# CHAPTER 8. NATIONAL IMPACT ANALYSIS

## TABLE OF CONTENTS



## LIST OF TABLES

## LIST OF FIGURES

# CHAPTER 8. NATIONAL IMPACT ANALYSIS

## 8.1 INTRODUCTION

This chapter describes the method for estimating the future national energy savings (NES) to customers from possible efficiency levels for water and evaporatively cooled products, VRF water source heat pumps, and computer room air conditioners. This chapter also describes the method for estimating the magnitude and net present value (NPV) of the future NES for computer room air conditioners. Results of the national impact analysis (NIA) described here may include, depending on equipment, national energy consumption and savings, monetary value of energy savings to the nation as a result of standards, increased total installed costs to the Nation as a result of standards, and the NPV of energy savings (the difference between the present monetary values of energy savings and the increased total installed costs).

The NES for water- and evaporatively-cooled products considers the ASHRAE standard level as well as several higher efficiency standard levels for the eight equipment classes of commercial water and evaporatively cooled air conditioning equipment it analyzed. The Department examined various standard levels for each class of equipment, including the ASHRAE Standard 90.1 2010 efficiency level, the max-tech level (the highest efficiency level of equipment currently on the market), and several levels between. The baseline for each level is the current federal energy conservation standard.However, for levels higher than ASHRAE Standard 90.1-2010, DOE presents the energy savings as net of the savings from ASHRAE. The NES for VRF water source heat pumps follows the same method and analyzes two equipment classes of VRF water source heat pumps. However, the U.S. Department of Energy (DOE) did not find any models on the market below the ASHRAE Standard 90.1-2010 levels.

DOE determined both the NPV and the NES for each potential efficiency level it considered for each of the 15 equipment classes of computer room air conditioners it examined. DOE considered four efficiency levels above the baseline efficiency level defined by the American Society of Heating, Refrigerating and Air-Conditioning (ASHRAE) Standard 90.1-2010 plus one baseline efficiency level equivalent to the ASHRAE Standard 90.1-2010 level for each of the 15 equipment classes. DOE also included a market baseline level in the analysis spreadsheet. Because of the timing difference between DOE adopting standards at ASHRAE Standard 90.1-2010 levels as opposed to the adoption of standards of a higher efficiency level DOE must address the potential energy savings that could occur in the time between the dates at which compliance would be required. Therefore, DOE must include a market baseline efficiency level in its analysis of NES for DOE setting standards more efficient than those set forth in ASHRAE Standard 90.1-2010. DOE calculates the benefits for going higher than ASHRAE by analyzing the energy savings for adoption of standards at the ASHRAE Standard 90.1-2010 level compared with the market baseline and for adoption of more stringent standards compared with the ASHRAE Standard 90.1-2010 as baseline. Because DOE by statute may not adopt standards at efficiency levels less stringent than those specified in ASHRAE Standard 90.1-2010, it reports all energy and economic impacts in this analysis as potential impacts compared with adoption of the ASHRAE Standard 90.1-2010 baseline levels.

DOE performed all calculations using a Microsoft Excel spreadsheet, which is accessible on the Internet at http://www1.eere.energy.gov/buildings/appliance_standards/commercial/ashrae_products_docs_meeting.html.

The important facets of national energy consumption for each class of equipment include shipments, stock or inventory, national average electricity consumption, and the site-to-source conversion factor to convert the annual site energy savings into the annual amount of energy saved at the source of electric generation (the source energy). This chapter discusses how these are used in the calculation of national energy and economic impacts. Chapter 7, Shipments Analysis, provides a detailed description of the shipments analysis that DOE used to forecast future purchases of equipment.

DOE was not able to obtain information that quantified how voluntary energy efficiency programs affect equipment efficiencies on a national basis, but voluntary programs may increase the share of energy-efficient equipment prior to the implementation date of any new standards. Consequently, DOE did not explicitly incorporate the impact of market-based initiatives into the shipment forecasts detailed in Chapter 7 of this TSD.

## 8.2 NATIONAL ENERGY SAVINGS

### 8.2.1 National Energy Savings Definition

DOE calculates annual NES as the difference between two scenarios: a base case (without new standards) and a standards case (with new standards). DOE develops NES estimates for each product class independently. Positive values of NES correspond to net energy savings; i.e., national annual energy consumption (AEC) with standards is less than AEC in the base case. For each product class and standards case, DOE calculated the total energy savings using a stock accounting method. The number of new shipments in any given year is assumed to remain in the commercial building stock for a total of the assumed lifetime of the product, at which point that entire year's shipments disappears from existing stock. In this way, the total stock, or number of surviving units, in any given year is the sum of that year's shipments plus the shipments from the previous product lifetime minus one years.

The annual base total energy use in any given year is the sum product of the shipments for that year and the previous product life minus one years and the market weighted average base UEC[a] in each relevant year (multiplied by a site to source conversion factor).

$$Annual\ Base\ Total\ Energy\ Use_{year=n} = \sum_{year=n-(Life-1)}^{n} Shipments_{year} \times Base\ UEC_{year}$$

[a] The market weighted average base UEC is based on the distribution of efficiencies under the current federal standards (base case). It includes products both meeting and exceeding the current federal minimum efficiency. It is *not* the UEC for a product at a specified EER.

As currently modeled, the base UEC remains constant throughout time. As a result, in the calculation above, $Base\ UEC_{year}$could be moved outside the summation terms as $Base\ UEC$.

The annual standards case total energy use in any given year is the sum product of the shipments for that year and the previous product life minus one years and the market weighted average standards case UEC[b] in each relevant year (multiplied by a site to source conversion factor).

$$Annual\ Standards\ Case\ Total\ Energy\ Use_{year=n} = \sum_{year=n-(Life-1)}^{n} Shipments_{year} \times Standards\ UEC_{year}$$

Prior to the analysis period, the standards case UEC is equal to the Base UEC, as standards have not yet become effective. Therefore, in the earlier part of the analysis period, energy savings accrue from only the newer units in the building stock. Later in the analysis period, all units in the building stock will have the lower standards UEC (as they were all shipped within the analysis period) and will be providing energy savings.

For VRF water source heat pumps, energy savings for heating based on COP are also taken into account:

$$Annual\ Base\ Total\ Energy\ Use_{year=n} = \sum_{year=n-(Life-1)}^{n} Shipments_{year} \times (Base\ UEC_{year} + Base\ UEC\_heat_{year})$$

$$Annual\ Standards\ Case\ Total\ Energy\ Use_{year=n} = \sum_{year=n-(Life-1)}^{n} Shipments_{year} \times (Standards\ UEC_{year} + Standards\ UEC\_heat_{year})$$

For all products, the annual energy savings is the difference between the base case total energy use and the standards case total energy use.

$$Annual\ Energy\ Savings_{year=n} = Annual\ Base\ Total\ Energy\ Use_{year=n} - Annual\ Standards\ Case\ Total\ Energy\ Use_{year=n}$$

DOE calculated the cumulative energy savings over the analysis period by summing the annual energy savings for each year in the analysis period. The analysis period differs by product, as discussed in the next section.

---

[b] The market weighted average standards UEC is based on the distribution of efficiencies under a given amended federal standards scenario. It may include products both meeting and exceeding the given amended federal standards level (with the exception of the Max Tech scenario, in which it is assumed that no product exceeds the amended federal standards level). It is *not* the UEC for a product at a specified EER.

$$Cumulative\ Energy\ Savings = \sum_{year=x}^{x+29} Annual\ Energy\ Savings_{year}$$

For the ASHRAE standard, the cumulative energy savings are presented as above. For higher efficiency levels, the Department calculates cumulative energy savings as net of ASHRAE standard energy savings (water and evaporatively cooled equipment and VRF water source heat pumps) or uses the ASHRAE Standard as the base case in the equations shown above (computer room air conditioners).

## 8.3 INPUTS TO THE NES CALCULATION

Table 8.3.1 lists the inputs for the determination of NES. Each of the inputs is then discussed below.

