,918	96,343	94,974	93,803	92,841	92,106	94,664	94,122	93,752
SDG&E	14	LGO	261,947	237,449	223,625	214,777	213,631	213,648	213,662	213,673	213,681	213,692	213,704	213,718	213,689	213,693	213,696
SDG&E	14	MSC	165,922	171,989	187,699	182,619	176,701	177,703	178,860	154,712	156,150	157,827	159,752	161,956	161,543	158,657	159,314
SDG&E	14	RET	207,065	210,301	202,903	197,172	194,742	192,910	191,688	191,283	190,926	192,180	192,408	193,241	191,954	191,999	192,118
SDG&E	14	RST	31,054	30,899	30,852	30,953	31,144	31,334	31,484	31,594	31,625	31,627	31,530	31,393	31,542	31,552	31,545
SDG&E	14	SCH	68,781	70,634	71,843	73,162	74,502	75,910	77,396	78,931	80,485	82,040	83,575	85,063	81,248	81,890	82,384
SDG&E	14	SMO	184,588	182,216	194,333	191,189	186,901	187,104	186,908	167,985	167,103	166,035	164,849	163,645	169,421	166,506	166,260
SDG&E	14	WRH	156,890	160,912	151,654	148,121	146,308	145,184	144,749	145,221	145,384	147,604	147,810	148,511	146,547	146,846	147,117
SDG&E	16	COL	90,954	100,659	100,720	106,321	110,280	114,391	118,690	113,767	118,272	122,825	127,500	132,227	122,213	122,801	124,306
SDG&E	16	GRC	105,969	109,336	116,902	127,602	131,180	134,633	137,981	137,412	140,187	142,689	144,802	146,653	141,621	142,227	143,030
SDG&E	16	HLT	102,198	104,129	106,505	108,998	111,369	113,769	116,238	118,727	121,205	123,619	126,034	128,404	122,371	123,393	124,171
SDG&E	16	LDG	123,495	124,896	128,132	130,843	133,185	135,299	137,208	138,008	138,614	138,971	139,162	139,188	138,525	138,745	138,867
SDG&E	16	LGO	374,107	415,800	405,284	419,912	431,097	441,722	451,853	421,479	429,594	436,766	442,957	448,336	438,497	436,271	438,737
SDG&E	16	MSC	477,941	510,443	507,419	540,942	559,553	577,137	593,662	572,231	585,185	595,949	604,846	611,724	593,933	593,978	597,603
SDG&E	16	RET	394,070	406,744	422,653	428,966	440,111	450,825	461,041	456,241	464,402	471,592	477,346	482,105	468,788	470,079	472,385
SDG&E	16	RST	90,538	67,386	70,054	77,512	80,482	83,286	85,934	84,033	86,128	87,864	89,277	90,347	87,264	87,486	88,061
SDG&E	16	SCH	143,508	150,406	145,979	151,593	157,358	163,459	169,964	176,778	183,884	191,160	198,651	206,338	187,796	190,768	193,099
SDG&E	16	SMO	126,437	142,053	150,520	164,585	168,391	172,014	175,559	169,068	172,321	175,399	178,494	181,562	175,400	175,374	176,425
SDG&E	16	WRH	319,149	353,945	344,539	328,098	332,955	338,761	345,062	338,855	343,867	349,570	352,501	355,215	347,512	347,920	349,431

Energy Time-Of-Use Shares and Coincident Peak Factors

The following table lists the energy time-of-use shares associated with each technology and segment for commercial new construction units. The energy time-of-use shares change by region. Using the name of the energy time-of-use share, the actual load shape and peak factors are listed in Table P-27.

Table P-26: Energy Time-Of-Use Shares by Technology and Segment

Technology Name	Segment	Energy Time-Of-Use Share	Changes by
COL_01_00	COL	COL_T24Elec	Region
COL_01_15	COL	COL_T24Elec	Region
COL_01_25	COL	COL_T24Elec	Region
COL_05_00	COL	COL_T24Elec	Region
COL_05_10	COL	COL_T24Elec	Region
COL_05_15	COL	COL_T24Elec	Region
GRC_01_00	GRC	GRC_T24Elec	Region
GRC_01_15	GRC	GRC_T24Elec	Region
GRC_01_25	GRC	GRC_T24Elec	Region
GRC_05_00	GRC	GRC_T24Elec	Region
GRC_05_10	GRC	GRC_T24Elec	Region
GRC_05_15	GRC	GRC_T24Elec	Region
HLT_01_00	HLT	HLT_T24Elec	Region
HLT_01_15	HLT	HLT_T24Elec	Region
HLT_01_25	HLT	HLT_T24Elec	Region
HLT_05_00	HLT	HLT_T24Elec	Region
HLT_05_10	HLT	HLT_T24Elec	Region
HLT_05_15	HLT	HLT_T24Elec	Region
LDG_01_00	LDG	LDG_T24Elec	Region
LDG_01_15	LDG	LDG_T24Elec	Region
LDG_01_25	LDG	LDG_T24Elec	Region
LDG_05_00	LDG	LDG_T24Elec	Region
LDG_05_10	LDG	LDG_T24Elec	Region
LDG_05_15	LDG	LDG_T24Elec	Region
MSC_01_00	MSC	MSC_T24Elec	Region
MSC_01_15	MSC	MSC_T24Elec	Region
MSC_01_25	MSC	MSC_T24Elec	Region
MSC_05_00	MSC	MSC_T24Elec	Region
MSC_05_10	MSC	MSC_T24Elec	Region
MSC_05_15	MSC	MSC_T24Elec	Region

Table P-26 (cont'd): Energy Time-Of-Use Shares by Technology and Segment

Technology Name	Segment	Energy Time-Of-Use Share	Changes by
LGO_01_00	LGO	LGO_T24Elec	Region
LGO_01_15	LGO	LGO_T24Elec	Region
LGO_01_25	LGO	LGO_T24Elec	Region
LGO_05_00	LGO	LGO_T24Elec	Region
LGO_05_10	LGO	LGO_T24Elec	Region
LGO_05_15	LGO	LGO_T24Elec	Region
SMO_01_00	SMO	SMO_T24Elec	Region
SMO_01_15	SMO	SMO_T24Elec	Region
SMO_01_25	SMO	SMO_T24Elec	Region
SMO_05_00	SMO	SMO_T24Elec	Region
SMO_05_10	SMO	SMO_T24Elec	Region
SMO_05_15	SMO	SMO_T24Elec	Region
RST_01_00	RST	RST_T24Elec	Region
RST_01_15	RST	RST_T24Elec	Region
RST_01_25	RST	RST_T24Elec	Region
RST_05_00	RST	RST_T24Elec	Region
RST_05_10	RST	RST_T24Elec	Region
RST_05_15	RST	RST_T24Elec	Region
RET_01_00	RET	RET_T24Elec	Region
RET_01_15	RET	RET_T24Elec	Region
RET_01_25	RET	RET_T24Elec	Region
RET_05_00	RET	RET_T24Elec	Region
RET_05_10	RET	RET_T24Elec	Region
RET_05_15	RET	RET_T24Elec	Region
SCH_01_00	SCH	SCH_T24Elec	Region
SCH_01_15	SCH	SCH_T24Elec	Region
SCH_01_25	SCH	SCH_T24Elec	Region
SCH_05_00	SCH	SCH_T24Elec	Region
SCH_05_10	SCH	SCH_T24Elec	Region
SCH_05_15	SCH	SCH_T24Elec	Region
WRH_01_00	WRH	WRH_T24Elec	Region
WRH_01_15	WRH	WRH_T24Elec	Region
WRH_01_25	WRH	WRH_T24Elec	Region
WRH_05_00	WRH	WRH_T24Elec	Region
WRH_05_10	WRH	WRH_T24Elec	Region
WRH_05_15	WRH	WRH_T24Elec	Region

The following table lists the energy time-of-use shares for commercial new construction end uses by region. The TOU periods are the same as those given in previous sections of the appendix. The summer peak coincidence factor is also included.

Table P-27: TOU Load Shapes and Summer Peak Factors

Energy Time-Of-Use Share	Region	Summer On Peak	Summer Partial Peak	Summer Off Peak	Winter Partial Peak	Winter Off Peak	Summer Peak Factor
COL_T24Elec	Region 1	16%	13%	25%	18%	28%	1.15
COL_T24Elec	Region 2	20%	16%	21%	21%	22%	1.22
COL_T24Elec	Region 3	22%	15%	23%	19%	21%	1.28
COL_T24Elec	Region 4	22%	18%	22%	18%	20%	1.16
GRC_T24Elec	Region 1	10%	9%	32%	13%	35%	1.03
GRC_T24Elec	Region 2	10%	10%	33%	13%	35%	1.05
GRC_T24Elec	Region 3	10%	10%	33%	13%	35%	1.06
GRC_T24Elec	Region 4	10%	10%	33%	13%	34%	1.07
HLT_T24Elec	Region 1	15%	11%	28%	18%	28%	1.17
HLT_T24Elec	Region 2	12%	11%	30%	16%	31%	1.09
HLT_T24Elec	Region 3	18%	12%	26%	19%	24%	1.12
HLT_T24Elec	Region 4	20%	15%	22%	20%	22%	1.34
LDG_T24Elec	Region 1	11%	10%	30%	14%	34%	1.06
LDG_T24Elec	Region 2	15%	8%	27%	21%	28%	1.01
LDG_T24Elec	Region 3	10%	11%	33%	12%	34%	1.04
LDG_T24Elec	Region 4	10%	11%	34%	11%	34%	1.02
MSC_T24Elec	Region 1	20%	13%	22%	23%	22%	1.08
MSC_T24Elec	Region 2	20%	13%	22%	24%	21%	1.20
MSC_T24Elec	Region 3	21%	14%	22%	22%	21%	1.24
MSC_T24Elec	Region 4	23%	15%	20%	22%	19%	1.25
LGO_T24Elec	Region 1	15%	12%	28%	17%	28%	1.08
LGO_T24Elec	Region 2	13%	12%	28%	17%	30%	1.08
LGO_T24Elec	Region 3	14%	12%	28%	17%	29%	1.01
LGO_T24Elec	Region 4	16%	13%	29%	16%	27%	1.04
SMO_T24Elec	Region 1	14%	12%	28%	15%	31%	1.06
SMO_T24Elec	Region 2	14%	12%	29%	15%	31%	1.13
SMO_T24Elec	Region 3	13%	13%	28%	15%	31%	1.09
SMO_T24Elec	Region 4	15%	13%	28%	15%	28%	1.11
RST_T24Elec	Region 1	12%	11%	30%	15%	32%	1.02
RST_T24Elec	Region 2	12%	11%	30%	14%	32%	1.29
RST_T24Elec	Region 3	12%	11%	30%	14%	32%	1.02
RST_T24Elec	Region 4	13%	12%	30%	14%	31%	1.00

Table P-27 (cont'd.): TOU Load Shapes and Summer Peak Factors

Energy Time-Of-Use Share	Region	Summer On Peak	Summer Partial Peak	Summer Off Peak	Winter Partial Peak	Winter Off Peak	Summer Peak Factor
RET_T24Elec	Region 1	18%	17%	19%	25%	21%	1.32
RET_T24Elec	Region 2	19%	16%	19%	26%	20%	1.15
RET_T24Elec	Region 3	19%	19%	17%	26%	19%	0.99
RET_T24Elec	Region 4	18%	16%	22%	22%	22%	1.61
SCH_T24Elec	Region 1	19%	12%	23%	21%	24%	1.11
SCH_T24Elec	Region 2	17%	12%	24%	22%	25%	1.14
SCH_T24Elec	Region 3	19%	12%	22%	21%	25%	1.40
SCH_T24Elec	Region 4	21%	14%	23%	22%	21%	1.17
WRH_T24Elec	Region 1	12%	10%	30%	15%	33%	1.05
WRH_T24Elec	Region 2	17%	12%	28%	20%	23%	1.32
WRH_T24Elec	Region 3	14%	11%	28%	18%	29%	1.19
WRH_T24Elec	Region 4	12%	11%	28%	17%	32%	1.05

Appendix Q

Industrial New Construction Methodology and ASSET Inputs

As part of the New Construction Potential study, RLW Analytics (RLW) was charged with estimating the potential energy savings from energy efficiency features in the new construction and major renovation of industrial facilities in three market sectors in California: electronics manufacturing, wastewater treatment, and refrigerated warehouses. The potential savings estimates specifically targeted anticipated projects that will be eligible for incentives from the Savings By Design (Savings By Design) nonresidential new construction incentive program.

