Residential New Construction – Demand Impact

Final Report

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1. INTRODUCTION

The Investor owned electric utilities (IOUs) in California operate a range of energy efficiency programs. They coordinate and offer similar benefits to builders in the Residential New Construction (RNC) program area. Because of the "energy crisis" of 2000-2001, this set of programs has had a particular focus on achieving peak demand reductions.

The study described within this report provides an estimate of the impact of the various measures that were promoted in the RNC programs over the past two program years. This analysis maintained, as far as possible, the procedures and assumptions employed in the development of the most recent revisions (AB 970) to the state's Title 24 Residential Building Standards.[1] Bruce Wilcox and Ken Nittler were the principal experts engaged by the California Energy Commission (CEC or Commission) for analyzing the impacts of the residential changes. They were also part of this study's team.

The goal of this study was to provide the IOUs' Statewide Residential New Construction Evaluation Group with the means for assessing the demand impacts from each of several measures, by climate zone and as a function of conditioned floor area, residential units, and kWh saved. This will allow each utility to generate an estimate of the demand reduction due to their programs given the data already known about number of participants and area of affected residential building stock.

This analysis focused primarily on single family residential new construction but is applicable, with at least the same accuracy as the Commission's impact analysis (for the AB 970 Standards), to multifamily new construction and to retrofits.

[1] These standards are now called the 2001 Efficiency Standards for Residential and Nonresidential Buildings. We will refer to them in this report as the 2001 Standards. The baseline for the analysis however, was the 1998 Standards since the RNC programs for which we performed this analysis were operated before the adoption of the 2001 Standards.

2. ANALYSIS

2.1 Background

During the period from September 2000 through January 2001, the California Energy Commission developed and adopted changes to the state's building energy efficiency standards (Title 24, Part 6). These changes were mandated by Assembly Bill 970 and were known initially as the "AB970 Standards." They are now called the 2001 Standards. By state statute the Commission is required to assess the potential energy savings and economic costs and benefits of changes before adoption. The analysis methodology the CEC used during the AB970 revision guided the analysis for the work described in this report.

We used a methodology similar to that used by the Commission for several reasons. First, much of the team that performed the analysis for the Commission also worked on this project. Second, many of the measures adopted in the AB970 standards are the same measures that the IOUs' programs incented builders to install in new homes, and therefore are the measures we analyzed for this report. And third, the basic methodology is well recognized and accepted as valid.

2.2 Measures

The measures analyzed were:

- Attic radiant barriers
- Thermal expansion valves (TXV)
- Aluminum windows with low SHGC[1]
- Vinyl windows with low SHGC
- Tight ducts
- High SEER[2] air conditioners

In addition, two packages of measures were analyzed. They were:

- Tight ducts and TXV
- Radiant barrier, 12 SEER AC, vinyl windows with low SHGC, and tight ducts.

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[1] SHGC means solar heat gain coefficient and is the ratio of solar radiation that enters through a window relative to the solar radiation that strikes it.

[2] SEER means seasonal energy efficiency ratio and is a measure of air conditioning efficiency (cooling Btus delivered per watt-hours of input).

2.2.1 Radiant barriers

Attic radiant barriers reduce the heat transfer from the roof to the attic. Radiant barriers are installed at the underside of the roof sheathing or underside of the roof rafters. The most common and most cost-effective barrier is a film that is factory applied and therefore an integral part of the roof sheathing. Radiant barriers not only reduce the heat transfer to the living space by lowering the temperature of the attic, but they also improve the effectiveness of the A/C system by reducing the heat gain through ducts installed in the attic (the most common location for ducts).

2.2.2 Thermal Expansion Valves (TXV)

Research has shown that most residences have A/C systems that are either undercharged or overcharged with refrigerant. With fixed orifice expansion devices, this leads to decreases in efficiency of 10 to 40 percent. Most of the loss of efficiency can be regained through use of a TXV, which is an adjustable orifice valve that closes or opens to maintain the proper gas density/pressure within the condenser. TXVs can be either factory or field installed.

2.2.3 Aluminum Window with Low Solar Heat Gain Coefficient (SHGC)

Aluminum windows have a much smaller market share in California than they did just five years ago, but are still the window of choice for many builders. The most basic upgrade from a clear dual glazed aluminum window is an aluminum window with “high performance” glazing. This glass has a low emissivity (Low E) coating that is designed to both reduce winter heat losses and summer heat gains. Aluminum thermally broken window frames were not considered in this analysis since they tend to be more expensive than either aluminum non-thermally broken frames or vinyl frames, are not particularly common, and do not perform as well as vinyl frames from an energy standpoint.

2.2.4 Vinyl Window with Low SHGC

Vinyl frames significantly reduce heat losses compared to aluminum frames. They also help to cut summer heat gains, but the impact is proportionately much smaller. Vinyl framed windows seem rapidly to be taking over as the window of choice among production builders in California.[1]

[1] “Residential New Construction Study.” Pacific Gas and Electric. July 26, 2001. Prepared by Regional Economic Research (RER).

2.2.5 Tight Ducts

Research performed for PG&E by Proctor Engineering showed that residential ducts often leak badly enough that nearly half of all the energy used to heat and cool a home can be wasted through those leaks. The Energy Commission now makes an explicit assumption for purposes of the Standards, that "standard" duct installations have a leakage rate between 20 and 25 percent. "Tight ducts" are ducts proven through testing to leak no more than 6%.[1] This measure requires verification by a third party inspection service – generally a Home Energy Rating System (HERS) rater approved accredited per the CEC guidelines.

2.2.6 High SEER Air Conditioner

The federal standards only require SEER 10 for air conditioners installed as part of new construction. However, much more efficient equipment is available at fairly low incremental costs. SEER 12 and SEER 13 are both readily available and SEER 14 equipment is slightly less common. For this study we assumed that all "high SEER" equipment was SEER 12.

2.2.7 Tight Ducts and TXV Package

This is simply a package of measures that includes only the two listed measures. The energy and demand savings of the combination of the two measures is slightly less than the total of the savings of each individually due to interactive effects.

2.2.8 Package of all Measures

This package of measures includes radiant barriers, SEER 12 AC, vinyl windows with low SHGC, and tight ducts. There are three important issues to clarify for the "combination of all measures." First, although we could have chosen to include either the aluminum frame or the vinyl frame windows, a combination of measures clearly could not include both. The vinyl frame, low solar heat gain coefficient (SHGC) windows can be considered an "upgrade" to what Title 24 requires in all climate zones, while the aluminum frame windows are not. Therefore, the package includes vinyl windows in all cases.

The second issue is related. In Climate Zones 1 and 16, vinyl low SHGC windows result in negative energy "savings." This is due in part to the fact that there is virtually no cooling load in those two CZs, and low SHGC glass blocks the solar gains in the winter as well as the summer. Low SHGC results in higher winter heating loads that are not offset by reductions in cooling loads. In all other climate zones the losses in winter gains are more than balanced by savings in

[1] The entire system, including both ducts and HVAC equipment must have a leakage rate not to exceed 6% of the CFM flow of the system. The limit of 6% was chosen because often manufacturer's equipment (e.g., fan housing) has enough leakage that, regardless of how tight the duct system itself is at installation, the complete system leakage cannot be reduced below 6%.

cooling demand. Since this study is primarily interested in peak demand impacts, we felt it was appropriate to retain the measures that reduce peak electrical demand, regardless of the impact on heating energy.

The third issue relates to the relationship between TXVs and high SEER air conditioners. We did not include both in the “package” of measures because they are, or can be, essentially the same measure. Adding a TXV to a SEER 10 A/C essentially makes it perform (in terms of what the analysis tools can evaluate) as a SEER 11-13 A/C. There are other technological means of achieving these efficiencies, but at this time most residential equipment that **is** rated either SEER 12 or 13, **has** a TXV. Therefore, including both measures within a package would have resulted in double counting for a significant number of cases. In the combination package we added the 12 SEER AC and did not include the TXV as a separate measure.

