DEPARTMENT OF ENERGY

10 CFR Part 431

[Docket Numbers EERE–2013–BT–STD–0007 and EERE–2013–BT–STD–0021]

RIN 1904–AC95 and 1904–AD11

Energy Conservation Program for Certain Industrial Equipment: Energy Conservation Standards for Small, Large, and Very Large Air-Cooled Commercial Package Air Conditioning and Heating Equipment and Commercial Warm Air Furnaces

AGENCY: Office of Energy Efficiency and Renewable Energy, Department of Energy.

ACTION: Direct final rule.

SUMMARY: The Energy Policy and Conservation Act of 1975, as amended (EPCA), prescribes energy conservation standards for various consumer products and certain commercial and industrial equipment, including small, large, and very large air-cooled commercial package air conditioning and heating equipment and commercial warm air furnaces. EPCA also requires that the U.S. Department of Energy (DOE) periodically review and consider amending its standards for specified categories of industrial equipment, including commercial heating and air conditioning equipment, in order to determine whether more-stringent, amended standards would be technologically feasible and economically justified, and save a significant additional amount of energy. In this direct final rule, DOE is amending the energy conservation standards for both small, large, and very large air-cooled commercial package air conditioning and heating equipment and commercial warm air furnaces after determining that the amended energy conservation standards being adopted for these equipment would result in the significant conservation of energy and be technologically feasible and economically justified.

DATES: The effective date of this rule is May 16, 2016 unless adverse comment is received by May 4, 2016. If adverse comments are received that DOE determines may provide a reasonable basis for withdrawal of the direct final rule, a timely withdrawal of this rule will be published in the **Federal Register**. If no such adverse comments are received, compliance with the amended standards in this final rule will be required for small, large, and very large air-cooled commercial package air conditioning and heating equipment as detailed in the SUPPLEMENTARY INFORMATION. Compliance with the amended standards established for commercial warm air furnaces in this final rule is required starting on January 1, 2023.

ADDRESSES: The dockets, which include **Federal Register** notices, public meeting attendee lists and transcripts, comments, and other supporting documents/materials, is available for review at *www.regulations.gov*. All documents in the dockets are listed in the *www.regulations.gov* index. However, some documents listed in the index, such as those containing information that is exempt from public disclosure, may not be publicly available.

A link to the docket Web page for small, large, and very large air-cooled commercial package air conditioning and heating equipment can be found at: *www.regulations.gov/#!docketDetail;D=EERE-2013-BT-STD-0007*. A link to the docket Web page for commercial warm air furnaces can be found at: *www.regulations.gov/#!docketDetail;D=EERE-2013-BT-STD-0021*. The *www.regulations.gov* Web page will contain instructions on how to access all documents, including public comments, in the docket.

For further information on how to review the dockets, contact Ms. Brenda Edwards at (202) 586–2945 or by email: *Brenda.Edwards@ee.doe.gov*.

FOR FURTHER INFORMATION CONTACT: Mr. John Cymbalsky, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies, EE–5B, 1000 Independence Avenue SW., Washington, DC 20585–0121. Telephone: (202) 286–1692. Email: *John.Cymbalsky@ee.doe.gov*.

SUPPLEMENTARY INFORMATION:

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I. Synopsis of the Direct Final Rule

Title III, Part C [1] of the Energy Policy and Conservation Act of 1975 (EPCA or the Act), Public Law 94–163 (December 22, 1975), coupled with Section 441(a) Title IV of the National Energy Conservation Policy Act, Public Law 95–619 (November 9, 1978), (collectively codified at 42 U.S.C. 6311–6317), established the Energy Conservation Program for Certain Industrial Equipment, which includes the small, large, and very large air-cooled commercial package air conditioning and heating equipment and commercial warm air furnaces (''CWAFs'') that are the subject of this rulemaking.[2] The former group of equipment (*i.e.* air-cooled commercial package air conditioning and heating equipment) is referred to herein as air-cooled commercial unitary air conditioners and heat pumps (''CUACs'' and ''CUHPs'').

DOE received a statement submitted jointly by interested persons that are fairly representative of relevant points of view (including representatives of manufacturers of the covered equipment at issue, States, and efficiency advocates) containing recommendations with respect to energy conservation standards for the above equipment (see section III.B for description of the jointly-submitted statement). DOE has determined that the recommended standards contained in that jointly-submitted statement (hereinafter ''Joint Statement'') are in accordance with 42 U.S.C. 6313(a)(6)(B), which prescribes the conditions for adoption of a uniform national standard more stringent than the applicable levels prescribed by ASHRAE/IES Standard 90.1 for the above equipment. (The acronym ''ASHRAE/IES'' stands for the American Society of Heating, Refrigerating, and Air-Conditioning Engineers/Illuminating Engineering Society.) Under the authority provided by 42 U.S.C. 6295(p)(4) and 6316(b)(1), DOE is issuing this direct final rule establishing amended energy conservation standards for CUACs, CUHPs, and CWAFs.

The amended minimum standards for CUACs and CUHPs are shown in Table I–1, with the CUAC and CUHP cooling efficiency standards presented in terms of an integrated energy efficiency ratio (''IEER'') and the CUHP heating efficiency standards presented as a coefficient of performance (''COP''). The

[1] Part C was codified as Part A–1 of the corresponding portion of the U.S. Code.

[2] All references to EPCA in this document refer to the statute as amended through the Energy Efficiency Improvement Act of 2015, Public Law 114–11 (April 30, 2015).

IEER metric would replace the currently used energy efficiency ratio (''EER'') metric on which DOE's standards are currently based. The standards will adopt ASHRAE 90.1–2013 efficiency levels in that will apply starting on January 1, 2018 and a higher level that will apply starting on January 1, 2023 as recommended by the ASRAC Working Group's Joint Statement. The standards contained in the recommendations apply to all equipment listed in Table I–1 manufactured in, or imported into, the United States starting on the dates shown in that table.

TABLE I–1—AMENDED ENERGY CONSERVATION STANDARDS FOR SMALL, LARGE, AND VERY LARGE COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT

Equipment type	Heating type	Proposed energy conservation standard	Compliance date
Small Commercial Packaged AC and HP (Air-Cooled)—≥65,000 Btu/h and <135,000 Btu/h Cooling Capacity:			
AC	Electric Resistance Heating or No Heating.	12.9 IEER	January 1, 2018.
		14.8 IEER	January 1, 2023.
	All Other Types of Heating	12.7 IEER	January 1, 2018.
		14.6 IEER	January 1, 2023.
HP	Electric Resistance Heating or No Heating.	12.2 IEER, 3.3 COP	January 1, 2018.
		14.1 IEER, 3.4 COP	January 1, 2023.
	All Other Types of Heating	12.0 IEER, 3.3 COP	January 1, 2018.
		13.9 IEER, 3.4 COP	January 1, 2023.
Large Commercial Packaged AC and HP (Air-Cooled)—≥135,000 Btu/h and <240,000 Btu/h Cooling Capacity:			
AC	Electric Resistance Heating or No Heating.	12.4 IEER	January 1, 2018.
		14.2 IEER	January 1, 2023.
	All Other Types of Heating	12.2 IEER	January 1, 2018.
		14.0 IEER	January 1, 2023.
HP	Electric Resistance Heating or No Heating.	11.6 IEER, 3.2 COP	January 1, 2018.
		13.5 IEER, 3.3 COP	January 1, 2023.
	All Other Types of Heating	11.4 IEER, 3.2 COP	January 1, 2018.
		13.3 IEER, 3.3 COP	January 1, 2023.
Very Large Commercial Packaged AC and HP (Air-Cooled)—≥240,000 Btu/h and <760,000 Btu/h Cooling Capacity:			
AC	Electric Resistance Heating or No Heating.	11.6 IEER	January 1, 2018.
		13.2 IEER	January 1, 2023.
	All Other Types of Heating	11.4 IEER	January 1, 2018.
		13.0 IEER	January 1, 2023.
HP	Electric Resistance Heating or No Heating.	10.6 IEER, 3.2 COP	January 1, 2018.
		12.5 IEER, 3.2 COP	January 1, 2023.
	All Other Types of Heating	10.4 IEER, 3.2 COP	January 1, 2018.
		12.3 IEER, 3.2 COP	January 1, 2023.

For CWAFs, the amended standards, which prescribe the minimum allowable thermal efficiency (''TE''), are shown in Table I–2. These standards apply to all equipment listed in Table I–2 manufactured in, or imported into, the United States starting on January 1, 2023.

TABLE I–2—ENERGY CONSERVATION STANDARDS FOR COMMERCIAL WARM AIR FURNACES

Equipment class	Input capacity * (Btu/h)	Thermal efficiency ** (%)
Gas-Fired Furnaces	≥225,000	81
Oil-Fired Furnaces	≥225,000	82

* In addition to being defined by input capacity, a CWAF is ''a self-contained oil- or gas-fired furnace designed to supply heated air through ducts to spaces that require it and includes combination warm air furnace/electric air conditioning units but does not include unit heaters and duct furnaces.'' CWAFs coverage is further discussed in section IV.A.2, ''Scope of Coverage and Equipment Classes.''

** Thermal efficiency is at the maximum rated capacity (rated maximum input), and is determined using the DOE test procedure specified at 10 CFR 431.76.

A. Benefits and Costs to Commercial Consumers

Table I–3 presents DOE's evaluation of the economic impacts of the energy conservation standards on commercial consumers of CUACs and CUHPs, as measured by the average life-cycle cost (''LCC'') savings and the payback period (''PBP'').[3] The average LCC savings are positive for all equipment classes, and the PBP is less than the average lifetime of the equipment, which is estimated to be 22 years (see section IV.F.6).

[3] The average LCC savings are measured relative to the efficiency distribution in the no-new-standards case, which depicts the market in the compliance year in the absence of standards (see section IV.F.8). The simple PBP, which is designed to compare specific CWAF efficiency levels, is measured relative to the baseline model (see section IV.C.2.a).

TABLE I–3—IMPACTS OF AMENDED ENERGY CONSERVATION STANDARDS ON COMMERCIAL CONSUMERS OF SMALL, LARGE, AND VERY LARGE COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT

Equipment class	Average LCC savings (2014$)	Payback period (years)
Small CUACs	104	13.4
Large CUACs	2,336	1.9
Very Large CUACs	2,468	6.2

Table I–4 presents DOE's evaluation of the economic impacts of the energy conservation standards on commercial consumers of CWAFs, as measured by the average LCC savings and the PBP. The average LCC savings are positive for both equipment classes, and the PBP is less than the average lifetime of the equipment, which is estimated to be 23 years for both gas-fired and oil-fired CWAFs (see section IV.F.6).

TABLE I–4—IMPACTS OF AMENDED ENERGY CONSERVATION STANDARDS ON COMMERCIAL CONSUMERS OF COMMERCIAL WARM AIR FURNACES

Equipment class	Average LCC savings (2014$)	Simple pay-back period (years)
Gas-Fired CWAFs	284	1.4
Oil-Fired CWAFs	400	1.9

DOE's analysis of the impacts of the adopted standards on commercial consumers of CUACs/CUHPs and CWAFs is described in section IV.F of this document.

B. Impact on Manufacturers

1. Commercial Unitary Air Conditioners and Heat Pumps

The industry net present value (''INPV'') is the sum of the discounted cash flows to the industry from the base year through the end of the analysis period (2015 to 2048). Using a real discount rate of 6.2 percent, DOE estimates that the INPV for CUAC/CUHP manufacturers is $1,638.2 million in 2014$. Under the standards adopted in this direct final rule, DOE expects INPV may change approximately −26.8 percent to −2.3 percent, which corresponds to approximately −$440.4 million and −$38.5 million in 2014$. In order to bring equipment into compliance with the standards adopted in this direct final rule, DOE expects the industry to incur $520.8 million in total conversion costs.

2. Commercial Warm Air Furnaces

As indicated above, the INPV is the sum of the discounted cash flows to the industry from the base year through the end of the analysis period (2015 to 2048). Using a real discount rate of 8.9 percent, DOE estimates that the INPV for CWAF manufacturers is $96.3 million in 2014$. Under the standards adopted in this direct final rule, DOE expects INPV may be reduced by approximately 13.9 percent to 6.1 percent, which corresponds to −$13.4 million and −$5.9 million in 2014$. In order to bring products into compliance with the standards in this direct final rule, DOE expects the industry to incur $22.2 million in conversion costs.

DOE's analysis of the impacts of the standards in this direct final rule on manufacturers is described in section IV.J of this document.

C. National Benefits and Costs [4]

1. Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment

DOE's analyses indicate that energy conservation standards being adopted in this direct final rule for CUAC and CUHP equipment would save a significant amount of energy. Relative to the case without amended standards (referred to as the ''no-new-standards case''), the lifetime energy savings for CUAC and CUHP equipment purchased in 2018–2048 amount to 14.8 quadrillion British thermal units (Btu), or ''quads.'' [5] This represents a savings of 24 percent relative to the energy use of these products in the no-new-standards case.

The cumulative net present value (''NPV'') of total consumer costs and savings of the standards for CUACs and CUHPs ranges from $15.2 billion (at a 7-percent discount rate) to $50 billion (at a 3-percent discount rate). This NPV expresses the estimated total value of future operating-cost savings minus the estimated increased product and installation costs for CUACs and CUHPs purchased in 2018–2048.

In addition, the CUAC and CUHP equipment standards that are being adopted in this direct final rule are projected to yield significant environmental benefits as a result of the improvement in the conservation of energy. DOE estimates that the standards would result in cumulative greenhouse gas (''GHG'') emission reductions (over the same period as for energy savings) of 873 million metric tons (Mt) [6] of carbon dioxide (CO_2), 454 thousand tons of sulfur dioxide (SO_2), 1,634 tons of nitrogen oxides (NO_X), 3,917 thousand tons of methane (CH_4), 9.54 thousand tons of nitrous oxide (N_2O), and 1.68 tons of mercury (Hg).[3] The cumulative reduction in CO_2 emissions through 2030 amounts to 77 million Mt, which is equivalent to the

[4] All monetary values in this section are expressed in 2014 dollars and, where appropriate, are discounted to 2015 unless explicitly stated otherwise. Energy savings in this section refer to the full-fuel-cycle savings (see section IV.H for discussion).

[5] A quad is equal to 10^{15} British thermal units (''Btu''). The quantity refers to full-fuel-cycle (''FFC'') energy savings. FFC energy savings includes the energy consumed in extracting, processing, and transporting primary fuels (*i.e.,* coal, natural gas, petroleum fuels), and, thus, presents a more complete picture of the impacts of energy efficiency standards. For more information on the FFC metric, see section IV.H.2.

[6] A metric ton is equivalent to 1.1 short tons. Results for NO_X and Hg are presented in short tons.

[3] DOE calculated emissions reductions relative to the no-new-standards-case, which reflects key assumptions in the *Annual Energy Outlook 2015* (*AEO 2015*) Reference case, which generally represents current legislation and environmental regulations for which implementing regulations were available as of October 31, 2014.

emissions resulting from the annual electricity use of more than 10.6 million homes.

The value of the CO_2 reductions is calculated using a range of values per metric ton of CO_2 (otherwise known as the ''Social Cost of Carbon,'' or ''SCC'') developed by a Federal interagency working group.[7] The derivation of the SCC values is discussed in section IV.L. Using discount rates appropriate for each set of SCC values, DOE estimates that the net present monetary value of the CO_2 emissions reduction (not including CO_2-equivalent emissions of other gases with global warming potential) is between $5.0 billion and $75.9 billion, with a value of $24.9 billion using the central SCC case represented by $40.0/t in 2015. DOE also estimates that the net present monetary value of the NO_X emissions reduction to be $1.4 billion at a 7-percent discount rate, and $4.4 billion at a 3-percent discount rate.[8]

Table I–5 summarizes the national economic benefits and costs expected to result from the adopted standards for CUACs and CUHPs.

TABLE I–5—SUMMARY OF NATIONAL ECONOMIC BENEFITS AND COSTS OF AMENDED ENERGY CONSERVATION STANDARDS FOR SMALL, LARGE, AND VERY LARGE COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT *

Category	Present value (billion 2014$)	Discount rate (%)
Benefits		
Consumer Operating Cost Savings	23.0	7
	64.9	3
CO_2 Reduction Value ($12.2/t case) **	5.0	5
CO_2 Reduction Value ($40.0/t case) **	24.9	3
CO_2 Reduction Value ($62.3/t case) **	40.2	2.5
CO_2 Reduction Value ($117/t case) **	75.9	3
NO_X Reduction Value †	1.4	7
	4.4	3
Total Benefits ††	49.3	7
	94.1	3
Costs		
Consumer Incremental Installed Costs	7.7	7
	14.9	3
Net Benefits		
Including CO_2 and NO_X Reduction Value ††	41.6	7
	79.2	3

* This table presents the costs and benefits associated with equipment shipped in 2018–2048. These results include benefits to consumers which accrue after 2048 from the products purchased in 2018–2048. The costs account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series incorporate an escalation factor.

† The $/ton values used for NO_X are described in section IV.L.2. DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the *Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants,* published in June 2014 by EPA's Office of Air Quality Planning and Standards. (Available at: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf*.) See section IV.L.2 for further discussion. Note that the agency is primarily using a national benefit-per-ton estimate for particulate matter emitted from the Electricity Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski et al., 2009). If the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), the values would be nearly two-and-a-half times larger. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emissions, DOE intends to investigate refinements to the agency's current approach of one national estimate by assessing the regional approach taken by EPA's Regulatory Impact Analysis for the Clean Power Plan Final Rule.

†† Total Benefits for both the 3% and 7% cases are derived using the series corresponding to average SCC with 3-percent discount rate ($40.0/t case).

The benefits and costs of the adopted CUAC and CUHP standards for equipment sold in 2018–2048 can also be expressed in terms of annualized values. The monetary values for the total annualized net benefits are the sum of (1) the national economic value of the benefits in reduced operating costs, minus (2) the increases in product purchase prices and installation costs, plus (3) the value of the benefits of CO_2 and NO_X emission reductions, all annualized.[9]

[7] *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.* Interagency Working Group on Social Cost of Carbon, United States Government (May 2013; revised July 2015) (Available at: *https://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf*).

[8] DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the *Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants,* published in June 2014 by EPA's Office of Air Quality Planning and Standards. (Available at: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf*). See section IV.L.2 for further discussion. Note that the agency is primarily using a national benefit-per-ton estimate for particulate matter emitted from the Electricity Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski et al., 2009). If the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), the values would be nearly two-and-a-half times larger. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emissions, DOE intends to investigate refinements to the agency's current approach of one national estimate by assessing the regional approach taken by EPA's Regulatory Impact Analysis for the Clean Power Plan Final Rule. Note that DOE is currently investigating valuation of avoided and SO_2 and Hg emissions.

[9] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2015, the year used for discounting the NPV of total consumer costs and savings. For the benefits, DOE calculated a present value associated with each year's shipments in the year in which the shipments occur (*e.g.,* 2020 or 2030), and then discounted the present value from each year to 2015. The calculation uses discount rates of 3 and 7 percent for all costs and benefits except for the

Although the value of operating cost savings and CO_2 emission reductions are both important, two issues are relevant. First, the national operating cost savings are domestic U.S. consumer monetary savings that occur as a result of market transactions, whereas the value of CO_2 reductions is based on a global value. Second, the assessments of operating cost savings and CO_2 savings are performed with different methods that use different time frames for analysis. The national operating cost savings is measured for the lifetime of CUACs and CUHPs shipped in 2018–2048. Because CO_2 emissions have a very long residence time in the atmosphere,[10] the SCC values in future years reflect future CO_2-emissions impacts that continue beyond 2100.

Estimates of annualized benefits and costs of the adopted standards are shown in Table I–6. The results under the primary estimate are as follows. Using a 7-percent discount rate for benefits and costs other than CO_2 reduction, (for which DOE used a 3-percent discount rate along with the SCC series that has a value of $40.0/t in 2015),[11] the estimated cost of the standards in this rule is $708 million per year in increased equipment costs, while the estimated annual benefits are $2,099 million in reduced equipment operating costs, $1,320 million in CO_2 reductions, and $132.0 million in reduced NO_X emissions. In this case, the net benefit amounts to $2,843 million per year. Using a 3-percent discount rate for all benefits and costs and the SCC series that has a value of $40.0/t in 2015, the estimated cost of the standards is $792 million per year in increased equipment costs, while the estimated annual benefits are $3,441 million in reduced operating costs, $1,320 million in CO_2 reductions, and $231.3 million in reduced NO_X emissions. In this case, the net benefit amounts to $4,201 million per year.

TABLE I–6—ANNUALIZED BENEFITS AND COSTS OF AMENDED STANDARDS FOR SMALL, LARGE, AND VERY LARGE COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT *

	Million 2014$/year			
	Discount rate (%)	Primary estimate	Low net benefits estimate	High net benefits estimate
Benefits				
Consumer Operating Cost Savings	7	2,099	2,021	2,309
	3	3,441	3,287	3,830.
CO_2 Reduction Value ($12.2/t case) **	5	357	355	361.
CO_2 Reduction Value ($40.0/t case) **	3	1,320	1,313	1,337.
CO_2 Reduction Value ($62.3/t case) **	2.5	1,973	1,964	1,999.
CO_2 Reduction Value ($117/t case) **	3	4,028	4,009	4,080.
NO_X Reduction Value †	7	132.0	131.3	299.1.
	3	231.3	230.2	516.3.
Total Benefits ††	7 plus CO_2 range	2,588 to 6,259	2,507 to 6,160	2,970 to 6,689.
	7	3,551	3,465	3,946.
	3 plus CO_2 range	4,029 to 7,701	3,872 to 7,525	4,708 to 8,427.
	3	4,992	4,830	5,684.
Costs				
Consumer Incremental Product Costs	7	708	888	275
	3	792	1028	231.
Net Benefits				
Total ††	7 plus CO_2 range	1,880 to 5,551	1,619 to 5,273	2,695 to 6,414.
	7	2,843	2,578	3,671.
	3 plus CO_2 range	3,238 to 6,909	2,843 to 6,497	4,477 to 8,196.
	3	4,201	3,802	5,453.

* This table presents the annualized costs and benefits associated with CUACs and CUHPs shipped in 2018–2048. These results include benefits to consumers which accrue after 2048 from the CUACs and CUHPs purchased in 2018–2048. The results account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule. The Primary, Low Benefits, and High Benefits Estimates utilize projections of energy prices from the *AEO 2015* Reference case, Low Economic Growth case, and High Economic Growth case, respectively. In addition, incremental product costs reflect a constant price trend in the Primary estimate, a slightly increasing price trend in the Low Benefits estimate, and a slightly decreasing price trend in the Low Benefits estimate. The methods used to project price trends are explained in section IV.D.1.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series incorporate an escalation factor.

† The $/ton values used for NO_X are described in section IV.L.2. DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the Regulatory Impact Analysis titled, "*Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants,*" published in June 2014 by EPA's Office of Air Quality Planning and Standards. (Available at: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf*.) For DOE's Primary Estimate and Low Net Benefits Estimate, the agency used a national benefit-per-ton estimate for particulate matter emitted from the Electric Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski et al., 2009). For DOE's High Net Benefits Estimate, the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), which are nearly two-and-a-half times larger than those from the ACS study. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emission, DOE intends to investigate refinements to the agency's current approach of one national estimate by assessing the regional approach taken by EPA's Regulatory Impact Analysis for the Clean Power Plan Final Rule.

value of CO_2 reductions, for which DOE used case-specific discount rates, as shown in Table I.3. Using the present value, DOE then calculated the fixed annual payment over the analysis period, starting in the compliance year, that yields the same present value.

[10] The atmospheric lifetime of CO_2 is estimated of the order of 30–95 years. Jacobson, MZ (2005), "Correction to 'Control of fossil-fuel particulate black carbon and organic matter, possibly the most effective method of slowing global warming,' " 110 *J. Geophys. Res.* D14105.

[11] DOE used a 3% discount rate because the SCC values for the series used in the calculation were derived using a 3% discount rate (see section IV.L).

†† Total Benefits for both the 3% and 7% cases are derived using the series corresponding to the average SCC with 3-percent discount rate ($40.0/t) case. In the rows labeled "7% plus CO_2 range" and "3% plus CO_2 range," the operating cost and NO_X benefits are calculated using the labeled discount rate, and those values are added to the full range of CO_2 values.

DOE's analysis of the national impacts of the adopted standards is described in sections IV.H, IV.K and IV.L of this document.

2. Commercial Warm Air Furnaces

DOE's analyses indicate that the adopted energy conservation standards for CWAFs would save a significant amount of energy. Relative to the case without amended standards (referred to as the "no-new-standards case"), the lifetime energy savings for CWAFs purchased in 2023–2048 amount to 0.23 quads. This represents a savings of 0.8 percent relative to the energy use of these products in the case without amended standards (*i.e.* the no-new-standards case).

The cumulative NPV of total consumer costs and savings of the standards for CWAFs ranges from $0.3 billion (at a 7-percent discount rate) to $1.0 billion (at a 3-percent discount rate). This NPV expresses the estimated total value of future operating-cost savings minus the estimated increased product and installation costs for CWAFs purchased in 2023–2048.

In addition, the CWAF equipment standards that are being adopted in this direct final rule are projected to yield significant environmental benefits as a result of the improvement in the conservation of energy. Specifically, these standards are projected to result in cumulative GHG emission reductions (over the same period as for energy savings) of 12.4 Mt of CO_2, 0.40 thousand tons of SO_2, 41.2 tons of NO_X, 146 thousand tons of CH_4, 0.03 thousand tons of N_2O, and 0.001 tons of mercury. The cumulative reduction in CO_2 emissions through 2030 amounts to 0.9 Mt, which is equivalent to the emissions resulting from the annual electricity use of about 79,000 homes.

The value of the CO_2 reductions is calculated using a range of values per metric ton of CO_2 developed by the Federal interagency Working Group. The derivation of the SCC values is discussed in section IV.L. Using discount rates appropriate for each set of SCC values, DOE estimates that the net present monetary value of the CO_2 emissions reduction (not including CO_2-equivalent emissions of other gases with global warming potential) ranges from $71.4 million to $1,078 million, with a value of $353 million using the central SCC case represented by $40.0/t in 2015. DOE also estimates that the net present monetary value of the NO_X emissions reduction to be $36.1 million at a 7-percent discount rate, and $110 million at a 3-percent discount rate.

Table I–7 summarizes the national economic benefits and costs expected to result from the adopted CWAF standards.

TABLE I–7—SUMMARY OF NATIONAL ECONOMIC BENEFITS AND COSTS OF AMENDED ENERGY CONSERVATION STANDARDS FOR COMMERCIAL WARM AIR FURNACES *

Category	Present value (billion 2014$)	Discount Rate (%)
Benefits		
Operating Cost Savings	0.4	7
	1.0	3
CO_2 Reduction Value ($12.2/t case) **	0.07	5
CO_2 Reduction Value ($40.0/t case) **	0.35	3
CO_2 Reduction Value ($62.3/t case) **	0.57	2.5
CO_2 Reduction Value ($117/t case) **	1.08	3
NO_X Reduction Value †	0.04	7
	0.11	3
Total Benefits ††	0.75	7
	1.5	3
Costs		
Consumer Incremental Installed Costs	0.03	7
	0.06	3
Net Benefits		
Including CO_2 and NO_X Reduction Monetized Value††	0.72	7
	1.4	3

* This table presents the costs and benefits associated with CWAFs shipped in 2023–2048. These results include benefits to commercial consumers which accrue after 2048 from the products purchased in 2023–2048. The costs account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series incorporate an escalation factor.

† The $/ton values used for NO_X are described in section IV.L.2. DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the Regulatory Impact Analysis titled, *"Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants,"* published in June 2014 by EPA's Office of Air Quality Planning and Standards. (Available at: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.*) See section IV.L.2 for further discussion. Note that the agency is primarily using a national benefit-per-ton estimate for particulate matter emitted from the Electricity Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski et al., 2009). If the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), the values would be nearly two-and-a-half times larger. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emissions, DOE intends to investigate refinements to the agency's current approach of one national estimate by assessing the regional approach taken by EPA's Regulatory Impact Analysis for the Clean Power Plan Final Rule.

†† Total Benefits for both the 3% and 7% cases are derived using the series corresponding to average SCC with 3-percent discount rate ($40.0/t case).

The benefits and costs of the adopted standards, for CWAFs sold in 2023–2048, can also be expressed in terms of annualized values. The monetary values for the total annualized net benefits are the sum of (1) the national economic value of the benefits in reduced operating costs, minus (2) the increases in product purchase prices and installation costs, plus (3) the value of the benefits of CO_2 and NO_X emission reductions, all annualized.[12]

Estimates of annualized benefits and costs of the adopted standards are shown in Table I–8. The results under the primary estimate are as follows. Using a 7-percent discount rate for benefits and costs other than CO_2 reduction, (for which DOE used a 3-percent discount rate along with the SCC series that has a value of $40.0/t in 2015), the estimated cost of the standards in this rule is $4.31 million per year in increased equipment costs, while the estimated annual benefits are $49 million in reduced equipment operating costs, $24 million in CO_2 reductions, and $4.91 million in reduced NO_X emissions. In this case, the net benefit amounts to $74 million per year. Using a 3-percent discount rate for all benefits and costs and the SCC series has a value of $40.0/t in 2015, the estimated cost of the standards is $4.38 million per year in increased equipment costs, while the estimated annual benefits are $71 million in reduced operating costs, $24 million in CO_2 reductions, and $7.59 million in reduced NO_X emissions. In this case, the net benefit amounts to $99 million per year.

TABLE I–8—ANNUALIZED BENEFITS AND COSTS OF AMENDED STANDARDS FOR COMMERCIAL WARM AIR FURNACES *

	Discount rate (%)	Million 2014$/year		
		Primary estimate	Low estimate	High estimate
Benefits				
Operating Cost Savings	7	49	48	54.
	3	71	70	81.
CO_2 Reduction Value ($12.2/t case) **	5	6.99	7.08	7.37.
CO_2 Reduction Value ($40.0/t case) **	3	24	25	26.
CO_2 Reduction Value ($62.3/t case) **	2.50	36	36	38.
CO_2 Reduction Value ($117/t case) **	3	74	75	79.
NO_X Reduction Value †	7	4.91	4.98	11.44.
	3	7.59	7.70	17.61.
Total Benefits ††	7 plus CO_2 range	61 to 128	60 to 128	73 to 144.
	7	78	78	91.
	3 plus CO_2 range	86 to 153	84 to 152	106 to 177.
	3	103	102	124.
Costs				
Consumer Incremental Product Costs	7	4.31	5.04	3.92
	3	4.38	5.22	3.94.
Net Benefits				
Total ††	7 plus CO_2 range	57 to 124	55 to 123	69 to 140.
	7	74	72	87.
	3 plus CO_2 range	82 to 149	79 to 147	102 to 173.
	3	99	97	120.

* This table presents the annualized costs and benefits associated with CWAFs shipped in 2023–2048. These results include benefits to commercial consumers which accrue after 2048 from the CWAFs purchased from 2023–2048. The results account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule. The Primary, Low Benefits, and High Benefits Estimates utilize projections of energy prices from the *AEO 2015* Reference case, Low Economic Growth case, and High Economic Growth case, respectively. In addition, incremental product costs reflect a medium decline rate in the Primary Estimate, a low decline rate in the Low Benefits Estimate, and a high decline rate in the High Benefits Estimate. The methods used to derive projected price trends are explained in section IV.H.3.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series incorporate an escalation factor.

† The $/ton values used for NO_X are described in section IV.L.2. DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the *Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants,* published in June 2014 by EPA's Office of Air Quality Planning and Standards. (Available at: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.*) For DOE's Primary Estimate and Low Net Benefits Estimate, the agency used a national benefit-per-ton estimate for particulate matter emitted from the Electric Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski et al., 2009). For DOE's High Net Benefits Estimate, the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), which are nearly two-and-a-half times larger than those from the ACS study. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emission, DOE intends to investigate refinements to the agency's current approach of one national estimate by assessing the regional approach taken by EPA's Regulatory Impact Analysis for the Clean Power Plan Final Rule.

†† Total Benefits for both the 3% and 7% cases are derived using the series corresponding to the average SCC with 3-percent discount rate ($40.0/t) case. In the rows labeled "7% plus CO_2 range" and "3% plus CO_2 range," the operating cost and NO_X benefits are calculated using the labeled discount rate, and those values are added to the full range of CO_2 values.

[12] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2015, the year used for discounting the NPV of total consumer costs and savings. For the benefits, DOE calculated a present value associated with each year's shipments in the year in which the shipments occur (*e.g.,* 2020 or 2030), and then discounted the present value from each year to 2015. The calculation uses discount rates of 3 and 7 percent for all costs and benefits except for the value of CO_2 reductions, for which DOE used case-specific discount rates, as shown in Table I.7. Using the present value, DOE then calculated the fixed annual payment over the analysis period, starting in the compliance year to 2048, that yields the same present value.

DOE's analysis of the national impacts of the adopted standards is described in sections IV.H, IV.K and IV.L of this document.

3. Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment and Commercial Warm Air Furnaces

DOE's analyses indicate that energy conservation standards being adopted in this direct final rule for CUAC and CUHP equipment and CWAFs would save a significant amount of energy. Relative to the no-new-standards case, the lifetime energy savings for CUAC and CUHP equipment purchased in 2018–2048 and CWAFs purchased in 2023–2048 amount to 15.0 quads. This represents a savings of 24 percent relative to the energy use of these products in the no-new-standards case.

The cumulative NPV of total consumer costs and savings of the standards for CUACs and CUHPs and CWAFs ranges from $15.5 billion (at a 7-percent discount rate) to $51 billion (at a 3-percent discount rate). This NPV expresses the estimated total value of future operating-cost savings minus the estimated increased product and installation costs for CUACs and CUHPs purchased in 2018–2048 and CWAFs purchased in 2023–2048.

In addition, the standards that are being adopted in this direct final rule are projected to yield significant environmental benefits as a result of the improvement in the conservation of energy. DOE estimates that the standards would result in cumulative GHG emission reductions (over the same period as for energy savings) of 885 million Mt of CO_2, 454 thousand tons of SO_2, 1,675 tons of NO_X, 4,063 thousand tons of CH_4, 10 thousand tons of N_2O, and 1.68 tons of Hg. The cumulative reduction in CO_2 emissions through 2030 amounts to 78 million Mt, which is equivalent to the emissions resulting from the annual electricity use of approximately 10.7 million homes.

The value of the CO_2 reductions is calculated using a range of values per metric ton of CO_2 developed by a Federal interagency working group. The derivation of the SCC values is discussed in section IV.L. Using discount rates appropriate for each set of SCC values, DOE estimates that the net present monetary value of the CO_2 emissions reduction (not including CO_2-equivalent emissions of other gases with global warming potential) is between $5.1 billion and $77 billion, with a value of $25.3 billion using the central SCC case represented by $40.0/t in 2015. DOE also estimates that the net present monetary value of the NO_X emissions reduction to be $1.4 billion at a 7-percent discount rate, and $4.5 billion at a 3-percent discount rate.

Table I–9 summarizes the combined national economic benefits and costs expected to result from the adopted standards for CUACs and CUHPs and CWAF.

TABLE I–9—SUMMARY OF NATIONAL ECONOMIC BENEFITS AND COSTS OF AMENDED ENERGY CONSERVATION STANDARDS FOR SMALL, LARGE, AND VERY LARGE COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT AND COMMERCIAL WARM AIR FURNACES *

Category	Present value (billion 2014$)	Discount rate (%)
Benefits		
Operating Cost Savings	23.3	7
	65.9	3
CO_2 Reduction Value ($12.2/t case) **	5.1	5
CO_2 Reduction Value ($40.0/t case) **	25.2	3
CO_2 Reduction Value ($62.3/t case) **	40.8	2.5
CO_2 Reduction Value ($117/t case) **	77.0	3
NO_X Reduction Value †	1.5	7
	4.5	3
Total Benefits ††	50.1	7
	95.6	3
Costs		
Consumer Incremental Installed Costs	7.8	7
	15.0	3
Net Benefits		
Including CO_2 and NO_X Reduction Value ††	42.3	7
	80.6	3

* This table presents the costs and benefits associated with CUACs and CUHPs shipped in 2018–2048 and CWAFs shipped in 2023–2048. These results include benefits to commercial consumers which accrue after 2048. The costs account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series incorporate an escalation factor.

† The $/ton values used for NO_X are described in section IV.L.2. DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the *Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants,* published in June 2014 by EPA's Office of Air Quality Planning and Standards. (Available at: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.*) See section IV.L.2 for further discussion. Note that the agency is primarily using a national benefit-per-ton estimate for particulate matter emitted from the Electricity Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski et al., 2009). If the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), the values would be nearly two-and-a-half times larger. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emissions, DOE intends to investigate refinements to the agency's current approach of one national estimate by assessing the regional approach taken by EPA's Regulatory Impact Analysis for the Clean Power Plan Final Rule.

†† Total Benefits for both the 3% and 7% cases are derived using the series corresponding to average SCC with 3-percent discount rate ($40.0/t case).

The benefits and costs of the adopted standards for CUAC and CUHP and CWAFs can also be expressed in terms of annualized values. Estimates of annualized benefits and costs of the adopted standards are shown in Table I–10. The results under the primary estimate are as follows. Using a 7-percent discount rate for benefits and costs other than CO_2 reduction (for which DOE used a 3-percent discount rate along with the SCC series that has a value of $40.0/t in 2015), the estimated cost of the standards in this rule is $711 million per year in increased equipment costs, while the estimated annual benefits are $2,132 million in reduced equipment operating costs, $1,339 million in CO_2 reductions, and $135 million in reduced NO_X emissions. In this case, the net benefit amounts to $2,895 million per year. Using a 3-percent discount rate for all benefits and costs and the SCC series has a value of $40.0/t in 2015, the estimated cost of the standards is $795 million per year in increased equipment costs, while the estimated annual benefits are $3,496 million in reduced operating costs, $1,339 million in CO_2 reductions, and $237 million in reduced NO_X emissions. In this case, the net benefit amounts to $4,277 million per year.

TABLE I–10—ANNUALIZED BENEFITS AND COSTS OF AMENDED STANDARDS FOR SMALL, LARGE, AND VERY LARGE COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT AND COMMERCIAL WARM AIR FURNACES *

	Million 2014$/year			
	Discount rate (%)	Primary estimate	Low estimate	High estimate
Benefits				
Operating Cost Savings	7	2,132	2,053	2,346.
	3	3,496	3,340	3,892.
CO_2 Reduction Value ($12.2/t case) **	5	362	360	367.
CO_2 Reduction Value ($40.0/t case) **	3	1,339	1,332	1,357.
CO_2 Reduction Value ($62.3/t case) **	2.50	2,002	1,992	2,029.
CO_2 Reduction Value ($117/t case) **	3	4,085	4,067	4,141.
NO_X Reduction Value †	7	135	135	307.
	3	237	236	530.
Total Benefits ††	7 plus CO_2 range	2,629 to 6,353	2,548 to 6,254	3,019 to 6,794.
	7	3,606	3,520	4,010.
	3 plus CO_2 range	4,095 to 7,819	3,937 to 7,643	4,789 to 8,563.
		5,072	4,909	5,779.
Costs				
Consumer Incremental Product Costs	7	711	891	277.
	3	795	1033	234.
Net Benefits				
Total ††	7 plus CO_2 range	1,918 to 5,642	1,657 to 5,363	2,742 to 6,516.
	7	2,895	2,629	3,732.
	3 plus CO_2 range	3,300 to 7,024	2,904 to 6,610	4,555 to 8,330.
	3	4,277	3,876	5,545.

* This table presents the annualized costs and benefits associated with CUACs and CUHPs shipped in 2018–2048 and CWAFs shipped in 2023–2048. These results include benefits to commercial consumers which accrue after 2048. The results account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule. The Primary, Low Benefits, and High Benefits Estimates utilize projections of energy prices from the *AEO 2015* Reference case, Low Economic Growth case, and High Economic Growth case, respectively. In addition, incremental product costs reflect a medium decline rate in the Primary Estimate, a low decline rate in the Low Benefits Estimate, and a high decline rate in the High Benefits Estimate. The methods used to derive projected price trends are explained in section IV.H.3.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series incorporate an escalation factor.

† The $/ton values used for NO_X are described in section IV.L.2. DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the *Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants,* published in June 2014 by EPA's Office of Air Quality Planning and Standards. (Available at: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.*) For DOE's Primary Estimate and Low Net Benefits Estimate, the agency is primarily using a national benefit-per-ton estimate for particulate matter emitted from the Electric Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski et al., 2009). For DOE's High Net Benefits Estimate, the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), which are nearly two-and-a-half times larger than those from the ACS study. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emission, DOE intends to investigate refinements to the agency's current approach of one national estimate by assessing the regional approach taken by EPA's Regulatory Impact Analysis for the Clean Power Plan Final Rule.

†† Total Benefits for both the 3% and 7% cases are derived using the series corresponding to the average SCC with 3-percent discount rate ($40.0/t) case. In the rows labeled "7% plus CO_2 range" and "3% plus CO_2 range," the operating cost and NO_X benefits are calculated using the labeled discount rate, and those values are added to the full range of CO_2 values.

D. Conclusion

DOE has determined that the statement containing recommendations with respect to energy conservation standards for CUACs, CUHPs and CWAFs was submitted jointly by interested persons that are fairly representative of relevant points of view, in accordance with 42 U.S.C.

6295(p)(4)(A) and 6313(a)(6)(B).[13] After considering the analysis and weighing the benefits and burdens, DOE has determined that the recommended standards are in accordance with 42 U.S.C. 6313(a)(6)(B), which contains provisions for adopting a uniform national standard more stringent than the amended ASHRAE Standard 90.1 for the equipment considered in this document. Specifically, the Secretary has determined, supported by clear and convincing evidence, that the adoption of the recommended standards would result in significant additional conservation of energy and is technologically feasible and economically justified. In determining whether the recommended standards are economically justified, the Secretary has determined that the benefits of the recommended standards exceed the burdens, given that, when considering the benefits of energy savings, positive NPV of consumer benefits, emission reductions, the estimated monetary value of the emissions reductions, and positive average LCC savings would yield benefits outweighing the negative impacts on some consumers and on manufacturers, including the conversion costs that could result in a reduction in INPV for manufacturers.

Under the authority provided by 42 U.S.C. 6295(p)(4) and 6316(b)(1), DOE is issuing this direct final rule establishing amended energy conservation standards for CUACs/CUHPs and CWAFs. Consistent with this authority, DOE is also publishing elsewhere in this **Federal Register** a notice of proposed rulemaking proposing standards that are identical to those contained in this direct final rule.[14] See 42 U.S.C. 6295(p)(4)(A)(i).

II. Introduction

The following section briefly discusses the statutory authority underlying this direct final rule, as well as some of the relevant historical background related to the establishment of standards for small, large, and very large, CUAC/CUHP and CWAF equipment.

A. Authority

As indicated above, EPCA includes provisions covering the equipment addressed by this document.[15] EPCA addresses, among other things, the energy efficiency of certain types of commercial and industrial equipment. Relevant provisions of the Act specifically include definitions (42 U.S.C. 6311), energy conservation standards (42 U.S.C. 6313), test procedures (42 U.S.C. 6314), labeling provisions (42 U.S.C. 6315), and the authority to require information and reports from manufacturers (42 U.S.C. 6316).

Section 342(a) of EPCA concerns energy conservation standards for small, large, and very large, CUACs and CUHPs. (42 U.S.C. 6313(a)) This category of equipment has a rated capacity between 65,000 Btu/h and 760,000 Btu/h. This equipment is designed to heat and cool commercial buildings and is often located on the building's rooftop.

The initial Federal energy conservation standards for CWAFs were added to EPCA by the Energy Policy Act of 1992 (EPACT 1992), Public Law No. 102–486 (Oct. 24, 1992). See 42 U.S.C. 6313(a)(4). These types of covered equipment have a rated capacity (rated maximum input[16]) greater than or equal to 225,000 Btu/h, can be gas-fired or oil-fired, and are designed to heat commercial and industrial buildings. *Id.*

Pursuant to section 342(a)(6) of EPCA, DOE is to consider amending the energy efficiency standards for certain types of commercial and industrial equipment whenever ASHRAE amends the standard levels or design requirements prescribed in ASHRAE/IES Standard 90.1, and whenever more than 6 years had elapsed since the issuance of the most recent final rule establishing or amending a standard for the equipment as of the date of AEMTCA's enactment, December 18, 2012. (42 U.S.C. 6313(a)(6)(C)(vi)) Because more than six years had elapsed since DOE issued a final rule with standards for CUACs and CUHPs or CWAFs on October 18, 2005 (see 70 FR 60407), DOE initiated the process to review these standards.

Pursuant to EPCA, DOE's energy conservation program for covered equipment consists essentially of four parts: (1) Testing; (2) labeling; (3) the establishment of Federal energy conservation standards; and (4) certification and enforcement procedures. Subject to certain criteria and conditions, DOE is required to develop test procedures to measure the energy efficiency, energy use, or estimated annual operating cost of covered equipment. (42 U.S.C. 6314) Manufacturers of covered equipment must use the prescribed DOE test procedure as the basis for certifying to DOE that their equipment comply with the applicable energy conservation standards adopted under EPCA and when making representations to the public regarding their energy use or efficiency. (42 U.S.C. 6314(d)) Similarly, DOE must use these test procedures to determine whether a given manufacturer's equipment complies with standards adopted pursuant to EPCA. The DOE test procedures for small, large, and very large CUACs/CUHPs and CWAFs currently appear at title 10 of the Code of Federal Regulations (''CFR'') parts 431.96 and 431.76, respectively.

When setting standards for the equipment addressed by this document, EPCA prescribes specific statutory criteria for DOE to consider. See generally 42 U.S.C. 6313(a)(6)(A)–(C). In deciding whether a proposed standard is economically justified, DOE must determine whether the benefits of the standard exceed its burdens. DOE must make this determination after receiving comments on the proposed standard, and by considering, to the maximum extent practicable, the following seven statutory factors:

1. The economic impact of the standard on manufacturers and consumers of products subject to the standard;

2. The savings in operating costs throughout the estimated average life of the covered products in the type (or class) compared to any increase in the price, initial charges, or maintenance expenses for the covered products which are likely to result from the standard;

3. The total projected amount of energy savings likely to result directly from the standard;

4. Any lessening of the utility or the performance of the covered products likely to result from the standard;

5. The impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from the standard;

6. The need for national energy conservation; and

7. Other factors the Secretary of Energy considers relevant. (42 U.S.C. 6313(a)(6)(B)(ii))

With respect to the types of equipment at issue in this rule, EPCA also contains what is known as an ''anti-backsliding'' provision, which prevents the Secretary from prescribing any

[13] See 42 U.S.C. 6313(b) (applying 42 U.S.C. 6295(p)(4) to energy conservation standard rulemakings involving a variety of industrial equipment, including CUACs, CUHPs, and CWAFs).

[14] Because DOE has already published initial notices of proposed rulemaking for CUACs, CUHPs, and CWAFs, DOE is publishing a supplemental notice of proposed rulemaking that proposes the identical energy conservation standards detailed in this direct final rule.

[15] All references to EPCA in this document refer to the statute as amended through the Energy Efficiency Improvement Act of 2015, Public Law 114–11 (April 30, 2015).

[16] ''Rated maximum input'' means the maximum gas-burning capacity of a CWAF in Btus per hour, as specified by the manufacturer.

amended standard that either increases the maximum allowable energy use or decreases the minimum required energy efficiency of a covered product. (42 U.S.C. 6313(a)(6)(B)(iii)(I)) Also, the Secretary may not prescribe an amended or new standard if interested persons have established by a preponderance of the evidence that the standard is likely to result in the unavailability in the United States of any covered product type (or class) of performance characteristics (including reliability, features, sizes, capacities, and volumes) that are substantially the same as those generally available in the United States. (42 U.S.C. 6313(a)(6)(B)(iii)(II))(aa)

With respect to the equipment addressed by this direct final rule, DOE notes that EPCA prescribes limits on the Agency's ability to promulgate a standard if DOE has made a finding that interested persons have established by a preponderance of the evidence that a standard is likely to result in the unavailability of any product type (or class) of performance characteristics that are substantially the same as those generally available in the United States at the time of the finding. See 42 U.S.C. 6313(B)(iii)(II).

With particular regard to direct final rules, the Energy Independence and Security Act of 2007 (''EISA 2007''), Public Law 110–140 (December 19, 2007), amended EPCA, in relevant part, to grant DOE authority to issue a type of final rule (*i.e.,* a ''direct final rule'') establishing an energy conservation standard for a product on receipt of a statement that is submitted jointly by interested persons that are fairly representative of relevant points of view (including representatives of manufacturers of covered products, States, and efficiency advocates), as determined by the Secretary, and that contains recommendations with respect to an energy or water conservation standard. If the Secretary determines that the recommended standard contained in the statement is in accordance with 42 U.S.C. 6295(o) or 42 U.S.C. 6313(a)(6)(B), as applicable, the Secretary may issue a final rule establishing the recommended standard. A notice of proposed rulemaking (''NOPR'') that proposes an identical energy efficiency standard is published simultaneously with the direct final rule. A public comment period of at least 110 days is provided. See 42 U.S.C. 6295(p)(4). Not later than 120 days after the date on which a direct final rule issued under this authority is published in the **Federal Register**, the Secretary shall withdraw the direct final rule if the Secretary receives 1 or more adverse public comments relating to the direct final rule or any alternative joint recommendation and based on the rulemaking record relating to the direct final rule, the Secretary determines that such adverse public comments or alternative joint recommendation may provide a reasonable basis for withdrawing the direct final rule under subsection 42 U.S.C. 6295(o), 6313(a)(6)(B), or any other applicable law. On withdrawal of a direct final rule, the Secretary shall proceed with the notice of proposed rulemaking published simultaneously with the direct final rule and publish in the **Federal Register** the reasons why the direct final rule was withdrawn. This direct final rule provision applies to the equipment at issue in this direct final rule. See 42 U.S.C. 6316(b)(1).

B. Background

1. Current Standards

DOE last amended its standards for small, large, and very large, CUACs/CUHPs on October 18, 2005. At that time, DOE codified both the amended standards for small and large equipment and the then-new standards for very large equipment set by the Energy Policy Act of 2005 (''EPAct 2005''), Pub. L. 109–58. See also 70 FR 60407 (August 8, 2005). The current standards are set forth in Table II–1.

TABLE II–1—MINIMUM COOLING AND HEATING EFFICIENCY LEVELS FOR SMALL, LARGE, AND VERY LARGE COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT

Equipment type	Cooling capacity	Sub-category	Heating type	Efficiency level	Compliance date
Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled).	>=65,000 Btu/h and <135,000 Btu/h.	AC	Electric Resistance Heating or No Heating.	EER = 11.2	1/1/2010
			All Other Types of Heating.	EER = 11.0	1/1/2010
		HP	Electric Resistance Heating or No Heating.	EER = 11.0 COP = 3.3	1/1/2010
			All Other Types of Heating.	EER = 10.8 COP = 3.3	1/1/2010
Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled).	>=135,000 Btu/h and <240,000 Btu/h.	AC	Electric Resistance Heating or No Heating.	EER = 11.0	1/1/2010
			All Other Types of Heating.	EER = 10.8	1/1/2010
		HP	Electric Resistance Heating or No Heating.	EER = 10.6 COP = 3.2	1/1/2010
			All Other Types of Heating.	EER = 10.4 COP = 3.2	1/1/2010
Very Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled).	>=240,000 Btu/h and <760,000 Btu/h.	AC	Electric Resistance Heating or No Heating.	EER = 10.0	1/1/2010
			All Other Types of Heating.	EER = 9.8	1/1/2010
		HP	Electric Resistance Heating or No Heating.	EER = 9.5 COP = 3.2	1/1/2010

TABLE II–1—MINIMUM COOLING AND HEATING EFFICIENCY LEVELS FOR SMALL, LARGE, AND VERY LARGE COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT—Continued

Equipment type	Cooling capacity	Sub-category	Heating type	Efficiency level	Compliance date
			All Other Types of Heating.	EER = 9.3 COP = 3.2	1/1/2010

As noted above, EPACT 1992 amended EPCA to set the current minimum energy conservation standards for CWAFs. (42 U.S.C. 6313(a)(4)(A) and (B)) These standards, which apply to all CWAFs manufactured on or after January 1, 1994, are set forth in Table II–2.

TABLE II–2—FEDERAL ENERGY EFFICIENCY STANDARDS FOR CWAFS

Equipment type	Input capacity (Btu/h)	Thermal efficiency * %	Compliance date
Gas-Fired Furnaces	≥225,000	80	1/1/1994
Oil-Fired Furnaces	≥225,000	81	1/1/1994

* At the maximum rated capacity (rated maximum input).

2. History of Standards Rulemakings

a. Commercial Unitary Air Conditioners and Heat Pumps

On October 29, 1999, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)/Illuminating Engineering Society of North America (IESNA) adopted Standard 90.1–1999, ''Energy Standard for Buildings Except Low-Rise Residential Building,'' which included amended efficiency levels for CUACs and CUHPs. On June 12, 2001, the Department published a Framework Document that described a series of analytical approaches to evaluate energy conservation standards for CUACs and CUHPs with rated capacities between 65,000 Btu/h and 240,000 Btu/h, and presented this analytical framework to stakeholders at a public workshop. On July 29, 2004, DOE issued an Advance Notice of Proposed Rulemaking (''ANOPR'') (hereafter referred to as the ''2004 ANOPR'') to solicit public comments on its preliminary analyses for this equipment. 69 FR 45460. Subsequently, Congress enacted EPAct 2005, which, among other things, established amended standards for small and large CUACs and CUHPs and new standards for very large CUACs and CUHPs. As a result, EPAct 2005 displaced the rulemaking effort that DOE had already begun. DOE codified these new statutorily-prescribed standards on October 18, 2005. 70 FR 60407.

Section 5(b) of AEMTCA amended Section 342(a)(6) of EPCA (42 U.S.C. 6313(a)(6)) by requiring DOE to initiate a rulemaking to consider amending the standards for any covered equipment as to which more than 6 years has elapsed since the issuance of the most recent final rule establishing or amending a standard for the equipment as of the date of AEMTCA's enactment, December 18, 2012. (42 U.S.C. 6313(a)(6)(C)(vi)) Under this provision, DOE was also obligated to publish a notice of proposed rulemaking to amend the applicable standards by December 31, 2013. See 42 U.S.C. 6313(a)(6)(C)(vi). Consequently, DOE initiated a rulemaking effort to determine whether to amend the current standards for CUACs and CUHPs.

On February 1, 2013, DOE published a request for information (''RFI'') and notice of document availability for small, large, and very large, air cooled CUACs and CUHPs. 78 FR 7296. The document sought to solicit information from the public to help DOE determine whether national standards more stringent than those already in place would result in a significant amount of additional energy savings and whether those national standards would be technologically feasible and economically justified. Separately, DOE also sought information on the merits of adopting the IEER metric as the energy efficiency descriptor characterizing cooling-mode efficiency for small, large, and very large CUACs and CUHPs, rather than the current EER metric. (See section III.G for more details).

DOE notes that in October 2010, ASHRAE published ASHRAE Standard 90.1–2010, which amended its requirements for CUACs and CUHPs to include, among other things, new requirements for IEER. In October 2013, ASHRAE published ASHRAE Standard 90.1–2013, which further amended those IEER requirements. The provisions relating to EER and COP contained in ASHRAE Standard 90.1–2010 and ASHRAE Standard 90.1–2013, however, remained the same as the current DOE standards for this equipment. As discussed in section IV.C.2, DOE considered efficiency levels associated with the IEER requirements in both ASHRAE Standard 90.1–2010 and ASHRAE Standard 90.1–2013.

On September 30, 2014, DOE published a NOPR for small, large, and very large CUACs and CUHPs. 79 FR 58948. The document solicited information from the public to help DOE determine whether more-stringent energy conservation standards for small, large, and very large CUACs and CUHPs would result in a significant additional amount of energy savings and whether those standards would be technologically feasible and economically justified.

The September 2014 document also announced that a public meeting would be held on November 6, 2014 at DOE headquarters in Washington, DC At this meeting, DOE presented the methodologies and results of the analyses set forth in the NOPR, and interested parties that participated in the public meeting discussed a variety of topics.

DOE also received a number of written comments from interested parties in response to the NOPR. DOE considered these comments, as well as comments from the public meeting, in preparing the direct final rule. The commenters are summarized in Table II–3. Relevant comments, and DOE's responses, are provided in the appropriate sections of this document.

TABLE II–3—INTERESTED PARTIES PROVIDING WRITTEN COMMENT ON THE NOPR FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED CUACS AND CUHPS

Name	Acronyms	Type
A2H, Inc	A2H	E
Air-Conditioning, Heating and Refrigeration Institute	AHRI	TA
Appliance Standards Awareness Project (ASAP), Alliance to Save Energy (ASE), American Council for an Energy-Efficient Economy (ACEEE), Natural Resources Defense Council (NRDC), Northeast Energy Efficiency Partnerships (NEEP), and Northwest Energy Efficiency Alliance (NEEA).	Joint Efficiency Advocates	EA
Applied Engineering of East Tennessee, Inc	Applied Engineering	E
American Society of Heating, Refrigerating and Air-Conditioning Engineers	ASHRAE	TA
Balanced Principles, LLC	Balanced Principles	E
Pacific Gas and Electric Company (PG&E), Southern California Gas Company (SCGC), San Diego Gas and Electric (SDG&E), and Southern California Edison (SCE).	California IOUs	U
Cato Institute		PP
Coradini, Michael; Doss, Eddie; Heinrich; Michael; Huntley, John; Long, Robert		I
Danfoss	Danfoss	CS
Environmental Investigation Agency	EIA Global	EA
Gardiner Trane, H & H Sales Associates, Inc., Havtech, Heat Transfer Solutions, HVAC Equipment Sales, Inc., MWSK Equipment Sales Inc., Slade Ross, Inc.		D
Goodman Manufacturing	Goodman	M
Sofie Miller (George Washington University Regulatory Studies Center)	Miller	EI
I.C. Thomasson Associates, Inc	IC Thomasson	E
Ingersoll Rand (Trane)	Trane	M
KJWW	KJWW	E
Lennox International Inc	Lennox	M
Merryman-Farr, LLC	Merryman-Farr	C
Nidec Motor Corporation	Nidec	CS
Nortek Global HVAC LLC	Nordyne	M
Policy Navigation Group		PP
Regal-Beloit Corporation	Regal-Beloit	CS
Rheem Manufacturing Company	Rheem	M
Smith-Goth Engineers, Inc	Smith-Goth	E
Southern Company	Southern Company	U
Thompson Engineers, Inc	Thompson	E
United Technologies Corporation	Carrier	M
University of Michigan Plant Operations	UM	EI
Viridis Engineering	Viridis	E

C: Mechanical Contractor; CS: Component Supplier; D: Equipment Distributor: E: Engineering Consulting Firm; EA: Efficiency/Environmental Advocate; EI: Educational Institution; I: Individual; M: Manufacturer; PP: Public Policy Research Organization; TA: Trade Association; U: Utility; UR: Utility Representative.

b. Commercial Warm Air Furnaces

On October 21, 2004, DOE published a final rule in the **Federal Register** that adopted definitions for ''commercial warm air furnace'' and ''TE,'' promulgated test procedures for this equipment, and recodified the energy conservation standards to place them contiguously with the test procedures in the Code of Federal Regulations (''CFR''). 69 FR 61916, 61917, 61939–41. In the same final rule, DOE incorporated by reference (see 10 CFR 431.75) a number of industry test standards relevant to commercial warm air furnaces, including: (1) American National Standards Institute (''ANSI'') Standard Z21.47–1998, ''Gas-Fired Central Furnaces,'' for gas-fired CWAFs; (2) Underwriters Laboratories (''UL'') Standard 727–1994, ''Standard for Safety Oil-Fired Central Furnaces,'' for oil-fired CWAFs; (3) provisions from Hydronics Institute (HI) Standard BTS–2000, ''Method to Determine Efficiency of Commercial Space Heating Boilers,'' to calculate flue loss for oil-fired CWAFs, and (4) provisions from the American Society of Heating, Refrigerating, and Air-conditioning Engineers (''ASHRAE'') Standard 103–1993, ''Method of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers,'' to determine the incremental efficiency of condensing furnaces under steady-state conditions. *Id.* at 61940. DOE later updated the test procedures for CWAFs to match the procedures specified in ASHRAE Standard 90.1–2010, which referenced ANSI Z21.47–2006, ''Gas-Fired Central Furnaces,'' for gas-fired CWAFs, and UL 727–2006, ''Standard for Safety for Oil-Fired Central Furnaces,'' for oil-fired furnaces. 77 FR 28928, 28987–88 (May 16, 2012).

As with CUACs and CUHPs, DOE was obligated to publish either: (1) A notice of determination that the current standards do not need to be amended, or (2) a notice of proposed rulemaking containing proposed standards for CWAFs by December 31, 2013. (42 U.S.C. 6313(a)(6)(C)(i) and (vi)) Consequently, DOE initiated a rulemaking to determine whether to amend the current standards for CWAFs.

In starting this rulemaking process, DOE published an RFI and notice of document availability for CWAFs. See 78 FR 25627 (May 2, 2013). The document solicited information from the public to help DOE determine whether more-stringent energy conservation standards for CWAFs would result in a significant additional amount of energy savings and whether those standards would be technologically feasible and economically justified.

Based on feedback and additional analysis, on February 4, 2015, DOE published a NOPR for CWAFs. See 80 FR 6182. The NOPR, in addition to announcing a public meeting to discuss the proposal's details, solicited information from the public to help DOE determine whether more-stringent energy conservation standards for

CWAFs would result in a significant additional amount of energy savings and whether those standards would be technologically feasible and economically justified. The public meeting, which took place on March 2, 2015 at DOE headquarters in Washington, DC, centered on the methodologies and results of the analyses set forth in the NOPR. Participating interested parties also raised a variety of topics, which are discussed throughout this document.

DOE received a number of written comments from interested parties in response to the NOPR. DOE considered these comments, as well as comments from the public meeting, in the preparation of this final rule. The commenters are identified in Table II–4. Relevant comments, and DOE's responses, are provided in the appropriate sections of this document.

TABLE II–4—INTERESTED PARTIES PROVIDING WRITTEN COMMENTS ON THE NOPR FOR COMMERCIAL WARM AIR FURNACES

Name	Acronyms	Commenter Type *
Air-Conditioning, Heating and Refrigeration Institute	AHRI	TA
American Council for an Energy-Efficient Economy	ACEEE	EA
American Gas Association	AGA	IR
Appliance Standards Awareness Project, Alliance to Save Energy, American Council for an Energy-Efficient Economy, Natural Resources Defense Council.	ASAP, ASE, ACEEE, NRDC (The Advocates).	EA
Gas Technology Institute	GTI	RO
Goodman Global, Inc	Goodman	M
Ingersoll Rand	Trane	M
Lennox International Inc	Lennox	M
Nortek Global HVAC LLC	Nordyne	M
Rheem Manufacturing Company	Rheem	M
United Technologies Corporation	Carrier	M
The U.S. Chamber of Commerce, the American Chemistry Council, the American Coke and Coal Chemicals Institute, the American Forest & Paper Association, the American Fuel & Petrochemical Manufacturers, the American Petroleum Institute, the Brick Industry Association, the Council of Industrial Boiler Owners, the National Association of Manufacturers, the National Mining Association, the National Oilseed Processors Association, and the Portland Cement Association.	U.S. Chamber of Commerce	TA
U.S. Small Business Administration's Office of Advocacy	SBA	GA

* EA: Efficiency Advocate; GA: Government Agency; IR: Industry Representative; M: Manufacturer; RO: Research Organization; TA: Trade Association.

III. General Discussion

A. Combined Rulemaking

As discussed in section II.B.2, DOE had been conducting separate standards rulemakings for two sets of interrelated equipment: (1) Small, large, and very large, CUACs and CUHPs; and (2) CWAFs. In response to the CUAC/CUHP NOPR, Lennox and Goodman requested that DOE align the rulemakings for these equipment because of their inherent impact on each other. The commenters asserted that combining the rulemakings would reduce manufacturer burden by allowing manufacturers to consider both of these regulatory changes in one design cycle. (CUAC: Lennox, No. 60 at p. 8; Goodman, No. 65 at p. 5)[17]

In light of the broad overlap between these equipment, DOE agreed that a combined rulemaking for small, large, and very large, CUACs and CUHPs and CWAFs had certain advantages. For example, DOE observed that a large fraction of CWAFs are part of combined single-package CUACs/CWAF equipment, combining both air conditioning and gas-fired heating. Combining the rulemakings allowed simultaneous consideration of both functions of what is generally a single piece of equipment, thus allowing DOE to accurately account for the relations between the different systems. This approach also ensured that there would be no divergence of equipment development timelines for the separate functions, thus reducing costs and manufacturer impacts. As a result, DOE is setting standards for these equipment that aligns the effective dates of the CUAC/CUHP and CWAF rulemakings. DOE expects that aligning the effective dates will reduce total conversion costs and cumulative regulatory burden, while also allowing industry to gain clarity on potential regulations that could affect refrigerant availability before the higher appliance standard takes effect in 2023. Approximately 68.5 percent of industry equipment listings currently meet the 2018 standard, while 20.4 percent of current industry equipment listings meet the 2023 standard level.

