1997 AGRICULTURAL ENERGY EFFICIENCY INCENTIVES PROGRAM

FIRST YEAR LOAD IMPACT EVALUATION

FINAL REPORT

Study ID No. 1022

Prepared for

San Diego Gas & Electric
San Diego, California

Prepared by

XENERGY Inc.
San Diego, California

February 1999

1 INTRODUCTION

1.1 INTRODUCTION

San Diego Gas & Electric (SDG&E) commissioned XENERGY Inc. to evaluate the first year load impacts of measures installed under its *1997 Agricultural Energy Efficiency Incentives* (*Ag. EEI*) *Program*. These measures were installed to provide resource value by improving the energy efficiency of the facilities that participated in the *Ag. EEI Program*.

The overall objectives of SDG&E's *1997 Agricultural Energy Efficiency Incentives Program First Year Impact Evaluation* were to:

- evaluate the gross and net load impacts of the measures installed at these facilities; and
- verify the physical installation of the measures identified in the program tracking system.

These objectives were accomplished using the following methodology:

- verifying the physical installation of the measures identified in the program tracking system (electronic and hard copy);
- gathering data through direct measurement, observation, and interviews with site personnel; and
- performing engineering analysis of energy impacts based on the data.

1.2 REPORT ORGANIZATION

The remainder of this report is organized as follows:

Section 2	Summary
Section 3	Analysis for Pumping Measures
Section 4	Analysis for Process Measures
Section 5	Analysis for Space Conditioning Measures
Appendix A	*"Retroactive Waiver for 1997 Agricultural Energy Efficiency Incentives Program"*
Appendix B	Table 6: Pumping Measures: Protocols for Reporting of Results of Impact Measurement Studies Used to Support an Earnings Claim
Appendix C	Table 6: Pumping Measures: Protocols for Reporting of Results of Impact Measurement Studies Used to Support an Earnings Claim

Appendix D	Table 6: Pumping Measures: Protocols for Reporting of Results of Impact Measurement Studies Used to Support an Earnings Claim
Appendix E	Table 7: Documentation Protocols for Data Quality and Processing

2 SUMMARY OF LOAD IMPACTS

2.1 INTRODUCTION

This section provides summary of the ex post first year load impact evaluation for measures installed under San Diego Gas & Electric's *1997 Agricultural Energy Efficiency Incentives Program*.

2.2 SUMMARY OF LOAD IMPACTS OF PUMPING MEASURES

Table 2-1 provides an overview of the Agricultural EEI Program's 1997 measures and impacts. Twenty two participants installed 30 measures that saved 1,065,025 kWh (ex ante estimate).

Table 2-1
Ex Ante Program Summary
Pumping Measures
1997 Agricultural Energy Efficiency Incentives Program

End Use	Pumping
Participants	22
Measures	30
kWh Savings	1,065,025
kW Reduced	95.40
Motor Horsepower (HP)	678

Table 2-2 shows the net load impacts, both ex ante and ex post. These results show realization rates for the net load impacts of 0.5867 and 0.6731 for kWh and kW, respectively. A default net-to-gross ratio of 0.57 was used to estimate the net impacts as allowed under the *Retroactive Waiver for 1997 Agricultural Energy Efficiency Incentives Program* approved by CADMAC on January 20, 1999.

Table 2-2
Summary of Ex Post Net Load Impacts
Pumping Measures
1997 Agricultural Energy Efficiency Incentives Program

	kWh Savings	kW Reduced
Gross Program Impacts	981,041	99.80
Ex Post NTGR	0.57	0.57
Net Ex Post Program Impacts	559,193	56.89
Net Ex Ante Impacts	953,150	84.52
Net Realization Rate	0.5867	0.6731

2.3 SUMMARY OF LOAD IMPACTS OF PROCESS MEASURES

The results of the this ex post load impact evaluation are shown in Tables 2-3 and 2-4. These results show the measures installed saved more energy than anticipated in the ex ante load impact estimates, but the kW demand reduction was not as great as expected.

Table 2-3
Ex Post Gross Program Load Impacts
Process Measures
PY97 Agricultural EEI Program

	kWh Savings	kW Reduced
Ex Ante Gross Load Impacts	278,391	63.30
Ex Post Gross Load Impacts	327,945	29.24
Realization Rate	117.8%	46.2%
No. Projects	2	2

Table 2-4
Ex Post Net Program Load Impacts
Process Measures
PY97 Agricultural EEI Program

	kWh Savings	kW Reduced
Ex Post Gross Load Impacts	327,945	29.24
Ex Post Net-To-Gross Ratio	0.75	0.75
Ex Post Net Load Impacts	245,958	21.93
Ex Ante Net-To-Gross Ratio	0.75	0.75
Ex Ante Net Load Impacts	208,793	47.48
Net Realization Rate	117.8%	46.2%

2.4 SUMMARY OF LOAD IMPACT OF SPACE CONDITIONING MEASURES

Tables 2-5 and 2-6 summarize the findings of ex post load impact evaluation for space conditioning measures. Program participation for space conditioning measures for the PY97 AEEI program comprised the four projects shown in Table 2-5. These four projects were implemented at two sites. There results show a 98% realization rate for therm savings, and a somewhat deceptively low realization rates for electricity, 26% and 33% for kWh and kW, respectively. The reason for calling the electricity results deceptive is that the measure actually reduces electricity use to a greater degree when compared with the ex ante estimate. However, since the sign is negative, the realization rate as it is normally calculated leads to a deceptive result.

Table 2-5
Ex Post Gross Impact Summary and Comparison with Ex Ante Estimates
PY97 AEEI Space Conditioning Measures

		Ex Ante Gross			Ex Post Gross			Realization Rate		
Project No.	**Measure Description**	**kWh Savings**	**kW Reduced**	**Therm Savings**	**kWh Savings**	**kW Reduced**	**Therm Savings**	**kWh Savings**	**kW Reduced**	**Therm Savings**
40955	Expanded Polystyrene Insulation - 2 Inch	0	0	6,521			9,365			144%
40956	Polystyrene Insulation	0	0	2,173			3,110			143%
40957	Polystyrene Insulation	0	0	2,778			2,666			96%
49495	8400mm BTU Boilers w/stack heat recovery	-4,976	0	37,091	-1,282	-0.15	32,217	26%	33%	87%
Total		**-4,976**	**0**	**48,563**	**-1,282**	**0**	**47,358**	**26%**	**33%**	**98%**
No. Of Projects = 4										

Table 2-6 shows the square footage of the conditioned space affected by these measures.

Table 2-6
Conditioned Square Footage
PY97 AEEI Space Conditioning Measures

Project No.	**Conditioned Square Footage**
40955	9,555
40956	4,428
40957	2,916
49495	345,000
Total	**361,899**

Table 5-2 shows a summary of the ex post net load impacts. The default net-to-gross ratio of 0.75 was used as allowed under the Retroactive Waiver approved on January 20, 1999.

Table 2-7
Ex Post Net Impact Summary and Comparison with Ex Ante Estimates
PY97 AEEI Space Conditioning Measures

			Ex Ante Net			Ex Post Net			Net Realization Rate		
Project No.	**Measure Description**	**NTGR**	**kWh Savings**	**kW Reduced**	**Therm Savings**	**kWh Savings**	**kW Reduced**	**Therm Savings**	**kWh Savings**	**kW Reduced**	**Therm Savings**
40955	Expanded Polystyrene Insulation - 2 Inch	0.75	0	0	4,890.75	0.00	0.00	7,023.75	n/a	n/a	1.44
40956	Polystyrene Insulation	0.75	0	0	1,629.75	0.00	0.00	2,332.50	n/a	n/a	1.43
40957	Polystyrene Insulation	0.75	0	0	2,083.50	0.00	0.00	1,999.50	n/a	n/a	0.96
49495	8400mm BTU Boilers w/stack heat recovery	0.75	-3732	-0.3375	27,818.25	-961.50	-0.11	24,162.75	0.26	0.33	0.87
Total			**-3,732**	**-0.3375**	**36,422.25**	**-961.50**	**-0.11**	**35,518.50**	**0.26**	**0.33**	**0.98**

3 PUMPING MEASURES

3.1 INTRODUCTION

This section provides the site specific analyses for the pumping measures installed under San Diego Gas & Electric's *1997 Agricultural Energy Efficiency Incentives (EEI) Program*.

3.2 SUMMARY OF LOAD IMPACTS OF PUMPING MEASURES

Table 3-1 provides an overview of the Agricultural EEI Program's 1997 measures and impacts. Twenty two participants installed 30 measures that saved 1,065,025 kWh (ex ante estimate).

Table 3-1
Ex Ante Program Summary
Pumping Measures
1997 Agricultural Energy Efficiency Incentives Program

End Use	Pumping
Participants	21
Measures	30
kWh Savings	1,065,025
kW Reduced	95.40
Motor Horsepower (HP)	678

Table 3-2 shows the measures installed under the Agricultural EEI Program and the measures included in the ex post load impact evaluation. This table shows that the ex ante load impacts of the evaluation participants comprised 93 percent of both the ex ante kWh and kW load impacts.

Table 3-2
Overview of Program Participants and Ex Post Evaluation Participants
Pumping Measures
1997 Agricultural Energy Efficiency Incentives Program

Survey	Project No.	Meas. Quantity	Measure Description	Horse-power	Operating Hours	Ex Ante kWh Savings	Ex Ante kW Reduced
yes	46624	1	Redesign Booster Pump, Pumping Efficiency 86%		4,300	438,534	11.7
yes	49365	1	Efficient Pump		8,760	117,412	13.4
yes	46208	1	High Efficiency Motor		4,257	101,742	23.9
yes	46799	1	Variable Speed Pumping w/ VSD, 20hp		8,760	64,121	0.4
yes	46325	1	Vertical Turbine Pump		8,760	46,500	23.25
yes	47344	1	VSD on Blower Motor		8,760	44,236	-0.7
yes	14070	2	High Efficiency Motors		3,264	42,330	0
yes	47583	1	US/Model # G65260 Motor 60HP - 200HP	75	3,000	3,352	0.838125
yes	48954	1	US/Model # J366 Motor 15HP - 50HP	30	3,000	2,178	0.5445
yes	48797	1	Leeson/Model # N256T34DB5 Motor 15HP - 50HP	25	3,000	1,815	0.45375
yes	49797	1	US/Model J364 Motor 15HP - 50HP	25	3,000	1,815	0.45375
yes	49365	1	Efficient Pump		8,760	127,021	14.5
no	14069	2	Install High Efficiency Motors		3,163	30,868	0
no	14071	2	Low Friction Ball Valves		3,163	16,444	0
no	46829	3	US Electric/H338A Motor 60HP - 200HP	60	3,000	8,046	2.0115
no	46176	1	US Electric/Model # RZ12 Motor 125HP	125	3,000	5,587	1.396875
no	46900	1	US/Model# 5847 Motor 15HP - 50HP	50	3,000	3,630	0.9075
no	46190	1	US Electric/Model # RZ10 Motor 60HP	60	3,000	2,682	0.6705
no	47240	1	US/Model # R483A Motor 60HP - 200HP	60	3,000	2,682	0.6705
no	48266	1	Baldor/Model # 39K096W63861 Motor 15HP - 50HP	20	3,000	1,452	0.363
no	49797	1	Siemens/Model HJI1284 Motor 15HP - 50HP	20	3,000	1,452	0.363
no	47913	1	US/Model # A431 Motor 3HP - 10HP	5	3,000	630	0.1575
no	50754	3	Dayton/Model 3N643 Motor 1HP - 2HP	1	3,000	495	0.12375
		30		**556**		**1,065,025**	**95.40425**
			Impacts Surveyed			991,057	88.03
			Percent Surveyed			93.1%	93.0%

Table 3-3 shows the ex post first year load impacts of the 1997 Agricultural EEI Program. Realization rates of 0.92 and 1.05 for gross kWh and kW load impacts were estimated for the survey participants. These realization rates were applied to the total program ex ante load impacts to estimate the ex post program load impacts, as shown in Table 3-3. This table shows that the ex post program load impacts are 981,041 kWh saved and 99.80 kW reduced.

Table 3-3
Summary of Ex Post Gross First Year Load Impacts - Surveyed Projects
Pumping Measures
1997 Agricultural Energy Efficiency Incentives Program

			Ex Ante		Ex Post	
Project No.	Meas. Quantity	Measure Description	kWh Savings	kW Reduced	kWh Savings	kW Reduced
46624	1	Redesign Booster Pump, Pumping Efficiency 86%	438,534	11.7	486,317	46.97
49365	1	Efficient Pump Well #2	117,412	13.4	48,290	4.80
46208	1	High Efficiency Motor	101,742	23.9	102,455	15.60
46799	1	Variable Speed Pumping w/ VSD, 20hp	64,121	0.4	33,184	0.00
46325	1	Vertical Turbine Pump	46,500	23.25	112,505	12.84
47344	1	VSD on Blower Motor	44,236	-0.7	34,248	7.33
14070	2	High Efficiency Motors	42,330	0	24,852	0.56
47583	1	US/Model # G65260 Motor 60HP - 200HP	3,352	0.838125	2,106	0.24
48954	1	US/Model # J366 Motor 15HP - 50HP	2,178	0.5445	3,895	0.44
48797	1	Leeson/Model # N256T34DB5 Motor 15HP - 50HP	1,815	0.45375	0	0.00
49797	1	US/Model J364 Motor 15HP - 50HP	1,815	0.45375	1,943	0.25
49365	1	Efficient Pump Well #3	127,021	14.5	63,110	3.80
Total	**13**		**991,057**	**88.7**	**912,905**	**92.83**
Realization Rate					**92%**	**105%**
Total-Program Impacts			**1,065,025**	**95.4**	**981,041**	**99.80**

Table 3-4 shows the net load impacts, both ex ante and ex post. These results show realization rates for the net load impacts of 0.5867 and 0.6731 for kWh and kW, respectively. A default net-to-gross ratio of 0.57 was used to estimate the net impacts as allowed under the *Retroactive Waiver for 1997 Agricultural Energy Efficiency Incentives Program* approved by CADMAC on January 20, 1999.

Table 3-4
Summary of Ex Post Net Load Impacts
Pumping Measures
1997 Agricultural Energy Efficiency Incentives Program

	kWh Savings	kW Reduced
Gross Program Impacts	981,041	99.80
Ex Post NTGR	0.57	0.57
Ex Post Net Program Impacts	559,193	56.89
Ex Ante Net Impacts	953,150	84.52
Net Realization Rate	0.5867	0.6731

3.3 PROJECT NO. 14070 - HIGH-EFFICIENCY MOTORS

3.3.1 Pre-Installation Equipment and Operation

Two US Motors 600-hp standard efficiency (92.3%) motors were existing at this water pumping station. These motors were used to drive the water distribution pumps for the area. There are a total of five pumps at this station which operate according to system demand. Pumps #4 & #5 were retrofitted. Pump #5 runs less than #4. The estimated run hours for the pumps is shown in Table 3-5. The pre-retrofit motors were estimated to be operating at a 90% load factor, or 540 horsepower.

Table 3-5
Pump Annual Run Hours
Project No. 14070

	Annual Run Hours
Pump #4	2,256
Pump #5	656

3.3.2 Energy Efficiency Improvement

The motors on pumps #4 & 5 were replaced with new high-efficiency motors. The new motors are US Motors model number H04251, 600-hp with a full load efficiency of 94.1%.

3.3.3 Source of Savings

The energy and demand savings are a result of the efficiency improvement of the new motors versus standard efficiency motors of the same size and rpm. The standard efficiency was assumed to be equal to the pre-retrofit motors' efficiencies (92.3%). The operating load factor and number of hours per year for each pump are based on observations of the post-retrofit conditions at the pumping station. The load factor and hours of operation are considered equal for the basecase and postcase conditions in the savings analysis.

3.3.4 Ex Ante Load Impact Estimates

The ex ante load impacts were estimated by the customer in the application. The analysis was based on a calculated load factor and estimated annual hours of operation. The efficiency of the new motors was also estimated by the customer. The ex ante load impact calculation was performed as:

$$\text{Pump BHP} = \frac{\text{gpm} \times \text{TDH}}{3960 \times \text{Eff}_p}$$

$$= \frac{2{,}300 \times 740}{3{,}960 \times 0.80}$$

$$= 537.2 \text{ BHP}$$

where:
BHP = *Brake horsepower*
gpm = *Gallons per minute capacity of the pumps*
TDH = *Total Dynamic Head pressure of system*
Eff_P = *Efficiency of pump*

$$\text{Motor kW Savings} = (2 \text{ motors}) \times \left(\frac{\text{BHP} \times 0.746 \text{ kW / HP}}{\text{Baseline Motor Eff.}} - \frac{\text{BHP} \times 0.746 \text{ kW / HP}}{\text{New Motor Eff.}} \right)$$

$$= (2 \text{ motors}) \times \left(\frac{537.2\text{BHP} \times 0.746 \text{ kW / HP}}{0.923 \text{ BHP / HP}} - \frac{537.2\text{BHP} \times 0.746 \text{ kW / HP}}{0.937 \text{ BHP / HP}} \right)$$

$$= 12.97 \text{ kW}$$

Table 3-6
Ex Ante Energy Savings Estimates
Project No. 14070

Hourly kW difference between basecase and postcase	12.97
Annual Operating Hours	3,264
Ex Ante kWh Impact	42,330
Ex Ante kW Impact	0

3.3.5 Ex Post Load Impact Estimates

The ex post savings estimate is based on post-retrofit measurements and observations on-site. The new motors installation and efficiency was verified. The actual efficiency of the installed motors is 94.1% compared to the 93.7% efficiency estimated in the ex ante analysis. In order to estimate the average load profile of the motors, data loggers were installed on each motor for approximately one month. The loggers recorded the amperage consumption of each motor from December 12, 1998 to January 8, 1999. The data indicated that the operating load factor was quite constant. The average load factor of pump #4 is 81% and pump #5 is 83%. The hours of operation vary throughout the year. The customer was unable to provide any data indicating the annual hours of these pumps. Therefore, the hours of operation were based on the monitoring data. The hours for each pump was estimated by the percent of on time observed during the monitoring period multiplied by an entire year (8,760 hours). The operating hours per year are shown in Table 3-7.

Table 3-7
Annual Hours of Operation
Project No. 14070

	Pump #4	Pump #5
Count of on observations	1,714	498
Total period	6,655	6,655
%-On	26%	7%
Annual hours/year	2,256	656

The savings for each motor were determined by an engineering based load profile model. The measured load profile and efficiency ratings were input and the savings between a high-efficiency and standard-efficiency motor of the same size and type were calculated. The basic equations of the model used the same load profile for both the standard-efficiency and high-efficiency motors. The equations are illustrated below.

$$\text{kWh Savings} = (\text{Qty})(\text{HP})(0.746\text{kW} / \text{Hp})(\%\text{Load})\left(\frac{1}{\text{Eff}_{\text{basecase@load}}} - \frac{1}{\text{Eff}_{\text{postcase@load}}}\right)(\text{Hrs./yr.})$$

where:

Qty = Quantity of retrofit motors,

HP = Rated Output Horsepower,

0.746 kW/ hp = constant,

$$\%\text{Load} = \left(\frac{\text{Output Horsepower at Actual Load Conditions}}{\text{Rated Output Horsepower}}\right),$$

$\text{Eff}_{\text{basecase@load}}$ = Rated Baseline Motor Efficiency at Actual Load Conditions, and

$\text{Eff}_{\text{postcase@load}}$ = Rated Retrofit Motor Efficiency at Actual Load Conditions.

Hrs./yr.=Estimatedhoursperyearoperationatloadfactor

$$\text{Pump \#4 kWh Savings} = (1)(600)(0.746)(81\%)\left(\frac{1}{92.1\%} - \frac{1}{94.1\%}\right)(2{,}256)$$

$$= 18{,}875 \text{ kWh / yr.}$$

$$\text{Pump \#5 kWh Savings} = (1)(600)(0.746)(83\%)\left(\frac{1}{92.1\%} - \frac{1}{94.1\%}\right)(656)$$

$$= 5{,}977 \text{ kWh / yr.}$$

$$\text{Total kWh Savings / Yr.} = 18{,}875 + 5{,}977$$

$$= 24{,}852 \text{ kWh / yr.}$$

Table 3-8 shows the ex post load impacts by time-of-use (TOU) period.

Table 3-8
Ex Post Load Impacts by Time-of-Use Period
Project No. 14070

Time-of-Use Period	Hours	kWh Savings	Average kW Savings	Coincident kW Reduction
Summer On-peak	749	417	0.56	0.56
Summer Semi-peak	963	3,438	3.57	
Summer Off-peak	1,960	6,563	3.35	
Winter On-peak	441	577	1.31	1.31
Winter Semi-peak	1,911	4,763	2.49	
Winter Off-peak	2,736	9,094	3.32	
Total	**8,760**	**24,852**		

The annual kWh savings was divided into each TOU period in proportion to the total summer and winter hours. Each of the three TOU periods per season was estimated from the total proportionally to the TOU consumption observed in the billing data. The billing data indicates for 1997 and 1997 the percentage of energy consumption during the peak, semi-peak, and off-peak period was 4%, 33%, and 63% respectively.

3.3.6 Comparison with Ex Ante *Estimated Impacts*

The realization rates for energy and demand for this project are shown in Table 3-9. Comparison of the ex ante and ex post estimates of demand saving show a realization rate of 100% and annual energy savings realization rate of 63%. The main reasons for the differences are:

- Less operating hours per year than estimated in the ex ante analysis. The ex ante analysis estimated 3,263 hours per year for each motor. The ex post hours per year estimate is 2,256 for pump #4 and 656 for pump #5;
- The actual installed motors have an efficiency of 94.1%, while the ex ante estimated efficiency was 93.7%;
- There was a difference in load factor, where the ex ante load factor was 89.5% and the ex post load factors were 81% and 83% for pumps #4 and #5, respectively.