2.3 Methodology

2.3.1 MICROPAS

The most commonly used Alternative Compliance Method (computer program) for showing compliance with the Title 24 residential standards is MICROPAS. The impacts of the AB970 Standards were also analyzed by the Energy Commission using MICROPAS. We used MICROPAS in this study to estimate the kWh and therm impacts of the list of measures that the IOU’s RNC programs promoted over the past two years.

MICROPAS performs an hourly simulation for all 8760 hours of the year. It provides estimates of the heating, cooling and water heating energy uses for a user-described building with a given set of assumptions that are spelled out in the CEC’s Residential Alternative Compliance Method (ACM) Manual.

We used MICROPAS to model a base case building with each measure added individually to the base case model. In each case where we were analyzing a separate measure, we reset the building description to the minimum requirements of the 1998 Residential Standards. The list of measures included in the two package runs are described in Section 2.2.8 above.

2.3.2 Demand Analysis

Electrical peak demand savings were estimated based on a number of field studies of the impact of conservation on measured demand. Proctor[1] found that about 55% of the reduction in cooling load appeared as a reduction in demand for large groups of residential customers. The Proctor Demand Utilization Factor (DUF) is similar to a coincident peak factor, but aggregates a number of effects not necessarily accounted for in a coincident peak factor. For example, it accounts for air conditioners that are (for any reason) turned off during the peak, equipment that is cycling because it's oversized, equipment that is on but not meeting the building's design cooling load, and equipment that is started up after being off all day (whether or not the building's calculated cooling load indicates it should be). These conditions combine in such proportions that a change in peak demand will only be about 55% of the calculated change in cooling load, therefore a DUF of 0.55 is applied.

We estimated the reduction in cooling demand using standard industry air conditioner sizing calculations with the effects of ducts and radiant barriers added (see Table 1). On-peak or design condition losses from attic ducts are larger than the average losses found using seasonal calculations. ASHRAE Standard 152P, which is the technical basis for the ACM manual seasonal distribution efficiencies, includes a parallel procedure for calculating design values for use in equipment sizing. Assuming the design conditions for each climate zone, we used this procedure to calculate design efficiencies for each climate zone. These factors (the design efficiencies listed in Table 1) were then used in calculating the impact of proposed measures on the design size of the air conditioner and peak electrical demand for the prototype house. A radiant barrier also has a larger impact on distribution efficiency during peak conditions than during average seasonal conditions. This effect is also included in the ASHRAE 152P design calculation.

Table 1 shows the design distribution efficiencies by climate zone calculated with the 152P procedure with and without duct sealing and radiant barriers. As an example of how these factors are used, assume that MICROPAS indicates that a house has a 24 kBtu cooling load. Assuming the house is in Climate Zone 2, the

[1] John Proctor of Proctor Engineering Group performed studies of installed residential AC systems for the California Energy Commission and for PG&E. His research was principally responsible for the Demand Utilization Factor that was applied by the CEC in their quantification of the AB 970 Residential Standards changes. See:

- "White Paper on Residential Peak Reduction." John Proctor. July 12, 2001. Prepared for Pacific Gas and Electric Co.
- Support Documentation for John Proctor's Comments on the Central AC and Heat Pump NOPR," John Proctor. December 4, 2000. CEC AB970 Building Standards Proceedings.
- "Effects of Occupant Control, System Parameters, and Program measures on Residential Air Conditioner Peak Loads," Proctor Engineering. August 31, 1998. Proceedings of the ACEEE 1998 Summer Study.
- "Estimating Peak Reduction From Sub-metered Residential Air Conditioning Data," John Proctor. July 2, 1993. Proceedings of the Sixth International Energy Program Evaluation Conference, Chicago, IL.

ducts are sealed and it has a radiant barrier, Table 1 indicates the design distribution efficiency factor is 0.68. Divide 24 kBtu by 0.68. The adjusted AC size is 35 kBtu. This is then converted to kW load.

Ducts	Unsealed		Sealed	
Radiant Barrier	No	Yes	No	Yes
Climate Zone				
1	0.61	0.73	0.64	0.75
2	0.45	0.61	0.55	0.68
3	0.49	0.64	0.57	0.69
4	0.50	0.65	0.58	0.70
5	0.53	0.67	0.59	0.71
6	0.49	0.64	0.57	0.69
7	0.53	0.67	0.59	0.71
8	0.49	0.64	0.57	0.69
9	0.45	0.61	0.55	0.68
10	0.43	0.59	0.54	0.67
11	0.41	0.58	0.52	0.66
12	0.43	0.59	0.54	0.67
13	0.42	0.59	0.53	0.66
14	0.38	0.56	0.51	0.65
15	0.36	0.55	0.50	0.64
16	0.52	0.64	0.54	0.66

Table 1: Distribution Efficiencies by Climate Zone

The following is a simplified description of the procedure used for generating the demand impact estimates.

1. Calculate design cooling demand (kBtu) for each case using MICROPAS.
2. Adjust the MICROPAS design cooling demand upward for duct losses using the factors in Table 1 to produce the AC output at Peak.
3. Calculate design cooling load (kW) using CEC SEER to EER conversion.
4. Adjust kW for effect of TXV, improper charge, and air flow on EER using Proctor Engineering's factors.
5. Subtract kW for step 2 from kW for step 4 to get nominal kW savings.
6. Multiply nominal savings by the Demand Utilization Factor (0.55) to account for variations in occupancy and sizing.

Please note that the Demand Utilization Factor applied here is a reasonable benchmark based on statewide data. It is sound to use this factor when developing a statewide estimate of demand impacts. Individual utilities may find that data on their service territories leads to a different factor. We therefore also provide the results of our analysis with a factor of 1.0 so that any appropriate custom factor may be substituted.

2.3.3 Base Case Description

The base case residential building from which we calculated the demand impact of improved measures was the same base case used by the Commission in the AB970 Standards process. The building was a two story single family residence with 1761 square feet of conditioned floor area and the minimum features required by the 1998 Prescriptive Package D. The minimum measures are the same across all climate zones for some building features, but vary significantly for other features.

3. RESULTS

The first set of tables on the following pages (Section 3.1) provide the RNC Demand Impact analysis results for the individual measures and combinations of measures described in Section 2.2 by Climate Zone, using a Demand Utilization Factor of 0.55 as described in Section 2.3.2.

The first column of the tables indicates the impact of each measure on the heating therms. This is provided primarily for context since it has no direct relevance to the electricity demand savings.

The second and third columns show the annual electricity (kWh) savings for each measure per house and per 1000 square feet, respectively. The house used in the analysis is the CEC's 1761 sf. base case home. The kWh/1000sf estimate is based on a statewide average for construction using a prototypical two story home description. Application of this estimate to specific homes of a very different design (say, apartments or single story homes that are much larger or smaller) will generate erroneous results. These estimates are not intended to be used for estimating energy savings on individual homes, but rather on large populations of residential new construction.

The fourth, fifth and sixth columns show the demand reduction due to each measure. Column four is kW/home and represents the reduction from the base case demand listed in the same column, but directly below the rest of the table for that Climate Zone. Column five is reduction in cooling demand per one thousand square feet of conditioned floor area (kW/1000 ft2). Column six provides a ratio of demand reduction to energy saved (kW/kWh).

The seventh column shows the reduction in peak cooling load in Btu due to each measure. The eighth, ninth and tenth columns indicate the combined energy use impact from measures. These are stated in the terms reported out by MICROPAS: source kBtu per square foot of conditioned floor area.

The second set of tables (Section 3.2) provides estimates of energy and demand savings from the same measures, in the same format as the tables in Section 3.1, but with a factor of 1.0 applied (instead of 0.55). The description above of the columns applies equally to this set of tables. We provide these results so the user can choose a different factor as s/he deems appropriate for specific programs, specific service territories, or even specific cities. For example, if the reader has reason to believe that the appropriate factor for his/her service territory is 0.75 instead of 0.55, s/he can multiply the demand values (Cooling kW per …) in the Section 3.2 tables by 0.75.