The increase in load for the evaluated sectors in the CEC's 2003-2013 Demand Forecast[1] was used as a proxy for the new construction load.

Because energy consumption in industrial facilities is more a function of output than plant square footage, energy savings are expressed as a percentage of the forecasted sector load increase. Incremental measure costs are expressed as $ per kWh saved per year.

In this appendix, results are presented at the measure level rather than on a package basis, as is the case for both residential and commercial new construction. This is because 1) unlike commercial facilities, industrial facilities have limited interactive effects between measures, and 2) many of the industrial buildings that participate in Savings By Design install and receive rebates for individual measures.

Q.1. Objective

The primary objective of the industrial component of the New Construction Potential Study was to find the savings potential for industrial facilities buildings that would approximate the

[1] California Energy Commission. *California Energy Demand 2003-2013 Forecast.* 2003.

Savings By Design projects for the electronics manufacturing, wastewater treatment and refrigerated warehouses market sectors by IOU planning area.[2]

Q.2. Investigated Market Sectors

The methodology employed to estimate energy savings potential was quite different from the residential and commercial components of this study due to the highly varying nature of industrial facilities. The industrial methodology varied by sector and depended on the available data. For electronic manufacturing, potential savings were assessed through an end-use disaggregation and the savings were applied considering the market applicability of the measure. Alternatively, wastewater treatment and refrigerated warehouse savings potential were calculated using a sample of projects similar to the commercial analysis. The applicability of any given measure for these sectors was determined by the saturation of the measure in the sample.

Electronics Manufacturing

Electronics manufacturing was defined as facilities with standard industrial classification (SIC) codes 36 and 357. The SIC 36 sector was further split into two groups of facilities: clean rooms (SIC 3674, semiconductor manufacturing), and conventional facilities, which included the remainder of the SIC 36 load increase (hereafter referred to as 36x). The buildings, processes, installed equipment, and end-use energy consumption of these two facility types are fundamentally different enough that they were analyzed separately.

The increase in load for both sectors was disaggregated by end use. Potential measures and the incremental costs associated with the implementation of the measures were developed and tailored to each end use. The applicable measures were applied to each load increase to generate savings estimates.

Load Forecast. According to the 2003-2013 Energy Demand Forecast, there is no expected increase in SIC 357 load; therefore, the focus of the analysis is SIC 36 facilities. The forecasted load increases for both types SIC 36 facilities included in the analysis are shown Table Q-1.

2 While refrigerated warehouse and wastewater treatment are usually considered commercial load, the NC Potential Advisory Group requested that they be analyzed in more detail and therefore included them in this industrial analysis.

Table Q-1: Distribution of Forecasted SIC 36 Load Increase

SIC 36 Load	PG&E (GWh)	SCE (GWh)	SDG&E (GWh)
Clean Room Facilities (3674)			
2003 Load	1759.8	717.7	115.9
2008 Load	1954.0	866.8	128.0
2013 Load	2013.9	960.8	135.4
2003-2008 Increase	194.1	149.1	12.1
2003-2013 Increase	254.1	243.2	19.6
Conventional Facilities (36x)			
2003 Load	952.3	1090.0	261.6
2008 Load	1090.9	1228.5	285.8
2013 Load	1165.4	1313.1	299.3
2003-2008 Increase	138.6	138.5	24.2
2003-2013 Increase	213.1	223.1	37.7

Conventional Facilities

SIC (36x) Conventional Facility: Load Disaggregation by End Use

Excluding semiconductor-related manufacturing, electronics manufacturing contains numerous subsectors broadly characterized as precision and general industrial space types. The Energy Information Administration's Manufacturing Energy Consumption Survey (MECS 2002)[3] provides the most current information regarding end-use distribution of SIC 36 facilities, as shown in Table Q-2.

3 Energy Information Administration, Department of Energy. *2002 Manufacturing Energy Consumption Survey*. www.eia.doe.gov/emeu/mecs

Table Q-2: Conventional Facility Energy Use by End Use

Conventional	Load Share
HVAC	28.6%
Machine Drive	17.6%
Lighting	12.8%
Process Heating	11.3%
Process Cooling	9.0%
Other Facility Support	6.7%
Compressed Air	5.2%
End Use Not Reported	4.4%
Electro-chemical Process	1.4%
Other Process	2.8%

SIC 36x Conventional Facility: Savings and Cost Analysis

After the entire sector load was disaggregated, each of the end uses were analyzed in depth. SIC 36x facilities were evaluated with a two-prong approach. HVAC and lighting end uses were evaluated with a methodology similar to the commercial analysis. All other measure, broadly classified as "process" end uses considered measures individually.

Secondary sources were used to characterize the energy consuming equipment in each end use, the baseline efficiencies of the equipment, and the measures with energy saving potential for each end use. This following section provides details for the SIC 36x end-use analysis beginning with the process end uses.

SIC 36x Process End Uses

Motors. U.S. Industrial Motor Market Assessment[4] gives the distribution of SIC 36x motor energy usage by unit size and application. The four categories of applications are fans, pumps, air compressors, and "other." Table Q-3 presents the relative energy usage and average hours of operation of SIC 36 motors. In this analysis, the same distributions were assumed.

[4] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy (U.S. DOE EERE). *2002 U.S. Industrial Electric Motor System Market Opportunities Assessment*. 2002.

Table Q-3: SIC 36 Motor Usage and Size Distribution by Application

Size Range	Fans	Pumps	Air Compressors	Other	All
Energy Usage Distribution					
1-5 HP	68%	18%	1%	13%	14.6%
6-20 HP	24%	18%		75%	23.7%
21-50 HP	7%	23%	54%	12%	28.1%
51-100 HP		40%	24%		28.8%
101-200 HP			21%		4.8%
Annual Hours of Operation					
1-5 HP	3,326	5,585	4,878	3,732	4,838
6-20 HP	2,691	5,613		4,913	5,090
21-50 HP	2,160	7,200	5,495	6,069	6,181
51-100 HP		6,437	7,036		6,541
101-200 HP			8,400		8,400
All Sizes	3,026	6,251	6,270	4,819	5,815

The study team used Motor Master 4.0 software to generate Table Q-4 for calculating incremental motor costs and efficiencies for each motor size bin.

Table Q-4: Motor Efficiency and Incremental Cost by Size

Size Range	EPACT Eff.	Premium Eff.	Inc $/hp
1-5 HP	87.0	89.5	$22.52
6-20 HP	91.6	93.0	$29.92
21-50 HP	93.3	94.5	$16.99
51-100 HP	94.7	95.4	$16.51
101-200 HP	95.4	96.2	$19.18

The incremental costs of variable speed drives (VSD), shown in Table Q-5, were taken from the DEER 2001 Update Study.[5] Subsequent discussions with VSD manufacturers confirmed that these estimates are still valid.

5 Xenergy, Inc. *2001 DEER (Database for Energy Efficient Resources) Update Study*. Prepared for the California Energy Commission. August 2001.

Table Q-5: VSD Incremental Cost by Controlled Motor Size

Size	$/HP
5 HP	$385
10 HP	$265
15 HP	$231
20 HP	$202
40 HP	$157
50 HP	$136
200 HP	$89

Compressed Air Systems. A sample of six Savings By Design projects with compressed air measures were used to calculate energy savings and incremental measure costs from VSD air compressors and thermal mass dryers. PG&E's compressed air system baseline studies and program documentation[6] describe the baseline conditions and assumptions required for analysis of these projects. Compressed air measure costs were backed out from measure payback from the Savings By Design project files.

VSD Air Compressors. VSD air compressors save energy via greater efficiency during part load operation. There is a large difference in savings for large (100+hp) and smaller (<100hp) compressors because smaller compressors operate at part load more often. The size distribution of air compressors for SIC 36 is given by the U.S. Industrial Motor Assessment.[7] The incremental measure costs were extracted from Savings By Design project files.

Thermal Mass Compressed Air Dryers. Baseline compressed air dryers use constant refrigeration to maintain a refrigerant-to-air heat transfer as air passes through the system. Thermal mass air dryers cool the air via an intermediate fluid, usually propylene glycol. The refrigeration system only maintains a setpoint for the intermediate fluid and can cycle off when not needed, thereby providing a part load match. The standard dryer continues to run in a recirculation/bypass mode even when cooling is unnecessary. These types of air dryer save approximately 2% of compressed air energy and are applicable to 75% of the market.

Process Cooling Measures

Process cooling refers to facility cooling requirements other that space cooling.

Waterside Economizer for Process. The use of a waterside economizer, such as a plate and frame heat exchanger, is often used for HVAC applications but rarely for process cooling

6 Pacific Gas & Electric. *Compressed Air System New Construction Energy Baselines and Program Requirements.* New Construction Energy Management Program. 2002.

7 U.S. DOE EERE 2002 op. cit.

applications. Free cooling is the term used for the weather conditions that permit use of only cooling tower energy, which can be up to 10 times more efficient than using both cooling tower and chiller energy. The applicability of 60% represents the percent of facilities utilizing process cooling equipment.

Dual Temperature Cooling Loops. Process cooling water typically has different requirements than water for space cooling. Operating dual temperature cooling loops can allow different chillers to operate at different setpoints to improve efficiency. The applicability of this measure is 60% (the percent of facilities using process cooling equipment) with the potential drawback being the cost of an additional chilled water loop.

Table Q-6 summarizes the results of the process measure analysis.

Table Q-6: Summary of SIC 36x Conventional Facility Process Measures

Base Case Description	Energy Efficiency Measure	Incremental Cost $/kWh	Savings Over Baseline	Applic-ability	Sector Savings
No VSD	COP = 6.27	$0.36	25%	50%	2.20%
EPACT Motors	Motor VSD	$0.12	7%	90%	1.03%
CV Compressor 100+HP	NEMA PE Motors	$0.25	5%	11%	0.03%
CV Compressor <100HP	VSD Compressor	$0.08	28%	40%	0.57%
Baseline Air Dryer	VSD Compressor	$0.20	2%	75%	0.08%
No Free Cooling	Measure LPD = 0.96	$0.16	12%	60%	0.65%
Standard Chiller	Water Economizer for Process Cooling	$0.05	10%	50%	0.45%

SIC 36x Lighting and HVAC End Uses

Like the commercial sector, lighting and HVAC end uses are subject to Title 24 energy code and have interactive effects. Therefore, to accurately estimate potential savings, these end uses were analyzed with a building sample of DOE2 models similar to the commercial analysis. The detailed methodology for the commercial analysis is found in Appendix P.

In brief, the commercial analysis developed a set of least-cost packages of measures that achieved energy savings relative to minimally code compliant buildings. The packages had measure targets of 15% and 25% savings relative to 2001 Title 24 standard and 10% and 15% savings relative to the more stringent 2005 standards. The measures included for the packages for SIC 36x models are shown in Table Q-7.

Table Q-7: Measure Packages for SIC 36x Models

Measure type	15% above 2001	25% above 2001	10% above 2005	15% above 2005
Lighting - LPD	X	X	X	X
Mechanical - HVAC efficiency	X	X	X	X
Mechanical - fan power		X		X
Envelope - walls and roofs		X		X
Envelope - windows	X	X	X	X

A building sample of 13 SIC 36x facility simulation models were extracted from the Nonresidential New Construction (NRNC) database to produce the potential estimates for this sector. Since this sample did not have statewide coverage, all 13 models were simulated in all 16 CEC climate zones. The results were aggregated to the four CNC climate zones described below.

- **CNC Climate Zone 1:** CEC Title 24 Climate Zones 1-5, 16
- **CNC Climate Zone 2:** CEC Title 24 Climate Zones 6-7
- **CNC Climate Zone 3:** CEC Title 24 Climate Zones 8-10
- **CNC Climate Zone 4:** CEC Title 24 Climate Zones 11-15

Measure cost considerations were not only the incremental costs of higher efficient equipment and high performance materials, but also the credit for downsizing mechanical systems and the costs of design assistance.

Unlike the commercial sector, the forecast of anticipated new construction is given in terms of load rather than square footage. Therefore, the savings results are presented as a percentage of sector load and incremental measure costs are given in units $ per kWh per year saved to remain consistent with the rest of the industrial analysis. Note that HVAC and lighting end uses consume approximately 41.4% of SIC 36x sector load and the savings results are given in terms the entire sector load.