B. Consensus Agreement

1. Background

In response to the September 2014 CUAC/CUHP NOPR, Lennox suggested that DOE adopt the ASHRAE 90.1–2013 standards for the equipment subject to this rulemaking but also offered in the alternative that DOE should convene a negotiated rulemaking to address potential amendments to the current standards, which would enhance stakeholder input into the discussion, analysis and outcome of the rulemaking. (CUAC: Lennox, No. 60 at p. 3) Other manufacturers made similar suggestions. (CUAC: Trane, No. 63 at p. 14; Goodman, No. 65 at p. 22) In response to the CWAF NOPR, AHRI stated that the best approach to resolve the issues it identified, as well as the concerns of other stakeholders on this rulemaking and on the CUAC rulemaking, would be for DOE to conduct a negotiated rulemaking at

[17] In this direct final rule, DOE discusses comments received in regards to both the CUAC/CHUP and CWAF rulemakings. Comments received in regards to the CUAC/CUHP rulemaking and filed in the docket for this standards rulemaking (Docket No. EERE–2013–BT–STD–0007) are identified by ''CUAC'' preceding the comment citation. Comments received in regards to the CWAF rulemaking and filed in the docket for this standards rulemaking (Docket No. EERE–2013–BT–STD–0021) are identified by ''CWAF'' preceding the comment citation. Comments received in regards to the ASRAC Working Group activities (discussed in section III.B), while filed in the dockets for both the CUAC/CUHP and CWAF rulemakings, are identified by the equipment in regards to which the comment was made.

which stakeholders can work together to develop standards that will result in energy savings using technology that is feasible and economically justified. (CWAF: AHRI, No. 26 at p. 15) In addition, AHRI and ACEEE submitted a joint letter to the Appliance Standards and Rulemaking Federal Advisory Committee (''ASRAC'') requesting that it consider approving a recommendation that DOE initiate a negotiated rulemaking for commercial package air conditioners and commercial furnaces. (EERE–2013–BT–STD–0007–0080) ASRAC carefully evaluated this request and the Committee voted to charter a working group to support the negotiated rulemaking effort requested by these parties.

Subsequently, after careful consideration, DOE determined that, given the complexity of the CUAC/CUHP rulemaking and the logistical challenges presented by the related CWAF proposal, a combined effort to address these equipment types was appropriate to ensure a comprehensive vetting of issues and related analyses that would support any final rule settting standards for this equipment. To this end while highly unusual to do so after issuing a proposed rule, DOE solicited the public for membership nominations to the working group that would be formed under the ASRAC charter by issuing a Notice of Intent to Establish the Commercial Package Air Conditioners and Commercial Warm Air Furnaces Working Group To Negotiate Potential Energy Conservation Standards for Commercial Package Air Conditioners and Commercial Warm Air Furnaces. 80 FR 17363 (April 1, 2015). The CUAC/CUHP–CWAF Working Group (in context, ''the Working Group'') was established under ASRAC in accordance with the Federal Advisory Committee Act and the Negotiated Rulemaking Act—with the purpose of discussing and, if possible, reaching consensus on a set of energy conservation standards to propose or finalize for CUACs, CUHPs and CWAFs. The Working Group was to consist of fairly representative parties having a defined stake in the outcome of the proposed standards, and would consult, as appropriate, with a range of experts on technical issues.

DOE received 17 nominations for membership. Ultimately, the Working Group consisted of 17 members, including one member from ASRAC and one DOE representative.[18] The Working Group met six times (five times in-person and once by teleconference). The meetings were held on April 28, May 11–12, May 20–21, June 1–2, June 9–10, and June 15, 2015.[19] As a result of these efforts, the Working Group successfully reached consensus on energy conservation standards for CUACs, CUHPs, and CWAFs. On June 15, 2015, it submitted a Term Sheet to ASRAC outlining its recommendations, which ASRAC subsequently adopted.[20]

DOE carefully considered the consensus recommendations submitted by the Working Group in the form of a single Term Sheet, and adopted by ASRAC, related to amending the energy conservation standards for CUACs, CUHPs, and CWAFs. Based on this consideration, DOE has determined that these recommendations comprise a statement submitted by interested persons that are fairly representative of relevant points of view, consistent with 42 U.S.C. 6295(p)(4). In reaching this determination, DOE took into consideration the fact that the Working Group, in conjunction with ASRAC members who approved the recommendations, consisted of representatives of manufacturers of the covered equipment at issue, States, and efficiency advocates. Thus all of the groups specifically identified by Congress as potentially relevant parties to any consensus recommendation submitted by ASRAC participated in approving the recommendations submitted to DOE. (42 U.S.C. 6295(p)(4)(A)) As delineated above, the Term Sheet was signed and submitted by a broad cross-section of interests, including the manufacturers of the subject equipment, trade associations representing these manufacturers and installation contractors, environmental and energy-efficiency advocacy organizations, and electric utility companies. The ASRAC Committee approving the Working Group's recommendations included at least two members representing States—one representing the National Association of State Energy Officials (NASEO) and one representing the State of California.[21] DOE is not aware of a relevant point of view that was not represented by one or more of the participants in the Working Group or ASRAC.

By its plain terms, the statute contemplates that the Secretary will exercise discetion to determine whether a given statement is ''submitted jointly by interested persons that are fairly representative of relevant points of view (including representatives of manufacturers of covered products, States, and efficiency advocates).'' In this case, given the broad range of persons participating in the process that led to the submission—in the Working Group and in ASRAC—and given the breadth of perspectives expressed in that process, DOE has determined that the statement it received meets this criterion.

Pursuant to 42 U.S.C. 6295(p)(4), the Secretary must also determine whether a jointly-submitted recommendation for an energy or water conservation standard satisfies 42 U.S.C. 6295(o) or 42 U.S.C. 6313(a)(6)(B), as applicable. In making this determination, DOE has conducted an analysis to evaluate whether the potential energy conservation standards under consideration would meet these requirements. This evaluation is similar to the comprehensive approach that DOE typically conducts whenever it considers potential energy conservation standards for a given type of product or equipment. DOE applies these principles to any consensus recommendations it may receive to satisfy its statutory obligation to ensure that any energy conservation standard that it adopts achieves the maximum improvement in energy efficiency that is

[18] The group members were John Cymbalsky (U.S. Department of Energy), Marshall Hunt (Pacific Gas & Electric Company, San Diego Gas & Electric Company, Southern California Edison, and Southern California Gas Company), Andrew deLaski (Appliance Standards Awareness Project), Louis Starr (Northwest Energy Efficiency Alliance), Meg Waltner (Natural Resources Defense Council), Jill Hootman (Trane), John Hurst (Lennox), Karen Meyers (Rheem Manufacturing Company), Charlie McCrudden (Air Conditioning Contractors of America), Harvey Sachs (American Council for an Energy Efficient Economy), Paul Doppel (Mitsubishi Electric), Robert Whitwell (United Technologies Corporation (Carrier)), Michael Shows (Underwriters Laboratories), Russell Tharp (Goodman Manufacturing), Sami Zendah (Emerson Climate Technologies), Mark Tezigni (Sheet Metal and Air Conditioning Contractors National Association, Inc.), Nick Mislak (Air-Conditioning, Heating, and Refrigeration Institute).

[19] In addition, most of the members of the ASRAC Working Group held several informal meetings on March 19–20, 2015, March 30, 2015, and April 13, 2015. The purpose of these meetings was to initiate work on some of the analytical issues raised in stakeholder comments on the CUAC NOPR.

[20] Available at *http://www.regulations.gov/#!documentDetail;D=EERE-2013-BT-STD-0007-0093.* The following individuals served as members of ASRAC that received and approved the Term Sheet: Co-Chair John Mandyck (Carrier/United Technologies Corporation), Co-Chair Andrew deLaski (Appliance Standards Awareness Project), Ashley Armstrong (U.S. Department of Energy), John Caskey (National Electrical Manufacturers Association), Jennifer Cleary (Association of Home Appliance Manufacturers), Thomas Eckman (Northwest Power and Conservation Council), Charles Hon (True Manufacturing Company), Dr. David Hungerford (California Energy Commission), Dr. Diane Jakobs (Rheem Manufacturing Company), Kelley Kline (General Electric, Appliances), Deborah Miller (National Association of State Energy Officials), and Scott Blake Harris (Harris, Wiltshire & Grannis, LLP).

[21] These individuals were Deborah E. Miller (NASEO) and David Hungerford (California Energy Commission).

technologically feasible and economically justified and will result in the significant conservation of energy. Upon review, the Secretary determined that the Term Sheet's recommendations submitted in the instant rulemaking comports with the standard-setting criteria set forth under 42 U.S.C. 6313(a)(6)(B). Accordingly, the efficiency levels recommended to DOE by the Working Group through ASRAC were included as the ''recommended trial standard level (TSL)'' for CUACs/CUHPs and as TSL 2 for CWAFs in this rule (see section V.A for description of all of the considered TSLs). The details regarding how the consensus-recommended TSLs comply with the standard-setting criteria are discussed and demonstrated in the relevant sections throughout this document.

In sum, as the relevant criteria under 42 U.S.C. 6295(p)(4) have been satisfied, the Secretary has determined that it is appropriate to adopt the amended energy conservation standards recommended in the Joint Statement for CUACs, CUHPs, and CWAFs through this direct final rule.

Pursuant to the same statutory provision, DOE is also simultaneously publishing a NOPR proposing that the identical standard levels contained in this direct final rule be adopted. Consistent with the statute, DOE is providing a 110-day public comment period on both the direct final rule and the NOPR. Based on the comments received during this period, the direct final rule will either become effective or DOE will withdraw it if (1) one or more adverse comments is received and (2) DOE determines that those comments, when viewed in light of the rulemaking record related to the direct final rule, provide a reasonable basis for withdrawal of the direct final rule under 42 U.S.C. 6313(a)(6)(B) and for DOE to continue this rulemaking under the NOPR. (Receipt of an alternative joint recommendation may also trigger a DOE withdrawal of the direct final rule in the same manner.) See 42 U.S.C. 6295(p)(4)(C). Typical of other rulemakings, it is the substance, rather than the quantity, of comments that will ultimately determine whether a direct final rule will be withdrawn. To this end, the substance of any adverse comment(s) received will be weighed against the anticipated benefits of the jointly-submitted recommendations and the likelihood that further consideration of the comment(s) would change the results of the rulemaking. DOE notes that, to the extent an adverse comment had been previously raised and addressed in the rulemaking proceeding, such a submission will not typically provide a basis for withdrawal of a direct final rule.

2. *Recommendations*

For commercial package air conditioners and heat pumps (*i.e.* CUACs/CUHPs), the Working Group recommended two sets of standards along with two sets of compliance dates—one would apply starting on January 1, 2018, and the other would apply on January 1, 2023. The 2018 standards for CUACs and CUHPs—excluding double-duct air conditioners and heat pumps (see discussion below)—recommended by the Working Group are contained in Table III–1 and Table III–2. The 2023 standards for the same equipment are contained in Table III–3 and Table III–4.

TABLE III–1—CONSENSUS RECOMMENDED MINIMUM COOLING EFFICIENCY STANDARDS FOR COMMERCIAL PACKAGE AIR-COOLED AIR CONDITIONERS AND HEAT PUMPS MANUFACTURED STARTING ON JANUARY 1, 2018

Equipment category	Rated cooling capacity	Sub-category	Heating type	Minimum energy efficiency standard
Small Commercial Split and Single Package Air-Conditioners and Heat Pumps (Air-Cooled).	≥65,000 Btu/h and <135,000 Btu/h.	AC	Electric Resistance Heating or No Heating	IEER = 12.9.
			All Other Types of Heating	IEER = 12.7.
		HP	Electric Resistance Heating or No Heating	IEER = 12.2.
			ll Other Types of Heating	IEER = 12.0.
Large Commercial Split and Single Package Air-Conditioners and Heat Pumps (Air-Cooled).	≥135,000 Btu/h and <240,000 Btu/h.	AC	Electric Resistance Heating or No Heating	IEER = 12.4.
			All Other Types of Heating	IEER = 12.2.
		HP	Electric Resistance Heating or No Heating	IEER = 11.6.
			All Other Types of Heating	IEER = 11.4.
Very Large Commercial Split and Single Package Air-Conditioners and Heat Pumps (Air-Cooled).	≥240,000 Btu/h and <760,000 Btu/h.	AC	Electric Resistance Heating or No Heating	IEER = 11.6.
			All Other Types of Heating	IEER = 11.4.
		HP	Electric Resistance Heating or No Heating	IEER = 10.6.
			All Other Types of Heating	IEER = 10.4

TABLE III–2—CONSENSUS RECOMMENDED MINIMUM HEATING EFFICIENCY STANDARDS FOR AIR-COOLED HEAT PUMPS MANUFACTURED STARTING ON JANUARY 1, 2018

Equipment category	Rated cooling capacity	Heating type	Minimum energy efficiency standard
Small Commercial Split and Single Package Heat Pumps (Air-Cooled).	≥65,000 Btu/h and <135,000 Btu/h.	Electric Resistance Heating or No Heating All Other Types of Heating	COP = 3.3.
Large Commercial Split and Single Package Heat Pumps (Air-Cooled) (Air-Cooled).	≥135,000 Btu/h and <240,000 Btu/h.	Resistance Heating or No Heating All Other Types of Heating	COP = 3.2.
Very Large Commercial Split and Single Package Heat Pumps (Air-Cooled).	≥240,000 Btu/h and <760,000 Btu/h.	Resistance Heating or No Heating All Other Types of Heating	COP = 3.2

TABLE III–3—CONSENSUS RECOMMENDED MINIMUM COOLING EFFICIENCY STANDARDS FOR COMMERCIAL PACKAGE AIR-COOLED AIR CONDITIONERS AND HEAT PUMPS MANUFACTURED STARTING ON JANUARY 1, 2023

Equipment category	Rated cooling capacity	Sub-category	Heating type	Minimum energy efficiency standard
Small Commercial Split and Single Package Air-Conditioners and Heat Pumps (Air-Cooled).	≥65,000 Btu/h and <135,000 Btu/h.	AC	Electric Resistance Heating or No Heating	IEER = 14.8.
			All Other Types of Heating	EER = 14.6.
		HP	Electric Resistance Heating or No Heating	IEER = 14.1.
			All Other Types of Heating	IEER = 13.9.
Large Commercial Split and Single Package Air-Conditioners and Heat Pumps (Air-Cooled).	≥135,000 Btu/h and <240,000 Btu/h.	AC	Electric Resistance Heating or No Heating	IEER = 14.2.
			All Other Types of Heating	IEER = 14.0.
		HP	Electric Resistance Heating or No Heating	IEER = 13.5.
			All Other Types of Heating	IEER = 13.3.
Very Large Commercial Split and Single Package Air-Conditioners and Heat Pumps (Air-Cooled).	≥240,000 Btu/h and <760,000 Btu/h.	AC	Electric Resistance Heating or No Heating	IEER = 13.2.
			All Other Types of Heating	IEER = 13.0.
		HP	Electric Resistance Heating or No Heating	IEER = 12.5.
			All Other Types of Heating	IEER = 12.3

TABLE III–4—CONSENSUS RECOMMENDED MINIMUM COOLING EFFICIENCY STANDARDS FOR COMMERCIAL PACKAGE AIR-COOLED AIR CONDITIONERS AND HEAT PUMPS MANUFACTURED STARTING ON JANUARY 1, 2023

Equipment category	Rated cooling capacity	Heating type	Minimum energy efficiency standard
Small Commercial Split and Single Package Heat Pumps (Air-Cooled).	≥65,000 Btu/h and <135,000 Btu/h.	Electric Resistance Heating or No Heating .... All Other Types of Heating	COP = 3.4.
Large Commercial Split and Single Package Heat Pumps (Air-Cooled).	≥135,000 Btu/h and <240,000 Btu/h.	Resistance Heating or No Heating .... All Other Types of Heating	COP = 3.3.
Very Large Commercial Split and Single Package Heat Pumps (Air-Cooled).	≥240,000 Btu/h and <760,000 Btu/h.	Resistance Heating or No Heating .... All Other Types of Heating	COP = 3.2

The ASRAC Working Group also recommended that DOE separately define double-duct air conditioners and heat pumps, as discussed further in section IV.A.2.a, and that the current energy conservation standards continue to apply to these equipment. See 10 CFR 431.97, Table 1.

For CWAFs, the Working Group recommended that the standards provided in Table III–5 apply to equipment manufactured starting on January 1, 2023.

TABLE III–5—CONSENSUS RECOMMENDED MINIMUM ENERGY CONSERVATION STANDARDS FOR COMMERCIAL WARM AIR FURNACES

Equipment category	Minimum energy efficiency standard (%)
Gas-fired Commercial Warm Air Furnaces	Thermal efficiency * = 81.
Oil-fired Commercial Warm Air Furnaces	Thermal efficiency * = 82.

* At the maximum rated capacity (rated maximum input).

C. Compliance Dates

When DOE amends the standards for CUACs, CUHPs, and CWAFs through an ordinary notice-and-comment process, EPCA prescribes a set of timelines based on the particular circumstances surrounding that amendment. The proposed rule that eventually led to the formation of the Working Group was the beginning of DOE's six-year evaluation of the standards for these products. Consistent with 42 U.S.C. 6313(a)(6)(C)(iv), DOE originally proposed a compliance date of December 2018.[22]

Commenting on the CUAC/CUHP NOPR, AHRI, Nordyne and Goodman disagreed with DOE's interpretation of the statutory lead time requirements for amended standards for CUACs and CUHPs. They argued that section 6313(a)(6)(D), which specifies a lead time of four years, should apply to any new standard that DOE promulgates. (CUAC: AHRI, No. 68 at pp. 14–17; Nordyne, No. 61 at pp. 11–15; Goodman, No. 65 at p. 3) Lennox added that DOE's proposed 3-year time frame is not feasible and stated that at least a 5-year development cycle would be required to meet the proposed standard. (CUAC: Lennox, No. 60 at p. 8)

In resolving these timeline differences, the Working Group gave careful consideration to these concerns and recommended to ASRAC, which ASRAC then adopted, a set of jointly-submitted recommendations that specified a compliance date of January 1, 2018, for the first tier of standards, and January 1, 2023 for the second tier. These tiered dates were accepted and recommended by the signatories to the Term Sheet, which included

[22] For purposes of its analysis, DOE used 2019, which would be the first full year of compliance.

manufacturers who critiqued the initial proposed lead times presented by DOE.

While the January 1, 2018 compliance date is earlier than the proposed three-year lead time, DOE has the authority under section 325(p)(4) to accept recommendations for compliance dates contained in a joint submission recommending amended standards. In DOE's view, the direct final rule authority provision specifies the finding DOE has to make. Specifically, Congress specified that if DOE determines that the recommended standard is in accordance with 42 U.S.C. 6295(o) or section 342(a)(6)(B) of EPCA (*i.e.* 42 U.S.C. 6313(a)(6)(B)), DOE may issue a final rule establishing those standards. See 42 U.S.C. 6295(p)(4)(A)(i). Applying the direct final rule provision in this manner meets Congress's goal to promote consensus agreements that reflect broad input from interested parties who can fashion agreements that best promote the aims of the statute. In the absence of that kind of agreement, DOE notes that the more specific prescriptions of EPCA would ordinarily prevail. However, when DOE receives a recommendation resulting from the appropriate process—in this case, the detailed procedure laid out in the direct final rule provision of EPCA—that process provides the necessary fidelity to the statute, along with compliance with section 6295(o) (or, in this case, 42 U.S.C. 6313(a)(6)(B)), that Congress instructed DOE to apply. DOE also notes that the January 1, 2018 standard levels are the same as the efficiency levels already adopted in ASHRAE Standard 90.1–2013, which has an effective date of January 1, 2016. In light of this fact, most manufacturers are already developing equipment designs and planning the production of equipment that will meet this efficiency level.

For CWAFs, the consensus agreement specifies a compliance date of January 1, 2023. As with the lead time for CUACs and CUHPs, DOE has the authority when adopting recommended standards submitted in a consensus agreement pursuant to section 325(p)(4), to accept recommendations regarding compliance dates. See 42 U.S.C. 6295(p)(4) and 6316(b)(1). See also 76 FR at 37426. DOE has made the determination that the rulemaking record in this case supports the adoption of this recommended lead time for CWAFs.

In its analysis of the other TSLs considered for the direct final rule, DOE used a compliance date that is 3 years after the expected publication of the final rule establishing amended standards (see discussion at the beginning of this section).

D. Technological Feasibility

1. General

In each energy conservation standards rulemaking, DOE conducts a screening analysis based on information gathered on all current technology options and prototype designs that could improve the efficiency of the products or equipment that are the subject of the rulemaking. As the first step in such an analysis, DOE develops a list of technology options for consideration in consultation with manufacturers, design engineers, and other interested parties. See chapter 3 of the direct final rule's Technical Support Documents (''TSDs'') for a discussion of the list of technology options that were identified. DOE then determines which of those means for improving efficiency are technologically feasible. DOE considers technologies incorporated in commercially-available equipment or in working prototypes to be technologically feasible. 10 CFR part 430, subpart C, appendix A, section 4(a)(4)(i).

After DOE has determined that particular technology options are technologically feasible, it further evaluates each technology option in light of the following additional screening criteria: (1) Practicability to manufacture, install, and service; (2) adverse impacts on equipment utility or availability; and (3) adverse impacts on health or safety. 10 CFR part 430, subpart C, appendix A, section 4(a)(4)(ii)–(iv). Section IV.B of this document discusses the results of the screening analysis, particularly the designs DOE considered, those it screened out, and those that are the basis for the trial standard levels (TSLs) in this rulemaking. For further details on the screening analysis for this rulemaking, see chapter 4 of the direct final rule TSDs.

Additionally, DOE notes that these screening criteria do not directly address the proprietary status of design options. DOE only considers efficiency levels achieved through the use of proprietary designs in the engineering analysis if they are not part of a unique path to achieve that efficiency level (*i.e.,* if there are other non-proprietary technologies capable of achieving the same efficiency). DOE believes the amended standards for the equipment covered in this rulemaking would not mandate the use of any proprietary technologies, and that all manufacturers would be able to achieve the amended levels through the use of non-proprietary designs. Specifically, the efficiency levels considered in the analysis are all represented by commercially-available equipment examples. Further, the technologies used in these equipment are available to all manufacturers.

2. Maximum Technologically Feasible Levels

DOE assessed the recommended standards by accounting for the elements contained in 42 U.S.C. 6313(a)(6)(B). That provision requires DOE to determine in cases where standards more stringent than those already prescribed by ASHRAE 90.1 whether those more stringent standards will yield a significant amount of additional conservation of energy and will be technologically feasible and economically justified. In determining whether the ''economically justified'' prong is met, DOE must, after receiving views and comments on the standard, determine whether the benefits of the standard exceed the burdens that the standard would impose by, to the maximum extent practiable, considering seven different factors. See generally, 42 U.S.C. 6313(a)(6)(B)(ii)(I)–(VII). Consistent with this approach, DOE's engineering analysis helped identify the maximum technologically feasible (''max-tech'') improvements in energy efficiency for CUACs/CUHPs and CWAFs by using the design parameters for the most efficient equipment available on the market. (See chapter 5 of the direct final rule TSDs.) The max-tech levels that DOE determined for this rulemaking are described in section IV.C.2.b of this direct final rule.

E. Energy Savings

1. Determination of Savings

For the adopted standards, DOE projected energy savings over the entire lifetime of equipment purchased in 2018–2048 for CUACs/CUHPs and 2023–2048 for CWAFs. DOE quantified the energy savings attributable to each TSL as the difference in energy consumption between each standards case and the no-new-standards case. The no-new-standards case represents a projection of energy consumption that reflects how the market for a type of equipment would likely evolve in the absence of amended energy conservation standards.

DOE used its national impact analysis (''NIA'') spreadsheet model to estimate energy savings from potential amended standards for CUACs/CUHPs and CWAFs. The NIA spreadsheet model (described in section IV.H of this document) calculates savings in site energy, which is the energy directly consumed by products at the locations where they are used. Based on the calculated site energy, DOE calculates national energy savings (''NES'') in terms of primary energy savings at the site or at power plants, and also in terms of full-fuel-cycle (''FFC'') energy savings. The FFC metric includes the energy consumed in extracting, processing, and transporting primary fuels (*i.e.,* coal, natural gas, petroleum fuels), and thus, presents a more complete picture of the impacts of energy conservation standards.[23] DOE's approach is based on the calculation of an FFC multiplier for each of the energy types used by covered products or equipment. For more information on FFC energy savings, see section IV.H of this document. For CWAFs, the energy savings are primarily in the form of natural gas, of which the primary energy savings are considered to be equal to the site energy savings.[24]

2. Significance of Savings

To adopt more-stringent standards for the covered equipment at issue, DOE must determine on the basis of clear and convincing evidence that such action would result in the significant additional conservation of energy over levels that would be achieved through the adoption of the relevant ASHRAE standards. (42 U.S.C. 6313(a)(6)(A)(ii)(II)) Although the term ''significant'' is not defined in the Act, the U.S. Court of Appeals, in *Natural Resources Defense Council* v. *Herrington,* 768 F.2d 1355, 1373 (D.C. Cir. 1985), indicated that Congress intended ''significant'' energy savings in the context of EPCA to be savings that were not ''genuinely trivial.'' The energy savings for all the TSLs considered in the rulemakings for CUACs/CUHPs and CWAFs, including the adopted standards, are nontrivial, and, therefore, DOE considers them ''significant'' within the meaning of section 325 of EPCA. To this end, DOE views the considerable data and analysis in support of the standards being adopted as satisfying the clear and convincing threshold set out in EPCA for the adoption of energy conservation standards more stringent that the relevant ASHRAE levels.

F. Economic Justification

1. Specific Criteria

As noted above, EPCA provides seven factors to be evaluated in determining whether a potentially more-stringent energy conservation standard for the equipment addressed by this direct final rule is economically justified. (42 U.S.C. 6313(a)(6)(B)(ii)(I)–(VII)) The following sections discuss how DOE has addressed each of those seven factors in this rulemaking.

Commenting on the CUAC/CUHP NOPR, AHRI stated that DOE is not performing the full cost-benefit analysis that EPCA Section 6313(a)(6)(B)(ii) requires. It stated that DOE performed cost-benefit considerations at various points of its analysis yet never fully reconciled those analyses or the assumptions and scope of coverage underlying them. It added that DOE's cost-benefit analyses to the Nation, to manufacturers, and on employment take very different geographic scopes, ignore the immediately apparent effects on employment, and rely on unsupported analyses for effects on the general economy. In its view, DOE must reconcile these various approaches and their assumptions and also make available any models or inputs/outputs it relies upon. AHRI stated that DOE should remedy these shortcomings by performing an integrated, full cost-benefit analysis considering all factors including the effects on all directly related domestic industries. (CUAC: AHRI, No. 68 at pp. 26–29)

As noted above, EPCA Section 6313(a)(6)(B)(ii) lays out the factors DOE shall, to the maximum extent practicable, consider in determining whether the benefits of a given standard exceed the burdens. EPCA does not mention or require the type of integrated cost-benefit analysis that AHRI envisions. It does not state or imply that all of the benefits and burdens need to be quantified in monetary terms. DOE's historical practice has been to analyze each of the factors to the maximum extent practicable. EPCA does not provide guidance as to the relative importance that DOE should attach to the listed factors. Therefore, in considering the factors listed in EPCA, DOE has historically used data and analysis to determine whether standards that satisfy other EPCA requirements are also economically justified.

DOE also notes that it laid out a process to elaborate on the procedures, interpretations and policies that will guide the Department in establishing new or revised energy efficiency standards for consumer products. 61 FR 36974 (July 15, 1996). That process provides for greatly enhanced opportunities for public input, improved analytical approaches, and encouragement of consensus-based standards. This enhanced approach was developed by the Department on the basis of extensive consultations with many stakeholders.

a. Economic Impact on Manufacturers and Consumers

In determining the impacts of a potential amended standard on manufacturers, DOE conducts a manufacturer impact analysis (''MIA''), as discussed in section IV.J. (42 U.S.C. 6313(a)(6)(B)(ii)(I)) DOE first uses an annual cash-flow approach to determine the quantitative impacts. This step includes both a short-term assessment—based on the cost and capital requirements during the period between when a regulation is issued and when entities must comply with the regulation—and a long-term assessment over the analysis period. The industry-wide impacts analyzed include: (1) Industry net present value (''INPV''), which values the industry on the basis of expected future cash flows; (2) cash flows by year; (3) changes in revenue and income; and (4) other measures of impact, as appropriate. Second, DOE analyzes and reports the impacts on different subgroups of manufacturers, including impacts on small manufacturers. Third, DOE considers the impact of standards on domestic manufacturer employment and manufacturing capacity, as well as the potential for standards to result in plant closures and loss of capital investment. Finally, DOE takes into account cumulative impacts of various DOE regulations and other regulatory requirements on manufacturers.

For individual commercial consumers, measures of economic impact include the changes in LCC and PBP associated with new or amended standards. These measures are discussed further in the following section. For consumers in the aggregate, DOE also calculates the national net present value of the economic impacts applicable to a particular rulemaking. DOE also evaluates the LCC impacts of potential standards on identifiable subgroups of consumers that may be affected disproportionately by a national standard.

b. Savings in Operating Costs Compared to Increase in Price (LCC and PBP)

EPCA requires DOE to consider the savings in operating costs throughout the estimated average life of the covered equipment in the type (or class) compared to any increase in the price of, or in the initial charges for, or maintenance expenses of, the covered product that are likely to result from a standard. (42 U.S.C. 6313(a)(6)(B)(ii)(II))

[23] The FFC metric is discussed in DOE's statement of policy and notice of policy amendment. 76 FR 51282 (August 18, 2011), as amended at 77 FR 49701 (August 17, 2012).

[24] Primary energy consumption refers to the direct use at the source, or supply to users without transformation, of crude energy; that is, energy that has not been subjected to any conversion or transformation process.

DOE conducts this comparison in its LCC and PBP analysis.

The LCC is the sum of the purchase price of a product (including its installation) and the operating cost (including energy, maintenance, and repair expenditures) discounted over the lifetime of the equipment. The LCC analysis requires a variety of inputs, such as equipment prices, equipment energy consumption, energy prices, maintenance and repair costs, equipment lifetime, and discount rates appropriate for commercial consumers. To account for uncertainty and variability in specific inputs, such as equipment lifetime and discount rate, DOE uses a distribution of values, with probabilities attached to each value.

The PBP is the estimated amount of time (in years) it takes commercial consumers to recover the increased purchase cost (including installation) of more-efficient equipment through lower operating costs. DOE calculates the PBP by dividing the change in purchase cost due to a more-stringent standard by the change in annual operating cost for the year that standards are assumed to take effect.

For its LCC and PBP analysis, DOE assumes that commercial consumers will purchase the covered equipment in the first year of compliance with amended standards. The LCC savings for the considered efficiency levels are calculated relative to the case that reflects projected market trends in the absence of amended standards. DOE's LCC and PBP analysis is discussed in further detail in section IV.F.

c. Energy Savings

Although the significant conservation of energy is a separate statutory requirement for adopting an energy conservation standard, EPCA requires DOE, in determining the economic justification of a standard, to consider the total projected energy savings that are expected to result directly from the standard. (42 U.S.C. 6313(a)(6)(B)(ii)(III)) As discussed in section IV.H, DOE uses the NIA spreadsheet to project national energy savings.

Commenting on the CUAC NOPR, AHRI stated that DOE gave energy savings disproportionate weight in its analysis, which conflicts with 42 U.S.C. 6313(a)(6)(A)(ii)(II) and 6313(a)(6)(B)(ii)(I)–(VII). In its view, DOE should consider seven different factors in determining whether the benefits of a proposed standard exceed its burdens, and stated that there is no indication in the statute or otherwise that Congress intended this to be anything other than a roughly equal weighting of factors where no particular factor is king over all the others. (CUAC: AHRI, No. 68 at p. 22)

Section 6313(a)(6)(A)(ii)(II) concerns DOE's authority to adopt a national standard more stringent than the amended ASHRAE/IES Standard 90.1 if such standard would result in the significant additional conservation of energy and is technologically feasible and economically justified. Section V.C of this document sets forth in detail the reasons why DOE has concluded that the adopted standards for CUACs/CUHPs would result in the significant additional conservation of energy and are technologically feasible and economically justified.

Section 6313(a)(6)(B)(ii)(I)–(VII) lists the factors that DOE must consider in determining whether a standard is economically justified for the purposes of subparagraph (A)(ii)(II). Weighing these factors, in DOE's view, requires a careful balancing of each factor to help ensure the comprehensiveness of the Agency's review of any potential standard under consideration. Accordingly, DOE has weighed these factors in assessing the energy efficiency levels recommended by the Working Group.

d. Lessening of Utility or Performance of Equipment

In establishing equipment classes, and in evaluating design options and the impact of potential standard levels, DOE evaluates potential standards that would not lessen the utility or performance of the considered equipment. (42 U.S.C. 6313(a)(6)(B)(ii)(IV)) Based on data available to DOE, the standards adopted in this final rule would not reduce the utility or performance of the equipment under consideration in this rulemaking.

e. Impact of Any Lessening of Competition

EPCA directs DOE to consider the impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from a proposed standard. (42 U.S.C. 6313(a)(6)(B)(ii)(V)) Specifically, it instructs DOE to consider the impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from the imposition of the standard. DOE is simultaneously publishing a NOPR containing proposed energy conservation standards identical to those set forth in this direct final rule and has transmitted a copy of the rule and the accompanying TSD to the Attorney General, requesting that the U.S. Department of Justice (''DOJ'') provide its determination on this issue. DOE will consider DOJ's comments on the direct final rule in determining whether to proceed with finalizing its standards. DOE will also publish and respond to the DOJ's comments in the **Federal Register** in a separate notice.

f. Need for National Energy Conservation

DOE also considers the need for national energy conservation in determining whether a new or amended standard is economically justified. (42 U.S.C. 6313(a)(6)(B)(ii)(VI)) The energy savings from the adopted standards for CUACs/CUHPs and CWAFs are likely to provide improvements to the security and reliability of the Nation's energy system. Reductions in the demand for electricity also may result in reduced costs for maintaining the reliability of the Nation's electricity system. DOE conducts a utility impact analysis to estimate how standards may affect the Nation's needed power generation capacity, as discussed in section IV.M.

The adopted standards also are likely to result in environmental benefits in the form of reduced emissions of air pollutants and GHGs associated with energy production and use. DOE conducts an emissions analysis to estimate how potential standards may affect these emissions, as discussed in section IV.K; the emissions impacts are reported in section V.B.6 of this document. DOE also estimates the economic value of emissions reductions resulting from the considered TSLs, as discussed in section IV.L.

Commenting on the CUAC/CUHP NOPR, AHRI questioned DOE's inclusion of environmental benefits in its consideration since none of the more specific factors in section 6313(a)(6)(B)(ii)(I)–(VI) refer to environmental matters. (AHRI asserted that DOE must have based its inclusion of environmental and SCC benefits on the catch-all ''other factors'' provision of 42 U.S.C. 6313(a)(6)(B)(ii)(VII).) AHRI stated that DOE must clarify precisely why and how it believes that it has the statutory authority under section 6313(a)(6)(B)(ii) to consider SCC issues in any fashion, and, if so, under what sub-provision (*i.e.,* which of the seven factors) such analysis comes. (CUAC: AHRI, No. 68 at p. 28)

DOE maintains that environmental and public health benefits associated with the more efficient use of energy are important to take into account when considering the need for national energy and water conservation, which is one of the factors to consider under EPCA. (42 U.S.C. 6295(o)(2)(B)(i)(VI)) Given the threats posed by global climate change to the economy, public health, ecosystems, and national security,[25] combined with the well-recognized potential of well-designed energy conservation measures to reduce GHG emissions, DOE believes that evaluation of the potential benefits from slowing anthropogenic climate change must be part of the consideration of the need for national energy conservation.

g. Other Factors

In determining whether an energy conservation standard is economically justified, DOE may consider any other factors that the Secretary deems to be relevant. (42 U.S.C. 6313(a)(6)(B)(ii)(VII)) In developing the direct final rule, DOE has also considered the submission of the jointly-submitted Term Sheet from the Working Group and approved by ASRAC. In DOE's view, the Term Sheet sets forth a statement by interested persons that are fairly representative of relevant points of view (including representatives of manufacturers of covered equipment, States, and efficiency advocates) and contains recommendations with respect to energy conservation standards that are in accordance with 42 U.S.C. 6313(a)(6)(B), as required by EPCA's direct final rule provision. See 42 U.S.C. 6295(p)(4). DOE has encouraged the submission of agreements such as the one developed and submitted by the CUAC–CUHP–CWAF Working Group as a way to bring diverse stakeholders together, to develop an independent and probative analysis useful in DOE standard setting, and to expedite the rulemaking process. DOE also believes that standard levels recommended in the Term Sheet may increase the likelihood for regulatory compliance, while decreasing the risk of litigation.

2. Rebuttable Presumption

EPCA creates a rebuttable presumption that an energy conservation standard is economically justified if the additional cost to the commercial consumer of an equipment that meets the standard is less than three times the value of the first year's energy savings resulting from the standard, as calculated under the applicable DOE test procedure. 42 U.S.C. 6295(o)(2)(B)(iii) Although this rebuttable presumption is not specifically mentioned in section 6316(b)(1) as applying to CUACs/CUHPs and CWAFs, DOE nonetheless considered the rebuttable presumption criteria as part of its analysis. DOE's LCC and PBP analyses generate values used to calculate the effect potential amended energy conservation standards would have on the payback period for consumers. These analyses include, but are not limited to, the 3-year payback period contemplated under the rebuttable-presumption test. In addition, DOE routinely conducts an economic analysis that considers the full range of impacts to consumers, manufacturers, the Nation, and the environment, as required under 42 U.S.C. 6295(o)(2)(B)(i), and 42 U.S.C. 6313(a)(6)(B)(ii). The results of this analysis serve as the basis for DOE's evaluation of the economic justification for a potential standard level (thereby supporting or rebutting the results of any preliminary determination of economic justification). The rebuttable presumption payback calculation is discussed in section IV.F of this document.

G. Energy Efficiency Descriptors for Commercial Unitary Air Conditioners and Heat Pumps

The current energy conservation standards for CUACs and CUHPs are based on the metrics EER for cooling efficiency and COP for CUHP heating efficiency. See 10 CFR 431.97(b). In this direct final rule, DOE is adopting energy conservation standards based on IEER for cooling efficiency and is continuing to use COP for denoting CUHP heating efficiency.

1. Cooling Efficiency Metric

In the CUAC/CUHP RFI, DOE noted that it was considering whether to replace the existing cooling efficiency descriptor, EER, with a new energy-efficiency descriptor, IEER. 78 FR at 7299. Unlike the EER metric, which only uses the efficiency of the equipment operating at full-load in high-ambient-temperature conditions (*i.e.,* 95 degrees Fahrenheit (°F)), the IEER metric factors in the efficiency of equipment operating at part-loads of 75 percent, 50 percent, and 25 percent of capacity at reduced ambient temperature consistent with part-load operation as well as the efficiency at full-load. This is accomplished by weighting the full- and part-load efficiencies with a representative average amount of time operating at each loading point. The IEER metric incorporates part-load efficiencies measured with outside temperatures appropriate for the load levels, *i.e.* at lower temperatures for lower load levels. As part of a final rule published on May 16, 2012, DOE amended the test procedure for this equipment to incorporate by reference AHRI Standard 340/360—2007, ''Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment'' (''AHRI Standard 340/360–2007''). 77 FR 28928. DOE notes that AHRI Standard 340/360–2007 already includes methods and procedures for testing and rating equipment with the IEER metric. ASHRAE, through its Standard 90.1, includes requirements based on the part-load performance metric, IEER. These IEER requirements were first established in *Addenda* to the 2008 Supplement to Standard 90.1–2007, and were required for compliance with ASHRAE Standard 90.1 on January 1, 2010.[26]

EPCA requires that test procedures be reasonably designed to produce test results that measure the energy efficiency of covered equipment during a representative average use cycle or period of use. (42 U.S.C. 6314(a)(2)) As discussed above, the IEER metric weights the efficiency of operating at different part-loads and full-load based on usage patterns, which collectively provide a more representative measure of annual energy use than the EER metric. A manufacturer that was involved in the development of the IEER metric indicated that the usage pattern weights for the IEER metric were developed by analyzing equipment usage patterns of several buildings across the 17 ASHRAE Standard 90.1–2010 (appendix B) climate zones. (Docket ID: EERE–2013–BT–STD–0007–0018, Carrier, at p. 1) These usage patterns and climate zones were based on a comprehensive analysis performed by industry in assessing the manner in which CUAC and CUHP equipment operate in the field, both in terms of actual usage and the climatic conditions in which they are used. The weighting factors accounted for the hours of operation where mechanical cooling was active—*i.e.,* the associated analysis assumed use of economizing (use of cool outdoor air for cooling) for appropriate hours in climate zones for which equipment would be installed with this feature. *Id.* As a result, DOE stated in the CUAC/CUHP NOPR that the IEER metric, as a whole, provides a more accurate representation of the annual energy use for this equipment than the EER metric, which only considers full-load energy use. For these reasons, DOE proposed to amend its

[25] National Climate Assessment 2014. Available at: *http://nca2014.globalchange.gov/*. The National Security Implications of a Changing Climate. May 2015. The White House. Available at: *https://www.whitehouse.gov/the-press-office/2015/05/20/white-house-report-national-security-implications-changing-climate.*

[26] ASHRAE. ASHRAE Addenda. 2008 Supplement. *http://www.ashrae.org/File%20Library/docLib/Public/20090317_90_1_2007_supplement.pdf.*

energy conservation standards for CUACs/CUHPs to be based on the IEER metric. 79 FR at 58959.

AHRI, Nordyne, Rheem, Trane, the Joint Efficiency Advocates, and Southern Company all generally supported using IEER as the proposed metric. (CUAC: AHRI, No. 68 at p. 42; Nordyne, No. 61 at p. 35; Rheem, No. 70 at p. 2; Trane, No. 63 at p. 6; Joint Efficiency Advocates, No. 69 at pp. 1–2; Southern Company, Public Meeting Transcript, No. 104 at p. 25) The Joint Efficiency Advocates supported DOE's proposal to replace EER with IEER. In their view, DOE could retain the EER standards while adding IEER. They added that if DOE decided to use a single metric, IEER would better reflect annual energy consumption than EER since this equipment rarely operates at full-load. (CUAC: Joint Efficiency Advocates, No. 69 at pp. 1–2)

While supporting the use of IEER, AHRI, Nordyne, and Lennox recognized that EER will continue to be an important metric for utilities when managing peak load electricity usage. (CUAC: AHRI, No. 68 at p. 42; Nordyne, No. 61 at p. 35; Lennox, No. 60 at p. 14) The California IOUs recommended that DOE establish standards using both EER and IEER metrics to prevent poor equipment performance at high temperature full-load conditions. Given the low weighting (2 percent) of the full-load condition for the IEER metric, there is an incentive for manufacturers to optimize equipment at the part-load conditions with ambient temperatures between 65 °F and 82 °F. The California IOUs indicated that moving to an IEER-only metric could potentially mean that a new standard could result in equipment that is designed with full-load EER values lower than the current standards. (CUAC: California IOUs, No. 67 at p. 2; California IOUs, ASRAC Public Meeting, No. 102 at p. 99) The California IOUs commented that, in the absence of dual metrics using both EER and IEER, they supported standards based on EER, or use of IEER accompanied by required reporting of each of the IEER test points, including full-load EER. (CUAC: California IOUs, No. 67 at pp. 2, 7–8) The Joint Efficiency Advocates similarly supported the reporting of each IEER test point. (CUAC: Joint Efficiency Advocates, No. 69 at p. 8)

However, the California IOUs and other members of the ASRAC Working Group more recently agreed as Term Sheet signatories to recommend that DOE adopt standards for CUACs and CUHPs based on IEER for cooling efficiency. (CUAC: ASRAC Term Sheet, No. 93 at pp. 2–4) DOE also notes that ASHRAE Standard 90.1 includes requirements and reporting for both EER and IEER. As a result, although DOE is setting energy conservation standards for CUACs and CUHPs based on the IEER metric, EER ratings of equipment would still be available through the AHRI certification database. DOE notes that AHRI and manufacturers agreed to continue to require verification and reporting of EER for equipment through AHRI's certification program. AHRI also agreed to submit a letter to the docket for this rulemaking committing to continuing to require verification and reporting of EER for it's certification program. (CUAC: ASRAC Public Meeting, No. 101 at pp. 9, 55; ASRAC Public Meeting, No. 103 at pp. 113–116) Thus, utilities, and others, would still be able to consider full-load efficiency in their energy efficiency programs. For these reasons, and for the reasons stated previously that the IEER metric provides a more accurate representation of the annual energy use for this equipment, DOE is adopting standards for small, large, and very large, CUACs and CUHPs cooling efficiency based on the IEER metric.

DOE notes that a change in metrics (*i.e.,* from EER to IEER) necessitates an initial DOE determination that the new requirement would not result in backsliding when compared to the current standards. See 42 U.S.C. 6313(a)(6)(B)(iii)(I). As discussed in section IV.A, DOE conducted energy modeling by selecting actual models available on the market that comply with the current DOE energy conservation standards for these equipment based on EER, to evaluate each IEER efficiency level (by analyzing the efficiency at each loading condition, including full-load EER). Based on this analysis, staged-air volume (''SAV'') and variable-air volume (''VAV'') equipment—two types of CUAC/CUHP equipment that include design features focused on improved part-load performance as opposed to full-load EER performance [27]—that already meet the energy conservation standard levels adopted in this direct final rule had EER values higher than the current standard levels for this equipment—*i.e.,* these equipment were more efficient than what the current EER-based standards require. Even with the design changes that are focused on improved part-load performance (as with SAV and VAV units), the equipment exceeded the current EER standard levels, which suggests that the risk of backsliding is low.

As discussed in section IV.A.2.a, DOE is establishing separate equipment classes for double-duct CUACs and CUHPs and is maintaining the current energy conservation standards for this equipment. As a result, DOE is maintaining the existing EER metric for the double-duct CUAC and CUHP equipment classes.

2. Heating Efficiency Metric

The current energy conservation standards for small, large, and very large air-cooled CUHPs heating efficiency are based on the COP metric.[28] 10 CFR 431.97(b) For the CUAC/CUHP NOPR, DOE proposed standards for heating efficiency based on the COP metric. See 79 FR at 58960.

AHRI, Nordyne, Goodman and Rheem supported the continued use of COP as the heating efficiency metric for CUHPs. (CUAC: AHRI, No. 68 at p. 42; Nordyne, No. 61 at p. 35; Goodman, No. 65 at p. 12; Rheem, No. 70 at p. 2) In addition, members of the ASRAC Working Group agreed as signatories to the Term Sheet to standards for air-cooled CUHPs based on COP for heating efficiency. (CUAC: ASRAC Term Sheet, No. 93 at pp. 2–4) As discussed in section IV.A, DOE is adopting standards for air-cooled CUHPs in this direct final rule based on COP for heating efficiency.

H. Other Issues

1. Economic Justification of the Proposed Standards

a. Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment

In response to the CUAC/CUHP NOPR, AHRI commented that DOE did not explain how it concluded that the proposed rulemaking would result in the significant additional conservation

[27] SAV units typically use a multiple-speed indoor fan motor, which is achieved by incorporating a variable frequency drive (''VFD'') to adjust the motor speed to provide two stages of indoor air flow to match staged compressor operation and thus provide improved part-load performance. For the first stage of operation, the indoor fan motor is controlled to provide two-thirds of the total air flow established for the unit. For the second stage, the VFD adjusts the indoor fan motor to provide the total air flow established for the unit (*i.e.,* 100-percent air flow). VAV units are capable of providing more accurate control of supply air temperature by varying cooling capacity and air flow rates. VAV units are typically equipped with a VFD to control the indoor fan speed based on supply air pressure and operate at multiple stages of air flow rates to match the variable cooling capacity (either by multiple compressor staging or variable-speed compressors). In contrast, constant air volume (CAV) CUACs and CUHPs typically use a single speed indoor fan motor and operate by controlling cooling capacity based on temperature/humidity in the conditioned space and operate at a fixed indoor air flow rate supplying variable temperature air.

[28] COP is defined as the ratio of the produced heating effect to its net work input.

of energy and is technologically feasible and economically justified by clear and convincing evidence, as required by 42 U.S.C. 6313(a)(6)(A)(ii)(II). (CUAC: AHRI, No. 68 at pp. 12–13) Lennox and Nordyne made similar comments. (CUAC: Lennox, No. 60 at pp. 4–5; Nordyne, No. 61 at pp. 6–8) AHRI stated that DOE's analysis fell short of this elevated requirement of proof. AHRI added that instead of starting with the max-tech standard level, DOE was obliged by Section 6313(a)(6)(A)(ii) to first consider the amended ASHRAE standard for adoption, and consider a higher level only based on clear and convincing evidence. (CUAC: AHRI, No. 68 at p. 13)

Trane stated that DOE's CUAC/CUHP NOPR analysis grossly underestimated the costs at all the TSL levels and, therefore, overstated the benefits to the nation. (CUAC: Trane, No. 63 at p. 8)

AHRI also commented that the proposed minimum efficiency level (EL3) represents a significant increase from the ASHRAE 90.1–2013 levels that will become effective in 2016. It stated that in order to achieve EL 3 levels it will be necessary to redesign approximately 80 percent of all units that are commercially-available today, and as a result, many classes of products will be eliminated, causing a significant contraction of the market. AHRI stated that the required design modifications will come at a significant cost to the consumer, and consumers who are unable to afford more efficient units will likely continue to repair and not replace units in service. It added that the situation could potentially alter the competitive landscape as other technologies are favored as alternatives (*e.g.,* water-cooled, evaporatively-cooled, and variable refrigerant flow mult-split air conditioners and heat pumps). (CUAC: AHRI, Public Meeting Transcript, No. 104 at pp. 15–16) Lennox also stated that the proposed standards would require over 90 percent of its current products to be redesigned. (CUAC: Lennox, No. 60 at p. 8)

b. Commercial Warm Air Furnaces

Trane stated that the LCC savings for gas-fired CWAFs at the proposed standard are hardly measurable, and any slight change in the increase in product cost, installation or maintenance costs, and energy prices can change these savings to an increase in LCC. Similar results would occur in the NPV calculation where a positive NPV could easily become an increase in costs to the nation. (CWAF: Trane, No. 27 at p. 7)

c. Response

DOE notes that while it is not adopting the proposed standards from the CUAC/CUHP and CWAF NOPRs, these comments, along with the intensive feedback received during the Working Group discussions contributed to the modified approach and revised standards recommended by the ASRAC Working Group that DOE is presenting in this direct final rule. As discussed in section V.C, DOE has determined that the recommendations are in accordance with the provisions of 42 U.S.C. 6313(a)(6)(B), as required by 42 U.S.C. 6295(p)(4) and 6316(b)(1). The evidence supporting this determination is clearly described in detail in the direct final rule TSDs and the accompanying spreadsheets. The evidence that the adopted standards would result in the significant additional conservation of energy and are technologically feasible is convincing, as the projected energy savings exceed the threshold for significance by a wide margin (see section III.E.2), and their technological feasibility, based on DOE's examination, is well-established (see section III.D). The evidence that the adopted standards are economically justified is also convincing. In particular, the economic impact of the standards on the consumers of CUACs/CUHPs and CWAFs is positive by a wide margin, as discussed in section V.C.

2. ASHRAE 90.1 Process

Commenting on the CUAC/CUHP NOPR, a number of parties stated that DOE should rely on the ASHRAE process in setting amended commercial equipment efficiency standards.

ASHRAE urged DOE to rely on the efficiencies established in ASHRAE Standard 90.1–2013 for the equipment listed in this rulemaking. It noted that: (1) ASHRAE 90.1–2013 underwent the fully open ANSI/ASHRAE consensus process with buy-in and consensus from manufacturers, energy advocates, representatives from DOE, and other materially affected and interested parties; (2) the efficiency levels were established in a cost-effective manner using the ASHRAE "scalar ratio" economic analysis methodology; and (3) many interested parties, including DOE, invested a significant amount of time and energy in establishing the efficiency levels currently found in ASHRAE 90.1–2013 with ample opportunities to provide input. ASHRAE recommended that DOE no longer pursue the proposed rulemaking, and approve the ASHRAE 90.1–2013 efficiency levels for this equipment. (CUAC: ASHRAE, No. 59 at pp. 1–4). AHRI, Goodman and Lennox made a similar comment. (CUAC: AHRI, No. 68 at pp. 2, 10–11; Goodman, No. 65 at pp. 2–3; Lennox, No. 60 at pp. 8–9) A number of other parties made similar comments. (CUAC: Huntley, No. 62 at p. 1; Viridis, No. 56 at p. 1; Merryman-Farr, No. 49 at p. 1; KJWW, No. 46 at p. 1; Smith-Goth, No. 45 at p. 1; A2H, No. 44 at p. 1)

Notwithstanding DOE's participation in the development of ASHRAE Standard 90.1–2013, which did not impact the EER standards for which DOE already incorporated into its regulations, amendments to EPCA established by AEMTCA required DOE to initiate the current rulemaking, which DOE began in advance of the ASHRAE 90.1–2013 amendments (see section II.A). EPCA, as amended, also directs DOE to prescribe standards that are designed to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified, and would result in the significant additional conservation of energy. (42 U.S.C. 6313(a)(6)(A)(ii)(II)) It also provides the factors that DOE has considered to select and adopt standards for which the benefits exceed the burdens. (42 U.S.C. 6313(a)(6)(B)(ii)) In DOE's view, the standards being adopted in this direct final rule satisfy these elements. DOE further notes that AHRI, Goodman and Lennox are parties to the recommendations that form the basis for this direct final rule, pursuant to 42 U.S.C. 6295(p)(4) and 6316(b)(1), indicating that the direct final rule's standard levels and supporting analyses resolved their concerns related to DOE's initial NOPR.

3. Other

Referring to section VI.A of the CUAC/CUHP NOPR, AHRI stated that DOE did not present evidence to support two of the market failures that it identified pursuant to section 1(b)(1) of Executive Order 12866.[29] (CUAC: AHRI, No. 68 at pp. 24–25) AHRI stated that DOE must demonstrate that such market failures actually exist in the real world and that once quantified, DOE's assessment of costs and benefits for its

[29] Specifically, in AHRI's view, DOE did not establish that the following market failures exist: (1) There is a lack of customer information in the commercial space conditioning market, and the high costs of gathering and analyzing relevant information leads some customers to miss opportunities to make cost-effective investments in energy efficiency; and (2) In some cases, the benefits of more efficient equipment are not relized due to misaligned incentives between purchasers and users. (*E.g.* where an equipment purchase decision is made by a building contractor or building owner who does not pay the energy costs.) See CUAC; AHRI, No. 68 at 24.

rules in this area align with such an important external validity check on its analysis.

Section 1(b)(1) of Executive Order (E.O.) 12866, ''Regulatory Planning and Review,'' 58 FR 51735 (Oct. 4, 1993), requires each agency to identify the problem that it intends to address (including, where applicable, the failures of private markets or public institutions that warrant new agency action), as well as to assess the significance of that problem. As discussed in section VI.A of this direct final rule, DOE identified two problems that would generally be considered ''market barriers'' (numbers 1 and 2 in section VI.A, which are related to certain features concerning consumer decision-making), and one problem that most economists would consider a ''market failure'' (number 3, which concerns environmental externalities).[30] E.O. 12866 does not require any quantification of the problems, which in any case would be extremely difficult. Such quantification would unlikely bear any relationship to the costs and benefits estimated for energy conservation standards. E.O. 12866 does not provide any specific guidance regarding how agencies should assess the significance of the identified problems. However, DOE's extensive activities in promoting energy conservation over several decades have demonstrated that the problems of (1) lack of consumer information and/or information processing capability about energy efficiency opportunities, and (2) and asymmetric information and/or high transactions costs are significant enough to warrant policy actions designed to help overcome them.

Miller indicated that neither of the potential market failures cited by DOE (externalities related to GHG emissions and asymmetric information (and related misaligned incentives) regarding high-efficiency commercial appliances is solved by its proposed energy efficiency standards, leaving the proposal economically unjustifiable. Miller further stated that DOE does not explain why sophisticated, profit-motivated purchasers of CUACs and CUHPs would suffer from either informational deficits or cognitive biases that would cause them to purchase products with high lifetime costs without demanding higher-price, higher-efficiency products. Miller added that this asymmetric information, if it exists, could be remedied by improved labeling or other types of consumer education campaigns rather than banning products from the marketplace. (Miller, No. 39 at p. 13)

The proposed standards, as well as the adopted standards contained in this direct final rule, are intended to address the above-cited problems, but DOE's action is primarily responsive to the statutes that govern the amendment of energy efficiency standards (see section II.A). Neither the relevant statutes nor the relevant Executive Order (Executive Order 12866, ''Regulatory Planning and Review'')[31] make any mention of solving the problems that DOE has identified. Incorporating external costs into energy prices is outside the scope of any existing DOE authority. DOE agrees that improved labeling or other types of consumer education campaigns could help to ameliorate information problems, but DOE is still required to follow the statutory obligations concerning amendment of energy efficiency standards.

Miller stated that DOE expects only 10 percent of the externality benefits of carbon reductions to accrue to Americans, so the costs to American citizens outweigh the social benefits of the standard by almost 3 to 1, calling into question whether the proposal is economically justified. (Miller, No. 39 at p. 13)

DOE notes that the domestic SCC values were estimated by the interagency Working Group as a range from 7 percent to 23 percent of the global values. Using the central SCC value, the domestic CO_2 reduction monetized value from the proposed standards amounts to $2.2 to $7.1 billion. The incremental costs range from $4.1 to $8.8 billion for 7-percent and 3-percent discount rates, respectively, but the operating cost savings are far larger, such that the NPV of consumer benefit ranges from $16.5 billion to $50.8 billion for 7-percent and 3-percent discount rates, respectively.

Miller stated that DOE's proposal does not maintain flexibility and freedom of choice for purchasers of CUAC and CUHP equipment. (Miller, No. 39 at p. 13) In contrast to the proposed standards, which DOE is not adopting, the standards adopted for CUACs and CUHPs allow a much higher share of currently-produced models to remain on the market. The models that would be allowed under the standards cover a wide range of efficiencies and other attributes, thereby maintaining considerable choice for purchasers of CUACs and CUHPs.

[30] Note that since the publication of the CUAC/CUHP NOPR, DOE has refined the description of the problems identified pursuant to E.O. 12866. See section VI.A.

[31] 58 FR 51735 (Oct. 4, 1993).

IV. Methodology and Discussion of Related Comments

This section addresses the analyses DOE has performed for this rulemaking. Separate subsections address each component of DOE's analyses.

DOE used several analytical tools to estimate the impact of the standards considered in support of this direct final rule. The first tool is a spreadsheet that calculates the LCC savings and PBP of potential amended or new energy conservation standards. The national impacts analysis uses a second spreadsheet set that provides shipments forecasts and calculates national energy savings and net present value of total consumer costs and savings expected to result from potential energy conservation standards. DOE uses the third spreadsheet tool, the Government Regulatory Impact Model (GRIM), to assess manufacturer impacts of potential standards. These spreadsheet tools are available on the DOE Web site for the rulemaking for CUACs/CUHPs: *http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx?ruleid=59*; and for CWAFs: *http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/70*. Additionally, DOE used output from the latest version of EIA's *Annual Energy Outlook* (*AEO),* a widely known energy forecast for the United States, for the emissions and utility impact analyses.

A. Market and Technology Assessment

1. General

For the market and technology assessment, DOE developed information that provided an overall picture of the market for the equipment concerned, including the purpose of the equipment, the industry structure, market characteristics, and the technologies used in the equipment. This activity included both quantitative and qualitative assessments, based primarily on publicly-available information. The subjects addressed in the market and technology assessment for this rulemaking include scope of coverage, equipment classes, types of equipment sold and offered for sale, manufacturers, and technology options that could improve the energy efficiency of the equipment under examination. The key findings of DOE's market and technology assessment are summarized below. For additional detail, see chapter 3 of the CUAC/CUHP and CWAF direct final rule TSDs.

2. Scope of Coverage and Equipment Classes

a. Commercial Unitary Air Conditioners and Heat Pumps

The energy conservation standards adopted in this direct final rule cover small, large, and very large, CUACs and CUHPs under section 342(a) of EPCA. (42 U.S.C. 6313(a)) This category of equipment has a rated capacity between 65,000 Btu/h and 760,000 Btu/h. It is designed to heat and cool commercial buildings. In the case of single-package units, which house all of the components (*i.e.,* compressor, condenser and evaporator coils and fans, and associated operating and control devices) within a single cabinet, these units are typically located on the building's rooftop. In the case of split-system units, the compressor and condenser coil and fan (or in the case of CUHPs, the outdoor coil and fan) are housed in a cabinet typically located on the outside of the building, and the evaporator coil and fan (or in the case of CUHPs, the indoor coil and fan) are housed in a cabinet typically located inside the building.

When evaluating and establishing energy conservation standards, DOE divides covered equipment into equipment classes by the type of energy used, capacity, or other performance-related features that would justify a different standard. In determining whether a performance-related feature would justify a different standard, DOE considers such factors as the utility to the consumer of the feature and other factors DOE determines are appropriate. All of the different air conditioning and heat pump equipment addressed by this rule are air-cooled unitary air-conditioners and heat pumps.

The current equipment classes that EPAct 2005 established for small, large, and very large CUACs and CUHPs divide this equipment into twelve classes characterized by rated cooling capacity, equipment type (air conditioner versus heat pump), and heating type. Table IV–1 shows the current equipment class structure.

TABLE IV–1—CURRENT AIR-COOLED CUAC AND CUHP EQUIPMENT CLASSES

Equipment class	Equipment type	Cooling capacity	Sub-category	Heating type
1	Small Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled).	≥65,000 Btu/h and <135,000 Btu/h.	AC	Electric Resistance Heating or No Heating.
2				All Other Types of Heating.
3			HP	Electric Resistance Heating or No Heating.
4				All Other Types of Heating.
5	Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled).	≥135,000 Btu/h and <240,000 Btu/h.	AC	Electric Resistance Heating or No Heating.
6				All Other Types of Heating.
7			HP	Electric Resistance Heating or No Heating.
8				All Other Types of Heating.
9	Very Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled).	≥240,000 Btu/h and <760,000 Btu/h.	AC	Electric Resistance Heating or No Heating.
10				All Other Types of Heating.
11			HP	Electric Resistance Heating or No Heating.
12				All Other Types of Heating.

AC = Air conditioner; HP = Heat pump.

In the CUAC/CUHP NOPR, DOE proposed energy conservation standards based on this existing equipment class structure, which is also provided in Table 1 of 10 CFR 431.97. 79 FR 58964.

United CoolAir Corporation (''UCA'') submitted a request that DOE exempt a specific type of air conditioning equipment (''double-duct air-cooled air conditioners''). See UCA, EERE–2013–BT–STD–0007–0020. These units are designed for indoor installation in constrained spaces using ducting to an outside wall for the supply and discharge of condenser air to and from the condensing unit. The sizing of these units is constrained both by the space available in the installation location and the available openings in the building through which the unit's sections must be moved to reach the final installation location. These size constraints, coupled with the higher power required by the condenser fan to provide sufficient pressure to move the condenser air through the supply and return ducts, affect the energy efficiency of these types of systems. More conventional designs for which condensers are located outdoors can more easily draw in condenser air through the condenser (or outdoor coil for heat pumps) and can move the air using direct-drive propeller fans. These design differences allow a manufacturer to maximize condenser surface area, reduce the pressure rise requirement of the fan, significantly reduce condenser (outdoor) fan power and improve equipment efficiency.

Currently, double-duct air conditioners are tested and rated under the same test conditions as single-duct air conditioners, without any ducting connected to, or an external static pressure applied on, the condenser side. UCA has asserted that the double-duct design provides customer utility in that it allows interior field installations in existing buildings in circumstances where space constraints make an outdoor unit impractical to use. Id. DOE noted in the CUAC/CUHP NOPR that the design features associated with the described double-duct designs may affect energy use while providing justifiable customer utility. 79 FR at 58964.