It is worth pointing out some perhaps unexpected results that are revealed in the tables. The kWh savings and the ratios of kW/kWh from measures varies significantly across the climate zones. In particular, one might expect that the savings and kW/kWh ratios for any single measure should be very similar in CZs

11-13. There are a few reasons why the results of the analysis do not provide these “intuitive” results.

In those CZs with the highest cooling loads, the code already (before the AB970 changes, and before the IOU NRC program effects) required high performance glass: 0.40 SHGC on the east and west in CZs 11-14, and 0.40 on the east, west AND south for CZ15. The 1998 Standards also required a higher level of ceiling and wall insulation, and a lower amount of glazing. Therefore, more of the peak impacts of high performance measures would already have been captured there than in the other zones. Further, since the glass area is smaller, changes to the glass performance values will tend to have a smaller effect.

The problem defies a truly intuitive feel however. While on the one hand, the climate almost insures a larger cooling load in CZs 11-15, the code already accounts for that and sets the minimum prescriptive requirements higher. So, when one wants to analyze how much effect improving one or a combination of efficiency measures will have, there are two countervailing influences:

- the climate is more severe so improvements should make more difference, and
- the baseline is already higher so improvements should make less difference.

There is, practically speaking, no way to intuit which way the answer will come out.

Add to that that we are not talking about simply demand impacts or energy savings, but rather the arcane relationship of one to the other, across a set of measures, and across a set of climate zones, and hunches become little more than idle speculation.

A second related issue is that (in CZs 11-13 particularly) the design temperatures are approximately the same while the seasonal cooling requirements are very different. Specifically:

1. The peak load kW reductions are primarily dependant on the cooling design temperature in each zone and are pretty consistent. For example, Zone 11, 12 and 13 savings are 1.9, 1.6 and 1.7 kW for the Combination of Measures case.

2. The annual kWh savings are dependant on the number of hours the air conditioner runs and are significantly different between zones. The kWh/yr savings for the Combination of Measures case in Zonse 11, 12 and 13 are 1543, 1092 and 1974, respectively. Even though we may think of climate zone 12 and 13 as being similar, CZ13 is hotter and does not cool off at night. It has twice as much cooling energy consumption and savings. This is consistent with actual cooling energy use in new houses as reported in my 1996 report "Energy Use of California 1993 Title 24 Houses" done for the California DSM Measurement Advisory Committee.

Figure 1 is a set of tables that compares the effect of individual measures and packages across the climate zones (except CZ1), by kW, kWh and kW/kWh.

kW															
Savings															
Measure / Zone	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Attic Radiant Barrier	0.6	0.4	0.3	0.2	0.4	0.2	0.3	0.6	0.7	0.7	0.6	0.6	1.1	1.2	0.1
TXV	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1
Aluminum Window Low SHGC	0.6	0.7	0.7	0.5	0.8	0.7	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.5
Vinyl Window Low SHGC	0.9	0.9	0.9	0.7	1.0	0.8	0.5	0.7	0.7	0.6	0.5	0.5	0.7	0.6	0.7
Tight Ducts	0.8	0.6	0.6	0.4	0.7	0.5	0.5	0.9	1.0	1.0	0.8	0.9	1.4	1.5	0.4
High SEER	0.4	0.3	0.3	0.2	0.4	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.6	0.5	0.3
Tight Ducts and TXV	0.9	0.7	0.7	0.5	0.8	0.6	0.6	1.0	1.1	1.1	0.9	1.0	1.6	1.6	0.5
Combination of All Measures	1.9	1.6	1.6	1.2	1.8	1.4	1.2	1.9	2.1	1.9	1.6	1.7	2.6	2.5	1.2
Base Case Consumption															
98 Standards	3.1	2.6	2.5	2.0	3.0	2.4	2.3	3.3	3.6	3.3	2.9	3.1	4.4	4.3	2.1

kWh															
Savings															
Measure	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Attic Radiant Barrier	139	29	89	15	52	67	110	181	258	256	179	311	359	801	58
TXV	163	34	124	24	55	86	138	229	328	287	189	394	387	896	86
Aluminum Window Low SHGC	691	227	691	174	371	518	358	538	669	420	365	461	435	201	468
Vinyl Window Low SHGC	822	255	788	191	409	583	513	789	1016	722	586	841	817	1037	538
Tight Ducts	155	24	84	15	41	57	98	218	359	356	206	445	538	1355	62
High SEER	258	55	198	40	91	143	215	342	473	402	272	550	502	1164	136
Tight Ducts and TXV	301	57	200	38	91	136	227	425	654	607	377	795	870	2117	141
Combination of All Measures	1140	291	965	212	471	698	834	1352	1866	1543	1092	1974	1985	4078	664
Base Case Consumption															
98 Standards	1637	346	1238	244	550	870	1390	2317	3325	2895	1916	3975	3897	9043	862

kW / Wh															
Savings															
Measure	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Attic Radiant Barrier	4.0	12.3	3.9	12.9	8.2	3.6	2.9	3.4	2.8	2.7	3.3	2.0	3.1	1.5	1.3
TXV	1.0	4.0	1.1	4.4	2.9	1.5	0.9	0.8	0.6	0.6	0.8	0.4	0.6	0.3	1.3
Aluminum Window Low SHGC	0.9	3.2	1.0	3.1	2.0	1.3	0.6	0.5	0.5	0.4	0.4	0.3	0.4	0.3	1.1
Vinyl Window Low SHGC	1.1	3.6	1.2	3.5	2.5	1.4	0.9	0.9	0.7	0.8	0.8	0.6	0.9	0.6	1.3
Tight Ducts	5.2	25.0	6.9	26.6	17.1	8.8	5.5	4.0	2.7	2.7	3.8	2.0	2.6	1.1	6.6
High SEER	1.5	5.8	1.6	6.2	4.1	2.1	1.3	1.2	0.9	1.0	1.3	0.7	1.1	0.5	2.0
Tight Ducts and TXV	3.1	12.5	3.5	13.1	9.1	4.4	2.8	2.4	1.7	1.8	2.4	1.3	1.8	0.8	3.6
Combination of All Measures	1.7	5.5	1.6	5.5	3.9	2.0	1.5	1.4	1.1	1.2	1.5	0.9	1.3	0.6	1.8
Base Case Consumption															
98 Standards	1.9	7.4	2.0	8.1	5.5	2.8	1.6	1.4	1.1	1.1	1.5	0.8	1.1	0.5	2.5

Figure 1: kW, kWh and kW/Wh by Climate Zone

In the table, we show the ratio as kW/Wh, rather than per kWh, to eliminate all the extra zeros. We have also eliminated CZ1 from the table since it would only confuse the issue - there is essentially only one hour of heating in CZ1, so the ratio is very large and totally meaningless.

To illustrate these trends graphically, we plotted kW and kW/kWh for one particular measure, tight ducts, across the climate zones. We also omitted CZ1 in the graph for the obvious reasons.