Similar to the results of the commercial analysis, packages with envelope measures show a negative incremental cost for the entire measure package. This is a result of system sizing credit, the cost savings associated with reduced cooling and heating system capacity. Even after considering the added cost of integrated design assistance to properly specify correct system size, the downsizing credit is greater than the cost of all measures.

Table Q-8: Results of HVAC and Lighting Measure Packages

Climate Zone	Package Electrical Savings	Incremental Measure Cost ($/kWh per yr)	Electricity Savings (% of Sector Load)
15% above 2001 Standards			
1-5, 16	9.92%	$1.50	4.11%
6,7	11.32%	$0.98	4.69%
8-10	13.75%	$1.20	5.69%
11-15	10.68%	$1.62	4.42%
25% above 2001 Standards			
1-5, 16	28.80%	($0.28)	11.92%
6,7	29.55%	($0.28)	12.23%
8-10	39.25%	($0.29)	16.25%
11-15	29.34%	($0.22)	12.15%
10% above 2005 Standards			
1-5, 16	9.08%	$0.10	3.76%
6,7	10.45%	$0.10	4.32%
8-10	12.48%	$0.09	5.17%
11-15	9.84%	$0.09	4.07%
15% above 2005 Standards			
1-5, 16	26.57%	($0.07)	11.00%
6,7	27.37%	($0.06)	11.33%
8-10	36.49%	($0.06)	15.11%
11-15	27.15%	($0.07)	11.24%

Clean Room Facilities

SIC 3674 Clean Room Facility Load Disaggregation by End Use

There are two basic categories of SIC 3674 clean room facilities: production facilities and research and development (R&D) facilities. The differences between these two types of facilities are substantial enough that the population of future projects needs to be considered when estimating an energy consumption end-use distribution. Rumsey Engineers, clean room design experts, assert[8] that in California the primary function of newly constructed and/or renovated clean room space will be mostly R&D facilities. The ongoing Lawrence Berkeley National Laboratory (LBNL) Clean Room Benchmarking Study[9] provided a

8 Correspondence with Peter Rumsey and Kim Traber. January-March 2005

9 Lawrence Berkeley National Laboratory. *Clean Room Benchmarking Study*. http://ateam.lbl.gov/cleanroom/benchmarking/index.htm

starting point for load disaggregation of R&D clean room energy usage by end use. This end-use distribution was refined through discussions with Rumsey Engineers to accurately reflect the usage of R&D clean rooms consistent with new construction in California. The finalized end-use distribution for clean rooms is shown in Table Q-9.

Table Q-9: Clean Room Energy Use by End Use

End Use	Load Share
Fans	31%
HVAC Pumps	10%
Chillers	14%
Process Tools	15%
De-ionized Water	5%
Compressed Air	8%
Process Vacuum	7%
Lights	4%
Miscellaneous	4%
Plug Loads	2%

SIC 3674 Clean Room Facility Savings and Cost Analysis

Although some of the conventional facility end-use analysis is applicable to clean room facilities, such as lighting and compressed air, separate analyses are necessary in most cases.

A sample of five Savings By Design clean room facility projects was used to generate estimates of savings and costs for measures unique to clean room facilities. The incremental costs were first calculated in terms of simple payback for the measure considered. The simple paybacks for the clean room specific measures were calculated from the project sample. The payback estimates for these measures were discussed with the senior staff of Rumsey Engineers as a quality control step. In a few cases, the calculated paybacks were adjusted to agree with Rumsey Engineers' experience. During this same discussion, Rumsey Engineers senior staff provided estimates of market applicability for all of the clean room specific measures to the study team. Table Q-10 presents the incremental cost for each high efficiency measure included in the analysis.

The payback figures were converted into incremental cost per annual energy savings (kWh saved per year). Where payback estimates were not available, incremental cost were calculated using expected effective full load hours (EFLH) of the systems considered.

SIC 3674 Clean Room Energy Efficiency Measures

Several of the measures analyzed are described by PG&E's Clean room Energy Baseline Report[10] by Rumsey Engineers and the LBNL Clean room Benchmarking Study.[11.] Additional measures are drawn from Savings By Design projects, case studies, and further conversations with Rumsey Engineers. Incremental costs of clean room-specific measures were backed out from simple payback estimates.

Fan Systems. Fan systems are the largest energy consuming end use in clean rooms. Approximately two-thirds of fan energy is consumed for recirculation air, and the other third is for make-up air. The baseline efficiency for recirculation systems is 2,222 CFM/kW and 926 CFM/kW for makeup systems. The efficiency of the recirculation system design measures applied are averages from the LBNL Cleanroom Energy Benchmarking Study for the particular designs. The standard effective full load hours of clean room fan system in 8760 hours per year.[12]

Exhaust System Optimization. Exhaust optimization may be achieved by staging exhaust stacks off a common plenum or header, or any other strategy that eliminates the need to pull air strictly for dilution of harmful airborne compounds. This measure saves 10% of fan system energy and is the most cost-effective fan system measure. However, only 30% of 3674 clean room facilities have the type of airborne contamination that would be applicable for this measure.

Unoccupied Airflow Setback. Typical clean room fan systems run constantly to maintain cleanliness levels. However, since human activity is the primary source of contaminants, fan systems may be controlled to allow an unoccupied recirculation airflow rate setback. Typical energy savings of this measure average 15% of fan energy use. This may be achieved either through a combination of time clock and occupancy sensors or, more expensively and slightly more accurately, by the use of a particle counter controlled system. Due to equipment costs the first option is currently more cost effective. It is estimated that 75% of clean rooms have operating schedules that would realize savings from this measure.

Pressurized Plenum Design. The most cost effective efficient design option for new construction recirculation systems is a pressurized plenum design. This design uses a large VAV air handlers to overcome the pressure drop required of air filters located between the plenum and clean room space, instead of the standard small constant volume fan filter units. The control afforded by this design can reduce the recirculation air flow rate as low as conditions dictate rather than using an on/off control. The reduced flow rates decrease the

---

10 Rumsey Engineers. *Cleanroom Energy Baseline Study.* Prepared for Pacific Gas & Electric. 2003

11 LBNL op. cit.

12 Rumsey 2003 Op. cit.

pressure drop across the high efficiency filter and typically result in a recirculation system with efficiencies over twice that of a baseline system. The market applicability for this design measure is approximately 50%.

Efficient Fan Selection. Overall fan system efficiency is the product of fan, drive, and motor efficiencies. The baseline for overall fan system efficiency is 60%. The combination of a directly coupled fan (which has no drive losses), an efficient fan, and premium efficiency motor can achieve an overall efficiency of 70% while delivering the same flow rate. The market applicability for this type of optimal fan system selection is 50%.

Reduced Air Change Rates. The baseline air change rate for clean rooms is ten air changes per hour (ACH), although rates as high as 15 ACH or more have been observed. In most cases, the desired level of cleanliness for production may be achieved while using reduced air change rates, averaging 6 ACH. The market applicability for this measure is approximately 75%.

Low Pressure Drop Filters.[13] Designing filter banks with an increased surface area and using low pressure drop filters also improves fan system efficiency. A baseline air filter pressure drop is 1.1 inches water gage. Efficient filter combinations can achieve pressure drop as low as 0.1 in. water gage. Widely available filters (75% applicability) can save 8% of fan system energy.

Low Face Velocity Air Handler Design. Baseline air handing units have a face velocity of 500 feet per minute. A low face velocity air handler design will yield a reduction in pressure drop and increase energy savings. Face velocities in the 200-300 feet per minute range can reduce energy consumption by 10% and would apply to 75% of the market. This measure requires early intervention in the design process and the additional costs of an increased air handler size, though payback is still less than three years.

Efficient Fan Filter Units. The most feasible efficient design option for renovation and late intervention projects for recirculation systems is efficient fan-filter units (2,555 CFM/kW). Benchmarking and efficiency standards are emerging for these units, which are particularly common in the semiconductor industry. The large market for these designs is represented in the high applicability factor of 75%.

[13] Weale, J., P. Rumsey, D. Sartor, L. Eng Lock. *How Low Can You Go? Low Pressure Drop Laboratory Design*. Lawrence Berkeley Laboratory . December 2001. http://btech.lbl.gov/papers/49366.pdf

Space Cooling Measures

The cooling load for clean rooms facilities is primarily internal load and is largely not a function of weather. Space cooling incremental measure costs are evaluated with an estimated 3504 effective full load hours per year.[14]

High Efficiency VSD Chiller with Condenser Wet Bulb Temperature Reset. The combination of a VSD and high efficiency chiller greatly increases energy savings. In initial measure analyses, the presence of a high efficiency chiller alone was analyzed, but it was found that, due to frequent part load operation, high efficiency is only truly realized with the application of VSD. This measure has a market applicability of 75%.

Variable Primary Cooling Loop. Baseline clean room pump systems employ a constant-volume primary and variable-volume secondary cooling loop configuration. A system designed with a variable-volume primary-only cooling loop with VSD control will typically save 20% of pump energy. Market applicability is estimated at 50%.

NEMA Premium Motor and Efficient Pump Selection. The baseline industrial pump system, which uses EPACT efficient motors and standard pumps, has a combined efficiency of 74%. Using premium efficiency motors and efficient pumps can increase efficiency to an average of 80%. The applicability of both measures is 50%.[15]

Process Vacuum Systems and De-Ionized Water System Measures

Clean room facilities use enough process vacuum and de-ionized water to be classified as separate end uses. The majority of energy usage by process vacuum and de-ionized water systems is consumed by pump systems. The measures were evaluated assuming a 5815 EFLH, the typical usage of a drive motor for this market sector reported in the U.S. Industrial Motor Market Assessment.

NEMA Premium Motor and Efficient Pump Selection. The average industrial pump system using EPACT efficient motors and standard pumps has an efficiency of 74%. Improving the pump components can improve efficiency to an average of 80% using premium efficiency motors and efficient pumps. The applicability of this measure is 50% for both end uses.

Variable Speed Drive. Motor savings may be realized in both process vacuum and de-ionized water end uses via VSD control of pumping applications**.** Motor VSD costs are based on the Database of Energy Efficient Resources (DEER) and from manufacturers' info

---

14 Mills, et al. *Energy Efficiency in California Laboratory-Type Facilities.* 1996

15 Motor cost and savings are determined using the U.S. Industrial Motor Market Assessment and MotorMaster+ software, U.S. Department of Energy.

and savings calculation methodology from IEEE references. The applicability of these measures is 50% for both end uses.

Table Q-10: Summary of Clean Room Measures

Base Case Description	Energy Efficiency Measure	Incr. Cost $/kWh	Savings Over Baseline	Applicability	Sector Savings
Standard Distributed Exhaust	Exhaust Optimization	$0.05	10%	30%	0.32%
Constant Operation	Unoccupied Airflow Setback	$0.06	15%	75%	2.31%
Standard Ducted System	Pressurized Plenum	$0.07	28%	50%	2.87%
Standard Efficiency Fan System	Efficient Fan Selection	$0.10	7%	50%	0.33%
10 ACH	Proper Air Change Rates (6 ACH)	$0.08	26%	75%	6.05%
Standard Filter	Low Pressure Drop Filter	$0.08	8%	75%	1.86%
Standard AHU	Low Face Velocity AHU	$0.25	10%	75%	2.33%
Standard Efficiency Filter Units	Efficient Fan Filter Units	$0.31	13%	75%	2.00%
Non VSD Chiller, Fixed Condensing Temp	High Efficiency VSD Chiller +Wet Bulb Offset	$0.10	16%	75%	1.68%
No Waterside Economizer	Waterside Economizer	$0.16	12%	60%	1.01%
Single Cooling Loop	Dual Temperature Cooling Loops	$0.33	9%	60%	0.76%
Primary and Secondary Loop	Primary Only VSD HVAC Pumps	$0.07	20%	50%	1.00%
CV Compressor <100HP	VSD Air Compressor <100HP	$0.08	28%	59%	1.31%
CV Compressor 100+HP	VSD Air Compressor 100+HP	$0.25	5%	16%	0.07%
Refrigeration Air Dryer	Thermal Mass Air Dryer	$0.20	2%	75%	0.12%
Standard Pump and Motor	NEMA Premium Motor + Efficient Pump	$0.10	7%	50%	0.23%
Throttled/Cycling	Process Vacuum Pump VSD	$0.29	25%	50%	0.88%
Standard Pump and Motor	NEMA Premium Motor + Efficient Pump	$0.10	7%	50%	0.16%
Throttled/Cycling	De-ionized Water Pump VSD	$0.29	25%	50%	0.63%
Title 24 LPD =1.3	High Efficacy Lighting LPD=0.96	$0.19	26%	50%	0.52%
Common Practice LPD =1.0	High Efficacy Lighting LPD=0.96	$0.14	4%	50%	0.08%

Wastewater Treatment

For this study, wastewater treatment is defined as municipal wastewater treatment plants (WWTPs), also known as publicly owned treatment works (POTWs). This market sector was evaluated with all committed and completed Savings By Design WWTP projects since the inception of the program in 1999.