In response to the CUAC/CUHP NOPR, a number of heating, ventilating and air conditioning (''HVAC'') equipment distributors—MWSK Equipment Sales Inc. (''MWSK''), H & H Sales Associates, Inc. (''H&H''), Gardiner Trane, Heat Transfer Solutions (''HTS''), HVAC Equipment Sales, Inc., Havtech, and Slade Ross, Inc.—all supported establishing a new equipment class for the indoor horizontal double-duct units. These commenters explained that UCA's double-duct units are unique in that they are modular and are applied completely inside buildings where rooftop air conditioners and split systems are not practical or possible. (CUAC: MSWK, No. 72 at pp. 1–2; H&H,

No. 73 at p. 1; Gardiner Trane, No. 74 at pp. 1–2; HTS, No. 75 at p. 1; HVAC Equipment Sales, Inc., No. 76 at p. 1; Havtech, No. 77 at p. 1; Slade Ross, Inc., No. 78 at p. 1) MWSK added that the substantial increase in cost (unit and installation) imposed by the proposed standards that will not be able to be recouped with savings in energy expenditures will cause these indoor air conditioners to cease to exist and customers will continue to repair units rather than replace them. Alternative systems are limited and costly for customers to have the application re-engineered. (CUAC: MSWK, No. 72 at pp. 1–2)

Goodman commented that if DOE creates a separate equipment class for double-duct units, the definitions should be very clearly specified to prevent gaming. Goodman stated that the definition should include (a) physical properties of the equipment (fan type and orientation, maximum product height/width/depth, duct connection sizes, or other such parameters), (b) application properties (minimum external static pressure for condenser airflow, refrigerant line set lengths, maximum capacities, etc.), (c) literature requirements (statements within installation and operation manuals and specification sheets), and (d) certification requirements. (CUAC: Goodman, No. 65 at pp. 12–13)

Members of the ASRAC Working Group agreed that a separate equipment class should be established for double-duct CUACs and CUHPs. The ASRAC Term Sheet recommended the following approach with respect to these equipment:

- The existing EER standard levels provided in Table 1 of 10 CFR 431.97 shall continue to apply for double-duct CUACs and CUHPs.
- Double-duct air conditioner or heat pump would be defined as meaning air-cooled commercial package air conditioning and heating equipment that satisfies the following elements:
  - It is either a horizontal single package or split-system unit; or a vertical unit that consists of two components that may be shipped or installed either connected or split;
  - It is intended for indoor installation with ducting of outdoor air from the building exterior to and from the unit, where the unit and/or all of its components are non-weatherized and are not marked (or listed) as being in compliance with UL 1995, ''Heating and Cooling Equipment,'' or equivalent requirements for outdoor use;
  - (a) If it is a horizontal unit, the complete unit has a maximum height of 35 inches or the unit has components that do not exceed a maximum height of 35 inches; (b) If it is a vertical unit, the complete (split, connected, or assembled) unit has components that do not exceed maximum depth of 35 inches; and
  - It has a rated cooling capacity greater than or equal to 65,000 Btu/h and up to 300,000 Btu/h. (CUAC: ASRAC Term Sheet, No. 93 at pp. 4–5)

Based on DOE's review of double-duct CUACs and CUHPs available on the market, DOE agrees with the ASRAC Term Sheet recommendations. First, DOE agrees that these units have features that justify establishing separate equipment classes for them. Double-duct units, as evidenced by several commenters, offer a unique utility that may otherwise become unavailable if these units were subjected to the more rigorous standards required by this direct final rule for other CUAC and CUHP equipment. DOE notes that double-duct units, which are installed within the building envelope and use ductwork to transfer outdoor air to and from the outdoor unit, would have added challenges in meeting more stringent energy conservation standards due to space constraints and added condenser fan power.

Second, DOE agrees that the definition for these units recommended in the ASRAC Term Sheet, with minor modifications, appropriately distinguish them from other classes. Double-duct units must have limited width or height to be able to fit through doorways and to fit in above-ceiling space (for horizontal units) or in closets (for vertical units) for interior installation. DOE's research showed that vertical and horizontal double-duct units had a width or height of 34 inches or less, respectively. As a result, DOE agrees that specifying a maximum width or height of 35 inches to include only units that can be installed indoors, as presented in the ASRAC Term Sheet recommendations, is appropriate. To this end, DOE is adopting this approach by clarifying the provision. Specifically, since a complete unit cannot be smaller than its largest component, placing the 35-inch restriction on the finished equipment itself addresses the dimensional restrictions intended by the Working Group while simplifying the text of the definition itself. DOE also notes that because these units are designed for indoor installation, as noted by UCA, DOE agrees that these units would require ducting of outdoor air from the building exterior and that units intended for outdoor use should not be considered in the same equipment class. As a result, DOE agrees with the ASRAC Term Sheet recommendations that double-duct units and/or all of their components should be non-weatherized and not marked as being in compliance with UL Standard 1995 or equivalent requirements for outdoor use. DOE also notes that single package vertical units (''SPVUs'') are already covered under separate standards (10 CFR 431.97(d)). As a result, to ensure that SPVUs are not covered under the definition of double-duct CUACs and CUHPs, DOE agrees with the ASRAC Term Sheet recommendations that for vertical double-duct units, only those with split configurations (that may be installed with the two components attached together) should be included as part of this separate equipment class. For these reasons, DOE is adopting the definition proposed in the ASRAC Term Sheet for double-duct CUACs and CUHPs and is maintaining the existing EER standards contained in Table 1 of 10 CFR 431.97 for this equipment.

b. Commercial Warm Air Furnaces

The energy conservation standards adopted in this direct final rule cover CWAFs, as defined by EPCA and DOE. EPCA defines a ''warm air furnace'' as ''a self-contained oil- or gas-fired furnace designed to supply heated air through ducts to spaces that require it and includes combination warm air furnace/electric air conditioning units but does not include unit heaters and duct furnaces.'' (42 U.S.C. 6311(11)(A)) DOE defines the term ''commercial warm air furnace'' as meaning ''a warm air furnace that is industrial equipment, and that has a capacity (rated maximum input) of 225,000 Btu per hour or more.'' 10 CFR 431.72. Accordingly, this rulemaking covers equipment in these categories having a rated capacity of 225,000 Btu/h or higher and that are designed to supply heated air in commercial and industrial buildings via ducts (excluding unit heaters and duct furnaces).[32]

As discussed above for CUACs/CUHPs, DOE divides covered equipment into equipment classes based on the type of energy used, capacity, or other performance-related features that would justify having a higher or lower standard from that which applies to other equipment classes.

The equipment classes for CWAFs were defined in the EPACT 1992

[32] At its most basic level, a CWAF operates by using a burner to combust fuel (*e.g.* natural gas or oil) and then pass the products of combustion through a heat exchanger, which is used to warm the indoor air stream by transferring heat from the combustion products. This warm indoor air is delivered via ducts to *e.g.*the conditioned spaces within the building's interior.

amendments to EPCA, and are divided into two classes based on fuel type (*i.e.,* one for gas-fired units, and one for oil-fired units). Table IV–2 shows the equipment class structure for CWAFs and the current federal minimum energy efficiency standards.

TABLE IV–2—CWAFS EQUIPMENT CLASSES

Fuel type	Heating capacity (Btu/h)	Federal minimum thermal efficiency (%)
Gas-fired	≥225,000	80
Oil-fired	≥225,000	81

In response to the CWAFs NOPR, Nordyne commented that the CWAF definition should include gas-fired ''makeup'' air furnaces.[33] Nordyne stated that gas-fired makeup air furnaces follow the same test procedure to determine energy efficiency as do gas-fired CWAFs, and noted that the heat exchangers, air burners, and other components of gas-fired makeup air furnaces are similar to those in CWAFs. Further, Nordyne asserted that there is little difference in functionality between these equipment, and there is no sense in performing extra analysis to consider separate equipment classes/standards for gas-fired makeup air furnaces and gas-fired CWAFs (CWAF: Nordyne, NOPR Public Meeting Transcript, No. 17 at p. 35–36). DOE reiterates that the definition of a CWAF requires that (among other criteria) a unit be able to ''supply heated air through ducts to spaces that require it'' (42 U.S.C. 6311(11)(A)). Therefore, if a makeup air furnace is capable of operating in this manner, and if it meets all other criteria to be classified as a CWAF, then it would be considered as such under DOE's regulations.

3. Technology Options

As part of the market and technology assessment, DOE uses information about existing and past technology options and prototype designs to help identify technologies that manufacturers could use to improve CUAC/CUHP and CWAF energy efficiency. Initially, these technologies encompass all those that DOE believes are technologically feasible. Chapter 3 of the CUAC/CUHP and CWAF direct final rule TSDs includes the detailed list and descriptions of all technology options identified for this equipment.

[33] ''Makeup'' air furnaces may be used to precondition fresh outdoor air for distribution to other air handling units, which then provide further conditioning and distribute the air via ducts to the conditioned space. Alternatively, makeup air furnaces may also condition fresh outdoor air and directly distribute it via ducts to the conditioned space.

a. Commercial Unitary Air Conditioners and Heat Pumps

For the CUAC/CUHP NOPR, DOE considered the technology options presented in Table IV–3. 79 FR at 58969.

TABLE IV–3—TECHNOLOGY OPTIONS CONSIDERED IN THE CUAC/CUHP NOPR

Heat transfer improvements:
- Electro-hydrodynamic enhancement

Alternative refrigerants
Condenser and evaporator fan and fan motor improvements:
- Larger fan diameters
- More efficient fan blades (*e.g.,* air foil centrifugal evaporator fans, backward-curved centrifugal evaporator fans, high efficiency propeller condenser fans)
- High efficiency motors (*e.g.,* copper rotor motor, high efficiency induction, permanent magnet, electronically commutated)
- Variable speed fans/motors

Larger heat exchangers
Microchannel heat exchangers
Compressor Improvements:
- High efficiency compressors
- Multiple compressor staging
- Multiple-tandem or variable-capacity compressors

Thermostatic expansion valves
Electronic expansion valves
Subcoolers
Reduced indoor fan belt loss:
- Synchronous (toothed) belts
- Direct-drive fans

In the CUAC/CUHP NOPR, DOE noted that for the majority of the identified technology options, the analysis considered designs that are generally consistent with existing equipment on the market (*e.g.,* heat exchanger sizes, fan and fan motor types, controls, air flow). 79 FR at 58969.

Goodman commented that all of the technology options listed by DOE are available in the market today and manufacturers can and do use such options whenever they are cost effective. All of the proposed technology options can be used to provide minor improvements to the HVAC system's efficiency, specifically IEER, but have minimal, if any, impact on EER. (CUAC: Goodman, No. 65 at p. 13) Goodman stated that the majority of the technology options increase physical size of the components and/or unit. Face area of indoor/outdoor coils can be held constant while improving heat transfer by either additional coil rows or increased fin density. However, Goodman noted that both of those options also increase the fan power required to move air through the coils which at least partially counteracts the gains from more coil surface area. Goodman stated that some of the proposed technology options such as increased condenser fan diameter, while technologically feasible, are not practically feasible. (CUAC: Goodman, No. 65 at p. 13)

Rheem commented that a larger diameter forward-curved indoor fan performs well at the low static test condition but can be unstable when the system is installed with a high static duct system. Rheem also stated that the applicability of the backward-inclined blower wheel requires a complete redesign of a package unit outside envelope, which will add cost to the system. Other options, such as multiple compressors or variable frequency drives, are not as disruptive to the footprint design. Rheem noted that the footprint of the unit intended for the replacement market is restricted to existing roof curbs and duct configurations. Rheem added that additional unit height on very large equipment may be restricted by internal tractor trailer clearances when the equipment is shipped. (CUAC: Rheem, No. 70 at p. 3)

As discussed in section IV.A, DOE selected and analyzed currently available models using their rated efficiency to characterize the energy use and manufacturing production costs at each efficiency level. As a result, DOE analyzed equipment designs, including unit dimensions, expansion devices, and indoor and outdoor coils and fans/

motors, consistent with currently available models and the design of the equipment as a whole. As discussed in section IV.A, DOE also considered how changes in the equipment footprint would impact the need for roof curb adapters for replacement installations. For these reasons, DOE believes that the technology options analyzed in this direct final rule accurately reflect the efficiency improvement and incremental manufacturing costs associated with these designs.

Regarding copper rotor motors, DOE noted in the CUAC/CUHP NOPR that manufacturing more efficient copper rotor motors requires using copper instead of aluminum for critical components of an induction motor's rotor (*e.g.,* conductor bars and end rings). DOE noted that in the case of motor rotors for similar horsepower motors, copper rotors can reduce the electric motor total energy losses by between 15 percent and 23 percent as compared to aluminum rotors. As a result, DOE considered copper rotor motors as a technology option. 79 FR at 58966.

Nidec commented that the reduction in electric motor total energy losses estimated by DOE to be achievable with copper rotors when compared to aluminum rotors is not consistent with what has been reported as achievable in previous DOE rulemakings for electric motors nor is it consistent with Nidec's experience. Nidec noted that the TSD for electric motors showed a reduction in total losses of less than 10 percent when changing from an aluminum rotor to a die-cast copper rotor along with additional enhancements to the motor design such as increased stack length, increased slot fill, and/or different lamination steel material. Nidec added that DOE may also be overstating in the electric motors rulemaking the reduction in total losses that can typically be achieved, citing comments made by the National Electrical Manufacturers Association (''NEMA'') on that rulemaking indicating that the full-load loss for a prototype 10-hp motor was only 5.9 percent less than that for the motor with the aluminum rotor. (CUAC: Nidec, No. 55 at pp. 2–5)

DOE appreciates the additional information regarding the reduction in total losses associated with copper rotors. As discussed above, DOE considered design options for the engineering analysis consistent with equipment currently available on the market and considered the efficiency of the equipment as a whole rather than quantifying the energy savings associated with individual components. Accordingly, as part of its technology options analysis, DOE screened in copper rotors as one possible option to improve overall CUAC/CUHP efficiency. However, DOE notes that, based on its review of equipment available on the market, it did not observe any models that incorporated copper rotor motors. Because DOE analyzed the full system design of equipment and specific design options consistent with actual equipment available on the market, DOE did not specifically analyze copper rotor motors as part of the engineering analysis.

Regal-Beloit commented that DOE should consider electronically commutated motors (''ECMs'') as an alternate technology for the indoor fan. ECM technology is now a viable alternative to variable frequency drives (''VFDs'') for CUACs and CUHPs. Regal-Beloit also commented that DOE should consider ECM technology at efficiency levels other than the max-tech. (CUAC: Regal-Beloit, No. 66 at p. 1) As noted in Table IV–3, DOE considered ECMs as a technology option. As discussed in section IV.C.3.a, DOE revised the engineering analysis to be based on rated models at each efficiency level so that equipment design and specific design options analyzed were consistent with actual equipment at each efficiency level. Based on DOE's review of equipment available on the market, DOE did not observe any models using ECMs for the indoor fan. In addition, Carrier commented as part of the ASRAC Working Group meetings that ECMs are not currently used for indoor fan motor above 1 horsepower. (CUAC: Carrier, ASRAC Public Meeting, No. 94 at p. 186) However, DOE notes that manufacturers would not be precluded from incorporating ECMs for the indoor fan. Details of the design options at each efficiency level are presented in chapter 5 of the CUAC/CUHP direct final rule TSD.

b. Commercial Warm Air Furnaces

In the analyses for this direct final rule, DOE reviewed the market for CWAFs, as well as information gathered from interviews with CWAF manufacturers during the NOPR analyses, to determine the common technologies implemented to improve CWAF efficiency. Based on this information, DOE primarily considered the following technology options to improve CWAF thermal efficiency:

- Increased heat exchanger (HX) surface area [34]
- HX enhancements (*e.g.,* dimples, turbulators)
- Condensing secondary HX (stainless steel) [35]

DOE notes that a secondary heat exchanger for condensing operation is a possible technology option for CWAFs, but also that this technology has considerable issues to overcome when used in weatherized equipment. These issues relate specifically to the handling of acidic condensate produced by a condensing furnace in the secondary heat exchanger. Condensate must be drained from the furnace to prevent build-up in the secondary heat exchanger, and properly disposed of after exiting into the external environment. Some building codes limit the disposal of condensate into the municipal sewage system, so the condensate must be passed through a neutralizer to reduce its acidity to appropriate levels prior to disposal. In weatherized installations, it is more difficult to access the municipal sewage system than in non-weatherized installations. Condensate produced by a weatherized condensing furnace must flow naturally or be pumped through pipes to the nearest disposal drain, which may not be in close proximity to the furnace. In cold environments, there is a risk of the condensate freezing as it flows through these pipes, which can cause an eventual back-up of condensate into the heat exchanger, resulting in significant damage to the furnace.

Despite these issues, DOE found in its review of the market that multiple manufacturers offer weatherized HVAC equipment with a condensing furnace heating section. DOE believes that this fact indicates that many of the issues related to a condensing secondary heat exchanger can be overcome, and thus, DOE considered a condensing secondary heat exchanger as a technology option. As discussed in section IV.B.1, this technology was ultimately passed through the screening analysis and considered in the engineering analysis. Regarding condensate disposal, DOE included the cost of condensate disposal lines for all condensing installations; for further details on the installation costs of a

[34] This design option includes a larger combustion inducer (to overcome the pressure drop of the increased HX area). The larger combustion inducer does not directly lead to a higher TE, but would allow the implementation of other technologies (*i.e.,* HX improvements) that would cause the furnace to operate more efficiently.

[35] This design option includes a larger combustion inducer fan, upgraded housing for combustion blowers, stainless steel impellers, condensate heater, and condensate drainage system that would be required for condensing operation. Although these design changes do not directly lead to a higher TE, they allow the implementation of condensing operation, which causes the furnace to operate more efficiently.

condensate disposal system, see section IV.F.1 of this direct final rule, and chapter 8 of the CWAF direct final rule TSD.

DOE also identified the following additional technology options for improving CWAF efficiency. Many of these technologies were either removed from the analysis because they were screened out or because they did not improve the rated TE of CWAFs as measured by the DOE test procedure (see section IV.B for further details):

- Pulse combustion
- Low NO_X premix burner
- Low pressure, air-atomized burner (oil-fired CWAFs only)
- Burner de-rating
- Two-stage or modulating combustion
- Insulation improvements
- Delayed-action oil pump solenoid valve (oil-fired CWAFs only)
- Off-cycle dampers
- Electronic ignition
- Concentric venting
- High-static flame-retention head oil burner (oil-fired CWAFs only)

B. Screening Analysis

After DOE identified the technologies that might improve CUAC/CUHP and CWAF energy efficiency, DOE conducted a screening analysis. The purpose of the screening analysis is to determine which options to consider further and which to screen out. DOE consulted with industry, technical experts, and other interested parties in developing a list of design options. DOE then applied the following set of screening criteria to determine which design options are unsuitable for further consideration in the rulemaking:

- *Technological Feasibility:* DOE will consider only those technologies incorporated in commercial equipment or in working prototypes to be technologically feasible.
- *Practicability to Manufacture, Install, and Service:* If mass production of a technology in commercial equipment and reliable installation and servicing of the technology could be achieved on the scale necessary to serve the relevant market at the time of the effective date of the standard, then DOE will consider that technology practicable to manufacture, install, and service.
- *Adverse Impacts on Equipment Utility or Equipment Availability:* DOE will not further consider a technology if DOE determines it will have a significant adverse impact on the utility of the equipment to significant subgroups of customers. DOE will also not further consider a technology that will result in the unavailability of any covered equipment type with performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as equipment generally available in the United States at the time.
- *Adverse Impacts on Health or Safety:* DOE will not further consider a technology if DOE determines that the technology will have significant adverse impacts on health or safety.

Additionally, DOE notes that these screening criteria do not directly address the proprietary status of technology options. DOE only considers efficiency levels achieved through the use of proprietary designs in the engineering analysis if they are not part of a unique path to achieve that efficiency level (*i.e.,* if there are other non-proprietary technologies capable of achieving the same efficiency). DOE believes the standards for the equipment covered in this rulemaking would not require the use of any proprietary technologies, and that all manufacturers would be able to achieve the proposed levels through the use of non-proprietary designs.

Technologies that pass through the screening analysis are referred to as ''design options'' and are subsequently examined in the engineering analysis for consideration in DOE's downstream cost-benefit analysis.

1. Commercial Unitary Air Conditioners and Heat Pumps

For CUACs and CUHPs, DOE screened out the following technology options in the CUAC/CUHP NOPR. 79 FR at 58969–58970.

TABLE IV–4—TECHNOLOGY OPTIONS SCREENED OUT FOR THE CUAC/CUHP NOPR

Technology option	Reason for screening out
Electro-hydrodynamic enhanced heat transfer	Practicability to manufacture, install, and service; technological feasibility.
Alternative refrigerants	Technological feasibility.
Sub-coolers	Technological feasibility.

Regarding the use of potential refrigerants, in the CUAC/CUHP NOPR, DOE considered ammonia, carbon dioxide, and various hydrocarbons (such as propane and isobutane) as alternative refrigerants to those that are currently in use, such as R–410A. DOE noted that safety concerns need to be taken into consideration when using ammonia and hydrocarbons in air conditioning systems. The Environmental Protection Agency (''EPA'') created the Significant New Alternatives Policy (''SNAP'') Program to evaluate alternatives to ozone-depleting substances. Substitutes are reviewed on the basis of ozone depletion potential, global warming potential, other environmental impacts, toxicity, flammability, and exposure potential. DOE noted at the time of the CUAC/CUHP NOPR that ammonia used in vapor compression cycles, carbon dioxide, and hydrocarbons were approved or were being considered under SNAP for certain uses, but these or other low global warming potential (''GWP'') alternatives were not listed as acceptable substitutes for this equipment.[36] DOE also stated in the CUAC/CUHP NOPR that it is not aware of any other more efficient refrigerant options that are SNAP-approved. Because these alternative refrigerants that may be more efficient had not yet been approved for this equipment at the time of its analysis, DOE did not consider alternate refrigerants for further consideration. 79 FR at 58970.

Danfoss and the Environmental Investigation Agency (EIA Global) commented that the United States is supporting a phasedown of HFC refrigerants, including HFC–410A, through the Montreal Protocol. (CUAC: Danfoss, No. 53 at p. 2; EIA Global, No. 58 at pp. 3–4) Danfoss added that Europe has already mandated a 40-percent reduction in HFC production by 2020. Danfoss stated that it is likely that EPA will also set limits on the use of HFC–410A in the future, but the timing and impact on the use of R–410A is unknown at this time. Danfoss encouraged DOE to work closely with EPA and to align standards for CUACs and CUHPs with EPA SNAP rules, so that major equipment redesigns can be

[36] On April 10, 2015, EPA listed certain hydrocarbons and R–32 for residential self-contained A/C appliances as acceptable subject to use conditions to address safety concerns (See 80 FR 19453). EPA is also evaluating new refrigerants for other A/C applications, including commercial A/C. Additional information regarding EPA's SNAP Program is available online at: *http://www.epa.gov/ozone/snap/.*

kept to a minimum. (CUAC: Danfoss, No. 53 at p. 2)

EIA Global expressed its concern that DOE's analysis will be incomplete without the inclusion of alternative hydrocarbon refrigerants and that the high GWP of current HFC refrigerants for this equipment category will further damage the stability of the climate, thus offsetting the efficiency gains associated with standards. EIA Global commented that DOE should consider currently available systems using alternative refrigerants and the effects of the EPA's finalization of its proposed rule, ''Protection of Stratospheric Ozone: Listing Substitutes for Refrigeration and Air-Conditioning and Revision of the Venting Prohibition for Certain Refrigerant Substitutes,'' which lists propane (R–290) and hydrocarbon blend R–441A as acceptable alternatives under the EPA's SNAP program for end uses including light commercial air conditioners and heat pumps. EIA Global commented that DOE should consider the energy efficiency savings and the reduction in GHG emissions from these alternative low-GWP refrigerants. EIA Global also urged DOE to include provisions to enable persons to petition for an interim revisiting of the standard in light of the EPA SNAP rule approving the use of these alternative refrigerants. (CUAC: EIA Global, No. 58 at pp. 1–2, 4–8)

EIA Global stated that, given the President's recent Executive Action, ''Invest in New Technologies to Support Safer Alternatives,'' DOE should be using its authority to not only conduct its own research and commercialization of HFC-free technologies, but also to incentivize U.S. industry to manufacture HFC-free and energy efficient CUACs and CUHPs, so they can lead the world in the development and marketing of the next generation of this equipment. (CUAC: EIA Global, No. 58 at pp. 1–4)

DOE recognizes that EPA published a final rule approving alternative refrigerants, subject to use conditions, in specific end-uses. 80 FR 19454 (Apr. 10, 2015). However, DOE notes that these end-use applications did not include CUACs and CUHPs that are the subject of this rulemaking. DOE notes that hydrocarbon refrigerants have not yet been approved by the EPA SNAP program for these types of equipment and, hence, cannot be considered as a technology option in DOE's analysis. DOE also notes that, while it is possible that HFC refrigerants currently used in CUACs and CUHPs may be restricted by future rules, DOE cannot speculate on the outcome of a rulemaking in progress and can only consider in its rulemakings rules that are currently in effect. Therefore, DOE has not included possible outcomes of potential EPA SNAP rulemakings. This position is consistent with past DOE rulings, such as in the 2014 final rule for commercial refrigeration equipment (79 FR 17725, 17753–54 (March 28, 2014)) and the 2015 final rule for automatic commercial icemakers (80 FR 4646, 4670–71 (Jan. 28, 2015)) DOE notes that recent rules by the EPA that allow use of hydrocarbon refrigerants or that impose new restrictions on the use of HFC refrigerants do not address air-cooled CUACs and CUHPs applications. 80 FR 19454 (April 10, 2015) and 80 FR 42879 (July 20, 2015). DOE acknowledges that there are government-wide efforts to reduce emissions of HFCs, and such actions are being pursued both through international diplomacy as well as domestic actions. DOE, in concert with other relevant agencies, will continue to work with industry and other stakeholders to identify safer and more sustainable alternatives to HFCs while evaluating energy efficiency standards for this equipment.

DOE also recognizes that while some alternative refrigerants may be under consideration as potential future replacements for CUACs and CUHPs, including low-GWP blends submitted to EPA's SNAP program, the development of safety and other related building code standards that will impact decisions regarding the final selected alternatives are still under way. DOE cannot consider all of the potential alternatives to accurately analyze the efficiency impacts for this equipment. Goodman similarly noted as part of the ASRAC Working Group meetings that the safety standards for alternative refrigerants are in the process of being developed, and the current standards, UL 1995, ''Heating and Cooling Equipment'' and UL 60335–2–40, ''Safety of Household and Similar Electrical Appliances, Part 2–34: Particular Requirements for Motor-Compressors,'' specifically ban any flammable refrigerant from comfort air conditioning products. (CUAC: Goodman, ASRAC Public Meeting, No. 99 at pp. 43–44)

DOE also notes that performance information regarding all alternative refrigerants, such as CUACs and CUHPs with proven test data and publicly available compressor performance information, are not available at this time to properly evaluate the impacts of alternative refrigerants on energy use.

As mentioned in section VI.B.4, if a manufacturer believes that its design is subjected to undue hardship by regulations, the manufacturer may petition DOE's Office of Hearing and Appeals (OHA) for exception relief or exemption from the standard pursuant to OHA's authority under section 504 of the DOE Organization Act (42 U.S.C. 7194), as implemented at subpart B of 10 CFR part 1003. OHA has the authority to grant such relief on a case-by-case basis if it determines that a manufacturer has demonstrated that meeting the standard would cause hardship, inequity, or unfair distribution of burdens. DOE also notes that any person may petition DOE for an amended standard applicable to a variety of consumer products and commercial/industrial equipment. See 42 U.S.C. 6295(r) and 42 U.S.C. 6313(a). This provision, however, does not apply to the equipment addressed by this rulemaking. See 42 U.S.C. 6316(b).

In recognition of the issues related to alternative refrigerants, members of the ASRAC Working Group agreed as part of the Term Sheet to delay implementation of the second phase of increased energy conservation standard levels until January 1, 2023, in part to align dates with potential refrigerant phase-outs and to provide sufficient development lead time after safety requirements for acceptable alternatives have been established. (CUAC: ASRAC Term Sheet, No. 93 at pp. 3–4; ASRAC Public Meeting, No. 100 at pp. 82; ASRAC Public Meeting, No. 101 at pp. 48–49) Delaying the implementation of the second phase of standards in the manner recommended and agreed to by the Working Group will provide manufacturers with flexibility and additional time to comply with both energy conservation standards and potential refrigerant changes, allowing manufacturers to better coordinate equipment redesign to reduce the cumulative burden. As discussed in section III.C, DOE is adopting the proposed two-phased approach recommended in the ASRAC Term Sheet.

With respect to copper rotors, Nidec disagreed with DOE's determination not to screen out this option. In its view, copper rotor motors do not satisfy either the screening criteria of (a) practicability to manufacture, install, and service; or (b) adverse impacts on equipment utility or equipment availability. (CUAC: Nidec, No. 55 at p. 2–5) Nidec stated that the very short lifespans for the end ring dies and casting pistons for copper die-casting presses would prevent motor manufacturers from mass producing copper rotors on a sufficient scale due to the constant need to replace this tooling. (CUAC: Nidec, No. 55 at p. 5) Nidec also noted that there is a lack of die-cast copper rotor production capability in place today, which, given the dramatic increase in production capability that would be required in a very short amount of time to satisfy the demand for air conditioning and heating equipment impacted by the present rulemaking if such equipment required motors with die-cast copper rotors to meet the proposed standards, should counsel against the inclusion of this option from DOE's analysis. (CUAC: Nidec, No. 55 at pp. 5–6)

As noted in the electric motors final rule, DOE noted that two large motor manufacturers currently offer die-cast copper rotor motors up to 30-horsepower. DOE also noted in the electric motors rule that full scale deployment of copper would likely require considerable capital investment and that such investment could increase the production cost of copper rotor motors considerably. 79 FR 30934, 30963–65 (May 29, 2014). However, increased motor cost alone would not be a reason to screen out this technology. For these reasons, DOE did not screen out this technology on the basis of practicability to manufacture, install, and service, or adverse impacts on equipment utility or equipment availability.

Based on the screening analysis, DOE identified the design options listed in Table IV–5 for further consideration in the engineering analysis:

TABLE IV–5—CUAC/CUHP DESIGN OPTIONS RETAINED FOR ENGINEERING ANALYSIS

Condenser and evaporator fan and fan motor improvements:
- Larger fan diameters
- More efficient fan blades (*e.g.,* air foil centrifugal evaporator fans, backward-curved centrifugal evaporator fans, high efficiency propeller condenser fans)
- High efficiency motors (*e.g.,* copper rotor motor, high efficiency induction, permanent magnet, electronically commutated)
- Variable speed fans/motors

Larger heat exchangers
Microchannel heat exchangers
Compressor Improvements:
- High efficiency compressors
- Multiple compressor staging
- Multiple- or variable-capacity compressors

Thermostatic expansion valves
Electronic expansion valves
Reduced indoor fan belt loss:
- Synchronous (toothed) belts
- Direct-drive fans

A full description of each technology option is included in chapter 3 of the CUAC/CUHP direct final rule TSD, and additional discussion of the screening analysis is included in chapter 4 of the CUAC/CUHP direct final rule TSD.

2. Commercial Warm Air Furnaces

For CWAFs, DOE screened out the technology options listed in Table IV–6. Each of these technology options failed to meet at least one of the four screening criteria: (1) technological feasibility; (2) practicability to manufacture, install, and service; (3) impacts on equipment utility or equipment availability; and (4) adverse impacts on health or safety. See 10 CFR part 430, subpart C, appendix A, 4(a)(4) and 5(b).

TABLE IV–6—TECHNOLOGY OPTIONS SCREENED OUT FOR COMMERCIAL WARM AIR FURNACES

Technology option	Reason for screening out
Pulse combustion	Adverse impact on utility; potential for adverse impact on safety.
Low NO_X premix burner.	Technological feasibility.
Burner de-rating	Adverse impact on utility.
Low pressure, air-atomized burner (oil-fired CWAFs only).	Technological Feasibility.

In addition, the following technology options met all four of the screening criteria, but were removed from further consideration in the engineering analysis because they do not impact the CWAF efficiency as measured by the DOE test procedure:
- Two-stage or modulating combustion
- Insulation improvements
- Off-cycle dampers
- Delayed-action oil pump solenoid valve (oil-fired CWAFs only)
- Electronic ignition

Based on the screening analysis, DOE identified the following five technology options for further consideration in the engineering analysis:
- Condensing secondary heat exchanger
- Increased heat exchanger surface area
- Heat exchanger enhancements (*e.g.,* dimples, baffles, and turbulators)
- Concentric venting
- High-static flame-retention head oil burner (oil-fired CWAFs only)

A full description of each technology option is included in chapter 3 of the CWAF direct final rule TSD, and additional discussion of the screening analysis is included in chapter 4 of the CWAF direct final rule TSD.

C. Engineering Analysis

The engineering analysis establishes the relationship between an increase in energy efficiency of equipment and the increase in manufacturer selling price (''MSP'') required to achieve that efficiency increase. This relationship serves as the basis for the cost-benefit calculations for commercial customers, manufacturers, and the Nation. In determining the cost-efficiency relationship, DOE estimates the increase in manufacturer cost associated with increasing the efficiency of equipment to incrementally higher efficiency levels above the baseline efficiency level, up to the maximum technologically feasible (''max-tech'') efficiency level for each equipment class.

1. Methodology

DOE typically structures its engineering analysis using one or more of three identified basic methods for generating manufacturing costs: (1) The design-option approach, which provides the incremental costs of adding individual technology options (as identified in the market and technology assessment and passed through the screening analysis) that can be added alone or in combination with a baseline model in order to improve its efficiency (*i.e.,* lower its energy use); (2) the efficiency-level approach, which provides the incremental costs of moving to higher energy efficiency levels, without regard to the particular design option(s) used to achieve such increases; and (3) the reverse-engineering (or cost-assessment) approach, which provides ''bottom-up'' manufacturing cost assessments for achieving various levels of increased efficiency, based on teardown analyses (or physical teardowns) providing detailed data on costs for parts and material, labor, shipping/packaging, and investment for models that operate at particular efficiency levels. A supplementary method called a catalog teardown uses published manufacturer catalogs and supplementary component data to estimate the major physical differences between a piece of equipment that has been physically disassembled and another piece of similar equipment for which catalog data are available to determine the cost of the latter equipment.

For CUACs and CUHPs, DOE conducted the engineering analyses using a combination of the efficiency-level approach and the reverse-engineering approach and analyzed three specific capacities, one representing each of the three equipment class capacity ranges (*i.e.,* small, large, and very large). Based on a review of manufacturer equipment offerings, information from the previous standards rulemaking regarding cooling capacities that represent volume equipment shipment points within the equipment class capacity ranges, and information obtained from manufacturer interviews, DOE selected representative cooling capacities of 90,000 Btu/h (7.5 tons) for the ≥65,000 to <135,000 Btu/h capacity range, 180,000 Btu/h (15 tons) for the ≥135,000 to <240,000 Btu/h capacity range, and 360,000 Btu/h (30 tons) for the ≥240,000 to <760,000 Btu/h capacity range. Where feasible, DOE selected models for reverse engineering with low and high efficiencies from a given manufacturer that are built on the same platform. DOE also supplemented the teardown analysis by conducting catalog teardowns for equipment spanning the full range of capacities and efficiencies from all manufacturers selling equipment in the United States.

For CWAFs, DOE conducted the engineering analysis using the reverse-engineering approach to estimate the costs of achieving various efficiency levels. DOE selected two gas-fired CWAF units in the non-condensing efficiency range for physical teardowns, both at a heating input rating of 250,000 Btu/h, which was considered to be the representative heating input rating for the gas-fired equipment class. In addition, DOE purchased a condensing, 92-percent TE gas-fired makeup air furnace for physical examination. Makeup air furnaces are the only type of 92-percent TE gas-fired CWAFs currently available on the market. DOE also performed a physical teardown of an oil-fired CWAF at 81-percent TE at an input rating of 400,000 Btu/h, which was subsequently scaled down via cost estimation techniques to represent a unit with a 250,000 Btu/h heating input rating. Similar to gas-fired CWAFs, 250,000 Btu/h was also considered the representative heating input rating for oil-fired CWAFs. GTI commented that at around a heating input of 400,000 Btu/h, in gas-fired CWAFs, it may be common practice for manufacturers to transition from a single furnace to two furnaces in packaged equipment. This would necessitate additional components associated with the second furnace including additional gas valves and inducer fans, which may contribute to a different price regime (CWAF: GTI, NOPR Public Meeting Transcript, No. 17 at pp. 74–75). DOE agrees that gas-fired CWAFs are generally not manufactured with individual combustion modules (*i.e.,* a single gas valve, inducer assembly, and heat exchanger assembly) with heating inputs of greater than 400,000 Btu/h, usually due to insurance and liability reasons. DOE acknowledges that the manufacturing costs for equipment using multiple combustion modules will be higher than for equipment using single modules. However, DOE believes that at efficiency levels higher than baseline for units with multiple combustion modules, the energy savings relative to the baseline efficiency level scales proportionally with the increased incremental cost (relative to baseline) to manufacture equipment with multiple combustion modules. As such, DOE did not estimate manufacturing costs for units above 400,000 Btu/h heating input, because it does not believe that the relationship between incremental equipment cost and incremental energy savings at efficiency levels higher than baseline will be significantly different than at the representative heating input capacity selected for analysis.

DOE used catalog data, information from the physical teardown examinations, and manufacturer feedback to estimate the manufacturing costs for gas-fired CWAFs at the 80-percent, 81-percent, 82-percent and 92-percent TE levels, as well as the manufacturing costs for oil-fired CWAFs at the 81-percent, 82-percent and 92-percent TE levels. Additional detail on the teardowns performed is provided in chapter 5 of the CWAF direct final rule TSD.

2. Efficiency Levels

a. Baseline Efficiency Levels

The baseline model is used as a reference point for each equipment class in the engineering analysis and the life-cycle cost and payback-period analyses, which provides a starting point for analyzing potential technologies that provide energy efficiency improvements. Generally, DOE considers ''baseline'' equipment to refer to a model or models having features and technologies that just meet, but do not exceed, the minimum energy conservation standard.

Commercial Unitary Air Conditioners and Heat Pumps

As discussed in section III.G, for CUACs and CUHPs, DOE decided to replace the current cooling performance energy efficiency descriptor, EER, with IEER. With this change in metrics (*i.e.,* from EER to IEER), DOE must ensure that a new IEER-based standard would not result in a backsliding of energy efficiency levels when compared to the current standards (42 U.S.C. 6313(a)(6)(B)(iii)(I)). To this end, DOE must first establish a baseline IEER for each CUAC and CUHP equipment class to compare that level against the various standards that DOE evaluated for this equipment.

In the CUAC/CUHP NOPR, DOE noted that it is typically obligated either to adopt those standards developed by ASHRAE or to adopt levels more stringent than the ASHRAE levels if there is clear and convincing evidence in support of doing so. (42 U.S.C. 6313(a)(6)(A)) DOE noted that ASHRAE Standard 90.1–2010 specifies minimum efficiency requirements using both the EER and IEER metrics. As discussed in the CUAC/CUHP RFI, DOE evaluated the relationship between EER and IEER by considering models that are rated at the current DOE standard levels based on the EER metric for each equipment class. DOE then analyzed the distribution of corresponding rated IEER values for each equipment class, noting that a single EER level can correspond to a range of IEERs. DOE also noted that the lowest IEER values associated with the current DOE standards for EER generally correspond with the ASHRAE Standard 90.1–2010 minimum efficiency requirements. See 78 FR at 7299. Based on this evaluation, because DOE is considering energy conservation standards based on the IEER metric, DOE proposed in the CUAC/CUHP NOPR to use the ASHRAE Standard 90.1–2010 minimum IEER requirements to characterize the baseline cooling efficiency for each equipment class. Because the baseline efficiency level is intended to be representative of the minimum efficiency of equipment, DOE did not consider higher IEER levels for the baseline. (79 FR at 58972.)

For CUHPs, DOE considered heating efficiency standards based on the COP metric. As discussed in section II.B.1, EPAct 2005 established minimum COP levels for small, large, and very large air-cooled CUHPs, which DOE codified in a final rule on October 18, 2005. 70 FR 60407. DOE proposed in the CUAC/CUHP NOPR to use these current COP standard levels to characterize the baseline heating efficiency for each equipment class. (79 FR at 58972.)

Table IV–7 presents the baseline efficiency levels for each equipment class considered in the CUAC/CUHP NOPR.

TABLE IV–7—BASELINE EFFICIENCY LEVELS PROPOSED IN THE CUAC/CUHP NOPR

Equipment type	Heating type	Baseline efficiency level
Small Commercial Packaged AC and HP (Air-Cooled)—≥65,000 Btu/h and <135,000 Btu/h Cooling Capacity:		
AC	Electric Resistance Heating or No Heating.	11.4 IEER
	All Other Types of Heating	11.2 IEER
HP	Electric Resistance Heating or No Heating.	11.2 IEER 3.3 COP
	All Other Types of Heating	11.0 IEER 3.3 COP
Large Commercial Packaged AC and HP (Air-Cooled)—≥135,000 Btu/h and <240,000 Btu/h Cooling Capacity:		
AC	Electric Resistance Heating or No Heating.	11.2 IEER
	All Other Types of Heating	11.0 IEER
HP	Electric Resistance Heating or No Heating.	10.7 IEER 3.2 COP
	All Other Types of Heating	10.5 IEER 3.2 COP
Very Large Commercial Packaged AC and HP (Air-Cooled)—≥240,000 Btu/h and <760,000 Btu/h Cooling Capacity:		
AC	Electric Resistance Heating or No Heating.	10.1 IEER
	All Other Types of Heating	9.9 IEER
HP	Electric Resistance Heating or No Heating.	9.6 IEER 3.2 COP
	All Other Types of Heating	9.4 IEER 3.2 COP

Based on a review of equipment available on the market, DOE notes that an IEER of 10.6 is more representative of the baseline cooling efficiency for major manufacturers of units falling into the very large CUACs with ''electric resistance heating or no heating'' equipment class. As a result, DOE revised the baseline cooling efficiency level for this equipment class. DOE also revised the baseline cooling efficiency levels for the very large equipment classes for (1) all other types of heating and (2) heat pumps by using the corresponding differences in IEER specifications for these pairs of equipment classes prescribed in ASHRAE Standard 90.1–2010. For all other equipment classes, DOE maintained the baseline efficiency levels from the CUAC/CUHP NOPR. The efficiency levels considered in this final rule are presented below in Table IV–8.

TABLE IV–8—DIRECT FINAL RULE BASELINE EFFICIENCY LEVELS

Equipment type	Heating type	Baseline efficiency level
Small Commercial Packaged AC and HP (Air-Cooled)—≥65,000 Btu/h and <135,000 Btu/h Cooling Capacity:		
AC	Electric Resistance Heating or No Heating.	11.4 IEER
	All Other Types of Heating	11.2 IEER
HP	Electric Resistance Heating or No Heating.	11.2 IEER 3.3 COP
	All Other Types of Heating	11.0 IEER 3.3 COP
Large Commercial Packaged AC and HP (Air-Cooled)—≥135,000 Btu/h and <240,000 Btu/h Cooling Capacity:		
AC	Electric Resistance Heating or No Heating.	11.2 IEER
	All Other Types of Heating	11.0 IEER
HP	Electric Resistance Heating or No Heating.	10.7 IEER 3.2 COP
	All Other Types of Heating	10.5 IEER 3.2 COP
Very Large Commercial Packaged AC and HP (Air-Cooled)—≥240,000 Btu/h and <760,000 Btu/h Cooling Capacity:		
AC	Electric Resistance Heating or No Heating.	10.6 IEER
	All Other Types of Heating	10.4 IEER
HP	Electric Resistance Heating or No Heating.	10.1 IEER 3.2 COP
	All Other Types of Heating	9.9 IEER 3.2 COP

Commercial Warm Air Furnaces

In establishing the baseline efficiency level for this analysis, DOE used the existing minimum energy conservation standards for CWAFs to identify baseline units. The baseline TE levels for each equipment class are presented in Table IV–9.

TABLE IV–9—BASELINE THERMAL EFFICIENCY LEVELS FOR CWAFS

Equipment class	Baseline efficiency level (%)
Gas-fired Commercial Warm Air Furnace	80
Oil-fired Commercial Warm Air Furnace	81

b. Incremental and Max-Tech Efficiency Levels

For each equipment class, DOE analyzes several efficiency levels and determines the incremental cost at each of these levels.

Commercial Unitary Air Conditioners and Heat Pumps

For the CUAC/CUHP NOPR, DOE developed efficiency levels based on a review of industry standards and available equipment. For Efficiency Level 1, DOE used the IEER levels specified in the draft of addendum CL [37] to ASHRAE Standard 90.1–2010 (Draft Addendum CL).[38] For the higher efficiency levels, DOE initially determined the levels for CUAC equipment classes with electric resistance heating or no heating based on the range of efficiency levels associated with equipment listed in the AHRI certification database and the California Energy Commission's (''CEC'') database. DOE noted in the CUAC/CUHP NOPR that the max-tech efficiency levels rely on the performance of recently introduced models. DOE conducted its analysis for the small, large, and very large equipment classes using equipment with 7.5-ton, 15-ton, and 30-ton cooling capacities to represent their respective classes. DOE chose efficiency levels for CUACs with all other types of heating equal to the efficiency levels for equipment with electric resistance heating or no heating, minus the differences in the IEER specifications for these pairs of equipment classes prescribed in Draft Addendum CL. DOE stated in the CUAC/CUHP NOPR that these decreases in IEER appropriately reflect the additional power required for gas furnace pressure drop. 79 FR at 58972–73.

For the CUHP equipment classes, DOE proposed cooling mode efficiency levels equal to the CUAC efficiency levels minus the difference in IEER specifications for these two equipment types prescribed in Draft Addendum CL. DOE stated that these decreases in IEER are representative of the efficiency differences that occur due to losses from the reversing valve and the reduced potential for optimization of coil circuitry for cooling, since coils in heat pumps must work for both heating and cooling operation. *Id.*

For the CUHP equipment classes, DOE proposed heating efficiency levels in the CUAC/CUHP NOPR based on a variation of COP with IEER. 79 FR at 58973. In the previous standards rulemaking from 2004 for these equipment, DOE proposed to address the energy efficiency of air-cooled CUHP by developing functions relating COP to EER. 69 FR at 45468. DOE noted that this method was also used by industry to establish minimum performance requirements for ASHRAE Standard 90.1–1999. *Id.* AHRI supplied the ASHRAE Standard 90.1–1999 committee with curves relating the COP as a function of EER. Using this information, the committee then set the minimum COP levels to the COP corresponding to the selected minimum EER level. *Id.* To determine COP efficiency levels for the CUAC/CUHP NOPR, DOE evaluated AHRI and CEC data for small, large, and very large air-cooled CUHP units with electric resistance heat or no heat to analyze the relationship between COP and both IEER and EER. DOE's review of data showed that for each cooling capacity range, the correlations between COP and IEER using linear regressions are no less strong than the correlations between COP and EER, the latter of which was used in DOE's prior standards rulemaking for this equipment and in developing ASHRAE Standard 90.1–1999's minimum COP levels (69 FR at 45468). Based on this evaluation, DOE proposed in the CUAC/CUHP NOPR to use the functions relating COP to IEER based on AHRI and CEC data to select the COP level associated with each of the IEER-based efficiency levels. 79 FR at 58973.

The efficiency levels for each equipment class proposed in the CUAC/CUHP NOPR are presented in Table IV–10.

TABLE IV–10—INCREMENTAL EFFICIENCY LEVELS PRESENTED IN THE CUAC/CUHP NOPR

Equipment type	Heating type	Efficiency levels;				
		Baseline	EL1	EL2	EL3	EL4 (Max-Tech)
Small Commercial Packaged AC and HP (Air-Cooled)—≥65,000 Btu/h and <135,000 Btu/h Cooling Capacity:						
AC	Electric Resistance Heating or No Heating.	11.4 IEER	12.9 IEER	14 IEER	14.8 IEER	19.9 IEER
	All Other Types of Heating	11.2 IEER	12.7 IEER	13.8 IEER	14.6 IEER	19.7 IEER
HP	Electric Resistance Heating or No Heating.	11.2 IEER, 3.3 COP	12.2 IEER, 3.3 COP	13.3 IEER, 3.4 COP	14.1 IEER, 3.5 COP	19.2 IEER, 3.7 COP
	All Other Types of Heating	11.0 IEER, 3.3 COP	12 IEER, 3.3 COP	13.1 IEER, 3.4 COP	13.9 IEER, 3.4 COP	19.0 IEER, 3.6 COP

[37] ASHRAE periodically updates specifications in its Standard 90.1 through a public review process. Draft Addendum CL, which was made available for public review in October 2012, included changes in required efficiency levels for CUACCUACsCUACs and CUHPs falling into the small, large, and very large capacity ranges. ''CL'' refers to the revision number.

[38] The Addendum CL to ASHRAE Standard 90.1–2010 included the latest revisions to the ASHRAE 90.1 efficiency levels for the equipment considered in this rulemaking at the time DOE conducted the analyses for the NOPR. ASHRAE later finalized the Addendum CL changes in ASHRAE 90.1–2013, with minor changes to the IEER levels for large CUACCUACsCUACs and CUHPs (*i.e.,* cooling capacity of >=135,000 Btu/h and <240,000 Btu/h).

TABLE IV–10—INCREMENTAL EFFICIENCY LEVELS PRESENTED IN THE CUAC/CUHP NOPR—Continued

Equipment type	Heating type	Efficiency levels;				
		Baseline	EL1	EL2	EL3	EL4 (Max-Tech)
Large Commercial Packaged AC and HP (Air-Cooled)—≥135,000 Btu/h and <240,000 Btu/h Cooling Capacity:						
AC	Electric Resistance Heating or No Heating.	11.2 IEER	12.2 IEER	13.2 IEER	14.2 IEER	18.4 IEER
	All Other Types of Heating	11.0 IEER	12.0 IEER	13.0 IEER	14.0 IEER	18.2 IEER
HP	Electric Resistance Heating or No Heating.	10.7 IEER, 3.2 COP	11.4 IEER, 3.2 COP	12.4 IEER, 3.3 COP	13.4 IEER, 3.3 COP	17.6 IEER, 3.3 COP
	All Other Types of Heating	10.5 IEER, 3.2 COP	11.2 IEER, 3.2 COP	12.2 IEER, 3.3 COP	13.2 IEER, 3.3 COP	17.4 IEER, 3.3 COP
Very Large Commercial Packaged AC and HP (Air-Cooled)—≥240,000 Btu/h and <760,000 Btu/h Cooling Capacity:						
AC	Electric Resistance Heating or No Heating.	10.1 IEER	11.6 IEER	12.5 IEER	13.5 IEER	15.5 IEER
	All Other Types of Heating	9.9 IEER	11.4 IEER	12.3 IEER	13.3 IEER	15.3 IEER
HP	Electric Resistance Heating or No Heating.	9.6 IEER, 3.2 COP	10.6 IEER, 3.2 COP	11.5 IEER, 3.2 COP	12.5 IEER, 3.2 COP	14.5 IEER, 3.2 COP
	All Other Types of Heating	9.4 IEER, 3.2 COP	10.4 IEER, 3.2 COP	11.3 IEER, 3.2 COP	12.3 IEER, 3.2 COP	14.3 IEER, 3.2 COP

Lennox commented that DOE is required to consider ASHRAE 90.1–2013 according to 42 U.S.C. 6313(a)(6)(A). Lennox noted that Efficiency Level 1 mirrors the values in ASHRAE 90.1–2013 except for large CUAC/CUHP equipment class. (CUAC: Lennox, No. 60 at p. 7) As discussed above, DOE based the CUAC/CUHP NOPR Efficiency Level 1 IEERs on ASHRAE 90.1–2010 Addendum CL. After the NOPR, DOE reviewed ASHRAE 90.1–2013 and updated the IEERs for Efficiency Level 1 accordingly for this direct final rule.

The Joint Efficiency Advocates and California IOUs reacted to the CUAC/CUHP NOPR by urging DOE to evaluate intermediate efficiency levels between Efficiency Level 3 and Efficiency Level 4, noting that the presence of gaps between these levels. The Joint Efficiency Advocates and California IOUs noted that there are models at various IEER levels available between Efficiency Level 3 and Efficiency Level 4 across the equipment classes. (CUAC: Joint Efficiency Advocates, No. 69 at p. 2; California IOUs, No. 67 at pp. 3–5; ASAP, ASRAC Public Meeting, No. 102 at pp. 202, 209–210, 211–212, 217–218).

The Joint Efficiency Advocates and the California IOUs urged DOE to reevaluate the max-tech levels and noted that for each equipment class, the highest IEERs of commercially-available equipment listed in the AHRI directory are higher than the max-tech levels. (CUAC: Joint Efficiency Advocates, No. 69 at pp. 2–3; California IOUs, No. 67 at pp. 6–7)

Carrier supported DOE's approach for determining the max-tech efficiency levels based on recently introduced models. These models represent technologies that are both available for all of the capacity sizes within a given equipment class and that are economically justified for their performance improvement. (CUAC: Carrier, No. 48 at p. 3) Goodman commented during the negotiated rulemaking that DOE should also consider an additional efficiency level between the CUAC/CUHP NOPR Efficiency Level 2 and Efficiency Level 3. (CUAC: Goodman, ASRAC Public Meeting No. 102 at pp. 208—209)

Based on DOE's review of equipment listed in the AHRI directory, DOE agreed with interested parties that additional efficiency levels should be considered in its analysis. For all equipment classes, DOE added an efficiency level between Efficiency Level 2 and Efficiency Level 3 from the CUAC/CUHP NOPR, identified in this direct final rule as Efficiency Level 2.5. DOE also added an efficiency level, identified in this direct final rule as efficiency level 5, above CUAC/CUHP NOPR Efficiency Level 4, to represent the max-tech models available on the market. For small and large equipment, DOE added an efficiency level between Efficiency Level 3 and Efficiency Level 4 from the CUAC/CUHP NOPR, identified in this direct final rule as Efficiency Level 3.5. As part of the ASRAC Working Group meeting, interested parties agreed on these additional efficiency levels for the analysis. (CUAC: ASRAC Public Meeting, No. 94 at pp. 170—171)

For this direct final rule, the IEER values for the baseline efficiency level and Efficiency Level 1 for the ''all other types of heating equipment'' classes are based on the IEER difference of 0.2 as compared to the electric resistance heating or no heating equipment class specified in ASHRAE 90.1–2010 and ASHRAE 90.1–2013. As discussed further in section IV.E.1, DOE chose cooling efficiency levels for CUACs coupled with all other types of heating above Efficiency Level 1 that provided the same energy savings between incremental efficiency levels as was determined for the electric resistance or no heating equipment classes within each equipment class capacity range (*i.e.,* small, large, and very large). Using this approach, the IEER differential between these equipment classes ranged from 0.2 to 0.4 at the higher efficiency levels and reflect the additional power required for gas furnace pressure drop. Therefore, DOE estimated that the energy savings for any efficiency level relative to the baseline would be identical for both sets of equipment classes.

Based on DOE's review of equipment available on the market, the majority of models with electric resistance heating or no heating equipment are designed on the same basic platform and cabinet size as the equivalent models with all other types of heating equipment. Because these equipment have the same or similar designs, DOE estimates that implementing the same design changes would result in the same or similar energy savings for both sets of equipment classes. For small and large heating equipment classes at Efficiency Level 3 and the very large heating equipment class at Efficiency Level 2.5, DOE analyzed the cooling efficiency levels based on the IEER values included in the ASRAC Working Group recommendations, as presented in section III.B.2, which used an IEER differential of 0.2 compared to the electric resistance heating or no heating equipment classs. Table IV–11 shows, as an example, these differences in IEER for each CUAC ''all other types of heating equipment'' class relative to the electric resistance heating equipment classes.

TABLE IV–11—CUACS WITH ALL OTHER TYPES OF HEATING IEER DIFFERENTIALS RELATIVE TO CUACS WITH ELECTRIC RESISTANCE HEATING OR NO HEATING

Efficiency level	IEER differentials		
	Small CUACs	Large CUACs	Very Large CUACs
Baseline	0.2	0.2	0.2
EL 1	0.2	0.2	0.2
EL 2	0.2	0.2	0.2
EL 2.5	0.3	0.2	* 0.2
EL 3	* 0.2	* 0.2	0.3
EL 3.5	0.3	0.3	....
EL 4	0.3	0.3	0.3
EL 5	0.4	0.4	0.3

* IEER differential for these levels were based on the recommended efficiency levels in the ASRAC Term Sheet.

For the CUHP equipment classes, DOE used a similar approach for determining the IEER differentials relative to the CUAC equipment classes. The IEER values for the baseline efficiency level and Efficiency Level 1 for the CUHP equipment classes are based on the IEER differences as compared to the CUAC equipment classes specified in ASHRAE 90.1–2010 and ASHRAE 90.1–2013. As discussed further in section IV.E.1, DOE chose cooling efficiency levels for the CUHP equipment classes above Efficiency Level 1 that provided the same energy savings between incremental efficiency levels as was determined for the CUAC equipment classes within each equipment class capacity range (*i.e.*, small, large, and very large). Using this approach, the IEER differential between these equipment classes ranged from 0.8 to 1.3 at the higher efficiency levels and reflect the efficiency differences that occur due to losses from the reversing valve and the reduced potential for optimization of coil circuitry for cooling, since coils in heat pumps must work for both heating and cooling operation. Therefore, DOE estimated that the energy savings for any efficiency level relative to the baseline would be identical for both sets of equipment classes. Because DOE considered the same design changes at each efficiency level for both sets of equipment classes, DOE estimates that this would result in the same or similar energy savings for both sets of equipment classes. For small and large CUHP equipment classes at Efficiency Level 3 and the very large CUHP equipment class at Efficiency Level 2.5, DOE analyzed the cooling efficiency levels based on the IEER values included in the ASRAC Working Group recommendations, as discussed in section III.B.2, which used an IEER differential of 0.7 compared to the CUAC equipment classes. Table IV–12 shows these differences in IEER for the CUHP equipment classes relative to the CUAC equipment classes.

TABLE IV–12—CUHP IEER DIFFERENTIALS RELATIVE TO CUAC LEVELS

Efficiency level	IEER differentials		
	Small CUACs	Large CUACs	Very Large CUACs
Baseline	0.2	0.5	0.5
EL 1	0.7	0.8	1.0
EL 2	0.8	0.9	1.1
EL 2.5	0.8	0.9	* 0.7
EL 3	* 0.7	* 0.7	1.2
EL 3.5	0.9	1.0	....
EL 4	1.1	1.2	1.3
EL 5	1.2	1.3	1.3

* IEER differential for these levels were based on the recommended efficiency levels in the ASRAC Term Sheet.

Regarding the incremental COP heating efficiency levels for CUHPs, AHRI, Nordyne, Carrier, Goodman and Rheem commented that they did not support DOE's approach for determining the COP levels based on a correlation with IEER. These commenters stated that there is no technical or statistical justification to support that a correlation exists between IEER and COP. IEER is a part-load metric while COP is a full-load heating metric similar to EER for cooling. (CUAC: AHRI, No. 68 at p. 32; Nordyne, No. 61 at p. 27; Carrier, No. 48 at pp. 3–4; Goodman, No. 65 at p. 14; Rheem, No. 70 at p. 4)

Members of the ASRAC Working Group were not able to suggest a more appropriate approach for assigning COP values to the efficiency levels analyzed. Because the use of correlations between

COP and EER was generally accepted by industry and interested parties involved in the development of ASHRAE Standard 90.1–1999 and because the correlations between COP and IEER using linear regressions are no less strong than the correlations between COP and EER, DOE maintained the same approach used in the CUAC/CUHP NOPR for determining the CUHP heating mode efficiency levels, using the relationship between COP and IEER to select the COP levels corresponding to each incremental IEER level. DOE also notes that the COP values analyzed at each incremental efficiency level represent modest increases above the current DOE standard levels. Members of the ASRAC Working Group also agreed as Term Sheet signatories to recommend that DOE adopt standards to increase the stringency of the requirements for COP. At Efficiency Level 3 for the small and large equipment classes and Efficiency Level 2.5 for the very large equipment class, DOE analyzed the heating efficiency levels based on the COP values included in the ASRAC Working Group recommendations, as discussed in section III.B.2.

Based on the discussion above, DOE considered the efficiency levels presented in Table IV–13 for this direct final rule.

TABLE IV–13—DIRECT FINAL RULE INCREMENTAL EFFICIENCY LEVELS

Equipment type	Heating type	Metric	Efficiency levels							
			Baseline	EL1	EL2	EL2.5	EL3	EL3.5	EL4	EL5 (Max-Tech)
Small Commercial Packaged AC and HP (Air-Cooled)—≥65,000 Btu/h and <135,000 Btu/h Cooling Capacity:										
AC	Electric Resistance Heating or No Heating.	IEER	11.4	12.9	14.0	14.5	14.8	15.8	19.9	21.5
	All Other Types of Heating.	IEER	11.2	12.7	13.8	14.2	14.6	15.5	19.6	21.1
HP	Electric Resistance Heating or No Heating.	IEER	11.2	12.2	13.2	13.7	14.1	14.9	18.8	20.3
		COP	3.3	3.3	3.4	3.4	3.4	3.5	3.7	3.7
	All Other Types of Heating	IEER	11.0	12.0	13.0	13.5	13.9	14.6	18.5	19.9
		COP	3.3	3.3	3.4	3.4	3.4	3.5	3.6	3.7
Large Commercial Packaged AC and HP (Air-Cooled)—≥135,000 Btu/h and <240,000 Btu/h Cooling Capacity:										
AC	Electric Resistance Heating or No Heating.	IEER	11.2	12.4	13.2	13.7	14.2	15.0	18.5	20.1
	All Other Types of Heating.	IEER	11.0	12.2	13	13.5	14	14.7	18.2	19.7
HP	Electric Resistance Heating or No Heating.	IEER	10.7	11.6	12.3	12.8	13.5	14.0	17.3	18.8
		COP	3.2	3.2	3.3	3.3	3.3	3.3	3.3	3.3
	All Other Types of Heating	IEER	10.5	11.4	12.1	12.6	13.3	13.7	17.0	18.4
		COP	3.2	3.2	3.3	3.3	3.3	3.3	3.3	3.3
Very Large Commercial Packaged AC and HP (Air-Cooled)—≥240,000 Btu/h and <760,000 Btu/h Cooling Capacity.	AC	Electric Resistance Heating or No Heating.	IEER	10.6	11.6	12.5	13.2	13.5	14.9	15.6
		All Other Types of Heating.	IEER	10.4	11.4	12.3	13.0	13.2	14.6	15.3
	HP	Electric Resistance Heating or No Heating.	IEER	10.1	10.6	11.4	12.5	12.3	13.6	14.3
			COP	3.2	3.2	3.2	3.2	3.2	3.2	3.2
	All Other Types of Heating	IEER	9.9	10.4	11.2	12.3	12.1	13.3	14.0	
		COP	3.2	3.2	3.2	3.2	3.2	3.2	3.2	

Commercial Warm Air Furnaces

For CWAFs, DOE developed efficiency levels for analysis higher than the baseline efficiency level (*i.e.,* the Federal minimum standard level) based on a review of equipment available on the market. DOE compiled a database of the CWAF market to determine what types of equipment are currently available to commercial customers. At the representative capacity for each equipment class, DOE surveyed manufacturers' equipment offerings to identify commonly-available efficiency levels. By identifying the most prevalent energy efficiencies in the range of available equipment, DOE was then able to establish a technology path that manufacturers typically use to increase the TE of a CWAF to incrementally higher efficiency levels above baseline, up to the max-tech efficiency level.

In its analysis, DOE focused on specific incremental TE levels above the baseline for each equipment class. The incremental TE levels are representative of efficiency levels along the technology paths that CWAF manufacturers commonly use to maintain cost-effective designs while increasing the TE of equipment. DOE reviewed its Compliance Certification Management

System (''CCMS'') database,[39] as well as AHRI's Directory of Certified Product Performance,[40] manufacturer catalogs, and other publicly-available literature to determine which TE levels are the most prevalent for each equipment class. For gas-fired CWAFs, DOE chose two efficiency levels between the baseline and max-tech for analysis (see Table IV–14). For oil-fired CWAFs, DOE chose one TE level between the baseline and max-tech for analysis (see Table IV–15).

DOE found several manufacturers that offer gas-fired equipment at 81-percent TE. In the analysis for the direct final rule, DOE found only one manufacturer of gas-fired equipment rated at 82-percent TE, which is available across a limited range of input capacities. In addition, all of the 82-percent TE units offered by this manufacturer are non-weatherized, and are thus not representative of the large majority of gas-fired CWAF model offerings, which are weatherized. Therefore, in its analyses for the direct final rule, DOE did not identify any weatherized gas-fired CWAFs at 82-percent TE. However, in the analyses for the CWAF NOPR, DOE identified a different manufacturer of gas-fired 82-percent TE CWAFs. These particular units were weatherized. This manufacturer offered equipment at this efficiency level across a wide range of input capacities, indicating that meeting the 82-percent TE level is technologically feasible for weatherized gas-fired CWAFs at most input capacities. Thus, DOE considered 81-percent and 82-percent as incrementally higher TE levels for the gas-fired CWAF analysis.

DOE also considered the max-tech efficiency level. As discussed in section IV.C.1, DOE purchased a 92-percent thermally efficient gas-fired makeup air furnace for teardown, as makeup air units are currently the only type of gas-fired CWAF at a condensing efficiency level. There are substantially more non-makeup air CWAFs product offerings than makeup air furnace product offerings. However, based on manufacturer feedback, physical teardowns and examination of equipment, and product literature, DOE observed that gas-fired makeup air furnaces are technologically very similar to non-makeup air CWAFs.

Further, DOE identified a residential-sized (*i.e.,* input rating below 225,000 Btu/h) weatherized furnace design that utilizes condensing technology. As such, DOE identified the max-tech efficiency level for gas-fired CWAFs as 92-percent TE, which is based on the use of condensing heat exchanger technology. For oil-fired furnaces, which are typically installed indoors, DOE surveyed the market and identified the baseline efficiency level as 81-percent TE (which is the current federal energy conservation standard for this equipment class). DOE also found that the majority of non-condensing equipment had a TE of 82-percent. One unit with a TE of 92-percent, which is the max-tech efficiency level, was identified. As such, DOE selected 81-percent, 82-percent, and 92-percent TE as the efficiency levels for analysis. The efficiency levels DOE analyzed for each equipment class (including the baseline levels) are presented in Table IV–14 and Table IV–15.

TABLE IV–14—EFFICIENCY LEVELS ANALYZED FOR GAS-FIRED CWAFS

Efficiency level	Thermal efficiency (%)
EL0 (Baseline)	80
EL1	81
EL2	82
Max-Tech	92

TABLE IV–15—EFFICIENCY LEVELS ANALYZED FOR OIL-FIRED CWAFS

Efficiency level	Thermal efficiency (%)
EL0 (Baseline)	81
EL1	82
Max-Tech	92

3. Equipment Testing, Reverse Engineering and Energy Modeling

a. Commercial Unitary Air Conditioners and Heat Pumps

As discussed above, for the engineering analysis, DOE specifically analyzed representative capacities of 7.5 tons, 15 tons, and 30 tons to develop incremental cost-efficiency relationships.