**Table 8.3.1 National Energy Saving Inputs**

| Input |
|---|
| Shipments |
| Annual Unit Energy Consumption (UEC) (quads) |
| Product Lifetime |
| Site-to-Source Conversion Factor (quads) (Btu/kwh) |

#### 8.3.1.1 Shipments

DOE forecasted shipments for the base case and all standards cases (see chapter 6, Shipments Analysis). DOE thinks that the shipment projections under the standards cases could be lower than those in the base-case projection because the higher installed costs would cause some customers to forego new equipment purchases. However, DOE has no information that would allow a calculation of this effect. For the Notice of Proposed Rulemaking (NOPR), the projections of total shipments are the same in both the base case and standards cases.

#### 8.3.1.2 National Annual Energy Consumption

The national AEC is the product of the annual UEC and the stocks of units of each vintage. This approach accounts for differences in UEC from year to year. DOE initially calculated the AEC at the site (i.e., electricity in kilowatt hours [kWh] consumed by the units). DOE then calculated primary energy consumption from site energy consumption by applying a conversion factor to account for losses associated with the generation, transmission, and distribution of electricity.

DOE uses a market- or shipment-weighted average annual UEC in its calculation of the national AEC. This takes into account that the equipment markets reflect shipments with a distribution of efficiencies as was shown in chapter 2. To assess the impacts on the market from the introduction of higher standards, DOE calculates impacts based on efficiency-distribution weighted annual UEC. Because DOE only developed energy use for explicit efficiency levels, the distribution of efficiencies used in the calculation is based on the data outlined in chapter 2 to describe the current market, but is "compressed" to fit into the range of efficiency levels selected for analysis. To do this, each DOE-analyzed efficiency level was examined. The fraction of the current market distribution that surrounds a given analyzed efficiency level is allocated to that efficiency level.

DOE considers setting standards for each analyzed efficiency level. For each standard level analyzed, DOE has assumed that all equipment shipped in the base case with efficiencies below the standard level become shipments at that standard level in the standard-level shipment distributions. Shipments in the base-case distribution that are above the efficiency defined by the standard level are assumed to be unaffected. DOE terms this a "rollup" scenario, because base-case efficiency shipments below the proposed standard level "roll up" to meet the standard.

Table 8.3.2 is an example of how DOE compresses the market distribution into efficiency levels by binning as well as the use of the roll-up scenario and resultant market-weighted average UECs..

**Table 8.3.2 Efficiency Distributions and Market Weighted-Average UECs: Small Water Cooled Equipment with Electric Resistance or No Heat**

| Standard Scenario | EER | | | | | | | Market Weighted Average UEC |
|---|---|---|---|---|---|---|---|---|
| | **11.5** (11.5-11.8) | **12.1** (11.9-12.5) | **13** (12.6-13.4) | **14** (13.5-14.4) | **15** (14.5-15.6) | **16.4** (15.7-16.4) | **Total** | |
| Base Case | 7% | 27% | 13% | 13% | 20% | 20% | 100% | 8,088 |
| ASHRAE Standard | | 34% | 13% | 13% | 20% | 20% | 100% | 8,065 |
| 13 EER | | | 47% | 13% | 20% | 20% | 100% | 7,912 |
| 14 EER | | | | 60% | 20% | 20% | 100% | 7,705 |
| 15 EER | | | | | 80% | 20% | 100% | 7,473 |
| Max Tech | | | | | | 100% | 100% | 7,101 |

The compressed market baseline distribution, used for the NES analyses (and NPV analyses in the case of computer room air conditioners), are shown in the Table 8.3.3 through Table 8.3.5, followed by the market- or shipment-weighted average annual UECs for each product class and analyzed efficiency levels (Table 8.3.6 through Table 8.3.8).

**Table 8.3.3 Water and Evaporatively Cooled Equipment Market Shares by Efficiency Level, Base Case Used for NIA Analysis**

| Equipment Class | Market Baseline | ASHRAE | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|---|---|
| Small Water-Cooled E/N | 7% | 27% | 13% | 13% | 20% | 20% |
| Small Water-Cooled O | 7% | 27% | 13% | 13% | 20% | 20% |
| Large Water-Cooled E/N | 29% | 21% | 7% | 7% | 29% | 7% |
| Large Water-Cooled O | 29% | 21% | 7% | 7% | 29% | 7% |
| Very Large Water-Cooled E/N | 17% | 20% | 29% | 14% | 20% | - |
| Very Large Water-Cooled O | 14% | 23% | 29% | 14% | 20% | - |
| Very Large Evap Cooled E/N | 65% | 27% | 6% | 2% | - | - |
| Very Large Evap Cooled O | 56% | 35% | 7% | 2% | - | - |

**Table 8.3.4 VRF Water Source Heat Pump Market Shares by Efficiency Level, Base Case Used for NIA Analysis**

| Equipment Class | Market Baseline | ASHRAE | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|---|---|
| >135 without Heat Recovery | - | 3% | 73% | 15% | 3% | 5% |
| >135 with Heat Recovery | - | 5% | 64% | 18% | 5% | 8% |

**Table 8.3.5 Computer Room Air Conditioner Market Shares by Efficiency Level, Base Case Used for NIA Analysis**

| Equipment Class | Market Baseline | ASHRAE | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|---|---|
| **Air cooled, <65,000 Btu/h** | 2% | 9% | 20% | 45% | 18% | 5% |
| **Air cooled, ≥65,000 to <240,000 Btu/h** | - | 2% | 20% | 45% | 31% | 2% |
| **Air cooled, ≥240,000 Btu/h** | - | 2% | 20% | 45% | 31% | 2% |
| **Water cooled, <65,000 Btu/h** | 5% | 23% | 23% | 36% | 10% | 3% |
| **Water cooled, ≥65,000 to <240,000 Btu/h** | 2% | 26% | 30% | 22% | 16% | 4% |
| **Water cooled, ≥240,000 Btu/h** | 2% | 26% | 30% | 22% | 16% | 4% |
| **Water cooled with fluid economizers, <65,000 Btu/h** | 5% | 23% | 23% | 36% | 10% | 3% |
| **Water cooled with fluid economizers, ≥65,000 to <240,000 Btu/h** | 2% | 26% | 30% | 22% | 16% | 4% |
| **Water cooled with fluid economizers, ≥240,000 Btu/h** | 2% | 26% | 30% | 22% | 16% | 4% |
| **Glycol cooled, <65,000 Btu/h** | 5% | 23% | 23% | 36% | 10% | 3% |
| **Glycol cooled, ≥65,000 to <240,000 Btu/h** | 2% | 26% | 30% | 22% | 16% | 4% |
| **Glycol cooled, ≥240,000 Btu/h** | 2% | 26% | 30% | 22% | 16% | 4% |
| **Glycol cooled with fluid economizers, <65,000 Btu/h** | 5% | 23% | 23% | 36% | 10% | 3% |
| **Glycol cooled with fluid economizers, ≥65,000 to <240,000 Btu/h** | 2% | 26% | 30% | 22% | 16% | 4% |
| **Glycol cooled with fluid economizers, ≥240,000 Btu/h** | 2% | 26% | 30% | 22% | 16% | 4% |

**Table 8.3.6 Water and Evaporatively Cooled Equipment Market-Weighted Annual Average Energy Consumption by Standard Level (kwh/year)**

| Equipment Class | Market Baseline | ASHRAE | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|---|---|
| Small Water-Cooled E/N | 8,088 | 8,065 | 7,912 | 7,705 | 7,473 | 7,101 |
| Small Water-Cooled O | 8,126 | 8,102 | 7,912 | 7,705 | 7,473 | 7,101 |
| Large Water-Cooled E/N | 15,776 | 15,309 | 15,078 | 14,602 | 14,137 | 13,490 |
| Large Water-Cooled O | 15,818 | 15,407 | 15,078 | 14,602 | 14,137 | 13,490 |
| Very Large Water-Cooled E/N | 36,893 | 36,279 | 35,794 | 34,518 | 33,422 | - |
| Very Large Water-Cooled O | 36,980 | 36,452 | 35,794 | 34,518 | 33,422 | - |
| Very Large Evap Cooled E/N | 46,166 | 44,584 | 43,265 | 41,983 | - | - |
| Very Large Evap Cooled O | 46,436 | 45,033 | 43,265 | 41,983 | - | - |