The method employed for assessing the potential energy savings was to consider the Savings by Design projects as a representative sample of the population of newly constructed and thoroughly renovated WWTP projects.[16]

Load Forecast. WWTP load is classified as SIC 4952, sewerage systems. The CEC's 2003-2013 forecast[17] does not provide load forecast estimates for the four-digit subsectors of SIC 495, sanitary services. Because 4952 is the dominate load of 495, all other four-digit subsectors were considered negligible and the SIC 495 estimates were used as a proxy for SIC 4952, as shown in Table Q-11.

Table Q-11: WWTP Load Forecast

SIC 495 Load Forecast	PG&E (GWh)	SCE (GWh)	SDGE (GWh)
2003 Load	837.5	790.3	50.7
2008 Load	901.1	844.1	54.8
2013 Load	959.0	900.1	58.0
2003-2013 Increase	63.6	53.8	4.1
2003-2008 Increase	121.5	109.8	7.3

WWTP Savings and Cost Analysis

A wide array of measures exists in the sample of Savings By Design projects, which have been broadly classified into seven measure types described below. Measure baselines were taken directly from PG&E's Wastewater Baselines Studies.[18][19]

Premium Efficiency Motors and VSD Controls. EPACT efficiency motors and throttled on/off control is considered baseline for all WWTP applications.

---

16 Although this methodology is not ideal, the lack of data on future projects leaves very limited options for this analysis

17 CEC August 2003 op. cit.

18 M/J. Industrial Solutions. *Municipal Wastewater Treatment Plant Energy Baseline Study.* PG&E New Construction Energy Management Program. June 2003.

19 SBW Consulting. *Energy Benchmarking Secondary Wastewater Treatment and Ultraviolet Disinfection Processes at Various Municipal Wastewater Treatment.* Prepared for Pacific Gas & Electric. February 2002.

Low Pressure Ultraviolet (UV) Disinfection Lamps. Medium pressure UV lamps are considered baseline equipment for tertiary UV disinfection systems. Low pressure lamps are more energy efficient but at considerable cost with paybacks ranging from five to over 10 years in the projects investigated for this analysis.

Belt-Press Dewatering. Centrifugal dewatering is considered the baseline method of sludge dewatering. The belt press technique uses less energy per unit mass but needs a larger footprint for solar drying as the processed sludge has a higher water content than sludge processed with a typical centrifugal dewatering method.

High Efficiency Blowers. High efficiency blower systems realize energy savings by providing aeration air at better efficiencies than standard systems. Currently, systems are evaluated on a project-by-project basis and compared to original design. Blower systems with sufficient turn-down capabilities can save energy by matching power to load during "low flow" periods.

Reduced Pipe Friction. Effluent pumping energy savings may be realized by using a pipe with a diameter larger than originally specified and/or low friction coating on the inside of the pipe. This measure requires project-specific baseline analysis.

Reduced Pumping Head. Energy savings are realized when infrastructure design is altered to reduce the vertical distance that plant throughput is pumped. This is accomplished by lowering the level of a holding pond or removal of an obstruction that is being "pumped over."

Design Change. This measure refers to changing the fundamental technology of a facility in order to achieve energy savings. For example, under certain conditions, a sequence batch reactor can be used in place the common activated sludge technology with less energy requirements.

Incremental Measure Costs

Table Q-12 presents the incremental cost for the measures included in the analysis. These costs were developed directly from Savings By Design project files and from discussions with manufacturers, Motor Master software, and the DEER 2001 Update Study.

Table Q-12: Summary of WWTP Measure Savings and Cost

Efficiency Measures	Baseline Conditions	Energy Savings (% of Sector Load)	Incremental Measure Cost ($/kWh per Year Saved)
PE Motors and VSDs	EPACT Motors and On/Off or Throttle Control	10.2%	$0.08
Low Pressure UV lamps	Medium Pressure UV Lamps	8.2%	$0.48
Belt Press Dewatering	Centrifuge Dewatering	0.1%	$0.02
Efficient Blower	Standard Efficiency Blowers	6.5%	$0.56
Reduced Pipe Friction	Standard Piping	2.1%	$0.72
Pumping Head Reduction	Original or Standard Design	0.2%	$0.13
Design Change	Original or Standard Design	0.2%	$0.06

Refrigerated Warehouses (RWH)

Refrigerated warehouses (RWHs) are defined as facilities dominated by reduced temperature storage space.

Load Forecast. Since refrigerated warehouses are, technically, a commercial building type, the CEC 2003-2013 forecast[20] includes refrigerated warehouses in its commercial building forecast and reports the predicted usage by end use. Table Q-13 the forecast of the end uses considered for this analysis, refrigeration, and interior lighting.

Table Q-13: RWH Forecast Summary

	PG&E (GWh)	SCE (GWh)	SDGE (GWh)
2003 Load	423.8	262.6	14.7
2008 Load	459.0	297.2	16.6
2013 Load	505.0	330.5	18.0
2003-2008 Increase	35.2	34.6	1.9
2003-2013 Increase	81.2	67.9	3.3

<u>RWH Savings and Cost Analysis</u>

Eight prototype DOE2.2R RWH models were created for analysis of this market sector. The models used to project energy savings and incentive levels of each project were modified to reflect actual operating conditions found at the facility during an evaluation site visit conducted previously. These models were run with the appropriate weather data to generate

[20] CEC August 2003, op. cit.

whole premise impacts. Then parametric runs of individual measures were made in order to generate savings at the measure level. Individual measure savings were then proportioned down to balance with whole premise savings. In this manner, anticipated interactive effects of measures are accounted for even though savings are presented at the measure level.

There are two essential types of refrigerated warehouse considered for this analysis: distribution facilities/public storage warehouses and produce (fruit and vegetable) cold storage facilities. Produce facilities are generally smaller than distribution warehouses, but have considerably more energy usage on a per square foot basis. Distribution facilities and public cold storage, while having slightly different functions, have similar enough equipment and load profiles that they can be treated as the same building type for purposes of this analysis.

RWH Baseline

California's Title 24 energy regulations are largely not applicable to the refrigerated warehouse market sector. Attributes of common practice in RWH facilities is largely unavailable for California due the limited number of facilities being constructed. Additionally the deep penetration of the Savings By Design program for this market sector reduces the pool of available nonparticipants.

The assumed baseline features are included in the document *Basecase Summary for Refrigerated Warehouses*. This non-published "living" document is used as a guideline for the determination of baseline features for Savings by Design refrigerated warehouses on a project-specific basis. The document is continuously updated to reflect changes in technology, available data, and market conditions. Table Q-14 presents the base case and measure features for refrigerated warehouse project evaluation.

Table Q-14: RWH Measure and Baseline Features

Features	Baseline Description	Efficiency Measures
Condensing temperature for air condenser	10 and 15 F TD for LT and MT,	Low Approach, Variable Setpoint
Condensing temperature for evaporative condenser	Between 18 and 25 F TD	Low Approach, Variable Setpoint
Condenser specific efficiency	330 BTU/Watt for evaporative, 53 BTU/Watt for air cooled	Condenser with Higher than Baseline Efficiencies
Minimum condensing temperature	85 F SCT most cases	Floating Head Pressure, Variable Setpoint
Condenser control	Fixed setpoint, fan cycling , two speed if single fan	VSD Fan
Compressor control	Fixed setpoint or slide valves on screw compressors. On/off	Variable Setpoint
Zone control	Fixed setpoint cycling LL solenoid or EPR	Floating Suction Pressure
Evaporator fan control	Full time 100% operation unless scheduled load or highly variable load.	VSD Control
Fan/Compressor motor efficiency	Title 24/ EPACT Motors	NEMA Premium/CEE Motors
Lighting Control	Manual/Timer	Occupancy/Daylighting Control

<u>Measures</u>

Floating Head Pressure, VSD Control of Condenser Fans, and Variable Setpoint (Wet Bulb Offset). These measures have synergistic effects and are typically considered, analyzed and implemented as a bundle in Savings By Design projects. This group of measures is included in most Savings By Design RWH projects.

Air Unit (Evaporator Fan) VSD Control. VSD control saves fan power in facilities with variable load. Therefore, more savings are realized with this measure at seasonal produce facilities with greatly varying load than at large distribution facilities.

Lighting Controls. Lighting control measures in Savings By Design RWH projects utilize bi-level lighting with occupancy control inside cold storage areas and daylighting controls in adjacent dry storage areas to achieve energy savings. Given the 0.6 baseline LPD for the storage occupancy, few projects qualify based on installed LPD alone.

Floating Suction Pressure. Installing floating suction pressure capability allows suction pressure setpoint adjustment based upon load. This realizes compressor energy savings and is a viable measure in most RWH facilities.

Efficient Compressor Motor. Savings By Design provides incentives premium efficiency compressor motors.

Incremental Measure Costs

The incremental cost estimates for RWH measures are taken from estimates taken directly from Savings By Design project file estimates. The savings are normalized to dollars per annual energy savings in kWh as shown in Table Q-15. PG&E cost are different due to difference in anticipated facility types. The difference in measure savings comes from public storage/distribution warehouse and produce warehouses. PG&E was assumed to have 40% of its anticipated load comprised of produce warehouses, whereas SCE and SDG&E only had a 5% produce facility load.

Table Q-15: Summary of RWH Measure Savings and Incremental Costs

Energy Efficiency Measure	Baseline Description	Measure Savings (% of Sector Load)	Inc. Measure Cost ($/kWh of Savings/yr)	
			SCE a SDG&E	PG&E
Floating Head Pressure, Variable Setpoint, Variable Fan Speed	Fixed Setpoint, CV or Two-Speed Fans	6.18%	0.16	0.17
Air Unit VSDs	CV or Two-Speed Fan	9.19%	0.09	0.11
Lighting Controls	Manual Control or Timers	6.50%	0.27	0.27
PE Compressor Motor	EPACT Compressor Motor	0.12%	0.59	0.59
Floating Suction Pressure	Fixed Suction Pressure	9.57%	0.10	0.10
Efficient Condenser	Standard Efficiency Condenser	0.38%	0.11	0.09

Q.3. Development of ASSET Industrial New Construction Model Inputs

Awareness

The following table presents the awareness values used in the analysis for industrial new construction.