Table 3-9
Comparison of Ex Ante and Ex Post Demand and Energy Impacts
Project No. 14070

	kWh	kW	Therms
Ex Ante Load Impacts	42,330	0	-
Ex Post Load Impacts	24,852	0.56	-
Difference	-17,478	0.56	-
Realization Rate	59%	n/a	n/a

3.4 PROJECT NO. 46208 - HIGH EFFICIENCY MOTOR

3.4.1 Pre-Installation Equipment and Operation

A 700-hp water pumping system was replaced with a new pump and motor. The existing pump and motor, US Motors Model HV-4, 700-hp, was tested under SDG&E's Pump Test Program in November 1995. It was estimated that if this motor was repaired and rewound its efficiency would be 92%. The motor load factor during the test was 96.6%, or approximately 676 horsepower. The annual operating hours were estimated to be 4,257 hours per year.

3.4.2 Energy Efficiency Improvement

With the replacement of the pumping system a new high-efficiency motor was installed. The new motor efficiency is 96.2%. Energy and demand savings are realized by the motor efficiency improvement. The new pump is also more efficient than the pre-retrofit pump and was rebated under Project No. 46624.

3.4.3 Ex Ante Load Impact Estimates

A simple engineering analysis was used to estimate the load impacts as shown in Table 3-10. The motor load factor was taken from a pump test conducted by SDG&E during November 1995. The operating horsepower was calculated by multiplying the *horsepower* by *motor load factor*. The pre and post-retrofit kW were calculated using the formula below. The input values are shown in Table 3-10.

$$\text{kW} = \frac{(\text{Horsepower}) \times (0.746 \text{ kw / hp}) \times (\text{MotorLoadFactor})}{\text{Motor efficiency}}$$

The annual operating hours were multiplied by the basecase and postcase kW to estimate the annual basecase and postcase kWh consumption. The difference between these two figures is the ex ante kWh savings. The difference of the basecase and postcase kW was the ex ante kW estimate.

Table 3-10
Ex Ante Energy Savings Estimates
Project No. 46208

	Basecase	Postcase	Impacts
Horsepower	700	700	
Motor efficiency	92.0%	96.2%	
Motor load factor	0.966	0.966	
Operating horsepower	676.2	676.2	
kW, Calculated	548.3	524.4	23.9
Annual Operating Hours	4,257	4,257	
Annual kWh Consumption	**2,334,113**	**2,232,371**	**101,742**

3.4.4 Ex Post Load Impact Estimates

A simple engineering analysis was used to estimate the load impacts as shown in Table 3-11. The motor load factor was observed from an amperage meter on the motor drive on-site during evaluation site visit. The motor efficiency and power factor were estimated from the motor nameplate data. The operating horsepower was calculated as:

$$\text{Load Factor} = \left(\frac{\text{Amps} \times 1.732 \times \text{Volts} \times \text{Power Factor} \times \text{Eff}_M}{746\ \text{kW / HP}} \right) \div \text{Rated HP}$$

$$= \left(\frac{132\ \text{amps} \times 1.732 \times 2{,}300\ \text{Volts} \times 0.91\ \text{PF} \times 0.95\text{Eff}_M}{746\ \text{kW / HP}} \right) \div 700\ \text{HP}$$

$$= 87\%$$

The pumping operation varies throughout the year. The pumps are operated manually by the customer depending on the level of the water in the reservoir. However, due to hard start/stop problems with the new system the customer is operating the pump 24 hours per day during the summer and 12 hours per day during the winter. These 12 hours are daytime hours. This produces annual operation of 6,570 hours. The billing data correlates the reported hours of the customer. It indicates a total meter consumption of 61% during summer period and 39% during the winter period.

The savings were determined by an engineering based load profile model. The measured load profile and efficiency ratings were input and the savings between a high-efficiency and standard-efficiency motor of the same size and type were calculated. The basic equations of the model use the same load profile for both the standard-efficiency and high-efficiency motors. The equations are illustrated below.

$$\text{kWh Savings} = (\text{Qty})(\text{HP})(0.746\text{kW / HP})(\%\text{Load})\left(\frac{1}{\text{Eff}_{\text{basecase@load}}} - \frac{1}{\text{Eff}_{\text{postcase@load}}}\right)(\text{Hrs./yr.})$$

where:

Qty = Quantity of retrofit motors,

HP = Rated Horsepower,

0.746kW / HP = constant,

$$\%\text{Load} = \left(\frac{\text{Output Horsepower at Actual Load Conditions}}{\text{Rated Output Horsepower}}\right),$$

$\text{Eff}_{\text{basecase@load}}$ = Rated Baseline Motor Efficiency at Actual Load Conditions,

$\text{Eff}_{\text{postcase@load}}$ = Rated Retrofit Motor Efficiency at Actual Load Conditions.

Hrs./yr.=Estimatedhoursperyearoperationatloadfactor

$$\text{kWh Savings} = (1)(700)(0.746)(87\%)\left(\frac{1}{92.0\%} - \frac{1}{95.0\%}\right)(6{,}570)$$

$$= 102{,}455\text{kWh / yr.}$$

Table 3-11 shows the ex post load impacts by time-of-use period.

Table 3-11
Ex Post Load Impacts by Time-of-Use Period
Project No. 46208

Time-of-Use Period	Hours	kWh Savings	Average kW Savings	Coincident kW Reduction
Summer On-peak	749	11680	15.594	15.594
Summer Semi-peak	963	15017	15.594	
Summer Off-peak	1,960	30564	15.594	
Winter On-peak	441	2292	5.198	15.594
Winter Semi-peak	1,911	29800	15.594	
Winter Off-peak	2,736	13101	4.788	
Total	**8,760**	**102,455**		

3.4.5 Comparison with Ex Ante Estimated Impacts

The realization rates for energy and demand for this project are shown in Table 3-12. Comparison of the ex ante and ex post estimates of demand saving show a realization rate of 65% and annual energy savings realization rate of 101%. The main reasons for the differences are:

- A lower measured load factor on the new motors than estimated in the ex ante analysis (87% versus 97%);
- More operation hours than estimated in the ex ante analysis (6,570 hours/year versus 4,257 hours/year).

Table 3-12
Comparison of Ex Ante and Ex Post Demand and Energy Impacts
Project No. 46208

	kWh	kW	Therms
Ex Ante Load Impacts	101,742	23.9	-
Ex Post Load Impacts	102,455	15.6	-
Difference	713	-8.3	-
Realization Rate	101%	65%	n/a

3.5 PROJECT NO. 46325 - VERTICAL TURBINE PUMP

3.5.1 Pre-Installation Equipment and Operation

This project involves the installation of a new pump with a higher efficiency than the existing pump. The pre-retrofit pump was tested under SDG&E's Pump Test Program in March 1996. It was estimated to be operating at an efficiency of 52.6% at 608 gallons per minute. The annual operating hours were estimated to be 2,000 hours per year.

3.5.2 Energy Efficiency Improvement

The installation of a new pump was completed around February 1997. The new pump was tested by the same contractor that provided the test of the old pumping system. The new pump was estimated to be operating at an efficiency of 70.0% at 780 gallons per minute.

3.5.3 Source of Savings

The pre-retrofit system consumes 955.7 kWh/acre-ft of water pumped. The new pumping system consumes 678.8 kWh/acre-ft of water pumped. The improvement in efficiency of the pumping system yields an energy savings of 276.9 kWh/acre-ft. of water pumped.

3.5.4 Ex Ante Load Impact Estimates

The ex ante savings were calculated utilizing the pump test performed in March 1996 and an assumed new pump efficiency.

Ex Ante Basecase Energy Consumption

With the tested efficiency and flow rate and an estimated operating hours of 2,000 the consumption of the existing pump was calculated as:

$$BHP = \frac{GPM \times TDH}{3960 \times Eff_P}$$

$$= \frac{720 \times 480}{3,960 \times 0.69}$$

$$= 126.48$$

$$kW = \frac{BHP}{Eff_M} \times 0.746 \text{ kW / HP}$$

$$= \frac{126.48}{0.90} \times 0.746 \text{ kW / HP}$$

$$= 104.84$$

where:

BHP	=	Brake horsepower required;
GPM	=	Gallons per minute flow rate;
TDH	=	Total Dynamic Head in feet (system pressure);
3960	=	constant;
Eff_P	=	Efficiency of pump;
Eff_M	=	Efficiency of motor;
0.746 kW/HP	=	constant

Ex Ante Postcase Energy Consumption

The energy consumption of the post-retrofit system was calculated in the same manner with the substitution of a higher-efficiency pump and high-efficiency motor. The new pump efficiency was estimated at the time of the analysis.

$$BHP = \frac{GPM \times TDH}{3{,}960 \times Eff_P}$$

$$= \frac{720 \times 480}{3{,}960 \times 0.84}$$

$$= 103.9 \text{ BHP}$$

$$kW = \frac{BHP}{Eff_M} \times 0.746 \text{ kW / HP}$$

$$= \frac{103.9}{0.95} \times 0.746 \text{ kW / HP}$$

$$= 81.59 \text{ kW}$$

Ex Ante Energy and Demand Savings

The kW savings was calculated as the pre-retrofit kW minus the post-retrofit kW.

$$\text{kW Savings} = 103.9 - 81.59$$

$$= 23.25 \text{ kW}$$

The kWh savings was calculated as the kW savings multiplied by an estimated 2,000 hours per year.

$$\text{kWh Savings} = 23.25\text{kW} \times 2{,}000 \text{ hours / year}$$

$$= 46{,}500 \text{ kWh / yr.}$$

Table 3-13
Ex Ante Energy Savings Estimates
Project No. 46325

	Basecase	**Postcase**	**Impacts**
Type	Split Case	Vertical Turbine	
Horsepower	150	125	
GPM	720	720	
Feet	480	480	
Pump Efficiency	69%	84%	
Motor efficiency	90.0%	95.0%	
Motor load factor			
Bhp	126.48	103.9	
kW, Calculated	**104.8**	**81.6**	**23.25**
Annual Operating Hours	2,000	2,000	
Annual kWh Consumption	**209,676**	**163,178**	**46,500**

3.5.5 Ex Post Load Impact Estimates

The ex post savings impacts were estimated utilizing pre- and post-retrofit pump tests. The pre-retrofit conditions were normalized to the post-retrofit capacity (acre-feet of water pumped) by basing the saving on kWh per acre-ft. The pre-retrofit pumping system consumed 955.7 kWh/acre-ft. at an efficiency of 52.6%. The new system consumes 678.8 kWh/acre-ft. at an efficiency of 70.0%.

The total annual acre-ft. of water pumped was developed by multiplying the flow rate of the new system (780 gpm) by the run hours of the pump. The run hours were obtained during the on-site visit from a meter on the pump drive system. The run hour meter read 5,178 hours. The installation date was 2/15/97 and the on-site visit was on 12/15/98. This is a total of 668 days. The annual hours and annual acre-ft. of water pumped are estimated as:

$$\text{Average Annual Run Hours} = \frac{5{,}178 \text{ hours}}{668 \text{ days}} \times 365 \text{ days / year}$$

$$= 2{,}829 \text{ hours / year}$$

$$\text{Acre - ft./year} = \left(\frac{780 \text{ gal}}{\text{min.}}\right)\left(\frac{60 \text{ min}}{\text{hr.}}\right)\left(\frac{2{,}829 \text{ hrs.}}{\text{yr.}}\right)\left(\frac{1 \text{ Acre - ft.}}{325851 \text{ gal.}}\right)$$

$$= 406.3 \text{ Acre - ft./year}$$

The annual energy (kWh) savings are calculated as:

$$\text{kWh Savings} = \left((\text{Pre - Retrofit kWh / acre - ft.}) - (\text{Post - Retrofit kWh / acre - ft})\right) * \text{Acre - ft./yr.}$$

$$= \left(\frac{955.7\ \text{kWh}}{\text{Acre - ft}} - \frac{678.8\ \text{kWh}}{\text{Acre - ft}}\right) \times 406.3\ \text{Acre - ft / year}$$

$$= 112{,}505\ \text{kWh / year}$$

The annual energy savings were proportioned equally by the total hours of each costing period. The customer had no data to indicate seasonal or time-of-day usage. The billing data was reviewed to attempt to proportion the savings in the approximate seasonal variation as the total meter consumption, but billing data in 1996 indicated the majority of the consumption in January-June and the 1997 billing indicated the majority of the consumption in July-December. Therefore, no conclusions could be made from the billing history. Table 3-14 shows the ex post load impacts by time-of-use period.

Table 3-14
Ex Post Load Impacts by Time-of-Use Period
Project No. 46325

Time-of-Use Period	Hours	kWh Savings	Average kW Savings	Coincident kW Reduction
Summer On-peak	749	9,619	12.8	12.8
Summer Semi-peak	963	12,368	12.8	
Summer Off-peak	1,960	25,172	12.8	
Winter On-peak	441	5,664	12.8	12.8
Winter Semi-peak	1,911	24,543	12.8	
Winter Off-peak	2,736	35,139	12.8	
Total	**8,760**	**112,505**		

3.5.6 Comparison with Ex Ante Estimated Impacts

The realization rates for energy and demand for this project are shown in Table 3-15. Comparison of the ex ante and ex post estimates of demand saving show a realization rate of 55% and annual energy savings realization rate of 242%. The main reasons for the differences are:

- The post-retrofit pumping system is pumping a good deal more capacity on an annual basis. The ex ante analysis based both the pre-retrofit and estimated post-retrofit capacity on the pre-retrofit capacity. By normalizing the consumption to kWh/acre-ft. then multiplying by the post-retrofit annual acre-ft. the savings are increased.
- The ex ante analysis utilized a pre-retrofit pump efficiency of 69% and an estimated post-retrofit pump efficiency of 84%. As tested the pre-retrofit pump efficiency was 52.6% and the actual post-retrofit pump efficiency is 70.0%.

- The estimated hours of operation utilized in the ex ante analysis was 2,000 hours per year. Utilizing the run hour meter on-site, the estimated hours utilized in the ex post analysis are 2,829 hours per year.

Table 3-15
Comparison of Ex Ante and Ex Post Demand and Energy Impacts
Project No. 46325

	kWh	kW	Therms
Ex Ante Load Impacts	46,500	23.25	-
Ex Post Load Impacts	112,505	12.84	-
Difference	66,005	-10.41	-
Realization Rate	**242%**	**55%**	**n/a**

3.6 PROJECT NO. 46624 - NEW HIGH-EFFICIENCY PUMP

3.6.1 Pre-Installation Equipment and Operation

A 700-hp water pump was replaced with a new pump and motor. The existing pump and motor, Layne & Bowler pump with a US Motors Model HV-4, 700-hp motor, was tested under SDG&E's Pump Test Program in November 1995. The pump test results are shown below in Table 3-16.

Table 3-16
Pre-Retrofit Pump Test Results
Project No. 46624

Discharge, PSI	457.0
Discharge head, feet	1055.7
Suction lift, feet	3.4
Total pumping head, feet	1059.1
Flow, gallons per minute	1656
Acre feet pumped per 24 hours	7.320
kW input to motor	542.6
BHP input to motor	727.1
Motor load, % BHP	96.6
Measured speed of pump, RPM	1775
kWh per acre-foot	1779.2
Overall plant efficiency, %	60.9

3.6.2 Energy Efficiency Improvement

The new pumping system operates at a higher efficiency than the old pumping system. The pre-retrofit system efficiency, as shown above, was 60.9%. The new pumping system is operating at approximately 87% efficiency. The upgrade to a high-efficiency motor was rebated under a different SDG&E motors project (Project No. 46208). Therefore, the savings as a result of the upgraded motor efficiency were backed out of this project to avoid double counting.

3.6.3 Ex Ante Load Impact Estimates

The ex ante load impacts were calculated for equivalent annual pumping volume (4,257 hour/year @ 1,656 gpm; 1,298.3 acre-ft/yr.). The following assumptions were used in the estimation of savings:

- Efficiency of existing motor 92%
- Motor load factor as tested 96.6% 676 hp
- Existing annual operating hours 4,257 hours 1,298.3 acre-ft/year

- New pump optimal operating point of 2,000 gpm, 1,115 ft TDH, 86% pumping efficiency

The following equations were used to estimate the load impacts:

$$\text{Basecase kW} = 542.6\text{ kW} \quad \text{(measured in pump test)}$$

$$\text{Postcase kW} = \frac{(2{,}000\text{ gpm}) \times (1{,}115\text{ ft TDH}) \times (0.746\text{ kw / hp})}{3960 \times 0.86 \times 0.92}$$

$$= 530.9\text{ kW}$$

$$\text{Basecase kWh} = (542.6\text{ kW}) \times (4{,}257\text{ hours / year})$$

$$= 2{,}309{,}848\text{ kWh}$$

$$\text{Postcase kWh} = (530.9\text{ kW}) \times (4{,}257\text{ hours / year}) \times \left(\frac{1{,}656\text{ gpm}}{2{,}000\text{ gpm}}\right)$$

$$= 1{,}871{,}344\text{ kWh}$$

The ex ante load impacts are shown in Table 3-17.

Table 3-17
Ex Ante Energy Savings Estimates
Project No. 46624

	kWh	kW
Pre-Retrofit	2,309,848	542.6
Post-Retrofit	1,871,344	530.9
Ex Ante Impact	438,534	11.7

3.6.4 Ex Post Load Impact Estimates

The ex post savings impacts were estimated utilizing pre- and post-retrofit pump tests. However, the upgrade in efficiency of the new high-efficiency motor first needed to be backed out of the savings. This motor was rebated under a different project by SDG&E. The improvement in motor efficiency was removed from this analysis by converting the BHP measured during the pre-retrofit pump test to kW utilizing the new motor efficiency of 95.0%.

$$\text{Pre - Retrofit BHP} = \frac{542.6\text{ kW} \times 0.92\text{ BHP / HP}}{0.746\text{ kW / HP}}$$

$$= 669.16\text{ BHP}$$

$$\text{Adjusted Pre-Retrofit kW} = \frac{669.16\ \text{BHP} \times 0.746\ \text{kW / HP}}{0.950\ \text{BHP / HP}}$$

$$= 525.47\ \text{kW}$$

Ex Post Basecase Energy Consumption

The new system is pumping more water than the old system had been. The pre-retrofit capacity was normalized to the post-retrofit capacity, in acre-feet of water pumped, by basing the saving on kWh per acre-ft. The pre-retrofit pumping system consumed 1,723.4 kWh/acre-ft. at an efficiency of 60.9%. The new system consumes approximately 1,492.5 kWh/acre-ft. at an efficiency of 87.0%. The kWh/acre-ft. and efficiency of the old pumping system was obtained from the pump test performed in November 1995. The calculations are shown below.

$$\text{Pre-Retrofit kWh / acre-ft} = \frac{1{,}656\ \text{gal.}}{\text{min.}} \times \frac{60\ \text{min.}}{\text{hr.}} \times \frac{\text{acre\_ ft}}{32{,}585\ 1\ \text{gal.}} \times \frac{525.47\ \text{kW}}{\text{hr.}}$$

$$= 1{,}723.4\ \ \text{kWh / acre-ft.}$$

Ex Post Postcase Energy Consumption

The new pumping system values were determined by on-site measurement of the system kW (478.5 kW) and the manufacturer's pump curve and factory test of this particular pump. The factory pump test indicated that the pump was providing 1,741 gpm. The post-retrofit energy consumption per acre-ft. of water is calculated below.

$$\text{Post-Retrofit BHP} = \frac{478.5\ \text{kW} \times 0.95\ \text{BHP / HP}}{0.746\ \text{kW / HP}}$$

$$= 609\ \text{BHP}$$

$$\text{Post-Retrofit Flow Rate} = \frac{\text{BHP} \times 3{,}960 \times \text{Effpump}}{\text{TDH}} = \frac{609 \times 3{,}960 \times 87.0\%}{1{,}205}$$

$$= 1{,}741\ \text{gpm}$$

* *The TDH, total dynamic head in feet, and the Eff_{pump} were obtained from the manufacturer's pump curve developed from a factory test of this pump.*

$$\text{Post-Retrofit kWh / acre-ft} = \frac{1{,}741\ \text{gal.}}{\text{min.}} \times \frac{60\ \text{min.}}{\text{hr.}} \times \frac{\text{acre\_ ft}}{32{,}5851\ \text{gal.}} \times \frac{478.5\text{kW}}{\text{hr.}}$$

$$= 1{,}492.5\ \ \text{kWh / acre\_ ft.}$$

Ex Post Energy Savings

The energy savings is equal to the basecase kWh/acre-ft. minus the postcase kWh/acre-ft. multiplied by the total acre-ft. per year. The total annual acre-ft. of water pumped was developed by multiplying the flow rate of the new system (1,741 gpm) by the run hours of the pump. The pumping operation varies throughout the year. The pumps are operated manually by the customer depending on the level of the water in the reservoir. However, due to hard start/stop problems with the new system the customer is operating this pump 24 hours per day during the summer and 12 hours per day during the winter. These 12 hours are daytime hours. This produces annual operation of 6,570 hours. The billing data correlates the reported hours of the customer. It indicates a total meter consumption of 61% during summer period and 39% during the winter period. The energy savings calculation is shown below.

$$\text{kWh Savings} = \left(\frac{1{,}723.4 \text{ kWh}}{\text{acre - ft.}} - \frac{1{,}492.5 \text{ kWh}}{\text{acre - ft.}} \right) \times \frac{1{,}741 \text{ gal.}}{\text{min.}} \times \frac{60 \text{ min.}}{\text{hr.}} \times \frac{6{,}570 \text{ hrs.}}{\text{yr.}} \times \frac{1 \text{ acre - ft.}}{32{,}5851 \text{ gal.}}$$

$$= 486{,}317 \text{ kWh / yr.}$$

By normalizing the savings calculation to kWh per acre-ft., it must be assumed that the pre-retrofit condition would be required to run more hours per year because the flow rate is less. It is estimated that the old system would need to operate for 6,907 hours per year. However, to accurately determine the average coincident peak kW savings, the operating load (kW) difference between the pre- and post-retrofit conditions was calculated. That savings is: 525.47 kW - 478.5 kW = 46.97 kW.