**Table 8.3.7 VRF Water Source Heat Pump Market-Weighted Annual Average Energy Consumption by Standard Level (kwh/year)**

| Equipment Class | Market Baseline | ASHRAE | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|---|---|
| >135 without Heat Recovery (Cooling) | 18,641 | 18,641 | 18,598 | 17,797 | 17,011 | 15,872 |
| >135 without Heat Recovery (Heating) | 7,385 | 7,385 | 7,379 | 7,253 | 7,117 | 6,893 |
| >135 with Heat Recovery (Cooling) | 18,176 | 18,176 | 18,094 | 17,343 | 16,568 | 15,421 |
| >135 with Heat Recovery (Heating) | 4,799 | 4,799 | 4,788 | 4,680 | 4,558 | 4,355 |

**Table 8.3.8 Computer Room Air Conditioner Shipment-Weighted Annual Average Energy Consumption by Standard Level (kwh/year)**

| Equipment Class | ASHRAE | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|---|
| Air cooled, <65,000 Btu/h | 23,964 | 23,906 | 23,666 | 23,097 | 21,913 |
| Air cooled, ≥65,000 to <240,000 Btu/h | 84,095 | 84,095 | 83,897 | 82,138 | 77,655 |
| Air cooled, ≥240,000 Btu/h | 197,372 | 197,372 | 196,851 | 192,306 | 180,909 |
| Water cooled, <65,000 Btu/h | 22,772 | 22,674 | 22,213 | 21,487 | 20,407 |
| Water cooled, ≥65,000 to <240,000 Btu/h | 84,336 | 84,188 | 82,424 | 79,275 | 75,491 |
| Water cooled, ≥240,000 Btu/h | 190,411 | 190,059 | 185,897 | 178,506 | 169,672 |
| Water cooled with fluid economizers, <65,000 Btu/h | 14,419 | 14,369 | 14,133 | 13,761 | 13,210 |
| Water cooled with fluid economizers, ≥65,000 to <240,000 Btu/h | 53,455 | 53,379 | 52,472 | 50,858 | 48,924 |
| Water cooled with fluid economizers, ≥240,000 Btu/h | 120,173 | 119,992 | 117,848 | 114,054 | 109,531 |
| Glycol cooled, <65,000 Btu/h | 22,669 | 22,568 | 22,094 | 21,352 | 20,253 |
| Glycol cooled, ≥65,000 to <240,000 Btu/h | 92,059 | 91,865 | 89,621 | 85,701 | 81,081 |
| Glycol cooled, ≥240,000 Btu/h | 204,814 | 204,371 | 199,249 | 190,336 | 179,864 |
| Glycol cooled with fluid economizers, <65,000 Btu/h | 18,304 | 18,228 | 17,876 | 17,325 | 16,511 |
| Glycol cooled with fluid economizers, ≥65,000 to <240,000 Btu/h | 74,255 | 74,109 | 72,425 | 69,495 | 66,052 |
| Glycol cooled with fluid economizers, ≥240,000 Btu/h | 165,135 | 164,801 | 160,953 | 154,283 | 146,472 |

#### 8.3.1.3 Product Lifetime

The source for water and evaporatively cooled products was the advanced notice of proposed rulemaking on Energy Conservation Standards for Commercial Unitary Air Conditioners and Heat Pumps published in the Federal Register on July 29, 2004. 69 FR 45460. The product lifetime from the prior TSD was estimated to be a mean of 15.4 years. More recent sources confirm this estimate including the 2008 California Database for Energy Efficient Resources (15 years). For this preliminary analysis, DOE used a single-value lifetime of 15 years.

For VRF water source heat pumps, DOE used a product lifetime of 19 years based on the ASHRAE 2011 HVAC Applications Handbook.[c] For computer room air conditioners, DOE used a product lifetime of 15 years, based on information discussed in chapter 6.

### 8.3.2 Site-to-Source Energy Conversion Factors

For all products the Department calculated energy savings as site energy, which it then converted to source energy— the energy that electric power plants consume. The Department used site-to-source energy conversion factors from the *AEO 2010* (water and evaporatively cooled products – not updated from the NODA) or *AEO 2011* (computer room air conditioners and VRF water source heat pumps). The Department extrapolated the values in later years (after 2035) from their relative sources because the *AEO* does not forecast beyond 2035. To arrive at values for these later years, the Department used the forecast's trend from 2025 to 2035 to establish conversion factors in the years 2036 to 2043.

### 8.3.3 Compliance Dates and Analysis Period

If DOE were to propose a rule prescribing energy conservation standards at the efficiency levels contained in ASHRAE Standard 90.1 2010, EPCA states that compliance with amended standards is required on or after a date which is two or three years (depending on equipment size) after the effective date of the applicable minimum energy efficiency requirement in the amended ASHRAE standard (i.e., ASHRAE Standard 90.1 2010). (42 U.S.C. 6313(a)(6)(D))

For all water and evaporatively cooled equipment in this rulemaking, the effective date in ASHRAE Standard 90.1 2010 is June 1, 2011. Thus, if DOE decides to adopt the levels in ASHRAE Standard 90.1 2010, the rule would apply to small equipment (two product classes) manufactured on or after June 1, 2013, which is two years from the effective date specified in ASHRAE Standard 90.1 2010, and to large and very large equipment (six product classes)

---

[c] ASHRAE's handbook does not list a service life for VRF equipment specifically, but it does provide service life estimates for water-source heat pumps generally. In this regard, ASHRAE cites two different studies for equipment service life. The first study of this type of equipment reported a service life of 19 years. The second, more-recent study cited suggests a service life of 24 years for all classes of direct expansion cooling systems. This second study relies heavily on extrapolation of a survival curve based on a sample of 1907 DX equipment observations from various equipment classes from which 284 units had actually been replaced and most were still in service. (ASHRAE Research Project 1237-TRP *Interactive Web-based Owning and Operating Cost Database Final Report*, July 2005. Available at www.ashrae.org ) However, as VRF products are new to the U.S. with relatively little data on lifetime, DOE has relied on the older, more conservative, 19-year service life estimate for its analysis.

manufactured on or after June 1, 2014, which is three years from the effective date specified in ASHRAE Standard 90.1 2010.

For VRF water source heat pumps in this rulemaking, ASHRAE Standard 90.1–2010 does not specify an effective date; therefore the effective date is assumed to be the publication date of ASHRAE Standard 90.1-2010, or October 29, 2010. Thus, if DOE decides to adopt the levels in ASHRAE Standard 90.1–2010, the rule would apply to large and very large equipment (the product class analyzed here) manufactured on or after October 29, 2013, which is three years from the effective date specified in ASHRAE Standard 90.1–2010.

For computer room air conditioners, the rule would apply to equipment <65,000 Btu/h (10 product classes combined into five for analysis purposes) manufactured on or after October 29, 2012, which is two years after the publication date of ASHRAE Standard 90.1-2010, and to equipment ≥65,000 Btu/h (20 product classes combined into 10 for analysis purposes) manufactured on or after October 29, 2013, which is three years after the publication date of ASHRAE Standard 90.1-2010. Typically equipment at or above 65,000 Btu/h and less than 135,000 Btu/h would have a compliance date two years after the publication of ASHRAE Standard 90.1. However, because ASHRAE Standard 90.1-2010 established a product class for computer room air conditioners that combines traditional small and large categories, DOE has decided to assign the later compliance date of three years after the publication of ASHRAE 90.1-2010 to all computer room air conditioner product classes that cover products between 65,000 Btu/h and 240,000 Btu/h.

