Central Air Conditioners and Heat Pumps
Revised Life Cycle Cost Analysis

U.S. Department of Energy
June 2000

This document describes the revised life-cycle cost (LCC) analysis which was performed in response to written and oral comments provided by interested parties on the Supplemental Advance Notice of Proposed Rulemaking (SANOPR) for Central Air Conditioners and Heat Pump Energy Efficiency Standards published on November 24, 1999. In accordance with the Department's improved process for revising minimum efficiency standards, this information is presented to facilitate discussion among the interested parties before the Department issues its Notice of Proposed Rulemaking (NOPR). It appears to the Department that positive economic impacts on consumers are possible with an increased minimum efficiency standard up to 13 SEER.

1.0 Summary of Changes made to SANOPR Analysis

The revised LCC analysis is based on several changes made to the LCC analysis performed for the SANOPR. The most significant changes pertain to the revised markups (markups are used to convert from cost incurred by a manufacturer to price paid by a consumer) and the addition of replacement costs for original compressor failures. The other changes have a smaller impact on the LCC results. All of the changes made to the SANOPR analysis are summarized below and are discussed in greater detail after the presentation of the revised LCC results.

- **Baseline Manufacturer Costs:** The baseline manufacturer costs (i.e., costs associated with 10 SEER equipment) were modified slightly from those used in the SANOPR analysis. With the exception of Single Package Heat Pumps, the revised baseline manufacturer costs are lower than the costs used for the SANOPR analysis. Changes are described in the web file "Production Costs: Revisions to Reverse Engineering Analysis."

- **Standard Level Manufacturer Costs:** The manufacturer costs associated with increased efficiency levels are calculated from shipment-weighted mean manufacturer cost multipliers provided by the Air-Conditioning & Refrigeration Institute (ARI) for 11 SEER to 15 SEER equipment. The LCC calculations for the SANOPR incorporate both the ARI mean manufacturer cost figures and estimates determined through a reverse engineering analysis. In this revision, LCC calculations based on reverse engineering costs are described under LCC scenarios.

- **New Markups:** In the revised analysis it is assumed that distributors and dealers mark up their labor expenses differently from their equipment expenses. This results in equipment markups for distributors and dealers that are lower than what were used for the SANOPR analysis. Changes are described in the Revised LCC analysis web file "Estimation of the Distributor/Wholesaler and

Dealer/Contractor Markups on Incremental Central Air Conditioner and Heat Pump Costs." Changes to the SANOPR analysis which are less significant include: (1) a modest increase in the manufacturer markup and (2) the inclusion of a builder markup for those systems earmarked for the new construction market.

- **Installation Costs:** As a result of the lower markups used in the revised LCC analysis, equipment prices decreased relative to those derived for the SANOPR. Since we believe that overall installed costs (i.e., equipment price plus installation cost) determined for the SANOPR are relatively accurate, the installation costs (i.e., the costs associated with the labor to install the equipment) for the revised analysis were increased to offset the decrease in equipment prices.

- **Repair Costs:** The revised analysis assumes that the repair cost remains essentially flat up to and including equipment with efficiencies of 13 SEER and then increases in proportion to the consumer equipment price for systems with efficiencies exceeding 13 SEER. For the SANOPR analysis, the efficiency "break point" was 12 rather than 13 SEER.

- **Lifetime and Compressor Replacement Cost:** The lifetime is based on the same retirement function that was used in the SANOPR analysis. Based on the survey which was used to establish the retirement function, a systems's original compressor fails, on average, in the 14th year of the system's life. As a result, although the overall system lifetime has not been altered, the revised analysis has been modified to include a compressor replacement cost. Since more efficient systems utilize more expensive compressors, the compressor replacement costs associated with higher efficiency equipment are noticeably greater than those for baseline equipment (i.e., 10 SEER).

- **1997 Residential Energy Consumption Survey (RECS):** The revised analysis has been updated to include annual energy consumption, equipment efficiency, and electricity price data from the 1997 RECS rather than the 1993 RECS.

- **Commercial Applications:** The LCC results in the SANOPR considered only the use of central air conditioners and heat pumps in residences. The revised analysis takes into account equipment use in commercial buildings based on the assumption that 10% of equipment applications are in commercial buildings.

- **Discount Rates:** The revised analysis uses a new methodology for establishing discount rates resulting in an average value of 5.6% rather than the 6.5% value determined for the SANOPR.

2.0 Results Summary

The revised LCC analysis introduces a new concept with regard to the percentage of consumers (both residential and commercial) that are negatively impacted by an increase in the minimum efficiency standard..

(For the SANOPR, all consumers that would incur an LCC increase were considered to be adversely impacted by an increase in the standard. This included even consumers that would incur a relatively small LCC increase e.g., as small as $10, as compared to a relatively large baseline level total LCC. Note that the baseline LCC is approximately $5000 for central air conditioners and $10,000 for heat pumps.)

The revised analysis defines negative impacts by including in this category only those consumers which incur LCC increases greater than 2% of the baseline LCC. For central air conditioners, this translates to an LCC increase of approximately $100 or an annual expense of approximately $5 over the lifetime of the system. Table 1 summarizes the baseline LCCs for split system and single package central air conditioners and heat pumps and also provides the 2% threshold at which consumers are considered to be adversely impacted.

Table 1 Baseline Life-Cycle Costs and Threshold for Adverse Impacts

Product Class	Baseline Life-Cycle Cost	Threshold for Adverse Impacts: 2% of Baseline LCC
Split Air Conditioners	$5,170	$103
Split Heat Pumps	$9,679	$194
Single Package Air Conditioners	$5,629	$113
Single Package Heat Pumps	$9,626	$193

Tables 2 through 5 and Figures 1 through 8 depict the revised LCC results for split system and single package central air conditioners and heat pumps. The tables show the average LCC values for the baseline level (10 SEER), three efficiency levels (11 through 13 SEER), and the maximum technologically feasible (i.e., max tech) efficiency level (18 SEER). Note that since manufacturer cost multipliers were not available for the 18 SEER efficiency levels, 15 SEER cost multipliers were used for all 18 SEER calculations resulting in 18 SEER LCC results which underestimate their true cost level.

Tables 2 through 5 also provide for each product class the difference in LCC at each efficiency level relative to the baseline. The differences represent either an LCC savings or an LCC cost increase. In addition, each table shows the subset of consumers (both residential and commercial) at each efficiency level who are impacted in one of three ways: consumers who achieve *significant* net LCC savings (i.e., LCC savings greater than 2% of the baseline LCC), consumers who are impacted in an insignificant manner by having either a small reduction or small increase in LCC (i.e., within ±2% of the baseline LCC), or consumers who achieve a *significant* net LCC increase (i.e., an LCC increase exceeding 2% of the baseline LCC). Accompanying each percentage value is the average LCC savings or increase that corresponds to each subset of consumers. For example, in the case of the 12 SEER efficiency level for split system air conditioners (Table 2), the percentage of consumers with significant net savings is 27% and the corresponding average LCC savings for those consumers is $457.

For each product class, two figures are presented ; one showing the average LCC by efficiency level and the other showing the percentage of consumers for each efficiency level that fall within the three consumer subsets (i.e., net savings, no significant impacts, or net costs). For the figure presenting the percentage of consumers with net savings, no significant impacts, and net costs, the corresponding average LCC savings or increase is also presented.

Table 2 LCC Results for Split System Central Air Conditioners

SEER	Average LCC	Average LCC (Savings) Costs	Percent of consumers with					
			Net Savings (>2%)	Avg LCC (Save) Cost	No significant impact	Avg LCC (Save) Cost	Net Costs (>2%)	Avg LCC (Save) Cost
10	$5,170	-	-		-		-	
11	$5,126	($44)	23%	($304)	68%	($82)	9%	$127
12	$5,125	($45)	27%	($457)	34%	$17	39%	$188
13	$5,199	$29	25%	($602)	17%	$11	58%	$313
18	$5,725	$555	15%	($1,072)	4%	$6	81%	$880

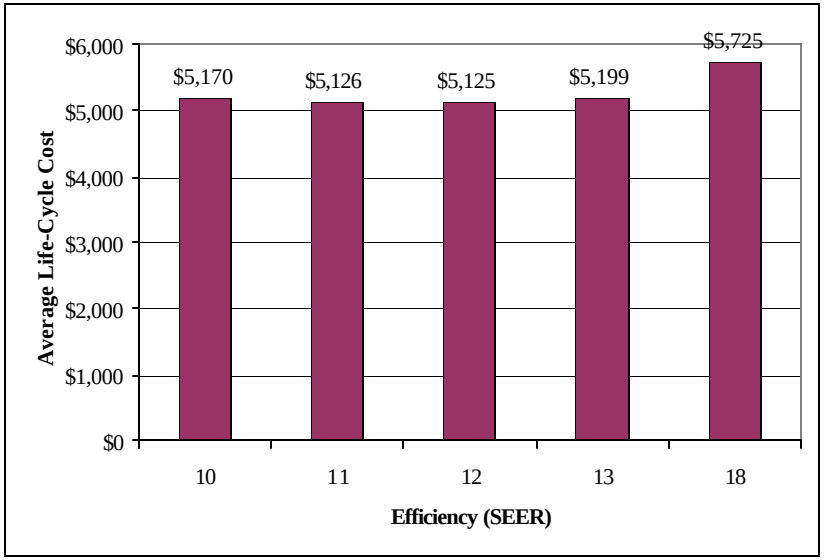

Figure 1 Average LCCs for Split System Central Air Conditioners

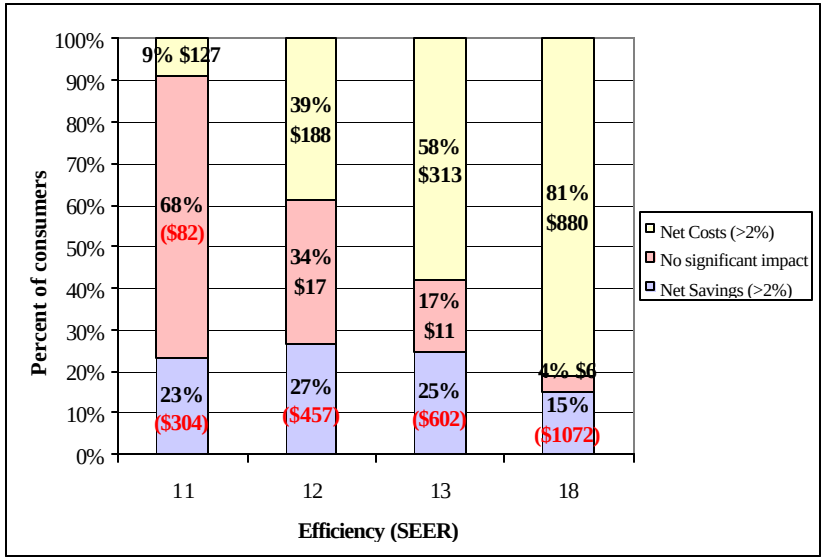

Figure 2 Percent of Split System Central A/C Consumers with Net Costs, No Significant Impacts, and Net Savings

Table 3 LCC Results for Split System Heat Pumps

SEER	Average LCC	Average LCC (Savings) Costs	Percent of consumers with					
			Net Savings (>2%)	Avg LCC (Save) Cost	No significant impact	Avg LCC (Save) Cost	Net Costs (>2%)	Avg LCC (Save) Cost
10	$9,679	-	-		-		-	
11	$9,529	($150)	30%	($44)	70%	($40)	0%	$0
12	$9,437	($242)	42%	($592)	55%	($2)	3%	$234
13	$9,464	($215)	39%	($748)	39%	$15	22%	$312
18	$9,955	$276	23%	($1,280)	11%	$20	66%	$850