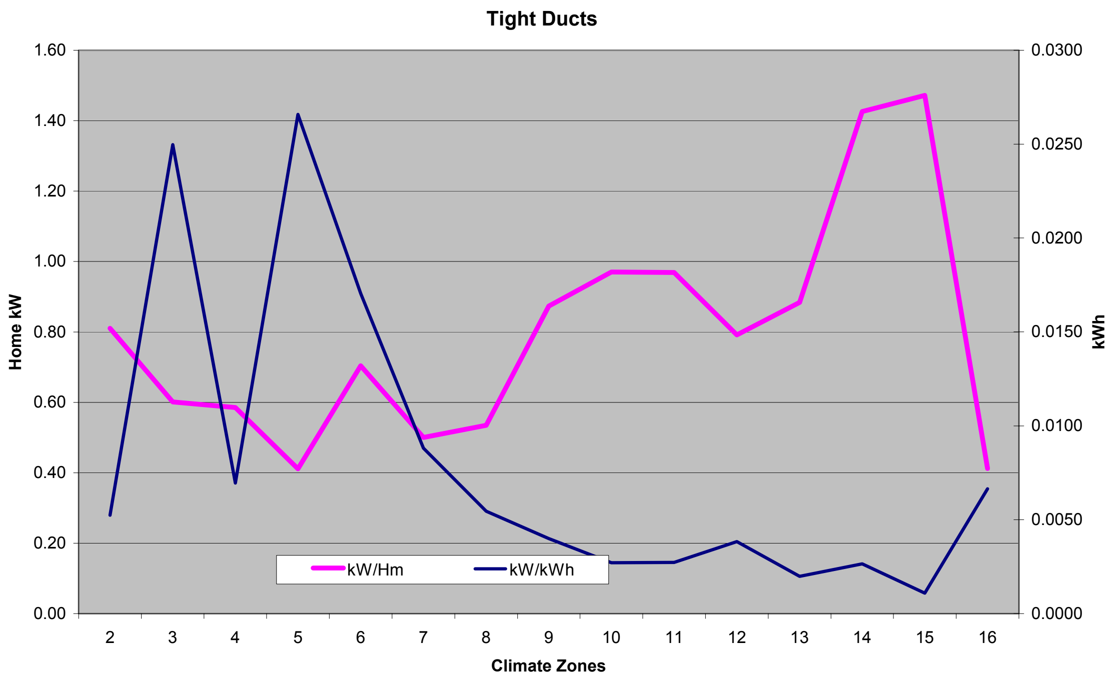

Figure 2: kW and kWh impacts from Tight Ducts by Climate Zone

3.1 Energy and Demand Impact Tables by Climate Zone: with an adjustment factor of 0.55

Climate Zone 01

Factor for actual kW savings = 0.55

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	2	0	0	0.1	0.0		1104	0.1	0.1	0.0
2	TXV	0	0	0	0.1	0.0		1270	0.0	0.0	0.0
3	Aluminum Window Low SHGC	-89	5	3	0.4	0.3	0.0870	7140	-5.0	-5.1	0.0
4	Vinyl Window Low SHGC	-17	5	3	0.5	0.3	0.1023	8396	-0.9	-0.9	0.0
5	Tight Ducts	30	0	0	0.2	0.1		3873	1.7	1.7	0.0
6	High SEER	0	0	0	0.2	0.1		0	0.0	0.0	0.0
7	Tight Ducts and TXV	30	0	0	0.3	0.2		4934	1.7	1.7	0.0
8	Combination of All Measures	17	5	3	0.8	0.5	0.1626	11892	1.0	0.9	0.0
	Base Case Consumption 98 Standards	346	5	3	1.5	0.8	0.2870	23559	33.8	19.6	0.03

Climate Zone 02

Factor for actual kW savings = 0.55

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	3	139	79	0.6	0.3	0.0040	8933	1.0	0.2	0.8
2	TXV	0	163	93	0.2	0.1	0.0010	2650	0.9	0.0	0.9
3	Aluminum Window Low SHGC	-54	691	393	0.6	0.3	0.0009	9679	0.9	-3.1	4.0
4	Vinyl Window Low SHGC	3	822	467	0.9	0.5	0.0011	14200	5.0	0.2	4.8
5	Tight Ducts	32	155	88	0.8	0.5	0.0052	12887	2.7	1.8	0.9
6	High SEER	0	258	146	0.4	0.2	0.0015	0	1.5	0.0	1.5
7	Tight Ducts and TXV	32	301	171	0.9	0.5	0.0031	14842	3.5	1.8	1.8
8	Combination of All Measures	37	1140	648	1.9	1.1	0.0017	27262	8.7	2.1	6.6
	Base Case Consumption 98 Standards	348	1637	930	3.1	1.8	0.0019	49133	43.4	19.7	9.52

Climate Zone 03

Factor for actual kW savings = 0.55

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	2	29	17	0.4	0.2	0.0123	5727	0.3	0.1	0.2
2	TXV	0	34	20	0.1	0.1	0.0040	2200	0.2	0.0	0.2
3	Aluminum Window Low SHGC	-38	227	129	0.7	0.4	0.0032	11542	-0.8	-2.2	1.3
4	Vinyl Window Low SHGC	12	255	145	0.9	0.5	0.0036	14575	2.2	0.7	1.5
5	Tight Ducts	20	24	14	0.6	0.3	0.0250	9563	1.3	1.1	0.1
6	High SEER	0	55	31	0.3	0.2	0.0058	0	0.3	0.0	0.3
7	Tight Ducts and TXV	20	57	32	0.7	0.4	0.0125	11248	1.5	1.1	0.3
8	Combination of All Measures	33	291	165	1.6	0.9	0.0055	23182	3.6	1.9	1.7
	Base Case Consumption 98 Standards	241	346	196	2.6	1.5	0.0074	40803	29.9	13.7	2.01

Climate Zone 04

Factor for actual kW savings = 0.55

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	2	89	51	0.3	0.2	0.0039	5568	0.6	0.1	0.5
2	TXV	0	124	70	0.1	0.1	0.0011	2177	0.7	0.0	0.7
3	Aluminum Window Low SHGC	-32	691	393	0.7	0.4	0.0010	11453	2.2	-1.8	4.0
4	Vinyl Window Low SHGC	19	788	447	0.9	0.5	0.0012	14778	5.7	1.1	4.6
5	Tight Ducts	21	84	48	0.6	0.3	0.0069	9315	1.7	1.2	0.5
6	High SEER	0	198	112	0.3	0.2	0.0016	0	1.2	0.0	1.2
7	Tight Ducts and TXV	21	200	113	0.7	0.4	0.0035	10990	2.4	1.2	1.2
8	Combination of All Measures	41	965	548	1.6	0.9	0.0016	23074	7.9	2.3	5.6
	Base Case Consumption 98 Standards	256	1238	703	2.5	1.4	0.0020	40365	35.9	14.5	7.2

Climate Zone 05

Factor for actual kW savings = 0.55

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	2	15	9	0.2	0.1	0.0129	3187	0.2	0.1	0.1
2	TXV	0	24	14	0.1	0.1	0.0044	1690	0.1	0.0	0.1
3	Aluminum Window Low SHGC	-36	174	99	0.5	0.3	0.0031	8484	-1.1	-2.1	1.0
4	Vinyl Window Low SHGC	7	191	108	0.7	0.4	0.0035	10593	1.5	0.4	1.1
5	Tight Ducts	19	15	9	0.4	0.2	0.0266	6548	1.2	1.1	0.1
6	High SEER	0	40	22	0.2	0.1	0.0062	0	0.2	0.0	0.2
7	Tight Ducts and TXV	19	38	21	0.5	0.3	0.0131	7885	1.3	1.1	0.2
8	Combination of All Measures	27	212	120	1.2	0.7	0.0055	16687	2.7	1.5	1.2
	Base Case Consumption 98 Standards	215	244	139	2.0	1.1	0.0081	31336	27.8	12.2	1.42

Climate Zone 06

Factor for actual kW savings = 0.55

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	1	52	29	0.4	0.2	0.0082	6707	0.4	0.1	0.3
2	TXV	0	55	31	0.2	0.1	0.0029	2577	0.3	0.0	0.3
3	Aluminum Window Low SHGC	-22	371	211	0.8	0.4	0.0020	11974	0.9	-1.3	2.2
4	Vinyl Window Low SHGC	4	409	232	1.0	0.6	0.0025	16085	2.6	0.2	2.4
5	Tight Ducts	7	41	23	0.7	0.4	0.0171	11200	0.7	0.4	0.2
6	High SEER	0	91	52	0.4	0.2	0.0041	0	0.5	0.0	0.5
7	Tight Ducts and TXV	7	91	52	0.8	0.5	0.0091	13173	1.0	0.4	0.5
8	Combination of All Measures	11	471	268	1.8	1.0	0.0039	26488	3.4	0.6	2.7
	Base Case Consumption 98 Standards	92	550	313	3.0	1.7	0.0055	47787	22.6	5.2	3.2