Industrial New Construction
Awareness

Tech	Awareness	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
REF_FxFn	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
REF_FlHP	AwareRef	0.95	0.95	0.96	0.97	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
REF_CVFn	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
REF_AVFD	AwareRef	0.95	0.95	0.96	0.97	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
REF_MnCn	1	0.00	0.00	0.00	0.00	0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
REF_LtC	AwareRef	0.95	0.95	0.96	0.97	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
REF_EPCM	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
REF_EfCM	AwareRef	0.95	0.95	0.96	0.97	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
REF_FxSP	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
REF_FlSP	AwareRef	0.95	0.95	0.96	0.97	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
REF_StCn	1	0.00	0.00	0.00	0.00	0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
REF_EfCn	AwareRef	0.95	0.95	0.96	0.97	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WWT_ThCn	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WWT_VFD	AwareWWT	0.95	0.95	0.96	0.97	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WWT_MPUV	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WWT_LPUV	AwareWWT	0.95	0.95	0.96	0.97	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WWT_CnDW	1	0.00	0.00	0.00	0.00	0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
WWT_PDW	AwareWWT	0.95	0.95	0.96	0.97	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WWT_StEB	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WWT_EfBl	AwareWWT	0.95	0.95	0.96	0.97	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WWT_01	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WWT_RPF	AwareWWT	0.95	0.95	0.96	0.97	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WWT_02	1	0.00	0.00	0.00	0.00	0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
WWT_PHR	AwareWWT	0.95	0.95	0.96	0.97	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WWT_OrDs	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WWT_Des	AwareWWT	0.95	0.95	0.96	0.97	0.98	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S36_StEM	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S36_Pmp	AwareS36	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S36_ThOF	1	0.00	0.00	0.00	0.00	0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S36_VSD	AwareS36	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S36_CVAS	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S36_ACrS	AwareS36	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S36_CVAL	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S36_ACrL	AwareS36	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S36_RfAD	1	0.00	0.00	0.00	0.00	0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S36_TMD	AwareS36	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S36_StEC	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S36_HEVC	AwareS36	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S36_NWEc	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S36_WtEc	AwareS36	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S01_01B	1	0.00	0.00	0.00	0.00	0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S01_0115	AwareS36	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S01_0125	AwareS36	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S01_05B	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S01_0510	AwareS36	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S01_0515	AwareS36	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S04_01B	1	0.00	0.00	0.00	0.00	0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S04_0115	AwareS36	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S04_0125	AwareS36	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S04_05B	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S04_0510	AwareS36	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
S04_0515	AwareS36	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90

Industrial New Construction
Awareness

Tech	Awareness	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
CRm_StDX	1	0.00	0.00	0.00	0.00	0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_ExOp	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_CnOp	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_UAS	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_StDS	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_PrPl	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_SFS	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_EfFS	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_SACR	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_PACR	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_StFl	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_LPDF	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_SAHU	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_LFV	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_SEFU	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_EFFU	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_SCCh	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_HECh	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_NWEc	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_WtEc	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_SCLp	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_DTCL	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_PSLp	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_POHP	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_PS74	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_PrPm	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_CVCS	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_VACS	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_CVCL	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_VACL	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_RfAD	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_CTMD	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_StPM	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_PMEV	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_ThCn	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_PVPV	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_SPmM	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_PMEW	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_ThrC	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_DWP	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CRm_MCLt	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CRm_HeLt	AwareCRm	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90

Willingness, Feasibility, Technology Density, and Applicability

The analysis used a willingness and feasibility factor of 100%. The technology density and applicability used were 1.

Industrial New Construction Energy Load Forecast

As discussed in Section Q.2 above, the industrial new construction load forecast was taken from the CEC's 2003-2013 Energy Demand Forecast.

Industrial New Construction
Energy Load Forecast

Utility	Area	Segment	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
PG&E	All	REF	6,450	6,450	6,773	7,111	7,467	7,840	8,232	8,644	9,076	9,530	10,006	10,006	10,006	10,006	10,006
PG&E	All	WWT	12,850	12,850	12,593	12,341	12,094	11,852	11,615	11,383	11,155	10,932	10,714	10,714	10,714	10,714	10,714
PG&E	All	S36	34,500	34,500	30,705	27,327	24,321	21,646	19,265	17,146	15,260	13,581	12,087	12,087	12,087	12,087	12,087
PG&E	All	CRm	58,000	58,000	46,400	37,120	29,696	23,757	19,005	15,204	12,163	9,731	7,785	7,785	7,785	7,785	7,785
SCE/SoCalGas	All	REF	7,250	7,250	7,178	7,034	6,893	6,755	6,620	6,488	6,358	6,231	6,106	6,106	6,106	6,106	6,106
SCE/SoCalGas	All	WWT	11,500	11,500	11,615	11,731	11,848	11,967	12,087	12,207	12,330	12,453	12,577	12,577	12,577	12,577	12,577
SCE/SoCalGas	All	S36	33,000	33,000	30,030	27,327	24,868	22,630	20,593	18,740	17,053	15,518	14,122	14,122	14,122	14,122	14,122
SCE/SoCalGas	All	CRm	35,900	35,900	32,669	29,729	27,053	24,618	22,403	20,387	18,552	16,882	15,363	15,363	15,363	15,363	15,363
SDG&E	All	REF	400	400	380	361	343	326	310	294	279	265	252	252	252	252	252
SDG&E	All	WWT	1,100	1,100	1,045	993	943	896	851	809	768	730	693	693	693	693	693
SDG&E	All	S36	6,000	6,000	5,340	4,753	4,230	3,765	3,350	2,982	2,654	2,362	2,102	2,102	2,102	2,102	2,102
SDG&E	All	CRm	2,900	2,900	2,639	2,401	2,185	1,989	1,810	1,647	1,499	1,364	1,241	1,241	1,241	1,241	1,241

Energy Time-Of-Use Shares and Coincident Peak Factors

The following table lists the energy time-of-use shares associated with each technology and segment for industrial new construction units. The energy time-of-use shares change by utility or by region. Using the name of the energy time-of-use share, the actual load shape and peak factors are listed in Table Q-17.

Table Q-16: Energy Time-Of-Use Shares by Technology and Segment

Technology Name	Segment	Energy Time-Of-Use Share	Changes by
REF_FxFn	REF	REF_ELE	Utility
REF_FlHP	REF	REF_ELE	Utility
REF_CVFn	REF	REF_ELE	Utility
REF_AVFD	REF	REF_ELE	Utility
REF_MnCn	REF	REF_Light	Utility
REF_LtC	REF	REF_Light	Utility
REF_EPCM	REF	REF_ELE	Utility
REF_EfCM	REF	REF_ELE	Utility
REF_FxSP	REF	REF_ELE	Utility
REF_FlSP	REF	REF_ELE	Utility
REF_StCn	REF	REF_ELE	Utility
REF_EfCn	REF	REF_ELE	Utility
WWT_ThCn	WWT	WWT_ELE	Utility
WWT_VFD	WWT	WWT_ELE	Utility
WWT_MPUV	WWT	WWT_ELE	Utility
WWT_LPUV	WWT	WWT_ELE	Utility
WWT_CnDW	WWT	WWT_ELE	Utility
WWT_PDW	WWT	WWT_ELE	Utility
WWT_StEB	WWT	WWT_ELE	Utility
WWT_EfBl	WWT	WWT_ELE	Utility
WWT_01	WWT	WWT_ELE	Utility
WWT_RPF	WWT	WWT_ELE	Utility
WWT_02	WWT	WWT_ELE	Utility
WWT_PHR	WWT	WWT_ELE	Utility
WWT_OrDs	WWT	WWT_ELE	Utility
WWT_Des	WWT	WWT_ELE	Utility
S36_StEM	S36	S36_Motor	Utility
S36_Pmp	S36	S36_Motor	Utility
S36_ThOF	S36	S36_Proc	Utility
S36_VSD	S36	S36_Proc	Utility
S36_CVAS	S36	S36_Proc	Utility
S36_ACrS	S36	S36_Proc	Utility
S36_CVAL	S36	S36_Proc	Utility

Table Q-16 (cont'd.): Energy Time-Of-Use Shares by Technology and Segment

Technology Name	Segment	Energy Time-Of-Use Share	Changes by
S36_ACrL	S36	S36_Proc	Utility
S36_RfAD	S36	S36_Proc	Utility
S36_TMD	S36	S36_Proc	Utility
S36_StEC	S36	S36_Proc	Utility
S36_HEVC	S36	S36_Proc	Utility
S36_NWEc	S36	S36_Proc	Utility
S36_WtEc	S36	S36_Proc	Utility
S36_01_00	S36	S36_HVAC	Region
S36_01_15	S36	S36_HVAC	Region
S36_01_25	S36	S36_HVAC	Region
S36_05_00	S36	S36_HVAC	Region
S36_05_10	S36	S36_HVAC	Region
S36_05_15	S36	S36_HVAC	Region
CRm_StDX	CRm	CRm_Proc	Utility
CRm_ExOp	CRm	CRm_Proc	Utility
CRm_CnOp	CRm	CRm_OffHr	Utility
CRm_UAS	CRm	CRm_OffHr	Utility
CRm_StDS	CRm	CRm_Proc	Utility
CRm_PrPl	CRm	CRm_Proc	Utility
CRm_SFS	CRm	CRm_Proc	Utility
CRm_EfFS	CRm	CRm_Proc	Utility
CRm_SACR	CRm	CRm_Proc	Utility
CRm_PACR	CRm	CRm_Proc	Utility
CRm_StFl	CRm	CRm_Proc	Utility
CRm_LPDF	CRm	CRm_Proc	Utility
CRm_SAHU	CRm	CRm_Proc	Utility
CRm_LFV	CRm	CRm_Proc	Utility
CRm_SEFU	CRm	CRm_Proc	Utility
CRm_EFFU	CRm	CRm_Proc	Utility
CRm_SCCh	CRm	CRm_Proc	Utility
CRm_HECh	CRm	CRm_Proc	Utility
CRm_NWEc	CRm	CRm_Proc	Utility
CRm_WtEc	CRm	CRm_Proc	Utility
CRm_SCLp	CRm	CRm_Proc	Utility
CRm_DTCL	CRm	CRm_Proc	Utility
CRm_PSLp	CRm	CRm_Proc	Utility
CRm_POHP	CRm	CRm_Proc	Utility
CRm_PS74	CRm	CRm_Proc	Utility
CRm_PrPm	CRm	CRm_Proc	Utility
CRm_CVCS	CRm	CRm_Proc	Utility

Table Q-16 (cont'd.): Energy Time-Of-Use Shares by Technology and Segment

Technology Name	Segment	Energy Time-Of-Use Share	Changes by
CRm_VACS	CRm	CRm_Proc	Utility
CRm_CVCL	CRm	CRm_Proc	Utility
CRm_VACL	CRm	CRm_Proc	Utility
CRm_RfAD	CRm	CRm_Proc	Utility
CRm_CTMD	CRm	CRm_Proc	Utility
CRm_StPM	CRm	CRm_Proc	Utility
CRm_PMEV	CRm	CRm_Proc	Utility
CRm_ThCn	CRm	CRm_Proc	Utility
CRm_PVPV	CRm	CRm_Proc	Utility
CRm_SPmM	CRm	CRm_Proc	Utility
CRm_PMEW	CRm	CRm_Proc	Utility
CRm_ThrC	CRm	CRm_Proc	Utility
CRm_DWP	CRm	CRm_Proc	Utility
CRm_MCLt	CRm	CRm_Light	Utility
CRm_HeLt	CRm	CRm_Light	Utility

The following table lists the energy time-of-use shares for commercial new construction end uses by region. The TOU periods are the same as those given in previous sections of the appendix. The summer peak coincidence factor is also included.

Table Q-17: TOU Load Shapes and Summer Peak Factors

Energy Time-Of-Use Share	Region	Summer On Peak	Summer Partial Peak	Summer Off Peak	Winter Partial Peak	Winter Off Peak	Summer Peak Factor	Coincidence Factor
CRm_Light	PG&E	15%	14%	25%	27%	19%	1.00	1.00
CRm_Light	SCE	12%	10%	13%	38%	27%	1.00	1.00
CRm_Light	SDG&E	12%	12%	20%	32%	23%	1.00	1.00
CRm_OffHr	PG&E	0%	0%	50%	0%	50%	1.00	1.00
CRm_OffHr	SCE	0%	0%	50%	0%	50%	1.00	1.00
CRm_OffHr	SDG&E	0%	0%	50%	0%	50%	1.00	1.00
CRm_Proc	PG&E	11%	12%	29%	23%	25%	1.00	1.00
CRm_Proc	SCE	9%	5%	20%	24%	42%	1.00	1.00
CRm_Proc	SDG&E	10%	9%	25%	26%	30%	1.00	1.00
REF_Ele	PG&E	11%	12%	35%	17%	25%	1.00	1.00
REF_Ele	SCE	10%	11%	35%	17%	27%	1.00	1.00
REF_Ele	SDG&E	9%	11%	36%	17%	28%	1.00	1.00
REF_Light	PG&E	15%	14%	25%	27%	19%	1.00	1.00

Table Q-17 (cont'd.): TOU Load Shapes and Summer Peak Factors

Energy Time-Of-Use Share	Region	Summer On Peak	Summer Partial Peak	Summer Off Peak	Winter Partial Peak	Winter Off Peak	Summer Peak Factor	Coincidence Factor
REF_Light	SCE	12%	10%	13%	38%	27%	1.00	1.00
REF_Light	SDG&E	12%	12%	20%	32%	23%	1.00	1.00
S36_HVAC	Region 1	15%	12%	30%	16%	27%	1.45	0.79
S36_HVAC	Region 2	14%	12%	32%	16%	26%	1.36	0.90
S36_HVAC	Region 3	15%	13%	31%	16%	25%	1.36	0.81
S36_HVAC	Region 4	15%	13%	33%	15%	24%	1.29	0.87
S36_Light	PG&E	15%	14%	25%	27%	19%	1.00	1.00
S36_Light	SCE	12%	10%	13%	38%	27%	1.00	1.00
S36_Light	SDG&E	12%	12%	20%	32%	23%	1.00	1.00
S36_Motor	PG&E	10%	11%	32%	19%	28%	1.00	1.00
S36_Motor	SCE	8%	7%	20%	24%	43%	1.00	1.00
S36_Motor	SDG&E	9%	10%	25%	26%	30%	1.00	1.00
S36_Proc	PG&E	11%	12%	29%	23%	25%	1.00	1.00
S36_Proc	SCE	9%	5%	20%	24%	42%	1.00	1.00
S36_Proc	SDG&E	10%	9%	25%	26%	30%	1.00	1.00
WWT_Ele	PG&E	15%	13%	23%	27%	23%	1.00	1.00
WWT_Ele	SCE	15%	13%	23%	27%	23%	1.00	1.00
WWT_Ele	SDG&E	15%	13%	23%	27%	23%	1.00	1.00

Appendix R

Glossary

Annual Fuel Utilization Efficiency (AFUE). A measure of heating efficiency, in consistent units, determined by applying the federal test method for furnaces. This value is intended to represent the ratio of heat transferred to the conditioned space by the fuel energy supplied over one year. (See California Code of Regulations, Title 20, Section 1602(d)(1).)