If DOE were to propose a rule prescribing energy conservation standards higher than the efficiency levels contained in ASHRAE Standard 90.1 2010, EPCA states that any such standards "shall become effective for products manufactured on or after a date which is four years after the date such rule is published in the Federal Register." (42 U.S.C. 6313(a)(6)(D)) Thus, for products which DOE might adopt a level more stringent than the ASHRAE efficiency levels, the rule would apply to products manufactured on or after April 29, 2017, which is four years from the date of publication of the final rule that DOE must meet for higher than ASHRAE efficiency levels (30 months after publication of ASHRAE, which was October 29, 2010).

A 30-year analysis period is used for the NES, extending from the compliance date based on adoption of the levels in ASHRAE Standard 90.1-2010. For small computer room air conditioners, the analysis period extends from 2012 to 2041; for large computer room air conditioners, small water and evaporatively cooled equipment, and VRF water source heat pumps, the analysis period extends from 2013 to 2042; for large water and evaporatively cooled equipment the analysis period extends from 2014 to 2043. The time period for energy savings for standards going higher than ASHRAE Standard 90.1-2010 is from 2017 to 2041, 2042, or 2043, based on the product classes described. This approach accounts for any lost energy savings from a delay incurred by DOE's not adopting ASHRAE efficiency levels, but instead adopting standards at efficiency levels higher than those specified in ASHRAE Standard 90.1-2010.

## 8.4 NET PRESENT VALUE (Computer Room Air Conditioners)

### 8.4.1 Net Present Value Definition

The NPV is the value in the present of a time series of costs and savings. The NPV is given by the following equation:

$$NPV = PVS - PVC$$

Where: *PVS* = present value of operating cost savings (including electricity, repair, and maintenance costs) ($),
*PVC* = present value of increased total installed costs (including equipment and installation) ($).

The *PVS* and *PVC* are determined according to the following expressions:

$$PVS = \sum_t OCS_t * DF_t$$

$$PVC = \sum_t TIC_t * DF_t$$

where: *OCS* = total annual operating cost savings ($),
*TIC* = total annual installed cost increases ($),
*DF* = discount factor,
*t* = year (*PVS* is summed over 2012 to 2055 or 2013 to 2056, and *PVC* is summed over 2012 to 2041 or 2013 to 2042).

DOE determined the contribution to *PVC* for each year, from the effective date of the standard (2012 or 2013) to the year 2041 or 2042, discounted for the NOPR analysis to the year 2012. The contribution to PVS was determined for each year, from the effective date of the standard (2012 or 2013) to the year when the last units purchased in 2041 or 2042 have retired (assumed to be 2055 or 2056). DOE first calculated costs and savings as the difference between a standards case and a base case represented as adoption of the ASHRAE Standard. DOE calculated a discount factor from the discount rate and the number of years between the "present" (i.e., year to which the sum is being discounted) and the year in which the costs and savings occur. DOE calculated the NPV as the sum over time of the discounted net savings.

### 8.4.2 Net Present Value Inputs

Table 8.4.1 lists the inputs to the NPV calculation. Each of the inputs is then discussed below.

**Table 8.4.1 Net Present Value Inputs**

| Input |
|---|
| Total Annual Installed Cost (TICt) ($) |
| Total Annual Operating Cost Savings (OCSt) ($) |
| Discount Factor |
| Present Value of Costs (PVC) ($) |
| Present Value of Savings (PVS) ($) |

#### 8.4.2.1 Total Annual Installed Cost

The increase in the total annual installed cost is equal to the annual change in the per-unit total installed cost (difference between base case and standards case) multiplied by the shipments forecasted in the standards case. The total installed cost includes both the equipment cost and the installation price. DOE based average equipment costs on average manufacturer prices (see chapter 6, LifeCycle Cost and Payback Period Analysis) multiplied by average overall markup values shown in chapter 5). DOE based average installation prices on nationally representative values for each equipment class and efficiency level (see chapter 6), and developed base-case and standards-case energy-efficiency shipment scenarios as discussed in chapter 7. For both the base-case and standards-case energy-efficiency scenarios, DOE calculated annual shipment-weighted-average efficiencies. Associated with each annual shipment-weighted-average efficiency, DOE assigned a total installed cost, based on shipment-weighted total installed cost for all efficiency levels shipped under that standards-case scenario.

DOE determined the relationship between efficiency level and total installed cost for each computer room air conditioner class as shown in Table 8.4.2. DOE considers the ASHRAE level as the base minimum standard that it could set under Federal law. In the NIA, DOE establishes the NPV for going above the ASHRAE base case, but does not need to determine the NPV of adoption of that minimum base case. DOE only looked at subsequent higher standard levels to determine whether each higher level, when examined independently, has a positive NPV compared with the ASHRAE base case.

**Table 8.4.2 Total Installed Cost per Unit by Efficiency Level from Life-Cycle Cost (2011$)**

| Equipment Class | ASHRAE | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|---|
| Air cooled, <65,000 Btu/h | $ 11,982 | $ 13,471 | $ 15,222 | $ 17,281 | $ 19,700 |
| Air cooled, ≥65,000 to <240,000 Btu/h | $ 39,412 | $ 41,651 | $ 44,063 | $ 46,664 | $ 49,467 |
| Air cooled, ≥240,000 Btu/h | $ 56,879 | $ 60,102 | $ 63,577 | $ 67,322 | $ 71,358 |
| Water cooled, <65,000 Btu/h | $ 23,748 | $ 20,311 | $ 17,527 | $ 15,273 | $ 13,447 |
| Water cooled, ≥65,000 to <240,000 Btu/h | $ 22,983 | $ 28,614 | $ 36,183 | $ 46,355 | $ 60,027 |
| Water cooled, ≥240,000 Btu/h | $ 42,217 | $ 52,902 | $ 67,262 | $ 86,562 | $ 112,498 |
| Water cooled with fluid economizers, <65,000 Btu/h | $ 25,059 | $ 21,422 | $ 18,476 | $ 16,090 | $ 14,158 |
| Water cooled with fluid economizers, ≥65,000 to <240,000 Btu/h | $ 24,169 | $ 30,129 | $ 38,138 | $ 48,903 | $ 63,372 |
| Water cooled with fluid economizers, ≥240,000 Btu/h | $ 44,469 | $ 55,777 | $ 70,973 | $ 91,397 | $ 118,844 |
| Glycol cooled, <65,000 Btu/h | $ 24,353 | $ 20,916 | $ 18,132 | $ 15,878 | $ 14,052 |
| Glycol cooled, ≥65,000 to <240,000 Btu/h | $ 24,377 | $ 30,001 | $ 37,559 | $ 47,717 | $ 61,368 |
| Glycol cooled, ≥240,000 Btu/h | $ 42,217 | $ 52,902 | $ 67,262 | $ 86,562 | $ 112,498 |
| Glycol cooled with fluid economizers, <65,000 Btu/h | $ 25,664 | $ 22,027 | $ 19,081 | $ 16,695 | $ 14,763 |
| Glycol cooled with fluid economizers, ≥65,000 to <240,000 Btu/h | $ 25,563 | $ 31,514 | $ 39,512 | $ 50,261 | $ 64,708 |
| Glycol cooled with fluid economizers, ≥240,000 Btu/h | $ 44,469 | $ 55,777 | $ 70,973 | $ 91,397 | $ 118,844 |

#### 8.4.2.2 Annual Installed Cost–Weighted by Efficiency Distribution

Using the base-case market distribution and the calculated distributions at each possible standard level, discussed in the NES section, DOE developed an average shipment-weighted total installed cost for all shipments for each proposed standard level. The shipment-weighted total installed costs for each possible standard level are listed in Table 8.4.3.