Climate Zone 07

Factor for actual kW savings = 0.55

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	1	67	38	0.2	0.1	0.0036	3873	0.4	0.1	0.4
2	TXV	0	86	49	0.1	0.1	0.0015	2054	0.5	0.0	0.5
3	Aluminum Window Low SHGC	-15	518	294	0.7	0.4	0.0013	10605	2.2	-0.9	3.0
4	Vinyl Window Low SHGC	7	583	331	0.8	0.5	0.0014	13244	3.8	0.4	3.4
5	Tight Ducts	6	57	32	0.5	0.3	0.0088	7959	0.7	0.3	0.3
6	High SEER	0	143	81	0.3	0.2	0.0021	0	0.8	0.0	0.8
7	Tight Ducts and TXV	6	136	77	0.6	0.3	0.0044	9583	1.1	0.3	0.8
8	Combination of All Measures	13	698	397	1.4	0.8	0.0020	20542	4.8	0.7	4.1
	Base Case Consumption 98 Standards	77	870	494	2.4	1.4	0.0028	38087	23.6	4.4	5.06

Climate Zone 08

Factor for actual kW savings = 0.55

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	1	110	63	0.3	0.2	0.0029	5094	0.7	0.1	0.6
2	TXV	0	138	78	0.1	0.1	0.0009	1957	0.8	0.0	0.8
3	Aluminum Window Low SHGC	-4	358	203	0.2	0.1	0.0006	3497	1.9	-0.2	2.1
4	Vinyl Window Low SHGC	21	513	291	0.5	0.3	0.0009	7429	4.2	1.2	3.0
5	Tight Ducts	9	98	56	0.5	0.3	0.0055	8506	1.1	0.5	0.6
6	High SEER	0	215	122	0.3	0.2	0.0013	0	1.3	0.0	1.3
7	Tight Ducts and TXV	9	227	129	0.6	0.4	0.0028	10004	1.8	0.5	1.3
8	Combination of All Measures	29	834	474	1.2	0.7	0.0015	16900	6.5	1.6	4.9
	Base Case Consumption 98 Standards	112	1390	789	2.3	1.3	0.0016	36291	28.6	6.3	8.08

Climate Zone 09

Factor for actual kW savings = 0.55

Case	Savings from 98 Stds for 1761 ft2 Prototype	Heating	Cooling kWh per		Cooling kW per			Cool Size	EnergyUse skBtu/cfa		
	Measure	Therms	Home	1000ft2	Home	1000ft2	kWh	BTU	Total	Heating	Cooling
1	Attic Radiant Barrier	1	181	103	0.6	0.3	0.0034	9632	1.1	0.1	1.1
2	TXV	0	229	130	0.2	0.1	0.0008	2857	1.3	0.0	1.3
3	Aluminum Window Low SHGC	-1	538	306	0.3	0.2	0.0005	4590	3.1	-0.1	3.1
4	Vinyl Window Low SHGC	25	789	448	0.7	0.4	0.0009	10826	6.0	1.4	4.6
5	Tight Ducts	10	218	124	0.9	0.5	0.0040	13895	1.9	0.6	1.3
6	High SEER	0	342	194	0.4	0.2	0.0012	0	2.0	0.0	2.0
7	Tight Ducts and TXV	10	425	241	1.0	0.6	0.0024	16002	3.1	0.6	2.5
8	Combination of All Measures	35	1352	768	1.9	1.1	0.0014	26586	9.8	2.0	7.9
	Base Case Consumption 98 Standards	123	2317	1316	3.3	1.9	0.0014	52974	34.6	7.0	13.47

Climate Zone 10

Factor for actual kW savings = 0.55

Case	Savings from 98 Stds for 1761 ft2 Prototype	Heating	Cooling kWh per		Cooling kW per			Cool Size	EnergyUse skBtu/cfa		
	Measure	Therms	Home	1000ft2	Home	1000ft2	kWh	BTU	Total	Heating	Cooling
1	Attic Radiant Barrier	2	258	146	0.7	0.4	0.0028	11593	1.6	0.1	1.5
2	TXV	0	328	187	0.2	0.1	0.0006	3069	1.9	0.0	1.9
3	Aluminum Window Low SHGC	-2	669	380	0.3	0.2	0.0005	4886	3.8	-0.1	3.9
4	Vinyl Window Low SHGC	33	1016	577	0.7	0.4	0.0007	11617	7.8	1.9	5.9
5	Tight Ducts	15	359	204	1.0	0.6	0.0027	15434	2.9	0.8	2.1
6	High SEER	0	473	269	0.4	0.3	0.0009	0	2.8	0.0	2.8
7	Tight Ducts and TXV	15	654	371	1.1	0.6	0.0017	17670	4.6	0.8	3.8
8	Combination of All Measures	46	1866	1060	2.1	1.2	0.0011	29410	13.5	2.6	10.9
	Base Case Consumption 98 Standards	173	3325	1888	3.6	2.0	0.0011	56911	43.3	9.9	19.33

Climate Zone 11

Factor for actual kW savings = 0.55

Case	Savings from 98 Stds for 1761 ft2 Prototype	Heating	Cooling kWh per		Cooling kW per			Cool Size	EnergyUse skBtu/cfa		
	Measure	Therms	Home	1000ft2	Home	1000ft2	kWh	BTU	Total	Heating	Cooling
1	Attic Radiant Barrier	2	256	146	0.7	0.4	0.0027	11119	1.6	0.1	1.5
2	TXV	0	287	163	0.2	0.1	0.0006	2835	1.7	0.0	1.7
3	Aluminum Window Low SHGC	-24	420	238	0.2	0.1	0.0004	2588	1.1	-1.4	2.4
4	Vinyl Window Low SHGC	28	722	410	0.6	0.3	0.0008	8752	5.8	1.6	4.2
5	Tight Ducts	32	356	202	1.0	0.5	0.0027	15406	3.9	1.8	2.1
6	High SEER	0	402	229	0.4	0.2	0.0010	0	2.3	0.0	2.3
7	Tight Ducts and TXV	32	607	345	1.1	0.6	0.0018	17410	5.4	1.8	3.5
8	Combination of All Measures	60	1543	876	1.9	1.1	0.0012	26815	12.4	3.4	9.0
	Base Case Consumption 98 Standards	357	2895	1644	3.3	1.9	0.0011	52563	51.2	20.3	16.83

Climate Zone 12

Factor for actual kW savings = 0.55

Case	Savings from 98 Stds for 1761 ft2 Prototype	Heating	Cooling kWh per		Cooling kW per			Cool Size	EnergyUse skBtu/cfa		
	Measure	Therms	Home	1000ft2	Home	1000ft2	kWh	BTU	Total	Heating	Cooling
1	Attic Radiant Barrier	2	179	102	0.6	0.3	0.0033	9463	1.2	0.1	1.0
2	TXV	0	189	107	0.2	0.1	0.0008	2505	1.1	0.0	1.1
3	Aluminum Window Low SHGC	-26	365	207	0.2	0.1	0.0004	2467	0.6	-1.5	2.1
4	Vinyl Window Low SHGC	23	586	333	0.5	0.3	0.0008	7852	4.7	1.3	3.4
5	Tight Ducts	28	206	117	0.8	0.4	0.0038	12597	2.8	1.6	1.2
6	High SEER	0	272	154	0.4	0.2	0.0013	0	1.6	0.0	1.6
7	Tight Ducts and TXV	28	377	214	0.9	0.5	0.0024	14423	3.8	1.6	2.2
8	Combination of All Measures	50	1092	620	1.6	0.9	0.0015	23015	9.2	2.9	6.4
	Base Case Consumption 98 Standards	314	1916	1088	2.9	1.7	0.0015	46452	43.1	17.8	11.14

Climate Zone 13

Factor for actual kW savings = 0.55

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	2	311	177	0.6	0.4	0.0020	10128	1.9	0.1	1.8
2	TXV	0	394	224	0.2	0.1	0.0004	2632	2.3	0.0	2.3
3	Aluminum Window Low SHGC	-21	461	262	0.2	0.1	0.0003	2526	1.5	-1.2	2.7
4	Vinyl Window Low SHGC	20	841	478	0.5	0.3	0.0006	8208	6.0	1.1	4.9
5	Tight Ducts	23	445	253	0.9	0.5	0.0020	14061	3.9	1.3	2.6
6	High SEER	0	550	313	0.4	0.2	0.0007	0	3.2	0.0	3.2
7	Tight Ducts and TXV	23	795	451	1.0	0.6	0.0013	15934	5.9	1.3	4.6
8	Combination of All Measures	42	1974	1121	1.7	1.0	0.0009	24361	13.9	2.4	11.5
	Base Case Consumption 98 Standards	249	3975	2257	3.1	1.7	0.0008	48799	51.4	14.1	23.11