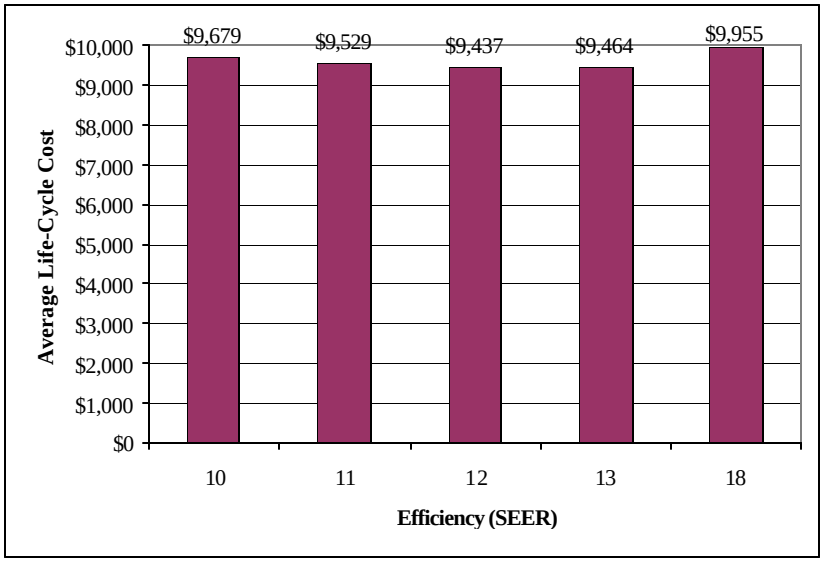

Figure 3 Average LCCs for Split System Heat Pumps

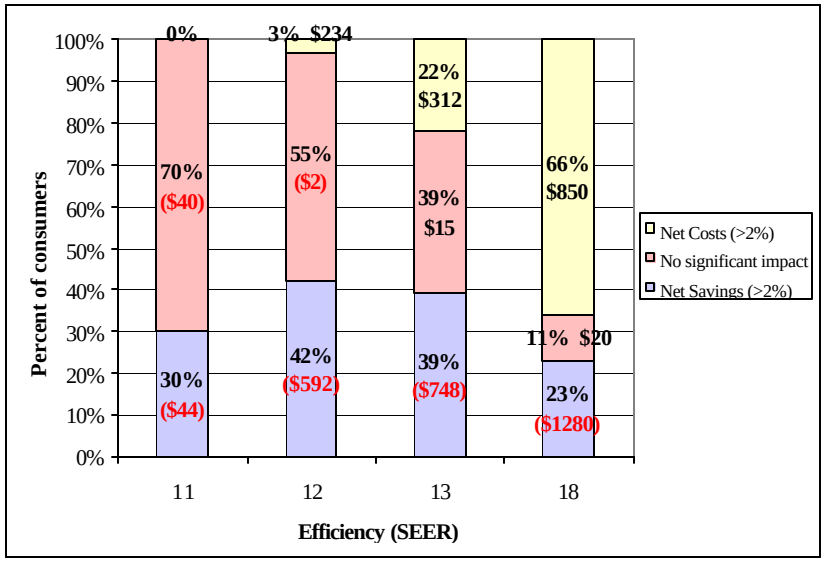

Figure 4 Percent of Split System Heat Pump Consumers with Net Costs, No Significant Impacts, and Net Savings

Table 4 LCC Results for Single Package Central Air Conditioners

SEER	Average LCC	Average LCC (Savings) Costs	Percent of consumers with					
			Net Savings (>2%)	Avg LCC (Save) Cost	No significant impact	Avg LCC (Save) Cost	Net Costs (>2%)	Avg LCC (Save) Cost
10	$5,629	-	-		-		-	
11	$5,649	$20	16%	($318)	47%	$31	37%	$157
12	$5,600	($29)	26%	($482)	30%	$18	44%	$206
13	$5,804	$175	18%	($660)	11%	$10	71%	$413
18	$6,370	$741	12%	($1,147)	4%	$10	84%	$1,052

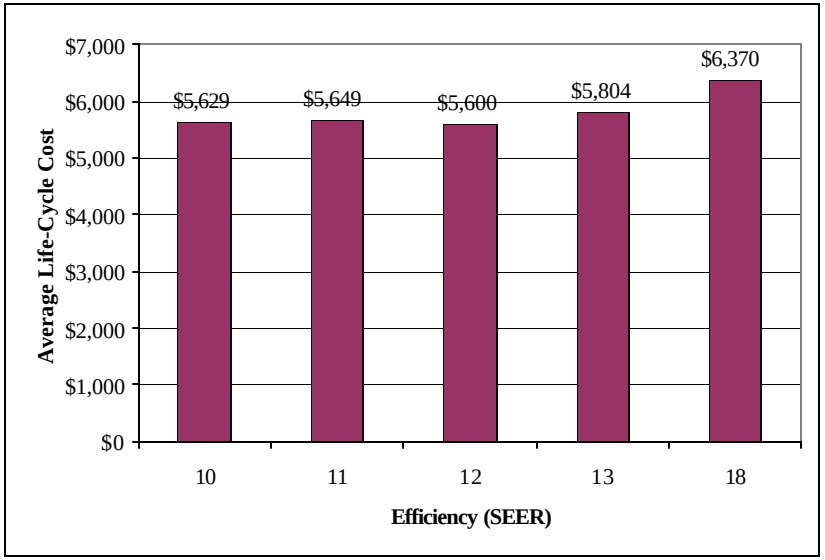

Figure 5 **Average LCCs for Single Package Central Air Conditioners**

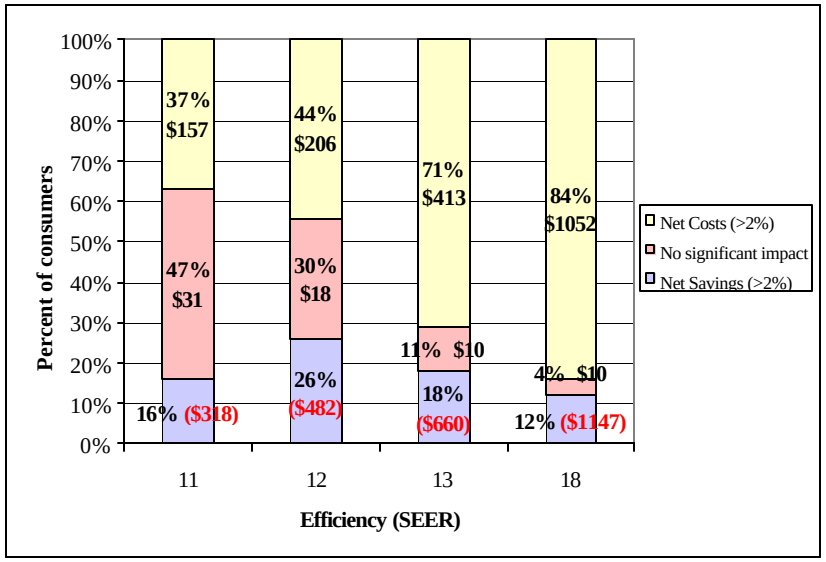

Figure 6 **Percent of Single Package Central A/C Consumers with Net Costs, No Significant Impacts, and Net Savings**

Table 5 LCC Results for Single Package Heat Pumps

SEER	Average LCC	Average LCC (Savings) Costs	Percent of consumers with					
			Net Savings (>2%)	Avg LCC (Save) Cost	No significant impact	Avg LCC (Save) Cost	Net Costs (>2%)	Avg LCC (Save) Cost
10	$9,626	-	-		-		-	
11	$9,492	($134)	28%	($431)	72%	($19)	0%	$213
12	$9,372	($254)	44%	($623)	49%	($1)	7%	$256
13	$9,514	($112)	33%	($810)	31%	$19	36%	$407
18	$9,922	$296	24%	($1,342)	10%	$15	66%	$936

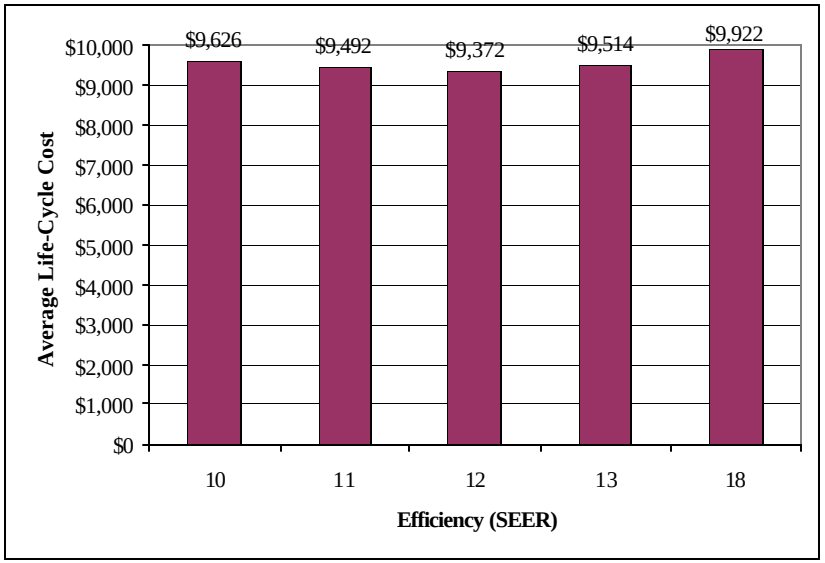

Figure 7 Average LCCs for Single Package Heat Pumps

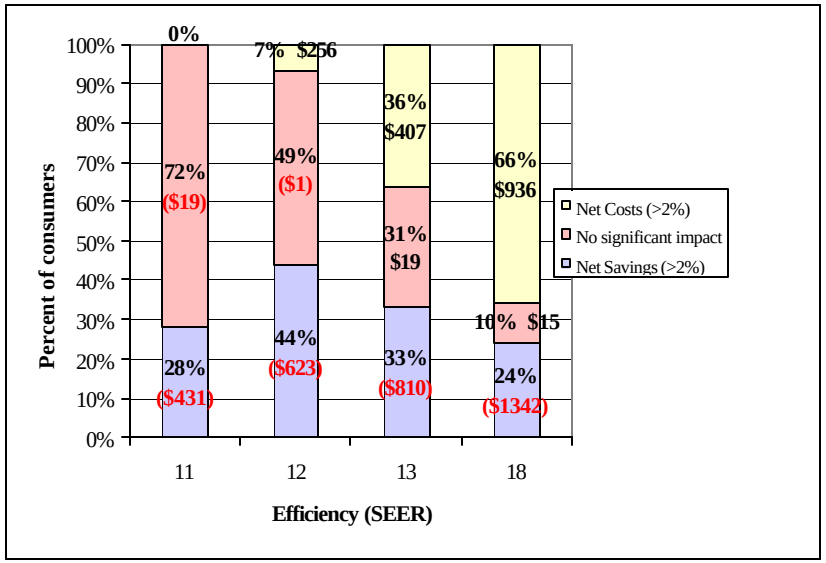

Figure 8 Percent of Single Package Heat PumpConsumers with Net Costs, No Significant Impacts, and Net Savings

LCC Scenarios

The Department received a number of comments which recommended re-evaluation of two key assumptions for the LCC analysis: manufacturer costs and system lifetime. These comments suggested that values assumed for both factors may be overestimated. Thus, we investigate two scenarios where lower estimates of the manufacturer costs and system lifetime are analyzed.