Annual Maximum Demand. The greatest of all demands of the electrical load that occurred during a prescribed interval in a calendar year.

Appliance Efficiency Standards. California Code of Regulations, Title 20, Chapter 2, Subchapter 4: Energy Conservation, Article 4: Appliance Efficiency Standards. Appliance Efficiency Standards regulate the minimum performance requirements for appliances sold in California and apply to refrigerators, freezers, room air conditioners, central air conditioners, gas space heaters, water heaters, plumbing fittings, fluorescent lamp ballasts and luminaries, and ignition devices for gas cooking appliances and gas pool heaters. New National Appliance Standards are in place for some of these appliances and will become effective for others at a future date.

Applicable Fraction. The percent of the market with the qualifying end use or technology. The applicable fraction is a screen limiting the market size for the technical, economic, and market forecasts.

Applicable Market. The size of the market for which the high efficiency technology can be applied. For new construction, the applicable market is the number of new units with the qualifying equipment. For replace-on-burnout technologies, the applicable market is the number of decaying units that are to be replaced (usually 1). For conversion technologies, the applicable market is the cumulative conversion from the base option to other options within the competition group (usually 1). For retrofits, the applicable market is the number of existing units with the qualifying configuration or equipment.

Autorep. Autorep is an ASSET feature that allows the technology to be repurchased automatically upon burnout. The energy savings and avoided cost benefits associated with technology purchased under the program continue, but there are no incentives for the additional repurchases.

Avoided Cost (Regulatory). The amount of money that an electric utility would need to spend for the next increment of electric generation to produce or purchase elsewhere the power that it instead buys from a cogenerator or small-power producer. Federal law establishes broad guidelines for determining how much a qualifying facility (QF) is paid for power sold to the utility. The avoided costs used in this analysis include avoided generation, transmission, and distribution costs.

Awareness. The percent aware of technology is the share of decision makers within the feasible market who have been exposed to a technology and have formed an opinion about the operating characteristics of that option. The level of awareness can change over time. Awareness works as a market screen to reduce the size of the energy efficiency potential for the market forecasts.

Base Share. A percentage telling what proportion of all households/floorspace in a given geographical area have the technology in place in the base year. For devices that depend on the presence of a specific type of equipment, the compound saturation level is used. For example, if the share of electric water heaters is 50%, and 20% of these units have a tank wrap, then the base share of tank wraps on electric water heaters is 10%.

Baseline Forecast. A prediction of future energy needs that does not take into account the likely effects of energy efficiency programs in the future. Subtracting the baseline forecast from the market forecast is one method of calculating a net forecast.

Building Energy Efficiency Standards. California Code of Regulations (California Code of Regulations), Title 24, Part 2, Chapter 2-53; regulating the energy efficiency of buildings constructed in California.

Building Energy Simulation Model. Computer models based on physical engineering principals and/or standards used to estimate energy usage and/or savings. These models do not make use of billing or metered data, but usually incorporate site-specific data on customers and physical systems. Building Simulation Models usually require such site-specific data as square footage, weather, surface orientations, elevations, space volumes, construction materials, equipment use, lighting, and building occupancy. Building simulation models can usually account for interactive effects between end uses (e.g., lighting and HVAC), part-load efficiencies, and changes in external and internal heat gains/losses. Examples of building simulation models include ADM2, BLAST, and DOE-2.

Building Envelope. The assembly of exterior partitions of a building that enclose conditioned spaces, through which thermal energy may be transferred to or from the exterior, unconditioned spaces, or the ground. See California Code of Regulations, Title 24, Section 2-5302.

California Energy Commission (CEC or Commission). The state agency established by the Warren-Alquist State Energy Resources Conservation and Development Act in 1974 (Public Resources Code, Sections 25000 et seq.) responsible for energy policy. Funding for the CEC's activities comes from the Energy Resources Program Account, Federal Petroleum Violation Escrow Account, and other sources. The CEC has statewide power plant siting, supply and demand forecasting, as well as multiple types of energy policy and analysis responsibilities.

California Public Utilities Commission (CPUC). A state agency created by constitutional amendment in 1911 to regulate the rates and services of more than 1,500 privately owned utilities and 20,000 transportation companies. The CPUC is an administrative agency that exercises both legislative and judicial powers; its decisions and orders may be appealed only to the California Supreme Court. The major duties of the CPUC are to regulate privately owned utilities, and secure adequate service to the public at rates that are just and reasonable both to customers and shareholders of the utilities, including rates, electricity transmission lines and natural gas pipelines. The CPUC also provides electricity and natural gas forecasting, and analysis and planning of energy supply and resources. Its main headquarters are in San Francisco.

Competition Group. A set of technologies grouped together to represent that the high efficiency technologies that can replace the lower efficiency technologies. The list of technology options is mutually exclusive, implying that only one option can be selected and installed.

Conditioned Floor Area. The floor area of enclosed conditioned spaces on all floors measured from the interior surfaces of exterior partitions for nonresidential buildings and from the exterior surfaces of exterior partitions for residential buildings. See California Code of Regulations, Title 24, Section 2-5302.

Control Share. In ASSET, the control share is the fraction of the applicable market that adopts a measure. For example, if a competition group is applicable to 60% of the market, and a measure in the group has a control share of 10%, this implies an overall adoption rate of 6%.

Conversion Model. For the conversion model, the existing technology is converted into a high efficiency technology. Existing technology saturation levels define the size of the conversion market. The adoption models give the fraction of customers with the specific equipment who convert to the high efficiency option. Saturation levels change because the stock of the base option declines and the stock of the high efficiency option increase.

Cooling Degree Days. The cumulative number of degrees in a month or year by which the mean temperature is above 18.3°C/65°F.

Cost-Effectiveness. An indicator of the relative performance or economic attractiveness of any energy efficiency investment or practice when compared to the costs of energy produced and delivered in the absence of such an investment. In the energy efficiency field, the present value of the estimated benefits produced by an energy efficiency program as compared to the estimated total program's costs, from the perspective of either society as a whole or of individual customers, to determine if the proposed investment or measure is desirable from a variety of perspectives, e.g., whether the estimated benefits exceed the estimated costs. See **Total Resource Cost Test – Societal Version.**

Cross-Cutting Program. A program that involves any or all of the following: multiple customer types (residential and/or nonresidential), and/or multiple building types (retrofit, remodeling, and/or new construction).

DEER. Database for Energy Efficient Resources.

Demand. The time rate of energy flow. Demand usually refers to electric power and is measured in kW (equals kWh/h), but can also refer to natural gas, usually as Btu/hr, kBtu/hr, therms/day, or ccf/day.

Demand (Utility). The level at which electricity or natural gas is delivered to users at a given point in time. Electric demand is expressed in kilowatts.

Demand Billing. The electric capacity requirement for which a large user pays. It may be based on the customer's peak demand during the contract year, on a previous maximum or on an agreed minimum. Measured in kilowatts.

Demand Charge. The sum to be paid by a large electricity consumer for its peak usage level.

Demand Responsiveness. Sometimes referred to as load shifting. Activities or equipment that induce consumers to use energy at different (lower cost) times of day or to interrupt energy use for certain equipment temporarily, usually in direct response to a price signal. Examples: interruptible rates, doing laundry after 7 p.m., air conditioner recycling programs.

Demand Savings. The reduction in the demand from the pre-retrofit baseline to the post-retrofit demand, once independent variables (such as weather or occupancy) have been adjusted for. This term is usually applied to billing demand, to calculate cost savings, or to peak demand, for equipment sizing purposes. The forecast demand savings are peak demand savings.

Demand-Side Management (DSM). The methods used to manage energy demand including energy efficiency, load management, fuel substitution, and load building. See **Load Management.**

Direct Installation Programs. These types of programs provide free energy efficiency measures for qualified customers. Typical measures distributed by these programs include low flow showerheads and compact fluorescent bulbs.

Discount Rate. Is the discount factor used by decision makers for investments in energy equipment. The discount rate is used to compute present values for a technology option.

Discretionary Decisions. For discretionary decisions, there is no physical process that dictates that a decision must be made. In any year, a large number of customers might be situated to enter the market, but they are not compelled to do so by a physical event. In ASSET, the two types of discretionary decisions are equipment conversion and retrofit models.

Double Glazing. Windows having two sheets of glass with an airspace between the two sheets.

Economic Potential. Refers to that part of the technical potential that can cost-effectively be obtained when compared to supply-side alternatives. The most efficient technology option that is cost effective is selected subjet to applicability and feasibility.

Effective Useful Life (EUL). An estimate of the median number of years that the measures installed under the program are still in place and operable.

Efficacy, Lighting. The ratio of light from a lamp to the electrical power consumed, including ballast losses, expressed as lumens per watt. See California Code of Regulations, Title 24, Section 2-5302.

Efficiency. The ratio of the useful energy delivered by a dynamic system (such as a machine, engine, or motor) to the energy supplied to it over the same period or cycle of operation. The ratio is usually determined under specific test conditions.

Electric Public Goods Charge (PGC). Per Assembly Bill (AB) 1890, a universal charge applied to each electric utility Customer's bill to support the provision of public goods. Public goods covered by California's electric PGC include public purpose energy efficiency programs, low-income services, renewables, and energy-related research and development.

End Use (Measures/Groups). Refers to a broad or sometimes narrower category upon which the program is concentrating. Examples of end uses include refrigeration, food service, HVAC, appliances, envelope and lighting.

Energy Cost. The total cost for energy, including such charges as base charges, demand charges, customer charges, power factor charges, and miscellaneous charges.

Energy Efficiency. Using less energy/electricity to perform the same function. Programs designed to use electricity more efficiently—doing the same with less. For the purpose of this report, energy efficiency is distinguished from DSM programs in that the latter are utility sponsored and financed, while the former is a broader term not limited to any particular sponsor or funding source. "Energy conservation" is a term that has also been used, but it has the connotation of doing without in order to save energy rather than using less energy to do the same thing; thus, it is not used as much today. Many people use these terms interchangeably.

Energy Efficiency Measure. Installation of equipment, subsystems, or systems or modification of equipment, subsystems, systems, or operations on the customer side of the meter to reduce energy usage and/or demand (and, hence, energy and/or demand costs) at a comparable level of service.

Energy Efficiency of a Measure. A measure of the energy used to provide a specific service or to accomplish a specific amount of work (e.g., kWh per cubic foot of a refrigerator, therms per gallon of hot water).

Energy Efficiency of Equipment. The percentage of gross energy input that is realized as useful energy output of a piece of equipment.

Energy Efficiency Ratio (EER). The ratio of cooling capacity of an air conditioning unit in Btus per hour to the total electrical input in watts under specified test conditions. See California Code of Regulations, Title 20, Section 1602(c)(6).

Energy Savings. The reduction in use of energy from the pre-retrofit baseline to the post-retrofit energy use, once independent variables (such as weather or occupancy) have been adjusted for.

Event Driven Decissions. A customer decision that must occur due to an event. ASSET has two types of event-driven decisions, new construction, and replace-on-burnout models. For these types of models, the size of the market is defined by a physical process, such as construction or the decay of an existing piece of equipment.