Table 3-18 shows the ex post load impacts by time-of-use period.

Table 3-18
Ex Post Load Impacts by Time-of-Use Period
Project No. 46624

Time-of-Use Period	Hours	kWh Savings	Average kW Savings	Coincident kW Reduction
Summer On-peak	749	55442	74.02	46.97
Summer Semi-peak	963	71282	74.02	
Summer Off-peak	1,960	145081	74.02	
Winter On-peak	441	10881	24.67	46.97
Winter Semi-peak	1,911	141454	74.02	
Winter Off-peak	2,736	62177	22.73	
Total	**8,760**	**486,317**		

3.6.5 Comparison with Ex Ante Estimated Impacts

The realization rates for energy and demand for this project are shown in Table 3-19. Comparison of the ex ante and ex post estimates of demand saving show a realization rate of 401% and annual energy savings realization rate of 111%. The main reasons for the differences are:

- The ex ante estimated efficiency of the post-retrofit pumping system was 75%. The actual tested efficiency of the system is 87%.
- The measured operating kW of the old system (after adjusted for the new motor efficiency) was 525.5 kW. The measured operating kW of the new system is 478.5 kW. The estimated post kW was 530.9 kW, but this is at an assumed higher flow rate than actual.
- The ex ante analysis utilized the estimated 75% efficiency at the same flow rate as the pre-retrofit system. The actual post-retrofit system is operating at a much higher flow rate.
- The ex ante estimated hours per year was 4,257 compared to the actual operation of 6,570 hours per year.

Table 3-19
Comparison of Ex Ante and Ex Post Demand and Energy Impacts
Project No. 46624

	kWh	kW	Therms
Ex Ante Load Impacts	438,534	11.7	-
Ex Post Load Impacts	486,317	46.97	-
Difference	47,783	35.27	-
Realization Rate	111%	401%	n/a

3.7 PROJECT NO. 46799 - VARIABLE SPEED PUMPING W/ VSD

3.7.1 Pre-Installation Equipment and Operation

This project involves the installation of a variable speed drive (VSD) on a water booster pump. The pump is in a district domestic water distribution system. The pump operates to maintain the pressure in the system. Typically the system operates between 4,000-8,000 hours per year. The pump is driven by a 20 horsepower, 3,600 rpm, Weinman Inverter Drive AC motor. The system pressure is maintained between 120-140 feet of head. Prior to the installation of a VSD the outlet flow of the pump was controlled with a by-pass valve. The existing pumping system would operate at a constant volume and a percentage of the water would be bypassed back to the suction side of the pump. This is a very inefficient method of controlling system flow and pressure. The pump was reported to be operating at approximately an 85% load factor and 380 gpm.

3.7.2 Energy Efficiency Improvement

The installation of a new variable speed drive allows the pumping system to be controlled in a more efficient manner. Rather than pumping water and then bypassing it back into the suction side of the pump to be pumped again, the flow and pressure are controlled by slowing the speed of the pump so that it only pumps at the rate required. By slowing the speed of the pump the energy consumption requirement is reduced by the cube of the speed[1].

3.7.3 Ex Ante Load Impact Estimates

The ex ante kWh impacts were estimated using a Bell & Gosset Centrifugal Pump Selection Guide Software that compares pump operation with variable speed drives and constant speed pumps.

Ex Ante Basecase

The flow profile before the VSD installation was 100% at 380 gpm. The pump curve was estimated to determine the total dynamic head (137.7 ft.) and efficiency (77.6%) of the pump at this flow rate. Using the pump equations, as shown below, the operating kW of the pump was calculated to be 14.1 kW. The pump was assumed to operate 8,760 hours per year. The annual kWh was calculated as the operating kW multiplied by the hours per year. The calculations are shown below.

$$\text{Pump kW} = \frac{\text{gpm} \times \text{TDH} \times 0.746\text{kW / hp}}{3{,}960 \times \text{Eff}_P \times \text{Eff}_M}$$

$$= \frac{380 \times 137.7 \times 0.746\text{kW / hp}}{3{,}960 \times 0.776 \times 0.901}$$

$$= 14.1\ \text{kW}$$

$$\text{Pump kWh} = 14.1\ \text{kW} \times 8{,}760\ \text{hours / year}$$

$$= 123{,}445\ \text{kWh / year}$$

where:

gpm = gallons per minute flow rate through pump;
TDH = Total Dynamic Head. Head pressure of system in feet;
kW/hp = constant conversion factor;
3960 = constant conversion factor;
Eff_P = Pump Efficiency;
Eff_M = Motor Efficiency.

[1] Affinity Laws for Centrifugal Applications. $\frac{Pres._1}{Pres._2} = \frac{(RPM_1)^2}{(RPM_2)^2}$

Ex Ante Postcase

The postcase flow profile was estimated at five points with the hours per day operating at each point, as shown in Table 3-21. The profile and energy savings of the system with the VSD in operation was estimated with the same equation as above using the following parameters for each operating point. The total annual energy consumption is the sum of the five points multiplied by 365 days/yr.

Table 3-20
Ex Ante Postcase Energy Savings
Project No. 46799

GPM	RPM	Hrs./day	TDH (ft.)	EffP	BHP	EffM	kW	kWh
40	2,996	10.50	120.10	18.50	6.54	85.60	5.71	21,902
100	2,996	5.25	120.60	46.40	6.57	85.60	5.72	10,961
180	3,011	4.50	122.00	64.50	8.60	85.70	7.48	12,293
280	3,153	3.50	124.90	75.20	11.74	86.20	10.16	12,984
380	3,405	0.25	129.00	77.30	16.02	87.00	13.73	1,253
Total								**59,392**

*values may differ from ex ante file slightly due to rounding.

The kW impacts were estimated using the values calculated above at 95% flow rate, or 380 gpm. This was the customer's assumed peak demand and was also claimed as the utility coincident demand.

Basecase kW @95% flow = 14.1 kW
Postcase kW @95% flow = 13.7 kW

kW Savings = Basecase kW - Postcase kW

= 14.1 kW - 13.7 kW

= 0.4 kW

The ex ante load impacts for this measure are shown in Table 3-21.

Table 3-21
Ex Ante Energy Savings Estimates
Project No. 46799

	kWh	kW
Pre-Retrofit	123,445	14.1
Post-Retrofit	59,324	13.7
Ex Ante Impact	64,121	0.4

3.7.4 Ex Post Load Impact Estimates

The main approach to the ex post analysis utilized post-retrofit billing consumption history, operator log sheets, and the pre-retrofit operating load from the ex ante analysis. A site visit was made to the pumping station on December 1st, 1998. The variable speed drive was in operation at between 2,400 and 3,000 rpm. The outlet bypass valve was 100% open. The pumping station is on one SDG&E time-of-use meter. There is only this pump and a seldom used light on the meter. Time-of-use billing data was obtained for January 1996-Novemeber 1998. However, the billing history for this meter shows zero consumption before August 1997. Also, the period from January-April 1998 the station was not used. Therefore, the billing data only provided history for seven months of post-retrofit consumption.

Operator log sheets were obtained from the customer covering the period from July 1997 through November 1998. The log sheet data includes gallons/month and total run hours/month.

The savings analysis utilized the ex ante estimated operating load (14.1 kW) multiplied by the hours of operation per year estimated from the log sheet data. The post-retrofit consumption was estimate from the seven months of billing history. The analysis is shown below.

Constant Speed Operation (Basecase)

The operating conditions of the pump prior to the installation of the VSD were utilized to calculate the ex post basecase energy consumption. These values were obtained from the ex ante analysis and are listed below.

- GPM 380
- TDH (ft.) 137.7
- Pump Efficiency 77.6%
- Motor Efficiency 90.1%

The basecase operating kW of the pump is calculated as:

$$\text{Pump kW} = \frac{\text{gpm} \times \text{TDH} \times 0.746\text{kW / hp}}{3{,}960 \times \text{Eff}_P \times \text{Eff}_M}$$

$$= \frac{380 \times 137.7 \times 0.746\text{kW / hp}}{3{,}960 \times 0.776 \times 0.901}$$

$$= 14.1\ \text{kW}$$

VSD Operation

The energy consumption and operation of the pump with the VSD control is estimated from a combination of monthly time-of-use billing history and operator log sheets. Only seven months of data was considered clean and useful for the analysis. The seven months of data is shown in Table 3-22.

Table 3-22
Time-of-Use Billing History and Log Sheet Data
Project No. 46799

Read Date	On Peak kWh	Semi Peak kWh	Off Peak kWh	Total kWh	On Peak kW	Semi Peak kW	Off Peak kW	Gallons	Run Hours
12/4/97	0	1,880	2,480	4,360	0.00	16.80	16.80	1,088,800	552.6
1/2/98	0	3,680	280	3,960	0.00	16.80	16.80	1,588,000	477.0
7/7/98	0	960	1,920	2,880	0.00	0.00	0.00	n/a	346.9
8/5/98	0	1,600	2,880	4,480	0.00	14.80	0.00	n/a	545.7
9/3/98	0	1,800	3,120	4,920	0.00	16.40	0.00	201,700	580.8
10/6/98	0	1,320	2,920	4,240	8.40	11.60	0.00	879,100	521.5
11/4/98	0	2,120	2,960	5,080	0.00	16.00	0.00	952,800	576.8

Using the operator log sheet data the savings for the seven months is calculated as the pre-retrofit kW (14.1 kW) multiplied by the run time hours, minus the post kWh consumption shown in the billing history, as shown in Table 3-23.

Table 3-23
Monthly Savings
Project No. 46799

Month	Post-Retrofit kWh	Run Hours	Pre-Retrofit kWh	kWh Savings	Period
11/97	4,360	552.6	7,791	3,431	Winter
12/98	3,960	477.0	6,725	2,765	Winter
6/98	2,880	346.9	4,891	2,011	Summer
7/98	4,480	545.7	7,694	3,214	Summer
8/98	4,920	580.8	8,188	3,268	Summer
9/98	4,240	521.5	7,352	3,112	Summer
10/98	5,080	576.8	8,132	3,052	Winter

The total annual savings are estimated by multiplying the total Winter period savings by 7/3 to extrapolate the three months of available data to the seven months/yr. in SDG&E's Winter TOU period. The Summer season savings is 11,605 kWh and the Winter season savings are 21,579 kWh, and the total annual kWh savings is 33,184 kWh. Summarizing from Table 3-23 the savings are shown below.

$$\text{Summer kWh Savings} = 2{,}011 + 3{,}214 + 3{,}268 + 3{,}112$$
$$= 11{,}605 \text{ kWh}$$
$$\text{Winter kWh Savings} = (3431 + 2765 + 3052)\times(7/3)$$
$$= 21{,}579 \text{ kWh}$$
$$\text{Annual kWh Savings} = 11{,}605 \text{ kWh} + 21{,}579 \text{ kWh}$$
$$= 33{,}184 \text{ kWh}$$

The Summer and Winter savings were divided into each of the On-peak, Semi-peak, and Off-peak period proportional to the time-of-use consumption in the billing history. The time-of-use history and % of period breakdown is shown in Table 3-23.

Table 3-24
Time-of-Use Breakdown of Period Consumption
Project No. 46799

Read Date	On-Peak kWh	Semi-Peak kWh	Off-Peak kWh	Total kWh	On-Peak kWh %	Semi-Peak kWh %	Off-Peak kWh %	Period
12/4/97	0	1,880	2,480	4,360	0%	43%	57%	Winter
1/2/98	0	3,680	280	3,960	0%	93%	7%	Winter
7/7/98	0	960	1,920	2,880	0%	33%	67%	Summer
8/5/98	0	1,600	2,880	4,480	0%	36%	64%	Summer
9/3/98	0	1,800	3,120	4,920	0%	37%	63%	Summer
10/6/98	0	1,320	2,920	4,240	0%	31%	69%	Summer
11/4/98	0	2,120	2,960	5,080	0%	42%	58%	Winter
			Average	Summer	0%	34%	66%	
			Average	Winter	0%	59%	41%	

As the billing data shows, there is zero consumption during the peak periods. The pump is shutdown by a timeclock to remain off-peak in it's operation. Therefore, the coincident peak demand savings is zero. The ex post time-of-use load impacts are shown in Table 3-25.

Table 3-25
Ex Post Load Impacts by Time-of-Use Period
Project No. 46799

Time-of-Use Period	Hours	kWh Savings	Average kW Savings	Coincident kW Reduction
Summer On-peak	749	0	0.0	0.0
Summer Semi-peak	963	3,968	4.1	
Summer Off-peak	1,960	7,637	3.9	
Winter On-peak	441	0	0.0	0.0
Winter Semi-peak	1,911	12,788	6.7	
Winter Off-peak	2,736	8,791	3.2	
Total	**8,760**	**33,184**		

3.7.5 Comparison with Ex Ante *Estimated Impacts*

The realization rates for energy and demand for this project are shown in Table 3-26. Comparison of the ex ante and ex post estimates of demand saving show a difference of 0.4 kW and annual energy savings realization rate of 52%. The main reasons for the differences are:

- The ex ante estimated hours of operation of the pump was 8,760 hrs./yr. The operator 1og sheets indicated that the pump operated approximately 3,600 hrs./yr. This discrepancy accounts for nearly all of the energy savings difference.
- The billing history indicates, as expected because of the timeclock, that the pump is not run during peak periods. Therefore, zero kW savings were found. The ex ante estimate of 0.4 kW savings was assuming that the pump would operate during peak.

Table 3-26
Comparison of Ex Ante and Ex Post Demand and Energy Impacts
Project No. 46799

	kWh	kW	Therms
Ex ante Load Impacts	64,121	0.4	-
Ex post Load Impacts	33,184	0.0	-
Difference	-30,937	-0.4	-
Realization Rate	52%	n/a	n/a

3.8 Project No. 47344 - VSD on Blower Motor

3.8.1 Pre-Installation Equipment and Operation

Prior to the installation of a variable speed drive (VSD) on the grit blower motor, this customer was controlling the volume of air delivered by the use of an outlet damper. The blower has a 25 horsepower motor and delivers 400 cfm to aeration diffusion panels in a water treatment tank. The blower operates 24 hours per day, year round. The outlet damper was controlled manually be customer as needed. The customer's staff visually inspected the water treatment tank 2-3 times per day and adjusted the outlet damper of the blower as needed. Currently, the air volume is adjusted by the use of a VSD. According to the operating staff they still operate the system in the same manner, however, they now use the VSD to control the air volume rather than the outlet dampers. It was assumed that the air flow profile for the basecase is the same as the post-retrofit profile.

3.8.2 Energy Efficiency Improvement

The technology of a variable speed drive allows for the reduction of air volume of a system without the use of dampers or vanes. Reducing the air volume using dampers increases the pressure on the blower system. The motor load must provide the work to overcome this pressure. Variable speed drives allow the speed of the blower to be reduced and thus reduces the air volume output. As the speed of the motor is decreased the power consumption is reduced by the cube of the speed.

After the installation of the VSD the outlet dampers of the blower system were opened 100% and the air volume of the water treatment tank is controlled by the speed of the blower.

3.8.3 Ex Ante Load Impact Estimates

The ex ante energy and demand savings were calculated using a vendor's software package. The parameters of the system are put into the modeling program and a comparison of control options is produced. The inputs listed in the project file and the output results of the model are listed in Table 3-27. The calculations of the software package, and the ex ante savings claim, could not be replicated. Table 3-28 shows the ex ante load impact estimates.

Table 3-27
Ex Ante Simulation Model Inputs and Results
Project No. 47344

Input	
System Pressure (inches)	161
Maximum Flow (CFM)	400
Static Head	5
Fan Efficiency	47%
Motor Efficiency	88%
Drive Efficiency	96%
Annual Hours	8,760
Hrs. @ 400 cfm	87.6
Hrs. @ 280 cfm	1,314
Hrs. @ 200 cfm	7,358

Output	
Total kWh	
Outlet Damper	113,960
Inlet Vanes	62,934
VSD	27,500
kWh Savings w/ VSD vs:	
Outlet Damper	86,460
Inlet Vanes	35,430

Table 3-28
Ex Ante Energy Savings Estimates
Project No. 47344

	kWh	kW
Ex Ante Impact	44,236	-0.7

3.8.4 Ex Post Load Impact Estimates

The ex post savings estimates were developed from on-site measurement data and common engineering principals. The grit blower and motor were verified. The blower is Hoffman Centrifugal blower m/n 4206A with a full output capacity of 400 cfm. The blower is driven by Lesson WattSaver m/n N256T34DB5, 25 hp, 3600 rpm motor. The variable speed drive is a Cutler Hammer AF95 VFD.

Ex Post Postcase Energy Consumption

As reported by the customer, the speed of the motor is manually set through the VSD by the technician on duty. There is no speed controlling sensor in the system. The customer reported that the VSD is typically operated on one of three settings- 3,500 rpm, 3,260 rpm, or 3,000 rpm. During the on-site visit the drive was adjusted to each of these settings and the kW value was obtained from the VSD display. The values obtained at each speed and the energy consumption are shown in Table 3-29.

Table 3-29
Post-Retrofit Operating Parameters and Energy Consumption w/ ASD
Project No. 47344

RPM	CFM	% Load	Amps	kW	% Hrs.	Hrs./yr.	kWh/yr.
3,500	395	78	16.8	16.7	10	876	14,629
3,260	368	58	n/a	11.4	80	7008	79,891
3,000	339	31	9.7	5.8	10	876	5,081
Total					**100**	**8760**	**99,601**

The cfm values above were calculated using the affinity laws for centrifugal applications.

$$\frac{\text{Flow}_2}{\text{Flow}_1} = \frac{\text{RPM}_2}{\text{RPM}_1} \quad \text{or} \quad \text{Flow}_2 = \frac{\text{RPM}_2}{\text{RPM}_1} * \text{Flow}_1$$

$$\text{cfm@3,500 rpm} = \frac{\text{3,500rpm}}{\text{3,540, full speed rpm}} \times \text{400 cfm@ full speed}$$

$$= \text{395 cfm}$$

$$\text{cfm@3,260 rpm} = \frac{\text{3,260rpm}}{\text{3,540full speed rpm}} \times \text{400 cfm@ full speed}$$

$$= \text{368 cfm}$$

$$\text{cfm@3,000 rpm} = \frac{\text{3,000rpm}}{\text{3,540 full speed rpm}} \times \text{400 cfm@ full speed}$$

$$= \text{339 cfm}$$

Ex Post Basecase Energy Consumption

The basecase energy consumption was calculated using the same cfm profile with outlet damper control. The brake horsepower was obtained from the manufacturer's curve for this blower at each cfm. With a motor efficiency of 91.3% the kW and kWh were calculated as shown in Table 3-30.

$$\text{kW} = \frac{\text{BHP} \times \text{0.746kW / hp}}{\text{Motor Efficiency}}$$

Table 3-30
Basecase Operating Parameters and Energy Consumption w/ Outlet Dampers
Project No. 47344

RPM	CFM	BHP	% Load	Mtr. Eff.	kW.	Hrs./yr.	kWh/yr.
3,540	395	19.4	78	91.3%	15.85	876	13,886
3,540	368	18.7	75	91.3%	15.28	7,008	107,079
3,540	339	18.0	72	91.3%	14.71	876	12,884
Total						**8,760**	**133,849**

Ex Post Energy and Demand Savings

The annual energy savings is the basecase kWh minus the postcase kWh. The kWh savings calculation is shown below.

$$\text{kWh Savings} = 133{,}849\text{ kWh} - 99{,}601\text{ kWh}$$

$$= 34{,}248\text{ kWh / yr.}$$

The coincident kW savings was estimated by using a weighted average of the savings at each speed. The speed adjustments are made on a random schedule, therefore, a weighted average provides the best estimate of peak savings.

$$\text{Peak kW Savings} = \left(\frac{((19.4\text{kW} - 16.7\text{kW}) \times 876\text{ hrs.}) + ((18.7 - 11.4) \times 7008) + ((18.0 - 5.8) \times 876)}{8{,}760\text{ hrs.}}\right)$$

$$= 7.33\text{ kW}$$

Table 3-31 shows the ex post load impacts by time-of-use period.

Table 3-31
Ex Post Load Impacts by Time-of-Use Period
Project No. 47344

Time-of-Use Period	Hours	kWh Savings	Average kW Savings	Coincident kW Reduction
Summer On-peak	749	2,928	3.91	7.33
Summer Semi-peak	963	3,765	3.91	
Summer Off-peak	1,960	7,663	3.91	
Winter On-peak	441	1,724	3.91	7.33
Winter Semi-peak	1,911	7,471	3.91	
Winter Off-peak	2,736	10,697	3.91	
Total	**8,760**	**34,248**		

3.8.5 Comparison with Ex Ante Estimated Impacts

The realization rates for energy and demand for this project are shown in Table 3-32. Comparison of the ex ante and ex post estimates of demand saving show a realization rate of 105% and annual energy savings realization rate of 77%. The main reason for the difference is that the actual operating profile differs significantly from the ex ante estimated profile.