Climate Zone 14

Factor for actual kW savings = 0.55

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	2	359	204	1.1	0.6	0.0031	17992	2.2	0.1	2.1
2	TXV	0	387	220	0.2	0.1	0.0006	3806	2.3	0.0	2.3
3	Aluminum Window Low SHGC	-35	435	247	0.2	0.1	0.0004	2792	0.5	-2.0	2.5
4	Vinyl Window Low SHGC	22	817	464	0.7	0.4	0.0009	11297	6.0	1.3	4.8
5	Tight Ducts	36	538	306	1.4	0.8	0.0026	22688	5.2	2.0	3.1
6	High SEER	0	502	285	0.6	0.3	0.0011	0	2.9	0.0	2.9
7	Tight Ducts and TXV	36	870	494	1.6	0.9	0.0018	25270	7.1	2.0	5.1
8	Combination of All Measures	58	1985	1127	2.6	1.5	0.0013	37793	14.8	3.3	11.5
	Base Case Consumption 98 Standards	351	3897	2213	4.4	2.5	0.0011	70584	56.8	20.0	22.66

Climate Zone 15

Factor for actual kW savings = 0.55

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	1	801	455	1.2	0.7	0.0015	18977	4.7	0.0	4.7
2	TXV	0	896	509	0.2	0.1	0.0003	3655	5.2	0.0	5.2
3	Aluminum Window Low SHGC	-1	201	114	0.1	0.0	0.0003	939	1.1	-0.1	1.2
4	Vinyl Window Low SHGC	13	1037	589	0.6	0.3	0.0006	9331	6.8	0.7	6.0
5	Tight Ducts	6	1355	770	1.5	0.8	0.0011	23413	8.2	0.3	7.9
6	High SEER	0	1164	661	0.5	0.3	0.0005	0	6.8	0.0	6.8
7	Tight Ducts and TXV	6	2117	1202	1.6	0.9	0.0008	25806	12.7	0.3	12.3
8	Combination of All Measures	18	4078	2316	2.5	1.4	0.0006	36673	24.7	1.0	23.7
	Base Case Consumption 98 Standards	69	9043	5135	4.3	2.4	0.0005	67775	70.7	3.9	52.58

Climate Zone 16

Factor for actual kW savings = 0.55

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	5	58	33	0.1	0.0	0.0013	1179	0.6	0.3	0.3
2	TXV	0	86	49	0.1	0.1	0.0013	1830	0.5	0.0	0.5
3	Aluminum Window Low SHGC	-120	468	266	0.5	0.3	0.0011	8081	-4.1	-6.8	2.7
4	Vinyl Window Low SHGC	-2	538	306	0.7	0.4	0.0013	11046	3.0	-0.1	3.1
5	Tight Ducts	80	62	35	0.4	0.2	0.0066	6549	4.9	4.5	0.4
6	High SEER	0	136	77	0.3	0.2	0.0020	0	0.8	0.0	0.8
7	Tight Ducts and TXV	80	141	80	0.5	0.3	0.0036	8026	5.3	4.5	0.8
8	Combination of All Measures	82	664	377	1.2	0.7	0.0018	16834	8.5	4.6	3.9
	Base Case Consumption 98 Standards	716	862	489	2.1	1.2	0.0025	33928	59.8	40.7	5.01

3.2 Energy and Demand Impact Tables by Climate Zone: with an adjustment factor of 1.0

Climate Zone 01

Factor for actual kW savings = 1

	Savings from 98 Stds for 1761 ft2 Prototype	Heating	Cooling kWh per		Cooling kW per			Cool Size	EnergyUse skBtu/cfa		
Case	Measure	Therms	Home	1000ft2	Home	1000ft2	kWh	BTU	Total	Heating	Cooling
1	Attic Radiant Barrier	2	0	0	0.1	0.1		1104	0.1	0.1	0.0
2	TXV	0	0	0	0.1	0.1		1270	0.0	0.0	0.0
3	Aluminum Window Low SHGC	-89	5	3	0.8	0.5	0.1582	7140	-5.0	-5.1	0.0
4	Vinyl Window Low SHGC	-17	5	3	1.0	0.5	0.1860	8396	-0.9	-0.9	0.0
5	Tight Ducts	30	0	0	0.4	0.3		3873	1.7	1.7	0.0
6	High SEER	0	0	0	0.3	0.2		0	0.0	0.0	0.0
7	Tight Ducts and TXV	30	0	0	0.6	0.3		4934	1.7	1.7	0.0
8	Combination of All Measures	17	5	3	1.5	0.9	0.2957	11892	1.0	0.9	0.0
	Base Case Consumption 98 Standards	346	5	3	2.7	1.5	0.5218	23559	33.8	19.6	0.03

Climate Zone 02

Factor for actual kW savings = 1

	Savings from 98 Stds for 1761 ft2 Prototype	Heating	Cooling kWh per		Cooling kW per			Cool Size	EnergyUse skBtu/cfa		
Case	Measure	Therms	Home	1000ft2	Home	1000ft2	kWh	BTU	Total	Heating	Cooling
1	Attic Radiant Barrier	3	139	79	1.0	0.6	0.0073	8933	1.0	0.2	0.8
2	TXV	0	163	93	0.3	0.2	0.0019	2650	0.9	0.0	0.9
3	Aluminum Window Low SHGC	-54	691	393	1.1	0.6	0.0016	9679	0.9	-3.1	4.0
4	Vinyl Window Low SHGC	3	822	467	1.6	0.9	0.0020	14200	5.0	0.2	4.8
5	Tight Ducts	32	155	88	1.5	0.8	0.0095	12887	2.7	1.8	0.9
6	High SEER	0	258	146	0.7	0.4	0.0027	0	1.5	0.0	1.5
7	Tight Ducts and TXV	32	301	171	1.7	1.0	0.0056	14842	3.5	1.8	1.8
8	Combination of All Measures	37	1140	648	3.4	1.9	0.0030	27262	8.7	2.1	6.6
	Base Case Consumption 98 Standards	348	1637	930	5.6	3.2	0.0034	49133	43.4	19.7	9.52

Climate Zone 03

Factor for actual kW savings = 1

	Savings from 98 Stds for 1761 ft2 Prototype	Heating	Cooling kWh per		Cooling kW per			Cool Size	EnergyUse skBtu/cfa		
Case	Measure	Therms	Home	1000ft2	Home	1000ft2	kWh	BTU	Total	Heating	Cooling
1	Attic Radiant Barrier	2	29	17	0.7	0.4	0.0224	5727	0.3	0.1	0.2
2	TXV	0	34	20	0.3	0.1	0.0073	2200	0.2	0.0	0.2
3	Aluminum Window Low SHGC	-38	227	129	1.3	0.7	0.0058	11542	-0.8	-2.2	1.3
4	Vinyl Window Low SHGC	12	255	145	1.7	0.9	0.0065	14575	2.2	0.7	1.5
5	Tight Ducts	20	24	14	1.1	0.6	0.0454	9563	1.3	1.1	0.1
6	High SEER	0	55	31	0.6	0.3	0.0106	0	0.3	0.0	0.3
7	Tight Ducts and TXV	20	57	32	1.3	0.7	0.0226	11248	1.5	1.1	0.3
8	Combination of All Measures	33	291	165	2.9	1.6	0.0100	23182	3.6	1.9	1.7
	Base Case Consumption 98 Standards	241	346	196	4.7	2.6	0.0135	40803	29.9	13.7	2.01