Manufacturer Cost Scenario

Although manufacturer costs are only one of several inputs to the LCC analysis, they are one of the few input variables where strong sentiments were expressed that industry-provided cost estimates were overstated. Several comments suggested that once a new standard takes effect, competitive pressures would likely force manufacturers to produce equipment at costs lower than the shipment-weighted mean estimates provided by ARI.

To provide balance for this issue, we consider an LCC scenario in which manufacturer cost estimates based on the revised reverse engineering analysis are substituted for the estimates provided by ARI. Table 6 compares the ARI shipment-weighted mean and reverse engineering mean manufacturer cost multipliers.

Table 6 ARI Shipment-Weighted Mean and Revised Reverse Engineering Mean Manufacturer Cost Multipliers

	Product Class							
Efficiency Level	**Split A/C**		**Split Heat Pump**		**Package A/C**		**Package Heat Pump**	
SEER	ARI	Rev Eng	ARI	Rev Eng	ARI	Rev Eng	ARI	Rev Eng
11	1.16	1.12	1.10	1.05	1.19	1.09	1.25	1.08
12	1.36	1.28	1.24	1.13	1.30	1.16	1.50	1.13
13	1.63	1.44	1.44	1.30	1.63	1.43	1.90	1.38
18[a]	2.40	1.99	2.09	1.94	2.23	1.87	2.47	1.86

[a] Cost Multipliers for 18 SEER based on data for 15 SEER.

Tables 7 through 10 and Figures 9 through 16 show the LCC results for each of the product classes under the scenario of replacing the ARI manufacturer cost estimates with those from the reverse engineering analysis. The following results are presented in the same manner as the previous LCC results where average LCC savings or costs and the percentage of consumers with net savings, insignificant impacts, and net costs are presented for each efficiency level. Note that since manufacturer cost multipliers were not available for the 18 SEER efficiency levels, 15 SEER cost multipliers were used for all 18 SEER calculations resulting in 18 SEER LCC results which underestimate their true cost level.

Table 7 LCC Results for Split System A/C – LCC Scenario with Reverse Engineering Manufacturer Costs

SEER	Average LCC	Average LCC (Savings) Costs	Percent of consumers with					
			Net Savings (>2%)	Avg LCC (Save) Cost	No significant impact	Avg LCC (Save) Cost	Net Costs (>2%)	Avg LCC (Save) Cost
10	$5,170	-	-		-		-	
11	$5,095	($75)	28%	($305)	70%	($10)	2%	$118
12	$5,057	($113)	35%	($453)	40%	$18	25%	$158
13	$5,057	($113)	34%	($589)	27%	$11	39%	$217
18	$5,307	$137	25%	($1,045)	7%	$5	68%	$584

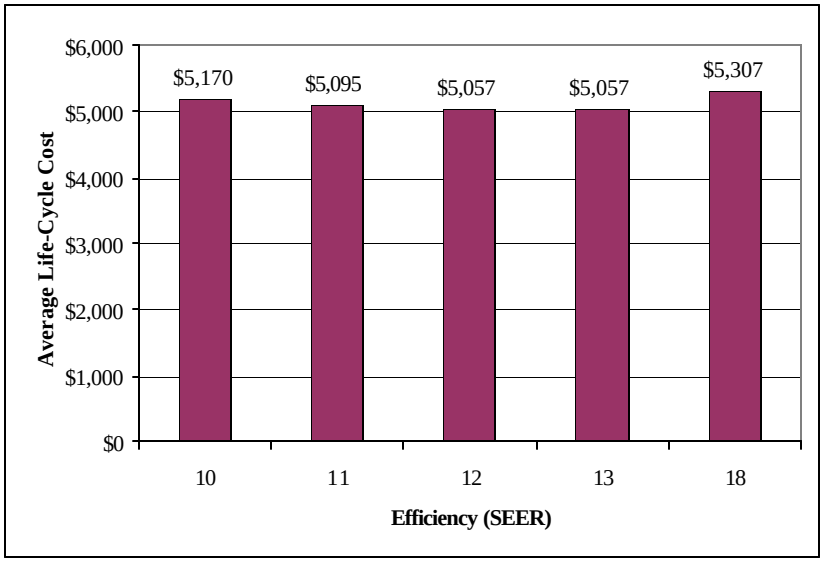

Figure 9 Average LCCs for Split A/C – LCC Scenario with Rev Eng Manufacturer Costs

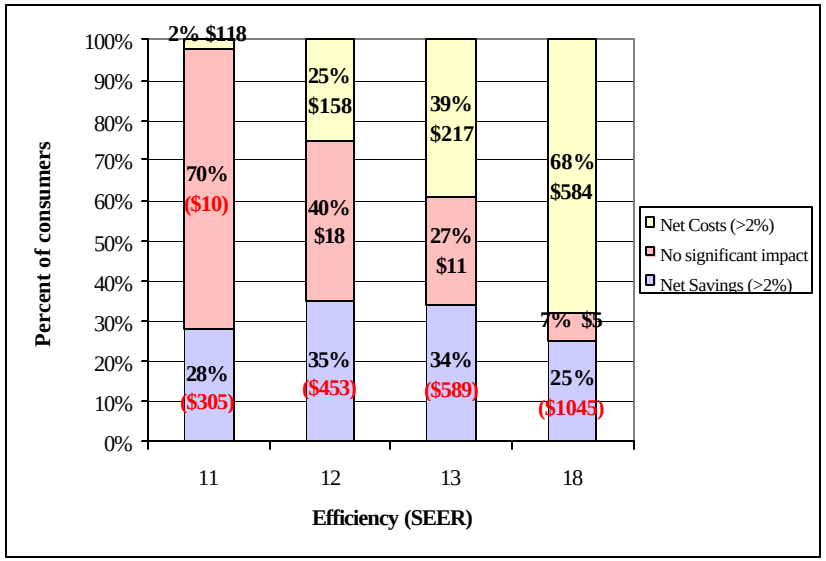

Figure 10 Percent of Split A/C Consumers with Net Costs, No Significant Impacts, and Net Savings – LCC Scenario with Rev Eng Manufacturer Costs

Table 8 LCC Results Split System Heat Pump – LCC Scenario with Reverse Engineering Manufacturer Costs

SEER	Average LCC	Average LCC (Savings) Costs	Percent of consumers with					
			Net Savings (>2%)	Avg LCC (Save) Cost	No significant impact	Avg LCC (Save) Cost	Net Costs (>2%)	Avg LCC (Save) Cost
10	$9,679	-	-		-		-	
11	$9,470	($209)	40%	($409)	60%	($77)	0%	$0
12	$9,314	($365)	58%	($591)	42%	($58)	0%	$216
13	$9,307	($372)	52%	($742)	42%	($2)	6%	$259
18	$9,720	$41	28%	($1,295)	15%	$11	57%	$712

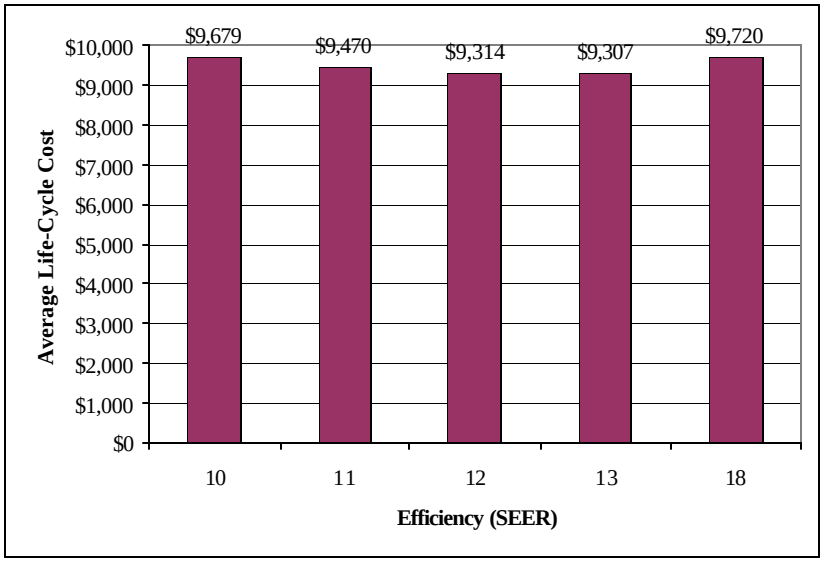

Figure 11 **Average LCCs for Split HP – LCC Scenario with Rev Eng Manufacturer Costs**

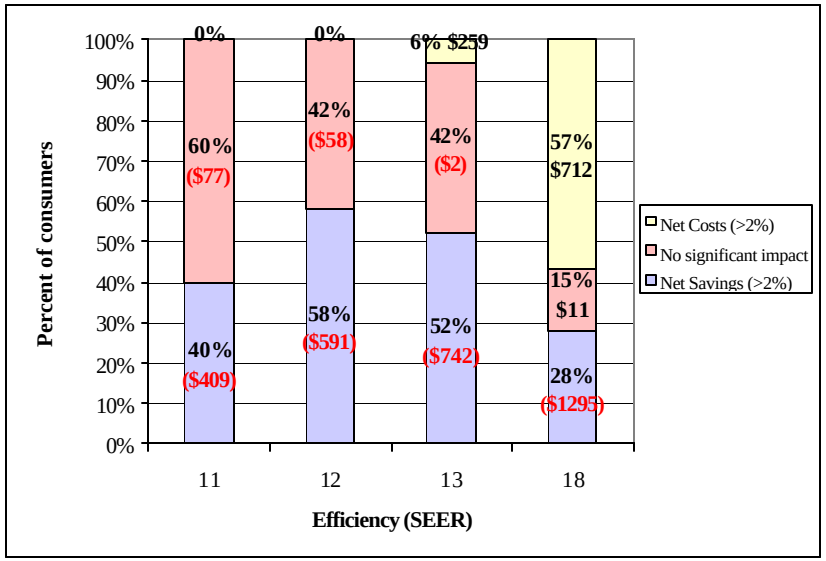

Figure 12 **Percent of Split HP Consumers with Net Costs, No Significant Impacts, and Net Savings – LCC Scenario with Rev Eng Manufacturer Costs**

Table 9 LCC Results for Single Package A/C – LCC Scenario with Reverse Engineering Manufacturer Costs

SEER	Average LCC	Average LCC (Savings) Costs	Percent of consumers with					
			Net Savings (>2%)	Avg LCC (Save) Cost	No significant impact	Avg LCC (Save) Cost	Net Costs (>2%)	Avg LCC (Save) Cost
10	$5,629	-	-		-		-	
11	$5,551	($78)	27%	($313)	72%	$9	1%	$120
12	$5,466	($163)	40%	($460)	51%	$13	9%	$140
13	$5,600	($29)	28%	($632)	20%	$16	52%	$275
18	$5,905	$276	21%	($1,101)	6%	$8	73%	$690