Feasibility. The feasibility percentage gives the sshare of the applicable market for which an individual measure is feasible given limitations on size, space, required level of service, and other configuration issues. The fraction effectively divides the applicable market into a segment where the measure is feasible and a segment where it is not.

Free Driver. A nonparticipant who adopted a particular efficiency measure or practice as a result of a utility program. See **Spillover Effects** for aggregate impacts.

Gigawatt-Hour (GWH). One million kilowatt-hours of electric power.

Gross Savings. Gross savings are the energy and demand savings forecast which have not netted out freeridership and freedrivership.

Heating Degree Days. The cumulative number of degrees in a month or year by which the mean temperature falls below 18.3°C/65°F.

Heating Seasonal Performance Factor (HSPF). A representation of the total heating output of a central air conditioning heat pump in Btus during its normal usage period for heating, divided by the total electrical energy input in watt-hours during the same period, as determined using the test procedure specified in the California Code of Regulations, Title 20, Section 1603(c).

HVAC (Heating, Ventilation, and Air Conditioning). A system that provides heating, ventilation, and/or cooling within or associated with a building.

Incremental Cost. The incremental cost is the additional cost of the high efficiency measure above the cost of the base efficiency option. The incremental cost includes additional equipment and labor costs. For retrofit devices, the incremental cost is the measure cost plus the labor costs.

Kilowatt (kW). One thousand (1,000) watts. A unit of measure of the amount of electricity needed to operate given equipment. On a hot summer afternoon, a typical home with central air conditioning and other equipment in use might have a demand of four kW each hour.

Kilowatt-Hour (kWh). The most commonly used unit of measure telling the amount of electricity consumed over time. It means one kilowatt of electricity supplied for one hour.

Life-Cycle Cost. Amount of money necessary to own, operate, and maintain a building over its useful life.

Load Factor. A percent telling the difference between the amount of electricity a consumer used during a given time span and the amount that would have been used if the usage had stayed at the consumer's highest demand level during the whole time. The term also is used to mean the percentage of capacity of an energy facility—such as a power plant or gas pipeline—that is utilized in a given period.

Load Shape. The time-of-use pattern of customer or equipment energy use. This pattern can be over 24 hours or a year (8760 hours).

Low-E. A special coating that reduces the emissivity of a window assembly, thereby reducing the heat transfer through the assembly.

Marginal Cost. The sum that must be paid for the next increment of product or service. The marginal cost of electricity is the price to be paid for kilowatt-hours above and beyond those supplied by presently available generating capacity.

Market Potential. The amount of savings that can occur in response to specific program designs and delivery approaches, including program funding and measure incentive levels. Achievable potential studies are sometimes referred to as Market Potential studies.

Megawatt (MW). One thousand kilowatts (1,000 kW) or one million (1,000,000) watts. One megawatt is enough energy to power 1,000 average California homes.

Natural Change. The change in base usage over time. Natural change represents the effects of energy-related decisions that would have been made in the absence of the utility programs by both program participants and nonparticipants.

Net Load Impact. The total change in load that is attributable to the utility DSM program. This change in load may include, implicitly or explicitly, the effects of free drivers, free riders, state, or federal energy efficiency standards, changes in the level of energy service, and natural change effects.

Net-To-Gross Ratio. A factor representing net program load impacts divided by gross program load impacts that is applied to gross program load impacts to convert them into net program load impacts. This factor is also sometimes used to convert gross measure costs to net measure costs.

New Construction. Residential and nonresidential buildings that have been newly built or have added major additions subject to Title 24, the California building standards code.

New Construction Models. For new construction decisions, adoption models give the fraction of new construction that adopts an option. The adoption rate is the market penetration rate.

Nonresidential. Facilities used for business, commercial, agricultural, institutional, and industrial purposes.

Nonresidential Building. Any building that is heated or cooled in its interior and is of an occupancy type other than Type H, I, or J, as defined in the Uniform Building Code, 1973 edition, as adopted by the International Conference of Building Officials.

Payback Period. The payback period is the number of years that it will take to recover an up-front investment in an energy efficiency measure. The payback is computed by dividing the incremental investment cost by the annual bill savings that accrue from adoption of that option relative to the base efficiency.

Peak Demand. The maximum level of metered demand during a specified period, such as a billing month, or during a specified peak demand period.

Radiant Barrier. A device designed to reduce or stop the flow of radiant energy.

Rebates. A type of incentive provided to encourage the adoption of energy efficient practices, typically paid after the measure has been installed. There are typically two types of rebates: a Prescriptive Rebate, which is a prescribed financial incentive per unit for a prescribed list of products, and a Customized Rebate, in which the financial incentive is determined using an analysis of the customer’s equipment and an agreement on the specific products to be installed. Upstream rebates are financial incentives provided for manufacturing, sales, stocking, or other per unit energy efficient product movement activities designed to increase use of particular type of products.

Replacement. Refers to the changing of equipment either due to failure, move to more efficient equipment or other reasons near the end of product life or earlier. Often used to refer to a move to a more energy efficient product that replaces an inefficient product.

Replace-On-Burnout Models. For replacement decisions, the total decay of all options in a competition group defines the market size. The adoption model gives the share of total group replacement by the high efficiency option.

Residential Building. Any hotel, motel, apartment house, lodging house, single dwelling, or other residential building that is heated or mechanically cooled.

Retrofit. Energy efficiency activities undertaken in existing residential or nonresidential buildings where existing inefficient equipment is replaced by efficient equipment.

Retrofit Models. For retrofit models, adoption rates are applied to the fraction of customers who qualify for the specific device. Saturation levels define the fraction of the market that already has a measure. Saturation levels changes as a direct result of the retrofit process.

R-Value. A unit of thermal resistance used for comparing insulating values of different material; basically a measure of the effectiveness of insulation in stopping heat flow. The higher the R-value number of a material, the greater its insulating properties and the slower the heat flow through it. The specific value needed to insulate a home depends on climate, type of heating system, and other factors.

Seasonal Energy Efficiency Ratio (SEER). The total cooling output of a central air conditioning unit in Btus during its normal usage period for cooling divided by the total electrical energy input in watt-hours during the same period, as determined using specified federal test procedures. See Title 20, Section 2-1602(c)(11).

Shading Coefficient (SC). The ratio of solar heat gain through fenestration, with or without integral shading devices, to that occurring through unshaded 1/8” thick clear double strength glass. See **Solar Heat Gain Coefficient**.

Solar Heat Gain Coefficient (SHGG). The ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation.

Spillover. Reductions in energy consumption and/or demand in a utility's service area caused by the presence of a DSM program, beyond program-related gross savings of participants. These effects could result from (a) additional energy efficiency actions that program participants take outside the program as a result of having participated, (b) changes in the array of energy-using equipment that manufacturers, dealers, and contractors offer all customers as a result of program availability, and (c) changes in the energy use of nonparticipants as a result of utility programs, whether direct (e.g., utility program advertising) or indirect (e.g., stocking practices such as (b) above, or changes in consumer buying habits).

Technology Density. A ratio or multiplier between segment units (homes, square footage) and technology units (appliances, tons, fixtures). The technology density can be greater than one, (e.g., 1.25 refrigerators per home, 45 light bulbs per home, 2 tons of cooling per thousand conditioned square feet).

Technical Potential. The complete penetration of all measures analyzed in applications where they were deemed technically feasible and applicable from an engineering perspective.

Therm. One hundred thousand (100,000) British thermal units (1 therm = 100,000 Btu).

Thermostat, Setback. A device containing a clock mechanism, which can automatically change the inside temperature maintained by an HVAC system according to a preset schedule. The heating or cooling requirements can be reduced when a building is unoccupied or when occupants are asleep. See California Code of Regulations, Title 24, Section 2- 5352(h).

Time-Of-Use (TOU) Rates. Electricity prices that vary depending on the periods in which the energy is consumed. In a time-of- use rate structure, higher prices are charged during utility peak-load times. Such rates can provide an incentive for consumers to curb power use during peak times.

Total Resource Cost Test, Societal Version. A cost-effectiveness test intended to measure the overall cost-effectiveness of energy efficiency programs from a societal perspective.

U-Value/U-Factor. A measure of how well heat is transferred by the entire window—the frame, sash, and glass—either into or out of the building. U-value is the opposite of R-value. The lower the U-factor, the better the window will keep heat inside a home on a cold day.

Variable Air Volume (VAV) HVAC System. HVAC systems that control the dry-bulb temperature within a space by varying the volume of supply air to the space.

Willingness. This term gives the fraction of the aware market that accepts the technology as being valid and useful. The types of factors that limit willingness to adopt include concerns about safety, reliability, and aesthetics. Willingness acts as a non-cost barrier to adoption.

Appendix S

Bibliography

ADM Associates, Inc. and TekMRKT Works, LLC. *Final Report: Statewide Survey of Multi-Family Common Area Building Owners Market: Volume 1: Apartment Complexes.* Prepared for Southern California Edison. June 2000.

Arasteh, D. Lawrence Berkeley National Laboratory. E-mail correspondence to G. Todesco. July 2003.

Boeing. "Boeing Completes Evaluation of Borealis Cool Chips™ Technology." http://www.boeing.com/news/releases/2001/q4/nr_011130a.html. 2001.

Bourne, D., and J. Stein. *Aeroseal: Sealing Ducts from the Inside Out.* ER-99-16. E-Source. 1999.

California Energy Commission. *Residential Manual for Compliance with California 1998 Energy Efficiency Standards.* Publication 400-98-002. 1999.

California Energy Commission. U.S. per capita electricity usage, http://www.energy.ca.gov/electricity/us_percapita_electricity.html. 2001.

California Energy Commission. *2002–2012 Electricity Outlook.* 2001.

California Energy Commission. *Staff Report. California Energy Demand Forecast 2003-2013*. August 2003.

California Energy Commission. *Funding and Energy Savings from Investor-Owned Utility Energy Efficiency Programs in California for Program Years 2000 Through 2004*. August 2005

California Energy Commission. *California Energy Demand 2006-2016 Staff Energy Demand Forecast.* CEC-400-2005-034-SF-ED2. (June 2005.) Revised September 2005.

California Public Utilities Commission. Ruling on Cost-Effectiveness Issues. A.00-09-049. October 25, 2000.

California Public Utilities Commission. *Interim Opinion R. 01-08-028.* August 23, 2001.

Calwell, C., C. Granda, L. Gordon, and M. Ton. *Lighting the Way to Energy Savings: How Can We Transform Residential Lighting Markets, Volume 2: Background and Reference.* http://www.ceel.org/resid/rs-lt/rs-lt-pubs/ltwy_vol2.pdf. National Resources Defense Council. 1999.

Campoy, L. Personal Communication. Southern California Edison. January 2004.

CMRC Cool Metal Roofing. http://coolmetalroofing.org.

Consortium for Energy Efficiency. *Residential Clothes Washer Initiative Program Description.* 1996. Revised 2002.

Consortium for Energy Efficiency. "CEE Super-Efficient High Efficiency Commercial Air Conditioning and Heat Pumps Initiative (HECAC)." http://www.cee1.org/com/hecac/hecac-tiers.pdf. 2004.

Cool Chips PLC. *Cool Chips PLC Business Plan.* 2003.

Craford, M.G. *Visible LEDs: The Trend toward High Power Emitters and Remaining Challenges for Solid State Lighting.* Presented to Lawrence Berkeley National Laboratory. http://ncem.lbl.gov/team/presentations/Craford/sld001.htm. 2002.

Criscione, P. "A New Reality for Refrigeration." ET Currents. 19:6-7. 2002.

David, S. Technical Consumer Products, Inc. Personal communication with Marycel Tuazon. August 2003.

Davis Energy Group. *Residential Construction Quality Assessment Project: Phase II Final Report.* CEC 400-98-004. Prepared for the California Energy Commission. 2002.

Degens, P. Northwest Energy Efficiency Alliance. Personal Communication with Hugh Dwiggins. September 25, 2003.

Emerging Technology Coordinating Council, on-line database at http://www.ca-etcc.com/.

Emerging Technology Coordinating Council, unpublished database, December 2004.

Energy and Environmental Economics, Inc. *A Forecast of Cost-Effectiveness Avoided Costs and Externality Adders.* Prepared for the California Public Utilities Commission, Energy Division. January 2004.

ENERGYGuide. "ENERGY STAR Lights®." Spring Product Catalog. 2003.