For the CUAC/CUHP NOPR, DOE selected four 7.5-ton, two 15-ton, and one 30-ton CUAC models, and one 7.5-ton CUHP model. The models were selected to develop a representative sample of the market at different efficiency levels. DOE based the selection of units for testing and reverse engineering on the efficiency data available in the AHRI certification database and the CEC equipment database. 79 FR at 58974. DOE conducted testing on each unit according to the IEER test method specified in AHRI Standard 340/360–2007. DOE then conducted physical teardowns on each test unit to develop a manufacturing cost estimation process and to evaluate key design features (*e.g.,* heat exchangers, compressors, fan/fan motors, control strategies, etc.). DOE supplemented these data by conducting catalog teardowns on 346 models spanning the full range of capacities from all manufacturers selling equipment in the United States. DOE based the catalog teardowns on information provided in equipment literature and experience from the physical teardowns. *Id.*

For CUACs, DOE conducted energy modeling using the modeling tools developed by the Center for Environmental Energy Engineering from the University of Maryland at College Park. The tools include a detailed heat exchanger modeling program and a refrigeration cycle modeling program. The refrigeration cycle modeling program can integrate the heat exchanger and compressor models to perform a refrigeration cycle model. Details regarding the energy modeling tools are discussed in section 5.5.5 and 5.6.4 of chapter 5 of the CUAC/CUHP direct final rule TSD.

As explained in the CUAC/CUHP NOPR, DOE applied the key design features identified during physical equipment teardowns and used the energy modeling tool to generate detailed performance data (*e.g.,* capacity and EER), validating them against the results obtained from laboratory testing at each IEER capacity level (25, 50, 75, and 100 percent), or with the published performance data. See 79 FR at 58974. With the validated energy models, DOE expanded the modeling tasks with various system design options and identified the key design features (consistent with equipment available on the market) required for 7.5-ton, 15-ton, and 30-ton CUAC units with electric resistance heating or no heating to achieve each efficiency level. Based on these equipment designs, DOE also generated energy use profiles for CUACs. These profiles included wattage inputs for key components (*i.e.,* compressor, indoor and outdoor fan motors, and controls) at each operating load level measured using the IEER test method for each efficiency level to serve as inputs for the energy use analysis. For the CUAC/CUHP NOPR, DOE also used the design details, some for the reverse-engineered models and some from DOE's energy modeling work, to determine the incremental manufacturing costs for each efficiency

[39] For more information see: *http://www.regulations.doe.gov/certification-data/CCMS–81578122497.html.*

[40] For more information see: *https://www.ahridirectory.org/ahridirectory/pages/cfr/defaultSearch.aspx.*

level for 7.5-ton, 15-ton and 30-ton CUACs units. *Id.*

Lennox expressed concern regarding the differences between using tested and rated IEER values to validate the energy modeling simulations. Lennox noted that Efficiency Level 1 for 7.5 tons (12.9 IEER) was based on a unit with a rated IEER of 11.4, but which DOE tested at 12.9 IEER. Lennox's modeling of this unit predicted an IEER of 12.2. Lennox commented that using a single test point to extrapolate well above manufacturer ratings to justify the proposed standard levels is arbitrary and not a valid approach. (CUAC: Lennox, No. 60 p. 13)

AHRI, Nordyne and Lennox commented that the design features that DOE used to characterize the energy use and costs for the baseline and incremental efficiency levels for 7.5 tons are not representative of realistic models. (CUAC: AHRI, No. 68 at p. 35; Nordyne, No. 61 at p. 29; Lennox, No. 60 at p. 13) They added that DOE's approach for the 7.5 ton analysis of developing a design for the baseline efficiency level by decreasing the size of the heat exchangers of the Efficiency Level 1 design results in a loss of EER performance below the current DOE minimum standard levels. (CUAC: AHRI, No. 68 at p. 35; Nordyne, No. 61 at p. 29; Lennox, No. 60 at p. 13) Goodman commented that manufacturers' published performance documents includes data for a specific model with specific physical parameters. Goodman stated that using these data and attempting to perform energy model modifications to these physical parameters could lead to inaccurate predictions of the effects of these design changes on performance and energy consumption. Goodman also expressed concern that there was no confirmation testing of the simulation results for the higher efficiency equipment and, based on their assessment, the performance of equipment at higher efficiency levels is overstated. (CUAC: Goodman, No. 65 at pp. 15, 17)

To address these concerns with DOE's engineering analysis (*i.e.,* limited number of tests and relying on energy-model-based extrapolation of design details to represent efficiency levels for which DOE had no test data), DOE revised its analysis to use rated IEER data from actual models. Using this approach, DOE selected actual models available on the market to represent each target efficiency level to conduct the energy modeling and to generate component wattage profiles and performance correlations. As discussed in section IV.E.1, these component wattage profiles and performance correlations developed for this direct final rule were then used in the energy use analysis along with hourly building cooling loads and generalized building samples to estimate the energy savings associated with each efficiency level. As discussed in section IV.C.5, instead of developing manufacturing production costs based on the specific design parameters used in the energy modeling as was done in the CUAC/CUHP NOPR, DOE decoupled the energy modeling and cost estimation analyses for this direct final rule. In this manner, DOE was able to develop the cost-efficiency relationship using models based on a full range of manufacturers and equipment offerings. DOE's methodology and analysis for developing and conducting the energy modeling and cost-efficiency analysis are discussed in detail in section 5.5 and 5.6 of chapter 5 of the CUAC/CUHP direct final rule TSD.

The IEER ratings for the units selected for energy modeling match the corresponding efficiency level's target IEER within ±0.2. In the case where selected unit's IEER rating differs from the target IEER, the model was first calibrated to match the unit's ratings. The dimensions of the heat exchangers were then slightly adjusted such that the adjusted model would produce the target IEER. With regards to the comments concerning the modeled full-load EER values, because the revised analysis is based on actual models available on the market that comply with the current standards for these equipment, none of the representative units have EER values that would not comply with the currently required EER-based standards. Details of the design features, corresponding component wattage profiles and performance correlations for each efficiency level and equipment class are presented in chapter 5 of the CUAC/CUHP direct final rule TSD.

AHRI and Nordyne commented that the modeling used in the NOPR-phase energy analysis of the equipment was extremely complex and very dependent upon the precision and accuracy of the parameters entered. AHRI, Nordyne, and Goodman commented that DOE did not provide sufficient details and data (*e.g.,* refrigerant charge, type of expansion device [41], sensible to latent capacity ratios [42], condenser fan power consumption, evaporator blower motor power, etc.) to thoroughly analyze the accuracy of the energy modeling results. (CUAC: AHRI, No. 68 at p. 34; Nordyne, No. 61 at pp. 28–29; Goodman, No. 65 at pp. 1–16) Goodman stated that, based on their estimates using the physical parameters provided by DOE, the performance of the designs chosen for Efficiency Level 2, 3, and 4 are overstated, and thus the costs of the equipment are incorrect. (CUAC: Goodman, No. 65 at p. 15) Trane commented that DOE did not test and analyze a significant sample size to develop significant data and validate the energy model given the broad range of equipment considered in this rulemaking and the variability in design, testing and manufacturing of these components. (CUAC: Trane, No. 63 at p. 7)

For each representative model analyzed at each efficiency level for the direct final rule analysis, DOE reviewed details of the assumptions for the equipment design parameters and the energy modeling results (*i.e.,* component wattage profiles and performance correlations) with the manufacturers of models used in the analysis. DOE revised inputs to the energy modeling (*e.g.,* component power consumption estimates, design feature specifications and operation sequences) based on manufacturer feedback. Based on the confirmation provided by the specific manufacturers of each unit analyzed regarding the inputs to the energy modeling, DOE believes the energy modeling results are representative of the operation and energy consumption of models at each efficiency level for each equipment class.

AHRI, Nordyne, Carrier and Goodman also commented that the geometry input for the CoilDesigner energy modeling tool that DOE used in preparing its NOPR analysis did not accurately model heat exchanger performance because it did not include inputs required for modeling the internally enhanced (*i.e.,* rifled [43]) tubing that are used in CUAC and CUHP heat exchangers. Carrier added that without including these internal enhancements, the overall coil performance prediction can be impacted as much as 5 to 10 percent. (CUAC: AHRI, No. 68 at p. 34; Nordyne, No. 61 at pp. 28–29; Carrier, No. 48 at p. 4; Goodman, No. 65 at p. 15) DOE notes that the CoilDesigner energy modeling

[41] Expansion devices (*e.g.,* capillary tubes, thermostatic expansion valves, electronic expansion valves) control the amount of refrigerant flow into indoor coil.

[42] The "sensible to latent capacity" ratio provides the conditions at the indoor coil that determine how much of the system's total cooling capacity is available for handling sensible loads (*i.e.,* the dry bulb temperature of the building load) versus latent loads (*i.e.,* the thermal load associated with water vapor in the air).

[43] Rifled tubes have grooves on the internal wall of the tube to increase the heat transfer surface area.

tool was updated after the analysis for the CUAC/CUHP NOPR had been conducted. These updates included inputs for modeling the internal enhancement for tubes for the condenser coils. As a result, DOE updated its analysis for this direct final rule using the latest version of CoilDesigner to account for the effects of rifled tubes.

As noted in chapter 5 of the CUAC/CUHP NOPR TSD, DOE's analysis for 7.5-ton units assumed that the baseline and Efficiency Level 1 both used a single refrigerant circuit design. AHRI and Nordyne disagreed with this approach and commented that use of a single-stage compressor and a single refrigerant circuit rather than multiple circuits and compressor stages is not broadly consistent with the current market trends for 7.5-ton units. AHRI and Nordyne added that nearly 90 percent of all units sold in this size have multiple compressors, which is required by ASHRAE 90.1 standards. (CUAC: AHRI, No. 68 at p. 35; Nordyne, No. 61 at p. 29) Lennox also commented that using a single compressor design to represent Efficiency Level 1 for the small equipment class is not consistent with current industry equipment designs. Lennox noted that nearly 90 percent of their current sales of 7.5 ton units use multiple compressors and that over 95 percent of 7.5 to 10 ton units use multiple compressors. (CUAC: Lennox, No. 60 at pp. 12–13) Carrier commented that the split for single- and dual-compressor units may be even at 7.5 tons, but that for 10-ton units and up to the high end of the capacity range for small equipment, everything uses dual-compressor designs. (CUAC: Carrier, ASRAC Public Meeting, No. 102 at pp. 129, 132–133) ASAP, the California IOUs, NEEA, and ACEEE commented that DOE should consider both single- and dual-compressor designs for the small equipment classes. (CUAC: ASAP, California IOUs, NEEA, ACEEE, ASRAC Public Meeting, No. 102 at pp. 129–140)

Based on DOE's review of models in the small CUAC and CUHP equipment classes, DOE noted that the majority of models at Efficiency Level 1 used a dual-compressor design. Based on this review, a dual-compressor design is more representative of models at Efficiency Level 1. As a result, DOE revised its analysis to use a dual-compressor design to characterize the energy use and manufacturing production cost for Efficiency Level 1. DOE noted that single- and dual-compressor designs are both available at the baseline efficiency level for the small equipment class. As a result, DOE conducted energy modeling to develop component wattage profiles and performance for both single- and dual-compressor designs for the 7.5-ton baseline efficiency level. As discussed in section IV.A, DOE also developed separate manufacturing production cost estimates for both single- and dual-compressor designs for the 7.5-ton baseline efficiency level.

AHRI, Nordyne, Carrier and Lennox commented in response to the CUAC/CUHP NOPR that a significant number of units at Efficiency Level 1 and Efficiency Level 2 for all equipment classes already incorporate multiple-speed indoor fans based on the requirements in ASHRAE 90.1 and California Title 24, and that the percentage of equipment with this feature will increase over the next several years. As a result, these commenters stated that DOE is overestimating the fan energy savings in ventilation mode at higher efficiency levels by considering only constant speed indoor fans at the lower efficiency levels. (CUAC: AHRI, No. 68 at pp. 33–34; Nordyne, No. 61 at p. 27–28; Carrier, No. 48 at pp. 2–3, 11; Lennox, No. 60 at pp. 9–11)

As discussed in section III.G.1, SAV and VAV CUACs/CUHPs incorporate multiple-speed or variable-speed indoor fan motors, as commented by interested parties, to stage indoor air flow rates. In contrast, constant-air volume (''CAV'') CUACs/CUHPs, which typically use a single- or constant-speed indoor fan motor, operate at a fixed indoor air flow rate. Based on DOE's review of equipment available on the market, CAV, SAV and VAV units are available at different efficiency levels for each of the equipment class cooling capacity ranges. Based on DOE's review of the indoor fan staging for models on the market, DOE notes that CAV units are available at Efficiency Level 2 and lower for the small and large equipment classes, and at Efficiency Level 2.5 and lower for the very large class. DOE notes that SAV or VAV units are available at Efficiency Level 1 and higher for all equipment classes. As a result, DOE revised the engineering analysis for this direct final rule to be based on two design paths for the different indoor fan staging options. Table IV–16 shows the design paths for each equipment class.

TABLE IV–16—CUAC/CUHP EQUIPMENT AIR FLOW DESIGN PATH

Efficiency level	Equipment air flow design		
	Small CUACs/ CUHPs	Large CUACs/ CUHPs	Very large CUACs/ CUHPs
Baseline	CAV	CAV	CAV.
EL1	Path-1: CAV Path-2: SAV	Path-1: CAV Path-2: SAV	Path-1: CAV. Path-2: VAV.
EL2	Path-1: CAV Path-2: SAV	Path-1: CAV Path-2: SAV	Path-1: CAV. Path-2: VAV.
EL2.5	SAV	SAV	Path-1: CAV. Path-2: VAV.
EL3	SAV	SAV	VAV.
EL3.5	SAV	SAV	VAV.
EL4	SAV	SAV	VAV.
EL5/Max-Tech	SAV	VAV	VAV.

AHRI, Nordyne, and Lennox stated that the power input that DOE used for the condenser fans and indoor fan in the CUAC/CUHP NOPR modeling analysis does not appear realistic across the efficiency levels. These commenters noted that the high-speed indoor fan power on the 7.5-ton model at Efficiency Level 3 and Efficiency Level 4, and 15 ton model at all efficiency levels is unrealistically low. (CUAC: AHRI, No. 68 at p. 44; Nordyne, No. 61 at p. 37; Lennox, No. 60 at p. 15) AHRI and Nordyne commented with regards to variable-speed fans that the negative impact on mechanical efficiency from high load and low fan speed is not considered. (CUAC: AHRI, No. 68 at p.

33; Nordyne, No. 61 at p. 27) Carrier also commented that the fan power reductions moving from Efficiency Level 2 to Efficiency Level 3 for the 7.5- and 15-ton analysis (31 percent and 36 percent, respectively) imply the use of very efficient motors at or approaching max-tech levels. (CUAC: Carrier, No. 48 at p. 3)

For this direct final rule, as discussed above, DOE analyzed actual models using their rated IEER values to represent each target efficiency level. DOE calculated indoor fan power using fan performance tables provided in manufacturer equipment literature for these models, including for variable-speed fans as noted by AHRI and Nordyne, and motor efficiency based on compliance with DOE electric motor standards established by EPCA (10 CFR 431.25). The indoor fan motors used in equipment are selected to overcome a wide range of external static pressures (''ESPs''). The actual horsepower delivered by the motors at the rated air flow and minimum ESP required by the test procedure are typically less than the nameplate horsepower. For CAV units, the calculation for horsepower loss is based on the approach adopted in DOE's rulemaking for commercial and industrial fans and blowers.[44] For SAV and VAV units, the calculation for horsepower loss is based on equation developed in DOE's rulemaking for commercial and industrial pumps test procedure.[45] The equation accounts for the combined motor and variable frequency drive loss during full-load and part-load operation. For the outdoor fans, DOE calculated the outdoor fan power input based on equipment literature, pressure estimates, typical fan efficiency and motor efficiency based on compliance with DOE small electric motor standards (10 CFR 431.25). Details of these analyses are presented in chapter 5 of the CUAC/CUHP direct final rule TSD.

ASRAC Working Group participants commented that DOE should further investigate the pressure drop associated with conversion curbs and the percentage of shipments that will require conversion curbs for each efficiency level, including the base case. Carrier and Trane both suggested discussing this issue with conversion curb suppliers. (CUAC: NEEA, ASAP, SMACNA, Carrier, Trane, ASRAC Public Meeting, No. 94 at pp. 147–167) Trane and Carrier commented that DOE should look across the range of capacities within each equipment class to determine the efficiency levels at which curb size changes. (CUAC: Trane, Carrier, ASRAC Public Meeting, No. 94 at pp. 193–199)

DOE collected information from major conversion curb vendors, including MicroMetl and Thybar (who were both identified during the Working Group's public discussions), regarding pressure drops, costs, and the size of the existing market for these products. (CUAC: ASRAC Public Meeting, No. 96 at pp. 75–77) DOE developed a distribution of efficiency levels at which conversion curbs are required by reviewing equipment size trends for key capacities of the equipment classes for four major manufacturers with equipment spanning the range of efficiencies considered for the analysis. DOE selected the efficiency levels that would require cabinet size increases for each manufacturer/capacity combination. DOE then developed a distribution of the percentage of shipments at each efficiency level that would require a conversion curb based on equal manufacturer market share. Regarding the pressure drop associated with conversion curbs, conversion curb vendors provided information regarding typical pressure drops for units installed with conversion curbs. Based on DOE's review of these data and discussions with conversion curb vendors, DOE determined that a pressure drop of 0.2 inch water column (in. wc.) represents the average pressure drop associated with CUAC/CUHP installations that include a conversion curb. Based on this evaluation, DOE applied a pressure drop of 0.2 in. wc. for full air flow across all equipment classes as a result of applying a conversion curb. ASRAC Working Group participants agreed to using a 0.2 in. wc. pressure drop for conversion curbs. (ASRAC Public Meeting, No. 97 at pp. 132–136) Using the 0.2 in. wc. conversion curb pressure drop at full air flow, DOE revised the cooling capacity and indoor fan power correlations used for the energy use analysis.

In the CUAC/CUHP NOPR, DOE did not conduct similar energy modeling for CUHP units since CUHP shipments represent a very small portion of industry shipments compared to CUACs shipments (9 percent versus 91 percent). With these small numbers, in DOE's view, modeling for CUHPs was unnecessary because DOE accounted for the difference in efficiency as compared to that which occurs with the CUAC equipment classes due to losses from the reversing valve and the reduced potential for optimization of coil circuitry for cooling, as discussed in section IV.C.2.b. In addition, because CUHPs represent a small portion of shipments, DOE noted, based on equipment teardowns and an extensive review of equipment literature[46], that manufacturers generally use the same basic design/platform for equivalent CUAC and CUHP models. DOE also considered the same design changes for the CUHP equipment classes that were considered for the CUAC equipment classes within a given capacity range. For these reasons, in the CUAC/CUHP NOPR, DOE focused energy modeling on CUAC equipment. 79 FR at 58974–58975. DOE maintained this approach for this direct final rule. Although not considered in the engineering and LCC and PBP analyses, DOE did analyze CUHP equipment in the NIA. From this analysis, DOE believes the energy modeling conducted for CUAC equipment provides a good estimate of CUHP cooling performance and provides the necessary information to estimate the magnitude of the national energy savings from increases in CUHP equipment efficiency.

b. Commercial Warm Air Furnaces

As discussed above, for the engineering analysis, DOE analyzed a representative input capacity of 250,000 Btu/h for both the gas-fired and oil-fired CWAF equipment classes to develop incremental cost-efficiency relationships. CWAF models selected for reverse engineering (physical teardown/examination) were used to estimate the costs to manufacture CWAFs at each efficiency level available on the market, ranging from the baseline 80-percent TE for gas-fired units, and baseline 81-percent TE for oil-fired units, up to the max-tech 92-percent TE for both gas-fired and oil-fired units. Because this reverse engineering was first conducted to inform the engineering analyses for the CWAF NOPR, the selection of units for testing and reverse engineering was based on the efficiency data available in the AHRI certification database,[47] the CEC equipment database, and manufacturers' catalogs[48] at the time of the CWAF

[44] DOE Energy Conservation Standards for Commercial and Industrial Fans and Blowers, NODA Life-Cycle Cost (LCC) Spreadsheet. Available at: *http://www.regulations.gov/#!documentDetail;D=EERE-2013-BT–STD-0006-0034.*

[45] DOE Test Procedure NOPR for Pumps. 80 FR at 17586, 17622 (Apr. 1, 2015). Available at: *http://www.regulations.gov/#!documentDetail;D=EERE-2013-BT-TP-0055-0001.*

[46] For examples of manufacturer literature used in the analysis, see EERE–2013–BT–STD–0007–0110.

[47] Available at: *https://www.ahridirectory.org/ahridirectory/pages/home.aspx.*

[48] Available at: *http://www.energy.ca.gov/appliances/.*

NOPR.[49] Details of the key features of the tested and reverse engineered units are presented in chapter 5 of the direct final rule TSD.

DOE conducted physical teardowns on each unit tested to inform manufacturing cost estimations and to evaluate key design features (*e.g.,* heat exchangers, blower and inducer fans/fan motors, controls).

For gas-fired CWAFs, DOE performed two teardowns on weatherized CWAFs units at non-condensing efficiency levels. Each CWAFs unit was part of a packaged CUAC/CWAF rooftop unit. One unit was rated at 80-percent TE and the other unit was rated at 82-percent TE. Prior to teardown, the units were tested by a third-party test lab and both tested at approximately 82-percent TE. The units were from the same manufacturer and had similarly designed furnace sections with different air conditioner sections. DOE determined that the similarity of the test results on both units indicated that the furnace designs that were torn down are representative of equipment with 82-percent TE. Using the cost-assessment methodology, DOE determined the manufacturing cost of each CWAFs torn down via reverse engineering.

Based on the CWAF teardowns, manufacturer feedback, product literature, and experience from the residential furnaces rulemaking, DOE determined that the primary method manufacturers use to achieve efficiency levels above baseline is to increase heat exchanger size. In the analyses for the February 2015 CWAF NOPR (80 FR 6181), DOE used feedback from manufacturer interviews to estimate that manufacturers will typically increase the surface area of the heat exchanger by 10 percent in order to increase TE by 1 percent.[50] DOE sought comment from stakeholders on the technologies that were identified for improving thermal efficiency. 80 FR at 6232. In addition, during the March 2, 2015 public meeting to discuss the CWAF NOPR, DOE again made clear the technology options that were considered for improving CWAF TE (including a 10 precent increase in heat exchanger size to achieve a 1 percent increase in TE), and sought comment regarding its engineering analysis. (CWAF: DOE, NOPR Public Meeting Transcript, No. 17 at pp. 57, 70–71) During the CWAF NOPR comment period and ASRAC public meetings, DOE did not receive any comments objecting to DOE's estimates of the heat exchanger size changes with increased efficiency, nor did DOE receive any data that would allow for the refinement of this approximation. Thus, DOE continued to use this estimate for this direct final rule analysis. However, feedback from manufacturers during the ASRAC public meetings did allow DOE to determine the specific variations in the design of the heat exchanger assembly components between units at the 80-percent (baseline), 81-percent, and 82-percent TE levels. Specifically, this feedback indicated that heat exchanger size is increased by adding tubes to the heat exchanger, rather than lengthening heat exchanger tubes, which DOE accounted for in its direct final rule analysis. (CWAF: Carrier, ASRAC Public Meeting, No. 94 at pp. 62–63; Trane, ASRAC Public Meeting, No. 94 at pp. 63; Rheem, ASRAC Public Meeting, No. 94 at pp. 63–64) At the 80-percent and 81-percent TE levels, DOE used this information to scale down the size of the heat exchanger examined in the units torn down at 82-percent TE as the initial step in estimating the costs to manufacture equipment at the 80-percent and 81-percent TE efficiency levels.

In response to the costs presented in the NOPR, multiple stakeholders commented that the methodology for estimating the manufacturing cost of an 82-percent TE gas-fired CWAF did not account for significant technological modifications required to maintain equipment reliability at that efficiency level. Specifically, DOE's cost estimates in the NOPR for the 80-percent through 82-percent TE levels incorporated the use of aluminized steel to construct key heat exchanger and inducer assembly components. Multiple stakeholders commented that the estimated manufacturing cost of an 82-percent TE unit was not accurate, and that heat exchanger and inducer assembly components would need to be constructed out of more resilient materials at 82-percent TE. AHRI commented that to meet an 82-percent TE standard without sacrificing safety, reliability, and durability, manufacturers would need to significantly modify their CWAFs offerings to account for the risk of corrosion in the heat exchanger and venting system as a result of condensation formation under certain ambient conditions. In its view, accounting for this factor would require that the incremental manufacturer production cost (''MPC'') over baseline be higher than that presented in the NOPR engineering analysis. (CWAF: AHRI, No. 26 at p. 2) The Advocates commented that if it is determined that some portion of CWAF sales will necessitate stainless steel heat exchangers to accommodate condensate formation during operation, then the engineering analysis should be modified to account for the additional costs associated with this engineering modification. (CWAF: The Advocates, No. 24 at p. 1–2) Lennox commented that at 82-percent TE, the combination of higher TE and reduced dilution air decreases the safety factor between flue gas temperature and condensation point temperature by 40 percent, which greatly increases the risk for condensation formation. To overcome this, more expensive corrosion-resistant heat exchanger materials are needed. As a result, for smaller heating input capacity products, Lennox estimates the incremental MPC to achieve 82-percent TE over baseline efficiency is 12 times higher than the DOE estimate of $10. For larger capacity products, Lennox estimates the incremental MPC will be over 20 times higher than the $10 estimate. Additionally, Lennox noted that at 82-percent TE, the inducer motor would need to be constructed out of more corrosion-resistant materials. (CWAF: Lennox, No. 22 at p. 7) Rheem commented that at 82-percent TE, excessive condensation will occur to the point of causing heat exchanger or vent system corrosion. As a result, it would need to redesign the combustion system, evaluate alternative materials, conduct reliability testing, and other field tests—none of which were captured in the manufacturer costs presented in the TSD. (CWAF: Rheem, No. 25 at p. 2) Rheem added that to increase TE to 82-percent above baseline, the estimated $10 incremental MPC is not accurate with regard to Rheem's product offerings. In its view, the $10 incremental cost included in DOE's analysis would not allow them to add turbulators to their designs to enhance furnace efficiency. (CWAF: Rheem, No.

[49] At the time of the analyses for the CWAF NOPR, the DOE CCMS database did not contain efficiency data for CWAFs. Upon review of current efficiency data from the CCMS database and manufacturers' catalogs in the analyses for the direct final rule, DOE found the current efficiency distribution of CWAF models to still include a majority of units at the same efficiency levels that were analyzed in the NOPR based on the AHRI database, CEC database, and manufacturers' catalogs. An exception to this was at the 82-percent TE level for gas-fired CWAFs, where the number of models offered significantly decreased between the NOPR and direct final rule analyses. As discussed previously in section IV.C.2.b, this was because a specific manufacturer of weatherized gas-fired CWAFs units listed as 82-percent TE at the time of the NOPR analyses no longer listed this equipment at the 82-percent TE level at the time of the direct final rule analyses.

[50] See chapter 5 of the February 2015 CWAF NOPR TSD for further information, located at: *http://www.regulations.gov/#!documentDetail;D=EERE-2013-BT-STD-0021-0012.*

25 at p. 4) Trane commented that the MPCs presented in the NOPR for the 81-percent and 82-percent TE levels are understated by about 3-fold, in part because they do not account for the needed use of stainless steel heat exchangers. CWAFs are designed to operate at the midpoint of possible air temperature rise across the heat exchanger (which will be at least a 30 degree Fahrenheit range), which means that 82-percent TE units will end up operating frequently at 83-percent TE or higher, and thus experience condensation. (CWAF: Trane, No. 27 p. 4–6)

In the engineering analyses for the direct final rule, DOE modified its cost estimates for the 82-percent TE level in response to the above comments. To account for the use of corrosion-resistant materials in both the heat exchanger and inducer assemblies at 82-percent TE, DOE estimated the costs of implementing both 409-grade stainless steel (SS409) and 316-grade stainless steel (SS316) into these assemblies, rather than aluminized steel. In addition, DOE has observed that a certain portion of units at 80-percent and 81-percent TE also utilize heat exchanger and inducer assemblies that incorporate corrosion-resistant materials into their designs in order to improve durability. As such, for the 80-percent, 81-percent, and 82-percent TE levels, DOE estimated individual MPCs for each of the specific material options that may be incorporated into the heat exchanger/inducer assembly at that efficiency level. For more information on the methodology used to estimate the MPCs for the 80-percent, 81-percent, and 82-percent TE levels, see chapter 5 of the CWAF direct final rule TSD. In the life-cycle cost and payback period analysis, DOE assigned a percentage of models at each efficiency level that would incorporate each of the various material types analyzed. (See chapter 8 of the CWAF direct final rule TSD for further details.)

As discussed in section IV.C.1, to estimate the manufacturing cost of a 92-percent TE (max-tech) CWAF, DOE obtained a condensing, 92-percent TE gas-fired makeup air furnace for physical examination. In addition, DOE used information gathered from a teardown of a condensing weatherized residential furnace to further inform the cost estimation. DOE examined the heat exchanger, inducer fan, condensate management system, and other aspects of the gas-fired makeup air furnace to develop an estimate of the cost to manufacture these specific sub-assemblies in a condensing CWAF. DOE then used information from the residential condensing weatherized furnace teardown to refine estimates of the specific costs of a condensate management system for a condensing efficiency level CWAF. Using these sub-assembly cost estimates, and additional information provided by the two teardowns of 82-percent TE gas-fired CWAFs, DOE estimated the MPC for a 92-percent TE gas-fired CWAF. For further information on the estimation of the manufacturing cost of a 92-percent TE gas-fired CWAF, see chapter 5 of the direct final rule TSD.

For oil-fired CWAFs, DOE performed a teardown of a non-weatherized unit at 81-percent TE. DOE used this teardown, along with product literature, prior industry experience, manufacturer feedback, and analysis previously performed on oil-fired residential furnaces to develop estimates of the manufacturing costs of both 82-percent and 92-percent TE oil-fired CWAFs.

In a previous analysis of residential non-weatherized oil-fired furnaces, DOE developed an estimate of the cost-efficiency relationship across a range of efficiency levels. In examining product literature for oil-fired CWAFs, DOE found that commercial units are very similar to residential units, except with higher input ratings and overall larger size. Based on information obtained from the physical teardown of the 81-percent TE oil-fired CWAF, in addition to the information gained from the residential furnace analysis and product literature, DOE was able to conduct a virtual teardown to estimate the manufacturing costs for an 82-percent TE unit. Key to this cost estimate was the growth in heat exchanger size necessary for a 1-percent increase in TE, which necessitates a larger cabinet to accommodate it. Sheet metal and other components sensitive to size changes were scaled in order to match the larger size of the unit, while components that are not sensitive to heat exchanger size changes remained unchanged.

Similarly, DOE relied on the physical teardown at the 81-percent TE level, as well as prior comparisons of residential oil-fired furnaces at condensing and non-condensing efficiency levels, to conduct a virtual teardown at the 92-percent TE level. At 92-percent TE, a secondary condensing heat exchanger made from a high-grade stainless steel was added in order to withstand the formation of condensate from the flue gases coupled with increased heat extraction into the building airstream (and, thus, higher TE). This additional heat exchanger was appropriately-sized based on information gathered from teardowns of oil-fired residential furnaces. According to product specification sheets, 92-percent TE oil-fired CWAFs use similar heat exchanger technology as condensing residential oil-fired furnaces. To accommodate the secondary heat exchanger, the cabinet was increased in size, and all associated sheet metal, wiring, and other components sensitive to cabinet size changes were also scaled as a result. In addition, the size of the blower fan blade was increased appropriately to account for the additional airflow needed over the secondary heat exchanger (however, based on observations in product literature, the rated fan power was unchanged). The manufacturing costs obtained from these physical and virtual teardowns served as the basis for the cost-efficiency relationship for this equipment class. The teardown analyses for oil-fired CWAFs are described in further detail in chapter 5 of the direct final rule TSD.

4. Cost Estimation Process

DOE developed a systematic process to estimate the MPCs of CUACs/CUHPs and CWAFs. The process utilizes a spreadsheet that calculates costs based on information about the materials and components in the bills of materials (''BOMs''), based on the price of materials, average labor rates associated with fabrication and assembly, and the costs of overhead and depreciation, as determined based on manufacturer interviews and DOE expertise. To support cost calculations using the information in the BOMs, DOE collected information on labor rates, tooling costs, raw material prices, and other factors. For purchased parts, DOE estimates the purchase price based on volume-variable price quotations and detailed discussions with manufacturers and component suppliers. For fabricated parts, the prices of raw metal materials (*e.g.,* tube, sheet metal) are estimated based on five-year averages. The cost of transforming both raw materials and purchased parts into finished assemblies and sub-assemblies is estimated based on current industry costs for labor, manufacturing equipment/tooling, space, etc. Additional details on the cost estimation process are contained in chapter 5 of the CUACs/CUHPs and CWAF direct final rule TSDs.

5. Manufacturing Production Costs

As discussed previously, for both CUACs/CUHPs and CWAFs, DOE calculated manufacturing costs at each efficiency level by totaling the costs of materials, labor, depreciation and direct overhead incurred in the manufacturing process. The total manufacturing cost of equipment at each efficiency level is broken down into two main costs: (1) The full MPC; and (2) the non-production cost, which includes selling, general, and administration (''SG&A'') costs; the cost of research and development; and interest from borrowing for operations or capital expenditures. DOE estimated the MPC at each efficiency level considered for each equipment class, from the baseline through the max-tech efficiency levels. DOE calculated the percentage of MPC attributable to each individual element of total production costs (*i.e.,* materials, labor, depreciation, and overhead). These percentages are used to validate the inputs to the cost estimation process by comparing them to manufacturers' actual financial data published in annual reports, along with feedback obtained from manufacturers during interviews. DOE uses these production cost percentages in the MIA.

a. Commercial Unitary Air Conditioners and Heat Pumps

For the CUAC/CUHP NOPR, DOE developed the cost-efficiency results using the design information of tested units and design changes identified as part of the energy modeling analysis. DOE developed cost-efficiency relationships for each cooling capacity range. DOE also noted in the CUAC/CUHP NOPR that the incremental manufacturing production and shipping costs for each efficiency level developed for the CUACs with electric resistance heating or no heat equipment class would apply to all of the other equipment classes (*i.e.,* CUACs units with all other types of heating, CUHPs units with electric resistance heating or no heat, CUHPs units with all other types of heating) within a given cooling capacity range. 79 FR at 58975. The cost-efficiency relationships developed for the CUAC/CUHP NOPR are presented in Table IV–17.

TABLE IV–17—CUAC/CUHP NOPR COST-EFFICIENCY RELATIONSHIPS

Efficiency level	Incremental manufacturing production cost		
	Small air-cooled CUACs and CUHPs	Large air-cooled CUACs and CUHPs	Very large air-cooled CUACs and CUHPs
Baseline	-	-	-
EL1	$115.93	$419.16	$542.65
EL2	583.47	792.76	1,296.41
EL3	788.88	1,236.98	1,834.67
EL4 (Max-Tech)	1,277.04	1,554.26	2,753.32

AHRI, Nordyne, Rheem, Trane, Lennox and Goodman commented that DOE has underestimated the costs of complying with the proposed standards. (CUAC: AHRI, No. 68 at pp. 29, 37–38, 44; Nordyne, No. 61 at pp. 24, 33, 37; Rheem, No. 70 at p. 4; Trane, No. 63 at p. 8; Lennox, No. 60 at p. 15; Goodman, No. 65 at pp. 13, 16)

DOE updated the raw materials and purchased parts costs used in the manufacturing cost estimation analysis based on U.S. Bureau of Labor Statistics and American Metals Market data. To address manufacturers concerns regarding DOE's estimated incremental MPCs, DOE provided detailed cost data, broken out by production factors (materials, labor, depreciation, and overhead) and also by major subassemblies (*e.g.,* indoor/outdoor heat exchangers and fan assemblies, controls, sealed system, etc.) and components (*e.g.,* compressors, fan motors, etc.), for each model analyzed in its physical and catalog teardowns to the manufacturers of the models. DOE refined its analysis based on all data and feedback provided by manufacturers.

For this direct final rule, DOE revised its analysis to be based on the physical and catalog teardown models using their IEER ratings at each efficiency level. For each equipment class, DOE estimated the incremental MPCs using the physical and catalog teardown models individually for each manufacturer that included sufficient information in their equipment literature to conduct the cost estimation analysis, then averaged the results across the manufacturers considered. As discussed above, DOE specifically focused its analysis on 7.5-ton, 15-ton, and 30-ton CUAC units with electric resistance heating or no heating. This approach for determining costs, which is different from the approach used for the energy modeling analysis discussed above, considers the full range of manufacturers and equipment offerings for which sufficient data were available to conduct the manufacturing estimation analysis using their rated IEER values. As discussed in section IV.C.3.a, DOE evaluated air flow design paths separately for CUAC and CUHP units with CAV and SAV/VAV air flow designs and also developed two separate costs for the baseline efficiency level for 7.5 tons for single- and dual-compressor designs.

Where the rated IEER values did not match exactly with the efficiency levels being considered, DOE's primary method to determine the MPCs for each efficiency level was to interpolate or extrapolate results. For example, to determine the costs at 7.5-ton Efficiency Level 1 (12.9 IEER), DOE determined the MPC for one manufacturer by interpolating the results for models rated at 12.2 IEER and 13.0 IEER. For efficiency levels with limited numbers of models, DOE developed incremental costs to be representative of the industry average cost to achieve those levels. For example, for Efficiency Level 4 for 7.5- and 15-ton units, DOE applied the relative percentage increase in cost for the one manufacturer with commercially-available equipment at that level across the other manufacturers to better represent average labor and production factors.

Based on this revised approach of considering the full range of manufacturers and equipment offerings using their rated IEER values and the consideration of additional feedback from manufacturers, DOE believes its revised cost estimates for this direct final rule provide a more accurate representation of the incremental manufacturing production costs required to achieve each efficiency level. Table IV–18 through Table IV–20 presents the cost-efficiency results developed for this direct final rule.

TABLE IV–18—DIRECT FINAL RULE SMALL AIR-COOLED CUACS AND CUHPS COST-EFFICIENCY RELATIONSHIPS

Efficiency Level	Total MPC	Incremental MPC (single compressor baseline)	Incremental MPC (dual compressor baseline)
Baseline Single Compressor	$1,947.33		
Baseline Dual Compressor	2,110.04		
EL 1 CAV	2,394.77	$447.44	$284.74
EL 1 SAV	2,365.85	418.52	255.82
EL 2 CAV	2,672.21	724.88	562.18
EL 2 SAV	2,737.46	790.13	627.43
EL 2.5	2,836.11	888.78	726.07
EL 3	2,924.49	977.16	814.46
EL 3.5	3,072.46	1,125.13	962.42
EL 4	3,452.52	1,505.19	1,342.49
EL 5 (Max-Tech)	4,105.51	2,158.18	1,995.48

TABLE IV–19—DIRECT FINAL RULE LARGE AIR-COOLED CUACS AND CUHPS COST-EFFICIENCY RELATIONSHIPS

EL	Total MPC	Incremental MPC
Baseline	$4,115.95	
EL 1 CAV	4,412.72	296.77
EL 1 SAV	4,462.10	346.15
EL 2 CAV	4,610.56	494.61
EL 2 SAV	4,797.55	681.60
EL 2.5	4,974.17	858.22
EL 3	5,169.16	1,053.21
EL 3.5	5,289.84	1,173.89
EL 4	5,545.71	1,429.76
EL 5 Max-Tech (VAV)	7,700.47	3,584.52

TABLE IV–20—DIRECT FINAL RULE VERY LARGE AIR-COOLED CUACS AND CUHPS COST-EFFICIENCY RELATIONSHIPS

EL	Total MPC	Incremental MPC
Baseline	$7,535.78	
EL1 CAV	8,766.75	$1,230.97
EL1 VAV	9,878.35	2,342.56
EL2 CAV	10,250.48	2,714.69
EL2 VAV	10,756.20	3,220.42
EL2.5 CAV	10,403.62	2,867.84
EL2.5 VAV	11,533.72	3,997.93
EL3	11,866.94	4,331.15
EL4	11,922.94	4,387.16
EL5 Max-Tech	12,743.07	5,207.29

b. Commercial Warm Air Furnaces

Based on the analytical methodology discussed in the sections above, DOE developed the cost-efficiency results for both gas-fired and oil-fired CWAFs shown in Table IV–21 and Table IV–22 for each TE level analyzed. As discussed in section IV.A, for each of the 80-percent, 81-percent, and 82-percent TE levels for gas-fired CWAFs, DOE developed multiple MPCs accounting for the use of either aluminized steel, SS409, or SS316 as a material type in the heat exchanger and inducer motor assemblies. The results shown in Table IV–21 represent the MPCs developed for each equipment class and efficiency level. Table IV–22 shows the incremental MPC increases, relative to the baseline MPC, needed to produce equipment at each specific efficiency level above baseline. Details of the cost-efficiency analysis, including descriptions of the technologies DOE analyzed at each efficiency level to develop the incremental manufacturing costs, are presented in chapter 5 of the CWAF direct final rule TSD.

TABLE IV–21—MANUFACTURING PRODUCTION COSTS *

Equipment type	EL0 (baseline)	EL1	EL2 (oil-fired Max-Tech)	EL3 (gas-fired Max-Tech)
Gas-fired CWAFs with aluminized steel HX/inducer assemblies at EL0 through EL2	$337	$350	$357	$1,074

TABLE IV–21—MANUFACTURING PRODUCTION COSTS *—Continued

Equipment type	EL0 (baseline)	EL1	EL2 (oil-fired Max-Tech)	EL3 (gas-fired Max-Tech)
Gas-fired CWAFs with SS409 HX/inducer assemblies at EL0 through EL2	447	469	486	1,074
Gas-fired CWAFs with SS316 HX/inducer assemblies at EL0 through EL2	599	635	664	1,074
Oil-fired CWAFs	1,613	1,638	2,304	

* DOE structures potential standards in terms of TSLs and examined five TSLs in the analysis for this direct final rule. TSL 1 includes EL1 for gas-fired CWAFs and EL0 for oil-fired CWAFs, TSL 2 includes EL1 for both equipment classes, TSL 3 includes EL2 for gas-fired CWAFs and EL0 for oil-fired CWAFs, TSL 4 includes EL2 for gas-fired CWAFs and EL1 for oil-fired CWAFs, and TSL 5 includes EL3 for gas-fired CWAFs and EL2 for oil-fired CWAFs. For more information on the TSL structure for CWAFs, see section V.A of this direct final rule.

TABLE IV–22—INCREMENTAL MANUFACTURING PRODUCTION COST INCREASES

Equipment type	EL0 (baseline)	EL1	EL2 (oil-fired Max-Tech)	EL3 (gas-fired Max-Tech)
Gas-fired CWAFs with aluminized steel HX/inducer assemblies at EL0 through EL2		$13	$20	$737
Gas-fired CWAFs with SS409 HX/inducer assemblies at EL0 through EL2		22	39	627
Gas-fired CWAFs with SS316 HX/inducer assemblies at EL0 through EL2		35	65	474
Oil-fired CWAFs		25	691	

6. Manufacturer Markup

To account for manufacturers' non-production costs and profit margin, DOE applies a non-production cost multiplier (the manufacturer markup) to the MPC. The resulting manufacturer selling price (''MSP'') is the price at which the manufacturer can recover all production and non-production costs and earn a profit. To meet new or amended energy conservation standards, manufacturers often introduce design changes to their equipment lines that result in increased MPCs. Depending on competitive pressures, some or all of the increased production costs may be passed from manufacturers to retailers and eventually to customers in the form of higher purchase prices. As production costs increase, manufacturers typically incur additional overhead. The MSP should be high enough to recover the full cost of the equipment (*i.e.*, full production and non-production costs) and yield a profit. The manufacturer markup has an important bearing on profitability. A high markup under a standards scenario suggests manufacturers can readily pass along the increased variable costs and some of the capital and product conversion costs (the one-time expenditure) to customers. A low markup suggests that manufacturers will not be able to recover as much of the necessary investment in plant and equipment. DOE developed the manufacturer markup through an examination of corporate annual reports and Securities and Exchange Commission (''SEC'') 10–K reports,[51] as well as comments from manufacturer interviews. Additional information is contained in chapter 6 of the CUACs/CUHPs and CWAF direct final rule TSDs.

7. Shipping Costs

HVAC equipment manufacturers typically pay for shipping during the first step in the distribution chain. Freight is not a manufacturing cost, but because it is a substantial cost incurred by the manufacturer, DOE is accounting for the shipping costs of CUACs/CUHPs and CWAFs separately from other non-production costs that comprise the manufacturer markup. To calculate the MSP at each efficiency level for CUACs/CUHPs and CWAFs, DOE multiplied the MPC at each efficiency level by the manufacturer markup and added shipping costs for equipment at the given efficiency level.

DOE calculated shipping costs at each efficiency level based on the average outer dimensions of equipment at the given efficiency and the use of a typical flat-bed, step-deck, or double-drop trailer to ship the equipment.

For CUACs and CUHPs, DOE's estimated shipping costs for each efficiency level are presented in Table IV–23 through Table IV–25. DOE notes that the shipping costs differ between CAV CUACs/CUHPs and SAV/VAV CUACs/CUHPs because of the design changes used in each type of unit to reach the higher efficiency levels. CAV CUACs/CUHPs generally rely on increasing the size of the heat exchangers to achieve higher efficiencies. As a result, CAV CUACs/CUHPs may require a larger overall cabinet size and thus a higher shipping cost compared to SAV or VAV CUACs/CUHPs at the same efficiency level, which generally rely on implementing airflow and compressor staging to achieve higher efficiencies that may not require an increase in cabinet size. DOE also notes that for the very large equipment class, the cabinet size increases associated with the higher efficiency levels did not change the number of units that fit on the trailer.

[51] U.S. Securities and Exchange Commission, Annual 10–K Reports (Various Years) (Available at: *http://www.sec.gov/edgar/searchedgar/companysearch.html*) (Last Accessed Dec. 13, 2013).

TABLE IV–23—DIRECT FINAL RULE SMALL AIR-COOLED CUACS AND CUHPS SHIPPING COST

Efficiency level	Shipping cost
Baseline Single Compressor	$278.57
Baseline Dual Compressor	$278.57
EL 1 CAV	278.57
EL 1 SAV	278.57
EL 2 CAV	278.57
EL 2 SAV	278.57
EL 2.5	278.57
EL 3	278.57
EL 3.5	278.57
EL 4	360.00
EL 5 (Max-Tech)	360.00

TABLE IV–24—DIRECT FINAL RULE LARGE AIR-COOLED CUACS AND CUHPS SHIPPING COST

Efficiency level	Shipping cost
Baseline	$360.00
EL 1 CAV	360.00

TABLE IV–24—DIRECT FINAL RULE LARGE AIR-COOLED CUACS AND CUHPS SHIPPING COST—Continued

Efficiency level	Shipping cost
EL 1 SAV	360.00
EL 2 CAV	405.00
EL 2 SAV	360.00
EL 2.5	405.00
EL 3	405.00
EL 3.5	405.00
EL 4	450.00
EL 5 Max-Tech (VAV)	450.00

TABLE IV–25—DIRECT FINAL RULE VERY LARGE AIR-COOLED CUACS AND CUHPS SHIPPING COST

Efficiency level	Shipping cost
Baseline	$900.00
EL1 CAV	900.00
EL1 VAV	900.00
EL2 CAV	900.00
EL2 VAV	900.00
EL2.5 CAV	900.00
EL2.5 VAV	900.00
EL3	900.00
EL4	900.00
EL5 Max-Tech	900.00

Gas-fired CWAF equipment is typically enclosed within a cabinet that also contains a CUAC.[52] Thus, the CUAC components are a significant factor in driving the overall cabinet dimensions. DOE found that the changes in CWAF component sizes necessary to achieve the 81-percent and 82-percent TE levels are not large enough to add any size to the cabinet, which is driven primarily by the size of the CUAC components. The shipping costs calculated for each CWAF efficiency level are shown in Table IV–26. Due to the noted impact of CUAC components on the overall shipping cost for gas-fired CWAFs, DOE presents only the incremental increase in shipping cost relative to the baseline efficiency level at each efficiency level analyzed for gas-fired CWAFs. For oil-fired CWAFs, DOE presents the cost of shipping the entire unit, since this equipment is not packaged with CUAC components, and thus, the shipping cost represents the cost to ship only the oil-fired CWAFs. Chapter 5 of the CWAF direct final rule TSD contains additional information pertaining to DOE's shipping cost estimates.

TABLE IV–26—CWAFS SHIPPING COST ESTIMATES

CWAFs equipment class	Thermal efficiency (%)	Shipping costs* (2014$)
Gas-Fired CWAFs	80	0
	81	0
	82	0
	92	43.15
Oil-Fired CWAFs	81	69.43
	82	75.76
	92	83.31

*Because gas-fired CWAFs are typically included in a cabinet with CUACs, which influence the shipping cost, the shipping costs for gas-fired CWAFs at each efficiency level are shown as the incremental increase in shipping cost above the baseline efficiency level. Since oil-fired CWAFs are normally self-contained units, the shipping costs for oil-fired CWAFs are representative of the entire cost to ship the unit.

D. Markups Analysis

At each step in the distribution channel, companies mark up the price of their equipment to cover business costs and profit margin. The markups analysis develops appropriate markups (*e.g.*, manufacturer markups, retailer markups, distributor markups, contractor markups) in the distribution chain and sales taxes to convert the MPC estimates derived in the engineering analysis to consumer prices, which are then used in the LCC and PBP analysis and other analyses.

1. Distribution Channels

In both the CUAC/CUHP and CWAF NOPRs, DOE characterized three distribution channels to describe how the equipment passes from the manufacturer to the commercial consumer. The first of these channels, the replacement distribution channel, was characterized as follows:

Manufacturer → Wholesaler → Small or Large Mechanical Contractor → Consumer

The second distribution channel—new construction—was characterized as follows:

Manufacturer → Wholesaler → Small or Large Mechanical Contractor → General Contractor → Consumer

In the third distribution channel, which applies to both the replacement and new construction markets, the manufacturer sells the equipment directly to the customer through a national account:

Manufacturer → Consumer (National Account)

In response to the CWAF NOPR, Lennox and Trane stated that the national account channel still requires a contractor to perform the installation, who has a markup on labor and materials as well. (CWAF: Lennox, Public Meeting Transcript, No. 17 at pp. 80–81; Trane, Public Meeting Transcript, No. 17 at pp. 82–83) In contrast, ACEEE stated that the markup refers to the value added by someone who takes ownership of the equipment. ACEEE questioned whether the installing contractor marks up the equipment itself. (CWAF: ACEEE, Public Meeting Transcript, No. 17 at pp. 83–84)

DOE notes that the markups analysis develops markups that are applied to the cost of purchasing only the equipment. Therefore, if the installing contractor only performs the installation, but does not purchase the equipment, the contractor is not part of the distribution channel. The installation, maintenance, and repair costs, including labor and material costs, are marked up separately using markups from RS Means data (see section IV.F).

[52] Based on shipments data provided by AHRI (see section 3.9.2 of chapter 3 of the CUAC/CUHP direct final rule TSD), DOE has determined that there are little to no shipments of combined CUHP/CWAF units.

DOE used the same distribution channels for the direct final rule analysis.

2. Markups and Sales Tax

The manufacturer markup converts MPC to MSP. DOE developed an average manufacturer markup by examining the annual SEC 10–K reports filed by publicly-traded manufacturers primarily engaged in appliance manufacturing and whose combined product range includes CUACs/CUHPs and CWAFs.

For all parties except for the manufacturer, DOE developed separate markups for baseline products (baseline markups) and for the incremental cost of more-efficient products (incremental markups). Incremental markups are coefficients that relate the change in the MSP of higher-efficiency models to the change in the retailer sales price.

AHRI stated in its response to the CUAC/CUHP NOPR that DOE unreasonably utilized incremental, rather than average markups, which significantly understates the cost of equipment meeting the proposed standards. (CUAC: AHRI, No. 68 at p. 3) It stated that DOE's analysis does not comport with empirical observations of markups in the air conditioning or heating equipment industries. (CUAC: AHRI, No. 68 at p. 29) According to AHRI, in using this technique, DOE is stating what should be happening in the market, which does not accurately reflect what is actually occurring. AHRI attached a report from Shorey Consulting to its comment to help explain what it perceives as fundamental flaws in using incremental markups as opposed to average markups. AHRI stated that average markups should be used in the DOE analysis, as these markups are, in its view, representative of the real-world HVAC marketplace. (CUAC: AHRI, No. 68 at p. 35)

DOE is not aware of any representative empirical observations of markups in the air conditioning or heating equipment industries, except at an aggregate level. The Shorey Consulting Report describes a survey of HVAC distributor/wholesalers and HVAC contractors that Shorey Consulting conducted in November 2014 to determine the actual pricing practices of both groups. The report states that (1) both distributor/wholesalers and HVAC contractors manage to target constant margin percentages across their whole businesses and do not vary margins for individual products; and (2) these entities respond to manufacturer price increases (or rare decreases) by passing these price changes through with their traditional markups. (CUAC: AHRI, No. 68, markups attachment at pp. 17–20)

To investigate the claims in the Shorey Consulting Report, DOE held discussions with Construction Programs & Results, Inc. (''CPR''), a company with long experience in the HVAC contracting field. Laying out a scenario that resembles what it expects to occur after amended standards take effect, DOE asked CPR whether HVAC contractors would be able to retain the same markup that they currently use if equipment prices increase while other relevant costs (*e.g.*, labor, material, and operation) remain constant. CPR stated that the contractors would likely attempt to use the same markup over time, but, assuming no increase in other costs, they will eventually either have to lower their markup based on market pressures, or choose to lower their markup after it has been reviewed and recalculated. The company further stated that the real-world situation is more complex than DOE's scenario, noting that the markup change will happen when the company's finances are reviewed, and the equipment cost increase will be only one factor in the adjustment. (DOE's questions and CPR's responses are provided in an appendix to chapter 6 in the CUAC/CUHP direct final rule TSD.)

The above characterization of contractor behavior is consistent with DOE's markup approach, which assumes that the markup changes for standards-compliant equipment that have a higher cost than non-compliant equipment. DOE also believes its approach is not entirely inconsistent with the information provided by the survey described in the Shorey Consulting Report. DOE does not mean to suggest that HVAC distributor/wholesalers and contractors will directly adjust their markups on equipment if the price they pay goes up as a result of appliance standards. Rather, the approach assumes that such adjustment will occur over a (relatively short) period of time as part of a business management process. This approach embodies the same perspective as the ''preservation of per-unit operating profit markup scenario'' used in the MIA (see section IV.J of this document).[53] DOE asked CPR if an increase in profitability, which is implied by keeping a fixed markup when the equipment price goes up, would be viable over time. The company indicated that, given the many pressures on contractors to lower their prices for various reasons, such an increase was unlikely to occur. DOE further notes that if increases in the cost of goods sold consistently lead to a sustainable increase in profitability, one would expect distributor/wholesalers and contractors to welcome such increases. DOE does not expect that such behavior is common in the HVAC market, or in any markets characterized by a reasonable degree of competition.

In summary, DOE acknowledges that its approach to estimating distributor and contractor markup practices after amended standards become required is necessarily an approximation of real-world practices that are both complex and varying with business conditions. However, given the supportive remarks from CPR, and the lack of any evidence that standards facilitate a sustainable increase in profitability for distributors and contractors (as would be implied by AHRI's recommendation), DOE continues to maintain that its use of incremental markups is reasonable. DOE welcomes information that could support improvement in its methodology.

To develop markups for the parties involved in the distribution of CUAC/CUHP and CWAF equipment, DOE utilized several sources, including: (1) The Heating, Air-Conditioning & Refrigeration Distributors International (''HARDI'') 2012 Profit Report[54] to develop wholesaler markups; (2) the 2005 Air Conditioning Contractors of America's (''ACCA'') financial analysis for the heating, ventilation, air conditioning, and refrigeration (''HVACR'') contracting industry[55] to develop mechanical contractor markups, and (3) the U.S. Census Bureau's 2007 Economic Census data[56] for the commercial and institutional building construction industry to develop general contractor markups. For mechanical contractors, DOE derived

[53] In the preservation of per unit operating profit scenario, manufacturer markups are set so that operating profit one year after the compliance date of the amended energy conservation standards is the same as in the base case on a per-unit basis. Under this scenario, as the production costs and sales price increase with more stringent efficiency standards, manufacturers are generally required to reduce their markups to a level that maintains base-case operating profit per unit. The implicit assumption behind this markup scenario is that the industry can only maintain its operating profit in absolute dollars per unit after compliance with the new standard.

[54] *Heating, Air Conditioning & Refrigeration Distributors International 2012 Profit Report* (Available at: *http://www.hardinet.org*) (Last accessed April 10, 2015).

[55] Air Conditioning Contractors of America (ACCA), *Financial Analysis for the HVACR Contracting Industry: 2005* (Available at: *https://www.acca.org*) (Last accessed April 10, 2013).

[56] U.S. Census Bureau, *2007 Economic Census Data* (2007) (Available at: *http://www.census.gov/econ/*) (Last accessed April 10, 2013).

separate markups for small and large contractors.

Trane questioned how the overall markup of CWAFs compared to that of CUACs/CUHPs. (CWAF: Trane, No. 17 p. 89–90) DOE notes that the overall markups for gas-fired CWAFs and CUACs/CUHPs are almost identical to each other.[57] DOE used the same general methodology and data sources for CWAFs as for CUACs/CUHPs.

In addition to the markups, DOE derived State and local taxes from data provided by the Sales Tax Clearinghouse.[58] These data represent weighted average taxes that include county and city rates. DOE derived shipment-weighted average tax values for each of the regions from the Energy Information Administration's 2003 Commercial Building Energy Consumption Survey (CBECS 2003)[59] considered in the analysis.[60]

Chapter 6 of the direct final rule TSDs for CUACs/CUHPs and CWAFs provides details on DOE's development of markups.

E. Energy Use Analysis

The purpose of the energy use analysis is to determine the annual energy consumption of CUACs and CWAFs at different efficiencies in representative U.S. commercial buildings and (in the case of CWAFs) multi-family buildings, and to assess the energy savings potential of increased equipment efficiency. DOE did not analyze CUHP energy use because, for the reasons explained in section IV.C.4, the energy modeling in the engineering analysis was performed only for CUAC equipment.

The energy use analysis estimates the range of energy use of the equipment in the field (*i.e.*, as they are actually used by commercial consumers). The energy use analysis provides the basis for other analyses DOE performed, particularly assessments of the energy savings and the savings in consumer operating costs that could result from adoption of amended standards.

Chapter 7 of the direct final rule TSDs provides details on DOE's energy use analysis for CUACs and CWAFs.

1. Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment

DOE developed energy consumption estimates only for the CUAC equipment classes that have electric resistance heating or no heating. As described in section IV.C.2.b, for equipment classes with all other types of heating, the incremental change in IEER for each efficiency level increases to maintain the same energy savings as was determined for the equipment classes with electric resistance heating or no heating within each equipment class capacity range (*i.e.*, small, large, and very large). Using this approach, the IEER differential between these equipment classes ranged from 0.2 to 0.4 at the higher efficiency levels. Therefore, DOE estimated that the energy savings for any efficiency level relative to the baseline would be identical for both sets of equipment classes. In turn, the energy savings estimates for the efficiency levels associated with the equipment classes that have electric resistance heating or no heating were used by DOE in the LCC and PBP analysis and the NIA to represent both sets of equipment classes.

In its analysis of the recommended TSL, DOE applied Efficiency Level 3 to the small and large ''all other types of heating equipment'' classes and Efficiency Level 2.5 to the very large ''all other types of heating equipment'' class. These were the IEER values recommended by the ASRAC Working Group, using an IEER differential of 0.2 compared to the ''electric resistance heating or no heating equipment'' classes. See supra, section IV.C.2.b. At Efficiency Level 3, based on an approach of maintaining a constant energy savings differential with the electric resistance heating or no heating equipment classes, the IEER differential should be 0.3 for both the small and large ''all other types of heating equipment'' classes. Since reducing the differential increases the efficiency of the equipment, additional energy savings are realized from reducing the IEER differential to 0.2 for the small and large ''all other types of heating equipment'' classes. The method for determinining the additional energy savings benefit is described in section IV.H.2.

The energy use analysis consists of two related parts. In the first part, DOE calculated energy savings for small, large, and very large CUACs at the considered efficiency levels based on modifications to the energy use simulations conducted for the 2004 ANOPR. These building simulation data are based on the 1995 CBECS. Because the simulation data reflect the building stock in 1995 that uses CUAC equipment, in the second part of the analysis, DOE developed a ''generalized building sample'' to represent the current installation conditions for CUACs. This part of DOE's analysis involved making adjustments to update the building simulation data to reflect the current building stock that uses CUAC equipment.

a. Energy Use Simulations

DOE's simulation database includes hourly profiles for more than 1,000 commercial buildings, which were based on building characteristics from the 1995 CBECS for the subset of buildings that uses CUAC equipment. Each building was assigned to a specific location along with a typical meteorological year (''TMY'') hourly weather file (referred to as ''TMY2'') to represent local weather. The simulations capture variability in cooling loads due to factors such as building activity, schedule, occupancy, local weather, and shell characteristics.

For the NOPR, DOE modified the energy use simulations conducted for the 2004 ANOPR to improve the modeling of equipment performance. The modifications that DOE performed included changes to the ventilation rates and economizer usage assumptions, the default part-load performance curve, and the minimum saturated condensing temperature limit. A more detailed description of the simulation model modifications can be found in appendix 7A of the direct final rule TSD.

Neither fan operation during ventilation nor economizer usage are accounted for in the DOE test procedure and, therefore, do not impact the rated efficiency of a CUAC. Although ventilation rates and economizer usage do not directly affect the rated equipment performance, they do impact how often the equipment needs to operate, whether at full or part-load. The building simulations for the 2004 ANOPR used ventilation rates based on ASHRAE Standard 62–1999.[61] Because a report prepared by the National Institute for Standards and Testing (''NIST'') on field measurements indicated that these ventilation rates were too high,[62] DOE reduced the rates

[57] There are slight differences in the overall markups due to small differences in manufacturer markups and in the distribution channel shares.

[58] Sales Tax Clearinghouse Inc., State Sales Tax Rates Along with Combined Average City and County Rates, 2013 (Available at: *http://thestc.com/STrates.stm*) (Last accessed Sept. 11, 2013).

[59] Energy Information Administration (EIA), 2003 Commercial Building Energy Consumption Survey (Available at: *http://www.eia.gov/consumption/commercial/*) (Last accessed April 10, 2013). Note: CBECS 2012 is currently in development but was not available in time for this rulemaking.

[60] CBECS 2012 is currently in development but will not be available in time for this rulemaking.

[61] American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. *ANSI/ASHRAE Standard 62–1999 Ventilation for Acceptable Indoor Air Quality*, 1999. Atlanta, Georgia.

[62] Persily, A. and J. Gorfain. 2004. ''Analysis of Ventilation Data from the U.S. Environmental

Continued

as part of the modified energy use simulations. In the case of economizer usage, the building simulations for the 2004 ANOPR assumed all economizers operated without fault. Various field studies have demonstrated that economizer usage is far from perfect, so in the modified simulations DOE assigned a 30-percent probability to each building modeled that the economizer would be non-operational.[63] With regard to changes made to how the equipment was modeled, DOE developed a modified part-load performance curve for the direct-expansion condenser unit model so that the overall performance would be more representative of a multi-compressor system. In addition, DOE lowered a user-input parameter representing the minimum saturated condensing temperature (''MSCT'') allowed for the refrigerant used in a CUAC—specifically, DOE dropped the MSCT from 100 °F to 80 °F.[64] Both of these parameters would affect system performance under part-load and off-design conditions.

The issue of economizer usage was first discussed in the Working Group meeting on May 11, 2015. (ASRAC Public Meeting, No. 94 at pp. 82–135) One concern was whether the model used in the simulations properly modelled the performace of economizers. Another was the market share of units that use economizers. The third concern was the fraction of economizers that are operating properly. DOE presented a sensitivity analysis that showed that even if it assumed that all economizers are operating properly below an outdoor ambient temperature of 60 °F,[65] the reduction in cooling load—and the accompanying potential for energy savings—would be very small. (ASRAC Public Meeting, No. 96 at pp. 164–174). The Working Group recommended that DOE maintain the assumptions regarding economizer usage applied in the NOPR for the direct final rule analysis. (ASRAC Public Meeting, No. 96 at pp. 177–182), and DOE did so. A description of the sensitivity analysis for economizers can be found in appendix 7B of the direct final rule TSD.

DOE used a two-step process to represent the performance of equipment at baseline and higher efficiency levels. For the NOPR, DOE first calculated the hourly cooling loads and hourly fan operation for each building from the compressor and fan energy consumption results that were generated from the modified building simulations based on equipment with an efficiency level of 11 EER. It was estimated that these simulated cooling loads had to be met by the CUACs equipment for every hour of the year that the equipment operates. Refer to chapter 7 of the CUAC/CUHP direct final rule TSD for more details.