Table 3-32
Comparison of Ex Ante and Ex Post Demand and Energy Impacts
Project No. 47344

	kWh	kW	Therms
Ex Ante Load Impacts	44,236	-0.7	-
Ex Post Load Impacts	34,248	7.33	-
Difference	-9,988	8.03	-
Realization Rate	77%	105%	n/a

3.9 PROJECT NO. 47583 - ONE ENERGY EFFICIENT MOTOR

3.9.1 Pre-Installation Equipment and Operation

This project involves the installation of a new high-efficiency motor. The motor drives a booster pump in a district water distribution system. The pump operates as demand dictates, which is approximately 1,056 hours per year.

3.9.2 Energy Efficiency Improvement

The new motor is a 75-hp US Motors m/n G62560, with a nominal efficiency of 95%. The savings are estimated by comparing this high-efficiency motor to the average standard-efficiency motor of the same size and speed. The improvement in efficiency is the source of savings. The load factor and hours of operation of the basecase and post-retrofit motors are considered equal.

3.9.3 Ex Ante Load Impact Estimates

This project was rebated under SDG&E's prescriptive motors program. The savings are based upon the horsepower, speed, and enclosure type of the motor. The ex ante impacts are 3,352 kWh per year and 0.84 kW.

3.9.4 Ex Post Load Impact Estimates

A simple engineering analysis was used to estimate the load impacts as shown in Table 3-34. The motor load was measured during the evaluation on-site visit. The operating volts and amperage were measured on December 1, 1998. The operating load factor was calculated as:

$$\text{LoadFactor} = \left(\frac{\text{Amps} \times 1.732 \times \text{Volts} \times \text{Power Factor} \times \text{Eff}_M}{746 \text{ kW / HP}} \right) \div \text{Rated HP}$$

$$= \left(\frac{78 \text{ amps} \times 1.732 \times 479 \text{ Volts} \times 0.86\text{PF} * 0.95\text{Eff}_M}{746 \text{ kW / HP}} \right) \div 75 \text{ HP}$$

$$= 94.5\%$$

The pumping operation varies throughout the year. There are two equal size pumps at this pumping station. They are the only equipment on the SDG&E meter. In order to estimate the annual hours of operation, the billing data was used to back into the hours of operation. This pump should consume about half of the total energy consumption of this account. The two pumps operate approximately equivalent hours according to the customer. The total annual energy consumption for this account in 1998 was approximately 111,744 kWh and the measured operating load of the new motor is 52.9 kW. The annual hours of operation were estimated as:

$$\text{Annual Hours / yr.} = \frac{\text{billing kWh} \times 0.5}{\text{Oper.kW}}$$

$$= \frac{111{,}744 \text{ kWh} \times 0.5}{52.9 \text{ kW}}$$

$$= 1{,}056 \text{ hours / yr.}$$

The savings was determined by an engineering based load profile model. The measured load profile and efficiency ratings were input and the savings between a high-efficiency and standard-efficiency motor of the same size and type were calculated. The basic equations of the model use the same load profile for both the standard-efficiency and high-efficiency motors. The equations are illustrated below.

$$\text{kWh\_ Savings} = (\text{Qty})(\text{HP})(0.746\text{kW / HP})(\%\text{Load})\left(\frac{1}{\text{Eff}_{\text{basecase@load}}} - \frac{1}{\text{Eff}_{\text{retrofit@load}}}\right)(\text{Hrs./yr.})$$

where:

Qty = Quantity of retrofit motors,

HP = Rated Horsepower,

0.746 kW/ HP = constant,

$$\%\text{Load} = \left(\frac{\text{Output Horsepower at Actual Load Conditions}}{\text{Rated Output Horsepower}}\right),$$

$\text{Eff}_{\text{basecase@load}}$ = Rated Basecase Motor Efficiency at Actual Load Conditions,

$\text{Eff}_{\text{retrofit@load}}$ = Rated Retrofit Motor Efficiency at Actual Load Conditions.

Hrs./yr.=Estimatedhoursperyearoperationatloadfactor

$$\text{kWh Savings} = (1)(75)(0.746)(94.5\%)\left(\frac{1}{91.9\%} - \frac{1}{95.2\%}\right)(1{,}056)$$

$$= 2{,}106 \text{ kWh / yr.}$$

Table 3-33 shows the ex post load impacts by time-of-use period.

Table 3-33
Ex Post Load Impacts by Time-of-Use Period
Project No. 47583

Time-of-Use Period	Hours	kWh Savings	Average kW Savings	Coincident kW Reduction
Summer On-peak	749	180	0.24	0.24
Summer Semi-peak	963	232	0.24	
Summer Off-peak	1,960	471	0.24	
Winter On-peak	441	106	0.24	0.24
Winter Semi-peak	1,911	459	0.24	
Winter Off-peak	2,736	658	0.24	
Total	**8,760**	**2,106**		

3.9.5 Comparison with Ex Ante Estimated Impacts

The realization rates for energy and demand for this project are shown in Table 3-34. Comparison of the ex ante and ex post estimates of demand saving show a realization rate of 29% and annual energy savings realization rate of 63%.

Table 3-34
Comparison of Ex Ante and Ex Post Demand and Energy Impacts
Project No. 47583

	kWh	kW	Therms
Ex Ante Load Impacts	3,352	0.84	-
Ex Post Load Impacts	2,106	0.24	-
Difference	-1,246	-0.60	-
Realization Rate	63%	29%	n/a

3.10 PROJECT NO. 48954 - ONE ENERGY EFFICIENT MOTOR

3.10.1 Pre-Installation Equipment and Operation

This project involves the installation of a new high-efficiency motor. The motor drives a booster pump in a water district distribution system. The pump operates as demand dictates, which is approximately 2,223 hours per year.

3.10.2 Energy Efficiency Improvement

The new motor is a 30-hp US Motors m/n J366A, with a nominal efficiency of 93.6%. The savings are estimated by comparing this high-efficiency motor to the average standard-efficiency motor of the same size and speed. The improvement in efficiency is the source of savings. The load factor and hours of operation of the basecase and post-retrofit motors are considered equal.

3.10.3 Ex Ante Load Impact Estimates

This project was rebated under SDG&E's prescriptive motors program. The savings are based upon the horsepower, speed, and enclosure type of the motor. The ex ante impacts are 2,178 kWh/year and 0.54 kW.

3.10.4 Ex Post Load Impact Estimates

A simple engineering analysis was used to estimate the load impacts as shown in Table 3-36. The motor load was measured during the evaluation on-site visit. The operating volts and amperage were measured on December 1, 1998. The operating load factor was calculated as:

$$\text{LoadFactor} = \left(\frac{\text{Amps} \times 1.732 \times \text{Volts} \times \text{Power Factor} \times \text{Eff}_M}{746 \text{ kW / HP}}\right) \div \text{RatedHP}$$

$$= \left(\frac{34 \text{ amps} \times 1.732 \times 484 \text{ Volts} \times 0.895 \text{ PF} \times 0.936\text{Eff}_M}{746 \text{ kW / HP}}\right) \div 30\text{HP}$$

$$= 107\%$$

The pumping operation varies throughout the year. The run hours were obtained during the on-site visit from a meter on the pump drive system. The run hour meter read 2,990 hours. The installation date was 7/28/97 and the on-site visit was on 12/1/98. This is a total of 491 days. The annual hours is estimated as:

$$\text{Average Annual Run Hours} = (2{,}990 \text{ hrs./491 days}) \times 365 \text{ days/yr.}$$

$$= 2{,}223 \text{ hours/yr.}$$

The savings were determined by an engineering based load profile model. The measured load profile and efficiency ratings are input and the savings between a high-efficiency and standard-efficiency motor of the same size and type are calculated. The basic equations of the model use the same load profile for both the standard-efficiency and high-efficiency motors. The equations are illustrated below.

$$\text{kWh Savings} = (\text{Qty})(\text{HP})(0.746\ \text{kW / HP})(\%\text{Load})\left(\frac{1}{\text{Eff}_{\text{basecase@load}}} - \frac{1}{\text{Eff}_{\text{retrofit@load}}}\right)(\text{Hrs./yr.})$$

where:

Qty = Quantity of retrofit motors,

HP = Rated Horsepower,

0.746 kW/ HP = constant,

$$\%\text{Load} = \left(\frac{\text{Output Horsepower at Actual Load Conditions}}{\text{Rated Output Horsepower}}\right),$$

$\text{Eff}_{\text{basecase@load}}$ = Rated Baseline Motor Efficiency at Actual Load Conditions,

$\text{Eff}_{\text{retrofit@load}}$ = Rated Retrofit Motor Efficiency at Actual Load Conditions.

Hrs./yr.=Estimated hours per year operation at load factor

$$\text{kWh Savings} = (1)(30)(0.746)(107\%)\left(\frac{1}{87.6\%} - \frac{1}{93.6\%}\right)(2{,}223)$$

$$= 3{,}895\ \text{kWh / yr.}$$

Table 3-35 shows the ex post load impacts by time-of-use period.

Table 3-35
Ex Post Load Impacts by Time-of-Use Period
Project No. 48954

Time-of-Use Period	Hours	kWh Savings	Average kW Savings	Coincident kW Reduction
Summer On-peak	749	333	0.44	0.44
Summer Semi-peak	963	428	0.44	
Summer Off-peak	1,960	871	0.44	
Winter On-peak	441	196	0.44	0.44
Winter Semi-peak	1,911	850	0.44	
Winter Off-peak	2,736	1,217	0.44	
Total	8,760	3,895		

3.10.5 Comparison with Ex Ante Estimated Impacts

The realization rates for energy and demand for this project are shown in Table 3-36. Comparison of the ex ante and ex post estimates of demand saving show a realization rate of 81% and annual energy savings realization rate of 179%.

Table 3-36
Comparison of Ex Ante and Ex Post Demand and Energy Impacts
Project No. 48954

	kWh	kW	Therms
Ex ante Load Impacts	2,178	0.54	-
Ex post Load Impacts	3,895	0.44	-
Difference	1,717	-0.10	-
Realization Rate	179%	81%	n/a

3.11 PROJECT NO. 49365 - EFFICIENT PUMPS

3.11.1 Pre-Installation Equipment and Operation

New pumps and motors were installed on Well #2 and Well #3 for this municipal water district. The pump station operates 24 hours a day, every day. The pre-retrofit pumps were tested as part of SDG&E's Pump Test Program on August 13, 1997. The test found that these well pumps were operating inefficiently. The pump test results are shown below in Table 3-37.

Table 3-37
Pre-Retrofit Pump Test Results
Project No. 49365

	Pump#2	**Pump#3**
Discharge, PSI	4.0	3.5
Discharge head, feet	9.2	8.1
Suction lift, feet	162.1	221.5
Total pumping head, feet	171.3	229.6
Flow, gallons per minute	372	740
Acre feet pumped per 24 hours	1.644	3.269
kW input to motor	31.9	60.9
BHP input to motor	42.7	81.6
Motor load, % BHP	64.1	97.9
Measured speed of pump, RPM	1775	1775
kWh per acre-foot	465.8	447.1
Overall plant efficiency, %	37.7	52.6

3.11.2 Energy Efficiency Improvement

Both Well #2 and #3 pumps were replaced with new pumps that operate at a higher efficiency than the old pumps. The pre-retrofit system efficiencies, as shown above, were 37.7% and 52.6%. The new pumping systems are operating at approximately 55.8% and 60.2% efficiency. The actual operating efficiencies of the new pumps was tested by the same contractor that performed the pre-retrofit pump tests. The new pump tests were performed in November 1998. The pre-retrofit pump tests were funded by SDG&E, but the new pump tests were paid by the customer. The results of the new pump tests are shown below in Table 3-38.

Table 3-38
Pre-Retrofit Pump Test Results
Project No. 49365

	Pump#2	Pump#3
Discharge, PSI	4.5	3.5
Discharge head, feet	10.4	8.1
Suction lift, feet	169.1	222.1
Total pumping head, feet	179.5	230.2
Flow, gallons per minute	447	792
Acre feet pumped per 24 hours	1.977	3.501
kW input to motor	27.1	57.1
BHP input to motor	36.3	76.5
Motor load, % BHP	85.5	96.9
Measured speed of pump, RPM	1780	1779
kWh per acre-foot	329.0	391.4
Overall plant efficiency, %	55.8	60.2

3.11.3 Ex Ante Load Impact Estimates

The ex ante load impacts for Wells #2 and #3 were calculated using data developed during the pre-retrofit pump tests. The calculations are shown below.

Well #2

$$\text{Well \#2 Basecase HP} = \frac{372\text{ gpm} \times 171.3\text{ feet}}{3{,}960 \times (0.377\text{ pump efficiency})}$$

$$= 42.68\text{ hp}$$

$$\text{Well \#2 Postcase HP} = \frac{372\text{ gpm} \times 171.3\text{ feet}}{3{,}960 \times (0.65\text{ pump efficiency})}$$

$$= 24.76\text{ hp}$$

$$\text{Well \#2 HP Savings} = 42.68\text{ hp - }24.76\text{ hp}$$

$$= 17.92\text{ hp}$$

$$\text{Well \#2 kW Reduced} = (17.92\text{ hp}) \times (0.746\text{ kW / hp})$$

$$= 13.44\text{ kW}$$

Well #3

$$\text{Well \#3 Basecase HP} = \frac{740 \text{ gpm} \times 229.6 \text{ feet}}{3{,}960 \times (0.526 \text{ pump efficiency})}$$

$$= 81.57 \text{ hp}$$

$$\text{Well \#3 Postcase HP} = \frac{740 \text{ gpm} \times 229.6 \text{ feet}}{3{,}960 \times (0.69 \text{ pump efficiency})}$$

$$= 62.18 \text{ hp}$$

$$\text{Well \#3 HP Savings} = 81.57 \text{ hp - } 62.18 \text{ hp}$$

$$= 19.39 \text{ hp}$$

$$\text{Well \#3 kW Reduced} = (19.39 \text{ hp}) \times (0.746 \text{ kW / hp})$$

$$= 14.54 \text{ kW}$$

The kW reduced for Wells #2 and #3 were multiplied by 8,760 operating hours to estimate the kWh impacts. These results are summarized in Table 3-39.

Table 3-39
Ex Ante Load Impacts Estimates
Project No. 49365

Well #2		Well #3	
kWh	kW	kWh	kW
117,412	13.4	127,021	14.5

3.11.4 Ex Post Load Impact Estimates

The ex post savings impacts were estimated utilizing the pre and post-retrofit pump tests. The new pumping system is pumping more water than the old system had been. The pre-retrofit capacity was normalized to the post-retrofit capacity of acre-feet of water pumped by basing the saving on kWh per acre-ft. The savings for each pump are calculated individually below.

Well Pump #2

The pre-retrofit pumping system consumed 465.8 kWh/acre-ft. at an efficiency of 37.7%. The new system consumes approximately 329.0 kWh/acre-ft. at an efficiency of 55.8%. These values were obtained from the pre- and post-retrofit pump tests. The calculations used in these pump tests are shown below.

$$\text{Pre- Retrofit kWh / acre - ft} = \frac{372\ \text{gal.}}{\text{min.}} \times \frac{60\ \text{min.}}{\text{hr.}} \times \frac{\text{acre - ft}}{325{,}851\ \text{gal.}} \times \frac{31.9\ \text{kW}}{\text{hr.}}$$

$$= 465.8\ \text{kWh / acre - ft.}$$

$$\text{Post -Retrofit kWh / acre - ft} = \frac{447\ \text{gal.}}{\text{min.}} \times \frac{60\ \text{min.}}{\text{hr.}} \times \frac{\text{acre - ft}}{325{,}851\ \text{gal.}} \times \frac{27.1\ \text{kW}}{\text{hr.}}$$

$$= 329.0\ \text{kWh / acre - ft}$$

The total annual acre-ft of water pumped was estimated from operator log sheets provided by the customer. Records were obtained covering the period of January through November 1998. December flow and run hours were estimated as the average of the previous 11 months. The pump station operator records are summarized in Table 3-40.

Table 3-40
Well Pump #2 Operator Log Sheet Summary
Project No. 49365

Month	Start Hrs	End Hrs	Days Oper.	Start Cu. Ft.	End Cu. Ft.	Cu. Ft./Min.	Acre-ft	%
January	58802	58802	0	8,666,800	8,666,800	0	0.0	0%
February	58802	58802	0	8,666,800	8,666,800	0	0.0	0%
March	58802	59375.3	24	8,666,800	10,985,000	2,318,200	53.2	15%
April	59375.3	60096.4	30	10,985,000	13,989,800	3,004,800	69.0	20%
May	60096.4	60638.9	23	13,989,800	16,235,600	2,245,800	51.6	15%
June	60638.9	60978.5	15	16,235,600	17,636,900	1,401,300	32.2	9%
July	60978.5	60978.5	0	17,636,900	17,636,900	0	0.0	0%
August	60978.5	60978.5	0	17,636,900	17,636,900	0	0.0	0%
September	60978.5	60978.5	0	17,636,900	17,636,900	0	0.0	0%
October	0.2	576.3	24	17,636,900	19,953,000	2,316,100	53.2	15%
November	576.3	1292.8	30	19,953,000	22,762,300	2,809,300	64.5	18%
December	n/a	n/a	13	n/a	n/a	1,281,409	29.4	8%
Annual			**159**			**15,376,909**	**353.0**	

The annual energy savings were calculated as the kWh/acre-ft savings between pre- and post-retrofit pumps multiplied by the acre-ft. of water pumped per year.

$$\text{kWh Savings / yr.} = \big((\text{Pre - kWh / acre - ft}) - (\text{Post kWh / acre\_ ft})\big) \times \text{Cu.Ft./yr.} \times \frac{\text{acre - ft.}}{43{,}560\ \text{Cu. Ft.}}$$

$$= (465.8 - 329.0) \times \frac{15{,}376{,}909\ \text{Cu. Ft}}{\text{Yr.}} \times \frac{\text{acre\_ ft.}}{43{,}560\ \text{Cu. Ft.}}$$

$$= 48{,}290\ \text{kWh / yr.}$$

By normalizing the savings calculation to kWh per acre-ft, it must be assumed that the pre-retrofit condition would be required to run more hours per year because the flow rate was less. To accurately determine the peak kW savings the operating load (kW) difference between the pre- and post-retrofit conditions was calculated. That savings was:

Coincident kW Savings = 31.9 kW - 27.1 kW
= 4.8 kW.

The energy savings were allocated between summer and winter costing periods based on the monthly variation of the flow as shown in Table 3-40 above. The peak/semi/off-peak allocation was proportional to the percent of the summer or winter period. Table 3-41 shows the ex post load impacts by time-of-use period.

Table 3-41
Ex Post Load Impacts by Time-of-Use Period
Well Pump #2
Project No. 49365

Time-of-Use Period	Hours	kWh Savings	Average kW Savings	Coincident kW Reduction
Summer On-peak	749	2,335	3.12	4.8
Summer Semi-peak	963	3,004	3.12	
Summer Off-peak	1,960	6,114	3.12	
Winter On-peak	441	3,193	7.24	4.8
Winter Semi-peak	1,911	13,836	7.24	
Winter Off-peak	2,736	19,809	7.24	
Total	**8,760**	**48,290**		

Well Pump #3

The pre-retrofit pumping system consumed 447.1 kWh/acre-ft. of water pumped at an efficiency of 52.6%. The new system consumes approximately 391.4 kWh/acre-ft. of water pumped at an efficiency of 60.2%. These values were obtained from the pre and post pump tests. The calculations used in these pump tests are shown below.

$$\text{Pre-Retrofit kWh / acre-ft} = \frac{740\text{ gal.}}{\text{min.}} \times \frac{60\text{ min.}}{\text{hr.}} \times \frac{\text{acre-ft}}{325{,}851\text{ gal.}} \times \frac{60.9\text{ kW}}{\text{hr.}}$$

$$= 447.1 \text{ kWh / acre-ft.}$$

$$\text{Post-Retrofit kWh / acre-ft} = \frac{792\text{ gal.}}{\text{min.}} \times \frac{60\text{ min.}}{\text{hr.}} \times \frac{\text{acre-ft}}{325851\text{ gal.}} \times \frac{57.1\text{ kW}}{\text{hr.}}$$

$$= 391.4 \text{ kWh / acre-ft.}$$

The log sheets for Well pump #3 are summarized below in Table 3-42.