**Table 8.4.3 Shipment-Weighted Average Total Installed Cost by Standard Level (2011$)**

| Equipment Class | ASHRAE | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|---|
| Air cooled, <65,000 Btu/h | $ 15,074 | $ 15,243 | $ 15,800 | $ 17,390 | $ 19,700 |
| Air cooled, ≥65,000 to <240,000 Btu/h | $ 44,421 | $ 44,465 | $ 44,985 | $ 46,719 | $ 49,467 |
| Air cooled, ≥240,000 Btu/h | $ 64,091 | $ 64,155 | $ 64,904 | $ 67,401 | $ 71,358 |
| Water cooled, <65,000 Btu/h | $ 19,588 | $ 18,619 | $ 17,191 | $ 15,226 | $ 13,447 |
| Water cooled, ≥65,000 to <240,000 Btu/h | $ 32,797 | $ 34,374 | $ 38,764 | $ 46,902 | $ 60,027 |
| Water cooled, ≥240,000 Btu/h | $ 60,839 | $ 63,831 | $ 72,160 | $ 87,599 | $ 112,498 |
| Water cooled with fluid economizers, <65,000 Btu/h | $ 20,657 | $ 19,631 | $ 18,121 | $ 16,041 | $ 14,158 |
| Water cooled with fluid economizers, ≥65,000 to <240,000 Btu/h | $ 34,556 | $ 36,224 | $ 40,870 | $ 49,482 | $ 63,372 |
| Water cooled with fluid economizers, ≥240,000 Btu/h | $ 64,176 | $ 67,342 | $ 76,156 | $ 92,495 | $ 118,844 |
| Glycol cooled, <65,000 Btu/h | $ 20,193 | $ 19,224 | $ 17,797 | $ 15,831 | $ 14,052 |
| Glycol cooled, ≥65,000 to <240,000 Btu/h | $ 34,178 | $ 35,753 | $ 40,137 | $ 48,263 | $ 61,368 |
| Glycol cooled, ≥240,000 Btu/h | $ 60,839 | $ 63,831 | $ 72,160 | $ 87,599 | $ 112,498 |
| Glycol cooled with fluid economizers, <65,000 Btu/h | $ 21,262 | $ 20,236 | $ 18,726 | $ 16,646 | $ 14,763 |
| Glycol cooled with fluid economizers, ≥65,000 to <240,000 Btu/h | $ 35,935 | $ 37,601 | $ 42,240 | $ 50,839 | $ 64,708 |
| Glycol cooled with fluid economizers, ≥240,000 Btu/h | $ 64,176 | $ 67,342 | $ 76,156 | $ 92,495 | $ 118,844 |

#### 8.4.2.1 Price Forecast

As discussed in chapter 6, DOE used a constant price assumption for the default forecast in the NIA. In order to investigate the impact of different product price forecasts on the consumer net present value (NPV) for the considered efficiency levels for computer room air conditioners, DOE also considered two alternative price trends. One of these used an exponential fit on the deflated price index for all other miscellaneous refrigeration and air-conditioning equipments, and the other is based on the "deflator— other durables excluding medical" that was forecasted for *AEO2011*. Details on how these alternative price trends were developed are in Appendix 10-B, which also presents the results of the sensitivity analysis.

#### 8.4.2.2 Total Annual Operating Cost Savings

The annual operating cost savings to the nation are equal to the change in the average annual operating costs (difference between base case and standards case) per unit in the stock for each year multiplied by the total number of units in the stock forecasted in the standards case. Calculations are done separately for each equipment class.

The annual operating cost includes electricity, repair, and maintenance costs.

***Annual Energy Cost Savings***. DOE calculated annual energy costs based on national commercial electricity prices shown in *AEO 2011*. To calculate annual energy cost savings for a particular equipment class in a given year, DOE first calculated the annual energy costs in each forecast year at each efficiency level by multiplying the U.S. average energy consumption at each efficiency level by the stock at each efficiency level and in each equipment class, as appropriate, in each year. This is then multiplied by the national average commercial fuel prices. To determine energy savings, the national energy costs at each efficiency level (Levels 1–4) were then subtracted from the national energy costs at the ASHRAE level. Commercial fuel prices for electricity are derived from the reference case AEO 2011 forecasts through 2035. DOE extrapolated the trend in values from 2025 to 2035 of the forecast to establish fuel prices from 2035 to 2056, through the end of the NPV analysis period. This method of extrapolation is in line with methods the EIA uses to forecast fuel prices for the Federal Energy Management Program.

***Annual Repair Costs***. DOE based average annual repair costs on a base repair cost, which increased with the value of the computer room air conditioner equipment in 2011$ (see chapter 5). Using the efficiency distribution of the stock at each standard level analyzed, DOE developed a weighted average repair cost for the stock based on the distribution at each standard level.

***Annual Maintenance Costs***. DOE determined average annual maintenance costs for computer room air conditioners from the life-cycle cost analysis (see chapter 6). DOE used a value of $84 per year for computer room air conditioners less than 240,000 Btu/h and $102 per year for computer room air conditioners greater than 240,000 Btu/h. These values were applied to all computer room air conditoiners in the stock at each year.

#### 8.4.2.3 Discount Factor

DOE multiplied monetary values in future years by the discount factor to determine the present value. The discount factor (DF) is described by the following equation:

$$DF = \frac{1}{(1+r)^{t-tp}}$$

where $r$ = discount rate (percent),
$t$ = year of the monetary value,
$tp$ = year in which the present value is being determined.

DOE estimated national impacts with both a 3 percent and a 7 percent real discount rate. These discount rates are used in accordance with the Office of Management and Budget's (OMB) guidance to Federal agencies on the development of regulatory analysis (OMB Circular A4, September 17, 2003), and section E, "Identifying and Measuring Benefits and Costs," therein. DOE defined the present year as 2012 for the NOPR analysis.

#### 8.4.2.4 Present Value of Costs

The present value of increased installed costs is the annual installed cost increase in each year (i.e., the difference between the standards case and the base case), discounted to the present, and summed for the time period that DOE is considering for the installation of computer room air conditioners (i.e., from the earliest effective date of standards, 2012 or 2013, to the year 2041 or 2042).

The increase in total installed cost refers to the equipment cost and installation cost associated with the higher-efficiency computer room air conditioners purchased in the standards case compared to the base case. DOE calculated annual installed costs as the difference in total installed cost for new equipment purchased each year, multiplied by the shipments in the standards case.

#### 8.4.2.5 Present Value of Savings

The present value of operating cost savings is the annual operating cost savings (i.e., the difference between the base case and standards case) discounted to the year 2012, and summed over the period from the effective date of the standard, 2012 or 2013, to the time when the last unit installed in 2041 or 2042 is retired from service (assumed to be 2055 or 2056). Operating cost savings represent decreases in operating costs (including electricity, repair, and maintenance) associated with the higher efficiency of computer room air conditioners purchased in the standards case compared to the base case. Total annual operating cost savings is the savings multiplied by the number of computer room air conditioners of each vintage surviving in a particular year. Equipment consumes energy over its entire lifetime, and for units purchased in 2041 or 2042, the PVS includes energy consumed until the last unit is retired from service at the end of 2055 or 2056.

## 8.5 NES AND NPV RESULTS

The NES spreadsheet model provides estimates of the NES and NPV for various efficiency levels. The inputs to the NES spreadsheet are discussed earlier in sections 7.2.2 (National Energy Savings Inputs) and 7.3.2 (Net Present Value Inputs).

### 8.5.1 National Energy Savings and Net Present Value Input Summary

Table 8.5.1 summarizes the inputs to the NES spreadsheet model. For each input, a brief description of the data source is given.