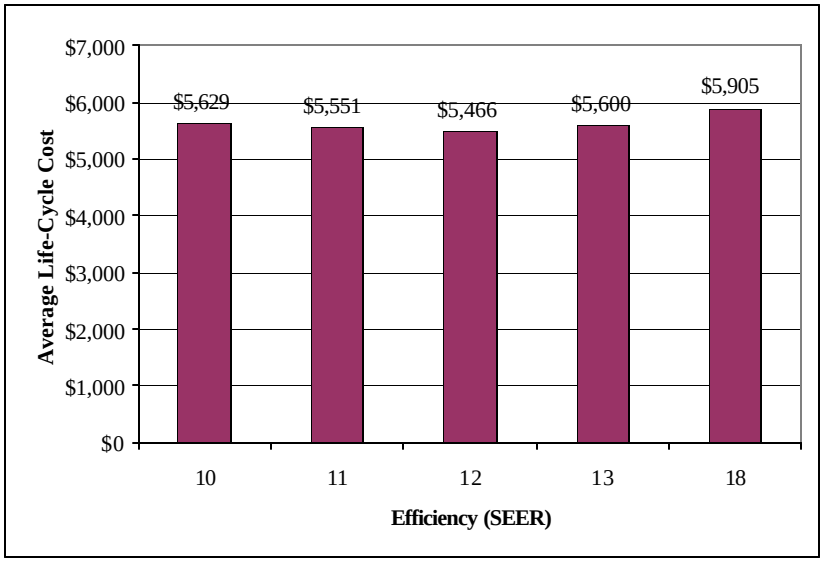

Figure 13 Average LCCs for Single Package A/C – LCC Scenario with Rev Eng Manufacturer Costs

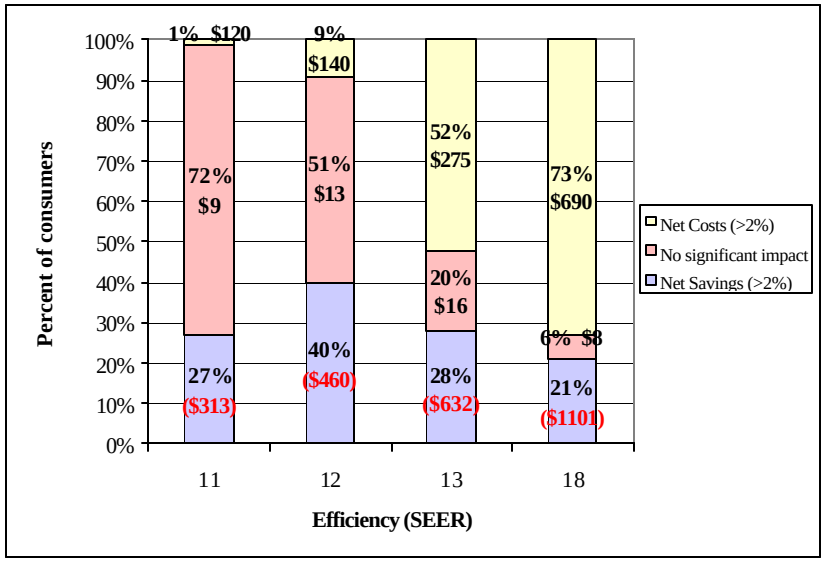

Figure 14 Percent of Single Package A/C Consumers with Net Costs, No Significant Impacts, and Net Savings – LCC Scenario with Rev Eng Manufacturer Costs

Table 10 LCC Results for Single Package HP – LCC Scenario with Reverse Engineering Manufacturer Costs

SEER	Average LCC	Average LCC (Savings) Costs	Percent of consumers with					
			Net Savings (>2%)	Avg LCC (Save) Cost	No significant impact	Avg LCC (Save) Cost	Net Costs (>2%)	Avg LCC (Save) Cost
10	$9,626	-	-		-		-	
11	$9,419	($207)	39%	($426)	61%	($65)	0%	$0
12	$9,205	($421)	66%	($606)	34%	($62)	0%	$214
13	$9,273	($353)	50%	($775)	38%	($1)	12%	$299
18	$9,460	($166)	37%	($1,344)	15%	$13	48%	$683

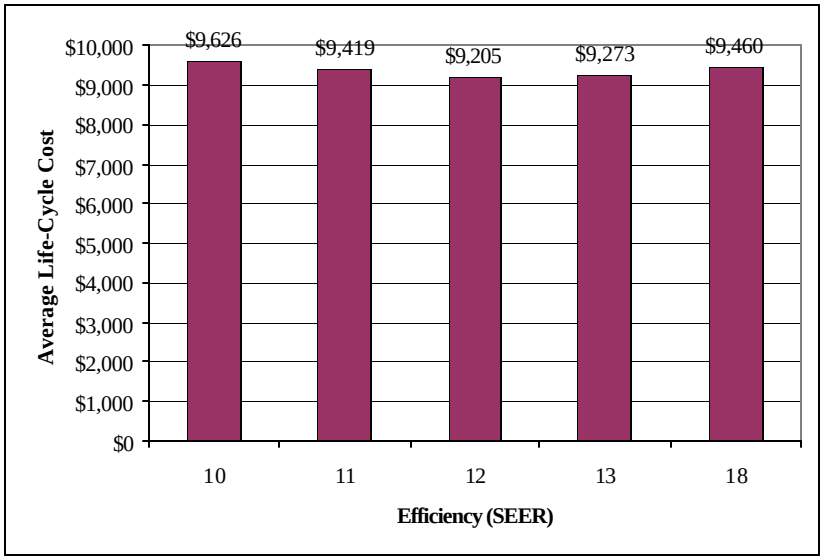

Figure 15 Average LCCs for Single Package HP – LCC Scenario with Rev Eng Manufacturer Costs

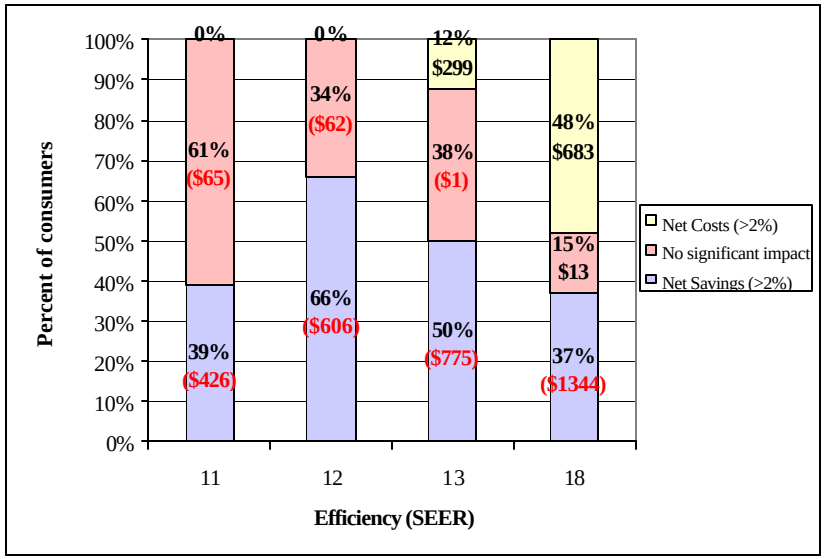

Figure 16 Percent of Single Package HP Consumers with Net Costs, No Significant Impacts, and Net Savings – LCC Scenario with Rev Eng Manufacturer Costs

Lifetime Scenario

Several comments suggested that the 18 year unit life used in the SANOPR analysis is too long and instead a 15 or even a 12 year life should be used. Another comment argued that when a major component breaks, the equipment is often repaired and its life extended. It is this extended life, where applicable, that is included in the analysis. The Department determined that the detailed published field study from which an 18 year lifetime was established also concluded that most heat pump owners extend the equipment's lifetime by replacing a compressor. But in order to investigate the impact of shorter equipment life, a lifetime scenario is considered based on a retirement function yielding an average lifetime of 14 years in which no compressor replacement occurs.

Tables 11 through 14 and Figures 17 through 24 show the LCC results for each of the product classes under the 14 year lifetime, no compressor replacement scenario. The following results are presented in the same manner as the previous LCC results where average LCC savings or costs and the percentage of consumers with net savings, insignificant impacts, and net costs are presented for each efficiency level. Note that since manufacturer cost multipliers were not available for the 18 SEER efficiency levels, 15 SEER cost multipliers were used for all 18 SEER calculations resulting in 18 SEER LCC results which underestimate their true cost level.

Table 11 LCC Results for Split System A/C – LCC Scenario with 14 year average Lifetime

SEER	Average LCC	Average LCC (Savings) Costs	Percent of consumers with					
			Net Savings (>2%)	Avg LCC (Save) Cost	No significant impact	Avg LCC (Save) Cost	Net Costs (>2%)	Avg LCC (Save) Cost
10	$4,682	-	-		-		-	
11	$4,650	($32)	22%	($252)	69%	$20	9%	$113
12	$4,672	($10)	24%	($392)	31%	$16	45%	$178
13	$4,769	$87	21%	($498)	15%	$14	64%	$296
18	$5,336	$654	12%	($928)	3%	$11	85%	$893

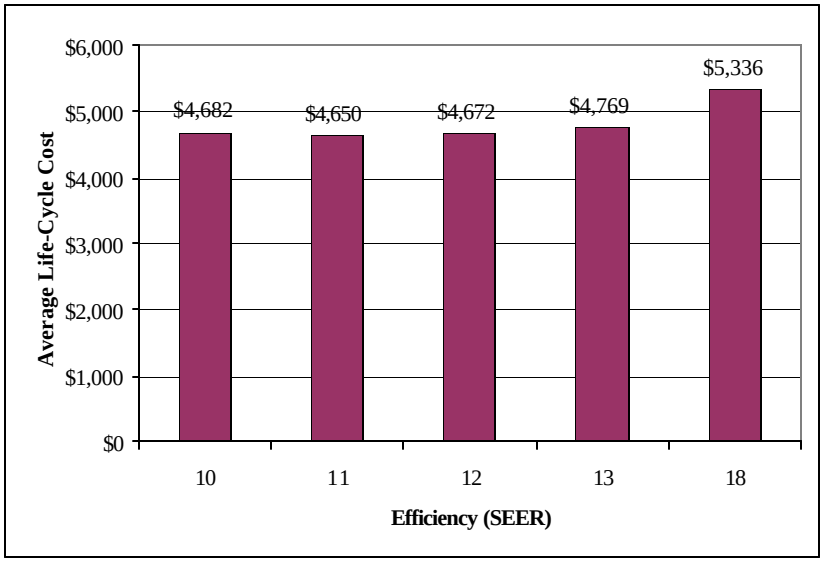

Figure 17 **Average LCCs for Split A/C – LCC Scenario with 14 year average Lifetime**

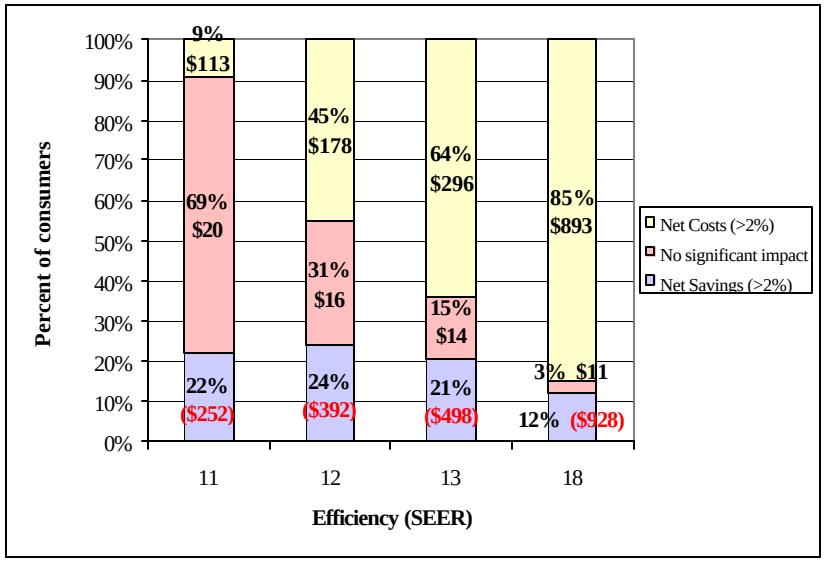

Figure 18 **Percent of Split A/C Consumers with Net Costs, No Significant Impact, and Net Savings – LCC Scenario with 14 year average Lifetime**