Table 3-42
Well Pump #3 Operator Log Sheet Summary
Project No. 49365

Month	Start Hrs	End Hrs	Days Oper.	Start Cu. Ft.	End Cu. Ft.	Cu. Ft./Min.	Acre-ft	%
January	9491.5	10122.1	26	17,689,000	22,308,000	4,619,000	106.0	9%
February	10122.1	10746	26	22,308,000	26,703,000	4,395,000	100.9	9%
March	10746	11478.7	31	26,703,000	31,932,000	5,229,000	120.0	11%
April	11478.7	12199.8	30	31,932,000	36,669,000	4,737,000	108.7	10%
May	12199.8	12743	23	36,669,000	40,222,000	3,553,000	81.6	7%
June	12743	13082.6	15	40,222,000	42,465,000	2,243,000	51.5	5%
July	13082.6	13319.1	10	42,465,000	44,418,000	1,953,000	44.8	4%
August	0	695.5	31	44,418,000	49,726,000	5,308,000	121.9	11%
September	695.5	1341.3	27	49,726,000	54,320,000	4,594,000	105.5	9%
October	1341.3	1920.5	24	54,320,000	58,210,000	3,890,000	89.3	8%
November	1920.5	2636.3	30	58,210,000	62,931,000	4,721,000	108.4	10%
December	n/a	n/a		n/a	n/a	4,112,909	94.4	8%
Annual			**273**			**49,354,909**	**1133.0**	

The annual energy savings are calculated as the kWh/acre-ft. savings between pre- and post-retrofit pumps multiplied by the acre-ft of water pumped per year.

$$\text{kWh Savings / yr.} = \left(\left(\text{Pre - kWh / acre - ft.}\right) - \left(\text{Post - kWh / acre - ft.}\right)\right) \times \text{Cu. Ft./yr.} \times \frac{\text{acre - ft.}}{43560\ \text{Cu. Ft.}}$$

$$= (447.1 - 391.4) \times \frac{49{,}354{,}909\ \text{Cu. Ft}}{\text{Yr.}} \times \frac{\text{acre - ft.}}{43560\ \text{Cu. Ft.}}$$

$$= 63{,}110\ \ \text{kWh / yr.}$$

The kW savings for pump #3 would also be the operating kW difference (same as pump#2). That savings is:

$$\begin{aligned} \text{Coincident kW Savings} &= 60.9\ \text{kW} - 57.1\ \text{kW} \\ &= 3.8\ \text{kW} \end{aligned}$$

The energy savings were allocated with the same method as pump #2. Table 3-43 shows the ex post load impacts by time-of-use period for pump #3.

Table 3-43
Ex Post Load Impacts by Time-of-Use Period
Well Pump #3
Project No. 49365

Time-of-Use Period	Hours	kWh Savings	Average kW Savings	Coincident kW Reduction
Summer On-peak	749	4,604	6.15	3.8
Summer Semi-peak	963	5,919	6.15	
Summer Off-peak	1,960	12,047	6.15	
Winter On-peak	441	3,514	7.97	3.8
Winter Semi-peak	1,911	15,226	7.97	
Winter Off-peak	2,736	21,800	7.97	
Total	**8,760**	**63,110**		

Total Site Load Impacts

The total project impacts are the sum of the load impacts for Well pump #2 and Well pump #3. The total project impacts by costing period is shown below in Table 3-44.

Table 3-44
Total Ex Post Load Impacts by Time-of-Use Period
(Well Pump #2 plus Well Pump #3)
Project No. 49365

Time-of-Use Period	Hours	kWh Savings	Average kW Savings	Coincident kW Reduction
Summer On-peak	749	6,940	9.27	8.6
Summer Semi-peak	963	8,923	9.27	
Summer Off-peak	1,960	18,161	9.27	
Winter On-peak	441	6,707	15.21	8.6
Winter Semi-peak	1,911	29,062	15.21	
Winter Off-peak	2,736	41,608	15.21	
Total	**8,760**	**111,401**		

3.11.5 Comparison with Ex Ante Estimated Impacts

The realization rates for energy and demand for this project are shown in Table 3-45. Comparison of the ex ante and ex post estimates of demand saving show a realization rate of 59% and annual energy savings realization rate of 88%. The main reasons for the differences are:

- Both Well pump #2 & #3 were assumed to operate 8,760 hours per year in the ex ante analysis. Pump #2 is actually operating closer to 3,800 hours/yr. and pump #3 is approximately 7,000 hours/yr.

- The actual tested efficiency of the installed pumps varies significantly from the ex ante estimates of post-retrofit efficiency. Pump #2 is 55.8% versus 65% and Pump #3 is 52.6% versus 69%.

Table 3-45
Comparison of Ex Ante and Ex Post Demand and Energy Impacts
Project No. 49365

	kWh	kW	Therms
Ex Ante Load Impacts	244,433	27.9	-
Ex Post Load Impacts	111,401	8.6	-
Difference	-133,032	-19.3	-
Realization Rate	46%	31%	n/a

3.12 PROJECT NO. 49797 - ENERGY EFFICIENT MOTOR

3.12.1 Pre-Installation Equipment and Operation

This project involves the installation of two high-efficiency motors. The motors operate a vacuum pump and a refrigeration unit. However, the refrigeration unit failed and is not being repaired. The motor is in storage. The vacuum pump operates 21 hours per day, seven days per week, or 7,665 hours per year. The savings realized by the vacuum pump motor will be described in this report. There are no savings from the 25-hp refrigeration unit motor since it is not operating.

3.12.2 Energy Efficiency Improvement

The new motor on the vacuum pump is a 20-hp Siemens model number PE21 Plus, 1,800 rpm, with a nominal efficiency of 91.0%. The savings were estimated by comparing this high-efficiency motor to the average standard-efficiency motor of the same size and speed. The improvement in efficiency is the source of savings. The load factor and hours of operation of the basecase and post-retrofit motors were considered equivalent.

3.12.3 Ex Ante Load Impact Estimates

This project was rebated under SDG&E’s energy efficient motors program. The savings were based on the horsepower, speed, and enclosure type of the motor. The ex ante impacts are 1,452 kWh/year and 0.36 kW for the 20-hp vacuum pump and 1,815 kWh/year and 0.45 kW for the 25-hp refrigeration pump. The total ex ante savings is 3,267 kWh/year and 0.86 kW.

3.12.4 Ex Post Load Impact Estimates

A simple engineering analysis was used to estimate the load impacts for the 20-hp motor. The motor load was measured during the post-retrofit on-site visit. The operating volts and amperage were measured on December 15, 1998. The operating load factor was calculated as:

$$\text{Load Factor} = \left(\frac{\text{Amps} \times 1.732 \times \text{Volts} \times \text{Power Factor} \times \text{Eff}_\text{M}}{746 \text{ kW / HP}} \right) \div \text{Rated HP}$$

$$= \left(\frac{33.2 \text{ amps} \times 1.732 \times 236 \text{ Volts} \times 0.81 \text{ PF} \times 0.912\text{Eff}_\text{M}}{746 \text{ kW / HP}} \right) \div 20 \text{ HP}$$

$$= 67\%$$

The pump operates 21 hours/day, 7 days/week which equals 7,665 hours per year. The three hours per day that the pump is not operating is during the off-peak TOU period.

The savings were determined by an engineering based load profile model. The measured load profile and efficiency ratings are input and the savings between a high-efficiency and standard-efficiency motor of the same size and type are calculated. The basic equations of the model use the same load profile for both the standard-efficiency and high-efficiency motors. The equations are illustrated below.

$$\text{kWh Savings} = (\text{Qty})(\text{HP})(0.746\ \text{kW / HP})(\%\text{Load})\left(\frac{1}{\text{Eff}_{\text{basecase@load}}} - \frac{1}{\text{Eff}_{\text{retrofit@load}}}\right)(\text{Hrs./yr.})$$

where:

Qty = Quantity of retrofit motors,

HP = Rated Horsepower,

0.746 kW/ HP = constant,

$$\%\text{Load} = \left(\frac{\text{Output Horsepower at Actual Load Conditions}}{\text{Rated Output Horsepower}}\right),$$

$\text{Eff}_{\text{basecase@load}}$ = Rated Baseline Motor Efficiency at Actual Load Conditions,

$\text{Eff}_{\text{retrofit@load}}$ = Rated Retrofit Motor Efficiency at Actual Load Conditions.

Hrs./yr.= Estimated hours per year operation at load factor

$$\text{kWh Savings} = (1)(20)(0.746)(67\%)\left(\frac{1}{89.2\%} - \frac{1}{91.3\%}\right)(7{,}665)$$

$$= 1{,}943\ \text{kWh / yr.}$$

**Values are slightly off due to rounding shown in this equation.*

Table 3-46 shows the ex post load impacts by time-of-use period.

Table 3-46
Ex Post Load Impacts by Time-of-Use Period
Project No. 49797

Time-of-Use Period	Hours	kWh Savings	Average kW Savings	Coincident kW Reduction
Summer On-peak	749	190	0.25	0.25
Summer Semi-peak	963	244	0.25	
Summer Off-peak	1,960	381	0.19	
Winter On-peak	441	112	0.25	0.25
Winter Semi-peak	1,911	484	0.25	
Winter Off-peak	2,736	532	0.19	
Total	**8,760**	**1,943**		

**The 3 hours per day that the pump is not operating is during the off-peak TOU period.*

3.12.5 Comparison with Ex Ante Estimated Impacts

The realization rates for energy and demand for this project are shown in Table 3-47. Comparison of the ex ante and ex post estimates of demand saving show a realization rate of 32% and annual energy savings realization rate of 59%. The main reasons for the difference is:

- The 25 horsepower refrigeration unit is not in operation any longer and the motor that was rebated is in storage. This accounts for 1,815 kWh and 0.45 kW of the ex ante impacts.

Table 3-47
Comparison of Ex Ante and Ex Post Demand and Energy Impacts
Project No. 49797

	kWh	kW	Therms
Ex Ante Load Impacts	3,267	0.82	-
Ex Post Load Impacts	1,943	0.25	-
Difference	-1,324	-0.57	-
Realization Rate	59%	30%	n/a

4 PROCESS MEASURES

4.1 OVERVIEW

A total of two agricultural process measures were installed during PY97 under the AEEI Program. Table 4-1 shows the ex ante load impacts associated with these measures.

Table 4-1
Ex Ante Load Impacts
Process Measures
PY97 Agricultural EEI Program

Project No.	Meas. Quantity	Measure Description	Operating Hours	Ex Ante Gross kWh Savings	Ex Ante Gross kW Reduced	Ex Ante Gross Therm Savings	Ex Ante NTGR
14072	1	Ultrafine Aeration Diffusers Panel	8,760	218,400	63.5	0	0.75
50616	1	VFD on 15 HP Motor	8,760	59,991	-0.2	0	0.75

The first measure was a diffuser system installed at a wastewater treatment plant, while the second was a variable frequency drive on a small motor installed at a dairy. The diffuser system accounted for almost 80 percent of the ex ante kWh savings and virtually all of the kW reduction for agricultural process measures. The diffusers were evaluated as part of the first year load impact evaluation. An on-site survey was conducted at the facility. The load impacts were estimated using a simplified engineering analysis based on data gathered through the on-site survey and ex post monitoring of affected energy using equipment at the facility. The realization rate of this evaluation was applied to the program ex ante load impacts to estimate the program ex post load impacts. The installation of the measure for Project No. 50616 was verified by telephone.

4.2 SUMMARY OF RESULTS

The results of the this ex post load impact evaluation are shown in Tables 4-2 and 4-3. These results show the measures installed saved more energy than anticipated in the ex ante load impact estimates, but the kW demand reduction was not as great as expected.

Table 4-2
Ex Post Gross Program Load Impacts
Process Measures
PY97 Agricultural EEI Program

	kWh Savings	kW Reduced
Ex Ante Gross Load Impacts	278,391	63.30
Ex Post Gross Load Impacts	327,945	29.24
Realization Rate	117.8%	46.2%
No. Projects	2	2

Table 4-3
Ex Post Net Program Load Impacts
Process Measures
PY97 Agricultural EEI Program

	kWh Savings	kW Reduced
Ex Post Gross Load Impacts	327,945	29.24
Ex Post Net-To-Gross Ratio	0.75	0.75
Ex Post Net Load Impacts	245,958	21.93
Ex Ante Net-To-Gross Ratio	0.75	0.75
Ex Ante Net Load Impacts	208,793	47.48
Net Realization Rate	117.8%	46.2%

4.3 Project ID 14072 - Installation of Ceramic Panel Diffusers vs. Perforated Tubes for Wastewater Reclamation Plant Aeration System

4.3.1 Summary of Findings

A fine bubble air diffusion system was installed and operated continuously at this wastewater reclamation plant. Table 4-5 compares the ex ante gross impact estimates with the ex post impact estimates.

Table 4-4
Summary of Ex Post Impacts
Project No. 14072

	kWh	kW	Therms
Ex Ante	218,400	63.50	n/a
Ex Post	257,266	29.40	n/a
Realization Rate	117.8%	46.2%	n/a

The ex post gross annual energy impact is 257,266 kWh, 17.8% greater than the ex ante estimate of 218,400 kWh. The ex post gross peak demand impact is 29.4 kW, 46.2% of the ex ante estimate, 63.5 kW.

4.3.2 Facility Description

This is a municipal wastewater reclamation plant. The portion of the facility addressed in this project is the secondary aeration tanks where air is bubbled through the liquid wastewater to support biological growth which consumes the organic compounds in the wastewater. The system is designed to maintain a set amount of dissolved oxygen in the wastewater at all times to support the aerobic bacteria. This report estimates the energy and demand savings realized from the installation of fine bubble aeration diffusers. There are a number of methods used to carry out the aeration process. Common alternatives include simple non-mixed aeration ponds, water sprays, propeller mixers, transverse paddles, and coarse bubble aeration. Coarse bubble aeration via perforated tubes or plates is the most commonly installed alternative.

4.3.3 Overview of Facility Schedule

The plant operates 24 hours per day, 365 days per year.

4.3.4 Measure Description

A fine bubble diffuser system was installed to provide aeration versus a lower cost, but more energy intensive, coarse bubble system. The system consists of a series of ceramic panels installed near the bottom of the aeration tank. Air is fed to the panels via piping from a blower located in the equipment building. The panels are maintained at a pressure of approximately 7 psi at the supply riser pipe from the header.

Ex Ante Basecase

The ex ante basecase consisted of a perforated pipe air diffusion system, or course bubble aeration. The perforated pipe system produces larger bubbles with a smaller surface area than the post-retrofit ceramic fine bubble diffuser system. The larger bubbles delivered via the perforated pipe transfer oxygen to the wastewater at a lower rate per cubic foot of bubbles as compared to a fine-bubble system. As a result, the perforated pipe system must deliver more air to maintain the same level of dissolved oxygen in the wastewater for a given influent oxygen demand, dissolved oxygen level and temperature.

Coarse bubble systems have been a common mode of aeration for several decades and their oxygen transfer performance for different influent conditions is well known and predictable. For this site, the basecase coarse bubble system was predicted to require an average of 2,095 scfm. The delivered air pressure is about the same for the two systems: approximately 7.0 psi at the riser from the header. The ex ante analysis assumed that the blower operated at 70% efficiency with a motor of 91.6% efficiency.

Ex Ante Postcase

The ex ante postcase consisted of the post-retrofit ceramic diffuser fine bubble aeration system. Because of the greater bubble surface area, it was predicted that the diffusers would require 1,375 cfm at 7.0 psi at the riser for average flow and influent conditions. The ex ante analysis assumed the blower operated at 70% efficiency and the motor was 91.6% efficient.

4.3.5 Ex Ante Load Impact Estimates

The *ex ante* load impact estimates were calculated using the standard formula for fan power:

$$\text{Fan kW} = \frac{0.746 \times Q \times P}{K \times \text{Eff}_{\text{Blower}} \times \text{Eff}_{\text{Motor}}},$$

where:

0.746 = conversion constant for brake horsepower to kW,

Q = blower air flow rate in standard cubic feet per minute,

P = air pressure rise across blower in lbs / sq. ft. (Psf)) used in ex ante analysis,

K = constant depending on pressure units use (for psf units, $K = 33{,}000$),

$\text{Eff}_{\text{Blower}}$ = blower efficiency (assumed 70%),

$\text{Eff}_{\text{Motor}}$ = motor efficiency (assumed 91.6%)

Table 4-5 and 4-6 show a summary of the ex ante kWh and kW impact calculation. These tables show total *ex ante* claimed load impacts of 218,400 kWh saved and 63.5 kW reduced.

Table 4-5
Ex Ante kWh Impact Calculation Summary
Project No. 14072

Variable	Post-retrofit Fine Bubble Ceramic Panel System	Basecase Coarse Bubble Perforated Pipe System	Notes
P1 psia	14.43	14.43	Atmospheric Pressure
P2 psia	30.87	29.25	Blower Discharge Pressure
n	1.4000	1.4000	specific heat ratio
M	0.285714	0.285714	M=(n-1)/n
Beta	0.849267	0.782900	Beta = [((p1/p2)^M-1)/M]
V1	13.3	13.3	Specific Volume - ft^3/lb
Head	23470.6	21636.5	144*P1*V1*Beta
scfm	1530	2095	ft^3/min Manufacturers Estimates from empirical tests
Density	0.075188	0.075188	lb/ft^3
air flow rate	115.03764	157.51886	lb/min W x density
Compressor Eff.	0.7	0.7	Est. from Mfr. Data
Gas horsepower	116.883312	147.5392111	scfm * Head/(33000*Compressor Eff.)
Motor Eff.	0.916	0.916	Manufacturer's Data
kW	95.19	120.16	BHP * 0.746 kW/hp / Motor Eff.
Annual kWh	833,873	1,052,580	kW * 8760 Hours/yr
Gross kWh Impact		218,706	Basecase kWh - Postcase kWh
Note: The ex ante kWh impact in the project file was 218,400 kWh. We believe that the difference is due to a small error and rounding in the above calculation.			

An identical calculation was carried out for the project maximum flow condition to estimate the demand impact. Table 4-6 shows these results.

Table 4-6
Ex Ante kW Impact Calculation Summary
Project No. 14072

Variable	Post-retrofit Fine Bubble Ceramic Panel System	Basecase Coarse Bubble Perforated Pipe System	Notes
P1 psia	14.43	14.43	Atmospheric Pressure
P2 psia	29.20	30.13	Blower Discharge Pressure
n	1.4000	1.4000	specific heat ratio
M	0.285714	0.285714	M=(n-1)/n
Beta	0.780849	0.819256	Beta = [((p1/p2)^M-1)/M]
V1	13.3	13.3	Specific Volume - ft^3/lb
Head	21579.8	22641.2	144*P1*V1*Beta
scfm	2236	3189	ft^3/min Manufacturers Estimates from empirical tests
Density	0.075188	0.075188	lb/ft^3
air flow rate	168.120368	239.774532	lb/min W x density
Compressor Eff.	0.7	0.7	Est. from Mfr. Data
Gas horsepower	157.0564819	235.0126165	scfm * Head/(33000*Compressor Eff.)
Motor Eff.	0.916	0.916	Manufacturer's Data
kW	127.91	191.40	BHP * 0.746 kW/hp / Motor Eff.
Gross kWh Impact		63.5	Basecase Max kW - Postcase Max kW

4.3.6 Ex Post Load Impact Estimates

The ex post analysis was carried out using an engineering methodology and formulae similar to the ex ante estimate calculations. The ex post analysis, however used direct measurements of post-retrofit compressor operating power as the basis for equipment pre- and post-retrofit compressor energy use. A data logger was installed on the blower to record true kW consumption in 15 minute intervals from December 16, 1998 to January 8, 1999. The operating flow rate of the post-retrofit blowers was based on continuous monitoring via the facility SCADA data system.

Ex Post Basecase

The ex post basecase consisted of the alternative coarse bubble diffuser system as described in the ex ante basecase description, however the ex post basecase was modified in several important ways:

- Given the post-retrofit system operating conditions observed at the site during the evaluation survey, the blower supply pressure was corrected to 7.0 psi to reflect the likely operating conditions that the basecase system would have experienced.
- The 1,375 cfm average air flow was lower than the 1,530 cfm assumed in the ex ante estimates. The basecase air flow rate was adjusted downward by multiplying the ex ante assumed basecase air flow (2,095 cfm) by the ratio of the actual post-retrofit average operating air flow to the ex ante projected air flow $\left(\frac{1{,}375\text{ cfm}}{1{,}530\text{ cfm}}\right)$.

$$\text{Revised Basecase cfm} = \frac{2{,}095\text{ cfm} \times 1375\text{ cfm}}{1{,}530\text{ cfm}}$$

$$= 1{,}883\text{ cfm}$$

- The basecase blower operating efficiency point was assumed to be the same as the calculated post-retrofit blower efficiency: 47.4% at the operating point. The motor efficiency was 91.6%.

Ex Post Postcase

The postcase consisted of the post-retrofit ceramic fine bubble diffuser system operating at an annual average 1,375 cfm at a pressure of 7.0 psig at the riser. The post-retrofit blower efficiency was calculated to be 47.4% at the average condition operating point. The motor efficiency was 91.6%. The cfm flow rate was determined from customer SCADA system monitoring history.

Ex Post Production Level Changes

No increase in productive output was caused by or occurred as a result of the installation of the post-retrofit system vs. the alternative system.

Data Collected Ex Post

- Blower air flow - continuously from customer SCADA system.
- Blower motor power (kW) consumption - data logger
- Air pressure at riser from site observations at the evaluation visit.

Ex Post kWh Savings and TOU Impact

Annual Gross kWh Impact

The post-retrofit blower average operating kW was obtained by the installation of a data logger, which recorded true kW in 15 minute intervals. The system operating schedule was verified as 8,760 annual hours (continuous operation), and operator records of air pressure at the risers were reviewed on-site.

The post-retrofit blower efficiency was calculated using the formula:

$$\text{Eff}_{\text{Blower}} = \frac{0.746 \times Q \times P}{K \times P_M \times \text{Eff}_M},$$

where:

0.746 = conversion constant for brake horsepower to kW,

Q = blower air flow rate in standard cubic feet per minute,

P = air pressure rise across blower in lbs / sq. in. (psi)) used in ex post analysis,

K = constant depending on pressure units use (for psi units, $K = 229$),

P_M = motor input power: 76 kW at 1,375 cfm,

Eff_M = motor efficiency (assumed 91.6%).

The values used in the above equation to calculate the efficiency at the time of the ex post site visit are shown in Table 4-7.