Climate Zone 04

Factor for actual kW savings = 1

	Savings from 98 Stds for 1761 ft2 Prototype	Heating	Cooling kWh per		Cooling kW per			Cool Size	EnergyUse skBtu/cfa		
Case	Measure	Therms	Home	1000ft2	Home	1000ft2	kWh	BTU	Total	Heating	Cooling
1	Attic Radiant Barrier	2	89	51	0.6	0.4	0.0071	5568	0.6	0.1	0.5
2	TXV	0	124	70	0.2	0.1	0.0020	2177	0.7	0.0	0.7
3	Aluminum Window Low SHGC	-32	691	393	1.3	0.7	0.0019	11453	2.2	-1.8	4.0
4	Vinyl Window Low SHGC	19	788	447	1.7	1.0	0.0021	14778	5.7	1.1	4.6
5	Tight Ducts	21	84	48	1.1	0.6	0.0126	9315	1.7	1.2	0.5
6	High SEER	0	198	112	0.6	0.3	0.0029	0	1.2	0.0	1.2
7	Tight Ducts and TXV	21	200	113	1.3	0.7	0.0063	10990	2.4	1.2	1.2
8	Combination of All Measures	41	965	548	2.9	1.6	0.0030	23074	7.9	2.3	5.6
	Base Case Consumption 98 Standards	256	1238	703	4.6	2.6	0.0037	40365	35.9	14.5	7.2

Climate Zone 05

Factor for actual kW savings = 1

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	2	15	9	0.4	0.2	0.0235	3187	0.2	0.1	0.1
2	TXV	0	24	14	0.2	0.1	0.0080	1690	0.1	0.0	0.1
3	Aluminum Window Low SHGC	-36	174	99	1.0	0.6	0.0056	8484	-1.1	-2.1	1.0
4	Vinyl Window Low SHGC	7	191	108	1.2	0.7	0.0063	10593	1.5	0.4	1.1
5	Tight Ducts	19	15	9	0.7	0.4	0.0483	6548	1.2	1.1	0.1
6	High SEER	0	40	22	0.4	0.3	0.0113	0	0.2	0.0	0.2
7	Tight Ducts and TXV	19	38	21	0.9	0.5	0.0238	7885	1.3	1.1	0.2
8	Combination of All Measures	27	212	120	2.1	1.2	0.0100	16687	2.7	1.5	1.2

Base Case Consumption	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse Total	EnergyUse Heating	EnergyUse Cooling
98 Standards	215	244	139	3.6	2.0	0.0147	31336	27.8	12.2	1.42

Climate Zone 06

Factor for actual kW savings = 1

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	1	52	29	0.8	0.4	0.0149	6707	0.4	0.1	0.3
2	TXV	0	55	31	0.3	0.2	0.0054	2577	0.3	0.0	0.3
3	Aluminum Window Low SHGC	-22	371	211	1.4	0.8	0.0037	11974	0.9	-1.3	2.2
4	Vinyl Window Low SHGC	4	409	232	1.8	1.0	0.0045	16085	2.6	0.2	2.4
5	Tight Ducts	7	41	23	1.3	0.7	0.0310	11200	0.7	0.4	0.2
6	High SEER	0	91	52	0.7	0.4	0.0075	0	0.5	0.0	0.5
7	Tight Ducts and TXV	7	91	52	1.5	0.9	0.0165	13173	1.0	0.4	0.5
8	Combination of All Measures	11	471	268	3.3	1.9	0.0071	26488	3.4	0.6	2.7

Base Case Consumption	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse Total	EnergyUse Heating	EnergyUse Cooling
98 Standards	92	550	313	5.5	3.1	0.0099	47787	22.6	5.2	3.2

Climate Zone 07

Factor for actual kW savings = 1

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	1	67	38	0.4	0.3	0.0066	3873	0.4	0.1	0.4
2	TXV	0	86	49	0.2	0.1	0.0027	2054	0.5	0.0	0.5
3	Aluminum Window Low SHGC	-15	518	294	1.2	0.7	0.0023	10605	2.2	-0.9	3.0
4	Vinyl Window Low SHGC	7	583	331	1.5	0.9	0.0026	13244	3.8	0.4	3.4
5	Tight Ducts	6	57	32	0.9	0.5	0.0160	7959	0.7	0.3	0.3
6	High SEER	0	143	81	0.5	0.3	0.0038	0	0.8	0.0	0.8
7	Tight Ducts and TXV	6	136	77	1.1	0.6	0.0081	9583	1.1	0.3	0.8
8	Combination of All Measures	13	698	397	2.6	1.5	0.0037	20542	4.8	0.7	4.1

Base Case Consumption	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse Total	EnergyUse Heating	EnergyUse Cooling
98 Standards	77	870	494	4.4	2.5	0.0050	38087	23.6	4.4	5.06

Climate Zone 08

Factor for actual kW savings = 1

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	1	110	63	0.6	0.3	0.0053	5094	0.7	0.1	0.6
2	TXV	0	138	78	0.2	0.1	0.0016	1957	0.8	0.0	0.8
3	Aluminum Window Low SHGC	-4	358	203	0.4	0.2	0.0011	3497	1.9	-0.2	2.1
4	Vinyl Window Low SHGC	21	513	291	0.8	0.5	0.0017	7429	4.2	1.2	3.0
5	Tight Ducts	9	98	56	1.0	0.6	0.0099	8506	1.1	0.5	0.6
6	High SEER	0	215	122	0.5	0.3	0.0024	0	1.3	0.0	1.3
7	Tight Ducts and TXV	9	227	129	1.1	0.6	0.0050	10004	1.8	0.5	1.3
8	Combination of All Measures	29	834	474	2.2	1.3	0.0026	16900	6.5	1.6	4.9

Base Case Consumption	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse Total	EnergyUse Heating	EnergyUse Cooling
98 Standards	112	1390	789	4.1	2.4	0.0030	36291	28.6	6.3	8.08

Climate Zone 09

Factor for actual kW savings = 1

	Savings from 98 Stds for 1761 ft2 Prototype	Heating	Cooling kWh per		Cooling kW per			Cool Size	EnergyUse skBtu/cfa		
Case	Measure	Therms	Home	1000ft2	Home	1000ft2	kWh	BTU	Total	Heating	Cooling
1	Attic Radiant Barrier	1	181	103	1.1	0.6	0.0061	9632	1.1	0.1	1.1
2	TXV	0	229	130	0.3	0.2	0.0014	2857	1.3	0.0	1.3
3	Aluminum Window Low SHGC	-1	538	306	0.5	0.3	0.0010	4590	3.1	-0.1	3.1
4	Vinyl Window Low SHGC	25	789	448	1.2	0.7	0.0016	10826	6.0	1.4	4.6
5	Tight Ducts	10	218	124	1.6	0.9	0.0073	13895	1.9	0.6	1.3
6	High SEER	0	342	194	0.8	0.4	0.0022	0	2.0	0.0	2.0
7	Tight Ducts and TXV	10	425	241	1.8	1.0	0.0043	16002	3.1	0.6	2.5
8	Combination of All Measures	35	1352	768	3.4	1.9	0.0025	26586	9.8	2.0	7.9
	Base Case Consumption 98 Standards	123	2317	1316	6.1	3.4	0.0026	52974	34.6	7.0	13.47

Climate Zone 10

Factor for actual kW savings = 1

	Savings from 98 Stds for 1761 ft2 Prototype	Heating	Cooling kWh per		Cooling kW per			Cool Size	EnergyUse skBtu/cfa		
Case	Measure	Therms	Home	1000ft2	Home	1000ft2	kWh	BTU	Total	Heating	Cooling
1	Attic Radiant Barrier	2	258	146	1.3	0.8	0.0051	11593	1.6	0.1	1.5
2	TXV	0	328	187	0.4	0.2	0.0011	3069	1.9	0.0	1.9
3	Aluminum Window Low SHGC	-2	669	380	0.6	0.3	0.0008	4886	3.8	-0.1	3.9
4	Vinyl Window Low SHGC	33	1016	577	1.3	0.8	0.0013	11617	7.8	1.9	5.9
5	Tight Ducts	15	359	204	1.8	1.0	0.0049	15434	2.9	0.8	2.1
6	High SEER	0	473	269	0.8	0.5	0.0017	0	2.8	0.0	2.8
7	Tight Ducts and TXV	15	654	371	2.0	1.1	0.0031	17670	4.6	0.8	3.8
8	Combination of All Measures	46	1866	1060	3.8	2.1	0.0020	29410	13.5	2.6	10.9
	Base Case Consumption 98 Standards	173	3325	1888	6.5	3.7	0.0020	56911	43.3	9.9	19.33