Table 12 LCC Results for Split System Heat Pump – LCC Scenario with 14 year average Lifetime

SEER	Average LCC	Average LCC (Savings) Costs	Percent of consumers with					
			Net Savings (>2%)	Avg LCC (Save) Cost	No significant impact	Avg LCC (Save) Cost	Net Costs (>2%)	Avg LCC (Save) Cost
10	$8,747	-	-		-		-	
11	$8,623	($124)	27%	($362)	73%	($33)	0%	$0
12	$8,587	($160)	35%	($505)	58%	$9	7%	$214
13	$8,630	($117)	33%	($645)	37%	$16	30%	$300
18	$9,184	$437	18%	($1,079)	9%	$11	73%	$862

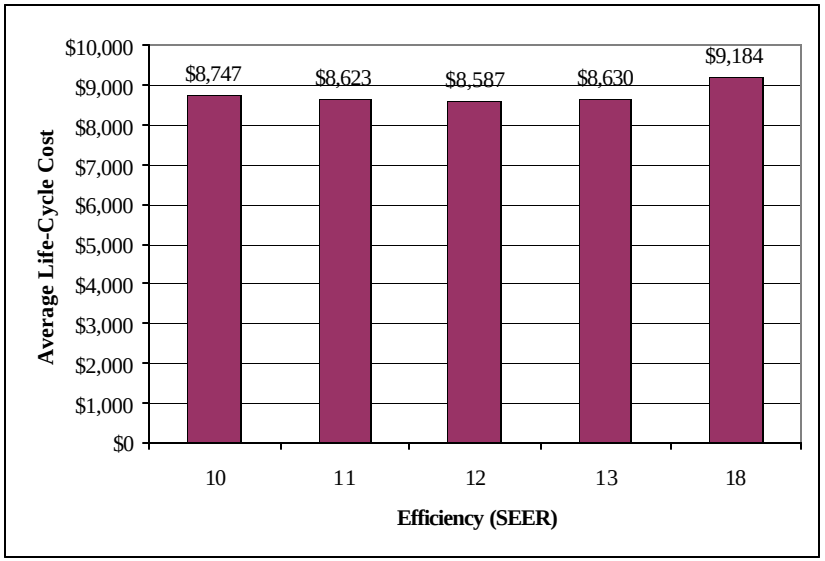

Figure 19 **Average LCCs for Split HP – LCC Scenario with 14 year average Lifetime**

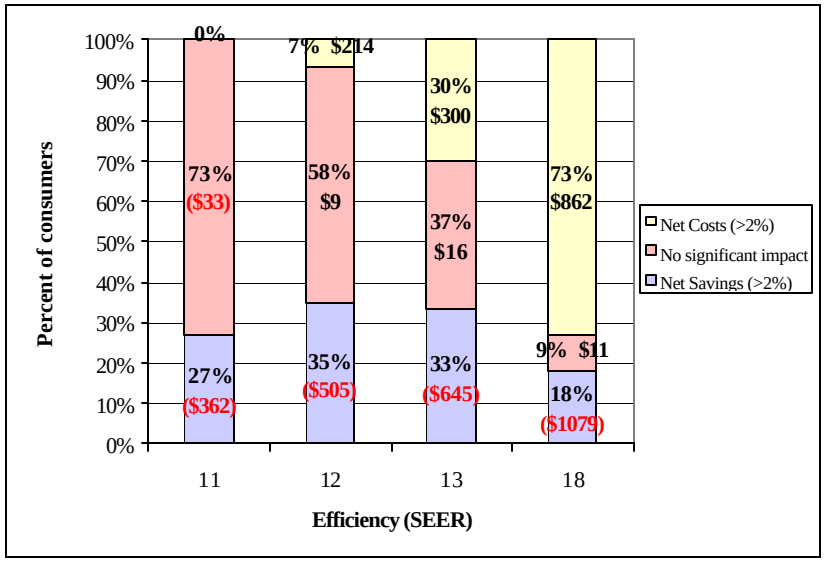

Figure 20 **Percent of Split HP Consumers with Net Costs, No Significant Impacts, and Net Savings – LCC Scenario with 14 year average Lifetime**

Table 13 LCC Results for Single Package A/C – LCC Scenario with 14 year average Lifetime

SEER	Average LCC	Average LCC (Savings) Costs	Percent of consumers with					
			Net Savings (>2%)	Avg LCC (Save) Cost	No significant impact	Avg LCC (Save) Cost	Net Costs (>2%)	Avg LCC (Save) Cost
10	$5,150	-	-		-		-	
11	$5,182	$32	14%	($286)	46%	$31	40%	$144
12	$5,157	$7	22%	($428)	29%	$18	49%	$199
13	$5,378	$228	14%	($564)	10%	$12	76%	$406
18	$6,011	$861	9%	($953)	3%	($4)	88%	$1,082

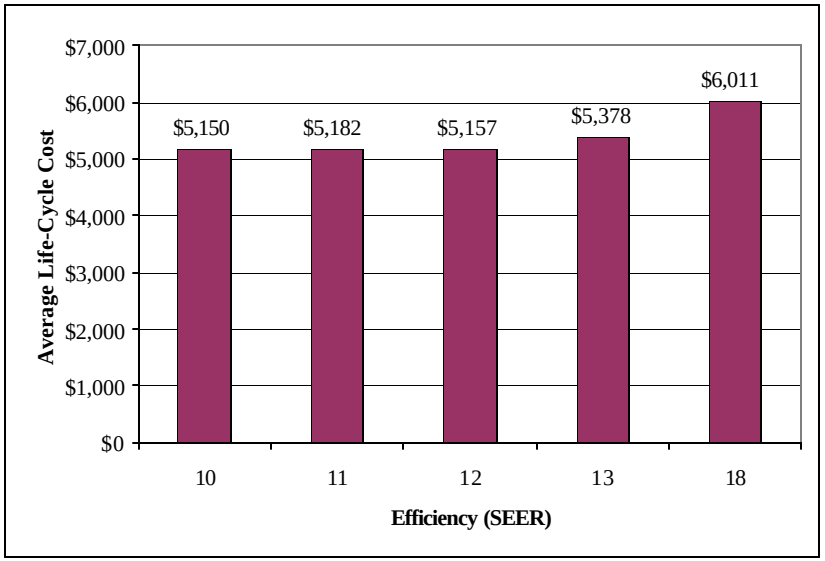

Figure 21 Average LCCs for Single Package A/C – LCC Scenario with 14 year average Lifetime

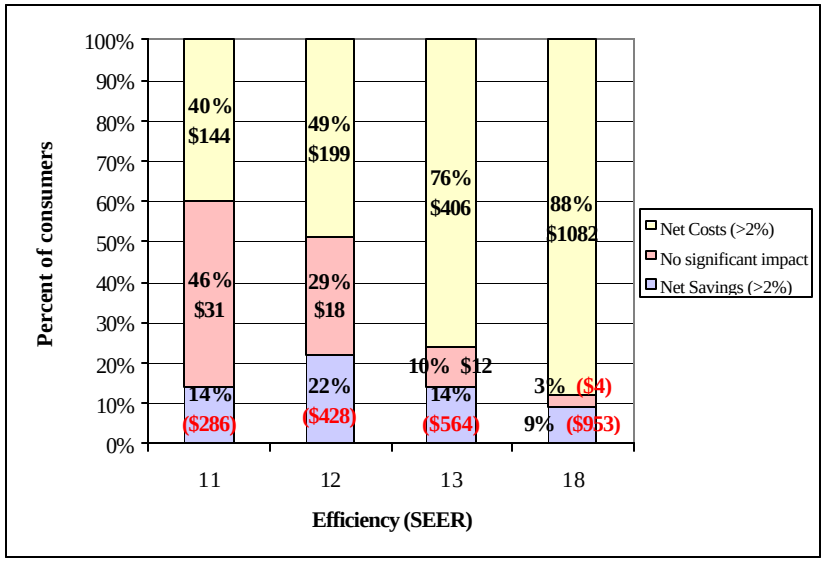

Figure 22 Percent of Single Package A/C Consumers with Net Costs, No Significant Impact, and Net Savings – LCC Scenario with 14 year average Lifetime

Table 14 LCC Results for Single Package Heat Pump – LCC Scenario with 14 year avenge Lifetime

SEER	Average LCC	Average LCC (Savings) Costs	Percent of consumers with					
			Net Savings (>2%)	Avg LCC (Save) Cost	No significant impact	Avg LCC (Save) Cost	Net Costs (>2%)	Avg LCC (Save) Cost
10	$8,695	-	-		-		-	
11	$8,597	($98)	25%	($369)	75%	($11)	0%	$185
12	$8,528	($167)	37%	($533)	51%	$8	12%	$236
13	$8,707	$12	26%	($687)	27%	$18	47%	$399
18	$9,179	$484	18%	($1,146)	8%	$14	74%	$933

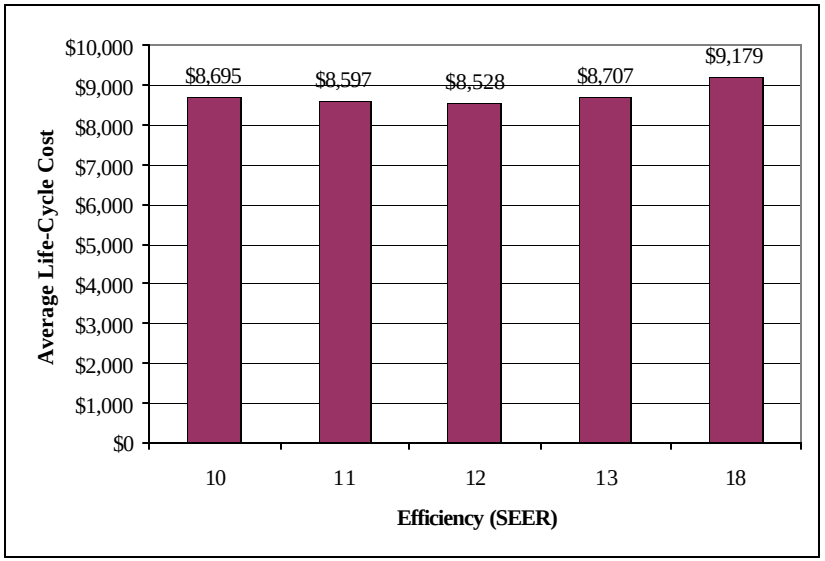

Figure 23 Average LCCs for Single Package HP – LCC Scenario with 14 year average Lifetime

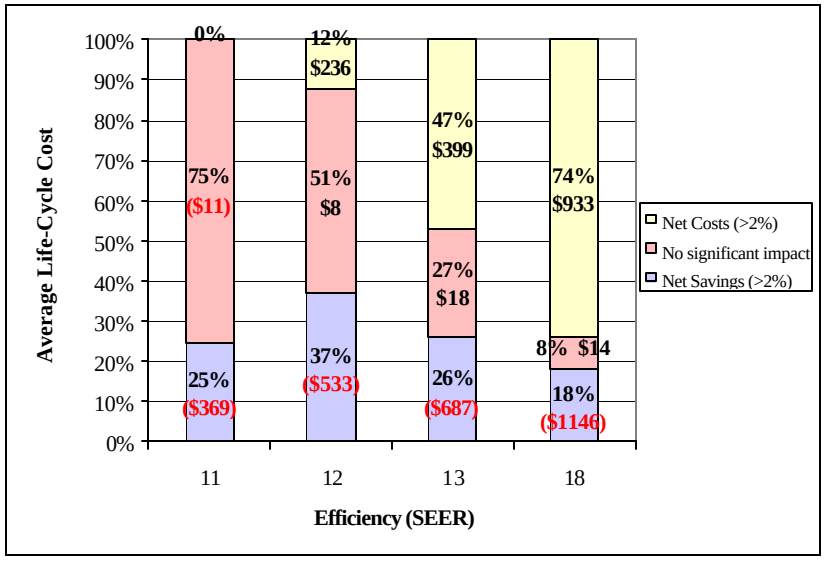

Figure 24 Percent of Single Package HP Consumers with Net Costs, No Significant Impacts, and Net Savings – LCC Scenario with 14 year average Lifetime

3.0 Details of Changes to SANOPR Analysis

The following provides a detailed explanation of the changes made to the SANOPR LCC analysis on which the revised LCC analysis was based.