The number of units serving a given building was based on the cooling load of the building and the cooling capacity of the representative CUAC unit at an outdoor ambient temperature of 95 °F—the specific ambient temperature at which manufacturers report a given unit's cooling capacity. In its informal meetings, the Working Group determined that the cooling capacity of the representative CUAC unit should instead be based on the 1-percent design temperature corresponding to the climate where the building is located. The 1-percent design temperature would generally be less than 95 °F, which means that the cooling capacity increases and the number of units needed to serve the building decreases. (ASRAC Public Meeting, No. 94 at pp. 80–82) As part of implementing the suggested approach, DOE allowed a fractional number of units, equivalent to system size increments of 2.5 tons, to be installed in a building as part of DOE's model. (ASRAC Public Meeting, No. 96 at p. 143)

In the second step, DOE coupled the hourly cooling loads and fan operation with equipment performance data, developed from laboratory and modeled IEER testing conducted according to AHRI Standard 340/360–2007, to generate the hourly energy consumption of baseline and more efficient CUAC equipment. DOE's use of the laboratory and modeled IEER test data allowed it to specifically address how capacity and control strategies vary with outdoor temperature and building load. The laboratory and modeled IEER test data were used to calculate the compressor efficiency (COP) and capacity at varying outdoor temperatures. The IEER rating test consists of measuring the net capacity, compressor power, condenser fan power, indoor fan power, and control power at three to five different rating conditions. The number of rated conditions the equipment is tested at is determined by the equipment's capabilities and control strategies. For the NOPR, the net capacity and compressor(s) power were determined as a linear function of outdoor temperature from the test results. If the indoor or outdoor fan was staged, its power consumption was also calculated as a linear function of outdoor temperature. The power for controls is a constant, but may vary by staging.

As described in section IV.C.3.a, DOE updated its approach by replacing the linear function described above with new correlations between outdoor temperature and the net capacity and compressor(s) power based on the design of the equipment. The considered designs included CAV, SAV, and VAV designs. Indoor and outdoor fan(s) power as well as control power were determined based on equipment staging. Based on informal Working Group meetings, the indoor fan power in heating mode assumes that the fan operates at its highest (*i.e.*, most energy consumptive) stage. (ASRAC Public Meeting, No. 94 at pp. 80–82)

For the NOPR, the determination of fan power was based on ESP values found in AHRI Standard 340/360–2007, which are also used in the DOE test procedure. The Working Group discussed the appropriate ESP to use in the analysis and agreed that DOE should use higher ESPs than those found in the DOE test procedure to help better simulate actual field conditions. For the direct final rule, the values used (0.75 and 1.25 in.w.c.) correspond to the ESPs used in the modified building simulations of the cooling load. (ASRAC Public Meeting, No. 94 at pp. 80–82; ASRAC Public Meeting, No. 95 at pp. 28–31; ASRAC Public Meeting, No. 96 at pp. 145–164) In addition, as described earlier in section IV.C.3.a, DOE accounted for the fraction of the market at each efficiency level that would require the installation of a conversion curb. The determination of fan power accounted for an increase in the ESP (0.2 in.w.c.) associated with a conversion curb. (ASRAC Public Meeting, No. 95 at pp. 28–52; ASRAC Public Meeting, No. 98 at pp. 10–15) The new correlations between outdoor temperature and the net capacity and compressor(s) power were based on the new ESPs as well as the impact of a conversion curb.

The compressor(s) power and capacity of the equipment for each hour of the year was calculated based on the outdoor temperature for the simulated buildings. The cooling capacity was calculated such that it met the simulated building cooling load for each hour. For multi-stage equipment, the

Protection Agency Building Assessment Survey and Evaluation (BASE) Study''. NISTIR 7145.

[63] As described in appendix 7–A of the TSD, field studies indicate that at least a third of installed economizers do not function properly and that economizer controls often are disconnected from the HVAC system.

[64] The default value in the simulation model for the minimum saturated condensing temperature (''MSCT'') allowed the refrigerant in a CUAC to reach 100 °F. DOE lowered the user-input parameter representing the allowed MSCT to the minimum condensing temperature of 80 °F to reflect compressor performance literature.

[65] The Working Group considered 60 °F as a reasonable estimate as to when economizier use would be allowed to cool the building.

staging for each hour was selected to ensure the equipment could meet the simulated building cooling load. When the cooling capacity exceeded the simulated building cooling load, the efficiency was adjusted for cyclic performance using the degradation coefficient and load factor as calculated according to section 6.2, Part-Load Rating, of AHRI 340/360, using the new correlations between outdoor temperature and the net capacity and compressor(s) power described above. The analysis accounted for the fact that the building cooling load includes the heat generated by the fan. The total amount of cooling the compressor must provide varies as the fan efficiency improves with different efficiency levels.

Members of the ASRAC Working Group discussed the load factor in informal meetings and, after closely examining DOE's calculation methods, the group shared its finding that DOE misinterpreted the determination of the load factor and degradation coefficient. The equation that DOE was using to determine the compressor load factor did not properly account for the way loads are distributed on multi-stage equipment when more than one stage is operating. As a result, DOE corrected the calculation for compressor power to ensure that the load factor and degradation coefficient were based only on the highest stage of operation. In addition, the same load factor and degradation coefficient were used to determine the indoor fan power at its upper stage. (ASRAC Public Meeting, No. 94 at pp. 80–82)

The NOPR analysis assumed that when there are multiple units in a building, all units serve the same share of the total cooling load. The validity of this assumption was discussed with the Working Group, and DOE conducted a sensitivity analysis with alternative assumptions. Assuming that the units serve different shares of the load, the total annual energy use of the units changes by approximately 1 percent. (ASRAC Public Meeting, No. 96 at pp. 174–176) Given this outcome, the Working Group recommended that DOE maintain the assumption applied in the NOPR for the direct final rule analysis (ASRAC Public Meeting, No. 96 at pp. 177–182). DOE followed this recommendation and a description of the sensitivity analysis of equipment loading can be found in appendix 7B of the direct final rule TSD.

Each building simulation determines the indoor fan run-time for each hour of the year. Energy use was calculated separately for the compressor, condenser fan, indoor fan, and controls for each hour of the year for the simulated building. Compressor and condenser fan energy were summed to reflect cooling energy use. Indoor fan and control energy were combined into a single category to represent indoor fan energy use during all modes of operation.

A number of stakeholders stated that it is inappropriate to incorporate energy savings attributed to fan operation (for ventilation) during modes of operation other than cooling. (AHRI, No. 68 at p. 33; Carrier, No. 48 at p. 5; Lennox, No. 60 at p. 14) ASAP agreed with the inclusion of supply fan power in the energy use analysis. (ASAP, No. 69 at p. 5)

This issue was discussed in informal meetings by a number of members of the Working Group. The outcome of these discussions was presented at the May 11, 2015 meeting of the Working Group. (ASRAC Public Meeting, No. 94 at p. 82) The Working Group agreed to include fan operation energy during all modes of operation in the energy use calculations, so DOE maintained the approach used in the NOPR for the direct final rule.[66]

The calculations provided the annual hourly cooling and fan energy use profiles for each building. The incremental energy savings between the baseline equipment and the equipment at higher efficiency levels was calculated for every hour for each of the 1,033 simulated buildings.

The building simulations were initially performed to analyze the energy use of small and large CUAC equipment, but the building cooling loads that were modeled are representative of CUACs irrespective of equipment cooling capacity. Therefore, DOE believes that its method of using these simulations provides a good representation of very large equipment performance as well as small and large equipment performance.

b. Generalized Building Sample

The NOPR analysis used a "generalized building sample" (GBS) to represent the installation conditions for the equipment covered in this rulemaking. The GBS was developed using data from the 2003 CBECS and from the Commercial Demand Module of the National Energy Modeling System version distributed with *AEO 2013.*

Only floor space cooled by the covered equipment was included in the sample. Conceptually, the main difference between the GBS and the sample of specific commercial buildings compiled in CBECS is that the GBS aggregates all building floor space associated with a particular set of building characteristics into a single category. The set of characteristics that is used to define a category includes all building features that are expected to influence either (1) the cooling load and energy use or (2) the energy costs. As an outcome of the Working Group meetings, it was decided that the building ventilation system type should be included as a feature because it affects energy use. Thus, for the direct final rule, a category was added, defining whether the building ventilation system is CAV or VAV. The primary motivation for specifying the building ventilation system was twofold: (1) To only assign CAV designs to CAV buildings and (2) to prevent CAV designs from being assigned to VAV buildings. The first issue addressed current equipment selection practices, *i.e.,* purchasers will continue to specify CAV designs if the building type allows for it. The second issue acknowledges that CAV designs are never applied to VAV buildings. As a result, CAV buildings received CAV, SAV or VAV designs, depending on the efficiency level analyzed. (ASRAC Public Meeting, No. 95, at pp. 33–52) And since CAV designs would not be appropriate for VAV buildings, these buildings received either SAV or VAV designs. The set of building characteristics, and the specific values these characteristics can take, are listed in Table IV–27.

[66] The Working Group recommended that DOE initiate a rulemaking to amend the test procedure for this equipment to better represent the total fan energy use, including considering: (a) Alternative external static pressures and (b) operation for other than mechanical cooling and heating. It also recommended that the energy consumption from the supply air fan during hours of operation when it is used to provide ventilation air, and the energy use with the supply fan operation when the unit is in heating mode, should be included in an energy efficiency metric as a result of this test procedure modification. Appliance Standards and Rulemaking Federal Advisory Committee, Commercial Package Air Conditioners and Commercial Warm Air Furnaces Working Group. Term Sheet. June 15, 2015. Recommendation #2.

TABLE IV–27—LIST OF CHARACTERISTICS AND THE ASSOCIATED VALUES USED TO DEFINE THE GENERALIZED BUILDING SAMPLE

Characteristic	Number of values	Range of values
Region	10	9 census divisions with Pacific subdivided into north and south.
Building Activity	7	assembly, education, food service, small office, large office, mercantile, warehouse.
Size (based on annual energy consumption)	3	small: < 100,000 kWh; medium: 100,000 to 1,000,000 kWh; large: > 1,000,000 kWh.
Vintage	3	category 1: before 1950; category 2: 1950–1979; category 3: 1980 and later.
Ventilation System Type	2	Constant Air Volume (CAV); Variable Air Volume (VAV).

The region in which the building is located affects both the cooling loads (through the weather) and the cost of electricity. The building activity affects building schedules and occupancy, which in turn influence the demand for cooling. The building size influences the cost of electricity, because larger facilities tend to have lower marginal prices. The building vintage may influence shell characteristics that can affect the cooling loads. The building ventilation system type dictates the type of equipment design assigned to a building.

As discussed with the Working Group, for the direct final rule, the amount of floor space allocated to each category for buildings built in or before 2012 was updated using the 2012 CBECS. The GBS was projected to 2019 (the year of the LCC analysis) using the *AEO 2015* projections of commercial building floor space by region and building type. (ASRAC Public Meeting, No. 95 at pp. 10–28)

Load profiles for each category in the GBS were developed from the simulation data just described. For each equipment class, a subset of the 1,033 buildings was used to develop the cooling energy use profiles. The subset included all buildings with a capacity requirement equal to or greater than 90 percent of the capacity of the particular representative unit. For each GBS type, a weighted average energy use profile, along with energy savings from the considered efficiency levels, was compiled from the simulated building subset. The average was taken over all buildings in the subset that have the same region, building type, size, and vintage category as the GBS category (load profiles were assumed to be independent of the building ventilation system type). This average was weighted by the number of units required to meet each building's cooling load. For some of the GBS categories, no simulation data were available. In these cases, the weighted-average energy use profile for the same building type and a nearby region or vintage were used.

Updating the sample to 2019 required some additional adjustments to the energy use data. The 1,033 building simulations used TMY2 weather data that were based on 1961–1990 data. The TMY2 weather data files were updated to TMY3, which also incorporates 1991–2005 data, in 2008. A comparison of the two datasets showed that total annual cooling degree-days (''CDD'') increased by 5 percent at all locations used in this analysis. This is accounted for by increasing the energy use (for all efficiency levels) by 5 percent at all locations. The TMY3 dataset is representative of calendar year 2005. To account for changes in CDD (and energy use) between 2005 and 2019, DOE used the projected *AEO 2015* CDD trend, which shows an increase of approximately 0.6% per year.

Changes to building shell characteristics and internal loads can lead to a change in the energy required to meet a given cooling load. The National Energy Modeling System (''NEMS'') commercial demand module accounts for these trends by adjusting the cooling energy use with a factor that is a function of region and building activity. These factors assume 100 percent compliance with existing building codes. In the GBS, these same factors were used to adjust the cooling energy use for floor space constructed after 1999. To account for more realistic levels of code compliance, the factors were multiplied by 0.35.

For the Working Group's analysis, DOE removed buildings with a cooling load of under five tons from the original sample because these buildings would be more likely to be served by smaller equipment than the CUACs covered in this rulemaking. DOE also screened out buildings with more than four stories for the 7.5-ton equipment class, since such equipment would likely be too small to meet the cooling load. (ASRAC Public Meeting, No. 95 at pp. 27–28) For the 15-ton and 30-ton equipment classes, DOE removed buildings from consideration that have cooling loads low enough that multiple smaller units would likely be used instead of a single 15-ton or 30-ton unit. The Working Group did not object to these changes, and DOE incorporated them in the direct final rule analysis.

Commenting on the NOPR, Rheem stated that the 1,033 simulated samples have limited applicability when predicting energy consumption in commercial buildings. Rheem questioned whether unoccupied or underutilized buildings were included. (Rheem, No. 70 at p. 5) AHRI and Nordyne commented that a generalized building sample may not accurately represent the energy consumption of equipment in the commercial building stock. They stated that benchmarked buildings are more effective in estimating actual energy use. (AHRI, No. 68 at p. 44; Nordyne, No. 61 at p. 37) Goodman commented that the ASHRAE 90.1 committee utilized a broad spectrum of buildings from the existing building stock, not a generalized building sample, which Goodman contends is less accurate. (Goodman, No. 65 at pp. 17–18)

The GBS includes only buildings that use covered equipment and are occupied with the equipment in use. Benchmarking may provide better estimates of energy use in individual buildings, but DOE requires a representation of the entire building stock, for which the only available data source is CBECS combined with information from building simulations. The ASHRAE 90.1 committee evaluated the cost-effectiveness of ASHRAE 90.1–2010 for new construction based on simulations of six building types in five climate locations, a more restricted sample than what is incorporated in the GBS.

2. Commercial Warm Air Furnaces

For CWAFs, DOE calculated the energy use associated with providing space heating in a representative sample of U.S commercial buildings and multi-family residential buildings. The CWAF annual energy consumption includes the gas and oil fuel used for space heating and the auxiliary electrical use associated with the furnace electrical components.

DOE estimated the heating load of CWAFs in commercial buildings and multi-family buildings by developing building samples for each of the two equipment classes covered by the standards based on CBECS 2003 and 2009 Residential Energy Consumption Survey (RECS 2009).[67] DOE used the heating energy consumption reported in CBECS 2003 or RECS 2009, which is based on the existing heating system, to calculate the space heating load of each building. The heating load represents the amount of heating required to keep a building comfortable throughout an average year. This approach captures the variability in heating loads due to factors such as building activity, schedule, occupancy, local weather, and shell characteristics. The heating load estimates from CBECS 2003 and RECS 2009 were adjusted for average weather conditions, existing CWAF equipment efficiency, and for projected improvements to the building shell efficiency.

Commenting on the NOPR, Goodman, Rheem, and AHRI stated that CBECS 2003 is outdated. (CWAF: Goodman, No. 23 at p. 4; Rheem, No. 23 at p. 6; AHRI, No. 26 at pp. 5–6) Goodman and AHRI further stated that DOE should use CBECS 2012 data when it is released in May 2015. (CWAF: Goodman, No. 23 at p. 4; AHRI, No. 26 at pp. 5–6) For the direct final rule, DOE used CBECS 2012 building sample characteristics to determine the CWAFs sample;[68] however, DOE continued to use CBECS 2003 data for all other portions of its analysis because the energy use data for CBECS 2012 was not available at the time of the analysis.[69]

In addition, Goodman and AHRI stated that DOE should not consider RECS data as part of the CWAF rulemaking. (CWAF: Goodman, No. 23 at p. 4; AHRI, No. 26 at pp. 5–6) Goodman stated that CWAFs installed in residential homes comprise a negligible percentage of CWAF installations. (CWAF: Goodman, No. 23 at p. 4) DOE believes that including CWAFs used in residential buildings provides a more complete picture of CWAF energy use, and that RECS provides data that reasonably represent multi-family buildings that use CWAFs. Based on RECS 2009 data, DOE estimates that about two percent of commercial furnaces are used in multi-family residential applications.[70]

To calculate CWAF energy consumption at each considered efficiency level, DOE determined the burner operating hours and equipment input capacity for each building. DOE used the equipment output capacity (determined using the TE rating) and the heating load in each building to determine the burner operating hours. DOE assigned the representative 250 kBtu/h input capacity for all CWAF efficiency levels.

Commenting on the CWAF NOPR, Rheem stated that it is unreasonable to assume that the burner and blower run-time will vary to the extent that DOE estimated (nearly 0-percent on-time to 100-percent on-time in any range of applications). Rheem stated that the unreasonable burner and blower on-time assumption inflates the energy consumption at the baseline efficiency level and proportionately inflates the savings from higher efficiency. (CWAF: Rheem, No. 26 at p. 6) On the other hand, GTI stated that on any given building there is significant diversity in unit run-times. (GTI, Public Meeting Transcript, No. 17 at p. 105) In response, DOE did not arbitrarily assume burner operating hours would apply to each CWAF sample. Rather, the burner operating hours are based on the annual heating energy use reported for sample buildings in CBECS 2003 and RECS 2009, as well as the assumed representative equipment input capacity. A wide range of burner operating hours is reflective of actual CWAF operation because some CWAFs in buildings with multiple furnaces may have limited use, while other CWAFs may serve very large building heating loads.

Trane stated that many local building codes require major building renovations to meet new building standards, affecting the energy efficiency of the building stock and in turn, the calculation of energy use. (CWAF: Trane, No. 27 at p. 8) Goodman made a similar comment. (CWAF: Goodman, No. 23 at p. 4)

DOE accounted for changes in building shell efficiency using the building shell efficiency index derived from the NEMS simulation performed for EIA's *Annual Energy Outlook 2015* (*AEO 2015*),[71] which projects changes in average building shell performance in the future. On average, this decreases the projected heating load for 2019 by 13 percent compared with the CBECS or RECS-derived values.

For the NOPR, DOE assumed that all CWAFs use single-stage permanent split capacitor motors. Lennox suggested that the analysis should take into account the impact of variable frequency drives that are called for under ASHRAE 90.1. Lennox stated that variable frequency drives will adjust the speed of the fans and reduce the energy use in certain applications. (CWAF: Lennox, Public Meeting Transcript, No. 17 at p. 101)

For the direct final rule, DOE used the average fan power values from the CUAC analysis. These fan power values include variable frequency drives for the very large CUAC equipment class.

For condensing CWAFs, DOE's NOPR analysis accounted for the increased blower fan electricity use in the field in both heating and cooling mode due to the presence of the secondary heat exchanger. DOE also accounted for condensate line freeze protection or a condensate pump electricity use for a fraction of installations. Condensing CWAFs installed outdoors that are located in regions with an outdoor design temperature of ≤32 °F, which constitute roughly 90 percent of gas-fired CWAFs based on location data from CBECS 2003 and RECS 2009, were assumed to require condensate freeze protection. All oil-fired CWAFs are assumed to be installed indoors so condensate line freeze protection was assumed to not be needed.

Lennox stated that condensing CWAFs designs require secondary heat exchangers, which increase static pressure in the airstream and pressure drop within the heat exchanger. This additional resistance must be overcome

[67] EIA, 2009 Residential Energy Consumption Survey (Available at: *http://www.eia.gov/consumption/residential/*) (Last accessed April 10, 2013).

[68] Energy Information Administration (EIA), 2003 Commercial Building Energy Consumption Survey (Available at: *http://www.eia.gov/consumption/commercial/*) (Last accessed April 10, 2013). Note: CBECS 2012 is currently in development but not all of the necessary data was available in time for this rulemaking.

[69] The full CBECS 2012 dataset is expected to be available in February 2016.

[70] EIA, 2009 Residential Energy Consumption Survey (Available at: *http://www.eia.gov/consumption/residential/*) (Last accessed April 10, 2013).

[71] Energy Information Administration (EIA), *Annual Energy Outlook 2015* (*AEO 2015*) Full Version (Available at: *http://www.eia.gov/forecasts/aeo/*) (Last accessed May 15, 2015).

with increased electrical power at all operating conditions, including in cooling and ventilation mode. (CWAF: Lennox, No. 22 at p. 6) Additionally, Lennox stated that enhancements that increase internal heat exchanger pressure drop will be needed to improve heat transfer, resulting in an increase in combustion air blower energy use. Further improvements to air-side heat transfer are needed through the use of baffles or increased airflow levels, which increase blower pressure drop and increase fan power. (CWAF: Lennox, No. 22 at p. 6) For the direct final rule analysis, DOE refined its approach to include the impact of condensing design on ventilation fan power. DOE's updated methodology resulted in 25 percent greater electricity use for condensing gas-fired CWAFs compared to non-condensing designs.

GTI, Goodman, AHRI, and Rheem stated that an 82-percent TE minimum standard will require a larger heat exchanger or other design changes that will restrict the airflow through the unit, which will increase the electricity use of the blower motor. (CWAF: GTI, Public Meeting Transcript, No. 17 at p. 104; Goodman, No. 23 at p. 2; Rheem, No. 25 at pp. 4–5; AHRI, No. 26 at p. 6) DOE concluded that the static pressure difference for 82-percent TE compared to baseline equipment is very small in terms of increased electricity use, because the increase in heat exchanger size in going from baseline equipment to 82-percent TE is not large enough to cause an increase in static pressure that would be relevant in terms of DOE's analysis. Therefore, DOE did not include higher electricity use for this efficiency level.

F. Life-Cycle Cost and Payback Period Analysis

DOE conducted LCC and PBP analyses to evaluate the economic impacts on representative commercial consumers of potential energy conservation standards for CUACs [72] and CWAFs. The effect of new or amended energy conservation standards on commercial consumers usually involves a reduction in operating cost and an increase in purchase cost. DOE uses the following two metrics to measure commercial consumer impacts:

- The LCC (life-cycle cost) is the total commercial consumer expense of an equipment over the life of that equipment, consisting of total installed cost (manufacturer selling price, distribution chain markups, sales tax, and installation costs) plus operating costs (expenses for energy use, maintenance, and repair). To compute the operating costs, DOE discounts future operating costs to the time of purchase and sums them over the lifetime of the equipment.
- The PBP (payback period) is the estimated amount of time (in years) it takes commercial consumers to recover the increased purchase cost (including installation) of more-efficient equipment through lower operating costs. DOE calculates the PBP by dividing the change in purchase cost at higher efficiency levels by the change in annual operating cost for the year that amended or new standards are assumed to take effect.

For any given efficiency level, DOE measures the change in LCC relative to the LCC in the no-new-standards case, which reflects the estimated efficiency distribution of CUACs or CWAFs in the absence of new or amended energy conservation standards. In contrast, the PBP for a given efficiency level is measured relative to the baseline equipment.

For each considered efficiency level in each equipment class, DOE calculated the LCC and PBP for the nationally representative sets of commercial consumers described in the preceding section. For each sample building, DOE determined the energy consumption for the covered equipment and the appropriate energy prices, thereby capturing variability in energy consumption and energy prices.

Inputs to the calculation of total installed cost include the cost of the equipment—which includes MPCs, manufacturer, wholesaler, and contractor markups, and sales taxes—and installation costs. Inputs to the calculation of operating expenses include annual energy consumption, energy prices and price projections, repair and maintenance costs, equipment lifetimes, and discount rates. DOE created distributions of values for equipment lifetime, discount rates, and sales taxes to account for their uncertainty and variability.

The computer model DOE uses to calculate the LCC and PBP, which incorporates Crystal Ball™ (a commercially-available software program), relies on a Monte Carlo simulation to incorporate uncertainty and variability into the analysis. The Monte Carlo simulations randomly sample input values from the probability distributions and the consumer samples. The model calculated the LCC and PBP for products at each efficiency level for 10,000 buildings per simulation run.

DOE calculates the LCC and PBP for commercial consumers as if each were to purchase new equipment in the expected year of compliance with amended standards. As discussed in section III.C, for the TSLs that represent the recommended standards, the compliance dates for CUACs are January 1, 2018, for the first tier of standards, and January 1, 2023 for the second tier of standards, For CWAFs, the compliance date for the new standards is January 1, 2023. For all other TSLs examined by DOE, the compliance January 1, 2019 compliance date would apply. For purposes of the LCC and PBP analysis, DOE used 2019 as the first full year of compliance for all TSLs.

For CUACs, the energy savings estimates for the efficiency levels associated with the equipment classes that have electric resistance heating or no heating were used in the LCC and PBP analysis to represent the equipment classes with all other types of heating.

Table IV–28 and Table IV–29 summarize the approach and data DOE used to derive inputs to the LCC and PBP calculations. The subsections that follow provide further discussion. Details of the spreadsheet models, and of all the inputs to the LCC and PBP analyses, are contained in chapter 8 of the direct final rule TSDs and their appendices.

[72] As indicated previously, DOE did not conduct LCC and PBP analyses for CUHPs because an energy use analysis was not performed for this equipment.

TABLE IV.28—SUMMARY OF INPUTS AND METHODS FOR THE LCC AND PBP ANALYSIS: SMALL, LARGE, AND VERY LARGE COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT *

Inputs	Method/source
Equipment Cost	Derived by multiplying MPCs by manufacturer, wholesaler, and contractor markups and sales tax, as appropriate. No change over time.
Installation Costs	Baseline installation cost determined with data from RS Means. Estimated increase in cost with increased efficiency as a function of equipment weight.
Annual Energy Use	See section IV.E.1.
Energy Prices	Marginal and average electricity prices for each member of the GBS based on utility electricity tariff data.
Energy Price Trends	Based on *AEO 2015* price forecasts.
Repair and Maintenance Costs	Based on RS Means data. Cost varies by efficiency level.
Product Lifetime	Derived from shipments model.
Discount Rates	Caclulated as the weighted average cost of capital for businesses purchasing CUACs. Primary data source was Damodaran Online.
Compliance Date	2019 (for purpose of analysis).

* References for the data sources mentioned in this table are provided in the sections following the table or in chapter 8 of the direct final rule TSD.

TABLE IV.29—SUMMARY OF INPUTS AND METHODS FOR THE LCC AND PBP ANALYSIS: COMMERCIAL WARMAIR FURNACES *

Inputs	Method/Source
Equipment Cost	Derived by multiplying MPCs by manufacturer, wholesaler, and contractor markups and sales tax, as appropriate. Used historical data to derive a price scaling index to forecast product costs.
Installation Costs	Cost determined with data from RS Means. Cost increases with efficiency.
Annual Energy Use	The total fuel use plus electricity use per year. Number of operating hours and energy use based on the 2003 CBECS and 2009 RECS.
Energy Prices	Natural Gas: Based on EIA's Natural Gas Navigator data for 2012. Fuel Oil and LPG: Based on EIA's State Energy Consumption, Price, and Expenditures Estimates (SEDS) for 2012. Electricity: Based on EIA's Form 826 data for 2012.
Energy Price Trends	Based on *AEO 2015* price forecasts.
Repair and Maintenance Costs	Based on RS Means data. Assumed variation in cost by efficiency.
Product Lifetime	Gas-fired CWAF: Based on the 2014 NOPR for CUAC equipment. Oil-fired CWAF: Based on the residential oil-fired furnace lifetime distribution in the 2009 residential furnaces direct final rule.
Discount Rates	Caclulated as the weighted average cost of capital for businesses purchasing CWAFs. Primary data source was Damodaran Online.
Compliance Date	2019 (2023 for TSL 2).

* References for the data sources mentioned in this table are provided in the sections following the table or in chapter 8 of the direct final rule TSD.

1. Equipment Cost

To calculate commercial consumer equipment costs, DOE multiplied the MPCs developed in the engineering analysis by the markups described in section IV.D (along with sales taxes). DOE used different markups for baseline equipment and higher-efficiency equipment, because DOE applies an incremental markup to the increase in MSP associated with higher-efficiency equipment.

The equipment costs estimated in the engineering analysis refer to costs when the analysis was conducted. To project the costs in the compliance years, DOE developed cost trends based on historical trends.

For CUACs, DOE derived an inflation-adjusted index of the producer price index (PPI) for ''unitary air-conditioners, except air source heat pumps'' from 1978 to 2014.[73] Although the inflation-adjusted PPI index shows a long-term declining trend, data for the last decade have shown a flat-to-slightly rising trend. Given the uncertainty as to which of the trends will prevail in coming years, DOE chose to apply a constant price trend (2013 levels) for the LCC and PBP analysis.

Commenting on the CUAC/CUHP NOPR, ASAP encouraged DOE to attempt to capture price trends of technologies that can improve efficiency of air conditioners and heat pumps. In its view, the prices of technologies used in high-efficiency equipment are likely to decline much faster than the total price of the equipment. With respect to CUACs and CUHPs, ASAP expects the prices of brushless permanent magnet fan motors and variable-speed supply fans to decline faster than the total price of the equipment. ASAP recommended that DOE use a component-based price trend. (ASAP, No. 69 at p. 8)

DOE acknowledges that the price of more recently introduced components may decline faster than the total price of the equipment. However, it is not aware of data that would allow estimation of a trend for such components and ASAP provided none. Accordingly, DOE did not use a separate price trend for technologies used in high-efficiency equipment.

For CWAFs, DOE used the historic trend in the PPI for ''Warm air furnaces'' [74] to estimate the change in price between the present and the compliance years. The inflation-

[73] Product series ID: PCU333&415333415E: Unitary air-conditioners, except air source heat pumps. (Available at: *www.bls.gov/ppi/*).

[74] Product series ID: PCU333415333415C: Warm air furnaces including duct furnaces, humidifiers and electric comfort heating. (Available at: *http://www.bls.gov/ppi/*).

adjusted PPI for ''Warm air furnaces'' shows a small rate of annual price decline.

2. Installation Cost

Installation cost includes labor, overhead, and any miscellaneous materials and parts needed to install the equipment.

a. Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment

For the CUAC/CUHP NOPR, DOE derived installation costs for CUACs equipment from current RS Means data.[75] Based on these data, DOE concluded that data for 7.5-ton, 15-ton, and 30-ton rooftop air conditioners would be sufficiently representative of the installation costs for the ≥65,000 Btu/h to <135,000 Btu/h, ≥135,000 Btu/h to <240,000 Btu/h, and ≥240,000 Btu/h to <760,000 Btu/h air conditioning equipment classes, respectively. Within a given capacity (equipment class), DOE chose to vary installation costs in direct proportion to the physical weight of the equipment. The weight of the equipment in each class and efficiency level was determined through the engineering analysis. Because labor rates vary significantly in each region of the country, DOE used RS Means data to identify how installation costs vary among regions and incorporated these costs into the analysis.

Commenting on the CUAC/CUHP NOPR, Carrier stated that RS Means should be used for installation cost based on unit tonnage, not weight or physical characteristics. (Carrier, No. 48 at p. 6) Trane and Goodman commented that RS Means underestimates installation costs. (Trane, No. 63 at p. 9; Goodman, No. 65 at p. 19) Rheem stated that the costs should include regional adjustments and demolition costs for removal of existing equipment. (Rheem, No. 70 at p. 5)

The Working Group debated the validity of DOE's method to vary installation costs in direct proportion to the physical weight of the equipment, and also discussed the cost of using a crane and whether the cost varies with efficiency. (ASRAC Public Meeting, No. 95 at pp. 103–126) DOE found that crane costs do not vary except past a threshold that is not relevant for this equipment. Because the Working Group did not find a compelling basis to recommend changes to DOE's method, DOE retained the approach used in the NOPR for the direct final rule (ASRAC Public Meeting, No. 96 at pp. 202–235). However, for a certain fraction of the market, DOE included additional costs for installing a conversion curb to accommodate equipment designs with large footprints. The cost was based on several factors, including equipment class, weight, and brand. As discussed by the Working Group, the fraction of the market that would require a conversion curb increases with efficiency. (ASRAC Public Meeting, No. 98 at pp. 17–20) The conversion curb costs for the small, large and very large CUAC equipment classes are $1,000, $1,750, and $4,000, respectively. (ASRAC Public Meeting, No. 96 at pp. 235–237) The installation costs used for the direct final rule include removal of existing equipment.

Carrier expressed concern that the variable-speed fan technology applied to supply fans at higher efficiency levels may have an additional cost increase to customers who are replacing equipment. It noted that many of these older building designs may need either the ductwork and/or the diffusers to be modified or replaced, as their designs may not be capable of managing the lower velocities that will occur with variable-speed supply fans. It added that if the ductwork/diffuser designs are not capable of these reduced velocities, then significant thermal discomfort can result and may actually cause increased equipment run-time due to poor air distribution within the occupied space. (Carrier, No. 48 at p. 2)

Based on the Working Group discussions, DOE included additional installed costs for adding controls (*e.g.,* thermostats) in CAV buildings to accommodate SAV and VAV equipment designs. (ASRAC Public Meeting, No. 95 at pp. 126–134) However, DOE did not include additional costs for replacing diffusers based on research commissioned by ASHRAE.[76] The research found that diffusers used in CAV buildings can also be used to accommodate single-zone SAV and VAV equipment. Specifically, CAV diffusers can provide proper air distribution for air volumes as low as 10-percent of full volume. (ASRAC Public Meeting, No. 96 at pp. 238–247)

b. Commercial Warm Air Furnaces

For the CWAF NOPR, DOE used data from the 2013 RS Means Mechanical Cost Data [77] to estimate the baseline installation cost. For CWAFs with condensing designs, DOE accounted for additional installation costs for condensate removal, which includes condensate drainage, freeze protection, and treatment. DOE also accounted for meeting the venting requirements for oil-fired commercial warm air furnaces, as well as for the small fraction of gas commercial warm air furnaces installed indoors.

Commenting on the CWAF NOPR, AGA stated that if the revised standard mandates condensing technology, installing condensing furnaces in many existing buildings would require additional installation requirements and costs to properly address condensate disposal issues, including the freezing of the condensate for commercial furnaces in outdoor installations that are typical for commercial buildings. AGA stated that DOE has not fully considered these added installation costs in its analysis. (CWAF: AGA, No. 20 at p. 2)

In the NOPR (as well as for the direct final rule), DOE included the cost of condensate disposal in the installation cost for condensing CWAFs in indoor and outdoor installations. It included the cost of a condensate pipe, condensate pump, use of heat tape for outdoor installations, additional electrical outlet for heat tape and condensate pump, and condensate neutralizer, when applicable, based on the installation location of the CWAFs and building characteristics reported in CBECS 2003 and RECS 2009. The use of heat tape was determined based on weather data from NOAA. DOE notes that the adopted standards do not require condensing technology. The details of the condensate removal costs are provided in appendix 8D of the direct final rule TSD.

AHRI stated that the standards may increase the size of the unit, which would potentially require rework of the installation platform. (CWAF: AHRI, No. 17 at pp. 185–186) Similarly, Lennox stated that DOE should consider the cost involved in converting existing building stock to accept larger footprint products and the renovation needed to accept a larger roof curb or an adapter curb. (CWAF: Lennox, No. 22 at p. 10)

DOE assumed in the engineering analysis that the increase in condensing CWAF unit size from the use of larger heat exchangers would only impact the height, and no change in the cabinet size of higher efficiency non-condensing CWAFs would be needed. Furthermore, the CUAC analysis already accounted for additional costs for installing a

[75] *http://www.rsmeansonline.com*; Accessed March 27, 2013.

[76] Arens, et al. Thermal and air quality acceptability in buildings that reduce energy by reducing minimum airflow from overhead diffusers. ASHRAE RP–1515: Final Report, Center for the Built Environment—University of California, Berkeley (2012).

[77] RS Means, 2013 Mechanical Cost Data (Available at: *http://rsmeans.reedconstructiondata.com/60023.aspx*) (Last accessed April 10, 2013).

conversion curb to accommodate equipment designs with larger footprints, making it unnecessary to consider such costs for CWAFs, most of which are packaged with CUACs.

AHRI stated that although 82-percent TE CWAFs are not designed for condensing, there will be conditions that make condensate production a much greater concern than for indoor furnaces. (CWAF: AHRI, No. 26 at p. 2) Goodman stated that in field installations, the likelihood of condensate production in 82-percent TE weatherized CWAFs is much higher than in the lab, particularly in cold climates and at higher altitudes. Goodman stated that prolonged exposure to condensate in 82-percent TE CWAFs will corrode major components within the CWAFs and will lead to reliability issues. (CWAF: Goodman, No. 23 at pp. 2–3) Similarly, Trane stated that there are condensate issues for both 82-percent TE and condensing CWAFs that will need to be addressed by the installer. Trane stated that to have a redundant protection against roof membrane failure, builders or installers may need to upgrade the roof around the CWAFs, which was not taken into account in DOE's analysis. Trane added that 82-percent TE CWAFs still need heat tape to be energized continuously in the winter months for the condensate not to freeze, which DOE's analysis did not take into account. (CWAF: Trane, No. 27 at p. 7) Lennox stated that due to the introduction of condensate at 82-percent TE and above, many components will be susceptible to corrosion. (CWAF: Lennox, No. 22 at p. 10)

As discussed with the Working Group, for the direct final rule analysis, DOE did not apply a cost of a condensate withdrawal system or heat tape for non-condensing CWAFs (*i.e.,* 82-percent TE) because these models do not produce enough condensate to require withdrawal from the unit, as is shown by the lack of equipment at this efficiency that require the use a condensate withdrawal system in the installation and operation manual. DOE did not apply redundant protection against roof membrane failure for condensing CWAFs, because it assumed that roof changes would already be done to accommodate the condensate from the CUAC unit (see section IV.F.2.a). See appendix 8D of the CWAF direct final rule TSD for more details.

Trane stated that calculating the total installed cost for the furnace separately from the entire rooftop unit (''RTU'') is not realistic, as replacing a failed CWAF would incur the full cost of the RTU even if the cooling side was still operating. (CWAF: Trane, Public Meeting Transcript, No. 17 at p. 128) Lennox agreed with this view. (CWAF: Lennox, Public Meeting Transcript, No. 17 at p. 130)

DOE's analyses for CWAFs and CUACs accounted for the likelihood that failure of either the CWAF or the CUAC would lead to replacement of the entire RTU. In calculating installation costs for CWAFs, DOE took into account only the additional costs that would be required for the furnace component, since all other installation components are already accounted for in the CUAC analysis.

3. Annual Energy Consumption

The calculation of annual per-unit energy consumption at each considered efficiency level is described above in section IV.E.

DOE typically considers the potential for a rebound effect, which occurs when a piece of equipment that is made more efficient is used more intensively, such that the expected energy savings from the efficiency improvement may not fully materialize.

Commenting on the CUAC/CUHP NOPR, Rheem agreed that it is appropriate to not include a rebound effect. (CUAC: Rheem, No. 70 at p. 7) Commenting on the CWAF NOPR, Rheem stated generally that no rebound effect exists for a commercial furnace because the person who pays the energy bill is usually not the building occupant, but such an effect could exist where the person who pays the energy bill is also the building occupant. (CWAF: Rheem, No. 25 at p. 7) AHRI agreed that there is minimum rebound effect associated with a higher efficiency standard for commercial furnaces. (CWAF: AHRI, No. 26 at p. 6) In contrast, Trane commented that DOE had previously included a rebound effect for residential air conditioners and furnaces, and it noted that EIA includes a rebound effect for CWAFs in the AEO. It recommended that this effect be included in DOE's analyses until data are developed proving it is not warranted or until EIA drops it from the AEO. (CWAF: Trane, No. 27 at p. 7)

DOE conducted a literature review on the direct rebound effect in commercial buildings, and found very few studies, especially with regard to space heating and cooling. In a paper from 1993, Nadel describes several studies on takeback in the wake of utility lighting efficiency programs in the commercial and industrial sectors.[78] The findings suggest that in general the rebound associated with lighting efficiency programs in the commercial and industrial sectors is very small. In a 1995 paper, Eto et al.[79] state that changes in energy service levels after efficiency programs have not been studied systematically for the commercial sector. They state that while pre-/post-billing analyses can implicitly pick up the energy use impacts of amenity changes resulting from program participation, the effect is usually impossible to isolate. A number of programs attempted to identify changes in energy service levels through customer surveys. Five concluded that there was no evidence of takeback, while two estimated small amounts of takeback for specific end uses, usually less than 10-percent. A recent paper by Qiu,[80] which describes a model of technology adoption and subsequent energy demand in the commercial building sector, does not present specific rebound percentages, but the author notes that compared with the residential sector, rebound effects are smaller in the commercial building sector. An important reason for this is that in contrast to residential heating and cooling, HVAC operation adjustment in commercial buildings is driven primarily by building managers or owners. The comfort conditions are already established in order to satisfy the occupants, and they are unlikely to change due to installation of higher-efficiency equipment. While it is possible that a small degree of rebound could occur for higher-efficiency CUACs/CUHPs and CWAFs, there is no basis to select a specific value. Because the available information suggests that any rebound would be small to negligible, DOE did not include a rebound effect for the direct final rule.

Regarding Trane's comment, DOE has confirmed that EIA includes a rebound effect for several end-uses in the commercial sector, including heating and cooling, as well as improvements in building shell efficiency in its AEO reports.[81] The DOE analysis presented

[78] S. Nadel (1993). The Takeback Effect: Fact or Fiction? Conference paper: American Council for an Energy-Efficient Economy.

[79] Eto et al. (1995). Where Did the Money Go? The Cost and Performance of the Largest Commercial Sector DSM Programs. LBL–3820. Lawrence Berkeley National Laboratory, Berkeley, CA.

[80] Qui, Y. (2014). Energy Efficiency and Rebound Effects: An Econometric Analysis of Energy Demand in the Commercial Building Sector. *Environmental and Resource Economics,* 59(2): 295–335.

[81] Energy Information Administration, Commercial Demand Module of the National Energy Modeling System: Model Documentation 2013, Washington, DC, November 2013, page 57. The building shell efficiency improvement index in the AEO accounts for reductions in heating and cooling load due to building code enhancements

Continued

here does not include either the rebound effect for building shell efficiency or the rebound effect for equipment efficiency as is included in the AEO, and therefore cannot definitively assess what the impact of including the rebound effect would have on this analysis. For example, if the building shell efficiency improvements included in the AEO reduced heating and cooling load by 10 percent and the rebound effect on building shell efficiency was assumed to be 10 percent, the total impact would be to reduce heating and cooling loads by 9 percent. The DOE analysis presented here includes only the building shell improvements from the AEO but not the rebound effect on the building shell efficiency improvements. DOE estimates that a rebound effect of 10 percent on CUAC/CUHP/CWAF efficiency for heating and cooling improvements could reduce the energy savings by 1.5 quads (10 percent) over the analysis period. However, this ignores that the rule would have saved more than 15 quads had the building shell efficiency rebound effect included in the AEO was also included in DOE's analysis.

4. Energy Prices

For the CUAC/CUHP NOPR, DOE used the electricity tariff data developed for the 2004 ANOPR, which were based on tariffs from a representative sample of electric utilities, to derive marginal and average electricity prices for each member of the GBS. The approach uses tariff data that have been processed into commercial building marginal and average electricity prices.[82]

The CBECS 1992 and CBECS 1995 surveys provide monthly electricity consumption and demand for a large sample of buildings. DOE used these values to help develop usage patterns associated with various building types. Using these monthly values in conjunction with the tariff data, DOE calculated monthly electricity bills for each building. The average price of electricity is defined as the total electricity bill divided by total electricity consumption. Two marginal prices are defined, one for electricity demand (in $/kW) and one for electricity consumption (in $/kWh). These marginal prices are calculated by applying a five-percent decrement to the CBECS demand or consumption data and recalculating the electricity bill.

Using the prices derived from the above method, an average price and a marginal price were assigned to each building in the GBS. For each member of the GBS, these prices were calculated as the average, weighted by floor space and survey sample weight, of all buildings in the CBECS 1992 and 1995 data meeting the set of characteristics defining the generalized building (*i.e.,* region, vintage, building activity, and building energy consumption). As most tariffs are seasonal, average and marginal prices are calculated separately for summer (May-September) and winter.

The average summer or winter electricity price multiplied by the baseline summer or winter electricity consumption for equipment of a given capacity defines the baseline LCC. For each efficiency level, the operating cost savings are calculated by multiplying the electricity consumption savings (relative to the baseline) by the marginal consumption price and the electricity demand reduction by the marginal demand price. The consumer's electricity bill is only affected by the electricity demand reduction that is coincident with the building's monthly peak load. Air-conditioning loads are strongly, but not perfectly, peak-coincident. Divergences between the building peak and the air conditioning peak were accounted for by multiplying the electricity demand reduction by a random factor drawn from a triangular distribution centered at 0.9 +/− 0.1.

The tariff-based prices were updated to 2013 using the commercial electricity price index published in the *AEO* (editions 2009 through 2012). An examination of data published by the Edison Electric Institute[83] indicates that the rate of increase of marginal and average prices is not significantly different, so the same factor was used for both pricing estimates.

There were no comments on the NOPR methodology, and DOE retained the approach used for NOPR for the direct final rule.

For CWAFs, DOE derived average and marginal monthly energy prices for a number of geographic areas in the United States using the latest data from EIA (Form 861 data[84] to calculate commercial electricity prices, Natural Gas Navigator[85] to calculate commercial natural gas prices, and State Energy Data System (SEDS)[86] to calculate LPG and fuel oil prices) and monthly energy price factors that it developed. Average energy prices are applied to the no-new-standards case energy use, while marginal prices are applied to the differential energy use from the higher efficiency options. This process assigns an appropriate energy price to each commercial building and household in the sample, depending on its sector (commercial or residential) and location.

AGA stated that DOE's methodology for calculating marginal natural gas prices results in higher prices than using individual natural gas utility tariffs, thus overstating the energy cost savings. (CWAF: AGA, No. 20 at p. 2) However, AGA did not provide data on natural gas utility tariffs that would enable DOE to modify its method. As a result, DOE could not evaluate whether AGA's claim is based on a sample that is representative of CWAFs users. Thus, DOE retained the approach used in the NOPR for the direct final rule.

For CUACs and CWAFs, to estimate energy prices in future years, DOE multiplied the recent energy prices by the forecast of annual change in national-average commercial energy prices in the Reference case from *AEO 2015,* which has an end year of 2040. To estimate price trends after 2040, DOE used the average annual rate of change in prices from 2030 to 2040.

For further discussion of energy prices, see chapter 8 of the direct final rule TSDs.

5. Maintenance and Repair Costs

Maintenance costs are expenses associated with ensuring continued operation of the covered equipment over time. DOE developed maintenance costs for its analysis using 2013 RS Means Facilities Maintenance & Repair Cost Data.[87] These data provide estimates of person-hours, labor rates, and materials required to maintain commercial air conditioning equipment and furnaces.

In response to the CUAC/CUHP NOPR, AHRI and Nordyne commented that RS Means maintenance costs do not reflect the normal amounts incurred by customers, which is double RS Means. (AHRI, No. 68 at p. 44; Nordyne, No. 61

and other improvements that could reduce the buildings need for heating and cooling.

[82] Coughlin, K., C. Bolduc, R. Van Buskirk, G. Rosenquist and J.E. McMahon. Tariff-based Analysis of Commercial Building Electricity Prices. 2008. Lawrence Berkeley National Laboratory: Berkeley, CA. Report No. LBNL–55551.

[83] Edison Electric Institute. EEI Typical Bills and Average Rates Report (bi-annual, 2007–2012). Washington, DC.

[84] Energy Information Administration (EIA), Survey form EIA–861—Annual Electric Power Industry Report (Available at: *http://www.eia.gov/electricity/data/eia861/index.html*) (Last accessed July 15, 2015).

[85] Energy Information Administration (EIA), Natural Gas Navigator (Available at: *http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm*) (Last accessed July 15, 2015).

[86] Energy Information Administration (EIA), State Energy Data System (SEDS) (Available at: *http://www.eia.gov/state/seds/*) (Last accessed July 15, 2015).

[87] RS Means, 2013 Facilities Maintenance & Repair Cost Data (Available at: *http://rsmeans.reedconstructiondata.com/60303.aspx*) (Last accessed April 10, 2013).

at p. 38) Lennox, Goodman and Trane commented that RS Means significantly underestimates preventative maintenance costs. (Lennox, No. 60 at p. 15; Goodman, No. 65 at pp. 19–20; Trane, No. 63 at p. 9) Carrier and Goodman stated that maintenence costs are likely to increase with efficiency. (Carrier, No. 48 at pp. 5–6; Goodman, No. 65 at p. 20)

The Working Group discussed maintenence costs and generally agreed with DOE's approach. (ASRAC Public Meeting, No. 95 at pp. 139–143). Accordingly, DOE retained this approach for the direct final rule.

For the CWAF NOPR, DOE included increased maintenance costs for condensing equipment. For condensing gas-fired commercial warm air furnaces, DOE added labor and material costs to account for checking the condensate withdrawal system, including: Inspecting, cleaning, and flushing the condensate trap and drain tubes; inspecting the grounding and power connection of heat tape; checking condensate neutralizer; and checking condensate pump for corrosion and proper operation. For condensing oil-fired commercial warm air furnaces, DOE added additional maintenance for installations in non-low-sulfur regions to account for extra cleaning of the heat exchanger for condensing designs, as well as checking of the condensate withdrawal system. DOE did not receive any comments on this issue, and retained the same approach for the direct final rule.

Repair costs are expenses associated with repairing or replacing components of the covered equipment that have failed.

For the CUAC/CUHP NOPR, DOE assumed that any routine or minor repairs are included in the maintenance costs. As a result, repair costs were not explicitly modeled in the LCC and PBP analysis. Instead, DOE incorporated a one-time cost for major repair (compressor replacement) as a primary input to the repair/replace consumer choice model in the shipments analysis, which models the decision between repairing a broken unit and replacing it.

DOE proposed to the Working Group to include compressor repairs in the LCC and PBP analysis because such repair work would occur regardless of whether new standards are set (ASRAC Public Meeting, No. 96 at pp. 247–248) The Working Group agreed with this proposal, and, because the Working Group estimated that compressor repairs occur later in a CUAC's life, suggested that this type of repair be assumed to take place in the 13th year. For the direct final rule, compressor repair costs are based on material costs from Grainger (a provider of commercial and industrial supplies) and labor costs from RS Means, and are assumed to scale with equipment price. The cost is applied to 20 percent of consumers, representing the portion of the population that chooses to repair rather than replace in the no-standards case. DOE also included non-compressor repairs, conducted in the 7th year, for all consumers (ASRAC Public Meeting, No. 96 at pp. 247–248).

For CWAFs, DOE developed repair costs for its analysis using 2013 RS Means Facilities Maintenance & Repair Cost Data.[88] DOE included additional repair costs for higher efficiency levels (*i.e.,* condensing furnaces).

Lennox stated that due to the introduction of condensate at a TE level of 82-percent and above, many components will be susceptible to corrosion, thus requiring components to be replaced more frequently. (CWAF: Lennox, No. 22 at p. 10) For the direct final rule, DOE assumed that all 82-percent TE CWAFs use stainless steel heat exchangers to resist corrosion; therefore, DOE did not assume any difference in repair frequency for 82-percent TE CWAFs.

See chapter 8 of the direct final rule TSDs for more details on maintenance and repair costs.

6. Equipment Lifetime

Equipment lifetime is the age at which a unit of covered equipment is retired from service. For the LCC and PBP analysis, DOE develops a distribution of lifetimes to reflect variability in equipment lifetimes in the field.

a. Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment

For the CUAC/CUHP NOPR, DOE used lifetime distributions based on calibration of the shipments model (see section IV.G.1). The mean lifetimes were 18.4 years for CUACs and 15.2 years for CUHPs. AHRI and Nordyne commented that the equipment lifetime assumptions are incorrect and that a lifetime range of 12–15 years is more appropriate for equipment in this rulemaking. (AHRI, No. 68 at p. 45; Nordyne, No. 61 at p. 35) Goodman commented that the lifetimes should be different for each equipment class. (Goodman, No. 65 at pp. 20–21)

The Working Group accepted DOE's approach of using the shipments model to determine equipment lifetime, along with extension of the equipment lifetime due to inclusion of compressor repairs. The group asked DOE to use more recent shipments data. AHRI provided recent data, but it was not representative of entire industry shipments, so DOE continued to use the shipments data from the NOPR analysis (ASRAC Public Meeting, No. 98 at pp. 125–133). Also, as discussed later in section IV.F.8.a, DOE also incorporated AHRI's more recent data into its analysis. For the direct final rule, the LCC analysis used lifetime distributions based on the revised shipments model (see section IV.G.1), which makes distinct estimates for each of the CUAC equipment classes.

b. Commercial Warm Air Furnaces

In addressing gas-fired CWAFs, DOE's CWAF NOPR used the same lifetime probability distribution that was developed in the NOPR analysis for small, large, and very large air-cooled commercial package air conditioning and heating equipment.[89] For oil-fired CWAFs, DOE used a lifetime Weibull probability distribution based on a method that utilizes national survey data,[90] which resulted in a 26-year average lifetime. DOE expects the lifetime of the equipment to not change due to any new energy efficiency standards.

Commenting on the CWAF NOPR, AHRI stated that the analysis overestimates the average lifetime of a commercial furnace, and that the proposed standard of 82-percent TE will reduce the life of the equipment. (CWAF: AHRI, No. 26 at pp. 2, 6)

As discussed with the Working Group, for the direct final rule analysis, DOE based the lifetime estimate for both gas-fired and oil-fired CWAFs on the revised CUAC lifetime. (ASRAC Public Meeting, No. 43 at p. 8) DOE does not believe a standard at 82-percent TE would reduce the life of equipment that use stainless steel heat exchangers for installations where such material would prevent corrosion issues. Therefore, as described in section IV.C.3.b, DOE assumed in its analysis that all 82-percent TE CWAFs would use stainless steel heat exchangers. In any case, DOE

[88] RS Means, 2013 Mechanical Cost Data (Available at: *http://rsmeans.reedconstructiondata.com/60023.aspx*) (Last accessed April 10, 2013).

[89] Technical Support Document for Small, Large, and Very Large Commercial Package Air Conditioners and Heat Pumps Notice of Proposed Rulemaking (Available at: *http://www.regulations.gov/#!documentDetail;D=EERE-2013-BT-STD-0007-0027*).

[90] Lutz, J., A. Hopkins, V. Letschert, V. Franco, and A. Sturges. Using national survey data to estimate lifetimes of residential appliances. *HVAC&R Research* (2011) 17(5): pp. 28 (Available at: *http://www.tandfonline.com/doi/abs/10.1080/10789669.2011.558166*).

notes that the standard adopted for gas-fired CWAFs does not require 82-percent TE.

7. Discount Rates

The discount rate is the rate at which future expenditures or savings are discounted to estimate their present value. The weighted average cost of capital is commonly used to estimate the present value of cash flows to be derived from a typical company project or investment. Most companies use both debt and equity capital to fund investments, so their cost of capital is the weighted average of the cost to the firm of equity and debt financing. DOE estimated the cost of equity using the capital asset pricing model, which assumes that the cost of equity for a particular company is proportional to the systematic risk faced by that company.

The primary source of data for this analysis was Damodaran Online, a widely used source of information about company debt and equity financing for most types of firms.[91] In analyzing these data, DOE estimated a separate weighted average cost of capital for each business sector that purchases CUACs and CWAFs. More details regarding DOE's estimates of consumer discount rates are provided in chapter 8 of the direct final rule TSDs.

8. Efficiency Distribution in the No-New-Standards Case

To accurately estimate the share of commercial consumers that would be affected by a potential energy conservation standard at a particular efficiency level, DOE's LCC analysis considered the distribution (market shares) of equipment efficiencies projected for the compliance years in the no-new-standards case (*i.e.,* the case without amended or new energy conservation standards).

a. Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment

For the CUAC/CUHP NOPR, DOE used a consumer choice model to estimate efficiency market shares in the expected compliance year. The consumer choice model considers customer sensitivity to total installation cost and annual operating cost. DOE used efficiency market share data for 1999–2001, based on model availability data from the AHRI-certified directory, to develop the parameters of the consumer choice model in the shipments analysis. Using these parameters, the model estimated the shipments at each IEER level based on the installed cost and operating cost at each efficiency level.

During the Working Group meetings, DOE requested data that might improve the efficiency distribution in the no-new-standards case. AHRI provided recent market share data by efficiency based on shipments. Using these data in preparing the analysis for the direct final rule, DOE extended the AHRI data to 2019 to estimate efficiency market shares for each equipment class in the no-new-standards case.[92] These shares are presented in chapter 8 of the direct final rule TSD.

As discussed in section IV.E.1, DOE assigned CAV designs to CAV buildings and SAV and VAV designs to VAV buildings. Therefore, DOE needed to develop separate efficiency distributions for CAV, SAV, and VAV designs for each equipment class. AHRI provided market share data based on shipments of each design, which DOE used for the direct final rule analysis. (ASRAC Public Meeting, No. 98 at pp. 22–37). These data were incorporated into the NIA spreadsheet model that DOE developed. The distributions used are presented in chapter 8 of the direct final rule TSD.

b. Commercial Warm Air Furnaces

For the CWAF NOPR, DOE developed the current distribution of equipment shipments by efficiency level for the CWAF equipment classes for 2013 based on the number of models at different efficiency levels from AHRI's Certification Directory for Commercial Furnaces.[93] These data show no market share for condensing CWAFs. For condensing gas-fired CWAFs, however, DOE found that models from non-AHRI member manufacturers are just now becoming available, so DOE estimated a market share of one percent by 2018 based on the fraction of condensing models available in 2013.

Commenting on the NOPR, Lennox stated that its CWAFs are expected to remain at 80-percent TE for the foreseeable future, as there is little market demand for higher-efficiency furnaces in the commercial sector. (CWAF: Lennox, No. 22 at pp. 10–11) As discussed with the Working Group, to estimate the efficiency distribution of CWAFs for the direct final rule, DOE updated its analysis using the most recent AHRI Certification Directory for Commercial Furnaces.[94] (ASRAC Public Meeting, No. 43 at pp. 7–8) These data include most manufacturers of CWAFs. DOE agrees with Lennox that the majority of gas-fired CWAFs are expected to remain at 80-percent TE for the foreseeable future because the fraction of non-condensing models sold has remained fairly constant over the last 20 years. In addition, there is a limited number of condensing CWAF models and lack of incentives (*e.g.* rebates, tax credits or similar consumer-focused approaches) to increase the condensing CWAF market share. Therefore, DOE did not include any increase in the efficiency of non-condensing CWAFs between 2014 and 2019. Similar to the NOPR analysis, based on the limited availability condensing gas-fired CWAF models, DOE estimated a market share of one percent by 2019. The estimated efficiency market shares for CWAFs in the no-new-standards case in 2019 are presented in chapter 8 of the CWAF direct final rule TSD.

See chapter 8 of the direct final rule TSDs for further information on the derivation of the efficiency distributions.

9. Payback Period Analysis

The payback period is the amount of time it takes the consumer to recover the additional installed cost of more-efficient equipment, compared to baseline equipment, through energy cost savings. Payback periods are expressed in years. Payback periods that exceed the life of the equipment mean that the increased total installed cost is not recovered in reduced operating expenses.

The inputs to the PBP calculation for each efficiency level are the change in total installed cost of the equipment and the change in the first-year annual operating expenditures relative to the baseline efficiency level. The PBP calculation uses the same inputs as the LCC analysis, except that discount rates are not needed.

As noted above, EPCA establishes a rebuttable presumption that a standard is economically justified if the Secretary finds that the additional cost to the consumer of purchasing equipment complying with an energy conservation standard level will be less than three times the value of the first year's energy savings resulting from the standard, as

[91] Damodaran Online, The Data Page: Cost of Capital by Industry Sector, 2001–2013. (Last accessed March, 2014.) See: *http://pages.stern.nyu.edu/~adamodar/.*

[92] DOE used the 2019 efficiency distribution for all of the TSLs analyzed, including the Recommended TSL.

[93] AHRI, 2013 AHRI Certification Directory for Commercial Furnaces (Available at: *http://www.ahridirectory.org/ahridirectory/pages/home.aspx*) Last accessed Oct. 15, 2013).

[94] AHRI, 2015 AHRI Certification Directory for Commercial Furnaces (Available at: *http://www.ahridirectory.org/ahridirectory/pages/home.aspx*) Last accessed July 1, 2015).

calculated under the applicable test procedure. (42 U.S.C. 6295(o)(2)(B)(iii)) For CUACs/CUHPs, the DOE test procedure prescribes how to calculate equipment efficiency, but not annual energy use. For the rebuttable presumption PBP, DOE used the same energy use calculated for the regular PBP calculation at each efficiency level. For CWAFs, DOE calculated energy consumption using the DOE test procedure.

G. Shipments Analysis

DOE uses projections of annual equipment shipments to calculate the national impacts of potential amended energy conservation standards on energy use, NPV, and future manufacturer cash flows.[95]

1. Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment

The shipments model for CUACs and CUHPs uses a stock accounting approach, tracking the number of units and vintage for each equipment class. The vintage (or age) distribution of in-service equipment is a key input to calculations of both the NES and NPV, because equipment efficiency varies with vintage, and this in turn affects the energy use and operating costs.

The primary inputs to the shipments model are time series of total commercial floor space, market share by equipment class, new construction market saturations, and equipment lifetimes. Floor space estimates are based on historic CBECS surveys and projections from *AEO 2015.* The fraction of cooled floor space assigned to each equipment class is based on the percentage of total capacity in each class for historic shipments. The market saturation (*i.e.,* percentage of new floor space that is cooled by the covered equipment) is a function of time. Using CBECS estimates of stock saturations and historic shipments data for each equipment class, DOE calibrated the shipments model by jointly varying both equipment lifetime and fits to the CBECS stock saturation. The resulting lifetime representations were Weibull distributions with mean lifetimes of 21.1 years, 22.6 years, and 33.7 years for small, large and very large equipment classes, respectively.

a. Shipments by Market Segment

The shipments model includes three market segments: (1) New commercial buildings acquiring new equipment, (2) existing buildings acquiring new equipment for the first time, and (3) existing buildings replacing broken equipment.

DOE estimated new equipment shipments to new buildings by multiplying the market saturation values by the total new floor space in each year. DOE estimated new shipments to existing buildings as the total floor space multiplied by the change in saturation with time. This market segment is approximately zero for the analysis period, as saturations are no longer changing significantly.

Replacement shipments are those that go into existing buildings to replace broken equipment. The number of units that break each year is equal to the total equipment stock minus the number of units that survive. The number of units that survive is calculated by multiplying the equipment stock as a function of age by the survival function. The survival function is the integral of the lifetime function used in the LCC. If all units that break are replaced, then the number of replacement shipments in each year is equal to the total number of broken units. However, in general, some fraction of broken units will be replaced, which reduces the number of replacement shipments.

For CUACs and CUHPs, the end of lifetime is generally associated with compressor failure. Installing a new compressor is costly, so customers typically replace the entire unit rather than simply replace the compressor. If standards significantly increase the cost of new equipment, however, one would expect that the repair option would become more attractive.

For the CUAC/CUHP NOPR, DOE modeled the repair rates for the small and large CUACs and CUHP equipment classes using a consumer choice model.[96] This model was based on an estimated sensitivity to cost and a comparison of total installation costs for new equipment compared to repair costs. The price sensitivity was estimated by calibrating the model to historic data on total shipments, and market share by efficiency for 1999–2001. Actual repair costs were not known, so DOE estimated repair costs based on labor costs and the cost of a new compressor. DOE assumed that repair costs increase in direct proportion to the price of the equipment. Given the price sensitivity, and an estimate of the cost of repairing vs. replacing a new unit, a drop in shipments was estimated for each standard level.

ASAP commented that DOE's model overestimated the impact of higher efficiency levels on shipments. It stated that there are only 3 years of data on market share and cost (which are 15 years old), and a customer's repair/replace decision is more complex than the decision to purchase a baseline or higher efficiency unit. ASAP commented that the DOE model fails to capture a number of complex factors affecting purchase and repair decisions, such as the fact that some manufacturers offer leases that include no upfront costs. It noted that many units use R–22 as a refrigerant and since it is being phased out those units will be more expensive to service and repair. (CUAC: ASAP, No. 69 at pp. 6–7) The California IOUs, through PG&E, stated that the decision model should include factors such as the need for immediate resumption of operation to avoid placing too much weight on the first cost of more efficient equipment. (CUAC: California IOUs, No. 67 at p. 6) Rheem commented that the repair/replace decision depends on the commercial use of the building, how extensive the repair is, whether a warranty covers the repair, the cost of removal, purchase cost and installation cost. (CUAC: Rheem, No. 70 at p. 7)

For the direct final rule, DOE examined a variety of potential modifications to the modeling approach used for the NOPR. The primary difficulty is that there are multiple parameters that need to be simultaneously estimated, including the actual repair costs, consumer price sensitivity, the fraction of consumers whose repair/replace decision is not driven solely by price, and the mean lifetime of a repaired unit. As very little additional data were available for the direct final rule, DOE adopted a simpler and more transparent modeling approach.

The simplified approach still uses logistic regression to estimate the rate of purchase of new equipment by owners of broken equipment, but does not attempt to explicitly model repair costs.[97] Instead the model assumes that the change in purchases of new equipment is equal to the price elasticity multiplied by a change in the utility function. The utility function for

[95] DOE uses data on manufacturer shipments as a proxy for national sales, as aggregate data on sales are lacking. In general, one would expect a close correspondence between shipments and sales.

[96] For the very large CUACs and CUHP equipment classes, in the NOPR DOE did not use the consumer choice model and simply assumed that, in the standards cases, 100% of broken units would be repaired at the first failure, and replaced at the second failure.