Table 4-7
Ex Post Blower Efficiency Calculation
Project No. 14072

	Observed Post-Retrofit Operation	Notes
Pressure at Riser psig	7	Observed Ex Post Site Visit
Pressure drop to Riser psi	0.3	Eng. Estimate.
Total Blower pressure psi	7.30	Total psi
scfm	1,350	Observed from SCADA System at Evaluation Site Visit
kW	76.0	Observed from SCADA system at evaluation site visit
Motor Efficiency	91.6%	Observed from nameplate.
BHP	93.3	kW*MotorEffic./0.746
Blower Efficiency	46.1%	Calculated from measured kW, flow and pressure (.746*scfm*psi/(229*kWMeas.*Motor Eff.)

The post-retrofit system operating power was calculated using the average system air flow obtained from site records, a 7.3 psi blower pressure and the calculated post-retrofit compressor operating efficiency of 46.1%. The basecase system operating power was calculated using the same procedure but using the reduced basecase cfm described above and assuming the same blower efficiency.

Table 4-8 shows the ex post kWh savings calculations.

Table 4-8
Ex Post kWh Savings Calculation
Project No. 14072

		Annual Average Operation Post-Retrofit System	**Annual Average Operation Basecase System**	**Notes**
	Col. A	Col. B	Col. C	Col. D
1	**Pressure at Riser psig**	7	7	Observed ex post site Visit
2	**Pressure drop to Riser psi**	0.5	0.5	Ex ante estimate
3	**Total Blower pressure psi**	7.50	7.50	A + B
4	**Ex ante projected cfm**	1,530	2,095	Ex ante projected cfm
5	**Post-retrofit average operating air flow: scfm**	1,375		Post-retrofit observed from customer SCADA system; Basecase flow calculated as ratio of ex ante estimates for
6	**Calculated basecase average operating air flow: scfm**		1,883	D x (B5/B4)
7	**Compressor Eff.**	46.1%	46.1%	Calculated from measured flow, pressure and power (See Table 4-4)
8	**BHP**	97.7	133.7	scfm × psi/(259×Compressor Eff.)
9	**Motor Eff.**	0.916	0.916	Manufacturer's Data
10	**kW**	79.5	108.9	BHP × 0.746 kW/hp / Motor Eff.
11	**Annual kWh**	696,667	953,932	kW × 8,760 Hours/yr
12	**Gross kWh Impact**		257,266	Basecase kWh - Postcase kWh
13	**Peak kW Impact =**		29.37	kW

TOU Period kWh Impacts

This system operates continuously. The plant wastewater treatment flow, oxygen requirement and temperature calls for the airflow rates which very from 1,000 to 1,500 scfm. The variation is not clearly related to season and/or time-of-day. The seasonal time-of-use period energy impacts are best distributed according to the total hours in each TOU period, and the peak-coincident demand impact is represented by the overall average kW impact. Table 4-6 summarizes the time-of-use period impacts:

Average Gross kW Impacts

Average gross kW impacts were calculated for each TOU period by dividing the total kWh impacts for the TOU period by the total number of hours in the TOU period:

$$\text{Average ex post kW reduced}_c = \frac{\text{Ex post kWh savings}_c}{\text{Hours}_c}$$

These results are shown in Table 4-9.

Table 4-9
Ex Post Load Impacts By TOU Period
Project No. 14072

Season	Period	Total Hours	Impact Weighting Factor	kWh Impact	Average kW
Col. A	Col. B	Col. C	Col. D	Col. E	Col. F
			C÷(8,760 hours)	D×(257,266 kWh)	E/C
Summer	On-peak	749	0.0855	21,997	29.4
	Semi-peak	963	0.1099	28,282	29.4
	Off-peak	1,960	0.2237	57,562	29.4
Winter	On-peak	441	0.0503	12,951	29.4
	Semi-peak	1,911	0.2182	56,123	29.4
	Off-peak	2,736	0.3123	80,352	29.4
Total		8,760		257,266	

4.3.7 Summary of Gross Impacts

Table 4-10 summarizes the ex post gross kW and kWh Impacts and shows a comparison of the ex ante gross impact estimates with the ex post estimates.

Table 4-10
Results and Comparison with Ex Ante Estimate
Project No. 14072

	kWh	kW	Therms
Ex Ante	218,400	63.50	n/a
Ex Post	257,266	29.4	n/a
Realization Rate	117.8%	46.2%	n/a

The ex post gross annual energy savings is 257,266 kWh, 17.8% greater than the ex ante estimate of 218,400 kWh. The ex post gross peak demand impact is 29.4 kW, 46.2% of the ex ante estimate, 63.5 kW.

There are two principal reasons for the kWh discrepancies:

1. The primary reason for the discrepancy is the difference between the ex post post-retrofit average cfm, revealed by the post-retrofit observations (1,375 cfm), was lower than the

ex ante post-retrofit cfm. When the basecase cfm was adjusted for the lower flow requirement, the difference between the ex post blower kW and the ex ante blower kW was reduced from the difference calculated in the ex ante estimates.

2. The reduced difference in air power was counteracted, however, by the ex post evaluation finding that the blower efficiency at the operating point was 46% rather than the 70% used in the ex ante estimates. The use of the lower efficiency increased the difference between the ex ante and ex post estimates.

The primary reason for the large kW discrepancy is a difference between the ex ante and ex post impact methodology. The ex ante methodology calculated the difference between the pre- and post-retrofit blower input power for the projected peak air demand hour of the year, without consideration of the time that the peak hour might occur or the coincidence of the air demand peak hour with the system peak hour. The ex post methodology assumed that the average kW impact was most representative of the impact on the system peak. This methodology is a better representation of the coincident peak, given that the annual air demand peak hour cannot be defined and changes year-to-year.

4.4 Ex Post Gross Program Load Impacts

The installation of the variable frequency drive installed under Project No. 50616 was verified via a telephone call to the customer. The results of the findings for Project No. 14072 were used to estimate the load impacts of the program by applying the realization rate to the program total ex ante load impacts, as shown in Table 4-11.

Table 4-11
Ex Post Gross Program Load Impacts
Process Measures
PY97 Agricultural EEI Program

	kWh Savings	kW Reduced
Realization Rate Project No. 14072	117.8%	46.2%
Ex Ante Gross Load Impacts	278,391	63.3
Ex Post Gross Load Impacts	327,945	29.2446

4.5 NET EX POST LOAD IMPACTS

Table 4-12 shows the net load impacts, both ex ante and ex post. These results show realization rates for the net load impacts of 117.8% and 46.2% for kWh and kW, respectively. A default net-to-gross ratio of 0.75 was used to estimate the net impacts as allowed under the *Retroactive Waiver for 1997 Agricultural Energy Efficiency Incentives Program* approved by CADMAC on January 20, 1999.

Table 4-12
Ex Post Net Program Load Impacts
Process Measures
PY97 Agricultural EEI Program

	kWh Savings	kW Reduced
Ex Post Gross Load Impacts	327,945	29.24
Ex Post Net-To-Gross Ratio	0.75	0.75
Ex Post Net Load Impacts	245,958	21.93
Ex Ante Net-To-Gross Ratio	0.75	0.75
Ex Ante Net Load Impacts	208,793	47.48
Net Realization Rate	117.8%	46.2%

5 SPACE CONDITIONING MEASURES

5.1 INTRODUCTION

This section provides the site specific analyses for the space heating measures installed under SDG&E's PY97 Agricultural Energy Efficiency Incentives Program.

5.2 SUMMARY

Tables 5-1 and 5-2 summarize the findings of ex post load impact evaluation for space conditioning measures. Program participation for space conditioning measures for the PY97 AEEI program comprised the four projects shown in Table 5-1. These four projects were implemented at two sites, with a total of five measures installed. There results show a 98% realization rate for therm savings, and a somewhat deceptively low realization rates for electricity, 26% and 33% for kWh and kW, respectively. The reason for calling the electricity results deceptive is that the measure actually reduces electricity use to a greater degree when compared with the ex ante estimate. However, since the sign is negative, the realization rate as it is normally calculated leads to a deceptive result.

Table 5-1
Ex Post Gross Impact Summary and Comparison with Ex Ante
ID No. 40955, 40956, 40957
PY97 AEEI Space Conditioning Measures

		Ex Ante Gross			Ex Post Gross			Gross Realization Rate		
Project No.	**Measure Description**	**kWh Savings**	**kW Reduced**	**Therm Savings**	**kWh Savings**	**kW Reduced**	**Therm Savings**	**kWh Savings**	**kW Reduced**	**Therm Savings**
40955	Expanded Polystyrene Insulation - 2 Inch	0	0	6,521			9,365			144%
40956	Polystyrene Insulation	0	0	2,173			3,110			143%
40957	Polystyrene Insulation	0	0	2,778			2,666			96%
49495	8400mm BTU Boilers w/stack heat recovery	-4,976	-0.45	37,091	-1,282	-0.15	32,217	26%	33%	87%
Total		**-4,976**	**-0.45**	**48,563**	**-1,282**	**-0.15**	**47,358**	**26%**	**33%**	**98%**
No. Of Projects = 4										

Table 5-2 shows a summary of the ex post net load impacts. The default net-to-gross ratio of 0.75 was used as allowed under the Retroactive Waiver approved on January 20, 1999.

Table 5-2
Ex Post Net Impact Summary and Comparison with Ex Ante
ID No. 40955, 40956, 40957
PY97 AEEI Space Conditioning Measures

			Ex Ante Net			Ex Post Net			Net Realization Rate		
Project No.	Measure Description	NTGR	kWh Savings	kW Reduced	Therm Savings	kWh Savings	kW Reduced	Therm Savings	kWh Savings	kW Reduced	Therm Savings
40955	Expanded Polystyrene Insulation - 2 Inch	0.75	0	0	4,890.75	0.00	0.00	7,023.75	n/a	n/a	1.44
40956	Polystyrene Insulation	0.75	0	0	1,629.75	0.00	0.00	2,332.50	n/a	n/a	1.43
40957	Polystyrene Insulation	0.75	0	0	2,083.50	0.00	0.00	1,999.50	n/a	n/a	0.96
49495	8400mm BTU Boilers w/stack heat recovery	0.75	-3732	-0.3375	27,818.25	-961.50	-0.11	24,162.75	0.26	0.33	0.87
Total			**-3,732**	**-0.3375**	**36,422.25**	**-961.50**	**-0.11**	**35,518.50**	**0.26**	**0.33**	**0.98**

Table 5-3 shows the square footage of the conditioned space affected by these measures.

Table 5-3
Conditioned Square Footage
PY97 AEEI Space Conditioning Measures

Project No.	Conditioned Square Footage
40955	9,555
40956	4,428
40957	2,916
49495	345,000
Total	**361,899**

5.3 PROJECT NO. 40955, 40957, 40958: SPACE HEATING MEASURE (THERMAL INSULATION) INSTALLED IN THREE GREENHOUSES (THREE PROJECT NOS. AT A SINGLE FACILITY)

Two-inch rigid foam thermal insulation was installed on the walls of sections of three greenhouse buildings, and one-inch insulation was installed in the roofs of parts of two greenhouse buildings. The projects were carried out under three separate Project Numbers, but are located at a single customer facility.

5.3.1 Facility Information and Basecase Assumptions

The facility consists of an agricultural greenhouse complex consisting of five major greenhouse buildings located in Fallbrook, California. Each of the three project applications applies to all or a part of one of the greenhouse buildings. The total greenhouse floor space addressed is 58,008 square feet. The breakdown of floor space addressed and wall or roof area insulated under each project is shown in Table 5-4.

Table 5-4
Area Addressed and Areas Insulated for Three Projects
PY97 AEEI Space Conditioning Measures

Project No.	40955	40956	40957	Insulated Area	Insulation Thickness
Building	GH #3 (Walls Only) (sf)	GH #2 Loading Dock Area (sf)	GH #5 Loading Dock Area (sf)	Total Area (sf)	(Expanded Polystyrene R=5 per inch) (inches)
Floor Area Addressed	52,812	2,916	2,280		
Roof Area Insulated	-	2,916	2,280	5,196	1"
Wall Area Insulated	9,555	1,620	1,580	12,755	2"

Seventy five percent of the greenhouse floor area is covered with movable light metal tables that are used to hold the greenhouse plants.

Heating is provided by 15 gas-fueled unit heaters, located along the north wall. The heaters have a rated input capacity ranging from 150,000 to 200,000 Btu/hour. The heating setpoint is 72° F. The setpoints are determined by the growing technological requirements, which require temperatures remain at or above 72° F. The heating system is available and operates year-round as required to meet heating demand.

5.3.2 Energy Efficiency Measures Installed

The energy efficiency measures installed are described below.

Wall insulation: Space heat loss was reduced by adding insulation to the greenhouse exterior walls. The basecase wall condition was the pre-retrofit wall which consisted of a single layer of polyethylene sheet material attached to a wood stud frame. Under the project, the sheeting was removed and two-inch thick expanded polystyrene rigid foam board-type insulation with a total thermal resistance (R-value) of 10 was applied to the interior surface of 1/16-inch galvanized sheet metal to create the exterior walls of the greenhouse part of the facility.

Roof insulation: Space heat loss was reduced by adding insulation to the roof. The basecase roof condition was the pre-retrofit roof which consisted of a double layer of polyethylene sheet material attached to a wooden framework. One-inch thick expanded polystyrene with an R-value of 5 was applied to the interior surface of 1/16-inch galvanized sheet metal to create the exterior roof of the applicable parts of the greenhouses at the facility.

5.3.3 Ex Ante Load Impact Estimation Methodology

The approach used to estimate the *ex ante* impacts of the projects is described in this subsection.

Wall and Roof Insulation: Energy use for a similar building at the site (proxy) was used to estimate basecase specific energy use for the greenhouses. The proxy building was a 107,568 square foot building with annual gas usage of 114,792 therms per year. This resulted in an estimated specific energy use index (EUI) of 1.067 therms per square foot per year. For each area, the floor space represented was then multiplied by the specific energy use to estimate the total annual energy use for that area of the building.

The fraction of total heat energy lost by conduction through the walls and roof was derived from industry literature obtained from the California Agricultural Extension Service. The total energy use calculated for each greenhouse floor area was then multiplied by the wall or roof fraction to estimate the total pre-retrofit heat losses attributed to that envelope component. The losses through each component were multiplied by the savings factor (0.8 for roofs and 0.9 for walls) to calculate the annual heat loss reduction. The heat loss reduction was divided by the estimated heater efficiency (70%) to calculate the gross annual therm impacts. The ex ante energy use and gross impact estimated for each component and each project are shown in Table 5-5.

Table 5-5
Ex Ante Algorithms, Calculations and Results
PY97 AEEI Space Conditioning Measures

Roof Insulation										
Col. A	Col. B	Col. C	Col. D	Col. E	Col. F	Col. G	Col. H	Col. I	Col. J	
Project No.	**Floor Area**	**Proxy Specific Energy Use**	**Total Annual Energy for Area**	**Percent Losses Thru Roof**	**Heat Lost Thru Roof**	**Roof Savings Factor**	**Roof Savings (Heat Loss)**	**Combus-tion Efficiency**	**Roof Savings**	
	sq. ft.	mBtu/sf/yr	therms	%	Therms			%	therms	
	data	Cornell Data	B×C	Cornell Data	D×E	1-1/R, (R=5)	F×G	Mfr. Data/Ex Ante Est.	H/I	
40955	52,812	1.067	56,350	n/app.	n/app.	n/app.	n/app.		n/app.	
40956	2,916	1.067	3,111	68%	2,116	0.8	1,693	70%	2,418	
40957	2,280	1.067	2,433	68%	1,654	0.8	1,323	70%	1,891	
Wall Insulation										**Total**
Project No.	**Floor Area**	**Proxy Specific Energy Use**	**Total Annual Energy for Area**	**Percent Losses Thru Walls**	**Heat Lost Thru Walls**	**Wall Savings Factor**	**Wall Savings (Heat Loss)**	**Combus-tion Efficiency**	**Wall Savings (Input at 70%)**	**Ex Ante Impacts**
	sq. ft.	mBtu/sf/yr	therms	%	Therms		therms	%	therms	therms
	data	Cornell Data	B×C	Cornell Data	D×E	1-1/R, (R=10)	F×G	Mfr. Data/Ex ante Est.	H/I	Roof + Wall
40955	52,812	1.067	56,350	9%	5,072	0.9	4,564	70%	6,521	6,521
40956	2,916	1.067	3,111	9%	280	0.9	252	70%	360	2,778
40957	2,280	1.067	2,433	9%	219	0.9	197	70%	282	2,173

5.3.4 Ex Post Load Impact Estimation Methodology

The site was visited during December 1999. The installation of the retrofit measures was inspected, an interview of facility staff was performed, and an inventory of equipment and the structure were collected during the site visit. This information was used to develop an engineering analysis using an annual bin temperature methodology and standard (ASHRAE) conductive heat loss equations.

The analysis approach comprised the following steps:

1. A site visit was conducted to verify the installed insulation area and thickness and to confirm heating equipment configuration, and setpoints. Data on operating schedule and control strategy were collected by observation and interview with the facility maintenance staff.
2. A temperature bin model using the standard heat transfer equation and 30 year average weather data was developed to calculate the impacts.

Basecase Building Definition

The basecase building reflects the geometrical and the thermal characteristics of the pre-retrofit facility. From pre-retrofit site information and customer interviews the basecase envelope thermal values are:

- The exterior walls were single-thickness heavy-duty polyethylene sheeting with an estimated overall U-value of 1.15 Btu/hr-sf-DegF.
- The roof were double polyethylene (U-value of 0.7 Btu/hr-sf-DegF).

U-values were taken from Cornell University data as described in the Greenhouse Energy Conservation Guide, California University Extension Service (detailed citation not available)

- Roof and wall areas and insulation thickness were shown in Table 5-1.
- The average interior temperature is 72°F, year-round.
- The space heaters are ceiling-suspended natural gas-fired unit heaters. The units are not vented to outdoors. All heat of combustion is released indoors, therefore, the efficiency is assumed to be 100%

Retrofit Building Definition

Envelope improvement cases include the following changes:

1. The exterior walls overall R-value is calculated to be 10.85. This represents the total R-value of 2-inches of foam insulation with an R-value of 5.0 per inch thickness plus interior and exterior film-resistance totaling 0.85. The assumed U-value is, therefore, 1/(10.0+0.85) = 0.09 Btu/hr-sf-DegF.
2. The exterior roof overall R-value is calculated to be 5.85. This represents the total R-value of 5.0 plus interior and exterior film-resistance totaling 0.85. The assumed U-value is therefore 1/(5.0+0.85) = 0.17 Btu/hr-sf-DegF.

Ex Post Energy Savings

The following equation was used to calculate the pre- and post-retrofit natural gas consumption and savings.

$$Q = \sum_{i=1}^{9} A x (U_0 - U_1) x (T_{in} - T_{Avbin,\, i}) x (H_i) / (CxE)$$

where:

Q = Total annual natural gas savings (therms)
A = Area of insulation retrofit

U_0 = Basecase wall or roof coefficient of thermal transmission (Btu/hr-sf-DegF): 1.15 for walls; 0.70 for roof

U_1 = Postcase coefficient of thermal transmission: (Btu/hr-sf-DegF): 0.09 for walls and 0.17 for roof. (See ex post post-retrofit building definition for calculation.)

T_{in} = Average inside temperature (setpoint): 72°F

$T_{avbin,i}$ = Average temperature of each 5° weather bin between 25°F and 70°F for San Diego (9 bins between 25°F and 70°F) (USAF 30 year average data)

H_i = Total annual hours temperatures are between minimum and maximum bin temperatures (USAF 30 year average data)

C = Conversion: Btu to therms (100,000 Btu/therm)

E = efficiency of conversion from gas therms to Btu's delivered (100% assumed due to internal venting of gas burners)

Tables 5-6, 5-7, and 5-8 show the calculations and results for projects: 40955, 40956, and 40957. Table 5-9 summarizes the impacts and compares the results with the ex ante estimates.