Baseline Manufacturer Costs

After publication of the SANOPR, the reverse engineering analysis was revised to estimate new baseline costs and efficiency cost multipliers for split and packaged heat pumps and packaged air conditioners. New estimates for those classes were derived from the split air conditioner results and knowledge of the similarities and differences across classes. This revision produced slightly different baseline manufacturer cost estimates than were used in the SANOPR analysis. Table 15 summarizes the new costs. For comparison purposes, the baseline manufacturer costs which were used in the SANOPR are also provided.

Table 15 Baseline Manufacturer Costs – Revised Analysis vs. SANOPR

Product	Revised Analysis	SANOPR
Split System A/C - Case Coil	$367	$367
Split System A/C - Fan Coil	$449	$454
Split System Heat Pump	$572	$615
Single Package A/C	$511	$534
Single Package Heat Pump	$593	$589

Standard Level Manufacturer Costs

The Department obtained numerous comments and recommendations over what set of manufacturer cost estimates should be used to represent the cost increases associated with increased equipment efficiency. Manufacturers, their trade association (ARI), and some electric utilities believe that the shipment-weighted mean manufacturer costs provided by ARI are the most representative costs. On the other hand, many non-industry organizations including the American Council for an Energy Efficiency Economy (ACEEE), the Natural Resources Defense Council (NRDC), the Northwest Power Planning Council (NPPC), the Oregon Office of Energy (OOE), the Vermont Energy Investment Corp. (VEIC), the California Energy Commission (CEC), and Pacific Gas & Electric Company (PG&E) argue that manufacturer costs should be based on the Department's reverse engineering analysis, which yields lower values than those provided by the industry.

During the SANOPR, the Department conducted the reverse engineering analysis for the purposes of developing: a) baseline manufacturer costs for current minimum efficiency equipment; and b) cost multipliers for higher efficiency equipment assuming a new standard. The product of the baseline cost and each cost multiplier would establish the Department's estimated cost to produce equipment at each efficiency level

assuming that level was the revised standard. A further objective of the reverse engineering analysis was to validate the cost multipliers provided by ARI. The product of the reverse engineering baseline cost and each ARI cost multiplier established the industry's estimated production costs under each potential new standard.

ARI provided a range of cost multipliers consisting of minimum, maximum and shipment weighted mean values at each efficiency level. The estimated production costs derived from the reverse engineering approach were lower than the mean values from ARI, and greater than the minimum values from ARI.

Given (1) the uncertainty associated with the baseline costs and cost multipliers from the reverse engineering analysis, (2) the variability of the ARI cost multipliers, (3) the substantial proportion of manufacturers represented by the ARI mean values, and (4) the overlap between the ARI minimum and mean and the reverse engineering cost multipliers, the Department concluded there was sufficient agreement between the two approaches to conduct the revised analyses using the production cost estimates based on the ARI mean cost multipliers. The LCC results based on reverse engineering manufacturing costs, were presented previously, are considered an LCC scenario.

Table 16 provides the ARI and reverse engineering manufacturer costs by product class for each of the efficiency levels under review. Manufacturer costs are obtained by multiplying the baseline manufacturer costs given in Table 15 by the appropriate manufacturer cost multiplier in Table 6. It is important to note that since neither ARI or the reverse engineering analysis provided manufacturer cost multipliers for the 18 SEER efficiency level, cost multipliers associated with the highest efficiency level which data were provided (i.e., 15 SEER) were used as a proxy.

Table 16 ARI Shipment-Weighted Mean and Reverse Engineering Mean Manufacturer Costs

Efficiency Level	Product Class							
	Split A/C		Split Heat Pump		Package A/C		Package Heat Pump	
SEER	ARI	Rev Eng	ARI	Rev Eng	ARI	Rev Eng	ARI	Rev Eng
11	1.16	1.12	1.10	1.05	1.19	1.09	1.25	1.08
12	1.36	1.28	1.24	1.13	1.30	1.16	1.50	1.13
13	1.63	1.44	1.44	1.30	1.63	1.43	1.90	1.38
18[a]	2.40	1.99	2.09	1.94	2.23	1.87	2.47	1.86

[a] Cost Multipliers for 18 SEER based on data for 15 SEER.

Markups

The comments submitted with regard to markups came mainly from such non-industry organizations as ACEEE, NRDC, VEIC, CEC and NPPC. Most comments focused on two issues: 1) the magnitude of

the dealer/contractor markup and 2) the need for including a builder markup for systems destined for the new construction market. Based on these comments we reconsidered all the markups (manufacturer, distributor, dealer/contractor, builder, and sales taxes) to determine if the values used in the SANOPR were appropriate.

The most significant changes pertain to the distributor and dealer/contractor markups. In reviewing these markups, state-by-state financial data from the U.S. Census Bureau, 1997 Economic Census were analyzed. The analysis consisted of disaggregating the average markups used in the SANOPR analysis into two components: one pertaining to equipment and materials and the other pertaining to labor. After that, the markup associated with an incremental change in equipment price (e.g., a price change that could arise from the imposition of a new minimum efficiency standard) was derived. The resulting markups are significantly lower than those which were used in the SANOPR. For more details on this analysis please refer to the *Revised Markup Analysis* on DOE's web site.

Each markup is briefly discussed below and its new value or range of values are presented.

Manufacturer Markup

For the revised analysis, another manufacturer was included for the determination of the weighted-average manufacturer markup. Because this additional manufacturer has a higher average markup than those manufacturers considered in the SANOPR, the revised weighted-average value is now 1.23, as opposed to the weighted-average value of 1.18 used in the SANOPR..

Distributor Markup

As discussed above, the distributor markup has been revised based on an analysis of wholesaler financial data from the U.S. Census Bureau, 1997 Economic Census. The analysis was verified with financial data from the *1998 Wholesaler PROFIT Survey Report* prepared by the Air-conditioning & Refrigeration Wholesalers Association (ARW). For more details on this analysis, please refer to the *Revised Markup Analysis* on DOE's web site.

The SANOPR analysis determined an average distributor markup of 1.37 which covered both labor- and equipment-related expenses at the baseline efficiency level (i.e., 10 SEER). The revised analysis confirmed this value but deconstructed the average markup to derive a value specifically for the markup on incremental changes in equipment price. The revised analysis yields a range of values for this markup, which can be represented with a near normal distribution that has an average value of 1.09 with minimum and maximum values of 1.03 and 1.16, respectively. This distribution is used in the revised analysis to represent the distributor's markup on those equipment cost increases associated with an increase in equipment efficiency. Thus, for efficiencies beyond the baseline level, the markup on equipment is essentially composed of two portions: the average markup that is applied to the "base" portion (i.e., expenses associated with cost levels corresponding to baseline equipment costs) and the marginal markup

that is applied to the incremental change in equipment cost. As a result of applying different markups to the "base" and "incremental" portions of the equipment cost, the aggregate markup decreases slightly with increasing efficiency. In the case of split system air conditioners, the aggregate markups are 1.33 at 11 SEER, 1.30 at 12 SEER, and 1.26 at 13 SEER.

Dealer/Contractor Markup

As discussed above, the dealer/contractor markup was revised in a fashion similar to the distributor markup based on an analysis of contractor financial data from the U.S. Census Bureau, 1997 Economic Census. The analysis was verified with financial data from the 1995 edition of the *Financial Analysis for the HVACR Contracting Industry* prepared by the Air Conditioning Contractors of America (ACCA). For more details on the analysis, please refer to the *Revised Markup Analysis* on DOE's web site.

A range of values was used in the SANOPR analysis to represent the dealer/contractor markup. The mean value from this distribution was 1.55. This markup was an average value which covered both labor-related and equipment-related expenses. The revised analysis confirmed this mean value but deconstructed the average markup to derive a value specifically for covering incremental changes in the equipment price. The revised analysis yields a range of values that can be represented with a near normal distribution which has an average value of 1.27 with minimum and maximum values of 1.05 and 1.48, respectively. This distribution is used in the revised analysis to represent the dealer/contractor's markup on those equipment cost increases associated with an increase in equipment efficiency.

Builder Markup

The SANOPR did not explicitly account for builder markups, i.e., markups by builders, developers, or general contractors for equipment installed in new construction. The revised analysis now explicitly accounts for this markup. A uniform distribution of values was determined ranging from a minimum of 1.20 to a maximum of 1.32. It is important to reiterate that the builder markup pertains only to equipment destined for the new construction market. The replacement/retrofit market includes no such markup (i.e., the builder markup is for practical purposes 1.0 for this market). Based on data from the Air-Conditioning, Heating, and Refrigeration News (Dec. 12, 1998), approximately 34% of sales are to the new construction market. Thus, using an average builder markup of 1.26, the weighted-average builder markup covering the entire central air-conditioning market is 1.09 (1.26*34% + 1.00*66%).

Sales Taxes

Sales tax rates for the revised analysis remained unchanged from those used in the SANOPR. A distribution of values ranging from 5% to 8% were used with a weighted-average value of 6.7%. However, since equipment earmarked for the new construction market were assumed to incur no sales taxes, the weighted-average sales tax covering the entire central air-conditioning market is 4.4% (0%*34% + 6.7%*66%).

Overall Markup

Table 17 presents the weighted-average manufacturer, distributor, dealer/contractor, and builder markups as well as the weighted-average sales tax that are used in the revised analysis. For comparison purposes, the weighted-average markups used in the SANOPR are also presented. It is important to note that even though weighted-average values are shown in Table 17, a distribution of markup and sales tax values are actually used in the revised analysis. The overall markup that is derived from multiplying the individual markups and the sales tax is presented at the bottom of Table 17.

Table 17 Weighted-Average Markups and Sales Tax – Revised Analysis vs. SANOPR

Type	Revised Analysis Markup	SANOPR Markup
Manufacturer Markup	1.23	1.18
Wholesaler/Distributor Markups[a]		
10 SEER	1.37	1.37
11 SEER	1.33[b]	
12 SEER	1.30[b]	
13 SEER	1.26[b]	
18 SEER	1.21[b]	
Dealer/Contractor	1.27	1.55
Builder Markup	1.09[c]	1.00[d]
Sales Tax	1.04[c]	1.07[e]
Overall Markup[a]		
10 SEER	2.42	2.68
11 SEER	2.36	2.68
12 SEER	2.30	2.68
13 SEER	2.24	2.68
18 SEER	2.14	2.68

[a] Distributor and Overall Markups are presented only for split system air conditioners. The markups are essentially identical for the other product classes.