**Table 8.5.1 Inputs to the NES Spreadsheet Model**

| Input Data | Description |
|---|---|
| Effective Date of Standard | 2012 or 2013 depending on product class. |
| Shipments | Annual shipments from shipments model (see chapter 7, Shipments Analysis). |
| Base-Case Effiicencies | Distribution of base-case shipments by efficiency level. |
| Standards-Case Efficiencies | Distribution of shipments by efficiency level for each standards case. Standards-case annual market shares by efficiency level remain constant over time for the base case and each standards case. |
| Annual Energy Consumption | Annual weighted-average values are a function of efficiency level. (Established from the Energy Use Characterization, chapter 4). |
| Site-to-Source Conversion | Site-to-source conversion determined from EIA's AEO2011 for electricity and varies over the analysis period. |
| Below inputs are for computer room air conditioners only | |
| Total Installed Cost | Annual weighted-average values are a function of efficiency level (see chapter 6, LifeCycle Cost and Payback Period Analysis). |
| Repair Cost | Annualized repair cost for baseline efficiency computer room air conditioners based on cost data from RS Means CostWorks 2011. DOE assumed that the materials portion of the repair costs would vary in direct proportion with the MSP at higher efficiency levels (see chapter 6). |
| Maintenance Cost | Annual maintenance costs were $84 for small computer room air conditioners and $102 for large computer room air conditioners based on data on annual maintenance costs for computer room air conditioners based on RS Means CostWorks 2011 (see chapter 6). Annual maintenance cost did not vary as a function of efficiency. |
| Escalation of Electricity Prices | 2011 EIA Annual Energy Outlook forecasts (to 2035) with extrapolation for beyond 2035. |
| Discount Rate | 3 and 7 percent real. |
| Present Year | Future costs are discounted to year 2012. |

### 8.5.2 National Energy Savings Results

The following section provides NES results for each efficiency level considered for the equipment analyzed. The results are cumulative to 2041, 2042, or 2043, depending on product class and are shown as primary energy savings in quads. Inputs to the NES spreadsheet model are based on weighted-average values, yielding results that are discrete point values, rather than a distribution of values as in the lifecycle cost (LCC) analysis.

***Water and Evaporatively Cooled Products***

Table 8.5.2 and Table 8.5.3 summarize the NES due to new energy conservation standards for the eight product classes of water and evaporatively cooled equipment examined. Results of the national energy savings analysis are provided for the two shipment case scenarios, Historical Trends and Fixed to 2009. Recall that all levels higher than ASHRAE are shown as net of ASHRAE savings.

**Table 8.5.2 National Energy Savings for Water and Evaporatively Cooled Products (Quads, 2013–2042 or 2014-2043): Based on Historical Trends**

| Efficiency Level | Small Water E/N 65-135 | Small Water O 65-135 | Large Water E/N 135-240 | Large Water O 135-240 | VL Water E/N 240-760 | VL Water O 240-760 | VL Evap E/N 240-760 | VL Evap O 240-760 |
|---|---|---|---|---|---|---|---|---|
| ASHRAE Standard | 0.000005 | 0.0000005 | 0.0001 | 0.00001 | 0.0002 | 0.002 | 0.0001 | 0.001 |
| 13/12.5 EER | 0.00002 | 0.000002 | 0.00002 | 0.00001 | 0.0001 | 0.001 | 0.00008 | 0.001 |
| 14 EER | 0.00004 | 0.000005 | 0.00013 | 0.00002 | 0.0005 | 0.005 | - | - |
| 15 EER | 0.00007 | 0.000009 | 0.00024 | 0.00003 | - | - | - | - |
| Max Tech | 0.00012 | 0.000014 | 0.00039 | 0.00005 | 0.0008 | 0.008 | 0.00017 | 0.002 |

**Table 8.5.3 National Energy Savings for Water and Evaporatively Cooled Products (Quads, 2013–2042 or 2014-2043): Shipments Fixed to 2009**

| Efficiency Level | Small Water E/N 65-135 | Small Water O 65-135 | Large Water E/N 135-240 | Large Water O 135-240 | VL Water E/N 240-760 | VL Water O 240-760 | VL Evap E/N 240-760 | VL Evap O 240-760 |
|---|---|---|---|---|---|---|---|---|
| ASHRAE Standard | 0.000011 | 0.0000013 | 0.0003 | 0.00003 | 0.0001 | 0.001 | 0.0001 | 0.001 |
| 13/12.5 EER | 0.00006 | 0.000008 | 0.00008 | 0.00001 | 0.0001 | 0.001 | 0.00005 | 0.001 |
| 14 EER | 0.00014 | 0.000017 | 0.00032 | 0.00004 | 0.0003 | 0.003 | - | - |
| 15 EER | 0.00024 | 0.000028 | 0.00056 | 0.00007 | - | - | - | - |
| Max Tech | 0.00039 | 0.000044 | 0.00089 | 0.00010 | 0.0005 | 0.005 | 0.00011 | 0.001 |

***VRF Water Source Heat Pumps***

Table 8.5.4 summarizes the NES due to new energy conservation standards for the two VRF water source heat pump product classes examined. Recall that all levels higher than ASHRAE are shown as net of ASHRAE savings.

**Table 8.5.4 National Energy Savings for VRF Water Source Heat Pumps >135,000 Btu/h (Quads, 2013-2042)**

| Efficiency Level | Without Heat Recovery | With Heat Recovery |
|---|---|---|
| Level 1 – ASHRAE – 10.0/9.8 EER | - | - |
| Level 2 – 11 EER | 0.0009 | 0.0008 |
| Level 3 – 12 EER | 0.0174 | 0.0083 |
| Level 4 – 13 EER | 0.0416 | 0.0195 |
| Level 5 – "Max-Tech" – 14.5 EER | 0.0761 | 0.0358 |

* The potential energy savings for efficiency levels more stringent than those specified by ASHRAE Standard 90.1-2010 were calculated relative to the efficiency levels that would result if ASHRAE Standard 90.1-2010 standards were adopted.

***Computer Room Air Conditioners***

Table 8.5.5 summarizes the NES due to new energy conservation standards for the 15 computer room air conditioner product classes examined. Recall that all levels higher than ASHRAE are based on ASHRAE as the baseline.

**Table 8.5.5 National Energy Savings for Computer Room Air Conditioners (Quads, 2012-2041 or 2013-2042)**

| Equipment Class | ASHRAE Level | Efficiency Level 1 | Efficiency Level 2 | Efficiency Level 3 | Efficiency Level 4 |
|---|---|---|---|---|---|
| **Air conditioners, air cooled, <65,000 Btu/h** | 0.00018 | 0.0006 | 0.0021 | 0.0052 | 0.0086 |
| **Air conditioners, air cooled, ≥65,000 to <240,000 Btu/h** | - | 0.006 | 0.059 | 0.196 | 0.364 |
| **Air conditioners, air cooled, ≥240,000 Btu/h** | - | 0.004 | 0.034 | 0.112 | 0.206 |
| **Air conditioners, water cooled, <65,000 Btu/h** | 0.00003 | 0.0001 | 0.0003 | 0.0007 | 0.0010 |
| **Air conditioners, water cooled, ≥65,000 to <240,000 Btu/h** | 0.0009 | 0.0088 | 0.0246 | 0.0435 | 0.0634 |
| **Air conditioners, water cooled, ≥240,000 Btu/h** | 0.0008 | 0.0079 | 0.0220 | 0.0388 | 0.0565 |
| **Air conditioners, water cooled with fluid economizers, <65,000 Btu/h** | 0.00001 | 0.00004 | 0.00011 | 0.00021 | 0.00031 |
| **Air conditioners, water cooled with fluid economizers, ≥65,000 to <240,000 Btu/h** | 0.0004 | 0.0038 | 0.0106 | 0.0187 | 0.0273 |
| **Air conditioners, water cooled with fluid economizers, ≥240,000 Btu/h** | 0.0002 | 0.0016 | 0.0043 | 0.0076 | 0.0111 |
| **Air conditioners, glycol cooled, <65,000 Btu/h** | 0.00003 | 0.00013 | 0.00033 | 0.00063 | 0.00092 |
| **Air conditioners, glycol cooled, ≥65,000 to <240,000 Btu/h** | 0.001 | 0.011 | 0.031 | 0.054 | 0.078 |
| **Air conditioners, glycol cooled, ≥240,000 Btu/h** | 0.0008 | 0.0080 | 0.0220 | 0.0384 | 0.0554 |
| **Air conditioners, glycol cooled with fluid economizers, <65,000 Btu/h** | 0.00002 | 0.0001 | 0.0002 | 0.0005 | 0.0007 |
| **Air conditioners, glycol cooled with fluid economizers, ≥65,000 to <240,000 Btu/h** | 0.001 | 0.010 | 0.027 | 0.047 | 0.067 |
| **Air conditioners, glycol cooled with fluid economizers, ≥240,000 Btu/h** | 0.0005 | 0.0054 | 0.0147 | 0.0257 | 0.0369 |

* All energy savings from efficiency levels above ASHRAE are calculated with ASHRAE levels as a baseline.