Climate Zone 11

Factor for actual kW savings = 1

	Savings from 98 Stds for 1761 ft2 Prototype	Heating	Cooling kWh per		Cooling kW per			Cool Size	EnergyUse skBtu/cfa		
Case	Measure	Therms	Home	1000ft2	Home	1000ft2	kWh	BTU	Total	Heating	Cooling
1	Attic Radiant Barrier	2	256	146	1.3	0.7	0.0050	11119	1.6	0.1	1.5
2	TXV	0	287	163	0.3	0.2	0.0011	2835	1.7	0.0	1.7
3	Aluminum Window Low SHGC	-24	420	238	0.3	0.2	0.0007	2588	1.1	-1.4	2.4
4	Vinyl Window Low SHGC	28	722	410	1.0	0.6	0.0014	8752	5.8	1.6	4.2
5	Tight Ducts	32	356	202	1.8	1.0	0.0049	15406	3.9	1.8	2.1
6	High SEER	0	402	229	0.8	0.4	0.0019	0	2.3	0.0	2.3
7	Tight Ducts and TXV	32	607	345	2.0	1.1	0.0033	17410	5.4	1.8	3.5
8	Combination of All Measures	60	1543	876	3.4	1.9	0.0022	26815	12.4	3.4	9.0
	Base Case Consumption 98 Standards	357	2895	1644	6.0	3.4	0.0021	52563	51.2	20.3	16.83

Climate Zone 12

Factor for actual kW savings = 1

	Savings from 98 Stds for 1761 ft2 Prototype	Heating	Cooling kWh per		Cooling kW per			Cool Size	EnergyUse skBtu/cfa		
Case	Measure	Therms	Home	1000ft2	Home	1000ft2	kWh	BTU	Total	Heating	Cooling
1	Attic Radiant Barrier	2	179	102	1.1	0.6	0.0060	9463	1.2	0.1	1.0
2	TXV	0	189	107	0.3	0.2	0.0015	2505	1.1	0.0	1.1
3	Aluminum Window Low SHGC	-26	365	207	0.3	0.2	0.0008	2467	0.6	-1.5	2.1
4	Vinyl Window Low SHGC	23	586	333	0.9	0.5	0.0015	7852	4.7	1.3	3.4
5	Tight Ducts	28	206	117	1.4	0.8	0.0070	12597	2.8	1.6	1.2
6	High SEER	0	272	154	0.7	0.4	0.0024	0	1.6	0.0	1.6
7	Tight Ducts and TXV	28	377	214	1.6	0.9	0.0044	14423	3.8	1.6	2.2
8	Combination of All Measures	50	1092	620	3.0	1.7	0.0027	23015	9.2	2.9	6.4
	Base Case Consumption 98 Standards	314	1916	1088	5.3	3.0	0.0028	46452	43.1	17.8	11.14

Climate Zone 13

Factor for actual kW savings = 1

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	2	311	177	1.2	0.7	0.0037	10128	1.9	0.1	1.8
2	TXV	0	394	224	0.3	0.2	0.0008	2632	2.3	0.0	2.3
3	Aluminum Window Low SHGC	-21	461	262	0.3	0.2	0.0006	2526	1.5	-1.2	2.7
4	Vinyl Window Low SHGC	20	841	478	0.9	0.5	0.0011	8208	6.0	1.1	4.9
5	Tight Ducts	23	445	253	1.6	0.9	0.0036	14061	3.9	1.3	2.6
6	High SEER	0	550	313	0.7	0.4	0.0013	0	3.2	0.0	3.2
7	Tight Ducts and TXV	23	795	451	1.8	1.0	0.0023	15934	5.9	1.3	4.6
8	Combination of All Measures	42	1974	1121	3.1	1.8	0.0016	24361	13.9	2.4	11.5
	Base Case Consumption 98 Standards	249	3975	2257	5.6	3.2	0.0014	48799	51.4	14.1	23.11

Climate Zone 14

Factor for actual kW savings = 1

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	2	359	204	2.1	1.2	0.0057	17992	2.2	0.1	2.1
2	TXV	0	387	220	0.4	0.2	0.0011	3806	2.3	0.0	2.3
3	Aluminum Window Low SHGC	-35	435	247	0.3	0.2	0.0007	2792	0.5	-2.0	2.5
4	Vinyl Window Low SHGC	22	817	464	1.3	0.7	0.0016	11297	6.0	1.3	4.8
5	Tight Ducts	36	538	306	2.6	1.5	0.0048	22688	5.2	2.0	3.1
6	High SEER	0	502	285	1.0	0.6	0.0020	0	2.9	0.0	2.9
7	Tight Ducts and TXV	36	870	494	2.9	1.6	0.0033	25270	7.1	2.0	5.1
8	Combination of All Measures	58	1985	1127	4.8	2.7	0.0024	37793	14.8	3.3	11.5
	Base Case Consumption 98 Standards	351	3897	2213	8.1	4.6	0.0021	70584	56.8	20.0	22.66

Climate Zone 15

Factor for actual kW savings = 1

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	1	801	455	2.2	1.2	0.0027	18977	4.7	0.0	4.7
2	TXV	0	896	509	0.4	0.2	0.0005	3655	5.2	0.0	5.2
3	Aluminum Window Low SHGC	-1	201	114	0.1	0.1	0.0005	939	1.1	-0.1	1.2
4	Vinyl Window Low SHGC	13	1037	589	1.1	0.6	0.0010	9331	6.8	0.7	6.0
5	Tight Ducts	6	1355	770	2.7	1.5	0.0020	23413	8.2	0.3	7.9
6	High SEER	0	1164	661	1.0	0.5	0.0008	0	6.8	0.0	6.8
7	Tight Ducts and TXV	6	2117	1202	2.9	1.7	0.0014	25806	12.7	0.3	12.3
8	Combination of All Measures	18	4078	2316	4.6	2.6	0.0011	36673	24.7	1.0	23.7
	Base Case Consumption 98 Standards	69	9043	5135	7.7	4.4	0.0009	67775	70.7	3.9	52.58

Climate Zone 16

Factor for actual kW savings = 1

Case	Savings from 98 Stds for 1761 ft2 Prototype Measure	Heating Therms	Cooling kWh per Home	Cooling kWh per 1000ft2	Cooling kW per Home	Cooling kW per 1000ft2	Cooling kW per kWh	Cool Size BTU	EnergyUse skBtu/cfa Total	EnergyUse skBtu/cfa Heating	EnergyUse skBtu/cfa Cooling
1	Attic Radiant Barrier	5	58	33	0.1	0.1	0.0023	1179	0.6	0.3	0.3
2	TXV	0	86	49	0.2	0.1	0.0024	1830	0.5	0.0	0.5
3	Aluminum Window Low SHGC	-120	468	266	0.9	0.5	0.0020	8081	-4.1	-6.8	2.7
4	Vinyl Window Low SHGC	-2	538	306	1.3	0.7	0.0023	11046	3.0	-0.1	3.1
5	Tight Ducts	80	62	35	0.7	0.4	0.0121	6549	4.9	4.5	0.4
6	High SEER	0	136	77	0.5	0.3	0.0036	0	0.8	0.0	0.8
7	Tight Ducts and TXV	80	141	80	0.9	0.5	0.0065	8026	5.3	4.5	0.8
8	Combination of All Measures	82	664	377	2.2	1.2	0.0033	16834	8.5	4.6	3.9
	Base Case Consumption 98 Standards	716	862	489	3.9	2.2	0.0045	33928	59.8	40.7	5.01