Table 5-6
Ex Post Impact Calculation for Project No. 40955
PY97 AEEI Space Conditioning Measures

A	B	C	D	E	F	G	I	J	K	L	M	N	O
Min Bin Temp (°F)	**Max Bin Temp (°F)**	**Avg. Bin Temp (Tavbin) (°F)**	**00-08 Bin-Hours (USAF)**	**08-16 Bin-Hours (USAF)**	**16-24 Bin-Hours (USAF)**	**Total Bin Hours, H (USAF) (E+F+G)**	**Delta T (72-C) (72-Tavbin) (°F)**	**U0 (Btu/hr-sf-°F) (Cornell Data in File)**	**U1 (Btu/hr-sf-°F) (1/(10+.85)**	**Basecase Annual Heat Loss (1580 sf Area x Delta T x Hours x U0) (GxIxJ)**	**Annual Btu's After Insul. (1580 sf Area x Delta T x Hours x U1) (GxIxK)**	**Btu's Saved (L-M)**	**Annual Therms Saved @ 100% Eff. (N/100000)**
100	105												
95	100			1		1							
90	95			2		2							
85	90			13	1	14							
80	85			45	8	53							
75	80		14	220	55	289							
70	75	72.5	141	581	278	1000							
65	70	67.5	443	662	582	1687	4.5	1.15	0.09	83,417,300	6,685,418	76,731,882	767.3
60	65	62.5	626	757	760	2143	9.5	1.15	0.09	223,704,288	17,928,615	205,775,673	2,057.8
55	60	57.5	709	453	716	1878	14.5	1.15	0.09	299,221,036	23,980,848	275,240,187	2,752.4
50	55	52.5	560	147	364	1071	19.5	1.15	0.09	229,484,107	18,391,834	211,092,273	2,110.9
45	50	47.5	280	24	110	414	24.5	1.15	0.09	111,453,820	8,932,384	102,521,436	1,025.2
40	45	42.5	96	5	35	136	29.5	1.15	0.09	44,084,859	3,533,148	40,551,711	405.5
35	40	37.5	39	2	11	52	34.5	1.15	0.09	19,712,921	1,579,877	18,133,043	181.3
30	35	32.5	14		1	15	39.5	1.15	0.09	6,510,538	521,782	5,988,756	59.9
25	30	27.5	1			1	44.5	1.15	0.09	488,977	39,189	449,788	4.5
Total													**9,364.8**

Table 5-7
Impact Calculation for Project No. 40956
PY97 AEEI Space Conditioning Measures

A	B	C	D	E	F	G	I	J	K	L	M	N	O
Walls													
Min Bin Temp (°F)	Max Bin Temp (°F)	Avg. Bin Temp (Tavbin) (°F)	00-08 Bin-Hours (USAF)	08-16 Bin-Hours (USAF)	16-24 Bin-Hours (USAF)	Total Bin Hours, H (USAF) (E+F+G)	Delta T (72-Avg. T)	U0 (Btu/hr-sf-°F) (Cornell Data in File)	U1 (Btu/hr-sf-°F) (1/(10+.85)	Basecase Annual Heat Loss (1580 sf Area x Delta T x Hours x U0) (GxIxJ)	Annual Btu's After Insul. (1580 sf Area x Delta T x Hours x U1) (GxIxK)	BTU's Saved (L-M)	Annual Therms Saved @ 100% Eff. (N/100000)
70	75	72.5	141	581	278	1000							
65	70	67.5	443	662	582	1687	4.5	1.15	0.09	14,142,965	1,133,477	13,009,487	130.1
60	65	62.5	626	757	760	2143	9.5	1.15	0.09	37,927,886	3,039,702	34,888,183	348.9
55	60	57.5	709	453	716	1878	14.5	1.15	0.09	50,731,353	4,065,827	46,665,526	466.7
50	55	52.5	560	147	364	1071	19.5	1.15	0.09	38,907,824	3,118,239	35,789,585	357.9
45	50	47.5	280	24	110	414	24.5	1.15	0.09	18,896,409	1,514,439	17,381,970	173.8
40	45	42.5	96	5	35	136	29.5	1.15	0.09	7,474,356	599,027	6,875,329	68.8
35	40	37.5	39	2	11	52	34.5	1.15	0.09	3,342,222	267,860	3,074,362	30.7
30	35	32.5	14		1	15	39.5	1.15	0.09	1,103,828	88,465	1,015,362	10.2
25	30	27.5	1			1	44.5	1.15	0.09	82,904	6,644	76,259	0.8
Subtotal-Wall													**1,587.8**
Roof													
Min Bin Temp (°F)	Max Bin Temp (°F)	Avg. Bin Temp (Tavbin) (°F)	00-08 Bin-Hours (USAF)	08-16 Bin-Hours (USAF)	16-24 Bin-Hours (USAF)	Total Bin Hours, H (USAF) (E+F+G)	Delta T (72-Avg. T)	U0 (Btu/hr-sf-°F) (Cornell Data in File)	U1 (Btu/hr-sf-°F) (1/(5+.85)	Basecase Annual Heat Loss (1580 sf Area x Delta T x Hours x U0) (GxIxJ)	Annual Btu's After Insul. (1580 sf Area x Delta T x Hours x U1) (GxIxK)	BTU's Saved (L-M)	Annual Therms Saved @ 100% Eff. (N/100000)
70	75	72.5	141	581	278	1000							
65	70	67.5	443	662	582	1687	4.5	0.70	0.17	15,495,770	3,784,071	11,711,699	117.1
60	65	62.5	626	757	760	2143	9.5	0.70	0.17	41,555,770	7,934,595	33,621,175	336.2
55	60	57.5	709	453	716	1878	14.5	0.70	0.17	55,583,917	10,613,108	44,970,810	449.7
50	55	52.5	560	147	364	1071	19.5	0.70	0.17	42,629,441	8,139,600	34,489,841	344.9
45	50	47.5	280	24	110	414	24.5	0.70	0.17	20,703,892	3,953,169	16,750,722	167.5
40	45	42.5	96	5	35	136	29.5	0.70	0.17	8,189,294	1,563,651	6,625,643	66.3
35	40	37.5	39	2	11	52	34.5	0.70	0.17	3,661,913	699,200	2,962,713	29.6
30	35	32.5	14		1	15	39.5	0.70	0.17	1,209,411	230,923	978,488	9.8
25	30	27.5	1			1	44.5	0.70	0.17	90,833	17,344	73,490	0.7
Subtotal-Roof													**1,521.8**
Total													**3,109.6**

Table 5-8
Impact Calculation for Project No. 40957
PY97 AEEI Space Conditioning Measures

A	B	C	D	E	F	G	I	J	K	L	M	N	O
Walls													
Min Bin Temp (°F)	**Max Bin Temp (°F)**	**Avg. Bin Temp (Tavbin) (°F)**	**00-08 Bin-Hours (USAF)**	**08-16 Bin-Hours (USAF)**	**16-24 Bin-Hours (USAF)**	**Total Bin Hours, H (USAF) (E+F+G)**	**Delta T (72-C)**	**U0 (Btu/hr-sf-°F) (Cornell Data in File)**	**U1 (Btu/hr-sf-°F) (1/(10+.85)**	**Basecase Annual Heat Loss (1580 sf Area x Delta T x Hours x U0) (GxIxJ)**	**Annual Btu's After Insul. (1580 sf Area x Delta T x Hours x U1) (GxIxK)**	**BTU's Saved (L-M)**	**Annual Therms Saved @ 100% Eff. (N/100000)**
70	75	72.5	141	581	278	1000							
65	70	67.5	443	662	582	1687	4.5	1.15	0.09	13,793,756	1,105,490	12,688,265	126.9
60	65	62.5	626	757	760	2143	9.5	1.15	0.09	36,991,395	2,964,648	34,026,747	340.3
55	60	57.5	709	453	716	1878	14.5	1.15	0.09	49,478,727	3,965,436	45,513,291	455.1
50	55	52.5	560	147	364	1071	19.5	1.15	0.09	37,947,137	3,041,245	34,905,891	349.1
45	50	47.5	280	24	110	414	24.5	1.15	0.09	18,429,831	1,477,045	16,952,786	169.5
40	45	42.5	96	5	35	136	29.5	1.15	0.09	7,289,804	584,236	6,705,568	67.1
35	40	37.5	39	2	11	52	34.5	1.15	0.09	3,259,698	261,246	2,998,452	30.0
30	35	32.5	14		1	15	39.5	1.15	0.09	1,076,573	86,281	990,291	9.9
25	30	27.5	1			1	44.5	1.15	0.09	80,857	6,480	74,376	0.7
Subtotal-Walls													**1,548.6**
Roof													
Min Bin Temp (°F)	**Max Bin Temp (°F)**	**Avg. Bin Temp (Tavbin) (°F)**	**00-08 Bin-Hours (USAF)**	**08-16 Bin-Hours (USAF)**	**16-24 Bin-Hours (USAF)**	**Total Bin Hours, H (USAF) (E+F+G)**	**Delta T (72-Avg. T)**	**U0 (Btu/hr-sf-°F) (Cornell Data in File)**	**U1 (Btu/hr-sf-°F) (1/(5+.85)**	**Basecase Annual Heat Loss (1580 sf Area x Delta T x Hours x U0) (GxIxJ)**	**Annual Btu's After Insul. (1580 sf Area x Delta T x Hours x U1) (GxIxK)**	**BTU's Saved (L-M)**	**Annual Therms Saved @ 100% Eff. (N/100000)**
70	75	72.5	141	581	278	1000							
65	70	67.5	443	662	582	1687	4.5	0.70	0.17	12,116,034	2,958,738	9,157,296	91.6
60	65	62.5	626	757	760	2143	9.5	0.70	0.17	32,492,166	7,934,595	24,557,571	245.6
55	60	57.5	709	453	716	1878	14.5	0.70	0.17	43,460,676	10,613,108	32,847,568	328.5
50	55	52.5	560	147	364	1071	19.5	0.70	0.17	33,331,662	8,139,600	25,192,062	251.9
45	50	47.5	280	24	110	414	24.5	0.70	0.17	16,188,228	3,953,169	12,235,059	122.4
40	45	42.5	96	5	35	136	29.5	0.70	0.17	6,403,152	1,563,651	4,839,501	48.4
35	40	37.5	39	2	11	52	34.5	0.70	0.17	2,863,224	699,200	2,164,024	21.6
30	35	32.5	14		1	15	39.5	0.70	0.17	945,630	230,923	714,707	7.1
25	30	27.5	1			1	44.5	0.70	0.17	71,022	17,344	53,678	0.5
Subtotal-Roof													**1,117.6**
Total													**2,666.2**

Table 5-9
Ex Post Gross Impact Summary and Comparison with Ex Ante
ID No. 40955, 40956, 40957
PY97 AEEI Space Conditioning Measures

Project No.	Measure	*Ex Ante* Therms per Year	*Ex Post* Therms per Year	Realization Rate
40955	Wall Insulation	6,521	9,365	144%
40956	Wall and Roof Insulation	2,173	3,110	143%
40957	Wall and Roof Insulation	2,778	2,666	96%
Total		**11,472**	**15,141**	**132%**

5.3.5 Comparison of Ex Ante and Ex Post Results

There are two primary reasons which explain the difference between ex ante and ex post load impact estimates.

1. Difference in methodology: The ex ante estimates used a prototype analysis method based on specific energy use, fraction of heat loss by building component (roof and wall) and expected percentage reductions in heat loss for each component. The estimates used values derived from an agricultural industry guidebook. The ex ante methodology did not explicitly use the building component dimensions, pre- and post-retrofit thermal conductivity values, local weather, or interior temperature setpoint. The ex post methodology used the accepted formula for thermal conduction and verified values of insulation thermal conductivity, thickness, insulation area, inside temperature setpoint and used 30-year average temperature bin data for San Diego. The difference in methodology resulted in a larger ex post estimate of reduced heat loss than the ex ante estimate.

2. Difference in heater efficiency. This factor tends to counteract the greater ex post estimate of reduced heat loss. The ex ante estimates assumed 70% fuel-to-heat efficiency which is considered typical of unit heaters in place at the facility. The ex post calculations used 100% efficiency because the heaters are not externally vented and all heat of combustion is released in the greenhouse. Because the efficiency factor appears in the denominator of the heat-loss-to-input-heat equation, this difference reduces the ex post therms impact estimate relative to same factor's effect on the ex ante impact by (1.0/0.7-1.0) x 100%=43%.

5.4 PROJECT NO. 49495 - BOILER STACK HEAT RECOVERY SYSTEM INSTALLED ON TWO BOILERS AT A GREENHOUSE FACILITY

"Thermastak" flue-gas-to-water heat exchangers were installed on the stacks of two lead boilers at this commercial green house facility.

5.4.1 Facility Information and Basecase Assumptions

The facility consists of a flower greenhouse complex consisting of several major greenhouse buildings located in Encinitas, California. The total greenhouse floor space addressed is 345,000 square feet. Space heating and humidity control and domestic hot water is provided year-round by four 8,400 kBtu/hr steam boilers. The two boilers which were modified under this project operate as lead boilers. Two other identical boilers operate as necessary to meet heating demand.

5.4.2 Energy Efficiency Measures Installed

"Thermastak" stack "economizer" flue-gas-to-water heat exchangers were installed on the two lead boilers, referred to as boilers #3 and #4. The heat exchangers preheat the boiler makeup water that is used for heating, humidification and domestic hot water. The detailed heat recovery system specifications are shown in Table 5-9 in the analysis section.

5.4.3 Ex Ante Load Impact Estimates

The approach used to estimate the *ex ante* impacts of the projects is described in this subsection.

The ex ante impact estimates were calculated by the heat recovery system vendor and revised by to include negative electric impacts. The vendor calculated the total heat recovered by multiplying the heat exchanger design flow rate by the make-up water temperature rise and by the appropriate conversion factor and annual hours of full load operation of the boiler during the year. The total heat recovered was divided by the measured boiler efficiency and the Btu-to-therm conversion factor to calculate the gross annual therm impacts.

The gross electric impacts are included in the tracking system gross impact estimate, however the calculations are not included in the project file. It appears that the ex ante electric load and energy impacts were calculated by estimating the additional pump power necessary to circulate the make-up water and the incremental boiler fan power necessary to overcome the increased pressure drop in the stack. The impacts are negative (indicating an increase in electrical load). The ex ante calculations are summarized in Table 5-10.

Table 5-10
Heat Exchanger Performance Data, and Ex Ante Gross Gas Impact Calculations
Project No. 49495
PY97 AEEI Space Conditioning Measures

A	B	C	D	E	F	G	H
	gpm	**Delta T (degF)**	**Btu/hr Reclaimed**	**Boiler Efficiency**	**Btu/hr Saved**	**Boiler Input**	**Percent Savings**
	Mfr. Design Data	Mfr. Design Data	B×c×8.33×60	Vendor Ex Ante Measurement	D÷E	Boiler Nameplate Data	F×100/G
Boiler #3	96	6.00	288,000	0.795	362,264	8,400,000	4.313%
Boiler #4	48	6.99063	167,775	0.79	212,374	8,400,000	2.528%
	Boiler Input Rating (Mbtu/hr)	**Estimated Load Factor**	**Hours/Year**	**Annual Therm Usage (therms/year)**	**Vendor Estimate of Savings Est.**	**Annual Therms Saved**	
	Site Data	Customer Estimate	Vendor Value	B×C×D/100000	Col H	E×F	
Boiler #3	8,400	0.68	8736	499,000	4.313%	21,520	
Boiler #4	8,400	0.58	8736	425,618	2.528%	10,761	
Total						**32,281**	

The ex ante calculations shown in Table 5-8 agree with the vendor estimates for gas savings shown in the project file but they do not agree with the tracking system gross impacts as shown in the file impact summary sheet. The source of the tracking system impacts is not shown clearly in the project file. The tracking system values are shown and compared with the values shown in the file in Table 5-11.

Table 5-11
Ex Ante Tracking System Gross Impact Estimates
Project No. 49495
PY97 AEEI Space Conditioning Measures

	kW	**kWh**	**Therms**
Tracking System	-0.45	-4976	37,091
File Calculations	n/a	n/a	32,281

5.4.4 Ex Post Load Impact Estimates

The site was visited during December 1998. The heat exchangers and boilers were observed in operation and key operating parameters were observed.

Ex Post Basecase System

The basecase system consisted of the four boilers operating at the post-retrofit loading, operating conditions and setpoints, but without the stack heat recovery system. The post-retrofit operating conditions were assumed to be the same as the pre-retrofit and the ex ante operating conditions. The boiler rated capacity and estimated load factor and efficiencies are shown in Table 5-12.

Ex Post Post-Retrofit System

1. A Thermastak flue-gas-to-water heat exchanger was installed in the stack of boiler #3. The heat exchanger was capable of heating 96 gallons per minute of make-up water averaging 160°F by 6°F. Make-up water includes condensate return and fresh make-up water. Other key specifications and operating values are shown in Table 5-12.
2. A Thermastak flue-gas-to-water heat exchanger was installed in the stack of boiler #4. This heat exchanger was capable of heating 48 gallons per minute of make-up water 6.9°F. Make-up water includes condensate return and fresh make-up water. Other key specifications and operating values are shown in Table 5-12.

Table 5-12
Boiler and Heat Recovery System Specifications
Project No. 49495
PY97 AEEI Space Conditioning Measures

Stack Economizer Design and Operating Data		
	Boiler #3 West	Boiler #4 East
Make-up water flow rate (gpm)	96	48
Water temp increase (°F)	6	6.9
Flue gas pressure drop increase (inches wg)	0.035	0.025
Water pressure drop (Feet)	2.6	2.7
Gals/hr @ 100°F Temp. Rise (°F)	345	201
Exit Flue Temp. (°F)	222	231
Coil Size (sq. Inches)	42	42
Coil rows	2	1
Thermastak Model #	125	80
Boiler Nameplate and Operating Data		
Input Rating (kBtu/hr)	8400	8400
Gross stack temperature (°F)	307	272
Stack gas percent CO2 (%)	6.4%	5.3%
Calculated efficiency (%)	79.5%	79.0%
Gas flow (Std. Cubic Feet per Minute)	2691	3250
Entering water temperature (°F)	160	160
Stack diameter (inches)	30	30

Ex Post Energy Savings

The ex post evaluation verified system was in operation and operated at the vendor design parameters. The ex post results were calculated using a methodology nearly identical to the ex ante method. The evaluation also calculated (negative) electrical impacts which reflect the additional pump and fan power. Table 5-13 shows the ex post impact calculations and results for Project No. 49495. Table 5-14 summarizes the impacts and compares the results with the ex ante estimates.

Table 5-13
Ex Post Load Impact Calculation
Project No. 49495
PY97 AEEI Space Conditioning Measures

A	B	C	D	E	F	G	H	I	J
Natural Gas Savings									
	Flow Rate	**Delta T**	**Heat Recovered**	**Annual Hours Available**	**Est. Load Factor**	**Annual Equiv. Full Load Operating Time**	**Annual Total Heat Recovered**	**Boiler Eff.**	**Annual Therms Saved**
	Mfr Data	Site Data	B × C × 60 × 8.33	Site Data	Customer Estimate	E × F	D × G	Vendor Measure-ment	H/(I × 100000)
	gpm	°F	Btu/hr	hours	fraction	hours	Btu	%	therms
Boiler #3	96	6	287,885	8760	0.68	5,956.8	1,714,872,177	79.5%	21,571
Boiler #4	48	6.9	165,534	8760	0.58	5,080.8	841,043,928	79.0%	10,646
Total Therms									**32,217**
Increased Electricity Use									
Circulating Pump	**Flow Rate**	**Delta p**	**Pump Brake horsepower**	**Average Pump kW @ 75% Motor Eff.**	**Annual Pump Op. Hours**	**Annual Pump**			
	Mfr Data	Mfr Data	B × C / (3960 × 0.75)	D ×0.746 / 0.75	Site Data	E × F			
	gpm	feet	hp	Btu	hours	%			
Boiler #3	96	2.6	0.08	0.08	8760	732			
Boiler #4	48	2.7	0.04	0.04	8760	380			
Total				**0.13**		**1,112**			
Draft Fan Increase	**Stack Gas Flow Rate**	**Stack Gas Pressure Drop**	**Fan Incremental BHP @ 75% Eff**	**Average Fan Motor kW @ 90% Eff.**	**Annual Hours Avail-able**	**Estimated Boiler Load Factor**	**Annual Fan Operating Time**	**Annual Fan kWh**	
	Mfr Data	Mfr data	B × C / (6344 × 0.75)	D ×0.746 / 0.9	Site Data	Customer Estimate	F × G	E × H	
	scfm	in. wg	hp	kW	hours	fraction	hours	kWh	
Boiler #3	2691	0.035	0.02	0.02	8760	0.68	5,956.8	98	
Boiler #4	3250	0.025	0.02	0.01	8760	0.58	5,080.8	72	
Total Fan kW				**0.03**			**Total Fan kWh**	**170**	
Average Fan kW					**0.02**				

Total Increase In Electric Use		
	kW	**kWh**
Fan	0.13	1,112
Pump	0.02	170
Total	0.15	1,282

Table 5-14
Gross Load Impact Summary and Comparison
Project No. 49495
PY97 AEEI Space Conditioning Measures

	kWh	kW	Therms
Ex Ante	-4976	-0.45	37,091
Ex Post	-1282	-0.15	32,217
Realization Rate	25.8% (1/RR=388%)	33.3% (1/RR=300%)	87%

5.4.5 Comparison of Ex Ante and Ex Post Results

The ex post estimated gross annual natural gas impact is 32,217 therms. This is 87% of the 37,091 therm tracking system ex ante estimate. The reason for the discrepancy is not clear because the source of the 37,091 therm value is not shown in the project file. The ex post gross therm impact is close to the vendor's ex ante estimate (32,281 therms).

The ex post (negative) kWh and kW impacts are 25% and 33% of the negative ex ante impacts, respectively, when the standard formula for calculating the realization rate is used. In this case, the measure impacts the electricity side by increasing electricity use. Thus, the ex post estimate shows the measure had a lower increase in electricity use. When the inverse of the realization rate is examined it can be seen that the kWh benefit is actually almost 4-times the ex ante estimate. The reason for the discrepancy is not clear because the calculation of the ex ante values is not shown in the project file.

SAN DIEGO GAS & ELECTRIC
RETROACTIVE WAIVER FOR
1997 AGRICULTURAL ENERGY EFFICIENCY INCENTIVES PROGRAM
(Study ID No. 1022)

Approved by CADMAC on January 20, 1999

REQUEST

This waiver requests that SDG&E be allowed to do the following evaluation for the PY97 Agricultural EEI Program:

1. In lieu of using a comparison group to estimate the net load impacts, SDG&E will use a default net-to-gross ratio of 0.75 to determine net load impacts for the process, space conditioning and miscellaneous end uses, and 0.57 for the water pumping end use.
2. Change reporting the results for the AEEI Program designated unit of measurement (DUOM) for the motors that were installed from "load impacts per acre foot of water pumped" to "load impacts per horsepower." These motors were purchased through the motor retail program and as such it is not possible to acquire the necessary information to satisfy the Protocols-established DUOM.
3. Evaluate the process and space heating measures (normally classified as miscellaneous measures) as separate end uses using on-site verification of engineering estimates. The designated unit of measurement will be "load impacts per participant" for the process end use and "load impacts per square foot" for the space heating end use.