[97] In statistics, logistic regression, or logit regression, or logit model is a regression model where the dependent variable is categorical. Logistic regression measures the relationship between the categorical dependent variable and one or more independent variables by estimating probabilities using a logistic function.

this logit model is defined as the total installed cost of the equipment plus the average discounted lifetime operating costs. DOE based the discount rate on commercial sector time preference premium parameters used in the NEMS Commercial Demand Module. For the price elasticity parameter, DOE presented an estimate of –0.68 to the Working Group. (ASRAC Public Meeting, No. 97 at p. 56; see also id at pp. 23–26 (background discussion)) This value is twice the value DOE has used for the residential sector, based on the assumption that commercial sector purchasers are more price sensitive. The Working Group did not object to this value, and DOE used it for the direct final rule analysis. For the standards cases, this approach predicts a drop in shipments relative to the base case due to the price increases associated with the higher IEER levels. DOE assumed that this drop in shipments represents the number of units that are repaired, so that the total number of units in the stock remains constant at all IEER levels. DOE applied this approach to all equipment capacities.

For the CUAC/CUHP NOPR, DOE assumed that if the unit is repaired (*i.e.,* with a new compressor), its life is extended by another lifetime using the same retirement function as for new equipment. If a unit encounters a second failure within the analysis period, it is replaced.

Carrier commented that while replacing a failed part with a new part returns a unit to service, it does not believe that the lifetime is reset after a repair, and therefore does not expect repaired units to last as long as new equipment. (Carrier, No. 48 at p. 7) The California IOUs, through PG&E, made a similar comment. (California IOUs, No. 67 at p. 6) Trane commented that assuming a compressor repair results in a new lifetime for the equipment is flawed—in its view, the lifetime is more likely cut in half. (Trane, No. 63 at p. 10) ASAP does not believe that a compressor repair will extend the life of the equipment by one whole lifetime, as there are also other components that could fail before the new compressor fails. (ASAP, No. 69 at p. 6)

Based on stakeholder comments, for the direct final rule, DOE assumed that the mean lifetime for repaired equipment is equal to one half the mean lifetime of new equipment.

b. Shipment Market Shares by Efficiency Level

The approach described in the preceding section provides total shipments in each equipment class for each year. To estimate the market shares of the considered efficiency levels in future shipments, DOE developed a customer choice model. The model was calibrated by estimating values for two parameters, representing customer sensitivity to total installation cost and annual operating cost.

To estimate values for the parameters, for the direct final rule the calibration method was changed to better fit the historic market shares. DOE used a maximum log likelihood approach that optimized the customer choice model fit to historical market shares at each efficiency level for the small and large CUAC equipment classes. To calibrate the model, DOE used IEER market share data for each CUAC equipment class provided by AHRI for the Working Group. These market shares are for 2011 and 2014. Starting in 2015, application of the parameters, along with data on the installed cost and operating cost at each efficiency level for each year in the analysis period, determines the market shares of each efficiency level in each year. Different sets of parameters were used to estimate market shares for CUACs and CUHP equipment classes. The details of the data and the method used can be found in chapter 9 of the CUAC/CUHP direct final rule TSD.

2. Commercial Warm Air Furnaces

For the CWAF NOPR, DOE developed shipment projections based on historical data and an analysis of key market drivers for each product. Historical shipments data were used to build up an equipment stock and also to calibrate the shipments model. Historical shipments data for CWAF equipment are very limited. DOE used 1994 shipments data from AHRI (previously the Gas Appliance Manufacturers Association, or ''GAMA'') that were presented in a report from PNNL,[98] and the historical shipments of non-heat pump commercial unitary air conditioners (CUACs and CUHPs),[99] which are usually packaged together with CWAFs. The ratio of the shipments of non-heat pump CUACs and CUHPs and the shipments of gas-fired CWAFs in 1994 was calculated.[100] DOE believes that this ratio should be reasonably stable over time, so DOE determined the historical shipments of gas-fired CWAFs by multiplying this ratio with the historical shipments of non-heat pump CUACs.

For the NOPR, since shipments data for oil-fired CWAFs were not publicly available, DOE used the ratio of oil-fired versus gas-fired residential furnace shipments from AHRI[101] and the historical shipments of gas-fired commercial furnaces to calculate the historical shipment of oil-fired commercial furnaces. DOE estimated from these data that oil-fired CWAFs account for about 1 percent of total CWAFs shipments.

Commenting on the CWAF NOPR, Lennox stated that most weatherized CWAFs are integrated into rooftop equipment that also provide cooling, so it is not logical that the CWAF NOPR has much different shipment projections than the projections for CUACs and CUHPs. (CWAF: Lennox, No. 22 at p. 11) As discussed with the Working Group, for the direct final rule, DOE modified the projection for CWAF shipments, with the results indicating that the magnitude is similar to the projected shipments for CUACs and CUHPs. (ASRAC Public Meeting, No. 41 at p. 28) Chapter 9 of the direct final rule TSD described the modifications.

a. Impact of Standards on Shipments

For the CWAF NOPR, for cases with potential CWAFs standards, DOE considered whether the increase in price would cause some commercial consumers to choose to repair rather than replace their CWAF equipment. The shipments model used a relative price elasticity to account for the combined effects of changes in purchase price and annual operating cost on the purchase versus repair decision. Because data for commercial consumers were lacking, DOE used a relative price elasticity that has been derived for residential consumers.

Commenting on the CWAF NOPR, AHRI stated that DOE's reliance on residential purchases to establish commercial product price elasticity and on car purchases to extend the elasticity over time is not appropriate. (CWAF: AHRI, No. 26 at p. 5) Lennox stated that the CUAC/CUHP NOPR projects a severe decline in shipments with amended standards, so CWAF shipment impacts should reflect a similar decline, since the two product categories are usually combined in one piece of

[98] Pacific Northwest National Laboratory (PNNL), Screening Analysis for EPACT-Covered Commercial HVAC and Water-Heating Equipment, April 2000. (Available at: *http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13232.pdf*) (Last accessed April 10, 2013).

[99] Air-Conditioning and Refrigeration Institute, Commercial Unitary Air Conditioner and Heat Pump Unit Shipments for 1980–2001 (Jan. 2005) (Prepared for Lawrence Berkeley National Laboratory).

[100] The fraction of non-heat pump CUACs equipment that is packaged with commercial furnaces is 80 percent.

[101] Air-Conditioning Heating and Refrigeration Institute, *Furnaces Historical Data (1994–2013).* 2015. (Available at: *http://www.ahrinet.org/site/497/Resources/Statistics/Historical-Data/Furnaces-Historical-Data*). (Last accessed January 7, 2015).

equipment. (CWAF: Lennox, No. 22 at p. 11) DOE notes that decreasing price elasticity over time is a common effect observed across numerous products and industries, including appliances. The automobile study used to develop the price elasticity for the NOPR contains greater detail on this effect than other studies. For the direct final rule, DOE used the same product price elasticity for CWAFs as it developed for CUACs and CUHPs. This value is twice the value DOE has used for the residential sector, based on the assumption that commercial sector purchasers are more price sensitive.

AHRI stated that the proposed standard of 82 percent TE for gas-fired CWAFs may cause some equipment switching because of installation complications resulting from larger units and modifications to handle condensate disposal. (CWAF: AHRI, No. 26 at p. 6) Trane argued that some businesses will elect to switch to less expensive electric heating options in response to a standard, and it is concerned that DOE has not modeled the possibility of fuel switching. While the effects of fuel switching would be greatest at the condensing level, Trane stated that there could be fuel switching at the lower levels as well. (CWAF: Trane, No. 27 at pp. 7–8) AGA stated that DOE did not account for fuel/product switching that will occur as a result of the proposed standard if manufacturers eliminate the manufacturing of non-condensing commercial furnaces because the 82 percent TE minimum level is no longer practical from a safety and durability point of view. (CWAF: AGA, No. 20 at p. 2)

DOE believes that a standard at 82 percent TE would cause minimal switching to electricity because of the very high operating costs of an electric furnace and significant additional electrical installation costs. DOE did not analyze such switching for the direct final rule because it is adopting a standard at 81 percent TE, a level where consumers would have no incentive to switch away from gas.

The details of the shipments analysis can be found in chapter 9 of the direct final rule TSDs.

H. National Impact Analysis

The NIA assesses the national energy savings (''NES'') and the national net present value (''NPV'') from a national perspective of total consumer costs and savings that would be expected to result from new or amended standards at specific efficiency levels.[102] (''Consumer'' in this context refers to commercial consumers of the equipment being regulated.) DOE calculates the NES and NPV based on projections of annual product shipments, along with the annual energy consumption and total installed cost data from the energy use and LCC analyses.[103] For most of the TSLs considered in this direct final rule, DOE forecasted the energy savings, operating cost savings, and equipment costs over the lifetime of CUACs/CUHPs and CWAFs sold from 2019 through 2048. For the TSLs that represent the Working Group recommendations, DOE accounted for the lifetime impacts of CUACs and CUHPs sold from 2018 through 2048 and CWAFs sold from 2023 through 2048.

DOE evaluates the impacts of new and amended standards by comparing a case without such standards with standards-case projections. The no-new-standards case characterizes energy use and consumer costs for each equipment class in the absence of new or amended energy conservation standards. For this projection, DOE considers historical trends in efficiency and various forces that are likely to affect the mix of efficiencies over time. DOE compares the no-new-standards case with projections characterizing the market for each equipment class if DOE adopted new or amended standards at specific energy efficiency levels (*i.e.,* the TSLs or standards cases) for that class. For the standards cases, DOE considers how a given standard would likely affect the market shares of equipment with efficiencies greater than the standard.

DOE uses a spreadsheet model to calculate the energy savings and the national consumer costs and savings from each TSL. Interested parties can review DOE's analyses by changing various input quantities within the spreadsheet. The NIA spreadsheet model uses typical values (as opposed to probability distributions) as inputs.

Table IV–30 summarizes the inputs and methods DOE used for the NIA analyses for the direct final rule. Discussion of these inputs and methods follows the table. See chapter 10 of the direct final rule TSDs for further details.

TABLE IV.30—SUMMARY OF INPUTS AND METHODS FOR THE NATIONAL IMPACT ANALYSIS: SMALL, LARGE, AND VERY LARGE COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT AND COMMERCIAL WARM AIR FURNACES

Inputs	Method
Shipments	See section IV.G.
Compliance Date of Standard	CUACs and CUHPs: Recommended TSL, 2018 for initial standards and 2023 for second-phase standards; Other TSLs: 2019. CWAF: Recommended TSL, 2023; Other TSLs, 2019.
Efficiency Trends	CUAC: Based on consumer choice model. CWAF: — No-New-Standards case: Based on likely trend. —Standard cases: ''roll-up'' scenario is used.
Annual Energy Consumption per Unit	Annual weighted-average values are a function of energy use at each efficiency level.
Total Installed Cost per Unit	Annual weighted-average values are a function of cost at each efficiency level. Incorporates projection of future product prices based on historical data.
Annual Energy Cost per Unit	Annual weighted-average values are a function of the annual energy consumption per unit and energy prices.
Repair and Maintenance Cost per Unit	Annual values are a function of efficiency level.

[102] The NIA accounts for impacts in the 50 States and the U.S. territories.

[103] For the NIA, DOE adjusts the installed cost data from the LCC analysis to exclude sales tax, which is a transfer.

TABLE IV.30—SUMMARY OF INPUTS AND METHODS FOR THE NATIONAL IMPACT ANALYSIS: SMALL, LARGE, AND VERY LARGE COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT AND COMMERCIAL WARM AIR FURNACES—Continued

Inputs	Method
Energy Prices	*AEO 2015* forecasts (to 2040) and extrapolation thereafter.
Energy Site-to-Primary Conversion	A time-series conversion factor based on *AEO 2015.*
Discount Rate	Three and seven percent.
Present Year	2015.

1. Equipment Efficiency Trends

A key component of the NIA is the trend in energy efficiency projected for the no-new-standards case. Section IV.F.8 describes how DOE developed an energy efficiency distribution for the no-new-standards case for each of the considered equipment classes for the first year of the forecast period.

For CUACs and CUHPs, DOE used the consumer choice model described in section IV.G to estimate efficiency market shares in each year of the shipments projection period. For each standards case, the efficiency levels that are below the standard are removed from the possible choices available to customers. The no-new-standards case shows a slight increasing trend in efficiency for small CUACs and CUHPs, but the shares were fairly constant for large and very large CUACs and CUHPs.

For the CWAF NOPR, DOE assumed no change in efficiency for non-condensing CWAFs over the shipments projection period in the no-new-standards case. For condensing gas-fired CWAFs, however, it estimated that market interest in efficiency would lead to a modest growth in market share.

Trane stated that the equipment minimum energy efficiency requirements (including CWAFs) in ASHRAE 90.1 have been updated a number of times and there is every reason to believe they will continue to be updated without further DOE equipment standards (*i.e.,* no-new-standards case). (Trane, No. 27 at p. 8) DOE agrees that ASHRAE 90.1 will continue to be updated; however, for CWAFs, the ASHRAE 90.1 requirements have not changed since 1992, so any future changes to CWAF requirements, within DOE's analysis period, are uncertain. Thus, DOE believes that its projected efficiency trend for the no-new-standards case is reasonable.

For the CWAFs standards cases, DOE used a ''roll-up'' scenario to establish the shipment-weighted efficiency for the compliance year. In this scenario, the market of products in the no-new-standards case that do not meet the standard under consideration would ''roll up'' to meet the new standard level, and the market share of products above the standard would remain unchanged. After the compliance year, DOE assumed no change in efficiency over time.

The projections of efficiency trends for CUACs/CUHPs and CWAFs are further described in chapter 10 of the direct final rule TSDs.

2. National Energy Savings

The NES analysis involves a comparison of national energy consumption of the considered products in each potential standards case (TSL) with consumption in the case without amended energy conservation standards. DOE calculated the national energy consumption by multiplying the number of units (stock) of each product (by vintage or age) by the unit energy consumption (also by vintage). Annual NES is based on the difference in national energy consumption for the no-new-standards case and for each standard case. Part of the reduction in energy consumption in a standards case may be due to decreasing shipments resulting from customers choosing to repair than replace broken equipment. Therefore, the NES calculation includes the estimated energy use of units that are repaired rather than replaced.

For CUACs, the per-unit annual site energy savings for each considered efficiency level come from the energy use analysis, which estimated energy consumption for the compliance year. For later years, DOE adjusted the per-unit annual site energy savings to account for changes in climate (cooling degree-days) and building shell efficiency based on projections in *AEO 2015*.

For CUHPs, DOE did not conduct an energy use analysis. Because the cooling-side performance of CUHPs is nearly identical to that of CUACs, DOE used the energy consumption estimates developed for CUACs to characterize the cooling-side performance of CUHPs of the same size. To characterize the heating-side performance, DOE analyzed CBECS 2003 data to develop a national-average annual energy use per square foot for buildings that use CUHPs. DOE assumed that the average COP of the CUHPs was 2.9.[104] DOE converted the energy use per square foot value to annual energy use per ton using a ton per square foot relationship derived from the energy use analysis for CUACs. This value is different for each equipment class. Because equipment energy use is a function of efficiency, DOE assumed that the annual heating energy consumption of a unit scales proportionally with its heating COP efficiency level. Finally, to determine the COPs of units with given IEERs, DOE correlated COP to IEER based on the AHRI Certified Equipment Database.[105] Thus, for any given cooling efficiency of a CUHP unit, DOE was able to establish the corresponding heating efficiency, and, in turn, the associated annual heating energy consumption.

DOE converted site electricity consumption and savings to primary energy (*i.e.,* the energy consumed by power plants to generate site electricity) using annual marginal conversion factors derived from *AEO 2015.* Cumulative energy savings are the sum of the NES for each year over the timeframe of the analysis. As explained in section IV.E, DOE did not incorporate a rebound effect for CUACs and CUHPs or CWAFs.

As noted in section IV.C.2.b and section IV.E.1, for Efficiency Level 3 for the small and large ''all other types of heating equipment'' classes and Efficiency Level 2.5 for the very large ''all other types of heating equipment'' class, the IEER values included in the ASRAC Working Group recommendations (discussed in section III.B.2) were based on an IEER differential of 0.2 compared to the ''electric resistance heating or no heating'' equipment classes. At Efficiency Level 3, based on an approach of maintaining a constant energy savings differential with the ''electric resistance heating or no heating'' equipment classes, the IEER

[104] A heating efficiency of 2.9 COP corresponds to the existing minimum heating efficiency standard for CUHPs, a value which the Department believes is representative of the heat pump stock characterized by CBECS.

[105] *http://www.ahridirectory.org/ahridirectory/pages/homeM.aspx.*

differential would be 0.3 for both the small and large ''all other types of heating equipment'' classes. Additional energy savings are realized from reducing the IEER differential to 0.2 for the small and large ''all other types of heating equipment'' classes. To calculate the additional energy savings realized from reducing the IEER differential to 0.2, DOE utilized a ''top-down'' approach by determining the national energy savings per IEER for the small and large equipment classes. DOE then multiplied the national energy savings per IEER by the IEER reduction of 0.1 to determine the additional energy savings associated with reducing the IEER differential.

For the CUHP equipment classes, DOE used the same ''top-down'' method for determining the additional energy savings realized from reducing the IEER differentials to the IEER values included in the ASRAC Working Group recommendations, as discussed in section III.B.2. As described in Section IV.C.2.b, the ASRAC Working Group recommendation included IEER values for the CUHP equipment classes based on IEER diffentials of 0.7 for all three CUHP equipment classes with electric resistance or no heating. At Efficiency Level 3, based on an approach of maintaining a constant energy savings differential with the CUAC equipment classes including electric resistance heating or no heating, the IEER differential would be 0.8, 0.9, and 1.1 for the small, large, and very large CUHP equipment classes with electric resistance or no heating, respectively. As a result, additional energy savings are realized from reducing the IEER differential to 0.7 for the CUHP equipment classes.

A more detailed description of the method and results for determining the additional energy associated with reducing the IEER differentials for both the CUAC equipment classes with all other types of heating and the CUHP equipment classes with electric resistance or no heating is given in appendix 10D of the direct final rule TSD.

In 2011, in response to the recommendations of a committee on ''Point-of-Use and Full-Fuel-Cycle Measurement Approaches to Energy Efficiency Standards'' appointed by the National Academy of Sciences, DOE announced its intention to use full-fuel-cycle (''FFC'') measures of energy use and GHGs and other emissions in the national impact analyses and emissions analyses included in future energy conservation standards rulemakings. 76 FR 51281 (August 18, 2011). After evaluating the approaches discussed in the August 18, 2011 notice, DOE published a statement of amended policy in which DOE explained its determination that EIA's NEMS is the most appropriate tool for its FFC analysis and its intention to use NEMS for that purpose. 77 FR 49701 (August 17, 2012). NEMS is a public domain, multi-sector, partial equilibrium model of the U.S. energy sector [106] that EIA uses to prepare its *Annual Energy Outlook.* The approach used for deriving FFC measures of energy use and emissions is described in appendix 10B of the direct final rule TSDs.

3. Net Present Value

The inputs for determining the NPV of the total costs and benefits experienced by consumers are: (1) Total annual installed cost; (2) total annual savings in operating costs; and (3) a discount factor to calculate the present value of costs and savings. DOE calculates net savings in each year as the difference between the no-new-standards case and each standards case in terms of total savings in operating costs versus total increases in installed costs. DOE calculates operating cost savings over the lifetime of the equipment shipped during the forecast period.

a. Total Annual Installed Cost

The total installed cost includes both the equipment price and the installation cost. DOE calculated equipment prices by efficiency level using manufacturer selling prices and weighted-average overall markup values (weights based on shares of the distribution channels used). Installation costs come from the LCC and PBP analysis.

For CUHPs, to estimate the cost at higher efficiency levels, DOE applied the same incremental equipment costs that were developed for the comparable CUAC efficiency levels for each equipment class).

As noted in section IV.F.1, DOE assumed no change in CUACs and CUHPs prices over the analysis period. For CWAFs, DOE derived a trend based on the PPI for ''Warm air furnaces,'' which shows a small rate of annual price decline. DOE applied the same trends to project prices for each CWAF equipment class at each considered efficiency level. DOE's projection of product prices is described in appendix 10C of the direct final rule TSDs.

To evaluate the effect of uncertainty regarding the price trend estimates, DOE investigated the impact of different equipment price trends on the consumer NPV for the considered TSLs. For CUACs and CUHPs, DOE conducted sensitivity analyses using one trend in which prices decline, and one in which prices rise. For CWAFs, DOE considered a high price decline case and a low price decline. The derivation of these price trends and the results of the sensitivity cases are described in appendix 10C of the direct final rule TSDs.

The NPV calculation includes the repair cost for units that are repaired rather than replaced.

b. Total Annual Operating Cost Savings

Operating cost savings are estimated by comparing total energy expenditures and repair and maintenance costs for the base case and the standards cases. DOE calculates annual energy expenditures from annual energy consumption by incorporating forecasted energy prices. To calculate future energy prices, DOE applied the projected trend in national-average commercial energy prices from the *AEO 2015* Reference case (which extends to 2040) to the recent prices derived in the LCC and PBP analysis. DOE used the trend from 2030 to 2040 to extrapolate beyond 2040. As part of the NIA, DOE also analyzed scenarios that used inputs from the *AEO 2015* Low Economic Growth and High Economic Growth cases. Those cases have higher and lower energy price trends compared to the Reference case.

c. Net Benefit

The aggregate difference each year between operating cost savings and increased equipment expenditures is the net savings or net costs. In calculating the NPV, DOE multiplies the net savings in future years by a discount factor to determine their present value. DOE estimates the NPV using both a 3-percent and a 7-percent real discount rate, in accordance with guidance provided by the Office of Management and Budget (''OMB'') to Federal agencies on the development of regulatory analysis.[107] The discount rates for the determination of NPV are in contrast to the discount rates used in the LCC analysis, which are designed to reflect a consumer's perspective. The 7-percent real value is an estimate of the average before-tax rate of return to private capital in the U.S. economy. The 3-percent real value represents the ''social rate of time preference,'' which is the rate at which society discounts

[106] For more information on NEMS, refer to *The National Energy Modeling System: An Overview,* DOE/EIA–0581 (2009) (Oct. 2009) (Available at: *http://www.eia.gov/oiaf/aeo/overview/*).

[107] OMB Circular A–4, section E (Sept. 17, 2003) (Available at: *http://www.whitehouse.gov/omb/circulars_a004_a-4).*

future consumption flows to their present value.

I. Consumer Subgroup Analysis

In analyzing the potential impact of new or amended standards on commercial consumers, DOE evaluates the impact on identifiable subgroups of consumers that may be disproportionately affected by a new or amended national standard. DOE evaluates impacts on particular subgroups of consumers by analyzing the LCC impacts and PBP for those particular consumers from alternative standard levels. For CUACs/CUHPs and CWAFs, DOE evaluated impacts on a small business subgroup using the LCC spreadsheet model. Chapter 11 in the direct final rule TSDs describes the consumer subgroup analysis.

J. Manufacturer Impact Analysis

1. Overview

DOE analyzed manufacturer impacts (*i.e.,* MIAs) to calculate the potential financial impact of amended energy conservation standards on CUAC/CUHP and CWAF manufacturers to estimate the potential impact of such standards on employment and manufacturing capacity. The MIA has both quantitative and qualitative aspects. The quantitative part of the MIA primarily relies on the GRIM, an industry cash-flow model with inputs specific to this rulemaking. The key GRIM inputs are data on the industry cost structure, equipment costs, shipments, and assumptions about markups and conversion expenditures. The key output is the INPV. Different sets of assumptions (markup scenarios) will produce different results. The qualitative part of the MIA addresses factors such as equipment characteristics, impacts on particular subgroups of firms, and important industry, market, and equipment trends. The complete MIA is outlined in chapter 12 of the CUACs/CUHPs and CWAFs direct final rule TSDs.

DOE conducted the MIA for this rulemaking in three phases. In Phase 1 of the MIA, DOE prepared profiles of the CUAC/CUHP and CWAF manufacturers that included top-down analyses that DOE used to derive preliminary financial inputs for the GRIM (*e.g.,* sales, general, and administration (*i.e.,* SG&A) expenses; research and development (''R&D'') expenses; and tax rates). DOE used public sources of information, including company SEC 10–K filings, corporate annual reports, the U.S. Census Bureau's Economic Census,[108] and Hoover's reports.[109]

In Phase 2 of the MIA, DOE prepared industry cash-flow analyses to quantify the potential impacts of an amended energy conservation standard. In general, new or more-stringent energy conservation standards can affect manufacturer cash flows in three distinct ways: (1) Create a need for increased investment; (2) raise production costs per unit; and (3) alter revenue due to higher per-unit prices and possible changes in sales volumes.

In Phase 3 of the MIA, DOE conducted structured, detailed interviews with a representative cross-section of manufacturers. During these interviews, DOE discussed engineering, manufacturing, procurement, and financial topics to validate assumptions used in the GRIM and to identify key issues or concerns. See sections IV.J.2.c in 79 FR 58948 (CUAC/CUHP NOPR) and 80 FR 6181 (CWAF NOPR) for a description of the key issues manufacturers raised during their respective interviews.

Additionally, in Phase 3, DOE evaluated subgroups of manufacturers that may be disproportionately impacted by new standards or that may not be accurately represented by the average cost assumptions used to develop the industry cash-flow analysis. For example, small manufacturers, niche players, or manufacturers exhibiting a cost structure that largely differs from the industry average could be more negatively affected. DOE identified one subgroup (*i.e.,* small manufacturers) for a separate impact analysis.

DOE applied the small business size standards published by the Small Business Administration (''SBA'') to determine whether a company is considered a small business. 65 FR 30836, 30848 (May 15, 2000), as amended by 65 FR 53533, 53544 (September 5, 2000) and codified at 13 CFR part 121. To be categorized as a small business under North American Industry Classification System (''NAICS'') code 333415, ''Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing,'' a CUAC/CUHP or CWAF manufacturer and its affiliates may employ a maximum of 750 employees. The 750-employee threshold includes all employees in a business's parent company and subsidiaries. Based on this classification, DOE identified three CUAC/CUHP manufacturers that qualify as small businesses under the SBA definition, and two CWAF manufacturers that qualify as small businesses. CUAC/CUHP and CWAF small manufacturer subgroups are discussed in sections V.B.2.d and VI.B of this document.

2. Government Regulatory Impact Model

DOE uses the GRIM to quantify the changes in cash flow due to new standards that result in a higher or lower industry value. The GRIM analysis uses a standard annual, discounted cash-flow methodology that incorporates manufacturer costs, markups, shipments, and industry financial information as inputs. The GRIM models changes in costs, distribution of shipments, investments, and manufacturer margins that could result from an amended energy conservation standard. The GRIM spreadsheet uses the inputs to arrive at a series of annual cash flows, beginning in 2015 (the base year of the analysis) and continuing to 2048. DOE calculated INPVs by summing the stream of annual discounted cash flows during this period. For CUAC/CUHP manufacturers, DOE used a real discount rate of 6.2 percent, which was derived from industry financials and then modified according to feedback received during manufacturer interviews. Similarly, using this approach, DOE estimated a real discount rate of 8.9 percent for CWAF manufacturers. The variance in discount rate is due to a different mix of manufacturers, as not all CUAC/CUHP manufacturers also produce CWAFs (and vice-versa), and resulting variances in manufacturer feedback.

The GRIM calculates cash flows using standard accounting principles and compares changes in INPV between a no-new-standards case and each standards case. The difference in INPV between the no-new-standards case and a standards case represents the financial impact of the amended energy conservation standard on manufacturers. As discussed previously, DOE collected this information on the critical GRIM inputs from a number of sources, including publicly-available data and interviews with a number of manufacturers. The GRIM results are shown in section V.B.2. Additional details about the GRIM, the discount rate, and other financial parameters can be found in chapter 12 of the CUACs/CUHPs and CWAFs direct final rule TSDs.

[108] U.S. Census Bureau, Annual Survey of Manufacturers: General Statistics: Statistics for Industry Groups and Industries (Available at: *http://factfinder2.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t*).

[109] Hoovers Inc., Company Profiles, Various Companies (Available at: *http://www.hoovers.com*). Last Accessed December 13, 2013.

a. Government Regulatory Impact Model Key Inputs

Manufacturer Production Costs

Manufacturing higher-efficiency equipment is typically more expensive than manufacturing baseline equipment due to the use of more complex components, which are typically more costly than baseline components. The changes in the MPC of the analyzed equipment can affect the revenues, gross margins, and cash flow of the industry, making these equipment cost data key GRIM inputs for DOE's analysis.

In the MIA, DOE used the MPCs for each considered efficiency level calculated in the engineering analysis, as described in section IV.C and further detailed in chapter 5 of the direct final rule TSD. In addition, DOE used information from its teardown analysis, described in chapter 5 of the TSD, to disaggregate the MPCs into material, labor, and overhead costs. To calculate the MPCs for equipment above the baseline, DOE added the incremental material, labor, and overhead costs from the engineering cost-efficiency curves to the baseline MPCs. These cost breakdowns and equipment markups were validated and revised based on manufacturer comments received during MIA interviews.

Shipments Forecasts

The GRIM estimates manufacturer revenues based on total unit shipment forecasts and the distribution of these values by equipment class and efficiency level. Changes in sales volumes and efficiency mix over time can significantly affect manufacturer finances. For the CUAC/CUHP and CWAF analyses, the GRIM used the Shipments Analysis to estimate shipments from 2015 to 2048. See chapter 9 of the CUACs/CUHPs and CWAFs direct final rule TSDs for additional details.

Conversion Costs

An amended energy conservation standard would cause manufacturers to incur one-time conversion costs to bring their production facilities and equipment designs into compliance. DOE evaluated the level of conversion-related expenditures that would be needed to comply with each considered efficiency level in each equipment class. For the MIA, DOE classified these conversion costs into two major groups: (1) Product conversion costs; and (2) capital conversion costs. Product conversion costs are one-time investments in research, development, testing, marketing, and other non-capitalized costs necessary to make product designs comply with the amended energy conservation standard. Capital conversion costs are one-time investments in property, plant, and equipment necessary to adapt or change existing production facilities such that equipment with new, compliant designs can be fabricated and assembled.

i. Commercial Unitary Air Conditioners and Heat Pumps

To evaluate the level of capital conversion expenditures manufacturers would likely incur to comply with amended energy conservation standards for CUACs/CUHPs, DOE used manufacturer interviews to gather data on the anticipated level of capital investment that would be required at each efficiency level. DOE supplemented manufacturer comments with estimates of capital expenditure requirements derived from the product teardown analysis and engineering analysis.

DOE assessed the product conversion costs at each considered efficiency level by integrating data from quantitative and qualitative sources. DOE considered market-share-weighted feedback regarding the potential cost of each efficiency level from multiple manufacturers to estimate product conversion costs and validated those numbers against engineering estimates of redesign efforts. In general, DOE assumes that all conversion-related investments occur between the year of publication of the final rule and the year by which manufacturers must comply with the new standard. The conversion cost figures used in the GRIM can be found in section V.B.2.a of this document. For additional information on the estimated product and capital conversion costs, see chapter 12 of the CUACs/CUHPs direct final rule TSD.

ii. Commercial Warm Air Furnaces

To evaluate the level of capital conversion expenditures manufacturers would likely incur to comply with amended energy conservation standards for CWAFs, two methodologies were used to develop conversion cost estimates: (1) A Top-Down approach using feedback from manufacturer interviews to gather data on the level of costs expected at each efficiency level, and (2) a Bottom-Up approach using engineering analysis inputs derived from the equipment teardown analysis and engineering model described in chapter 5 of the CWAF direct final rule TSD to evaluate the investment required to design, manufacture, and sell equipment that meets a higher energy conservation standard.

For estimating capital conversion costs, the Top-Down approach took available feedback from manufacturers and marketshare-weighted the responses to arrive at an approximation representative of the industry as a whole. Responses from manufacturers with the greatest market share were given the greatest weight, while responses from manufacturers with the lowest market share were given the lowest weight. The Bottom-Up approach took capital conversion costs from the engineering analysis on a per-manufacturer basis to develop an industry-wide cost estimate. This analysis included the expected equipment, tooling, conveyor, and plant costs associated with CWAF production, as estimated by DOE based on product tear-downs and on manufacturer interviews. The results of the two methodologies were integrated to create high and low capital conversion cost scenarios.

Product conversion costs for CWAFs are primarily driven by re-development and testing expenses. As the standard increases, increasing levels of re-development effort would be required to meet the efficiency requirements, as more equipment models would require redesign. Additionally, expected product conversion costs would ramp up significantly where DOE expects condensing technology to be necessary to meet a revised energy conservation standard.

To estimate product R&D costs, the Top-Down approach developed average costs per product platform based on manufacturer feedback. This feedback focused on the human capital investments, such as engineering and lab technician time necessary to update designs. In the Bottom-Up approach, DOE used vendor quotes, industry product information, and engineering cost estimation analysis data to estimate the expenses associated with TE testing, heat limit testing, product safety testing, reliability testing, and engineering effort.

In general, because manufacturer expenses related to meeting the new standards must occur prior to the production of compliant equipment, DOE assumes that all conversion-related investments occur between the year of publication of the direct final rule and the year by which manufacturers must comply with the amended standard. The conversion cost figures used in the GRIM can be found in section V.B.2 of this document. For additional information on the estimated product and capital conversion costs, see chapter 12 of the CWAFs direct final rule TSD.

b. Government Regulatory Impact Model Scenarios

Manufacturer Markup Scenarios

To calculate the MSPs in the GRIM, DOE applied manufacturer markups to the MPCs estimated in the engineering analysis for each equipment class and efficiency level. Modifying these manufacturer markups in the standards case yields different sets of manufacturer impacts. For the MIA, DOE modeled two standards-case manufacturer markup scenarios to represent the uncertainty regarding the potential impacts on prices and profitability for manufacturers following the implementation of amended energy conservation standards: (1) A preservation of gross margin percentage markup scenario; and (2) a preservation of per-unit operating profit markup scenario. These scenarios lead to different manufacturer markup values that, when applied to the inputted MPCs, result in varying revenue and cash flow impacts.

Under the preservation of gross margin percentage scenario, DOE applied a single uniform ''gross margin percentage'' markup across all efficiency levels, which assumes that manufacturers would be able to maintain the same amount of profit as a percentage of revenues at all efficiency levels within an equipment class. As production costs increase with efficiency, this scenario implies that the absolute dollar markup will increase as well. Based on publicly-available financial information for manufacturers of CUAC/CUHP and CWAF equipment, as well as comments from manufacturer interviews, DOE assumed the average non-production cost markup—which includes SG&A expenses, R&D expenses, interest, and profit—to be the following for each equipment class. The results are presented in Table IV–31 and Table IV–32.

TABLE IV.31—PRESERVATION OF GROSS MARGIN PERCENTAGE MARKUP FOR CUAC/CUHP EQUIPMENT IN THE NO-NEW-STANDARDS CASE

Equipment	Markup
Small Commercial Packaged Air-Conditioners ≥65,000 Btu/h and <135,000 Btu/h	1.3
Small Commercial Packaged Heat Pumps ≥65,000 Btu/h and <135,000 Btu/h	1.3
Large Commercial Packaged Air-Conditioners ≥135,000 Btu/h and <240,000 Btu/h	1.34
Large Commercial Packaged Heat Pumps ≥135,000 Btu/h and <240,000 Btu/h	1.34
Very Large Commercial Packaged Air-Conditioners ≥240,000 Btu/h and <760,000 Btu/h	1.41
Very Large Commercial Packaged Heat Pumps ≥240,000 Btu/h and <760,000 Btu/h	1.41

TABLE IV.32—PRESERVATION OF GROSS MARGIN PERCENTAGE MARKUP FOR CWAF EQUIPMENT IN THE NO-NEW-STANDARDS CASE

Equipment	Markup
Gas-fired Commercial Warm Air Furnaces ≥225,000 Btu/h	1.31
Oil-fired Commercial Warm Air Furnaces ≥225,000 Btu/h	1.28

This markup scenario assumes that manufacturers would be able to maintain their gross margin percentage markups as production costs increase in response to an amended energy conservation standard. Manufacturers stated that this scenario is optimistic and represents a high bound to industry profitability.

In the preservation of operating profit scenario, manufacturer markups are set so that operating profit one year after the compliance date of the amended energy conservation standard is the same as in the no-new-standards case. Under this scenario, as the costs of production increase under a standards case, manufacturers are generally required to reduce their markups to a level that maintains the no-new-standards case's operating profit. The implicit assumption behind this markup scenario is that the industry can only maintain its operating profit in absolute dollars after compliance with the new or amended standard is required. Therefore, operating margin in percentage terms is reduced between the no-new-standards case and standards case. DOE adjusted (*i.e.,* lowered) the manufacturer markups in the GRIM at each TSL to yield approximately the same earnings before interest and taxes in the standards case as in the no-new-standards case. This markup scenario represents a low bound to industry profitability under an amended energy conservation standard, as shown in Table IV–33 and Table IV–34 for CUAC/CUHP and CWAF equipment classes respectively. Table IV–33 includes markups for both the 2019 standard level and the 2023 standard level for CUAC/CUHP equipment adopted in this document.

TABLE IV.33—PRESERVATION OF OPERATING PROFIT MARKUPS FOR CUAC/CUHP EQUIPMENT AT THE ADOPTED STANDARD LEVELS

Equipment	Markups (2019/2023)
Small Commercial Packaged Air-Conditioners ≥65,000 Btu/h and <135,000 Btu/h	1.29/1.26
Small Commercial Packaged Heat Pumps ≥65,000 Btu/h and <135,000 Btu/h	1.29/1.27
Large Commercial Packaged Air-Conditioners ≥135,000 Btu/h and <240,000 Btu/h	1.33/1.31
Large Commercial Packaged Heat Pumps ≥135,000 Btu/h and <240,000 Btu/h	1.33/1.31
Very Large Commercial Packaged Air-Conditioners ≥240,000 Btu/h and <760,000 Btu/h	1.37/1.33
Very Large Commercial Packaged Heat Pumps ≥240,000 Btu/h and <760,000 Btu/h	1.39/1.35

TABLE IV.34—PRESERVATION OF OPERATING PROFIT MARKUPS FOR CWAFS EQUIPMENT AT THE ADOPTED STANDARD LEVELS

Equipment	Markup
Gas-fired Commercial Warm Air Furnaces ≥225,000 Btu/h	1.31
Oil-fired Commercial Warm Air Furnaces ≥225,000 Btu/h	1.28

3. Discussion of Comments

During the NOPR public meeting, interested parties commented on the assumptions and results of the NOPR analysis TSD. Oral and written comments addressed several topics, including employment impacts, conversion costs, and impacts on small businesses.

a. Employment Impacts on CUAC/CUHP Manufacturers

Nordyne expressed concern that DOE's NOPR CUAC/CUHP analysis indicates an increase in employment as a result of the rulemaking. (CUAC: Nordyne, No. 61 at p. 25) In response, DOE notes that the NOPR and Final Rule analyses present a range of potential employment impacts. These impacts are a function of the shipment forecasts and changes in production labor required to produce compliant products. At the NOPR stage, DOE presented direct employment impacts that ranged from a net loss of 94 production jobs to no change in production jobs at the proposed level.

For the final rule, DOE updated its employment analysis and continued to follow the same approach in light of the fact that, when presented with the details of DOE's analysis, manufacturers could not identify specific errors for DOE to correct. While manufacturers were unable to provide specific data regarding production employment numbers, either individually or for the industry as a whole, DOE accounted for the concerns that were raised regarding the initial projected employment impacts by incorporating the most recent data from the U.S. Census Bureau's 2013 Annual Survery of Manufacturers (ASM) and industry feedback from both written comments and the ASRAC Working Group meetings. The direct final rule analysis presents an updated set of direct employment impacts that range from a net loss of 829 jobs to no change in jobs at the adopted level.

In written comments, Lennox noted that DOE's direct employment estimates are too low. (CUAC: Lennox, No. 60 at pp. 5–6) Additionally, AHRI asked DOE to recalculate its employment forecast and methods to include all jobs associated within the equipment channel and not only the manufacturing portion. (CUAC: AHRI, No. 68 at p.41)

At the NOPR stage, DOE estimated production employment to be 1,085 workers in the no-new-standards case in 2019. For the final rule, DOE updated its analysis based on 2013 U.S. Census data, the updated engineering analysis, and the updated shipments analysis. DOE also revisited its assumption given the general feedback from industry that the initial employment figures were too low. DOE's revised direct final rule analysis forecasts that the industry will employ 2,643 production workers in the no-new-standards case in 2019.

DOE's employment analysis is based on three primary inputs: CUACs shipments in 2019, average labor content of the covered products, and an average production worker wage level. In the final rule analysis, DOE estimates there are 290,600 unit shipments in 2019. The engineering analysis shows that labor content can range from 8.2 percent to 17.5 percent of the MPC, depending on product class and model. The shipment-weighted average labor content of a unit is $342 per unit. Combining unit shipments and labor content, DOE estimates industry expenditures of $99.3 million on production labor. Using data from the ASM for NAICS code 333415, the average production worker's fully-burdened wage is $37,700 per year in the ''Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing'' industry. This value translates to 2,643 production workers supporting the industry in 2019.

When this figure was presented in ASRAC Working Group discussions, manufacturers stated that this figure was still too low. However, DOE did not receive any specific comments or suggestions on how it might modify this methodology to account for this issue. Furthermore, no manufacturer offered alternative estimates of company or industry employment data despite repeated requests in the NOPR and at the ASRAC Working Group meetings. The estimated number of production workers in DOE's analysis (*i.e.* 2,643) only accounts for the labor required to manufacture the most basic product that meets the applicable standard—it does not take into account additional features that manufacturers use to differentiate premium products, add-ons, or component in the cabinet that do not contribute to the cooling function. It also does not account for variations in worker salary for production performed in lower wage countries. These items could account for greater actual employment in the industry. Additional detail on the direct employment analysis can be found in Chapter 12 of the direct final rule TSD.

DOE notes that there were discrepancies between the NOPR Notice and NOPR TSD for CUAC/CUHP equipment with regard to the percentage of production labor that is domestically-based. For the final rule, DOE does not attempt to estimate the portion of foreign production of CUACs/CUHPs and CWAFs. Rather, the direct employment number captures the maximum number of domestic production workers based on the available data and DOE's methodology.

In response to AHRI's comments, DOE's manufacturer impact analysis focuses on the impacts to the regulated entities—the CUAC/CUHP manufacturers. The employment of component suppliers who manufacture components that may be used in a completed CUAC/CUHP system falls beyond the scope of the analysis. However, DOE does present the total employment impacts on the economy at large in the Indirect Employments Analysis in section IV.N of this document.

b. Conversion Costs Related to CUACs/CUHPs

Responding to the CUAC/CUHP NOPR, stakeholders pointed out that high capital costs and intensive redesign efforts would be required by the proposed standards. Manufacturers noted that they are currently redesigning equipment to meet ASHRAE 90.1–2013 minimum efficiency levels. Adopting a standard above ASHRAE 90.1–2013 would require the redesign of most product offerings in a short time frame. (CUAC: Nordyne, No. 61 at p. 32; Trane, No. 95 at p. 11; AHRI, No. 107 at p. 46)

DOE acknowledges manufacturers' concerns regarding the product redesign process. To lessen the product redesign burden on manufacturers to comply with ASHRAE 90.1–2013 and an amended CUACs energy conservation standard, the direct final rule adopts a two-tiered approach that applies the ASHRAE 90.1–2013 levels for compliance in 2018 (though this occurs at the end of the year and is modeled as a 2019 effective date for the purposes of the MIA) and then applies a higher standard starting in 2023, as recommended by the ASRAC Working Group.

Additionally, manufacturers stated that conversion costs of $12.7 million would not adequately cover all product conversion costs. (CUAC: Nordyne, No. 61 at p. 32; Trane, No. 95 at p. 11; AHRI, No. 107 at p. 45)

To clarify, in the CUAC/CUHP NOPR, DOE included an estimate of $12.7 million as a testing cost attributable to compliance, certification, and enforcement efforts that manufacturers would likely incur to re-rate all basic models using the IEER metric. However, this cost is only a small portion of the total conversion costs that DOE estimates that manufacturers are likely to incur. In the CUAC/CUHP NOPR, DOE expected the industry to incur $226.4 million in conversion costs at the proposed TSL. After evaluating further information gathered during additional interviews, as well as applying data from DOE's revised engineering analysis and shipments forecast, DOE estimates the industry would likely incur $520.8 million in conversion costs to comply with the CUAC/CUHP standard adopted in this direct final rule. This figure does not account for any cost savings that may result from aligning the CUACs/CUHPs and CWAFs standards' effective years. Conversion costs are discussed in detail in section V.B.2 of this document and in chapter 12 of the CUACs/CUHPs direct final rule TSD.

c. Small Business Impacts on CWAF Manufacturers

The SBA expressed concern about the impacts of the rulemaking on the one small manufacturer of CWAF equipment. Based on conversations with that small manufacturer, the SBA stated that the proposed standards are not economically feasible within the three-year period prescribed by DOE. (CWAF: SBA, No. 7 at p. 2)

For the direct final rule, DOE has adopted a later compliance date from the 2018 date proposed in the CWAF NOPR. For the direct final rule, DOE has extended the compliance year to 2023. This change will provide the small manufacturer with additional lead-time to comply with the amended standard level. In DOE's view, this additional lead-time, coupled with the more accommodating revised standards that are being adopted, will help this small manufacturer comply with the new efficiency levels in a timely manner.

K. Emissions Analysis

The emissions analysis consists of two components. The first component estimates the effect of potential energy conservation standards on power sector and site (where applicable) combustion emissions of carbon dioxide (CO_2), nitrogen oxides (NO_X), sulfur dioxide (SO_2), and mercury (Hg). The second component estimates the impacts of potential standards on emissions of two additional greenhouse gases, methane (CH_4) and nitrous oxide (N_2O), as well as the reductions to emissions of all species due to ''upstream'' activities in the fuel production chain. These upstream activities comprise extraction, processing, and transporting fuels to the site of combustion. The associated emissions are referred to as upstream emissions.

For CWAFs, the adopted standards would reduce use of fuel at the site and slightly reduce electricity use, thereby reducing power sector emissions. However, the highest efficiency levels (*i.e.,* the max-tech levels) considered for CWAFs would increase the use of electricity by the furnace and increase emissions accordingly.

For the CUACs/CUHPs and CWAF NOPRs, DOE used marginal emissions factors for CO_2 and most of the other gases that were derived from data in *AEO 2013.*

Commenting on the CUAC/CUHP NOPR and the CWAF NOPR, AHRI stated that DOE should use the most recent AEO data available, which would significantly reduce the environmental benefits resulting from reductions of CO_2, SO_2, and Hg, among other emissions. (CUAC: AHRI, No. 68 at p. 18; CWAF: AHRI, No. 26 at pp. 7–8) Nordyne and Lennox made a similar comment. (CUAC: Nordyne, No. 61 at p. 16; Lennox, No. 60 at p. 17)

For the direct final rule analysis, DOE used marginal emissions factors that were derived from data in *AEO 2015,* as described in section IV.K. The methodology is described in the appendices to chapter 13 and chapter 15 of the direct final rule TSDs.

Combustion emissions of CH_4 and N_2O are estimated using emissions intensity factors published by the EPA, GHG Emissions Factors Hub.[110] The FFC upstream emissions are estimated based on the methodology described in chapter 15 of the direct final rule TSDs. The upstream emissions include both emissions from fuel combustion during extraction, processing, and transportation of fuel, and ''fugitive'' emissions (direct leakage to the atmosphere) of CH_4 and CO_2.

The emissions intensity factors are expressed in terms of physical units per MWh or MMBtu of site energy savings. Total emissions reductions are estimated using the energy savings calculated in the national impact analysis.

For CH_4 and N_2O, DOE calculated emissions reduction in tons and also in terms of units of carbon dioxide equivalent (CO_2eq). Gases are converted to CO_2eq by multiplying each ton of gas by the gas' global warming potential (GWP) over a 100-year time horizon. Based on the Fifth Assessment Report of the Intergovernmental Panel on Climate Change,[111] DOE used GWP values of 28 for CH_4 and 265 for N_2O.

Because the on-site operation of CWAFs requires use of fossil fuels and results in emissions of CO_2, NO_X, and SO_2 at the sites where these appliances are used, DOE also accounted for the reduction in these site emissions and the associated upstream emissions due to potential standards. Site emissions were estimated using emissions intensity factors from an EPA publication.[112]

The *AEO* incorporates the projected impacts of existing air quality regulations on emissions. *AEO 2015* generally represents current legislation and environmental regulations, including recent government actions, for which implementing regulations were available as of October 31, 2014. DOE's estimation of impacts accounts for the presence of the emissions control programs discussed in the following paragraphs.

SO_2 emissions from affected electric generating units (EGUs) are subject to nationwide and regional emissions cap-and-trade programs. Title IV of the Clean Air Act sets an annual emissions cap on SO_2 for affected EGUs in the 48 contiguous States and the District of Columbia (DC). (42 U.S.C. 7651 *et seq.*)

[110] Available at: *http://www.epa.gov/climateleadership/inventory/ghg-emissions.html*.

[111] IPCC, 2013: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Chapter 8.

[112] U.S. Environmental Protection Agency, Compilation of Air Pollutant Emission Factors, AP–42, Fifth Edition, Volume I: Stationary Point and Area Sources (1998) (Available at: *http://www.epa.gov/ttn/chief/ap42/index.html*).

SO_2 emissions from 28 eastern States and DC were also limited under the Clean Air Interstate Rule (CAIR). 70 FR 25162 (May 12, 2005). CAIR created an allowance-based trading program that operates along with the Title IV program. In 2008, CAIR was remanded to EPA by the U.S. Court of Appeals for the District of Columbia Circuit, but it remained in effect.[113] In 2011, EPA issued a replacement for CAIR, the Cross-State Air Pollution Rule (CSAPR). 76 FR 48208 (August 8, 2011). On August 21, 2012, the DC Circuit issued a decision to vacate CSAPR,[114] and the court ordered EPA to continue administering CAIR. On April 29, 2014, the U.S. Supreme Court reversed the judgment of the DC Circuit and remanded the case for further proceedings consistent with the Supreme Court's opinion.[115] On October 23, 2014, the DC Circuit lifted the stay of CSAPR.[116] Pursuant to this action, CSAPR went into effect (and CAIR ceased to be in effect) as of January 1, 2015.

EIA was not able to incorporate CSAPR into *AEO 2015,* so it assumes implementation of CAIR. Although DOE's analysis used emissions factors that assume that CAIR, not CSAPR, is the regulation in force, the difference between CAIR and CSAPR is not relevant for the purpose of DOE's analysis of emissions impacts from energy conservation standards.

The attainment of emissions caps is typically flexible among EGUs and is enforced through the use of emissions allowances and tradable permits. Under existing EPA regulations, any excess SO_2 emissions allowances resulting from the lower electricity demand caused by the adoption of an efficiency standard could be used to permit offsetting increases in SO_2 emissions by any regulated EGU. In past rulemakings, DOE recognized that there was uncertainty about the effects of efficiency standards on SO_2 emissions covered by the existing cap-and-trade system, but it concluded that negligible reductions in power sector SO_2 emissions would occur as a result of standards.

Beginning in 2016, however, SO_2 emissions will fall as a result of the Mercury and Air Toxics Standards (MATS) for power plants. 77 FR 9304 (Feb. 16, 2012). In the MATS rule, EPA established a standard for hydrogen chloride as a surrogate for acid gas hazardous air pollutants (HAP), and also established a standard for SO_2 (a non-HAP acid gas) as an alternative equivalent surrogate standard for acid gas HAP. The same controls are used to reduce HAP and non-HAP acid gas; thus, SO_2 emissions will be reduced as a result of the control technologies installed on coal-fired power plants to comply with the MATS requirements for acid gas. *AEO 2015* assumes that, in order to continue operating, coal plants must have either flue gas desulfurization or dry sorbent injection systems installed by 2016. Both technologies, which are used to reduce acid gas emissions, also reduce SO_2 emissions. Under the MATS, emissions will be far below the cap established by CAIR, so it is unlikely that excess SO_2 emissions allowances resulting from the lower electricity demand would be needed or used to permit offsetting increases in SO_2 emissions by any regulated EGU.[117] Therefore, DOE believes that energy conservation standards will generally reduce SO_2 emissions in 2016 and beyond.

CAIR established a cap on NO_X emissions in 28 eastern States and the District of Columbia.[118] Energy conservation standards are expected to have little effect on NO_X emissions in those States covered by CAIR because excess NO_X emissions allowances resulting from the lower electricity demand could be used to permit offsetting increases in NO_X emissions from other facilities. However, standards would be expected to reduce NO_X emissions in the States not affected by the caps, so DOE estimated NO_X emissions reductions from the standards considered in this final rule for these States.

The MATS limit mercury emissions from power plants, but they do not include emissions caps and, as such, DOE's energy conservation standards would likely reduce Hg emissions. DOE estimated mercury emissions reduction using emissions factors based on *AEO 2015,* which incorporates the MATS.

L. Monetizing Carbon Dioxide and Other Emissions Impacts

As part of the development of this rule, DOE considered the estimated monetary benefits from the reduced emissions of CO_2 and NO_X that are expected to result from each of the TSLs considered. To make this calculation analogous to the calculation of the NPV of consumer benefit, DOE considered the reduced emissions expected to result over the lifetime of products shipped in the forecast period for each TSL. This section summarizes the basis for the monetary values used for each of these emissions and presents the values considered in this direct final rule.

For this final rule, DOE relied on a set of values for the social cost of carbon (SCC) that was developed by a Federal interagency process. The basis for these values is summarized in the next section, and a more detailed description of the methodologies used is provided as an appendix to chapter 14 of the direct final rule TSDs.

1. Social Cost of Carbon

The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) climate-change-related changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services. Estimates of the SCC are provided in dollars per metric ton of CO_2. A domestic SCC value is meant to reflect the value of damages in the United States resulting from a unit change in CO_2 emissions, while a global SCC value is meant to reflect the value of damages worldwide.

Under section 1(b) of Executive Order 12866, ''Regulatory Planning and Review,'' 58 FR 51735 (Oct. 4, 1993), agencies must, to the extent permitted by law, ''assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs.'' The purpose of the SCC estimates presented here is to allow agencies to incorporate the monetized social benefits of reducing CO_2 emissions into

[113] See *North Carolina* v. *EPA,* 550 F.3d 1176 (D.C. Cir. 2008); *North Carolina* v. *EPA,* 531 F.3d 896 (D.C. Cir. 2008).

[114] See *EME Homer City Generation, LP* v. *EPA,* 696 F.3d 7, 38 (D.C. Cir. 2012), *cert. granted,* 81 U.S.L.W. 3567, 81 U.S.L.W. 3696, 81 U.S.L.W. 3702 (U.S. June 24, 2013) (No. 12–1182).

[115] *See EPA* v. *EME Homer City Generation,* 134 S.Ct. 1584, 1610 (U.S. 2014).

[116] *See Georgia* v. *EPA,* Order *(D.C. Cir. filed October 23, 2014)* (*No. 11–1302).*

[117] DOE notes that the Supreme Court recently remanded EPA's 2012 rule regarding national emission standards for hazardous air pollutants from certain electric utility steam generating units. See *Michigan* v. *EPA* (Case No. 14–46, 2015). DOE has tentatively determined that the remand of the MATS rule does not change the assumptions regarding the impact of energy efficiency standards on SO_2 emissions. Further, while the remand of the MATS rule may have an impact on the overall amount of mercury emitted by power plants, it does not change the impact of the energy efficiency standards on mercury emissions. DOE will continue to monitor developments related to this case and respond to them as appropriate.

[118] CSAPR also applies to NO_X and it would supersede the regulation of NO_X under CAIR. As stated previously, the current analysis assumes that CAIR, not CSAPR, is the regulation in force. The difference between CAIR and CSAPR with regard to DOE's analysis of NO_X emissions is slight.

cost-benefit analyses of regulatory actions. The estimates are presented with an acknowledgement of the many uncertainties involved and with a clear understanding that they should be updated over time to reflect increasing knowledge of the science and economics of climate impacts.

As part of the interagency process that developed these SCC estimates, technical experts from numerous agencies met on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss key model inputs and assumptions. The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions grounded in the existing scientific and economic literatures. In this way, key uncertainties and model differences transparently and consistently inform the range of SCC estimates used in the rulemaking process.

a. Monetizing Carbon Dioxide Emissions

When attempting to assess the incremental economic impacts of CO_2 emissions, the analyst faces a number of challenges. A report from the National Research Council [119] points out that any assessment will suffer from uncertainty, speculation, and lack of information about: (1) Future emissions of GHGs; (2) the effects of past and future emissions on the climate system; (3) the impact of changes in climate on the physical and biological environment; and (4) the translation of these environmental impacts into economic damages. As a result, any effort to quantify and monetize the harms associated with climate change will raise questions of science, economics, and ethics and should be viewed as provisional.

Despite the limits of both quantification and monetization, SCC estimates can be useful in estimating the social benefits of reducing CO_2 emissions. The agency can estimate the benefits from reduced (or costs from increased) emissions in any future year by multiplying the change in emissions in that year by the SCC values appropriate for that year. The NPV of the benefits can then be calculated by multiplying each of these future benefits by an appropriate discount factor and summing across all affected years.

It is important to emphasize that the interagency process is committed to updating these estimates as the science and economic understanding of climate change and its impacts on society improves over time. In the meantime, the interagency group will continue to explore the issues raised by this analysis and consider public comments as part of the ongoing interagency process.

b. Development of Social Cost of Carbon Values

In 2009, an interagency process was initiated to offer a preliminary assessment of how best to quantify the benefits from reducing carbon dioxide emissions. To ensure consistency in how benefits are evaluated across Federal agencies, the Administration sought to develop a transparent and defensible method, specifically designed for the rulemaking process, to quantify avoided climate change damages from reduced CO_2 emissions. The interagency group did not undertake any original analysis. Instead, it combined SCC estimates from the existing literature to use as interim values until a more comprehensive analysis could be conducted. The outcome of the preliminary assessment by the interagency group was a set of five interim values: Global SCC estimates for 2007 (in 2006$) of $55, $33, $19, $10, and $5 per metric ton of CO_2. These interim values represented the first sustained interagency effort within the U.S. government to develop an SCC for use in regulatory analysis. The results of this preliminary effort were presented in several proposed and final rules.

c. Current Approach and Key Assumptions

After the release of the interim values, the interagency group reconvened on a regular basis to generate improved SCC estimates. Specially, the group considered public comments and further explored the technical literature in relevant fields. The interagency group relied on three integrated assessment models commonly used to estimate the SCC: The FUND, DICE, and PAGE models. These models are frequently cited in the peer-reviewed literature and were used in the last assessment of the Intergovernmental Panel on Climate Change (IPCC). Each model was given equal weight in the SCC values that were developed.

Each model takes a slightly different approach to model how changes in emissions result in changes in economic damages. A key objective of the interagency process was to enable a consistent exploration of the three models, while respecting the different approaches to quantifying damages taken by the key modelers in the field. An extensive review of the literature was conducted to select three sets of input parameters for these models: Climate sensitivity, socio-economic and emissions trajectories, and discount rates. A probability distribution for climate sensitivity was specified as an input into all three models. In addition, the interagency group used a range of scenarios for the socio-economic parameters and a range of values for the discount rate. All other model features were left unchanged, relying on the model developers' best estimates and judgments.

In 2010, the interagency group selected four sets of SCC values for use in regulatory analyses. Three sets of values are based on the average SCC from the three integrated assessment models, at discount rates of 2.5, 3, and 5 percent. The fourth set, which represents the 95th percentile SCC estimate across all three models at a 3-percent discount rate, was included to represent higher-than-expected impacts from climate change further out in the tails of the SCC distribution. The values grow in real terms over time. Additionally, the interagency group determined that a range of values from 7 percent to 23 percent should be used to adjust the global SCC to calculate domestic effects,[120] although preference is given to consideration of the global benefits of reducing CO_2 emissions. Table IV–35 presents the values in the 2010 interagency group report,[121] which is reproduced in appendix 14A of the direct final rule TSD.

[119] National Research Council, *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use,* National Academies Press: Washington, DC (2009).

[120] It is recognized that this calculation for domestic values is approximate, provisional, and highly speculative. There is no *a priori* reason why domestic benefits should be a constant fraction of net global damages over time.

[121] *Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.* Interagency Working Group on Social Cost of Carbon, United States Government (February 2010) (Available at: *www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf*).

TABLE IV–35—ANNUAL SCC VALUES FROM 2010 INTERAGENCY REPORT, 2010–2050

[2007$ per metric ton CO_2]

Year	Discount rate			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3
2045	14.2	42.1	61.7	127.8
2050	15.7	44.9	65.0	136.2

The SCC values used for this document were generated using the most recent versions of the three integrated assessment models that have been published in the peer-reviewed literature, as described in the 2013 update from the interagency Working Group (revised July 2015).[122] Table IV–36 shows the updated sets of SCC estimates from the latest interagency update in 5-year increments from 2010 to 2050. The full set of annual SCC values between 2010 and 2050 is reported in appendix 14B of the direct final rule TSD. The central value that emerges is the average SCC across models at the 3-percent discount rate. However, for purposes of capturing the uncertainties involved in regulatory impact analysis, the interagency group emphasizes the importance of including all four sets of SCC values.

TABLE IV–36—ANNUAL SCC VALUES FROM 2013 INTERAGENCY UPDATE (REVISED JULY 2015), 2010–2050

[2007$ per metric ton CO_2]

Year	Discount rate			
	5%	3%	2.5%	3%
	Average	Average	Average	95th percentile
2010	10	31	50	86
2015	11	36	56	105
2020	12	42	62	123
2025	14	46	68	138
2030	16	50	73	152
2035	18	55	78	168
2040	21	60	84	183
2045	23	64	89	197
2050	26	69	95	212

It is important to recognize that a number of key uncertainties remain, and that current SCC estimates should be treated as provisional and revisable because they will evolve with improved scientific and economic understanding. The interagency group also recognizes that the existing models are imperfect and incomplete. The National Research Council report mentioned previously points out that there is tension between the goal of producing quantified estimates of the economic damages from an incremental ton of carbon and the limits of existing efforts to model these effects. There are a number of analytical challenges that are being addressed by the research community, including research programs housed in many of the Federal agencies participating in the interagency process to estimate the SCC. The interagency group intends to periodically review and reconsider those estimates to reflect increasing knowledge of the science and economics of climate impacts, as well as improvements in modeling.

In summary, in considering the potential global benefits resulting from reduced CO_2 emissions, DOE used the values from the 2013 interagency report (revised July 2015), adjusted to 2014$ using the implicit price deflator for gross domestic product (GDP) from the Bureau of Economic Analysis. For each of the four sets of SCC cases specified, the values for emissions in 2015 were $12.2, $40.0, $62.3, and $117 per metric ton avoided (values expressed in 2014$). DOE derived SCC values after 2050 using the relevant growth rates for the 2040–2050 period in the interagency update.

DOE multiplied the CO_2 emissions reduction estimated for each year by the SCC value for that year in each of the four cases. To calculate a present value of the stream of monetary values, DOE discounted the values in each of the four cases using the specific discount rate that had been used to obtain the SCC values in each case.

In response to the CUAC/CUHP NOPR and the CWAF NOPR, DOE received a number of comments that were critical

[122] *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866,* Interagency Working Group on Social Cost of Carbon, United States Government (May 2013; revised July 2015) (Available at: *http://www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf*).

of DOE's use of the SCC values developed by the interagency group.

A group of trade associations led by the U.S. Chamber of Commerce objected to DOE's continued use of the SCC in the cost-benefit analysis and stated that the SCC calculation should not be used in any rulemaking until it undergoes a more rigorous notice, review and comment process. (CUAC: U.S. Chamber of Commerce, No. 40 at pp. 3–4; CWAF: U.S. Chamber of Commerce, No. 21 at pp. 3–4) AHRI, Lennox and Nordyne criticized DOE's use of SCC estimates that are subject to considerable uncertainty. (CUAC: AHRI, No. 68 at p. 21; Lennox, No. 60 at p. 17; Nordyne, No. 61 at p. 18; CWAF: AHRI, No. 26 at p. 9) AHRI stated that the emissions reductions and global social cost of carbon do not meet the requirement of clear and convincing evidence that a standard more stringent than ASHRAE is justified. (CWAF: AHRI, No. 26 at p. 7) AHRI stated that the interagency process was not transparent and the estimates were not subjected to peer review. (CWAF: AHRI, No. 26 at p. 12)

In response, in conducting the interagency process that developed the SCC values, technical experts from numerous agencies met on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss key model inputs and assumptions. Key uncertainties and model differences transparently and consistently inform the range of SCC estimates. These uncertainties and model differences are discussed in the interagency Working Group's reports, which are reproduced in appendix 14A and 14B of the direct final rule TSD, as are the major assumptions. Specifically, uncertainties in the assumptions regarding climate sensitivity, as well as other model inputs such as economic growth and emissions trajectories, are discussed and the reasons for the specific input assumptions chosen are explained. However, the three integrated assessment models used to estimate the SCC are frequently cited in the peer-reviewed literature and were used in the last assessment of the IPCC. In addition, new versions of the models that were used in 2013 to estimate revised SCC values were published in the peer-reviewed literature (see appendix 14B of the direct final rule TSD for discussion). Although uncertainties remain, the revised estimates that were issued in November 2013 are based on the best available scientific information on the impacts of climate change. The current estimates of the SCC have been developed over many years, using the best science available, and with input from the public. In November 2013, OMB announced a new opportunity for public comment on the interagency technical support document underlying the revised SCC estimates. 78 FR 70586. In July 2015, OMB published a detailed summary and formal response to the many comments that were received.[123] DOE stands ready to work with OMB and the other members of the interagency Working Group on further review and revision of the SCC estimates as appropriate.