### 8.5.3 Annual Costs and Savings

As a prelude to providing the NPVs for each efficiency level in each equipment class, this section presents the annual equipment cost (or total installed cost) increases and annual operating cost savings at the national level.

Figure 8.5.1 shows the changes over time of the non-discounted annual equipment price increases and the non-discounted operating cost savings for efficiency level 1 for the small air-cooled equipment class, as an example. The total net annual impact is the discounted value of the difference between annual equipment purchases and annual operating costs at a 7-percent discount rate. The annual equipment price change is the increase in equipment price for equipment purchased each year over the 30-year period from 2012 or 2013 to 2041 or 2042. The annual operating savings is the savings in operating costs for equipment purchased, and which have not been retired, for each year over the time period from 2012 or 2013 to 2055 or 2056. The NPV (the discounted total net annual impact) is the difference between the cumulative annual discounted savings and the cumulative annual discounted costs.

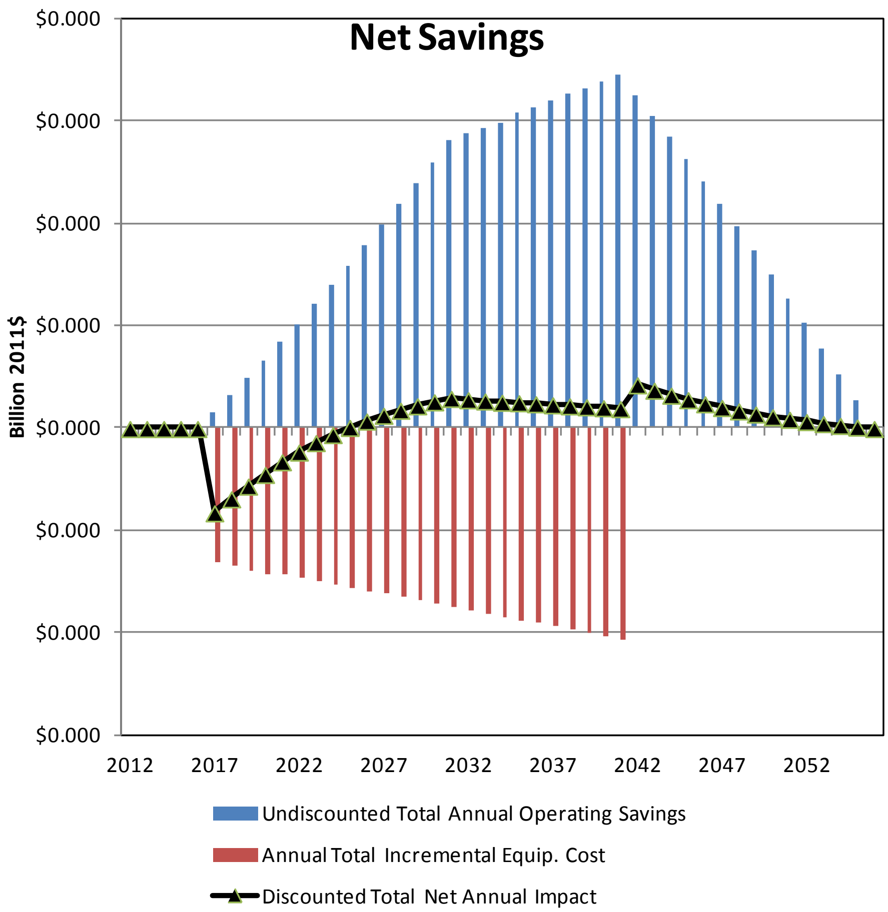


**Figure 8.5.1 National Annual Costs and Savings for Efficiency Level 1 (Small Air-Cooled Computer Room Air Conditioners)**

Figure 8.5.1 shows smaller annual operating cost savings compared to the increased equipment price costs through 2024, after which annual operating cost savings begin to eclipse increased equipment price costs. After 2041, no additional computer room air conditioner sales are included in the analysis; however the annual energy savings continues to accrue until the last of the computer room air conditioners installed in 2041 are removed from the stock after 2055.

### 8.5.4 Net Present Value Results

DOE developed NPV results for the efficiency levels considered for 15 computer room air conditioner equipment classes. Results are cumulative and are shown as the discounted value of these savings in dollar terms. The inputs to the NES spreadsheet model are based on weighted-average values yielding results that are discrete point values, rather than a distribution of values as in the LCC analysis. The present value of increased total installed costs is the total installed cost increase (i.e., the difference between the standards case and base case), discounted to 2012, and summed over the time period in which DOE evaluates the impact of standards (i.e., from the effective date of the standards, 2012 or 2013, to the year 2041 or 2042).

Savings are decreases in operating costs (including fuel costs, repair, and maintenance) associated with the higher energy efficiency of computer room air conditioners purchased in the standards case compared to the base case. Total operating cost savings are the average savings per unit multiplied by the number of units of each vintage (i.e., the year of manufacture) surviving in a particular year. Computer room air conditioner equipment consumes energy and must be maintained over its entire lifetime. For units purchased in 2041 or 2042, the operating cost includes energy consumed and maintenance and repair costs incurred until the last unit is retired from service in 2055 or 2056.

As an example, Figure 8.5.2 shows the NPV and NES results for the four efficiency levels analyzed for the small air-cooled equipment class, with NPVs calculated using a seven-percent discount rate. Both NES and NPV are calculated as benefits of the analyzed standard levels compared with adoption of the ASHRAE 90.1-2010 standard level.

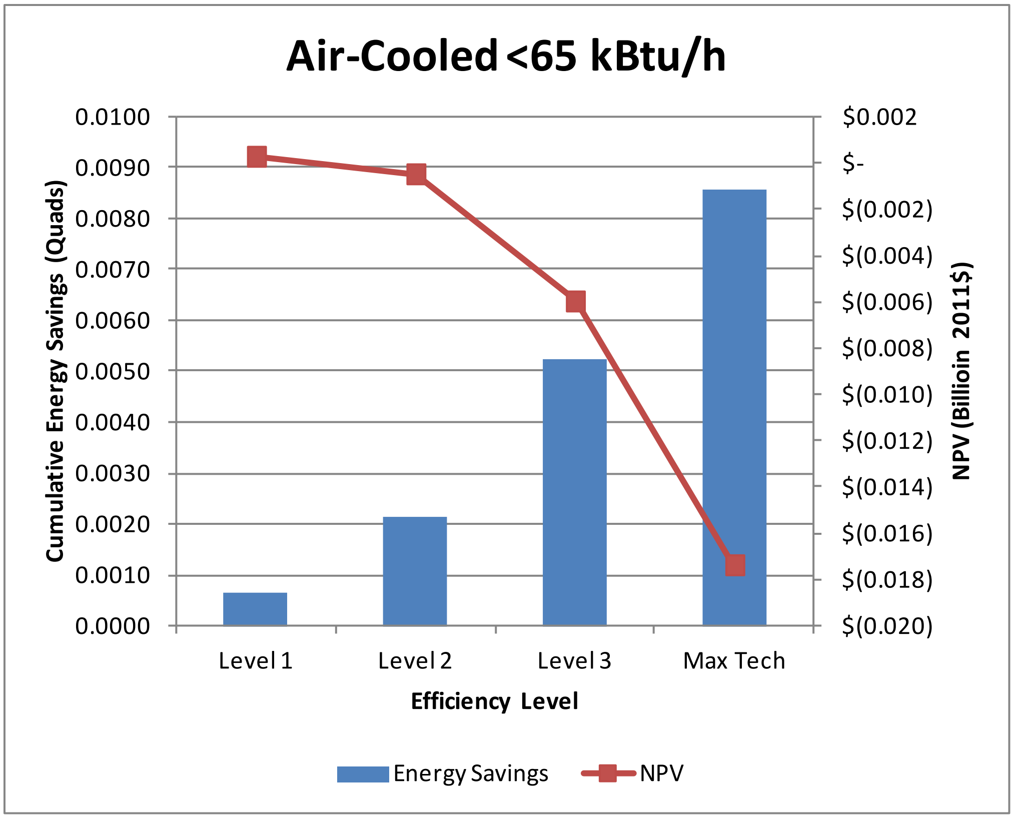


**Figure 8.5.2 Cumulative NES and NPV Results for Small Air-Cooled Computer Room Air Conditioners Based on a Seven-Percent Discount Rate**

Table 8.5.6 shows the NPV results for the efficiency levels considered for computer room air conditioner equipment based on a 7-percent discount rate. DOE based all results on electricity price forecasts from the AEO2011 Reference Case. Table 8.5.7 provides the NPV results based on the 3-percent discount rate and electricity price forecasts from the AEO 2011 Reference Case.