[b] Markups are an aggregate value consisting of a "base" markup of 1.37 that covers baseline expenses and an "incremental" markup of 1.09 covering the incremental increase in equipment price.

[c] Weighted-average markups representing both the new construction and replacement markets.

[d] For the SANOPR, builder markups were not considered.

[e] For the SANOPR, sales taxes representing only the replacement market were used.

Installation Cost

Due to the lower overall markup used in the revised analysis, the consumer equipment price for baseline equipment (i.e, 10 SEER) decreased relative to the price used in the SANOPR. Since we believe that overall installed costs (i.e., equipment price plus installation cost) determined for the SANOPR for baseline equipment are relatively accurate, the installation costs (i.e., the costs associated with the labor to install the equipment) for the revised analysis were increased to offset the decrease in equipment prices.

As was done for the SANOPR, the same installation cost is used for split and single package equipment. Also like the SANOPR, a range of installation cost values is used in the revised analysis. The range of values is represented by a triangular distribution with a minimum value equal to 80% of the mean and a maximum value equal to 120% of the mean.

Table 18 presents the weighted-average revised baseline installation, equipment, and total installed costs for each product class. For comparison purposes, the weighted-average cost values from the SANOPR are also reported. As was assumed in the SANOPR, it is important to note that the installation cost remains constant with increased efficiency.

Table 18 Weighted-Average Baseline Equipment: Installation, Equipment, and Total Installed Costs – Revised Analysis vs. SANOPR

	Revised Analysis			SANOPR*		
Product Class	**Installation Cost**	**Equipment Price**	**Total Installed Cost**	**Installation Cost**	**Equipment Price**	**Total Installed Cost**
Split A/C	$1,279	$957	$2,236	$1,190	$1,046	$2,236
Package A/C	$1,367	$1,240	$2,607	$1,190	$1,417	$2,607
Split HP	$2,280	$1,388	$3,668	$2,035	$1,663	$3,668
Package HP	$2,160	$1,439	$3,599	$2,035	$1,564	$3,599

* Costs based on ARI shipment-weighted mean manufacturer cost multipliers.

Annual Repair Costs

ACEEE, PG&E, and CEC all questioned the assumption used in the SANOPR that repair costs increase significantly for equipment with efficiencies greater than 12 SEER. They stated that any increase in repair cost should occur beyond 13 SEER as complex control systems which incur increased repair costs are not prevalent in systems with efficiencies equal to or less than 13 SEER.
These comments appear to be appropriate for variable-speed or two-speed compressors and we have revised the analysis assuming that annual repair costs remain essentially constant for equipment with efficiencies from 10 through 13 SEER. For baseline equipment (i.e., 10 SEER) and equipment beyond 13 SEER, the annual repair cost is determined with the same relationship as was used in the SANOPR.

$$RC = \frac{0.5 \cdot EQP}{Life_{avg}}$$

Where,

RC = Annual repair cost,
EQP = Consumer equipment price, and
$Life_{avg}$ = Average lifetime of the equipment.

As noted above, since consumer equipment prices in the revised analysis are lower than those in the SANOPR due to the overall lower markup, repair costs are also lower since the they are directly proportional to the consumer equipment price. Table 19 presents the weighted-average annual repair costs by efficiency level for each product class. Weighted-average repair costs from the SANOPR are also presented for comparison purposes.

Table 19 Weighted-Average Annual Repair Costs – Revised Analysis vs. SANOPR

Efficiency	Revised Analysis				SANOPR*			
SEER	Split A/C	Split HP	Pack. A/C	Pack HP	Split A/C	Split HP	Pack. A/C	Pack HP
10	$26	$38	$34	$39	$28	$44	$38	$42
11	$26	$38	$34	$39	$29	$45	$38	$43
12	$27	$38	$34	$40	$29	$45	$39	$43
13	$27	$39	$35	$40	$46	$64	$63	$68
18	$55	$70	$67	$74	$68	$93	$86	$91

* Costs based on ARI shipment-weighted mean manufacturer cost multipliers.

Lifetime and Compressor Replacement Costs

Several manufacturers and some electric utilities commented that the average equipment lifetime of 18.4 years assumed in the SANOPR is not representative and the actual lifetime is between 12 and 15 years, although no data were provided to support this position. Several non-industry organizations including ACEEE, NRDC, and VEIC cited the Shipments Model's ability to accurately estimate historical shipments as evidence that the 18.4 year equipment lifetime is reasonable. They reasoned that a shorter or longer average equipment lifetime would result in less accurate estimates of historical shipments.

We continue to use the survival function used in the SANOPR as the basis for equipment lifetime in the revised analysis since the survival function is based on a survey conducted on over 2100 heat pumps in a seven state region of the U.S.

However, in re-examining the results of the heat pump survey, we realized that the survey showed that the original compressor lifetime was, on average, 14 years. The survey also indicated that essentially all heat pump owners replaced their original compressor once in the lifetime of system. In the analysis conducted for the SANOPR, we did not include any repair costs associated with replacing the compressor. But since the heat pump survey clearly indicates that the original compressor is replaced once in the system's life, the analysis has been revised to include a repair cost for the compressor. Conducting the analysis in this manner retains the average system lifetime of 18.4 years but explicitly addresses the replacement cost of the most expensive component of the system.

In accordance with the survey data, we have assumed the compressor to be replaced in the 14th year of the system's life. Because more efficient systems tend to use more efficient and, thus, more expensive compressors, the compressor replacement cost is assumed to increase as system efficiency increases. Tables 20 shows the manufacturer cost, average consumer price, and the present value of the consumer price (discounted based on an average rate of 5.6%) for central air conditioner and heat pumps compressors that are used in the revised analysis. It is important to note that the compressor replacement price is the price for the compressor only. The labor cost associated with the compressor's installation is assumed to remain constant as system efficiency increases.

Table 20 Compressor Replacement Costs – Revised Analysis

Efficiency	Split System and Single Package A/C			Split System and Single Package Heat Pump		
	Manufacturer	Consumer Price		Manufacturer	Consumer Price	
SEER	Cost	In year replaced	Present Value	Cost	In year replaced	Present Value
10	$122	$278	$131	$124	$283	$133
11	$152	$332	$156	$153	$335	$157
12	$153	$334	$157	$153	$335	$157
13	$167	$360	$169	$169	$364	$171
18	$221	$458	$215	$279	$564	$265

Although the revised analysis was conducted based on a "18.4 year average lifetime" retirement function, an LCC scenario was conducted based on a modified retirement function yielding a 14 year average life (refer to Section 2.0, *LCC Scenarios*). The shorter lifetime is based on the assumption that most, if not all, consumers when faced with replacing a failed compressor would choose to replace the entire system rather than replace the compressor in a relatively old system. Thus, in using a shortened average lifetime retirement function, compressor replacement costs are no longer considered.

1997 Residential Energy Consumption Survey (RECS)

The LCC calculations conducted for the SANOPR were performed for a representative sample of households from the 1993 RECS. RECS is based on a representative sample of households which were surveyed for information on their housing units, energy consumption and expenditures, stock of energy-consuming appliances, and energy-related behavior. The information collected represents all households nationwide – approximately 97 million. It was the Department's intent to revise the LCC analysis using the 1997 RECS data when the information was released by the EIA.

Comments from Virginia Power, Edison Electric Institute, and Energy Market & Policy Analysis also requested that the information drawn from RECS, namely, residential annual energy consumption, equipment efficiency, and average and marginal electricity prices, be updated to be based on the 1997 RECS rather than the 1993 RECS.

The following tables summarize the weighted-average values drawn from the 1997 RECS and compare the data with those from the 1993 RECS used in the SANOPR analysis. Although weighted-average values are presented, it is important to keep in mind that a distribution of values were actually used in both the revised LCC and SANOPR analyses. Both LCC analyses were performed on a household-by-household basis to generate a distribution of LCC results. It is RECS which provides the households for conducting such an analysis. The weighted-average values presented in the following tables represent the mean from a wide distribution of values based on the household data in RECS. The distribution represents the large variability that exists when analyzing a large group of households.

Equipment Efficiency

Table 21 presents the weighted-average equipment efficiencies for those households in the 1997 RECS with central air conditioners and heat pumps. The weighted-average values used in the SANOPR and drawn from the 1993 RECS are also provided for comparison purposes. Note that the equipment efficiencies from the 1997 RECS are greater than those from the 1993 RECS indicating the central air conditioning and heat pump stock, as expected, has achieved greater efficiency with time as the older equipment are replaced.

Table 21 Weighted-Average Equipment Efficiencies – Revised Analysis vs. SANOPR

	Revised Analysis – 1997 RECS		**SANOPR – 1993 RECS**	
Product Type	*SEER*	*HSPF*	*SEER*	*HSPF*
Air Conditioners	9.1	-	8.6	-
Heat Pumps	9.3	6.8	8.7	6.5

Annual Energy Consumption

Table 22 presents the weighted-average annual energy consumption of the equipment stock for those households in the 1997 RECS with central air conditioners and heat pumps. The weighted-average values used in the SANOPR and drawn from the 1993 RECS are also provided for comparison purposes. Since the 1997 RECS weather data (as indicated by the cooling degree days (CDD) and heating degree days (HDD)) showed that the summer of 1997 was cooler than normal and the winter of 1997 was warmer than normal, the annual energy consumption data were weather-corrected with 30-year average CDD and HDD data. The weather-correction had the effect of increasing the annual energy consumption for both air conditioners and heat pumps by 5 to 10%. Even with the weather-correction, the annual energy consumption of the 1997 RECS equipment stock is significantly lower than the annual energy consumption data used for the SANOPR.

Table 22 Weighted-Average Stock Annual Energy Consumption – Revised Analysis vs. SANOPR

	Revised Analysis – 1997 RECS[a]		**SANOPR – 1993 RECS**	
Product Type	*Cooling kWh/yr*	*Heating kWh/yr*	*Cooling kWh/yr*	*Heating kWh/yr*
Air Conditioners	2132	-	2629	-
Heat Pumps	2585	3921	2987	4658

[a] 1997 RECS data weather-corrected with 30-year average CDD and HDD data.

Table 23 presents the weighted-average annual energy consumption of baseline equipment (i.e., 10 SEER and 6.8 HSPF) which is derived based on the efficiency and annual energy consumption data from Tables 21 and 22. The baseline annual energy consumption is derived by taking the stock annual energy consumption and multiplying it by the ratio of weighted-average stock efficiency to the baseline efficiency. These data suggest that a portion of the reduction in annual energy consumption from 1993 to 1997 was due to more efficient equipment being present in the housing stock. As evident by Table 14, this "normalization" tends to bring the weighted-average annual energy consumption values closer together, although the 1997 RECS values are still lower than those used in the SANOPR.

Table 23 Weighted-Average Baseline (10 SEER/6.8 HSPF) Annual Energy Consumption – Revised Analysis vs. SANOPR

	Revised Analysis – 1997 RECS		**SANOPR – 1993 RECS**	
Product Type	*Cooling kWh/yr*	*Heating kWh/yr*	*Cooling kWh/yr*	*Heating kWh/yr*
Air Conditioners	1965	-	2256	-
Heat Pumps	2469	3907	2605	4466

Electricity Prices

Table 24 presents the weighted-average marginal and average electricity prices for those households in the 1997 RECS. The weighted-average values used in the SANOPR and drawn from the 1993 RECS are also provided for comparison purposes. Marginal electricity prices based on the 1997 RECS were calculated in the same manner as that used for the SANOPR. Namely, marginal electricity prices were estimated directly from RECS household data by calculating the slopes of regression lines that relate customer bills and customer usage. The slopes of the regressions for four "summer" months (June to September) and, separately, for the remaining ("winter") months were calculated. Average electricity prices were determined by calculating the slopes of regression lines over the entire twelve month period. As shown in Table 15, all weighted-average electricity prices determined from the 1997 RECS are lower than those determined for the SANOPR, with the exception of the weighted-average average electricity price for air conditioners.