AHRI stated that the use of SCC as determined on a global basis for the world population is outside of DOE's regulatory authority under EPCA. AHRI stated that EPCA authorizes DOE to conduct a national analysis of energy savings, but there are no references to global environmental impacts in the statute. (CUAC: AHRI, No. 68 at p. 21; CWAF: AHRI, No. 26 at pp. 9–11) Nordyne made similar comments. (CUAC: Nordyne, No. 61 at p. 18)

In response, DOE's analysis estimates both global and domestic benefits of CO_2 emissions reductions. Following the recommendation of the interagency Working Group, DOE places more focus on a global measure of SCC. As discussed in appendix 14A of the direct final rule TSD, the climate change problem is highly unusual in at least two respects. First, it involves a global externality: Emissions of most greenhouse gases contribute to damages around the world even when they are emitted in the United States. Consequently, to address the global nature of the problem, the SCC must incorporate the full (global) damages caused by GHG emissions. Second, climate change presents a problem that the United States alone cannot solve. Even if the United States were to reduce its greenhouse gas emissions to zero, that step would be far from enough to avoid substantial climate change. Other countries would also need to take action to reduce emissions if significant changes in the global climate are to be avoided. Emphasizing the need for a global solution to a global problem, the United States has been actively involved in seeking international agreements to reduce emissions and in encouraging other nations, including emerging major economies, to take significant steps to reduce emissions. When these considerations are taken as a whole, the interagency group concluded that a global measure of the benefits from reducing U.S. emissions is preferable. DOE's approach is not in contradiction of the requirement to weigh the need for national energy conservation, as one of the main reasons for national energy conservation is to contribute to efforts to mitigate the effects of global climate change.

AHRI and Nordyne criticized DOE's inclusion of CO_2 emissions impacts over a time period greatly exceeding that used to measure the economic costs. (CUAC: AHRI, No. 68 at p. 22; Nordyne, No. 61 at p. 18) For the analysis of national impacts of standards, DOE considers the lifetime impacts of equipment shipped in the analysis period. With respect to energy cost savings, impacts continue until all of the equipment shipped in the analysis period is retired. Emissions impacts occur over the same period. With respect to the valuation of CO_2 emissions reductions, the SCC estimates developed by the interagency Working Group are meant to represent the full discounted value (using an appropriate range of discount rates) of emissions reductions occurring in a given year. For example, CO_2 emissions in 2050 have a long residence time in the atmosphere, and thus contribute to radiative forcing, which affects global climate, for a long time. In the case of both consumer economic costs and benefits and the value of CO_2 emissions reductions, DOE is accounting for the lifetime impacts of equipment shipped in the same analysis period.

AHRI and Nordyne stated that DOE wrongly assumes that SCC values will increase over time, contrary to historical experience and to economic development science. (CUACs and CUHPs: AHRI, No. 68 at p. 22; Nordyne, No. 61 at p. 19; CWAF: AHRI, No. 26 at p. 11) In response, the SCC increases over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change (see appendix 14A of the direct final rule TSDs). The approach used by the interagency Working Group allowed estimation of the growth rate of the SCC directly using the three IAMs, which helps to ensure that the estimates are internally consistent with other modeling assumptions.

2. Social Cost of Other Air Pollutants

As noted previously, DOE has estimated how the considered energy conservation standards would reduce site NO_X emissions nationwide and decrease power sector NO_X emissions in those 22 States not affected by the CAIR.

[123] *https://www.whitehouse.gov/blog/2015/07/02/estimating-benefits-carbon-dioxide-emissions-reductions*. OMB also stated its intention to seek independent expert advice on opportunities to improve the estimates, including many of the approaches suggested by commenters.

DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from Regulatory Impact Analysis titled, *Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants,* published in June 2014 by EPA's Office of Air Quality Planning and Standards.[124] The report includes high and low values for NO_X (as $PM_{2.5}$) for 2020, 2025, and 2030 discounted at 3 percent and 7 percent,[125] which are presented in chapter 14 of the direct final rule TSD. DOE assigned values for 2021–2024 and 2026–2029 using, respectively, the values for 2020 and 2025. DOE assigned values after 2030 using the value for 2030.

DOE multiplied the emissions reduction (tons) in each year by the associated $/ton values, and then discounted each series using discount rates of 3 percent and 7 percent as appropriate. DOE will continue to evaluate the monetization of avoided NO_X emissions and will make any appropriate updates in energy conservation standards rulemakings.

DOE is evaluating appropriate monetization of avoided SO_2 and Hg emissions in energy conservation standards rulemakings. DOE has not included monetization of those emissions in the current analysis.

M. Utility Impact Analysis

The utility impact analysis estimates several effects on the electric power industry that would result from the adoption of new or amended energy conservation standards. The utility impact analysis estimates the changes in installed electrical capacity and generation that would result for each TSL. The analysis for the direct final rule is based on published output from the NEMS associated with *AEO 2015.* NEMS produces the *AEO* Reference case, as well as a number of side cases to estimate the marginal impacts of reduced energy demand on the utility sector. These marginal factors are estimated based on the changes to electricity sector generation, installed capacity, fuel consumption and emissions in the *AEO* Reference case and various side cases. Details of the methodology are provided in the appendices to Chapters 13 and 15 of the direct final rule TSDs.

The output of this analysis is a set of time-dependent coefficients capturing the change in electricity generation, primary fuel consumption, installed capacity and power sector emissions due to a unit reduction in demand for a given end use. These coefficients are multiplied by the stream of electricity use calculated in the NIA to provide estimates of selected utility impacts of new or amended energy conservation standards.

N. Employment Impact Analysis

DOE considers employment impacts in the domestic economy as one factor in selecting a standard. Employment impacts from new or amended energy conservation standards include both direct and indirect impacts. Direct employment impacts are any changes in the number of employees of manufacturers of the products subject to standards, their suppliers, and related service firms. The MIA addresses those impacts. Indirect employment impacts are changes in national employment that occur due to the shift in expenditures and capital investment caused by the purchase and operation of more-efficient appliances. Indirect employment impacts from standards consist of the net jobs created or eliminated in the national economy, other than in the manufacturing sector being regulated, caused by: (1) Reduced spending by end users on energy; (2) reduced spending on new energy supply by the utility industry; (3) increased consumer spending on new products to which the new standards apply; and (4) the effects of those three factors throughout the economy.

One method for assessing the possible effects on the demand for labor of such shifts in economic activity is to compare sector employment statistics developed by the Labor Department's Bureau of Labor Statistics (''BLS'').[126] BLS regularly publishes its estimates of the number of jobs per million dollars of economic activity in different sectors of the economy, as well as the jobs created elsewhere in the economy by this same economic activity. Data from BLS indicate that expenditures in the utility sector generally create fewer jobs (both directly and indirectly) than expenditures in other sectors of the economy.[127] There are many reasons for these differences, including wage differences and the fact that the utility sector is more capital-intensive and less labor-intensive than other sectors. Energy conservation standards have the effect of reducing consumer utility bills. Because reduced consumer expenditures for energy likely lead to increased expenditures in other sectors of the economy, the general effect of efficiency standards is to shift economic activity from a less labor-intensive sector (*i.e.,* the utility sector) to more labor-intensive sectors (*e.g.,* the retail and service sectors). Thus, the BLS data shows that the net national employment may increase due to shifts in economic activity resulting from energy conservation standards.

DOE estimated indirect national employment impacts for the standard levels considered in this direct final rule using an input/output model of the U.S. economy called Impact of Sector Energy Technologies version 3.1.1 (''ImSET'').[128] ImSET is a special-purpose version of the ''U.S. Benchmark National Input-Output'' (''I–O'') model, which was designed to estimate the national employment and income effects of energy-saving technologies. The ImSET software includes a computer-based I–O model having structural coefficients that characterize economic flows among 187 sectors most relevant to industrial, commercial, and residential building energy use.

DOE notes that ImSET is not a general equilibrium forecasting model, and understands the uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Because ImSET does not incorporate price changes, the employment effects predicted by ImSET may over-estimate actual job impacts over the long run for this rule. Therefore, DOE generated results for near-term timeframes, where these uncertainties are reduced. For more details on the employment impact analysis, see chapter 16 of the direct final rule TSDs.

[124] *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.* See Tables 4–7, 4–8, and 4–9 in the report.

[125] For the monetized NO_X benefits associated with $PM_{2.5}$, the related benefits (derived from benefit-per-ton values) are based on an estimate of premature mortality derived from the ACS study (Krewski et al., 2009), which is the lower of the two EPA central tendencies. Using the lower value is more conservative when making the policy decision concerning whether a particular standard level is economically justified so using the higher value would also be justified. If the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2012), the values would be nearly two-and-a-half times larger. (See chapter 14 of the direct final rule TSD for further description of the studies mentioned above.)

[126] Data on industry employment, hours, labor compensation, value of production, and the implicit price deflator for output for these industries are available upon request by calling the Division of Industry Productivity Studies (202–691–5618) or by sending a request by email to *dipsweb@bls.gov.*

[127] See Bureau of Economic Analysis, *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMS II),* U.S. Department of Commerce (1992).

[128] J. M. Roop, M. J. Scott, and R. W. Schultz, *ImSET 3.1: Impact of Sector Energy Technologies,* PNNL–18412, Pacific Northwest National Laboratory (2009) (Available at: *www.pnl.gov/main/publications/external/technical_reports/PNNL-18412.pdf*).

V. Analytical Results and Conclusions

The following section addresses the results from DOE's analyses with respect to the considered energy conservation standards for CUACs/CUHPs and CWAFs. It addresses the TSLs examined by DOE, the projected impacts of each of these levels if adopted as energy conservation standards for CUACs/CUHPs and CWAFs, and the standard levels that DOE is adopting in the direct final rule. Additional details regarding DOE's analyses are contained in the direct final rule TSDs supporting this document.

A. Trial Standard Levels

DOE analyzed the benefits and burdens of eight TSLs for CUACs and CUHPs that consisted of combinations of efficiency levels for each equipment class. Table V–1 presents the TSLs and the corresponding efficiency levels for CUACs and CUHPs. TSL 5 represents the maximum technologically feasible (''max-tech'') efficiency. The Recommended TSL corresponds to the standard levels recommended by the Working Group.

TABLE V–1—TRIAL STANDARD LEVELS FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT

TSL	Commercial packaged air conditioners *			Commercial packaged heat pumps *		
	Small	Large	Very large	Small	Large	Very large
	Efficiency Level **					
1	1	1	1	1	1	1
2	2	2	2	2	2	2
2.5	2.5	2.5	2.5	2.5	2.5	2.5
Recommended	3	3	2.5	3	3	2.5
3	3	3	3	3	3	3
3.5	3.5	3.5	3	3.5	3.5	3
4	4	4	4	4	4	4
5	5	5	5	5	5	5

* Small = ≥65,000 Btu/h and <135,000 Btu/h Cooling Capacity; Large = ≥135,000 Btu/h and <240,000 Btu/h Cooling Capacity; Very Large = ≥240,000 Btu/h and <760,000 Btu/h Cooling Capacity.
** For the IEERs that correspond to the efficiency levels, see Table IV–6.

DOE also analyzed the benefits and burdens of five TSLs for CWAFs, which were developed by combining specific efficiency levels for each of the equipment classes analyzed. Table V–2 presents the TSLs and the corresponding efficiency levels for CWAFs. The results for all efficiency levels that DOE analyzed are in the direct final rule TSD. TSL 5 represents the max-tech efficiency levels, which rely on condensing technology. TSL 2 corresponds to the standard levels recommended by the Working Group.

TABLE V–2—TRIAL STANDARD LEVELS FOR COMMERCIAL WARM AIR FURNACES

Equipment class	Thermal efficiency (TE)				
	TSL 1 (%)	TSL 2 (%)	TSL 3 (%)	TSL 4 (%)	TSL 5 (%)
Gas-fired Furnaces	81	81	82	82	92
Oil-fired Furnaces	81	82	81	82	92

B. Economic Justification and Energy Savings

1. Economic Impacts on Individual Commercial Consumers

DOE analyzed the economic impacts on CUAC and CWAF consumers by looking at the effects potential amended standards at each TSL would have on the LCC and PBP. DOE also examined the impacts of potential standards on commercial consumer subgroups. These analyses are discussed below.

a. Life-Cycle Cost and Payback Period

In general, higher-efficiency products affect consumers in two ways: (1) Purchase prices increase, and (2) annual operating costs decrease. Inputs used for calculating the LCC and PBP include total installed costs (*i.e.,* product price plus installation costs), and operating costs (*i.e.,* annual energy use, energy prices, energy price trends, repair costs, and maintenance costs). The LCC calculation also uses product lifetime and a discount rate. Chapter 8 of the direct final rule TSD provides detailed information on the LCC and PBP analyses.

Small, Large, and Very Large Air-Cooled Commercial Package Air Conditioning and Heating Equipment

Table V–3 through Table V–12 show the key LCC and PBP results for the TSL efficiency levels considered for each CUAC equipment class. DOE did not conduct LCC and PBP analyses for the CUHP equipment classes because energy modeling was performed only for CUAC equipment. However, the LCC and PBP results for CUACs are a close proxy for the likely consumer impacts for CUHPs because: (1) Over 98 percent of the energy savings for CUHP comes from the cooling side; (2) the per-unit savings for CUAC equipment and the cooling side of CUHP equipment are about the same; and (3) the cost of increasing efficiency for CUHPs is approximately the same as for CUACs.

In the first of each pair of tables, the simple payback is measured relative to the baseline product. In the second table, the impacts are measured relative to the efficiency distribution in the no-new-standards case in the compliance year (see section IV.F.8 of this document). The average savings reflect the fact that some consumers purchase products with higher efficiency in the no-new-standards case, and the savings refer only to the other consumers who are affected by a standard at a given TSL. Consumers for whom the LCC increases at a given TSL experience a net cost.

TABLE V.3—AVERAGE LCC AND PBP RESULTS BY EFFICIENCY LEVEL FOR SMALL AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONERS (≥65,000 BTU/H AND <135,000 BTU/H COOLING CAPACITY) *

TSL	EL	Average costs (2014$)				Simple payback (years)	Average lifetime (years)
		Installed cost	First year operating cost	Lifetime operating cost	LCC		
1 **	1	10,024	2,142	31,342	41,366	14.9	20.9
2	2	10,865	1,992	29,354	40,219	8.5	20.9
2.5	2.5	11,263	1,748	25,983	37,246	4.9	20.9
Recommended †	3	11,564	1,691	25,216	36,780	4.9	20.9
3	3	11,564	1,691	25,216	36,780	4.9	20.9
3.5	3.5	12,002	1,706	25,499	37,501	5.9	20.9
4	4	13,384	1,626	24,599	37,984	7.5	20.9
5	5	14,848	1,342	20,845	35,692	6.7	20.9

* The analysis is for equipment purchased in 2019 for all TSLs. The results for each TSL are calculated assuming that all commercial consumers use equipment at that efficiency level. The PBP is measured relative to the baseline equipment.
** TSL 1 also corresponds to the recommended standards for compliance in 2018.
† For compliance in 2023.

TABLE V.4—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR SMALL AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONERS (≥65,000 BTU/H AND <135,000 BTU/H COOLING CAPACITY) *

TSL	EL	Average LCC savings (2014$)	Percent of consumers that experience net cost (%)
1 **	1	−210	48
2	2	870	25
2.5	2.5	3,777	5
Recommended †	3	4,233	5
3	3	4,233	5
3.5	3.5	3,517	13
4	4	3,035	25
5	5	5,326	16

* The analysis is for equipment purchased in 2019 for all TSLs. The savings represent the average LCC for affected consumers.
** TSL 1 also corresponds to the recommended standards for compliance in 2018.
† For compliance in 2023.

TABLE V.5—AVERAGE LCC AND PBP RESULTS BY EFFICIENCY LEVEL FOR LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONERS (≥135,000 BTU/H AND <240,000 BTU/H COOLING CAPACITY) *

TSL	EL	Average costs (2014$)				Simple payback (years)	Average lifetime (years)
		Installed cost	First year operating cost	Lifetime operating cost	LCC		
1 **	1	17,011	3,932	60,455	77,466	1.3	22.6
2	2	17,892	3,864	59,597	77,488	2.4	22.6
2.5	2.5	18,667	3,528	54,655	73,322	2.4	22.6
Recommended †	3	19,410	3,320	51,633	71,044	2.6	22.6
3	3	19,410	3,320	51,633	71,044	2.6	22.6
3.5	3.5	19,809	3,144	49,047	68,856	2.6	22.6
4	4	20,707	2,768	43,581	64,288	2.5	22.6
5	5	24,741	2,700	43,449	68,190	4.6	22.6

* The analysis is for equipment purchased in 2019 for all TSLs. The results for each TSL are calculated assuming that all commercial consumers use equipment at that efficiency level. The PBP is measured relative to the baseline equipment.
** TSL 1 also corresponds to the recommended standards for compliance in 2018.
† For compliance in 2023.

TABLE V.6—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONERS (≥135,000 BTU/H AND <240,000 BTU/H COOLING CAPACITY) *

TSL	EL	Average LCC savings (2014$)	Percent of consumers that experience net cost (%)
1 **	1	3,997	0
2	2	3,728	10
2.5	2.5	7,991	5
Recommended †	3	10,135	2
3	3	10,135	2
3.5	3.5	12,266	1
4	4	16,803	1
5	5	12,900	11

* The analysis is for equipment purchased in 2019 for all TSLs. The savings represent the average LCC for affected consumers.
** TSL 1 also corresponds to the recommended standards for compliance in 2018.
† For compliance in 2023.

TABLE V.7—AVERAGE LCC AND PBP RESULTS BY EFFICIENCY LEVEL FOR VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONERS (≥240,000 BTU/H AND <760,000 BTU/H COOLING CAPACITY) *

TSL	EL	Average costs (2014$)				Simple payback (years)	Average lifetime (years)
		Installed cost	First year operating cost	Lifetime operating cost	LCC		
1 **	1	34,582	6,661	130,022	164,605	5.8	33.9
2	2	38,075	6,262	122,919	160,993	7.0	33.9
2.5	2.5	39,107	5,974	117,513	156,620	6.2	33.9
Recommended †	2.5	39,107	5,974	117,513	156,620	6.2	33.9
3	3	41,510	5,809	114,885	156,396	7.2	33.9
3.5	3	41,510	5,809	114,885	156,396	7.2	33.9
4	4	42,406	5,256	104,351	146,758	5.6	33.9
5	5	44,556	5,131	102,237	146,793	6.3	33.9

The analysis is for equipment purchased in 2019 for all TSLs. The results for each TSL are calculated assuming that all commercial consumers use equipment at that efficiency level. The PBP is measured relative to the baseline equipment.
** TSL 1 also corresponds to the recommended standards for compliance in 2018.
† For compliance in 2023.

TABLE V.8—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONERS (≥240,000 BTU/H AND <760,000 BTU/H COOLING CAPACITY) *

TSL	EL	Average LCC savings (2014$)	Percent of consumers that experience net cost (%)
1 **	1	1,547	7
2	2	4,777	13
2.5	2.5	8,610	7
Recommended †	2.5	8,610	7
3	3	8,881	23
3.5	3	8,881	23
4	4	18,386	3
5	5	18,338	6

* The analysis is for equipment purchased in 2019 for all TSLs. The savings represent the average LCC for affected consumers.
TSL 1 also corresponds to the recommended standards for compliance in 2018.
† For compliance in 2023.

Commercial Warm Air Furnaces

Table V–9 through Table V–12 show the key LCC and PBP results for the TSL efficiency levels considered for each CWAF equipment class. In Table V–9, the simple payback is measured relative to the baseline product. In Table V–10, the LCC savings are measured relative to the efficiency distribution in the no-new-standards case in the compliance year (see section IV.F.8 of this document).

TABLE V–9—AVERAGE LCC AND PBP RESULTS BY EFFICIENCY LEVEL FOR GAS-FIRED COMMERCIAL WARM AIR FURNACES

TSL	EL	Average costs (2014$)				Simple payback (years)	Average lifetime (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC		
1	1	2,114	1,770	28,610	30,725	1.4	23
2	1	2,114	1,770	28,610	30,725	1.4	23
3	2	2,543	1,752	28,311	30,854	12.3	23
4	2	2,543	1,752	28,311	30,854	12.3	23
5	3	3,840	1,634	26,319	30,159	11.3	23

Note: The analysis is for equipment purchased in 2019 for all TSLs. The results for each TSL are calculated assuming that all commercial consumers use equipment at that efficiency level. The PBP is measured relative to the baseline equipment.

TABLE V–10—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR GAS-FIRED COMMERCIAL WARM AIR FURNACES

TSL	EL	Average LCC savings * (2014$)	Percent of consumers that experience net cost
1	1	284	6
2	1	284	6
3	2	75	58
4	2	75	58
5	3	766	58

Note: The analysis is for equipment purchased in 2019 for all TSLs.
* The savings represent the average LCC for affected consumers.

TABLE V–11—AVERAGE LCC AND PBP RESULTS BY EFFICIENCY LEVEL FOR OIL-FIRED COMMERCIAL WARM AIR FURNACES

TSL	EL	Average costs (2014$)				Simple payback (years)	Average lifetime (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC		
1	0	6,357	3,031	49,243	55,601	NA	23
2	1	6,410	3,004	48,782	55,192	1.9	23
3	0	6,357	3,031	49,243	55,601	NA	23
4	1	6,410	3,004	48,782	55,192	1.9	23
5	2	7,861	2,829	45,673	53,534	7.5	23

Note: The analysis is for equipment purchased in 2019 for all TSLs. The results for each TSL are calculated assuming that all commercial consumers use equipment at that efficiency level. The PBP is measured relative to the baseline equipment.

TABLE V–12—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR OIL-FIRED COMMERCIAL WARM AIR FURNACES

TSL	EL	Average LCC savings * (2014$)	Percent of consumers that experience net cost
1	0	NA	0
2	1	400	11
3	0	NA	0
4	1	400	11
5	2	1,817	54

Note: The analysis is for equipment purchased in 2019 for all TSLs.
* The savings represent the average LCC for affected consumers.

b. Consumer Subgroup Analysis

In the consumer subgroup analysis, DOE estimated the impact of the considered TSLs on small businesses. Table V–13 and Table V–14 compare the average LCC savings and PBP at each efficiency level for the commercial consumer subgroup, along with the average LCC savings for the entire sample, for small and large CUACs, while Table V–15 shows similar results for gas-fired CWAFs. DOE did not conduct a consumer subgroup analysis for very large CUACs or for oil-fired CWAFs because the sample sizes available to DOE were very small.

In most cases, the average LCC savings and PBP for small businesses at the considered efficiency levels are not substantially different from the average for all commercial consumers. However, for TSLs 3 and 4 for CWAFs, the average LCC savings for small businesses are slightly negative while the average LCC savings for all commercial consumers is slightly positive. Chapter 11 of the direct final rule TSDs presents the complete LCC and PBP results for the subgroups.

TABLE V–13—COMPARISON OF LCC SAVINGS AND PBP FOR SMALL BUSINESS CONSUMERS AND ALL CONSUMERS: SMALL AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING EQUIPMENT

TSL	Average life-cycle cost savings (2014$)		Payback period (years)	
	Small businesses	All buildings	Small businesses	All buildings
1 *	–262	–210	15.4	14.9
2	522	870	8.6	8.5
2.5	2,675	3,777	5.3	4.9
Recommended **	3,003	4,233	5.3	4.9
3	3,003	4,233	5.3	4.9
3.5	2,325	3,517	6.4	5.9
4	1,756	3,035	7.7	7.5
5	3,386	5,326	7.0	6.7

* TSL 1 also corresponds to the recommended standards for compliance in 2018.
** For compliance in 2023.

TABLE V–14—COMPARISON OF LCC SAVINGS AND PBP FOR SMALL BUSINESS CONSUMERS AND ALL CONSUMERS: LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING EQUIPMENT

TSL	Average life-cycle cost savings (2014$)		Payback period (years)	
	Small businesses	All buildings	Small businesses	All buildings
1 *	3,298	3,997	1.4	1.3
2	3,008	3,728	2.7	2.4
2.5	6,082	7,991	2.7	2.4
Recommended **	7,759	10,135	2.9	2.6
3	7,759	10,135	2.9	2.6
3.5	9,449	12,266	2.8	2.6
4	12,919	16,803	2.7	2.5
5	8,990	12,900	5.0	4.6

* TSL 1 also corresponds to the recommended standards for compliance in 2018.
** For compliance in 2023.

TABLE V–15—COMPARISON OF LCC SAVINGS AND PBP FOR SMALL BUSINESS CONSUMERS AND ALL CONSUMERS: GAS-FIRED COMMERCIAL WARM AIR FURNACES

TSL	Average life-cycle cost savings (2014$)		Payback period (years)	
	Small businesses	All buildings	Small businesses	All buildings
1	223	284	1.6	1.4
2	223	284	1.6	1.4
3	–28	75	13.8	12.3
4	–28	75	13.8	12.3
5	377	766	12.1	11.3

c. Rebuttable Presumption Payback

As discussed in section III.F.2, EPCA establishes a rebuttable presumption that an energy conservation standard is economically justified if the increased purchase cost for equipment that meets the standard is less than three times the value of the first-year energy savings resulting from the standard. Section IV.F describes the approach used to calculate the PBP for the rebuttable presumption. Table V–16 and Table V–17 shows the rebuttable presumption PBPs for the considered TSLs for CUACs/CUHPs and CWAFs, respectively. While DOE examined the rebuttable-presumption criterion, it also considered whether the standard levels considered for this rule are economically justified through a more detailed analysis of the economic impacts of those levels, pursuant to 42 U.S.C. 6313(a)(6)(B)(ii). The results of that analysis serve as the basis for DOE to definitively evaluate the economic justification of a potential standard level, thereby supporting or rebutting the results of any preliminary determination of economic justification.

TABLE V–16—REBUTTABLE-PRESUMPTION PAYBACK PERIOD (YEARS) FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT

Trial Standard Level	Small air-cooled commercial package air conditioning equipment	Large air-cooled commercial package air conditioning equipment	Very large air-cooled commercial package air conditioning equipment
1 *	30.0	1.5	10.1
2	10.0	3.2	12.7
2.5	5.4	3.5	9.3
Recommended **	5.4	3.4	9.3
3	5.4	3.4	11.9
3.5	6.6	3.2	11.9
4	8.9	3.0	6.5
5	7.3	5.6	7.6

* TSL 1 also corresponds to the recommended standards for compliance in 2018.
** For compliance in 2023.

TABLE V–17—REBUTTABLE-PRESUMPTION PAYBACK PERIOD (YEARS) FOR COMMERCIAL WARM AIR FURNACE

Trial Standard Level	Gas-fired CWAFs	Oil-fired CWAFs
1	1.0	
2	1.0	1.3
3	8.1	
4	8.1	1.3
5	5.9	3.8

2. Economic Impacts on Manufacturers

As noted above, DOE performed an MIA to estimate the impact of new energy conservation standards on CUAC/CUHP and CWAF manufacturers. The following section describes the expected impacts on manufacturers at each considered TSL. Chapter 12 of the CUACs/CUHPs direct final rule TSD and chapter 12 of the CWAFs direct final rule TSD explains the analysis in further detail.

a. Industry Cash-Flow Analysis Results

Table V–18 through Table V–21 depict the financial impacts (represented by changes in INPV) of new energy standards on CUAC/CUHP and CWAF manufacturers, as well as the conversion costs that DOE expects manufacturers would incur for all product classes at each TSL. To evaluate the range of cash flow impacts on the CUAC/CUHP and CWAF industries, DOE modeled two different markup scenarios using different assumptions that correspond to the range of anticipated market responses to potential new energy conservation standards: (1) The preservation of gross margin percentage; and (2) the preservation of per-unit operating profit. Each of these scenarios is discussed immediately below.

To assess the lower (less severe) end of the range of potential impacts, DOE modeled a preservation of gross margin percentage markup scenario, in which a uniform ‘‘gross margin percentage’’ markup is applied across all potential efficiency levels. In this scenario, DOE assumed that a manufacturer's absolute dollar markup would increase as production costs increase in the standards case.

To assess the higher (more severe) end of the range of potential impacts, DOE modeled the preservation of per-unit operating profit markup scenario, which assumes that manufacturers would be able to earn the same operating margin in absolute dollars per-unit in the standards case as in the no-new-standards case. In this scenario, while manufacturers make the necessary investments required to convert their facilities to produce new standards-compliant products, operating profit does not change in absolute dollars per unit and decreases as a percentage of revenue.

The results below show potential INPV impacts for CUAC/CUHP and CWAF manufacturers; Table V–18 and Table V–20 reflect the lower bound of impacts, and Table V–19 and Table V–21 represents the upper bound, respectively.

Each of the modeled scenarios results in a unique set of cash flows and corresponding industry values at each TSL. In the following discussion, the INPV results refer to the difference in industry value between the no-new-standards case and each standards case that results from the sum of discounted cash flows from the base year 2015 through 2048, the end of the analysis period for CUACs/CUHPs and CWAFs. To provide perspective on the short-run cash flow impact, DOE includes in the discussion of the results below a comparison of free cash flow between the no-new-standards case and the standards case at each TSL in the year before new standards would take effect. This figure provides an understanding of the magnitude of the required conversion costs relative to the cash flow generated by the industry in the no-new-standards case.

Commercial Unitary Air Conditioners and Heat Pumps

TABLE V–18—MANUFACTURER IMPACT ANALYSIS FOR CUACS/CUHPS—PRESERVATION OF GROSS MARGIN PERCENTAGE MARKUP SCENARIO

	Units	No new standards case	Trial Standard Level							
			1	2	2.5	Recommended	3	3.5	4	5
INPV	2014$M	1,645	1,706	1,759	1,721	1,606.1	1,697	1,670	1,660	1,738
Change in INPV	2014$M		61	114	77	(38.5)	53	26	16	91
	%		3.7	6.9	4.7	(2.3)	3.2	1.6	1.0	5.7
Product Conversion Costs	2014$M		64.8	112.1	173.1	294.0	234.0	296.6	342.0	390.0
Capital Conversion Costs	2014$M		42.7	74.7	129.4	226.8	184.1	192.6	196.8	201.0
Total Conversion Costs	2014$M		107.5	186.8	302.5	520.8	418.1	489.2	538.8	591.0
Free Cash Flow (2019)	2014$M	81.8	41.5	11.7	(32.8)	(76.5)	(77.2)	(105.3)	(127.2)	(150.3)
Change in Free Cash Flow	%		49.3	85.7	140.1	188.8	194.4	228.8	255.5	283.8

* Values in parentheses are negative values. All values have been rounded to the nearest tenth.

M = millions.

TABLE V–19—MANUFACTURER IMPACT ANALYSIS FOR CUACS/CUHPS—PRESERVATION OF OPERATING PROFIT MARKUP SCENARIO

	Units	No new standards case	Trial Standard Level							
			1	2	2.5	Recommended	3	3.5	4	5
INPV	2014$M	1,645	1,538	1,422	1,301	1,204.1	1,197	1,138	1,025	763
Change in INPV	2014$M	....	(107)	(223)	(344)	(440.4)	(447)	(506)	(620)	(882)
	%	....	(6.5)	(13.5)	(20.9)	(26.5)	(27.2)	(30.8)	(37.7)	(53.6)
Product Conversion Costs	2014$M	....	64.8	112.1	173.1	294.0	234.0	296.6	342.0	390.0
Capital Conversion Costs	2014$M	....	42.7	74.7	129.4	226.8	184.1	192.6	196.8	201.0
Total Conversion Costs	2014$M	....	107.5	186.8	302.5	520.8	418.1	489.2	538.8	591.0
Free Cash Flow (2019)	2014$M	81.8	41.5	11.7	(32.8)	(76.5)	(77.2)	(105.3)	(127.2)	(150.3)
Change in Free Cash Flow	%	....	49.3	85.7	140.1	188.8	194.4	228.8	255.5	283.8

* Values in parentheses are negative values. All values have been rounded to the nearest tenth.
M = millions.

TSL 1 represents the most common efficiency levels in the current market for all product classes. At TSL 1, DOE estimates impacts on INPV for CUAC/CUHP manufacturers to range from −$107.0 million to $60.9 million, or a change in INPV of −6.5 percent to 3.7 percent. At this potential standard level, industry free cash flow is estimated to decrease by as much as 49.3 percent to $41.5 million, compared to the no-new-standards case value of $81.8 million in 2018, the year before the modeled compliance year. DOE anticipates that 31.5 percent of industry platforms would require redesign at a total industry conversion cost of $107.5 million at TSL 1.

TSL 2 represents EL 2 for all product classes. At TSL 2, DOE estimates impacts on INPV for CUAC/CUHP manufacturers to range from −$222.7 million to $114.0 million, or a change in INPV of −13.5 percent to 6.9 percent. At this potential standard level, industry free cash flow is estimated to decrease by as much as 85.7 percent to $11.7 million, compared to the no-new-standards case value of $81.8 million in 2018. DOE anticipates that 59.2 percent of industry platforms would require redesign at a total industry conversion cost of $186.8 million at TSL 2.

TSL 2.5 represents EL 2.5 for all product classes. At TSL 2.5, DOE estimates impacts on INPV for CUAC/CUHP manufacturers to range from −$344.0 million to $76.6 million, or a change in INPV of −20.9 percent to 4.7 percent. At this potential standard level, industry free cash flow is estimated to decrease by as much as 140.1 percent to −$32.8 million, compared to the no-new-standards case value of $81.8 million in 2018. DOE anticipates that 73.8 percent of industry platforms would require redesign at a total industry conversion cost of $302.5 million at TSL 2.5.

The recommended TSL represents adopting EL 1 for small, large and very large CUAC/CUHP equipment in 2018; and adopting EL 3 for small and large CUAC/CUHP equipment and EL 2.5 for very large CUAC/CUHP equipment in 2023. At the recommended TSL, DOE estimates impacts on INPV for CUAC/CUHP manufacturers to range from −$440.4 million to −$38.5 million, or a change in INPV of −26.8 percent to −2.3 percent. At this potential standard level, industry free cash flow is estimated to decrease by as much as 193.5 percent to −$76.5 million by 2022, compared to the no-new-standards case value of $81.8 million in 2018; and decrease by as much as 188.8 percent to −$76.5 million compared to the no-new-standards case value of $86.2 millon in 2022. DOE anticipates that 79.6 percent of industry platforms would require redesign at a total industry conversion cost of $520.8 million at the recommended TSL.

TSL 3 represents EL 3 for all product classes. At TSL 3, DOE estimates impacts on INPV for CUAC/CUHP manufacturers to range from −$447.2 million to $52.4 million, or a change in INPV of −27.2 percent to 3.2 percent. At this potential standard level, industry free cash flow is estimated to decrease by as much as 194.4 percent to −$77.2 million, compared to the no-new-standards case value of $81.8 million in the year before the compliance date (2019). DOE anticipates that 81.6 percent of industry platforms would require redesign at a total industry conversion cost of $418.1 million at TSL 3.

TSL 3.5 represents EL 3.5 for all product classes. At TSL 3, DOE estimates impacts on INPV for CUAC/CUHP manufacturers to range from −$506.4 million to $25.7 million, or a change in INPV of −30.8 percent to 1.6 percent. At this potential standard level, industry free cash flow is estimated to decrease by as much as 228.8 percent to −$105.3 million, compared to the no-new-standards case value of $81.8 million in 2018. DOE anticipates that 93.5 percent of industry platforms would require redesign at a total industry conversion cost of $489.2 million at TSL 3.5.

TSL 4 represents EL 4 for all product classes. At TSL 4, DOE estimates impacts on INPV for CUAC/CUHP manufacturers to range from −$619.6 million to $16.3 million, or a change in INPV of −37.7 percent to 1.0 percent. At this potential standard level, industry free cash flow is estimated to decrease by as much as 255.5 percent to −$127.2 million, compared to the no-new-standards case value of $81.8 million in 2018. DOE anticipates 96.0 percent of industry platforms would require redesign at a total industry conversion cost of $538.8 million at TSL 4.

TSL 5 represents max-tech across all equipment classes. At TSL 5, DOE estimates impacts on INPV CUAC/CUHP manufacturers to range from −$881.9 million to $93.1 million, or a change in INPV of −53.6 percent to 5.7 percent. At this potential standard level, industry free cash flow is estimated to decrease by as much as 283.8 percent to −$150.3 million, compared to the no-new-standards case value of $81.8 million in 2018. DOE anticipates that 98.7 percent of industry platforms would require redesign at a total industry conversion cost of $591.0 million at TSL 5.

Commercial Warm Air Furnaces

Table V–20 and Table V–21 depict the estimated financial impacts (represented by changes in INPV) of amended energy standards on CWAFs, as well as conversion costs that DOE expects manufacturers would incur for all equipment classes at each TSL. To evaluate the range of cash flow impacts on the CWAF industry associated with potential amended energy conservation standards, DOE modeled two different markup scenarios and two different conversion cost scenarios, as described in section IV.J.2.b (Government Regulatory Impact Model Scenarios). The combination of markup scenarios and conversion cost scenarios created four sets of results: (1) Preservation of Gross Margin Percentage and Low Conversion Cost scenario; (2) Preservation of Gross Margin Percentage and High Conversion Cost scenario; (3) Preservation of Operating Profit and Low Conversion Costs scenario; (4) Preservation of Operating Profit and High Conversion Costs scenario. Each of the modeled scenarios results in a unique set of cash flows and corresponding industry values at each TSL. DOE presents the highest and lowest INPV results from the combined scenarios to portray the range of potential impacts on industry. The low end of the range of impacts in the Preservation of Gross Margin Percentage and Low Conversion Costs scenario. The high end of the range of impacts is the Preservation of Operating Profit and High Conversion Costs scenario.

In the following discussion, the INPV results refer to the difference in industry value between the no-new-standards case and each standards case that results from the sum of discounted cash flows from the base year 2015 through 2048, the end of the analysis period. To provide perspective on the short-run cash flow impact, DOE includes in the discussion of the results below a comparison of free cash flow between the no-new-standards case and the standards case at each TSL in the year before the standard takes effect. This figure provides an understanding of the magnitude of the required conversion costs relative to the cash flow generated by the industry in the no-new-standards case. The set of results below shows potential INPV impacts for CWAF manufacturers; Table V–20 represents the lower bound of impacts, and Table V–21 represents the upper bound.

TABLE V–20—MANUFACTURER IMPACT ANALYSIS FOR CWAFS—PRESERVATION OF GROSS MARGIN PERCENTAGE/LOW CONVERSION COST SCENARIO *

	Units	No new standards case	Trial Standard Level				
			1	2	3	4	5
INPV	2014$M	96.3	92.6	90.5	125.2	124.8	143.5
Change in INPV	2014$M		(3.8)	(5.9)	28.8	28.4	47.2
	%		(3.9)	(6.1)	29.9	29.5	49.0
Product Conversion Costs	2014$M		6.3	6.6	12.6	12.9	18.3
Capital Conversion Costs	2014$M		0.6	0.9	1.2	1.5	64.0
Total Conversion Costs	2014$M		6.9	7.5	13.8	14.4	82.3
Free Cash Flow (2018)	2014$M	7.8	5.5	3.8	3.2	3.0	(26.9)
Free Cash Flow (change from No-new-standards case) (2018)	%		29.7	51.2	59.3	62.1	444.5

* Values in parentheses are negative values. All values have been rounded to the nearest tenth.
M = millions.

TABLE V–21—MANUFACTURER IMPACT ANALYSIS FOR CWAFS—PRESERVATION OF OPERATING PROFIT/HIGH CONVERSION COST SCENARIO *

	Units	No new standards case	Trial Standard Level				
			1	2	3	4	5
INPV	2014$M	96.3	86.5	83.5	106.2	101.2	85.5
Change in INPV	2014$M		(10.6)	(13.4)	10.3	5.0	(11.3)
	%		(11.0)	(13.9)	(32.0)	(37.3)	(120.1)
Product Conversion Costs	2014$M		11.3	17.1	36.6	42.4	83.6
Capital Conversion Costs	2014$M		4.4	5.1	4.5	5.2	73.8
Total Conversion Costs	2014$M		15.7	22.2	41.0	47.6	157.4
Free Cash Flow (2018)	2014$M	7.8	2.2	(1.5)	(7.5)	(10.4)	(59.5)
Free Cash Flow (change from No-new-standards case) (2018)	%		72.3	119.3	196.5	233.4	861.3

* Values in parentheses are negative values. All values have been rounded to the nearest tenth.
M = millions.

In its analysis, DOE ran four scenarios based on combinations from two markup scenarios and two conversion cost scenarios. The results presented below represent the upper-bound and lower-bound of results from those scenarios only. Chapter 12 of the CWAF direct final rule TSD presents results for each markup and conversion cost scenario in further detail.

TSL 1 represents EL 1 (81 percent) for gas-fired CWAFs and baseline (81 percent) for oil-fired CWAFs. At this level, DOE estimates 55 percent of the industry platforms would require redesign at a total industry conversion cost of $6.9 million to $15.7 million. DOE estimates impacts on INPV for CWAF manufacturers to range from a change in INPV of −11.0 percent to −3.9 percent, or −$10.6 million to -$3.8 million. At this potential standard level, industry free cash flow is estimated to decrease by as much as 72.3 percent to $2.2 million, compared to the no-new-standards case value of $7.3 million in 2018, the year before the 2019 compliance year.

The recommended TSL represents an EL (81 percent for gas-fired and 82 percent for oil-fired) applicable across all equipment classes. At this level, DOE estimates 57.0 percent of the industry platforms would require redesign at at total industry conversion cost of $7.5 to $22.2 million. DOE estimates impacts on INPV for CWAF manufacturers to range from a change in INPV of −13.9 percent to −6.1 percent, or a change of −$13.4 million to −$5.9 million. At this potential standard level, industry free cash flow is estimated to decrease by much as 119.3 percent to −$1.5 million, compared to the no-new-standards case value of $7.3 million in 2022, the year before the 2023 compliance year. Much of this drop in free cash flow is due to conversion cost expenses manufacturers must make before the compliance year. However, industry noted that the alignment of the compliance dates for the CUAC/CUHP and CWAF standards would allow for coordination of redesign and testing expenses. If this occurs, there would be a reduction in the total conversion costs associated with this direct final rule. These synergies resulting from the alignment of the compliance dates for these standards would result in INPV impacts and free cash flow impacts that are less severe than forecasted by the GRIM model.

TSL 3 represents EL 2 (82 percent) for gas-fired equipment and baseline (81 percent) for oil-fired equipment. At this level, DOE estimates 91 percent of the industry platforms would require redesign at a total industry conversion cost of $13.8 million to $41.0 million. DOE estimates impacts on INPV for CWAF manufacturers to range from a change in INPV of −32.0 percent to 29.9 percent, or −$30.9 million to $28.8 million. At this potential standard level, industry free cash flow is estimated to decrease by as much as 196.5 percent to −$7.5 million, compared to the no-new-standards case value of $7.3 million in 2018.

TSL 4 represents EL 2 (82 percent) for gas-fired equipment and EL 1 (82 percent) for oil-fired equipment. At this level, DOE estimates 94 percent of the industry platforms would require redesign at a total industry conversion cost of $14.4 million to $47.6 million. DOE estimates impacts on INPV for CWAF manufacturers to range from a change in INPV of −37.3 percent to 29.5 percent, or −$35.9 million to $28.4 million. At this potential standard level, industry free cash flow is estimated to decrease by as much as 233.4 percent to −$10.4 million, compared to the no-new-standards case value of $7.3 million in 2018.

TSL 5 represents max-tech across all equipment classes (*i.e.,* EL 3 (92 percent) for gas-fired equipment and EL 2 (92 percent) for oil-fired equipment). At this level, DOE estimates 99 percent of the industry platforms would require redesign at a total industry conversion cost of $82.3 million to $157.4 million. Conversion costs more than triple from TSL 4 to TSL 5. The vast majority of the industry does not offer condensing commercial furnaces today and would need to develop condensing technology for commercial applications. Implementing a condensing commercial furnace would likely have design implications for the cooling side of the HVAC product and for the chassis that houses both the cooling and heating components. DOE estimates impacts on INPV for CWAF manufacturers to range from a change in INPV of -120.1 percent to 49.0 percent, or −$115.7 million to $47.2 million. At this potential standard level, industry free cash flow is estimated to decrease by as much as 861.3 percent to -$59.5 million relative to the no-new-standards case value of $7.3 million in 2018.

b. Impacts on Employment

To quantitatively assess the impacts of energy conservation standards on direct employment in the collective CUAC/CUHP and CWAF industry, DOE used the GRIM to estimate the domestic labor expenditures and number of employees in the no-new-standards case and at each TSL from 2015 through 2048, the end of the analysis period. DOE used statistical data from the U.S. Census Bureau's 2013 Annual Survey of Manufacturers (ASM),[1] the results of the engineering analysis, and interviews with manufacturers to determine the inputs necessary to calculate industry-wide labor expenditures and domestic employment levels. Labor expenditures related to manufacturing of the product are a function of the labor intensity of the product, the sales volume, and an assumption that wages remain fixed in real terms over time. The total labor expenditures in each year are calculated by multiplying the MPCs by the labor percentage of MPCs.

The total labor expenditures in the GRIM were then converted to domestic production employment levels by dividing production labor expenditures by the annual payment per production worker (production worker hours multiplied by the labor rate found in the U.S. Census Bureau's 2013 ASM). The estimates of production workers in this section cover workers, including line-supervisors who are directly involved in fabricating and assembling a product within the manufacturing facility. Workers performing services that are closely associated with production operations, such as materials handling tasks using forklifts, are also included as production labor. DOE's estimates only account for production workers who manufacture the specific products covered by this rulemaking.

The employment impacts shown in Table V–22 and Table V–23 represent the potential production employment changes that could result in 2019 for the collective CUAC/CUHP and CWAF industry, respectively. The upper end of the results in the table estimates the maximum increase in the number of production workers after the implementation of new energy conservation standards, and it assumes that manufacturers would continue to produce the same scope of covered products within the United States. The total direct employment impacts calculated in the GRIM are the changes in the number of production workers resulting from the amended energy conservation standards. In general, more efficient equipment is larger, more complex, and more labor intensive to build. Per unit labor requirements and production time requirements increase with a higher energy conservation standard. As a result, if shipments remain relatively steady, the model forecasts job growth at the upper bound on impact.

The lower bound assumes that, as the standard increases, manufacturers choose to retire sub-standard product lines rather than invest in manufacturing facility conversions and product redesigns. In this scenario, there is a loss of employment because manufacturers consolidate and operate fewer production lines. Since this is intended to be a worst-case scenario for employment, there is no consideration given to the fact that there may be employment growth in higher-efficiency lines. Additional detail can be found in chapter 12 of the TSDs.

DOE estimates that in the absence of amended energy conservation standards, there would be 2,643 domestic production workers for CUAC/CUHP equipment and 232 domestic production workers for CWAF equipment. For the final rule, DOE does not attempt to estimate the portion of production that occurs in other countries. Rather, as noted in section IV.J.3, the direct employment figure captures the maximum number of domestic production workers based on the available data and DOE's methodology. One noted constraint is that the production worker calculation methodology only takes into account the labor required for the most basic product that meets the appliance standard—it does not account for

[1] ''Annual Survey of Manufactures (ASM),'' U.S. Census Bureau (2013) (Available at: *http://www.census.gov/manufacturing/asm/*).

additional features that manufacturers use to differentiate premium products, optional features and add-ons, or components in the cabinet that do not contribute to the cooling and heating functions.

TABLE V–22—POTENTIAL CHANGES IN THE NUMBER OF CUACS/CUHPS INDUSTRY PRODUCTION WORKER EMPLOYMENT IN 2019

	Trial Standard Level *								
	No-new-standards case	1	2	2.5	Recommended TSL	3	3.5	4	5
Total Number of Domestic Production Workers in 2019.	2,643	2,954 to 1,810.	3,341 to 1,078.	3,577 to 692.	3,410 to 1,810.	4,005 to 486.	4,051 to 172.	3,825 to 106.	5,352 to 34.
Potential Changes in Domestic Production Workers in 2019.	....	311 to (833)	698 to (1,565).	934 to (1,951).	777 to (833)	1,362 to (2,157).	1,408 to (2,471).	1,182 to (2,537).	2,709 to (2,609).

* Numbers in parentheses represent negative values.

TABLE V–23—POTENTIAL CHANGES IN THE NUMBER OF CWAFS INDUSTRY PRODUCTION WORKER EMPLOYMENT IN 2019

	Trial Standard Level *					
	No-new-standards case	1	2	3	4	5
Total Number of Domestic Production Workers in 2019.	232	231 to 104	232 to 100	320 to 21	320 to 14	228 to 2.
Potential Changes in Domestic Production Workers in 2019.	....	(1) to (128)	0 to (132)	88 to (211)	88 to (218)	(4) to (230).

* Numbers in parentheses represent negative values.

DOE notes that the employment impacts discussed here are independent of the indirect employment impacts to the broader U.S. economy, which are documented in chapter 15 of the CUACs/CUHPs and CWAFs direct final rule TSDs.

c. Impacts on Manufacturing Capacity

Commercial Unitary Air Conditioners and Heat Pumps

CUAC/CUHP manufacturers noted during interviews that amended energy conservation standards could lead to higher fabrication labor hours. However, they also noted that industry shipments were down 40 percent from their peak in the 2007–2008 timeframe. Excess capacity in the industry today and any drop in shipments that result from higher prices could offset the additional production times. In the long-term, no manufacturers interviewed expected to have capacity constraints.

Manufacturers did, however, note concerns that engineering and testing capacity during the time period between the final rule's anticipated publication date and the 2019 compliance date initially proposed by DOE. Manufacturers were worried about the level of technical resources required to redesign and test all products at higher TSLs. The engineering analysis released with the NOPR showed that increasingly complex components and control strategies would be required as standards levels increase. Manufacturers noted in interviews that the industry would need to add electrical engineering and control systems, as well as engineering talent beyond current staffing, to meet the redesign requirements of higher TSLs. They also noted that additional training might be needed for manufacturing engineers, laboratory technicians, and service personnel if variable-speed components are broadly adopted. Furthermore, manufacturers indicated that as the stringency of standards increase, units tend to grow in size, requiring more lab resources and time to test. Some manufacturers were concerned that an amended standard would trigger the need for new test lab facilities, which would require significantly more lead time than what DOE had proposed to provide in its NOPR.

Commercial Warm Air Furnaces

According to the CWAF manufacturers interviewed, amended energy conservation standards could lead to decreased production capacity. Most manufacturers indicated there would be little to no production capacity decrease at 81 percent and 82 percent efficiency levels, but at 91 percent and 92 percent, there would be significant capacity shortfalls. This feedback is consistent with the engineering analysis, which found there would be sufficient capacity at current levels to meet slightly higher efficiency standards, but that significant investment would be required to support production of higher efficiency, condensing furnace standards. For additional information on the engineering analysis, see chapter 5 of the CWAF direct final rule TSD.

d. Impacts on Subgroups of Manufacturers

Small manufacturers, niche equipment manufacturers, and manufacturers exhibiting a cost structure substantially different from the industry average could be affected disproportionately. As discussed in section IV.J, using average cost assumptions developed for an industry cash-flow estimate is inadequate to assess differential impacts among manufacturer subgroups.

For the collective CUAC/CUHP and CWAF industry, DOE identified and evaluated the impact of new energy conservation standards on one subgroup—small manufacturers. The SBA defines a ''small business'' as having 750 employees or less for NAICS 333415, ''Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing.'' Based on this definition, DOE identified three CUAC/CUHP manufacturers and two CWAF manufacturers that qualify as small businesses. For a discussion of the impacts on the small manufacturer subgroup, see the regulatory flexibility analysis in section VI.B of this document.

e. Cumulative Regulatory Burden

While any one regulation may not impose a significant burden on manufacturers, the combined effects of recent or impending regulations may have serious consequences for some manufacturers, groups of manufacturers, or an entire industry. Assessing the impact of a single regulation may overlook this cumulative regulatory burden. In addition to energy conservation standards, other regulations can significantly affect manufacturers' financial operations. Multiple regulations affecting the same manufacturer can strain profits and lead companies to abandon product lines or markets with lower expected future returns than competing products. For these reasons, DOE conducts an analysis of cumulative regulatory burden as part of its rulemakings pertaining to appliance efficiency.

During previous stages of this rulemaking, DOE identified a number of requirements in addition to new energy conservation standards for CUAC/CUHP and CWAF equipment. The following section briefly summarizes those identified regulatory requirements and addresses comments DOE received with respect to cumulative regulatory burden, as well as other key related concerns that manufacturers raised during interviews.

DOE Energy Conservation Standards

Companies that produce a wide range of regulated products and equipment may face more capital and product development expenditures than competitors with a narrower scope of products and equipment. Many CUAC/CUHP and CWAF manufacturers also produce other residential and commercial equipment. In addition to the amended energy conservation standard for CUAC/CUHP and CWAF equipment, these manufacturers contend with several other Federal regulations and pending regulations that apply to other products and equipment. DOE recognizes that each regulation can significantly affect a manufacturer's financial operations. Multiple regulations affecting the same manufacturer can quickly strain manufacturer profits and possibly cause an exit from the market. Table V–24 lists the other DOE energy conservation standards that could also affect CUAC/CUHP and CWAF manufacturers in the three years leading up to and after the compliance date of the new energy conservation standards for this equipment. Additionally, at the request of stakeholders, DOE has listed several pending DOE rulemakings in the table below.

TABLE V–24—OTHER DOE REGULATIONS IMPACTING CUAC/CUHP AND CWAF MANUFACTURERS

Federal energy conservation standards	Approximate compliance date	Estimated total industry conversion expense
2007 Residential Furnaces & Boilers,* 72 FR 65136 (Nov. 19, 2007)	2015	$88M (2006$)
2010 Gas Fired and Electric Storage Water Heaters, 75 FR 20112 (April 16, 2010)	2015	95.4M (2009$)
2011 Residential Furnaces ** 76 FR 37408 (June 27, 2011); 76 FR 67037 (Oct. 31, 2011)	2015	2.5M (2009$)
2011 Residential Central Air Conditioners and Heat Pumps,** 76 FR 37408 (June 27, 2011); 76 FR 67037 (Oct. 31, 2011)	2015	26.0M (2009$)
Walk-in Coolers and Freezers, 79 FR 32049 (June 3, 2014)	2017	35.2M (2012$)
Commercial and Industrial Fans and Blowers †	2018	TBD
Furnace Fans, 79 FR 38129 (July 3, 2014)	2019	40.6M (2012$)
Packaged Terminal Air Conditioners and Heat Pumps, 80 FR 43162 (July 21, 2015); 80 FR 56894 (Sept. 21, 2015)	2019	7.6M (2013$)
Residential Boilers †	2019	TBD
Commercial Packaged Boilers †	2019	TBD
Single Package Vertical Units, 80 FR 57438 (Sept. 23, 2015)	2019	9.2M (2014$)
Residential Non-Weatherized Gas Furnaces †	2019	TBD
Residential Central Air Conditioners and Heat Pumps †	2021	TBD
Residential Water Heaters †	2021	TBD

* Conversion expenses for manufacturers of oil-fired furnaces and for manufacturers of gas-fired and oil-fired boilers associated with the November 2007 final rule for residential furnaces and boilers are excluded from this figure. With regard to oil-fired furnaces, the 2011 direct final rule for residential furnaces sets a higher standard and earlier compliance date for oil-fired furnaces than the 2007 final rule. As a result, manufacturers will be required design to the 2011 direct final rule standard. The conversion costs associated with the 2011 direct final rule are listed separately in this table. With regard to gas-fired and oil-fired boilers, EISA 2007 legislated higher standards and earlier compliance dates for residential boilers than were in the November 2007 final rule. As a result, gas-fired and oil-fired boiler manufacturers were required to design to the EISA 2007 standard beginning in 2012.

** Estimated industry conversion expense and approximate compliance date reflect a court-ordered May 1, 2013 stay of the residential non-weatherized and mobile home gas furnaces standards set in the 2011 Energy Conservation Standards for Residential Furnaces and Residential Central Air Conditioners and Heat Pumps.

† The final rule for this energy conservation standard has not been published. For energy conservation standards with a published NOPR, DOE lists the compliance date and conversion costs for the proposed standard level. However, standard level and analytical results are not finalized until the publication of the final rule. For energy conservation standards that have not yet reached the NOPR publication phase of the rulemaking, information is not yet available.

In addition to Federal energy conservation standards, DOE identified other Federal regulatory burdens that would affect CUAC/CUHP and CWAF manufacturers:

EPA Phase-Out of Hydrochlorofluorocarbons (HCFCs)

The U.S. is obligated under the Montreal Protocol to limit the production and consumption of HCFCs through incremental reductions, culminating in a complete phase-out of HCFCs by 2030. On October 28, 2015, EPA published the ''2015 HCFC Allocation Rule,'' which allocates production and consumption allowances for HCFC–22, HCFC–123, and HCFC–124 for each year between 2015 and 2019. 79 FR 64253. Production and import of virgin HCFC–22 for servicing appliances will cease at the end of 2019, however reclaimed material and stocks of refrigerant produced prior to 2020 will be available to service existing appliances.

HCFC–22, which is also known as R–22, is a popular refrigerant that is commonly used in air-conditioning products. As of January 1, 2010, EPA effectively prohibited the installation in the field of new appliances containing virgin R–22. 74 FR 66412. Additionally, there is a prohibition on the manufacture of new appliances and appliance components pre-charged with R–22 as of the same date. However, manufacturers can still manufacture components for servicing existing appliances. 74 FR 66450. Under the Clean Air Act and EPA's implementing regulations at 40 CFR part 82, subpart A, starting January 1, 2020, it will be illegal to manufacture any appliance containing virgin HCFCs. Manufacturers of CUAC/CUHP and CWAF equipment must comply with the these prohibitions and the allowances established by the allocation rule, thereby facing a cumulative regulatory burden. As such, no covered manufacturers offer R–22 products today. The MPCs used for the baseline and higher efficiency design options account for the move away from R–22 and the changes in production costs that resulted from the shift to HFC refrigerants.

DOE Certification, Compliance, and Enforcement (CC&E) Rule

Any amended standard that DOE adopts would also require manufacturers to follow accompanying CC&E requirements. DOE conducted a rulemaking to expand the coverage of DOE's alternative efficiency determination method (''AEDM'') regulations to commercial HVAC, including the equipment covered by this rulemaking. See 78 FR 79579 (December 31, 2013). An AEDM is a computer modeling or mathematical tool that predicts the performance of non-tested basic models of a type of covered equipment or product. In that final rule, DOE permits manufacturers of small, large, and very large air-cooled commercial package air conditioning equipment to rate basic models using AEDMs for compliance certification purposes, reducing the need for sample units and the overall burden on manufacturers. The AEDM final rule established revised verification tolerances for small, large, and very large air-cooled commercial package air conditioning equipment manufacturers. More information can be found at *http://www1.eere.energy.gov/buildings/appliance_standards/implement_cert_and_enforce.html*.

EPA ENERGY STAR

During interviews, some manufacturers stated that ENERGY STAR specifications for CUACs/CUHPs and CWAFs would be a source of cumulative regulatory burden.

DOE realizes that the cumulative effect of several regulations on an industry may significantly increase the burden faced by manufacturers that need to comply with multiple regulations and certification programs from different organizations and levels of government.

However, DOE notes that certain programs, such as ENERGY STAR, are optional for manufacturers. As these programs are voluntary in nature, they are not considered by DOE to be part of the manufacturers' cumulative regulatory burden since manufacturers are not legally required to meet the specifications prescribed by these voluntary programs.

DOE discusses these and other requirements (*e.g.,* Canadian Energy Efficiency Regulations, California Title 24, Low NO_X requirements), and includes the full details of the cumulative regulatory burden analysis, in chapter 12 of the direct final rule TSDs. DOE also discusses the impacts on the small manufacturer subgroup in the regulatory flexibility analysis in section VI.B of this direct final rule.

3. National Impact Analysis

DOE's analysis of the various national impacts flowing from amending the energy conservation standards for CUACs/CUHPs and CWAFs are summarized below and include a discussion of the energy savings and the related economic impacts that are projected to occur.

a. Significance of Energy Savings

To estimate the energy savings attributable to potential standards for CUACs/CUHPs and CWAFs, DOE compared their energy consumption under the no-new-standards case to their anticipated energy consumption under each TSL. For most of the TSLs considered in this direct final rule, DOE forecasted the energy savings, operating cost savings, and equipment costs over the lifetime of CUACs/CUHPs and CWAFs sold from 2019 through 2048. For the TSLs that represent the consensus recommendations, DOE accounted for the lifetime impacts of CUACs and CUHPs sold from 2018 through 2047 and CWAFs sold from 2023 through 2048. Table V–25 and Table V–26 present DOE's projections of the national energy savings for each TSL considered for CUACs/CUHPs and CWAFs, respectively. The savings were calculated using the approach described in section IV.H of this document. Separate savings for each equipment class are presented in chapter 10 of the direct final rule TSDs.

TABLE V–25—CUMULATIVE NATIONAL ENERGY SAVINGS FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT

Energy savings	Trial Standard Level* (projected quad savings)							
	1	2	2.5	Recommended	3	3.5	4	5
Primary energy	5.1	9.3	13.3	14.1	15.2	15.7	18.9	22.4
FFC energy	5.3	9.8	13.9	14.8	15.9	16.4	19.7	23.4

* For the Recommended TSL, the NES is forecasted over the lifetime of equipment sold from 2018–2048. For the other TSLs, the NES is forecasted over the lifetime of equipment sold from 2019–2048.

TABLE V–26—CUMULATIVE NATIONAL ENERGY SAVINGS FOR COMMERCIAL WARM AIR FURNACES

Energy savings	Trial Standard Level* (projected quad savings)				
	1	2	3	4	5
Primary energy	0.2	0.2	0.4	0.4	2.1
FFC energy	0.2	0.2	0.4	0.4	2.4

* For TSL 2, the NES is forecasted over the lifetime of equipment sold from 2023–2048. For the other TSLs, the NES is forecasted over the lifetime of equipment sold from 2019–2048.

OMB Circular A–4 [2] requires agencies to present analytical results, including separate schedules of the monetized benefits and costs that show the type and timing of benefits and costs. Circular A–4 also directs agencies to consider the variability of key elements underlying the estimates of benefits and costs. For this rulemaking, DOE undertook a sensitivity analysis using nine, rather than 30, years of equipment shipments. The choice of a nine-year period is a proxy for the timeline in EPCA for the review of certain energy conservation standards and potential revision of, and compliance with, such revised standards.[3] The review timeframe established in EPCA is generally not synchronized with the equipment lifetime, equipment manufacturing cycles, or other factors specific to CUACs/CUHPs and CWAFs. Thus, such results are presented for informational purposes only and are not indicative of any change in DOE's analytical methodology. The NES sensitivity analysis results based on a nine-year analytical period are presented in Table V–27 and Table V–28 for CUACs/CUHPs and CWAFs, respectively.

TABLE V–27—CUMULATIVE NATIONAL ENERGY SAVINGS FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT; NINE YEARS OF SHIPMENTS

Energy savings	Trial Standard Level* (projected quad savings)							
	1	2	2.5	Recommended	3	3.5	4	5
Primary energy	1.2	2.1	3.1	2.0	3.5	3.5	4.2	4.7
FFC energy	1.2	2.2	3.2	2.1	3.6	3.7	4.4	4.9

* For the Recommended TSL, the NES is forecasted over the lifetime of equipment sold from 2018–2026. For the other TSLs, the NES is forecasted over the lifetime of equipment sold from 2019–2027.

TABLE V–28—CUMULATIVE NATIONAL ENERGY SAVINGS FOR COMMERCIAL WARM AIR FURNACE; NINE YEARS OF SHIPMENTS

Energy savings	Trial Standard Level* (projected quad savings)				
	1	2	3	4	5
Primary energy	0.1	0.1	0.3	0.3	1.3

[2] U.S. Office of Management and Budget, ''Circular A–4: Regulatory Analysis'' (Sept. 17, 2003) (Available at: *http://www.whitehouse.gov/omb/circulars_a004_a-4/*).

[3] Section 342(a)(6)(C) of EPCA—like its consumer product-related counterpart in Section 325(m)—requires DOE to review its standards at least once every 6 years, and requires, for certain products, a 3-year period after any new standard is promulgated before compliance is required, except that in no case may any new standards be required within 6 years of the compliance date of the previous standards. While adding a 6-year review to the 3-year compliance period adds up to 9 years, DOE notes that it may undertake reviews at any time within the 6 year period and that the 3-year compliance date may yield to the 6-year backstop. A 9-year analysis period may not be appropriate given the variability that occurs in the timing of standards reviews and the fact that for some consumer products, the compliance period is 5 years rather than 3 years.

TABLE V–28—CUMULATIVE NATIONAL ENERGY SAVINGS FOR COMMERCIAL WARM AIR FURNACE; NINE YEARS OF SHIPMENTS—Continued

Energy savings	Trial Standard Level* (projected quad savings)				
	1	2	3	4	5
FFC energy	0.1	0.1	0.3	0.3	1.3

*For TSL 2, the NES is forecasted over the lifetime of equipment sold from 2023–2031. For the other TSLs, the NES is forecasted over the lifetime of equipment sold from 2019–2027.

b. Net Present Value of Commercial Consumer Costs and Benefits

DOE estimated the cumulative NPV of the total costs and savings for commercial consumers that would result from the TSLs considered for CUACs/CUHPs and CWAFs. In accordance with OMB's guidelines on regulatory analysis,[4] DOE calculated NPV using both a 7-percent and a 3-percent real discount rate.