Energy Information Administration, Department of Energy. *2002 Manufacturing Energy Consumption Survey*. www.eia.doe.gov/emeu/mecs

Frankenfield, G. Global Energy Group. Personal communication. October 30, 2003.

Gas Appliance Manufacturers Association. *Consumers' Directory of Certified Efficiency Ratings for Heating and Water Heating Equipment.* http://www.gamanet.org/consumer/certification/cerdir.htm. 2003.

General Electric. "Halogen Lamps." Product Catalog. http://www.gelighting.com. 2003.

Gordon, K.L., and J.J. McCullough. "Recessed Lighting in the Limelight." 21(1):12-13. Home Energy. 2003.

Hagspiel, A. National Grid. Personal communication with Marycel Tuazon. July 2003.

Heschong Mahone Group. *Lighting Efficiency Technology Report, Volume III: Market Barriers Report.* Prepared for the California Energy Commission. http://www.energy.ea.gov/efficiency/lighting/lighting_reports.html. 1999.

Hollingsworth, D. LGE. Personal communication with Harvey Sachs. October 2003.

Illuminating Engineering Society of North America, The. *The IESNA Lighting Handbook: Reference & Application.* Ninth Edition. 2000.

Itron, Inc. *Residential New Construction Baseline Study – 2001.* Prepared for Pacific Gas and Electric. September 2002.

Itron, Inc. *Incremental Costs Study.* Prepared for Pacific Gas and Electric. September 2003.

Itron, Inc. *WP#1: California Statewide Energy Efficiency Summary Study: Review of Existing Forecasts and Data Inputs Working Paper.* Prepared for Pacific Gas & Electric and the Energy Efficiency Project Advisory Group. August 2004.

Itron, Inc. *Residential New Construction Baseline Study of Building Characteristics - Homes Built After 2001 Codes.* Prepared for Pacific Gas and Electric. August 2004.

Itron, Inc. *California Lamp Report 2004.* Prepared for Southern California Edison. June 15, 2005.

Itron, Inc. *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study: Final Report.* Prepared for Southern California Edison. December 2005.

Itron, Inc. *California Commercial Energy Use Survey.* CEC-400-2006-005. Prepared for the California Energy Commission. March 2006.

Johnson, Russ. Johnson Research, LLC. Personal communication with Harvey Sachs. 2003.

Jump, D., I.S. Walker, and M.P. Modera. “Field Measurements of Efficiency and Duct Retrofit Effectiveness in Residential Forced Air Distribution Systems.” In *Proceedings of the 1996 ACEEE Summer Study on Energy Efficiency in Buildings.* 1.147-I.156. American Council for an Energy Efficient Economy. 1996.

Kallett, R., E. Hamzawi, C. Sherman, and J. Erickson. “SMUD’s New Residential Duct-Improvement Program Using an Aerosol-Based Duct Sealant.” In *Proceedings of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings.* 2-163-2.174. American Council for an Energy Efficient Economy. 2000.

KEMA-Xenergy, Inc. *California Statewide Residential Sector Energy Efficiency Potential Study Final Report. Volumes 1 & 2.* Prepared for Pacific Gas & Electric Company. April 2003.

KEMA-Xenergy, Inc. *California Statewide Commercial Sector Natural Gas Energy Efficiency Potential Study, Final Report Volumes 1 and 2*. Prepared for Pacific Gas & Electric Company. May 2003 (revised July 2003).

KEMA-Xenergy, Inc. *California Statewide Residential Appliance Saturation Study.* Prepared for the California Energy Commission. June 2004.

KEMA-Xenergy, Inc. *CFL Metering Study.* Prepared for Pacific Gas & Electric Company, San Diego Gas & Electric Company, and Southern California Edison. February 25, 2005

KEMA-Xenergy, Inc., Lawrence Berkeley Nation Laboratory, and Quantum Consulting. *California Industrial Sector Energy Efficiency Potential Study.* Prepared for Pacific Gas and Electric Company. April 2006.

Korn, D. The Cadmus Group. Personal communication with Harvey Sachs. 2003.

Krepchin, I. and J. Stein. *New Dimming Controls: Taking It Personally.* E Source, Inc. 2000.

Lawrence Berkeley National Laboratory, Environmental Energy Technologies. *Average Values: Manufacturer Price, Customer Equipment Price, Installation Cost, and Total Installed Cost.* Presentation slide. 2003.

Lennox. LG/LC/LH Models L Series® Brochure. 76M73. January 2004.

LumiLeds. "Lumileds to Ship Warm White, Incandescent-Equivalent LED in August." Press Release. http://www.lumileds.com. 2003.

M/J. Industrial Solutions. *Municipal Wastewater Treatment Plant Energy Baseline Study.* PG&E New Construction Energy Management Program. June 2003

Meier, Alan. Presentation at the California Energy Commission Public Interest Energy Research Workshop on Standyby Power. Berkeley, CA. 2002.

Modera, M., D. Dickerhoff, O. Nilssen, H. Duquette, and J. Geyselaers. "Residential Field Testing of an Aerosol-Based Technology for Sealing Ductwork." In *Proceedings of the 1996 ACEEE Summer Study on Energy Efficiency in Buildings.* 1.169-1.176. American Council for an Energy Efficient Economy. 1996.

National Fenestration Rating Council. "We Are Changing the Way America Shops for Windows, Doors, and Skylights." http://www.nfrc.org. 2002.

Natural Resources Canada. *Consumer's Guide to Buying Energy Efficient Windows and Doors.* 1994.

Natural Resources Canada. *Standards for Window Energy Performance.* Natural Resources Canada, Office of Energy Efficiency. 2002

Neal, C.L. "Field Adjusted SEER [SEERFA]." In *Proceedings of the 1998 ACEEE Summer Study on Energy Efficiency in Buildings.* 1.197-1.209. American Council for an Energy Efficient Economy. 1998.

Portland General Electric. "Lighting Rebates – Existing Buildings." http://www.portlandgeneral.com/business/energy_efficiency/programs/pdfs/existlight.pdf. 2003.

Proctor Engineering Group. *Performance of Residential High SEER Air Conditioning Units at High Ambient Temperature.* Prepared for Pacific Gas & Electric. 1993.

Proctor, John. Proctor Engineer Group. Personal communication to Marc Hoeschele. October 30, 2003.

Rand Coporation. *The Public Benefit of California's Investments in Energy Efficiency.* Prepared for the California Energy Commission. March 2000.

Regional Economic Research, Inc., and Opinion Dynamics Corporation. *Northern States Power Company Customer Survey Final Report.* Prepared for Nothern States Power Company. March 1995

Regional Economic Research, Inc. *Emerging Technology Efficiency Market Share Needs Assessment, Feasibility, and Market Penetration Scoping Study.* Prepared for the California Board for Energy Efficiency and Pacific Gas and Electric. December 1999.

Regional Economic Research, Inc. *Residential Energy Efficient Lighting Consumer Research.* Report #00-051. http://www.nwalliance.org/resources/reports/00051.pdf. Prepared for Northwest Energy Efficiency Alliance. 2000.

Reilly, S. *High Performance Glazing in Commercial Buildings.* ER-01-16. E-Source, Inc. 2001.

Roberson, J., et al. *Energy Use and Power Levels in New Monitors and Personal Computers.* LGNL-48581. Lawrence Berkeley National Laboratory. 2002.

Rumsey Engineers. *Clean Room Energy Baseline Study.* Prepared for Pacific Gas & Electric. 2003

Sachs, H.M. *Toward Market Transformation: Commercial Heat Pump Water Heaters for the New York Energy $mart^{SM} Program.* American Council for an Energy Efficiency Economy. 2002.

Sachs, H.M. and S. Smith. *Saving Energy with Efficient Residential Furnace Handlers: A Status Report and Program Recommendations.* American Council for an Energy Efficient Economy. 2003.

Sachs, H.M., S. Nadel, J. Thorne Amann, M. Tuazon, E. Mendelsohn, L. Rainer, G. Todesco, D. Shipley, and M. Adelaar. *Emerging Energy-Savings Technologies and Practices for the Buildings Sector as of 2004.* Report #A042. American Council for an Energy Efficient Economy. October 2004.

Savings by Design. "Savings by Design 2003 Participant Handbook: Policies and Procedures for Participation in the Statewide Savings by Design Program." http://www.savingsbydesign.com/pdfs/2003SBDParticipantHandbook.pdf. 2003.

SBW Consulting. *Energy Benchmarking Secondary Wastewater Treatment and Ultraviolet Disinfection Processes at Various Municipal Wastewater Treatment.* Prepared for Pacific Gas & Electric. February 2002

Scruton, C. Personal communication with E. Stubee. 2003.

Siminovitch, M. Lawrence Berkeley National Laboratory. Personal communication with Marc Hoeschele. January 22, 2004.

Simmons, J. Sandia National Laboratory. Personal communication with Marycel Tuazon. August 2003.

Spartz, Philip. Personal communication. California Energy Commission. 2004.

Stubee, E. Science Applications International Corporation (SAIC). Comments in review of draft document. 2004.

Talbot, D. "LEDs vs the Lightbulb." *Technology Review: MIT's Magazine of Innovation.* 106 (4):30-36. 2003.

Technical Consumer Products, Inc. "GALAXe LED Desk Lamp." Specification Sheet. http://www.tcpi.com/pdf/Galaxe%/20spec%20sheet.pdf. 2003.

Thatham, C. Verdiem. Personal communication with Hugh Dwiggins. August 21, 2003.

Thorne, J. and S. Nadel. *Commercial Lighting Retrofits: A Briefing Paper for Program Implementers.* American Council for an Energy Efficient Economy. 2003.

Ton, M., S. Foster, and C. Calwell. *LED Lighting Technologies and Potential for Near-Term Applications.* Market Research Report #E03-114. Ecos Consulting. Prepared for the Northwest Energy Efficiency Alliance. http://www.nwalliance.org/resources/reports/114ES.pdf. 2003.

Unger, R. "Development and Testing of a Linear Compressor Sized for the European Market." http://www.sunpower.com/pdf/doc0074.pdf. Sunpower. 1999.

U.S. Department of Energy. *Technical Support Document for Energy Efficiency Standards for Residential Central Air Conditioners.* 2001.

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. *2002 U.S. Industrial Electric Motor System Market Opportunities Assessment*. 2002.

U.S. Department of Energy. *U.S. Lighting Market Characterization, Volume 1: National Lighting Inventory and Energy Consumption Estimate.* Prepared by Navigant Consulting for the U.S. DOE, Office of Energy Efficiency and Renewable Energy, Building Technologies Program. 2002.

U.S. Department of Energy. *In Hot Water, a Newsletter.* 2(2):1. 2002.

U.S. Department of Energy. *ENERGY STAR® Labeling Potential for Water Heaters.* http://www.energystar.gov/ia/partners/gen_res/prod_development/new-specs/downloads/water_heaters/WH_Paper.pdf. 2003.

Vineyard, E.A., and J.R. Sand. "Experimental and Cost Analyses of a One Kilowatt-Hour/Day Domestic Refrigerator-Freezer." *ASHRAE Transactions*. Symposia 103, Paper BN-97-7-2, 621-629. 1997.

Walker, I., M. Sherman, M. Modera, and J. Siegel. *Leakage Diagnostics, Sealant Longevity, Sizing and Technology Transfer in Residential Thermal Distribution Systems*. LBL-41118. Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division, Energy Performance of Buildings Group. 1998

Weale, J., P. Rumsey, D. Sartor, L. Eng Lock. *How Low Can You Go? Low Pressure Drop Laboratory Design*. Lawrence Berkeley Laboratory. December 2001. http://btech.lbl.gov/papers/49366.pdf

Xcel Energy. "Xcel Energy New Construction Lighting Rebate Application." http://wwwxcelenergy.com/docs/retail/busmrkts/BusinessLightingNewConstruction-RebateMN.pdf. 2003.

Xenergy, Inc. *2001 DEER (Database for Energy Efficient Resources) Update Study.* Prepared for the California Energy Commission. August 2001.

Xenergy, Inc. *California Industrial Energy Efficiency Market Characterization Study*. Prepared for Pacific Gas and Electric Company. December 2001.

Xenergy, Inc. *California Statewide Commercial Sector Energy Efficiency Potential Study Final Report Volumes 1 & 2*. Prepared for Pacific Gas & Electric Company. July 2002.

Xenergy, Inc. *California's Secret Energy Surplus the Potential for Energy Efficiency.* Prepared for the Energy Foundation and the Hewlett Foundation. September 2002.