Table 24 Weighted-Average Marginal and Average Electricity Prices – Revised Analysis vs. SANOPR

	Revised Analysis – 1997 RECS		**SANOPR – 1993 RECS**	
	Average	**Marginal**	**Avearge**	**Marginal**
Product Type	*¢/kWh*	*¢/kWh*	*¢/kWh*	*¢/kWh*
Air Conditioners	8.90	8.62	8.62	8.87
Heat Pumps	7.39	6.86	7.98	8.12

Commercial Applications

NRDC, ACEEE, VEIC, CEC, and NPPC all requested that the Department analyze the application of residential central air conditioners and heat pumps (i.e., 1-phase equipment and less that 65,000 Btu/hr cooling capacity) in commercial buildings. They stated that there is a significant portion of residential equipment being used in small commercial buildings. They argued that since the energy use patterns in commercial buildings are distinctly different than those in households, the effort should be made to analyze residential equipment use in commercial applications.

We analyzed the use of residential equipment in commercial buildings based on the assumption that 10% of central air conditioning and heat pump equipment are used in commercial applications. This figure is based on ARI's estimate that approximately 10% of single-phase air conditioning and heat pump shipments are used in commercial buildings. As will be described, the simulation of prototypical commercial buildings was conducted to estimate representative annual energy consumption values as well as average and marginal electricity prices. Once the annual energy consumption and electricity prices corresponding to each of the commercial buildings were determined, the LCC spreadsheet models were modified so that the prototypical commercial buildings represented 10% of the entire residential and commercial building

population. As noted earlier, the residential building stock was composed from those households in the 1997 RECS with either central air conditioners or heat pumps.

Annual Energy Consumption

In revising the analysis to include commercial applications, 77 nationally representative commercial buildings (consisting of seven different commercial building types in eleven different regions of the country) were incorporated into the LCC spreadsheets. The weighting given to each building (i.e., the percentage each building represents of the commercial building stock) was based on data from the 1992 Commercial Building Energy Consumption Survey (CBECS). The space-conditioning energy consumption associated with each of the 77 buildings was determined through computer simulations performed at Pacific Northwest National Laboratory (PNNL) based on assumptions similar to what were used to develop ASHRAE Standard 90.1-99. The procedure for calculating space-conditioning energy consumption relied on the determination of full load equivalent operating hours (FLEOH) for each of the 77 buildings. The determination of space-cooling and space-heating FLEOHs assumed that a single type of equipment, in our case residential-sized space-conditioning equipment, were used to condition the building. Once the FLEOHs were determined, the corresponding annual energy consumption was established using the DOE test procedure's method for calculating annual energy use. In determining both space-cooling and space-heating annual energy use, cooling and heating capacities of 36,000 Btu/hr and efficiencies equal to the standard level being analyzed were assumed. Table 25 presents the weighted-average annual space-cooling and space-heating energy consumption for the 77 prototypical commercial buildings.

Table 25 Weighted-Average Baseline Annual Energy Consumption of Commercial Buildings

	Revised Analysis – Commercial Buildings	
Product Type	*Cooling kWh/yr*	*Heating kWh/yr*
Air Conditioners	5824	-
Heat Pumps	5824	2654

Table 26 presents weighted-average baseline annual energy consumption values for the entire stock of equipment in both residential and commercial buildings assuming that 10% of equipment resides in commercial buildings. The weighted-average values used in the SANOPR and drawn from the 1993 RECS are also provided for comparison purposes. Note that with the inclusion of commercial buildings, the weighted-average baseline space-cooling annual energy consumption for air conditioners and heat pumps now exceeds the weighted-average value used in the SANOPR. The inclusion of commercial buildings actually reduces the weighted-average baseline space-heating annual energy consumption for heat pumps.

Table 26 Weighted-Average Baseline (10 SEER/6.8 HSPF) Annual Energy Consumption – Revised Analysis including Commercial Buildings vs. SANOPR

	Revised Analysis – 1997 RECS & Comm.		SANOPR – 1993 RECS	
Product Type	*Cooling kWh/yr*	*Heating kWh/yr*	*Cooling kWh/yr*	*Heating kWh/yr*
Air Conditioners	2305	-	2256	-
Heat Pumps	2731	3780	2605	4466

Electricity Prices

A methodology developed by Lawrence Berkeley National Laboratory (LBNL) was used to determine both average and marginal electricity prices for each of the 77 commercial buildings. The procedure matches building loads and demands (determined from the computer simulation analysis for establishing FLEOHs) to actual modeled commercial tariffs. Upon matching loads to tariffs, customer's bills are then calculated. From the calculated bills average prices can be determined. For the determination of marginal prices, bills are calculated for a base case (10 SEER) and for a standard case, then the bill's cost difference in dollars is divided by the usage difference in kWh to give a "marginal" rate of $/kWh for that increment. For purposes of simplifying the analysis, only a standard level increase of 20% (i.e., 12 SEER) was considered. Thus, the marginal rate developed for a 20% increase in the standard was assumed to be applicable for all standards cases. Since several tariffs were applied to each building, the marginal rate calculated from each tariff was weighted by the number of customers covered by the tariff to determine an average-weighted marginal rate for each building. The above procedure was used to develop space-cooling marginal rates. Since detailed building loads and demands were not available for space-heating, average rather than marginal electricity rates were used to determine the energy costs associated with the operation of heat pumps during the space-heating season. Table 27 presents the weighted-average marginal and average electricity prices for the 77 prototypical commercial buildings.

Table 27 Weighted-Average Marginal and Average Electricity Prices of Commercial Buildings

	Revised Analysis – Commercial Buildings		
	Average	**Marginal**	
Product Type	*¢/kWh*	*Cooling ¢/kWh*	*Heating ¢/kWh*
Air Conditioners	7.95	8.08	-
Heat Pumps	7.95	8.08	7.95

Table 28 presents weighted-average marginal and average electricity prices for the entire stock of equipment in both residential and commercial buildings assuming that 10% of equipment resides in commercial buildings. The weighted-average values used in the SANOPR and drawn from the 1993 RECS are also provided for comparison purposes.

Table 28 Weighted-Average Marginal and Average Electricity Prices – Revised Analysis including Commercial Buildings vs. SANOPR

	Revised Analysis – 1997 RECS & Comm.		SANOPR – 1993 RECS	
	Average	**Marginal**	**Avearge**	**Marginal**
Product Type	*¢/kWh*	*¢/kWh*	*¢/kWh*	*¢/kWh*
Air Conditioners	8.81	8.57	8.62	8.87
Heat Pumps	7.45	6.98	7.98	8.12

Discount Rates

NRDC, ACEEE, VEIC, PG&E, and CEC asserted that the discount rates used in the SANOPR analysis were too high. Their primary criticism pertained to the assumed distribution of finance methods establishing the discount rate, in particular, the assumption that 35% of consumers purchasing a central air conditioner or heat pump used a credit card to finance their purchase. The comments argued for a much lower percentage and cited a recent PG&E survey that demonstrated that only 5% of consumers used credit cards.

Our methodology for establishing discount rates for the SANOPR relied upon defining the share of various finance methods that are used for purchasing air-conditioning equipment and then determining the associated interest rates for each of the finance methods. This method focused on establishing the type of financing established at the time of purchase. The Department believes that for equipment financed through the purchase of a new home, second mortgages, or home equity lines of credit, this approach is reasonable. But for purchases made to replace old or failed equipment where cash or some form of credit is used to finance the acquisition, it is more appropriate to establish how the purchase affects a consumer's overall household financial situation. For example, even though the purchase might be financed through a dealer loan or some other low interest financing vehicle, the more probable effect of the purchase is to either cause the consumer to incur additional credit card debt or forego investment in some type of savings-related asset. Cash that was once available to either pay for household expenses or to invest in an asset like the stock market or a simple savings account now must be earmarked to pay off the equipment purchase, thus either causing the consumer to incur additional credit card debt or to lose the opportunity to earn income from their assets.

With regard to equipment obtained through the purchase of a new home, data from the Air Conditioning, Heating, and Refrigeration News (Dec. 12, 1998) indicate that 34% of central air conditioner and heat pump shipments went to new homes. Thus, we assumed that 34% of equipment purchases are financed through new home mortgages. Of the remaining 66% of shipments, we assumed that most of the purchases impacted the home owner's finances by either increasing their credit card debt or reducing investment. A small portion of the shipments were assumed to be financed with second mortgages. For those 66% of shipments which were not purchased with a new home, the Federal Reserve Board's 1998 Survey of

Consumer Finances (SCF) estimated the percentage of households that used second mortgages to finance their equipment purchase. The 1998 SCF also estimated the percentage of households that either would incur more credit card debt or forego investments. The method relied upon determining those households in the 1998 SCF with second mortgages, credit card debt, and holdings in various assets (i.e., stocks, mutual funds, bonds, savings bonds, certificate of deposits, and transaction accounts (e.g., savings or checking accounts)). The percentage of households within the above categories were normalized so that their total equaled the percentage of shipments not earmarked for new construction (66%).

Table 29 presents the breakdown of finance methods including those through new home mortgages. After establishing the share captured by each finance method, the range of interest rates due to each method were established. The 1998 SCF was used to establish the range of interest rates for new home mortgages, second mortgages, and credit cards. A variety of sources were used to establish the interest rates for the above described assets. Rates of return on certificates of deposit, savings bonds, and bonds were based on historical interest rates associated with six-month, secondary market CDs (1964-1999), one-year Treasury Bills (1959-1999), and Moody's AAA Corporate Bonds (1976-1999), respectively. Historical stock and mutual fund interest rate data were based on historical returns from the Standard & Poor 500 (1950-1999) and the Nasdaq stock market (1985-1999), respectively. For each of the above assets, the historical data provided a distribution of interest rates where each year's corresponding rate of return was weighted equally. Transaction account real interest rates were assumed to range from zero to 4%. Table 29 provides the real interest rates associated with each of the finance methods outlined in the preceding paragraph. Also provided is the weighted-average discount rate of 5.6% that is calculated from the mean interest rates for each finance method. As a point of reference, a weighted-average discount rate of 6.5% was used in the SANOPR. It should also be noted that in the revised analysis, real interest below 0% were not considered. Since negative real interest rates represent approximately 7% of the entire distribution of interest rates, an equal percentage of excessively high interest rates were removed from the distribution. This had the effect of eliminating real interest rates in excess of 18%.

Table 29 Real Interest Rates associated with each Finance Method

		Real Interest Rates		
Finance Method	**Share**	**Minimum**	**Maximum**	**Mean**
New Home Mortgages (after tax)	34%	-1.6%	12.8%	4.2%
Second Mortgages (after tax)	2%	-1.6%	14.3%	5.9%
Credit Card	21%	-1.6%	37.4%	12.0%
Transaction Accounts	24%	0.0%	4.0%	2.0%
Certificates of Deposit	4%	-2.2%	6.4%	2.4%
Savings Bonds	5%	-3.3%	5.6%	1.8%
Bonds	1%	-1.7%	8.8%	4.5%
Stocks	5%	-19.4%	60.2%	13.3%
Mutual Funds	4%	-40.0%	37.2%	4.5%
			Weighted-Average	5.6%