**Table 8.5.6. Summary of Cumulative Net Present Value for Computer Room Air Conditioners (Seven Percent Discount Rate)**

| Equipment Class | Net Present Value (Billion 2011$) | | | |
|---|---|---|---|---|
| | Efficiency Level 1 | Efficiency Level 2 | Efficiency Level 3 | Efficiency Level 4 |
| Air conditioners, air cooled, <65,000 Btu/h | $ 0.0003 | $ (0.0005) | $ (0.0060) | $ (0.0174) |
| Air conditioners, air cooled, ≥65,000 to <240,000 Btu/h | $ 0.01 | $ 0.10 | $ 0.29 | $ 0.44 |
| Air conditioners, air cooled, ≥240,000 Btu/h | $ 0.01 | $ 0.07 | $ 0.22 | $ 0.37 |
| Air conditioners, water cooled, <65,000 Btu/h | $ 0.001 | $ 0.003 | $ 0.006 | $ 0.009 |
| Air conditioners, water cooled, ≥65,000 to <240,000 Btu/h | $ (0.008) | $ (0.053) | $ (0.166) | $ (0.377) |
| Air conditioners, water cooled, ≥240,000 Btu/h | $ (0.001) | $ (0.026) | $ (0.097) | $ (0.239) |
| Air conditioners, water cooled with fluid economizers, <65,000 Btu/h | $ 0.001 | $ 0.002 | $ 0.003 | $ 0.005 |
| Air conditioners, water cooled with fluid economizers, ≥65,000 to <240,000 Btu/h | $ (0.02) | $ (0.08) | $ (0.20) | $ (0.41) |
| Air conditioners, water cooled with fluid economizers, ≥240,000 Btu/h | $ (0.005) | $ (0.023) | $ (0.061) | $ (0.127) |
| Air conditioners, glycol cooled, <65,000 Btu/h | $ 0.001 | $ 0.003 | $ 0.006 | $ 0.008 |
| Air conditioners, glycol cooled, ≥65,000 to <240,000 Btu/h | $ (0.003) | $ (0.044) | $ (0.157) | $ (0.375) |
| Air conditioners, glycol cooled, ≥240,000 Btu/h | $ 0.002 | $ (0.017) | $ (0.077) | $ (0.200) |
| Air conditioners, glycol cooled with fluid economizers, <65,000 Btu/h | $ 0.001 | $ 0.003 | $ 0.005 | $ 0.008 |
| Air conditioners, glycol cooled with fluid economizers, ≥65,000 to <240,000 Btu/h | $ (0.01) | $ (0.08) | $ (0.24) | $ (0.53) |
| Air conditioners, glycol cooled with fluid economizers, ≥240,000 Btu/h | $ (0.004) | $ (0.031) | $ (0.10) | $ (0.23) |

* Numbers in parentheses indicate negative NPV.

**Table 8.5.7. Summary of Cumulative Net Present Value for Computer Room Air Conditioners (Three Percent Discount Rate)**

| Equipment Class | Net Present Value (Billion 2011$) | | | |
|---|---|---|---|---|
| | Efficiency Level 1 | Efficiency Level 2 | Efficiency Level 3 | Efficiency Level 4 |
| Air conditioners, air cooled, <65,000 Btu/h | $ 0.001 | $ 0.002 | $ (0.004) | $ (0.021) |
| Air conditioners, air cooled, ≥65,000 to <240,000 Btu/h | $ 0.03 | $ 0.26 | $ 0.76 | $ 1.25 |
| Air conditioners, air cooled, ≥240,000 Btu/h | $ 0.02 | $ 0.18 | $ 0.54 | $ 0.93 |
| Air conditioners, water cooled, <65,000 Btu/h | $ 0.003 | $ 0.006 | $ 0.012 | $ 0.017 |
| Air conditioners, water cooled, ≥65,000 to <240,000 Btu/h | $ (0.006) | $ (0.079) | $ (0.280) | $ (0.671) |
| Air conditioners, water cooled, ≥240,000 Btu/h | $ 0.006 | $ (0.028) | $ (0.150) | $ (0.407) |
| Air conditioners, water cooled with fluid economizers, <65,000 Btu/h | $ 0.001 | $ 0.003 | $ 0.006 | $ 0.009 |
| Air conditioners, water cooled with fluid economizers, ≥65,000 to <240,000 Btu/h | $ (0.03) | $ (0.14) | $ (0.37) | $ (0.77) |
| Air conditioners, water cooled with fluid economizers, ≥240,000 Btu/h | $ (0.008) | $ (0.039) | $ (0.110) | $ (0.235) |
| Air conditioners, glycol cooled, <65,000 Btu/h | $ 0.002 | $ 0.006 | $ 0.011 | $ 0.016 |
| Air conditioners, glycol cooled, ≥65,000 to <240,000 Btu/h | $ 0.004 | $ (0.058) | $ (0.258) | $ (0.665) |
| Air conditioners, glycol cooled, ≥240,000 Btu/h | $ 0.01 | $ (0.01) | $ (0.12) | $ (0.34) |
| Air conditioners, glycol cooled with fluid economizers, <65,000 Btu/h | $ 0.002 | $ 0.006 | $ 0.011 | $ 0.015 |
| Air conditioners, glycol cooled with fluid economizers, ≥65,000 to <240,000 Btu/h | $ (0.02) | $ (0.14) | $ (0.43) | $ (0.97) |
| Air conditioners, glycol cooled with fluid economizers, ≥240,000 Btu/h | $ (0.003) | $ (0.047) | $ (0.17) | $ (0.41) |

* Numbers in parentheses indicate negative NPV.

## REFERENCES


1 U.S. Department of Energy, *Technical Support Document: Energy Efficiency Program for Commercial and Industrial Equipment: Efficiency Standards for Commercial Heating, Air-Conditioning, and Water Heating Equipment Including Packaged Terminal Air-Conditioners and Packaged Terminal Heat Pumps, Small Commercial Packaged Boiler, Three-Phase Air-Conditioners and Heat Pumps <65,000 Btu/h, and Single-Package Vertical Air Conditioners and Single-Package Vertical Heat Pumps < 65,000 Btu/h*, March 2006. Washington, DC.

2 California Public Utility Commission 2008. Database for Energy Efficient Resources. (Last accessed April 20, 2011.) <www.deeresources.com>

3 2011 ASHRAE Handbook HVAC Application*s*. ASHRAE, 2011. Atlanta GA (Available at www.ashrae.org).

4 U.S. Department of Energy/Energy Information Administration. 2010. Annual Energy Outlook 2010. DOE/EIA0383(2010), DOE/EIA, Washington, D.C.

5 U.S. Department of Energy/Energy Information Administration. 2011. Annual Energy Outlook 2011. DOE/EIA0383(2011), DOE/EIA, Washington, D.C.


## ABBREVIATIONS AND ACRONYMS

AEC annual energy consumption

DF discount factor

LCC lifecycle cost

NES national energy savings

NIA national impact analysis

NODA Notice of Data Availability

NOPR Notice of Proposed Rulemaking

NPV net present value

OMB Office of Management and Budget

PVS present value of operating cost savings

TSD technical support document

UEC unit energy consumption