BACKGROUND

SDG&E has identified 27 participants who installed various measures in the 1997 AEEI Program with resource benefits, net (RBn) of $0.599 million and an associated earnings claim of $0.102 million.

END USE	PARTICIPANTS	RBn	EARNINGS
Pumping	18	$364,675	$63,289
Space Heating	1	$86,246	$16,394
Process	2	$99,203	$13,376
Miscellaneous	5	$49,512	$9,024
TOTALS	**27**	**$599,635**	**$102,084**

The pumping measures will be studied under Table C-6 using a simplified engineering model. This will involve the use of premise-specific engineering models that are adjusted to reflect post-installation hours of operation and other related equipment characteristics. SDG&E proposes to use the verification method similar to that described in Table C-5 for Industrial Motors, instead of direct end use metering.

In order to meet the requirements of Protocols Table C-9 of having no more than 15 percent of the program's RBn evaluated as miscellaneous measures, SDG&E created a process and space heating end use categories. SDG&E proposes to evaluate these end uses with on-site verification of installation and using the *ex ante* engineering models adjusted to reflect post-installation premise specific equipment characteristics.

B

TABLE 6 - PUMPING MEASURES

B TABLE 6 - PUMPING MEASURES

SAN DIEGO GAS & ELECTRIC
M&E PROTOCOLS TABLE 6 - RESULTS USED TO SUPPORT PY97 SECOND EARNINGS CLAIM FOR AGRICULTURAL ENERGY EFFICIENCY INCENTIVES PROGRAM
FIRST YEAR LOAD IMPACT EVALUATION, February 1999, STUDY ID NO. 1022

Designated Unit of Measurement: Load Impacts per Horsepower
End Use: Pumping

				5. A. 90% Confidence Level				5. B. 80% Confidence Level			
				Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound
1. Average Participant Group and Average Comparison Group		**Part Group**	**Comp Group**	**Part Group**	**Part Group**	**Comp Group**	**Comp Group**	**Part Group**	**Part Group**	**Comp Group**	**Comp Group**
A. Pre-install usage:	Pre-install kW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Pre-install kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Base kW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Base kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Base kW/ designated unit of measurement	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Base kWh/ designated unit of measurement	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
B. Impact year usage:	Impact Yr kW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Impact Yr kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Impact Yr kW/designated unit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Impact Yr kWh/designated unit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2. Average Net and Gross End Use Load Impacts		**Avg Gross**	**Avg Net**	**Avg Gross**	**Avg Gross**	**Avg Net**	**Avg Net**	**Avg Gross**	**Avg Gross**	**Avg Net**	**Avg Net**
	A. i. Load Impacts - kW	4.75	2.71	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	A. ii. Load Impacts - kWh	46,716	26,628	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	A. iii. Load Impacts - therm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B. i. Load Impacts/designated unit - kW	0.1472	0.0839	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B. ii. Load Impacts/designated unit - kWh	1,447.0	824.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B. iii. Load Impacts/designated unit - therm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	C. i. a. % change in usage - Part Grp - kW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	C. i. b. % change in usage - Part Grp - kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	C. ii. a. % change in usage - Comp Grp - kW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	C. ii. b. % change in usage - Comp Grp - kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
D. Realization Rate:	D.A. i. Load Impacts - kW, realization rate	1.05	0.67	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	D.A. ii. Load Impacts - kWh, realization rate	0.92	0.59	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	D.A. iii. Load Impacts - therm, realization rate	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	D.B. i. Load Impacts/designated unit - kW, real rate	1.05	0.67	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	D.B. ii. Load Impacts/designated unit - kWh, real rate	0.92	0.59	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	D.B. iii. Load Impacts/designated unit - therm, real rate	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3. Net-to-Gross Ratios		**Ratio**		**Ratio**	**Ratio**			**Ratio**	**Ratio**		
	A. i. Average Load Impacts - kW	0.57		N/A	N/A			N/A	N/A		
	A. ii. Average Load Impacts - kWh	0.57		N/A	N/A			N/A	N/A		
	A. iii. Average Load Impacts - therm	N/A		N/A	N/A			N/A	N/A		
	B. i. Avg Load Impacts/designated unit of measurement - kW	0.57		N/A	N/A			N/A	N/A		
	B. ii. Avg Load Impacts/designated unit of measurement - kWh	0.57		N/A	N/A			N/A	N/A		
	B. iii. Avg Net Load Impacts/designated unit of measurement - therm	N/A		N/A	N/A			N/A	N/A		
	C. i. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - kW	N/A		N/A	N/A			N/A	N/A		
	C. ii. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - kWh	N/A		N/A	N/A			N/A	N/A		
	C. iii. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - therm	N/A		N/A	N/A			N/A	N/A		
4. Designated Unit Intermediate Data		**Part Group**	**Comp Group**	**Part Group**	**Part Group**	**Comp Group**	**Comp Group**	**Part Group**	**Part Group**	**Comp Group**	**Comp Group**
	A. Pre-install average value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B. Post-install average value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6. Measure Count Data		**Number**									
	A. Number of measures installed by participants in Part Group	13									
	B. Number of measures installed by all program participants in the 12 months of the program year	30									
	C. Number of measures installed by Comp Group	N/A									
7. Market Segment Data		**SIC**	**Percent**								
	Distribution by 3 digit SIC	018	4%								
		024	9%								
		025	4%								
		494	83%								

C

TABLE 6 - PROCESS MEASURES

SAN DIEGO GAS & ELECTRIC
M&E PROTOCOLS TABLE 6 - RESULTS USED TO SUPPORT PY97 SECOND EARNINGS CLAIM FOR AGRICULTURAL ENERGY EFFICIENCY INCENTIVES PROGRAM
FIRST YEAR LOAD IMPACT EVALUATION, February 1999, STUDY ID NO. 1022

Designated Unit of Measurement: Load Impacts per Participant

End Use: Process

				5. A. 90% Confidence Level				5. B. 80% Confidence Level			
				Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound
1. Average Participant Group and Average Comparison Group		**Part Group**	**Comp Group**	**Part Group**	**Part Group**	**Comp Group**	**Comp Group**	**Part Group**	**Part Group**	**Comp Group**	**Comp Group**
A. Pre-install usage:	Pre-install kW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Pre-install kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Base kW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Base kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Base kW/ designated unit of measurement	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Base kWh/ designated unit of measurement	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
B. Impact year usage:	Impact Yr kW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Impact Yr kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Impact Yr kW/designated unit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Impact Yr kWh/designated unit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2. Average Net and Gross End Use Load Impacts		**Avg Gross**	**Avg Net**	**Avg Gross**	**Avg Gross**	**Avg Net**	**Avg Net**	**Avg Gross**	**Avg Gross**	**Avg Net**	**Avg Net**
	A. i. Load Impacts - kW	14.62	10.97	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	A. ii. Load Impacts - kWh	163,973	122,979	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	A. iii. Load Impacts - therm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B. i. Load Impacts/designated unit - kW	14.62	10.97	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B. ii. Load Impacts/designated unit - kWh	163,973	122,979	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B. iii. Load Impacts/designated unit - therm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	C. i. a. % change in usage - Part Grp - kW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	C. i. b. % change in usage - Part Grp - kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	C. ii. a. % change in usage - Comp Grp - kW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	C. ii. b. % change in usage - Comp Grp - kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
D. Realization Rate:	D.A. i. Load Impacts - kW, realization rate	0.46	0.46	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	D.A. ii. Load Impacts - kWh, realization rate	1.18	1.18	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	D.A. iii. Load Impacts - therm, realization rate	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	D.B. i. Load Impacts/designated unit - kW, real rate	0.46	0.46	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	D.B. ii. Load Impacts/designated unit - kWh, real rate	1.18	1.18	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	D.B. iii. Load Impacts/designated unit - therm, real rate	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3. Net-to-Gross Ratios		**Ratio**		**Ratio**	**Ratio**			**Ratio**	**Ratio**		
	A. i. Average Load Impacts - kW	0.75		N/A	N/A			N/A	N/A		
	A. ii. Average Load Impacts - kWh	0.75		N/A	N/A			N/A	N/A		
	A. iii. Average Load Impacts - therm	N/A		N/A	N/A			N/A	N/A		
	B. i. Avg Load Impacts/designated unit of measurement - kW	0.75		N/A	N/A			N/A	N/A		
	B. ii. Avg Load Impacts/designated unit of measurement - kWh	0.75		N/A	N/A			N/A	N/A		
	B. iii. Avg Net Load Impacts/designated unit of measurement - therm	N/A		N/A	N/A			N/A	N/A		
	C. i. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - kW	N/A		N/A	N/A			N/A	N/A		
	C. ii. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - kWh	N/A		N/A	N/A			N/A	N/A		
	C. iii. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - therm	N/A		N/A	N/A			N/A	N/A		
4. Designated Unit Intermediate Data		**Part Group**	**Comp Group**	**Part Group**	**Part Group**	**Comp Group**	**Comp Group**	**Part Group**	**Part Group**	**Comp Group**	**Comp Group**
	A. Pre-install average value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B. Post-install average value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6. Measure Count Data		**Number**									
	A. Number of measures installed by participants in Part Group	2									
	B. Number of measures installed by all program participants in the 12 months of the program year	2									
	C. Number of measures installed by Comp Group	N/A									
7. Market Segment Data		**SIC**	**Percent**								
	Distribution by 3 digit SIC	024	50%								
		494	50%								

D TABLE 6 - SPACE CONDITIONING MEASURES

SAN DIEGO GAS & ELECTRIC
M&E PROTOCOLS TABLE 6 - RESULTS USED TO SUPPORT PY97 SECOND EARNINGS CLAIM FOR AGRICULTURAL ENERGY EFFICIENCY INCENTIVES PROGRAM
FIRST YEAR LOAD IMPACT EVALUATION, FEBRUARY 1999, STUDY ID NO. 1022

Designated Unit of Measurement: LOAD IMPACTS PER SQUARE FOOT (The DUOM was changed to Load Impacts per Square Foot Per Retroactive Waiver, Approved January 20, 1999)
End Use: Space Conditioning

				5. A. 90% CONFIDENCE LEVEL				5. B. 80% CONFIDENCE LEVEL			
				LOWER BOUND	UPPER BOUND	LOWER BOUND	UPPER BOUND	LOWER BOUND	UPPER BOUND	LOWER BOUND	UPPER BOUND
1. Average Participant Group and Average Comparison Group		**PART GRP**	**COMP GRP**	**PART GRP**	**PART GRP**	**COMP GRP**	**COMP GRP**	**PART GRP**	**PART GRP**	**COMP GRP**	**COMP GRP**
A. Pre-install usage:	Pre-install kW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Pre-install kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Pre-install therm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Base kW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Base kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Base therm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Base kW/ designated unit of measurement	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Base kWh/ designated unit of measurement	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Base therm/ designated unit of measurement	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
B. Impact year usage:	Impact Yr kW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Impact Yr kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Impact Yr therm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Impact Yr kW/designated unit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Impact Yr kWh/designated unit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Impact Yr therm/designated unit	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2. Average Net and Gross End Use Load Impacts		**AVG GROSS**	**AVG NET**	**AVG GROSS**	**AVG GROSS**	**AVG NET**	**AVG NET**	**AVG GROSS**	**AVG GROSS**	**AVG NET**	**AVG NET**
	A. i. Load Impacts - kW	-0.04	-0.028	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	A. ii. Load Impacts - kWh	-321	-240	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	A. iii. Load Impacts - therm	11,840	8,880	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B. i. Load Impacts/designated unit - kW	0.0000	0.0000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B. ii. Load Impacts/designated unit - kWh	-0.0035	-0.0027	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B. iii. Load Impacts/designated unit - therm	0.1309	0.0981	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	C. i. a. % change in usage - Part Grp - kW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	C. i. b. % change in usage - Part Grp - kWh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	C. ii. a. % change in usage - Comp Grp - kW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	C. iii. b. % change in usage - Comp Grp - therm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
D. Realization Rate:	D.A. i. Load Impacts - kW, realization rate	0.3333	0.3259	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	D.A. ii. Load Impacts - kWh, realization rate	0.2576	0.2576	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	D.A. iii. Load Impacts - therm, realization rate	0.9752	0.9752	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	D.B. i. Load Impacts/designated unit - kW, real rate	0.3333	0.3259	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	D.B. ii. Load Impacts/designated unit - kWh, real rate	0.2576	0.2576	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	D.B. iii. Load Impacts/designated unit - therm real rate	0.9752	0.9752	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3. Net-to-Gross Ratios		**RATIO**		**RATIO**	**RATIO**			**RATIO**	**RATIO**		
	A. i. Average Load Impacts - kW	0.75		N/A	N/A			N/A	N/A		
	A. ii. Average Load Impacts - kWh	0.75		N/A	N/A			N/A	N/A		
	A. iii. Average Load Impacts - therm	0.75		N/A	N/A			N/A	N/A		
	B. i. Avg Load Impacts/designated unit of measurement - kW	0.75		N/A	N/A			N/A	N/A		
	B. ii. Avg Load Impacts/designated unit of measurement - kWh	0.75		N/A	N/A			N/A	N/A		
	B. iii. Avg Load Impacts/designated unit of measurement - therm	0.75		N/A	N/A			N/A	N/A		
	C. i. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - kW	N/A		N/A	N/A			N/A	N/A		
	C. ii. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - kWh	N/A		N/A	N/A			N/A	N/A		
	C. iii. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - therm	N/A		N/A	N/A			N/A	N/A		
4. Designated Unit Intermediate Data		**PART GRP**	**COMP GRP**	**PART GRP**	**PART GRP**	**COMP GRP**	**COMP GRP**	**PART GRP**	**PART GRP**	**COMP GRP**	**COMP GRP**
	A. Pre-install average value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	B. Post-install average value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6. Measure Count Data		**NUMBER**									
	A. Number of measures installed by participants in Part Group	5									
	B. Number of measures installed by all program participants in the 12 months of the program year	5									
	C. Number of measures installed by Comp Group	N/A									
7. Market Segment Data		**SIC or CZ**	**PERCENT**								
	Distribution by 3 digit SIC - Commercial/Industrial	018	100								

E

TABLE 7

M&E PROTOCOLS TABLE 7
DATA QUALITY AND PROCESSING DOCUMENTATION
For 1997 Agricultural Energy Efficiency Incentives Program
First Year Load Impact Evaluation
February 1999
Study ID No. 1022

A. OVERVIEW INFORMATION

1. **Study Title and Study ID:** 1997 Agricultural Energy Efficiency Incentives Program: First Year Load Impact Evaluation, February 1999, Study ID No. 1022.

2. **Program, Program Year(s), and Program Description (design):** 1997 Agricultural Energy Efficiency Incentives Program for the 1997 program year. The Program is designed to help agricultural customers control energy costs by providing incentives for the installation of energy efficient equipment at their facilities.

3. **End Uses and/or Measures Covered:** All end uses combined disaggregated by pumping, process, and space conditioning.

4. **Methods and models used:** Site-specific simplified engineering models with verified inputs.

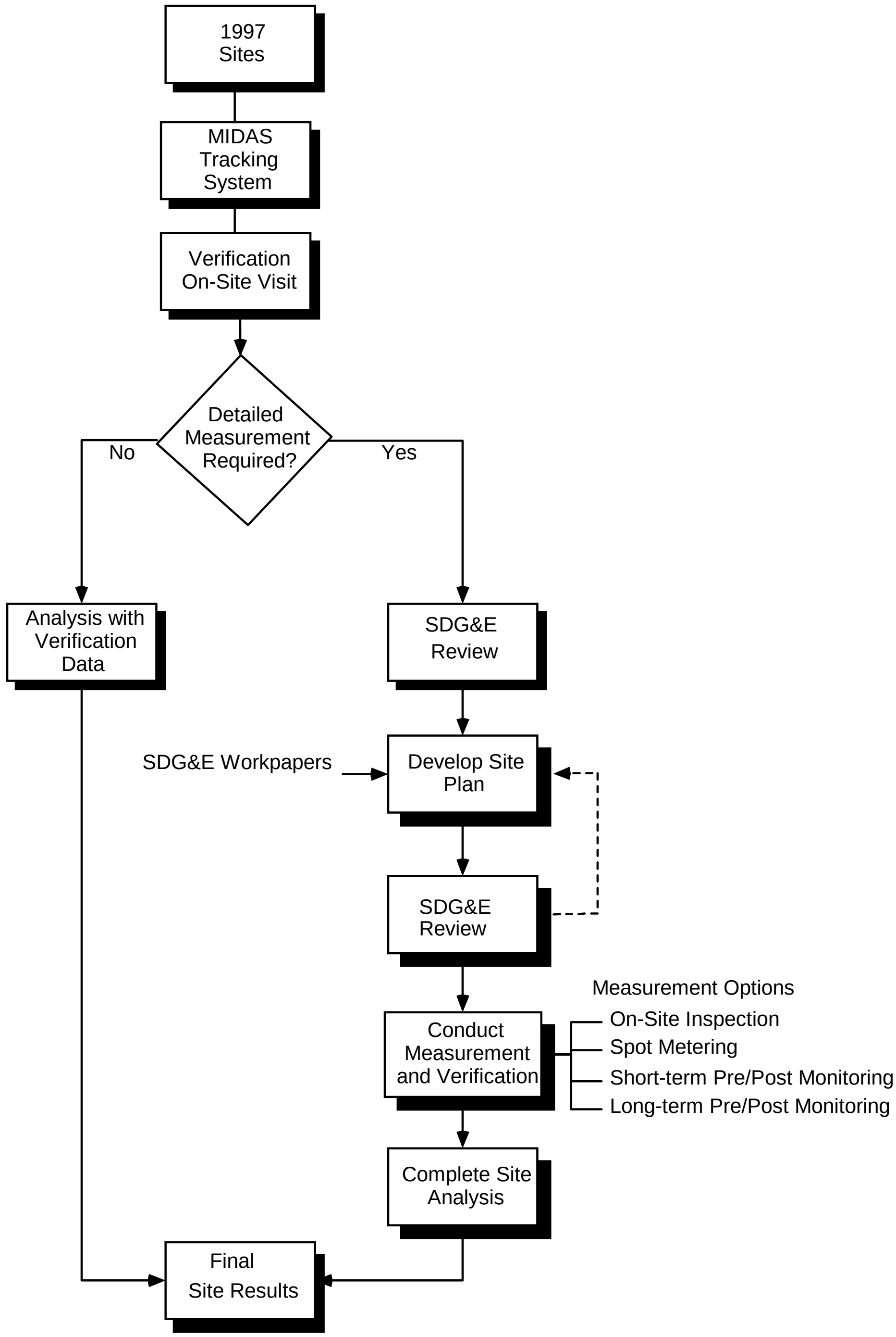
5. **Participant and comparison group definition:** For the load impact analysis, the participants in the 1997 Agricultural Energy Efficiency Incentives Program are defined as having at least one of the aforementioned measures installed. Per SDG&E's retroactive waiver a comparison group was not required for this evaluation.

6. **Analysis sample size:**

Electric Participant Sample for 1997 Agricultural Energy Efficiency Incentives Program			Gas Participant Sample for 1997 Agricultural Energy Efficiency Incentives Program			
Measure Type	**No. of Participants**	**No. of Measures**	**Measure Type**	**No. of Participants**	**No. of Projects**	**No. of Measures**
Pumping	11	13	**Pumping**	0	0	0
Process	1	1	**Process**	0	0	0
Space Conditioning	1	2	**Space Conditioning**	4	5	0
Total	13	16	**Total**	4	5	0

B. DATABASE MANAGEMENT

1. Flow Charts:



2. **Data sources:** the data came from the following sources:

- Customer name, address, installed measures, and participation date from the program tracking database.
- Electric and gas consumption history, where applicable, from the Customer Master File.
- *Ex ante* engineering assumptions and analyses from program project files.
- *Ex post* on-site survey data, including spot measurements, monitoring and verification of measure installation.

3. **Data Attrition:**

   a. **Participant Sample - Load Impact Analysis**

   No attrition.

   b. **Nonparticipant Sample - Load Impact Analysis**

   Not applicable.

4. **Data Quality Checks**

   Not applicable for this evaluation.

5. **All data collected** for this analysis were utilized.

C. SAMPLING

1. **Sampling procedures and protocols:** Participants comprising the top 70 percent of load impacts were included in the survey for pumping and process. A census was conducted for space conditioning measures.

2. **Survey information:** On-site inspections were conducted that included a review of operations logs, interviews of on-site staff, and measurements of the measures in operation.

3. **Statistical Descriptions:** Not applicable.

D. DATA SCREENING AND ANALYSIS

1. **Outliers:** Not applicable.

   Missing data points: Not applicable.

   Weather adjustments were implicit in the engineering models used in the evaluation.

2. **"Background" variables:** Not applicable.

3. **Screening procedures:** Not applicable.

4. **Regression statistics:** Not applicable.

5. **Specification:**

   a. Not applicable.

   b. Not applicable.

   c. Not applicable.

   d. Not applicable.

   e. Not applicable.

6. **Error in measuring variables:** On-site observation of measure installation and on-site measurements were taken to mitigate possible errors from project files.

7. **Autocorrelation:** Not applicable.

8. **Heteroskedasticity:** Not applicable.

9. **Collinearity:** Not applicable.

10. **Influential data points:** Not applicable.

11. **Missing Data:** Not applicable.

12. **Precision:** Not applicable. Standard errors and other statistically based measures of precision are not applicable to the site-specific engineering analyses employed in this analysis.

E. DATA INTERPRETATION AND APPLICATION

1. Calculation of net impacts: Not applicable. Default net-to-gross ratios specified in retroactive waiver approved January 20, 1999.

2. **Processes, choices made and rationale for E.1:** Not applicable.