Table V–29 and Table V–30 show the commercial consumer NPV results with impacts counted over the lifetime of equipment purchased in the relevant analysis period for each TSL.

TABLE V–29—CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT

Discount rate (%)	Trial Standard Level* (Billion 2014$)							
	1	2	2.5	Recommended	3	3.5	4	5
3	18.0	32.8	47.5	50.0	53.7	55.3	64.1	68.2
7	5.4	10.1	15.1	15.2	16.8	17.1	19.2	18.8

*For the Recommended TSL, the NES is forecasted over the lifetime of equipment sold from 2018–2048. For the other TSLs, the NES is forecasted over the lifetime of equipment sold from 2019–2048.

TABLE V–30—CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS FOR COMMERCIAL WARM AIR FURNACES

Discount rate (%)	Trial Standard Level* (Billion 2014$)				
	1	2	3	4	5
3	1.1	1.0	−0.1	−0.1	2.6
7	0.4	0.3	−0.4	−0.4	−0.4

*For TSL 2, the NES is forecasted over the lifetime of equipment sold from 2023–2048. For the other TSLs, the NES is forecasted over the lifetime of equipment sold from 2019–2048.

The results in Table V–29 reflect the use of a constant price trend for CUACs and CUHPs over the analysis period (see section IV.F.1). DOE also conducted a sensitivity analysis that considered one scenario with a lower rate of price decline than the reference case and one scenario with a higher rate of price decline than the reference case. The results of these alternative cases are presented in appendix 10C of the CUAC/CUHP direct final rule TSD.

The results in Table V–30 reflect the use of the historic trend in the inflation-adjusted PPI for ''Warm air furnaces'' to estimate the change in price for CWAFs over the analysis period (see section IV.F.1). The trend shows a small rate of annual price decline. DOE also conducted a sensitivity analysis that considered one scenario with a lower rate of price decline than the reference case and one scenario with a higher rate of price decline than the reference case. The results of these alternative cases are presented in appendix 10C of the CWAF direct final rule TSD.

The NPV results based on the aforementioned 9-year analytical period are presented in Table V–31 and Table V–32 for CUACs/CUHPs and CWAFs, respectively. As mentioned previously, such results are presented for informational purposes only and are not indicative of any change in DOE's analytical methodology or decision criteria.

TABLE V–31—CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT; NINE YEARS OF SHIPMENTS

Discount rate (%)	Trial Standard Level* (billion 2014$)							
	1	2	2.5	Recommended	3	3.5	4	5
3	4.6	8.0	12.4	7.2	13.6	13.6	15.1	13.4

[4] U.S. Office of Management and Budget, ''Circular A–4: Regulatory Analysis,'' section E (Sept. 17, 2003) (Available at: *http://www.whitehouse.gov/omb/circulars_a004_a-4*).

TABLE V–31—CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT; NINE YEARS OF SHIPMENTS—Continued

Discount rate (%)	Trial Standard Level * (billion 2014$)							
	1	2	2.5	Recommended	3	3.5	4	5
7	2.0	3.7	5.8	3.6	6.4	6.3	6.8	5.6

* For the Recommended TSL, the NES is forecasted over the lifetime of equipment sold from 2018–2026. For the other TSLs, the NES is forecasted over the lifetime of equipment sold from 2019–2027.

TABLE V–32—CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS FOR COMMERCIAL WARM AIR FURNACES; NINE YEARS OF SHIPMENTS

Discount rate (%)	Trial Standard Level * (billion 2014$)				
	1	2	3	4	5
3	0.4	0.4	0.9	0.9	4.4
7	0.2	0.2	0.2	0.2	1.2

* For TSL 2, the NES is forecasted over the lifetime of equipment sold from 2023–2031. For the other TSLs, the NES is forecasted over the lifetime of equipment sold from 2019–2027.

c. Indirect Impacts on Employment

DOE expects energy conservation standards for CUACs/CUHPs and CWAFs to reduce energy bills for consumers of those equipment, with the resulting net savings being redirected to other forms of economic activity. These expected shifts in spending and economic activity could affect the demand for labor. DOE used an input/output model of the U.S. economy to estimate indirect employment impacts of the TSLs that DOE considered in this rulemaking. DOE understands that there are uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Therefore, DOE generated results for timeframes within five years of the compliance date, where these uncertainties are reduced.

The results suggest that the adopted standards are likely to have a negligible impact on the net demand for labor in the economy. The net change in jobs is so small that it would be imperceptible in national labor statistics and might be offset by other, unanticipated effects on employment. Chapter 16 of the direct final rule TSDs presents detailed results regarding anticipated indirect employment impacts.

4. Impact on Utility or Performance of Equipment

DOE has concluded that the standards adopted in this final rule would not reduce the utility or performance of the CUACs/CUHPs and CWAFs under consideration in this rulemaking. Manufacturers of these equipment types currently offer units that meet or exceed the adopted standards.

5. Impact of Any Lessening of Competition

EPCA directs DOE to consider any lessening of competition that is likely to result from standards. It also directs the Attorney General of the United States (Attorney General) to determine the impact, if any, of any lessening of competition likely to result from a proposed standard and to transmit such determination in writing to the Secretary within 60 days of the publication of a proposed rule, together with an analysis of the nature and extent of the impact.

To assist the Attorney General in making this determination, DOE provided the Department of Justice (DOJ) with copies of the NOPR and the TSD for review. In its assessment letter responding to DOE, DOJ concluded that the proposed energy conservation standards for CUACs/CUHPs and CWAFs are unlikely to have a significant adverse impact on competition. DOE is publishing the Attorney General's assessments for both proposals at the end of this direct final rule.

6. Need of the Nation To Conserve Energy

Enhanced energy efficiency, where economically justified, improves the Nation's energy security, strengthens the economy, and reduces the environmental impacts (costs) of energy production. Reduced electricity demand due to energy conservation standards is also likely to reduce the cost of maintaining the reliability of the electricity system, particularly during peak-load periods. As a measure of this reduced demand, chapter 15 in the direct final rule TSDs presents the estimated reduction in generating capacity, relative to the no-new-standards case, for the TSLs that DOE considered in this rulemaking.

Energy conservation resulting from amended standards for CUACs/CUHPs and CWAFs are expected to yield environmental benefits in the form of reduced emissions of air pollutants and GHGs. Table V–33 and Table V–34 provide DOE's estimate of cumulative emissions reductions expected to result from the TSLs considered for CUACs/CUHPs and CWAFs, respectively. The emissions were calculated using the multipliers discussed in section IV.K. DOE reports annual emissions reductions for each TSL in chapter 13 of the direct final rule TSDs.

TABLE V–33—CUMULATIVE EMISSIONS REDUCTION FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT

	Trial Standard Level *							
	1	2	2.5	Recommended	3	3.5	4	5
Power Sector Emissions								
CO_2 (million metric tons)	297	546	778	824	890	919	1,103	1,307
SO_2 (thousand tons)	161	297	423	445	483	498	598	708
NO_X (thousand tons)	336	620	883	937	1,010	1,042	1,252	1,483
Hg (tons)	0.60	1.10	1.57	1.66	1.80	1.85	2.22	2.63
CH_4 (thousand tons)	23.3	43.0	61.3	64.7	70.1	72.3	86.7	102.7
N_2O (thousand tons)	3.29	6.06	8.63	9.10	9.87	10.18	12.21	14.46
Upstream Emissions								
CO_2 (million metric tons)	17	32	46	49	52	54	65	77
SO_2 (thousand tons)	3.2	5.9	8.4	9.0	9.6	9.9	11.9	14.2
NO_X (thousand tons)	249	459	654	697	749	773	928	1,101
Hg (tons)	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03
CH_4 (thousand tons)	1,378	2,539	3,616	3,852	4,137	4,270	5,128	6,083
N_2O (thousand tons)	0.16	0.29	0.42	0.44	0.48	0.49	0.59	0.70
Total Emissions								
CO_2 (million metric tons)	314	578	824	873	943	973	1,167	1,383
SO_2 (thousand tons)	164	303	431	454	493	508	610	722
NO_X (thousand tons)	586	1,080	1,538	1,634	1,759	1,815	2,180	2,584
Hg (tons)	0.61	1.12	1.59	1.68	1.82	1.88	2.25	2.66
CH_4 (thousand tons)	1,401	2,582	3,677	3,917	4,208	4,342	5,215	6,185
N_2O (thousand tons)	3.45	6.35	9.05	9.54	10.34	10.67	12.80	15.16
CH_4 (million tons CO_2eq) **	39.2	72.3	103.0	109.7	117.8	121.6	146.0	173.2
N_2O (thousand tons CO_2eq) **	913	1,682	2,397	2,528	2,741	2,828	3,392	4,017

* For the Recommended TSL, the NES is forecasted over the lifetime of equipment sold from 2018–2048. For the other TSLs, the NES is forecasted over the lifetime of equipment sold from 2019–2048.

TABLE V–34—CUMULATIVE EMISSIONS REDUCTION FOR COMMERCIAL WARM AIR FURNACES

	Trial Standard Level *				
	1	2	3	4	5
**Site and Power Sector Emissions ** **					
CO_2 (million metric tons)	11.8	10.9	19.3	19.3	109
SO_2 (thousand tons)	0.4	0.4	0.6	0.6	−10.1
NO_X (thousand tons)	16.5	16.8	27.1	28.8	194
Hg (tons)	0.00	0.00	0.00	0.00	−0.04
CH_4 (thousand tons)	0.3	0.3	0.5	0.5	1.0
N_2O (thousand tons)	0.03	0.03	0.05	0.05	0.06
Upstream Emissions					
CO_2 (million metric tons)	1.7	1.5	2.7	2.7	17.4
SO_2 (thousand tons)	0.0	0.0	0.0	0.0	−0.1
NO_X (thousand tons)	26.4	24.4	43.3	43.5	279
Hg (tons)	0.00	0.00	0.00	0.00	0.00
CH_4 (thousand tons)	158	146	260	260	1,672
N_2O (thousand tons)	0.00	0.00	0.01	0.01	0.02
Total FFC Emissions					
CO_2 (million metric tons)	13.4	12.4	22.	22.	126
SO_2 (thousand tons)	0.4	0.4	0.6	0.7	−10.2
NO_X (thousand tons)	43.	41.2	70.5	72.2	473
Hg (tons)	0.00	0.00	0.00	0.00	−0.04
CH_4 (thousand tons)	159	146	260	260	1,673
CH_4 (thousand tons CO_2eq) †	4,440	4,096	7,289	7,292	46,831
N_2O (thousand tons)	0.03	0.03	0.05	0.06	0.08

TABLE V–34—CUMULATIVE EMISSIONS REDUCTION FOR COMMERCIAL WARM AIR FURNACES—Continued

	Trial Standard Level *				
	1	2	3	4	5
N_2O (thousand tons CO_2eq) †	8.8	8.4	14.3	14.6	21.2

* For TSL 2, the NES is forecasted over the lifetime of equipment sold from 2023–2048. For the other TSLs, the NES is forecasted over the lifetime of equipment sold from 2019–2048.
** Primarily site emissions.
† CO_2eq is the quantity of CO_2 that would have the same global warming potential (GWP).

As part of the analysis for this rule, DOE estimated monetary benefits likely to result from the reduced emissions of CO_2 and NO_X that DOE estimated for each of the considered TSLs for CUACs/CUHPs and CWAFs. As discussed in section IV.L of this document, for CO_2, DOE used the most recent values for the SCC developed by an interagency process. The four sets of SCC values for CO_2 emissions reductions in 2015 resulting from that process (expressed in 2014$) are represented by $12.2/metric ton (the average value from a distribution that uses a 5-percent discount rate), $40.0/metric ton (the average value from a distribution that uses a 3-percent discount rate), $62.3/metric ton (the average value from a distribution that uses a 2.5-percent discount rate), and $117/metric ton (the 95th-percentile value from a distribution that uses a 3-percent discount rate). The values for later years are higher due to increasing damages (public health, economic and environmental) as the projected magnitude of climate change increases.

Table V–35 and Table V–36 present the global value of CO_2 emissions reductions at each TSL for CUACs/CUHPs and CWAFs, respectively. For each of the four cases, DOE calculated a present value of the stream of annual values using the same discount rate as was used in the studies upon which the dollar-per-ton values are based. DOE calculated domestic values as a range from 7 percent to 23 percent of the global values; these results are presented in chapter 14 of the direct final rule TSD.

TABLE V–35—ESTIMATES OF GLOBAL PRESENT VALUE OF CO_2 EMISSIONS REDUCTION FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT

TSL **	SCC Case * (million 2014$)			
	5% discount rate, average	3% discount rate, average	2.5% discount rate, average	3% discount rate, 95th percentile
Site and Power Sector Emissions				
1	1,745	8,531	13,755	26,019
2	3,223	15,745	25,382	48,025
2.5	4,604	22,470	36,214	68,538
Recommended	4,769	23,508	37,966	71,745
3	5,253	25,663	41,369	78,279
3.5	5,417	26,470	42,672	80,744
4	6,485	31,728	51,160	96,788
5	7,682	37,602	60,633	114,725
Upstream Emissions				
1	101	496	800	1,512
2	186	915	1,477	2,791
2.5	265	1,305	2,106	3,982
Recommended	277	1,374	2,223	4,196
3	303	1,491	2,407	4,550
3.5	312	1,538	2,484	4,695
4	374	1,845	2,980	5,632
5	444	2,189	3,535	6,683
Total Emissions				
1	1,845	9,026	14,555	27,531
2	3,409	16,660	26,859	50,816
2.5	4,870	23,775	38,320	72,520
Recommended	5,046	24,883	40,189	75,941
3	5,556	27,154	43,777	82,830
3.5	5,729	28,009	45,156	85,439
4	6,860	33,573	54,140	102,420
5	8,127	39,791	64,169	121,407

* For each of the four cases, the corresponding SCC value for emissions in 2015 is $12.2, $40.0, $62.3, and $117 per metric ton (2014$). The values are for CO_2 only (*i.e.,* not CO_{2eq} of other greenhouse gases).
** For the Recommended TSL, the NES is forecasted over the lifetime of equipment sold from 2018–2048. For the other TSLs, the NES is forecasted over the lifetime of equipment sold from 2019–2048.

TABLE V–36—ESTIMATES OF GLOBAL PRESENT VALUE OF CO_2 EMISSIONS REDUCTION FOR COMMERCIAL WARM AIR FURNACES

TSL **	SCC Case * (million 2014$)			
	5% discount rate, average	3% discount rate, average	2.5% discount rate, average	3% discount rate, 95th percentile
Site and Power Sector Energy Emissions †				
1	70.0	341	549	1,039
2	62.6	310	500	946
3	110	544	879	1,658
4	110	546	882	1,663
5	614	3,053	4,940	9,314
Upstream Emissions				
1	9.8	47.9	77.1	146
2	8.8	43.5	70.3	133
3	15.5	76.5	124	233
4	15.5	76.8	124	234
5	99.0	490	793	1,495
Total Emissions				
1	79.8	388	626	1,185
2	71.4	353	571	1,078
3	126	620	1,003	1,891
4	126	622	1,006	1,897
5	713	3,543	5,733	10,809

* For each of the four cases, the corresponding SCC value for emissions in 2015 is $12.2, $40.0, $62.3, and $117 per metric ton (2014$). The values are for CO_2 only (*i.e.,* not CO_{2eq} of other greenhouse gases).

** For TSL 2, the NES is forecasted over the lifetime of equipment sold from 2023–2048. For the other TSLs, the NES is forecasted over the lifetime of equipment sold from 2019–2048.

DOE is well aware that scientific and economic knowledge about the contribution of CO_2 and other GHG emissions to changes in the future global climate and the potential resulting damages to the world economy continues to evolve rapidly. Thus, any value placed on reduced CO_2 emissions in this rulemaking is subject to change. DOE, together with other Federal agencies, will continue to review various methodologies for estimating the monetary value of reductions in CO_2 and other GHG emissions. This ongoing review will consider the comments on this subject that are part of the public record for this and other rulemakings, as well as other methodological assumptions and issues. However, consistent with DOE's legal obligations, and taking into account the uncertainty involved with this particular issue, DOE has included in this rule the most recent values and analyses resulting from the interagency review process.

DOE also estimated the cumulative monetary value of the economic benefits associated with NO_X emissions reductions anticipated to result from the considered TSLs for CUACs/CUHPs and CWAFs. The dollar-per-ton values that DOE used are discussed in section IV.L of this document. Table V–37 and Table V–38 present the cumulative present values for NO_X emissions for each TSL calculated using 7-percent and 3-percent discount rates, respectively, for the equipment addressed in this direct final rule. This table presents values that use the low dollar-per-ton values, which reflect DOE's primary estimate. Results that reflect the range of NO_X dollar-per-ton values are presented in Table V–41 and Table V–45.

TABLE V–37—ESTIMATES OF PRESENT VALUE OF NO_X EMISSIONS REDUCTION FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT *

TSL **	Million 2014$	
	3% Discount rate	7% Discount rate
Site and Power Sector Emissions		
1	1,055	353
2	1,947	653
2.5	2,780	935
Recommended	2,899	937
3	3,174	1,064
3.5	3,274	1,095
4	3,923	1,307
5	4,649	1,543

TABLE V–37—ESTIMATES OF PRESENT VALUE OF NO_X EMISSIONS REDUCTION FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT *—Continued

TSL **	Million 2014$	
	3% Discount rate	7% Discount rate
Upstream Emissions		
1	774	253
2	1,429	468
2.5	2,040	670
Recommended	2,139	677
3	2,329	763
3.5	2,403	786
4	2,881	938
5	3,418	1,109
Total Emissions		
1	1,828	606
2	3,376	1,121
2.5	4,820	1,604
Recommended	5,038	1,614
3	5,503	1,826
3.5	5,677	1,881
4	6,804	2,245
5	8,067	2,652

* The results reflect use of the low benefits per ton values.

** For the Recommended TSL, the impacts are over the lifetime of equipment sold from 2018–2048. For the other TSLs, the NES is forecasted over the lifetime of equipment sold from 2019–2048.

TABLE V–38—ESTIMATES OF PRESENT VALUE OF NO_X EMISSIONS REDUCTION FOR COMMERCIAL WARM AIR FURNACES *

TSL **	Million 2014$	
	3% discount rate	7% discount rate
Site and Power Sector Emissions **		
1	46.1	16.3
2	44.9	14.7
3	72.2	24.7
4	76.8	26.3
5	516	174
Upstream Emissions		
1	73.6	26.0
2	65.4	21.4
3	115	39.5
4	116	39.6
5	741	249
Total Emissions		
1	120	42.3
2	110	36.1
3	188	64.2
4	192	65.9
5	1,258	423

* The results reflect use of the low benefits per ton values.

** For TSL 2, the NES is forecasted over the lifetime of equipment sold from 2023–2048. For the other TSLs, the NES is forecasted over the lifetime of equipment sold from 2019–2048.

7. Other Factors

The Secretary of Energy, in determining whether a standard is economically justified, may consider any other factors that the Secretary deems to be relevant. (42 U.S.C. 6313(a)(6)(B)(ii)(VII)) No other factors were considered in this analysis.

8. Summary of National Economic Impacts

The NPV of the monetized benefits associated with emissions reductions can be viewed as a complement to the NPV of the commercial consumer savings calculated for each TSL considered in this rulemaking. Table V–39 and Table V–40 present the NPV values that result from adding the estimates of the potential economic benefits resulting from reduced CO_2 and NO_X emissions in each of four valuation scenarios to the NPV of commercial consumer savings calculated for each TSL considered in this rulemaking, at both a 7-percent and 3-percent discount rate for CUACs/CUHPs and CWAFs, respectively. The CO_2 values used in the columns of each table correspond to the four sets of SCC values discussed above.

TABLE V–39—NET PRESENT VALUE OF CONSUMER SAVINGS COMBINED WITH PRESENT VALUE OF MONETIZED BENEFITS FROM CO_2 AND NO_X EMISSIONS REDUCTIONS FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT

TSL *	Consumer NPV at 3% discount rate added with: (billion 2014$)			
	SCC case $12.2/metric ton CO_2 and 3% low NO_X value	SCC case $40.0/metric ton CO_2 and 3% low NO_X value	SCC case $62.3/metric ton CO_2 and 3% low NO_X value	SCC case $117/metric ton CO_2 and 3% low NO_X value
1	21.4	28.6	34.2	47.1
2	39.2	52.5	62.6	86.6
2.5	56.6	75.5	90.1	124.3
Recommended	59.4	79.2	94.5	130.3
3	64.0	85.6	102.2	141.3
3.5	66.0	88.2	105.4	145.7
4	76.9	103.6	124.2	172.5
5	83.4	115.0	139.4	196.7
	Consumer NPV at 7% discount rate added with:			
	SCC case $12.2/metric ton CO_2 and 7% low NO_X value	SCC case $40.0/metric ton CO_2 and 7% low NO_X value	SCC case $62.3/metric ton CO_2 and 7% low NO_X value	SCC case $117/metric ton CO_2 and 7% low NO_X value
1	7.8	15.0	20.6	33.5
2	14.5	27.7	37.9	61.9
2.5	21.4	40.3	54.8	89.0
Recommended	21.7	41.6	56.9	92.6
3	24.0	45.6	62.3	101.3
3.5	24.5	46.8	63.9	104.2
4	28.1	54.8	75.4	123.7
5	29.3	61.0	85.4	142.6

* For the Recommended TSL, the NES is forecasted over the lifetime of equipment sold from 2018–2048. For the other TSLs, the NES is forecasted over the lifetime of equipment sold from 2019–2048.

TABLE V–40—NET PRESENT VALUE OF CONSUMER SAVINGS COMBINED WITH PRESENT VALUE OF MONETIZED BENEFITS FROM CO_2 AND NO_X EMISSIONS REDUCTIONS FOR COMMERCIAL WARM AIR FURNACES

TSL	Consumer NPV at 3% discount rate added with: (billion 2014$)			
	SCC case $12.2/metric ton and medium NO_X value	SCC case $41.2/metric ton and medium NO_X value	SCC case $63.4/metric ton and medium NO_X value	SCC case $121/metric ton and medium NO_X value
1	1.3	1.6	1.8	2.4
2	1.2	1.4	1.7	2.2
3	0.3	0.7	1.1	2.0
4	0.3	0.8	1.1	2.0
5	4.6	7.4	9.6	14.7
	Consumer NPV at 7% discount rate added with:			
	SCC case $12.0/metric ton and medium NO_X value	SCC case $40.5/metric ton and medium NO_X value	SCC case $62.4/metric ton and medium NO_X value	SCC case $119/metric ton and medium NO_X value
1	0.5	0.8	1.1	1.6
2	0.4	0.7	0.9	1.4
3	(0.2)	0.3	0.7	1.6
4	(0.2)	0.3	0.7	1.6
5	0.8	3.6	5.8	10.9

* For TSL 2, the NES is forecasted over the lifetime of equipment sold from 2023–2048. For the other TSLs, the NES is forecasted over the lifetime of equipment sold from 2019–2048.

In considering the above results, two issues are relevant. First, the national operating cost savings are domestic U.S. monetary savings that occur as a result of market transactions, while the value of CO_2 reductions is based on a global value. Second, the assessments of operating cost savings and the SCC are performed with different methods that use different time frames for analysis. The national operating cost savings is measured for the lifetime of equipment shipped in the applicable analysis period. Because CO_2 emissions have a very long residence time in the atmosphere,[5] the SCC values in future years reflect future climate-related impacts that continue beyond 2100.

C. Conclusion

When considering new or amended energy conservation standards, the standards that DOE adopts for any type (or class) of covered product or equipment must be designed to achieve significant additional conservation of energy that the Secretary determines is technologically feasible and economically justified. (42 U.S.C. 6313(a)(6)(A)(ii)(II)) In determining whether a standard is economically justified, the Secretary must determine whether the benefits of the standard exceed its burdens by, to the greatest extent practicable, considering the seven statutory factors discussed previously. (42 U.S.C. 6313(a)(6)(B)(ii)(I)–(VII))

For this direct final rule, DOE considered the impacts from amended standards for CUACs/CUHPs and CWAFs at each TSL, beginning with the maximum technologically feasible level, to determine whether that level was economically justified. Where the max-tech level was not justified, DOE then considered the next most efficient level and undertook the same evaluation until it reached the highest efficiency level that is both technologically feasible and economically justified and saves a significant amount of energy.

To aid the reader as DOE discusses the benefits and/or burdens of each TSL, tables in this section present a summary of the results of DOE's quantitative analysis for each TSL. In addition to the quantitative results presented in the tables, DOE also considers other burdens and benefits that affect economic justification.

1. Benefits and Burdens of TSLs Considered for Small, Large, and Very Large Air-Cooled Commercial Package Air Conditioning and Heating Equipment

Table V–41 and Table V–42 summarize the quantitative impacts estimated for each TSL for CUACs and CUHPs. The national impacts are measured over the lifetime of CUACs and CUHPs purchased in the 2018–2048 period. The energy savings, emissions reductions, and value of emissions reductions refer to FFC results. The efficiency levels contained in each TSL are described in section V.A.

TABLE V–41—SUMMARY OF ANALYTICAL RESULTS FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT: NATIONAL IMPACTS

Category	TSL 1	TSL 2	TSL 2.5	Recommended TSL *	TSL 3	TSL 3.5	TSL 4	TSL 5
National FFC Energy Savings (*quads*)								
	5.3	9.8	13.9	14.8	15.9	16.4	19.7	23.4

[5] The atmospheric lifetime of CO_2 is estimated of the order of 30–95 years. Jacobson, MZ, "Correction to 'Control of fossil-fuel particulate black carbon and organic matter, possibly the most effective method of slowing global warming,'" 110 *J. Geophys. Res.* D14105 (2005).

TABLE V–41—SUMMARY OF ANALYTICAL RESULTS FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT: NATIONAL IMPACTS—Continued

Category	TSL 1	TSL 2	TSL 2.5	Recommended TSL *	TSL 3	TSL 3.5	TSL 4	TSL 5
NPV of Consumer Benefits (*2014$ billion*)								
3% discount rate.	18.0	32.8	47.5	50.0	53.7	55.3	64.1	68.2
7% discount rate.	5.4	10.1	15.1	15.2	16.8	17.1	19.2	18.8
Cumulative Emissions Reduction (Total FFC Emissions)								
CO_2 (*million metric tons*).	314	578	824	873	943	973	1,167	1,383
SO_2 (*thousand tons*).	164	303	431	454	493	508	610	722
NO_X (*thousand tons*).	586	1,080	1,538	1,634	1,759	1,815	2,180	2,584
Hg (*tons*)	0.61	1.12	1.59	1.68	1.82	1.88	2.25	2.66
CH_4 (*thousand tons*).	1,401	2,582	3,677	3,917	4,208	4,342	5,215	6,185
N_2O (*thousand tons*).	3.45	6.35	9.05	9.54	10.34	10.67	12.80	15.16
CH_4 (*million tons CO_2eq ***).	39.2	72.3	103.0	109.7	117.8	121.6	146.0	173.2
N_2O (*thousand tons CO_2eq ***).	913	1,682	2,397	2,528	2,741	2,828	3,392	4,017
Value of Emissions Reduction (Total FFC Emissions)								
CO_2 (*2014$ billion*) †.	1.845 to 27.53	3.409 to 50.82	4.870 to 72.52	5.046 to 75.94	5.556 to 82.83	5.729 to 85.44	6.860 to 102.4	8.127 to 121.4
NO_X—3% discount rate (*2014$ million*).	1,592 to 3,514	2,941 to 6,492	4,203 to 9,276	4,361 to 9,610	4,795 to 10,583	4,945 to 10,913	5,922 to 13,066	7,020 to 15,483
NO_X—7% discount rate (*2014$ million*).	547 to 1,221	1,011 to 2,259	1,448 to 3,235	1,445 to 3,231	1,647 to 3,680	1,696 to 3,789	2,022 to 4,520	2,386 to 5,334

* For the Recommended TSL, the NES is forecasted over the lifetime of equipment sold from 2018–2048. For the other TSLs, the NES is forecasted over the lifetime of equipment sold from 2019–2048.
** CO_2eq is the quantity of CO_2 that would have the same global warming potential (GWP).
† Range of the economic value of CO_2 reductions is based on estimates of the global benefit of reduced CO_2 emissions.

TABLE V–42—SUMMARY OF ANALYTICAL RESULTS FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT: MANUFACTURER AND CONSUMER IMPACTS *

Category	TSL 1	TSL 2	TSL 2.5	Recommended TSL	TSL 3	TSL 3.5	TSL 4	TSL 5
Manufacturer Impacts								
Industry NPV (2014$ million) (No-new-standards case INPV = 1,638.2).	1,431.0 to 1,705.5.	1,421.9 to 1,758.6.	1,300.5 to 1,721.1.	1,204.1 to 1,606.1	1,197.4 to 1,697.0.	1,138.2 to 1,670.3.	1,025.0 to 1,660.9.	762.7 to 1,737.6
Industry NPV (*% change*).	(6.5) to 3.7	(13.5) to 6.9	(20.9) to 4.7	(26.8) to (2.3)	(27.2) to 3.2	(30.8) to 1.6	(37.7) to 1.0	(53.6) to 5.7
Commercial Consumer Average LCC Savings (*2014*)								
Small CUACs	(210)	870	3,777	4,233	4,233	3,517	3,035	5,326
Large CUACs	3,997	3,728	7,991	10,135	10,135	12,266	16,803	12,900
Very Large CUACs.	1,547	4,777	8,610	8,610	8,881	8,881	18,386	18,338
Average *	1,045	1,971	5,340	6,220	6,238	6,396	8,370	8,697
Commercial Consumer PBP (*years*)								
Small CUACs	14.9	8.5	4.9	4.9	4.9	2.6	2.5	4.6
Large CUACs	1.3	2.4	2.4	2.6	2.6	2.6	2.5	4.6
Very Large CUACs.	5.8	7.0	6.2	6.2	7.2	7.2	5.6	6.3
Average *	10.6	6.7	4.3	4.4	4.5	3.0	2.8	4.8

TABLE V–42—SUMMARY OF ANALYTICAL RESULTS FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT: MANUFACTURER AND CONSUMER IMPACTS*—Continued

Category	TSL 1	TSL 2	TSL 2.5	Recommended TSL	TSL 3	TSL 3.5	TSL 4	TSL 5
% of Consumers that Experience Net Cost								
Small CUACs	48%	25%	5%	5%	5%	13%	25%	16%
Large CUACs	0%	10%	5%	2%	2%	1%	1%	11%
Very Large CUACs.	7%	13%	7%	7%	23%	23%	3%	6%
Average*	32%	20%	5%	4%	6%	11%	16%	14%

Parentheses indicate negative (−) values.
* Weighted by shares of each equipment class in total projected shipments in the year of compliance.

DOE first considered TSL 5, which represents the max-tech efficiency levels. TSL 5 would save 23.4 quads of energy, an amount DOE considers significant. Under TSL 5, the NPV of consumer benefit would be $18.8 billion using a 7-percent discount rate, and $68.2 billion using a 3-percent discount rate.

The cumulative emissions reductions at TSL 5 are 1,383 million Mt of CO_2, 722 thousand tons of SO_2, 2,584 thousand tons of NO_X, 2.66 ton of Hg, 6,185 thousand tons of CH_4, and 15.16 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reduction at TSL 5 ranges from $8.127 billion to $121.4 billion.

At TSL 5, the average LCC impact is a savings of $5,326 for small CUACs, $12,900 for large CUACs, and $18,338 for very large CUACs. The simple payback period is 4.6 years for small CUACs, 4.6 years for large CUACs, and 6.3 years for very large CUACs. The fraction of consumers experiencing a net LCC cost is 16 percent for small CUACs, 11 percent for large CUACs, and 6 percent for very large CUACs. Although DOE did not estimate consumer impacts for CUHPs, the results would be very similar to those for CUACs for the reasons stated in section V.B.1.

At TSL 5, the projected change in INPV ranges from a decrease of $881.9 million to an increase of $93.1 million, which correspond to a change of −53.7 percent and 5.7 percent, respectively. The industry is expected to incur $591.0 million in total conversion costs at this level. DOE projects that 98.7 percent of current equipment listings would require redesign at this level to meet this standard level today. At this level, DOE recognizes that manufacturers could face technical resource constraints. Manufacturers stated they would require additional engineering expertise and additional test laboratory capacity. It is unclear whether manufacturers could complete the hiring of the necessary technical expertise and construction of the necessary test facilities in time to allow for the redesign of all equipment to meet max-tech by 2019. Furthermore, DOE recognizes that a standard set at max-tech could greatly limit equipment differentiation in the small, large, and very large CUAC/CUHP market. By commoditizing a key differentiating feature, a standard set at max-tech would likely accelerate consolidaton in the industry.

The Secretary concludes that at TSL 5 for CUACs and CUHPs, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, and the estimated monetary value of the emissions reductions would be outweighed by the economic burden on some consumers, and the impacts on manufacturers, including the conversion costs and profit margin impacts that could result in a large reduction in INPV. Consequently, the Secretary has concluded that TSL 5 is not economically justified.

DOE then considered TSL 4. TSL 4 would save 19.7 quads of energy, an amount DOE considers significant. Under TSL 4, the NPV of consumer benefit would be $19.2 billion using a 7-percent discount rate, and $64.1 billion using a 3-percent discount rate.

The cumulative emissions reductions at TSL 4 are 1,167 million Mt of CO_2, 610 thousand tons of SO_2, 2,180 thousand tons of NO_X, 2.25 ton of Hg, 5,215 thousand tons of CH_4, and 12.80 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reduction at TSL 4 ranges from $6.860 billion to $102.4 billion.

At TSL 4, the average LCC impact is a savings of $3,035 for small CUACs, $16,803 for large CUACs, and $18,386 for very large CUACs. The simple payback period is 2.5 years for small CUACs, 2.5 years for large CUACs, and 5.6 years for very large CUACs. The fraction of consumers experiencing a net LCC cost is 25 percent for small CUACs, 1 percent for large CUACs, and 3 percent for very large CUACs. Although DOE did not estimate consumer impacts for CUHPs, the results would be very similar to those for CUACs for the reasons stated in section V.B.1.

At TSL 4, the projected change in INPV ranges from a decrease of $619.6 million to an increase of $16.3 million, which corresponds to a change of −37.7 percent and 1.0 percent, respectively. The industry is expected to incur $538.8 million in total conversion costs at this level. DOE projects that 96.0 percent of current equipment listings would require redesign at this level to meet this standard level today.

The Secretary concludes that at TSL 4 for CUACs and CUHPs, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, and the estimated monetary value of the emissions reductions would be outweighed by the economic burden on some consumers, and the impacts on manufacturers, including the conversion costs and profit margin impacts that could result in a reduction in INPV. Consequently, the Secretary has concluded that TSL 4 is not economically justified.

DOE then considered TSL 3.5. TSL 3.5 would save 16.4 quads of energy, an amount DOE considers significant. Under TSL 3.5, the NPV of consumer benefit would be $17.1 billion using a 7-percent discount rate, and $55.3 billion using a 3-percent discount rate.

The cumulative emissions reductions at TSL 3.5 are 973 million Mt of CO_2, 508 thousand tons of SO_2, 1,815 thousand tons of NO_X, 1.88 ton of Hg, 4,342 thousand tons of CH_4, and 10.67 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reduction at TSL 3.5 ranges from $5.729 billion to $85.44 billion.

At TSL 3.5, the average LCC impact is a savings of $3,517 for small CUACs, $12,266 for large CUACs, and $8,881 for very large CUACs. The simple payback period is 2.6 years for small CUACs, 2.6 years for large CUACs, and 7.2 years for very large CUACs. The fraction of consumers experiencing a net LCC cost is 13 percent for small CUACs, 1 percent for large CUACs, and 23 percent for very large CUACs. Although DOE did not estimate consumer impacts for CUHPs, the results would be very similar to those for CUACs for the reasons stated in section V.B.1.

At TSL 3.5, the projected change in INPV ranges from a decrease of $506.4 million to an increase of $25.7 million, which corresponds to a change of −30.8 percent and 1.6 percent, respectively. The industry is expected to incur $489.2 million in total conversion costs at this level. DOE projects that 93.5 percent of current equipment listings would require redesign at this level to meet this standard level today.

The Secretary concludes that at TSL 3.5 for CUACs and CUHPs, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, and the estimated monetary value of the emissions reductions would be outweighed by the economic burden on some consumers, and the impacts on manufacturers, including the conversion costs and profit margin impacts that could result in a reduction in INPV. Consequently, the Secretary has concluded that TSL 3.5 is not economically justified.

DOE then considered TSL 3. TSL 3 would save 15.9 quads of energy, an amount DOE considers significant. Under TSL 3, the NPV of consumer benefit would be $16.8 billion using a 7-percent discount rate, and $53.7 billion using a 3-percent discount rate.

The cumulative emissions reductions at TSL 3 are 943 million Mt of CO_2, 493 thousand tons of SO_2, 1,759 thousand tons of NO_X, 1.82 ton of Hg, 4,208 thousand tons of CH_4, and 10.34 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reduction at TSL 3 ranges from $5.556 billion to $82.83 billion.

At TSL 3, the average LCC impact is a savings of $4,233 for small CUACs, $10,135 for large CUACs, and $8,881 for very large CUACs. The simple payback period is 4.9 years for small CUACs, 2.6 years for large CUACs, and 7.2 years for very large CUACs. The fraction of consumers experiencing a net LCC cost is 5 percent for small CUACs, 2 percent for large CUACs, and 23 percent for very large CUACs. Although DOE did not estimate consumer impacts for CUHPs, the results would be very similar to those for CUACs for the reasons stated in section V.B.1.

At TSL 3, the projected change in INPV ranges from a decrease of $447.2 million to an increase of $52.4 million, which corresponds to a change of −27.2 percent and 3.2 percent, respectively. DOE projects that 81.6 percent of current equipment listings would require redesign at this level to meet this standard level today.

The Secretary concludes that at TSL 3 for CUACs and CUHPs, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, and the estimated monetary value of the emissions reductions would be outweighed by the economic burden on some consumers, and the impacts on manufacturers, including the conversion costs and profit margin impacts that could result in a large reduction in INPV. Consequently, the Secretary has concluded that TSL 3 is not economically justified.

DOE then considered the Recommended TSL, which reflects the standard levels recommended by the ASRAC Working Group. The Recommended TSL would save 14.8 quads of energy, an amount DOE considers significant. Under the Recommended TSL, the NPV of consumer benefit would be $15.2 billion using a 7-percent discount rate, and $50.0 billion using a 3-percent discount rate.

The cumulative emissions reductions at the Recommended TSL are 873 million Mt of CO_2, 454 thousand tons of SO_2, 1,634 thousand tons of NO_X, 1.68 ton of Hg, 3,917 thousand tons of CH_4, and 9.54 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reduction at the Recommended TSL ranges from $5.046 billion to $75.94 billion.

At the Recommended TSL, the average LCC impact is a savings of $4,233 for small CUACs, $10,135 for large CUACs, and $8,610 for very large CUACs. The simple payback period is 4.9 years for small CUACs, 2.6 years for large CUACs, and 6.2 years for very large CUACs. The fraction of consumers experiencing a net LCC cost is 5 percent for small CUACs, 2 percent for large CUACs, and 7 percent for very large CUACs. Although DOE did not estimate consumer impacts for CUHPs, the results would be very similar to those for CUACs for the reasons stated in section V.B.1.

The Recommended TSL as developed by the Working Group and submitted to DOE by ASRAC, aligns the effective dates of the CUAC/CUHP and CWAF rulemakings. That recommended approach adopts the ASHRAE 90.1–2013 efficiency levels for this equipment for compliance starting in 2018 and will phase into a higher level starting in 2023 as recommended to ASRAC by the Working Group. DOE expects that aligning the effective dates reduces total conversion costs and cumulative regulatory burden, while also allowing industry to gain clarity on potential regulations that could affect refrigerant availability before the higher appliance standard takes effect in 2023. DOE projects that 31.5 percent of current equipment listings would require redesign at this level to meet the 2018 standard level, while 79.6 percent of current equipment listings would require redesign at this level to meet the 2023 standard level.

At the Recommended TSL, the projected change in INPV ranges from a decrease of $440.4 million to a decrease of $38.5 million, which corresponds to a change of −26.8 percent and −2.3 percent, respectively. The industry is expected to incur $520.8 million in total conversion costs at this level. However, the industry members of the Working Group noted that aligning the compliance dates for the CUAC/CUHP and CWAF standards in the manner recommended would allow manufacturers to coordinate their redesign and testing expenses for these equipment (CUAC: AHRI and ACEEE, No. 80 at p. 1). With this coordination, manufacturers explained that there would be a reduction in the total conversion costs associated with this direct final rule. These synergies resulting from the alignment of the CUAC/CUHP and CWAF compliance dates would yield INPV impacts that are less severe than the forecasted INPV range of −26.8 percent to −2.3 percent.

After considering the analysis and weighing the benefits and burdens, DOE has determined that the recommended standards are in accordance with 42 U.S.C. 6313(a)(6)(B), which contains provisions for adopting a uniform national standard more stringent than the amended ASHRAE Standard 90.1 for the equipment considered in this document. Specifically, the Secretary has determined, supported by clear and convincing evidence as described in this direct final rule and accompanying TSDs, that such adoption would result in the significant additional conservation of energy and is technologically feasible and economically justified. In determining whether the recommended standards are economically justified, the Secretary has determined that the benefits of the recommended standards exceed the burdens. Namely, the Secretary has concluded that under the recommended standards for CUACs and CUHPs, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, the estimated monetary value of the emissions reductions, and positive average LCC savings would outweigh the negative impacts on some consumers and on manufacturers, including the conversion costs that could result in a reduction in INPV for manufacturers.

Under the authority provided by 42 U.S.C. 6295(p)(4) and 6316(b)(1), DOE is issuing this direct final rule that establishes amended energy conservation standards for CUACs and CUHPs at the Recommended TSL. The amended energy conservation standards for CUACs and CUHPs, which prescribe the minimum allowable IEER and, for commercial unitary heat pumps, COP, are shown in Table V–43.

TABLE V–43—AMENDED ENERGY CONSERVATION STANDARDS FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT

Equipment type	Heating type	Proposed energy conservation standard	Compliance date
Small Commercial Packaged AC and HP (Air-Cooled)—≥65,000 Btu/h and <135,000 Btu/h Cooling Capacity			
AC	Electric Resistance Heating or No Heating.	12.9 IEER	January 1, 2018.
		14.8 IEER	January 1, 2023.
	All Other Types of Heating	12.7 IEER	January 1, 2018.
		14.6 IEER	January 1, 2023.
HP	Electric Resistance Heating or No Heating.	12.2 IEER 3.3 COP	January 1, 2018.
		14.1 IEER 3.4 COP	January 1, 2023.
	All Other Types of Heating	12.0 IEER 3.3 COP	January 1, 2018.
		13.9 IEER 3.4 COP	January 1, 2023.
Large Commercial Packaged AC and HP (Air-Cooled)—≥135,000 Btu/h and <240,000 Btu/h Cooling Capacity			
AC	Electric Resistance Heating or No Heating.	12.4 IEER	January 1, 2018.
		14.2 IEER	January 1, 2023.
	All Other Types of Heating	12.2 IEER	January 1, 2018.
		14.0 IEER	January 1, 2023.
HP	Electric Resistance Heating or No Heating.	11.6 IEER 3.2 COP	January 1, 2018.
		13.5 IEER 3.3 COP	January 1, 2023.
	All Other Types of Heating	11.4 IEER 3.2 COP	January 1, 2018.
		13.3 IEER 3.3 COP	January 1, 2023.
Very Large Commercial Packaged AC and HP (Air-Cooled)—≥240,000 Btu/h and <760,000 Btu/h Cooling Capacity			
AC	Electric Resistance Heating or No Heating.	11.6 IEER	January 1, 2018.
		13.2 IEER	January 1, 2023.
	All Other Types of Heating	11.4 IEER	January 1, 2018.
		13.0 IEER	January 1, 2023.
HP	Electric Resistance Heating or No Heating.	10.6 IEER 3.2 COP	January 1, 2018.
		12.5 IEER 3.2 COP	January 1, 2023.
	All Other Types of Heating	10.4 IEER 3.2 COP	January 1, 2018.
		12.3 IEER 3.2 COP	January 1, 2023.

The benefits and costs of the adopted standards can also be expressed in terms of annualized values. The annualized net benefit is the sum of: (1) The annualized national economic value (expressed in 2014$) of the benefits from operating equipment that meet the adopted standards (consisting primarily of operating cost savings from using less energy, minus increases in product purchase costs, and (2) the annualized monetary value of the benefits of CO_2 and NO_X emission reductions.[6]

Table V–44 shows the annualized values for CUACs and CUHPs under the Recommended TSL, expressed in 2014$. The results under the primary estimate are as follows. Using a 7-percent discount rate for benefits and costs other than CO_2 reduction, (for which DOE used a 3-percent discount rate along with the SCC series that has a value of $40.0/t in 2015),[7] the estimated cost of the standards in this rule is $708 million per year in increased equipment costs, while the estimated annual benefits are $2,099 million in reduced equipment operating costs, $1,320

[6] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2014, the year used for discounting the NPV of total consumer costs and savings. For the benefits, DOE calculated a present value associated with each year's shipments in the year in which the shipments occur (2020, 2030, *etc.*), and then discounted the present value from each year to 2015. The calculation uses discount rates of 3 and 7 percent for all costs and benefits except for the value of CO_2 reductions, for which DOE used case-specific discount rates. Using the present value, DOE then calculated the fixed annual payment over the analysis period, starting in the compliance year that yields the same present value.

[7] DOE used a 3-percent discount rate because the SCC values for the series used in the calculation were derived using a 3-percent discount rate (see section IV.L).

million in CO_2 reductions, and $132.0 million in reduced NO_X emissions. In this case, the net benefit amounts to $2,843 million per year. Using a 3-percent discount rate for all benefits and costs and the SCC series has a value of $40.0/t in 2015, the estimated cost of the standards is $792 million per year in increased equipment costs, while the estimated annual benefits are $3,441 million in reduced operating costs, $1,320 million in CO_2 reductions, and $231.3 million in reduced NO_X emissions. In this case, the net benefit amounts to $4,201 million per year.

TABLE V–44—ANNUALIZED BENEFITS AND COSTS OF ADOPTED STANDARDS FOR SMALL, LARGE, AND VERY LARGE AIR-COOLED COMMERCIAL PACKAGE AIR CONDITIONING AND HEATING EQUIPMENT

	Discount rate	Million 2014$/year		
		Primary estimate *	Low net benefits estimate	High net benefits estimate
Benefits				
Consumer Operating Cost Savings	7%	2,099	2,021	2,309
	3%	3,441	3,287	3,830
CO_2 Reduction Value ($12.2/t case) **	5%	357	355	361
CO_2 Reduction Value ($40.0/t case) **	3%	1,320	1,313	1,337
CO_2 Reduction Value ($62.3/t case) **	2.5%	1,973	1,964	1,999
CO_2 Reduction Value ($117/t case) **	3%	4,028	4,009	4,080
NO_X Reduction Value †	7%	132.0	131.3	299.1
	3%	231.3	230.2	516.3
Total Benefits ††	7% plus CO_2 range	2,588 to 6,259	2,507 to 6,160	2,970 to 6,689
	7%	3,551	3,465	3,946
	3% plus CO_2 range	4,029 to 7,701	3,872 to 7,525	4,708 to 8,427
	3%	4,992	4,830	5,684
Costs				
Consumer Incremental Product Costs	7%	708	888	275
	3%	792	1028	231
Net Benefits				
Total ††	7% plus CO_2 range	1,880 to 5,551	1,619 to 5,273	2,695 to 6,414
	7%	2,843	2,578	3,671
	3% plus CO_2 range	3,238 to 6,909	2,843 to 6,497	4,477 to 8,196
	3%	4,201	3,802	5,453

* This table presents the annualized costs and benefits associated with CUACs and CUHPs shipped in 2018–2048. These results include benefits to consumers which accrue after 2048 from the CUACs and CUHPs purchased in 2018–2048. The results account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule. The Primary, Low Benefits, and High Benefits estimates utilize projections of energy prices from the *AEO 2015* Reference case, Low Economic Growth case, and High Economic Growth case, respectively. In addition, incremental product costs reflect a constant price trend in the Primary estimate, a slightly increasing price trend in the Low Benefits estimate, and a slightly decreasing price trend in the Low Benefits estimate. The methods used to project price trends are explained in section IV.D.1.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series incorporate an escalation factor.

† The $/ton values used for NO_X are described in section IV.L.2. DOE estimated the monetized value of NOx emissions reductions using benefit per ton estimates from the *Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants,* published in June 2014 by EPA's Office of Air Quality Planning and Standards. (Available at: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.*) For DOE's Primary Estimate and Low Net Benefits Estimate, the agency is primarily using a national benefit-per-ton estimate for particulate matter emitted from the Electric Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski et al., 2009). For DOE's High Net Benefits Estimate, the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), which are nearly two-and-a-half times larger than those from the ACS study. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emission, DOE intends to investigate refinements to the agency's current approach of one national estimate by assessing the regional approach taken by EPA's Regulatory Impact Analysis for the Clean Power Plan Final Rule.

†† Total Benefits for both the 3% and 7% cases are derived using the series corresponding to the average SCC with 3-percent discount rate ($40.0/t) case. In the rows labeled "7% plus CO_2 range" and "3% plus CO_2 range," the operating cost and NO_X benefits are calculated using the labeled discount rate, and those values are added to the full range of CO_2 values.

2. Benefits and Burdens of TSLs Considered for Commercial Warm Air Furnaces

Table V–45 and Table V–46 summarize the quantitative impacts estimated for each TSL for CWAFs. For TSL 2, the national impacts are projected over the lifetime of equipment sold in 2023–2048. For the other TSLs, the impacts are projected over the lifetime of equipment sold in 2019–2048. The energy savings, emissions reductions, and value of emissions reductions refer to FFC results. The efficiency levels contained in each TSL are described in section V.A.

TABLE V–45—SUMMARY OF ANALYTICAL RESULTS FOR COMMERCIAL WARM AIR FURNACES: NATIONAL IMPACTS

	Trial standard level				
	1	2	3	4	5
Cumulative FFC Energy Savings *quads*	0.25	0.23	0.41	0.41	2.4.

TABLE V–45—SUMMARY OF ANALYTICAL RESULTS FOR COMMERCIAL WARM AIR FURNACES: NATIONAL IMPACTS—Continued

	Trial standard level				
	1	2	3	4	5
NPV of Consumer Costs and Benefits (2014$ billion)					
3% discount rate	1.1	1.0	−0.1	−0.1	2.6.
7% discount rate	0.4	0.3	−0.4	−0.4	−0.4.
Cumulative FFC Emissions Reduction					
CO_2 *million metric tons*	13.4	12.4	22.0	22.0	126.
SO_2 *thousand tons*	0.40	0.40	0.63	0.67	−10.2.
NO_X *thousand tons*	43.0	41.2	70.5	72.2	473.
Hg *tons*	0.001	0.001	0.002	0.002	−0.04.
CH_4 *thousand tons*	159	146	260	260	1,673.
CH_4 *thousand tons* CO_2eq*	4,440	4,096	7,289	7,292	46,831.
N_2O *thousand tons*	0.03	0.03	0.05	0.06	0.08.
N_2O *thousand tons* CO_2eq*	8.8	8.4	14.3	14.6	21.2.
Value of Emissions Reduction					
CO_2 *2014$ million***	79.8 to 1,185	71.4 to 1,078	126 to 1,891	126 to 1,897	713 to 10,809.
NO_X—3% discount rate *2014$ million*	120 to 264	110 to 243	188 to 414	192 to 424	1258 to 2772.
NO_X—7% discount rate *2014$ million*	42.3 to 94.4	36.1 to 80.9	64.2 to 144	65.9 to 147	423 to 945.

For TSL 2, the impacts are projected over the lifetime of equipment sold in 2023–2048. For the other TSLs, the impacts are projected over the lifetime of equipment sold in 2019–2048.
* CO_2eq is the quantity of CO_2 that would have the same global warming potential (GWP).
** Range of the economic value of CO_2 reductions is based on estimates of the global benefit of reduced CO_2 emissions.

TABLE V–46—SUMMARY OF ANALYTICAL RESULTS FOR COMMERCIAL WARM AIR FURNACES: MANUFACTURER AND CONSUMER IMPACTS

Category	Trial standard level				
	1	2	3	4	5
Manufacturer Impacts					
Industry NPV (2014$ million) (No-New-Standards Case INPV = 96.3).	85.8 to 92.6	83.0 to 90.5	65.5 to 125.2	60.4 to 124.8	(19.3) to 143.5.
Industry NPV *(% change)*	(11.0) to (3.9)	(13.9) to (6.1)	(32.0) to 29.9	(37.3) to 29.5	(120.1)† to 49.0.
Consumer Average LCC Savings (2014$)					
Gas-Fired Commercial Warm Air Furnaces	$284	$284	$75	$75	$766.
Oil-Fired Commercial Warm Air Furnaces	NA	$400	NA	$400	$1,817.
Average*	$284	$285	$75	$79	$781.
Consumer Simple PBP (*years*)					
Gas-Fired Commercial Warm Air Furnaces	1.4	1.4	12.3	12.3	11.3.
Oil-Fired Commercial Warm Air Furnaces	NA	1.9	NA	1.9	7.5.
Average*	1.4	1.4	12.3	12.1	11.3.
% of Consumers That Experience Net Cost					
Gas-Fired Commercial Warm Air Furnaces	6%	6%	58%	58%	58%.
Oil-Fired Commercial Warm Air Furnaces	0%	11%	0%	11%	54%.

* Weighted by shares of each equipment class in total projected shipments in 2019.
† At max tech, the standard will likely require CWAF manufacturers to make design changes to the cooling components of commercial HVAC products and to the chassis that houses the heating and cooling components. Because these cooling system changes are triggered by the CWAFs standard, they are taken into account in the MIA's estimate of conversion costs. The additional expense of updating the commercial cooling product contributes to an INPV loss that is greater than 100%.

DOE first considered TSL 5, which represents the max-tech efficiency levels. TSL 5 would save 2.4 quads of energy, an amount DOE considers significant. Under TSL 5, the NPV of consumer cost would be $0.4 billion using a 7-percent discount rate, and the NPV of consumer benefit would be $2.6 billion using a 3-percent discount rate.

The cumulative emissions reductions at TSL 5 are 126 Mt of CO_2, 473 thousand tons of NO_X, 1,673 thousand tons of CH_4, and 0.08 thousand tons of N_2O. Projected emissions show an increase of 10.2 thousand tons of SO_2 and 0.04 ton of Hg, The estimated monetary value of the CO_2 emissions reduction at TSL 5 ranges from $713 million to $10,809 million.

At TSL 5, the average LCC impact is a savings of $766 for gas-fired CWAFs and $1,817 for oil-fired CWAFs. The simple payback period is 11.3 years for gas-fired CWAFs and 7.5 years for oil-fired CWAFs. The fraction of consumers experiencing a net LCC cost is 58 percent for gas-fired CWAFs and 54 percent for oil-fired CWAFs.

At TSL 5, the projected change in INPV ranges from a decrease of $115.7 million to an increase of $47.2 million, which corresponds to a change of −120.1 percent and 49.0 percent, respectively. The industry is expected to incur $157.5 million in total conversion costs at this level. DOE projects that 99 percent of current equipment listings would require redesign at this level.

The Secretary concludes that at TSL 5 for CWAFs, the benefits of energy savings, positive NPV of consumer benefits using a discount rate of 3-percent, emission reductions, and the estimated monetary value of the emissions reductions would be outweighed by the economic burden on most consumers, the negative NPV of consumer benefits using a 7-percent discount rate, and the impacts on manufacturers, including the conversion costs and profit margin impacts that could result in a large reduction in INPV. Consequently, the Secretary has concluded that TSL 5 is not economically justified.

DOE then considered TSL 4. TSL 4 would save 0.41 quads of energy, an amount DOE considers significant. Under TSL 4, the NPV of consumer cost would be $0.4 billion using a 7-percent discount rate, and $0.1 billion using a 3-percent discount rate.

The cumulative emissions reductions at TSL 4 are 22 Mt of CO_2, 0.67 thousand tons of SO_2, 72.2 thousand tons of NO_X, 0.002 ton of Hg, 260 thousand tons of CH_4, and 0.06 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reduction at TSL 4 ranges from $126 million to $1,897 million.

At TSL 4, the average LCC impact is a savings of $75 for gas-fired CWAFs and $400 for oil-fired CWAFs. The simple payback period is 12.3 years for gas-fired CWAFs and 1.9 years for oil-fired CWAFs. The fraction of consumers experiencing a net LCC cost is 58 percent for gas-fired CWAFs, and 11 percent for oil-fired CWAFs.

At TSL 4, the projected change in INPV ranges from a decrease of $35.9 million to an increase of $28.4 million, which corresponds to a change of −37.3 percent and 29.5 percent, respectively. The industry is expected to incur $47.6 million in total conversion costs at this level; DOE projects that 94 percent of current product listings would require redesign at this level.

The Secretary concludes that at TSL 4 for CWAFs, the benefits of energy savings, emission reductions, and the estimated monetary value of the emissions reductions would be outweighed by the economic burden on many consumers, negative NPV of consumer benefits, and the impacts on manufacturers, including the conversion costs and profit margin impacts that could result in a large reduction in INPV. Consequently, the Secretary has concluded that TSL 4 is not economically justified.

DOE then considered TSL 3. TSL 3 would save 0.41 quads of energy, an amount DOE considers significant. Under TSL 3, the NPV of consumer cost would be $0.4 billion using a 7-percent discount rate, and $0.1 billion using a 3-percent discount rate.

The cumulative emissions reductions at TSL 3 are 22 Mt of CO_2, 0.63 thousand tons of SO_2, 70.5 thousand tons of NO_X, 0.002 ton of Hg, 260 thousand tons of CH_4, and 0.05 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reduction at TSL 3 ranges from $126 million to $1,891 million.

At TSL 3, the average LCC impact is a savings of $75 for gas-fired CWAFs. The simple payback period is 12.3 years for gas-fired CWAFs. The fraction of consumers experiencing a net LCC cost is 58 percent for gas-fired CWAFs. The EL at TSL 3 for oil-fired CWAFs is the baseline, so there are no LCC impacts for oil-fired CWAFs at TSL 3.

At TSL 3, the projected change in INPV ranges from a decrease of $30.9 million to an increase of $28.8 million, which corresponds to a change of −32.0 percent and 29.9 percent, respectively. The industry is expected to incur $41.0 million in total conversion costs at this level; DOE projects that 91 percent of current equipment listings would require redesign at this level.

The Secretary concludes that at TSL 3 for CWAFs, the benefits of energy savings, emission reductions, and the estimated monetary value of the emissions reductions would be outweighed by the economic burden on many consumers, negative NPV of consumer benefits, and the impacts on manufacturers, including the conversion costs and profit margin impacts that could result in a large reduction in INPV. Consequently, the Secretary has concluded that TSL 3 is not economically justified.

DOE then considered TSL 2. TSL 2 would save 0.23 quads of energy, an amount DOE considers significant. Under TSL 2, the NPV of consumer benefit would be $0.3 billion using a 7-percent discount rate, and $1.0 billion using a 3-percent discount rate.

The cumulative emissions reductions at TSL 2 are 12.4 Mt of CO_2, 0.40 thousand tons of SO_2, 41.2 thousand tons of NO_X, 0.001 ton of Hg, 146 thousand tons of CH_4, and 0.03 thousand tons of N_2O. The estimated monetary value of the CO_2 emissions reduction at TSL 2 ranges from $71.4 million to $1,078 million.

At TSL 2, the average LCC impact is a savings of $284 for gas-fired CWAFs and $400 for oil-fired CWAFs. The simple payback period is 1.4 years for gas-fired CWAFs and 1.9 years for oil-fired CWAFs. The fraction of consumers experiencing a net LCC cost is 6 percent for gas-fired CWAFs and 11 percent for oil-fired CWAFs.

At TSL 2, 57 percent of current equipment listings would require redesign at this level. The projected change in INPV ranges from a decrease of $13.4 million to a decrease of $5.9 million, which corresponds to a decrease of 13.9 percent and 6.1 percent, respectively. The CWAF industry is expected to incur $22.2 million in total conversion costs. However, the industry noted that aligning the compliance dates for the CUAC/CUHP and CWAF standards, as recommended by the Working Group, would allow manufacturers to coordinate their redesign and testing expenses for this equipment. If this occurs, there could be a reduction in the total conversion costs associated with this direct final rule. These synergies resulting from aligning the compliance dates of the CUAC/CUHP and CWAF standards would result in INPV impacts that are less severe than the forecasted INPV range of −13.9 percent to −6.1 percent.

After considering the analysis and weighing the benefits and burdens, DOE has determined that the recommended standards are in accordance with 42 U.S.C. 6313(a)(6)(B), which contains provisions for adopting a uniform national standard more stringent than the amended ASHRAE/IES Standard 90.1 for the equipment considered in this document. Specifically, the Secretary has determined, supported by clear and convincing evidence, that such adoption would result in significant additional conservation of energy and is technologically feasible and economically justified. In determining whether the recommended standards are economically justified, the

Secretary has determined that the benefits of the recommended standards exceed the burdens. Namely, the Secretary has concluded that under the recommended standards for CWAFs, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, the estimated monetary value of the emissions reductions, and positive average LCC savings would outweigh the negative impacts on some consumers and on manufacturers, including the conversion costs that could result in a reduction in INPV for manufacturers.

Under the authority provided by 42 U.S.C. 6295(p)(4) and 6316(b)(1), DOE is issuing this direct final rule that establishes amended energy conservation standards for CWAFs at TSL 2. The amended energy conservation standards for CWAFs, which are expressed in terms of TE, are shown in Table V–47.

TABLE V–47—AMENDED ENERGY CONSERVATION STANDARDS FOR COMMERCIAL WARM AIR FURNACES

Equipment type	Input capacity (Btu/h)	Thermal efficiency (%)
Gas-fired CWAFs	≥225,000 Btu/h	81
Oil-fired CWAFs	≥225,000 Btu/h	82

The benefits and costs of the adopted standards can also be expressed in terms of annualized values. The annualized net benefit is the sum of: (1) The annualized national economic value (expressed in 2014$) of the benefits from operating equipment that meet the adopted standards (consisting primarily of operating cost savings from using less energy, minus increases in equipment purchase costs), and (2) the annualized monetary value of the benefits of CO_2 and NO_X emission reductions.

Table V–48 shows the annualized values for CWAFs under TSL 2, expressed in 2014$. The results under the primary estimate are as follows. Using a 7-percent discount rate for benefits and costs other than CO_2 reductions, (for which DOE used a 3-percent discount rate along with the average SCC series corresponding to a value of $40.0/ton in 2015 (2014$)), the estimated cost of the adopted standards for CWAFs is $4.31 million per year in increased equipment costs, while the estimated benefits are $49 million per year in reduced equipment operating costs, $24 million per year in CO_2 reductions, and $4.91 million per year in reduced NO_X emissions. In this case, the net benefit amounts to $74 million per year.

Using a 3-percent discount rate for all benefits and costs and the average SCC series corresponding to a value of $40.0/ton in 2015 (in 2014$), the estimated cost of the adopted standards for CWAFs is $4.38 million per year in increased equipment costs, while the estimated benefits are $71 million per year in reduced operating costs, $24 million per year in CO_2 reductions, and $7.59 million per year in reduced NO_X emissions. In this case, the net benefit amounts to $99 million per year.

TABLE V–48—ANNUALIZED BENEFITS AND COSTS OF ADOPTED STANDARDS (TSL 2) FOR COMMERCIAL WARM AIR FURNACES

	Discount rate %	(Million 2014$/year)		
		Primary estimate*	Low net benefits estimate*	High net benefits estimate*
Benefits				
Consumer Operating Cost Savings	7	49	48	54
	3	71	70	81
CO_2 Reduction Value ($12.2/t case)**	5	6.99	7.08	7.37
CO_2 Reduction Value ($40.0/t case)**	3	24	25	26
CO_2 Reduction Value ($62.3/t case)**	2.5	36	36	38
CO_2 Reduction Value ($117/t case)**	3	74	75	79
NO_X Reduction Value †	7	4.91	4.98	11.44
	3	7.59	7.70	17.61
Total Benefits ††	7 plus CO_2 range	61 to 128	60 to 128	73 to 144
	7	78	78	91
	3 plus CO_2 range	86 to 153	84 to 152	106 to 177
	3	103	102	124
Costs				
Consumer Incremental Installed Costs	7	4.31	5.04	3.92
	3	4.38	5.22	3.94
Net Benefits				
Total ††	7 plus CO_2 range	57 to 124	55 to 123	69 to 140
	7	74	72	87
	3 plus CO_2 range	82 to 149	79 to 147	102 to 173

TABLE V–48—ANNUALIZED BENEFITS AND COSTS OF ADOPTED STANDARDS (TSL 2) FOR COMMERCIAL WARM AIR FURNACES—Continued

	Discount rate %	(Million 2014$/year)		
		Primary estimate*	Low net benefits estimate*	High net benefits estimate*
	3	99	97	120

*This table presents the annualized costs and benefits associated with CWAFs shipped in 2023–2048. These results include benefits to consumers which accrue after 2048 from the CWAFs purchased from 2023–2048. The results account for the incremental variable and fixed costs incurred by manufacturers due to the standard, some of which may be incurred in preparation for the rule. The Primary, Low Benefits, and High Benefits Estimates utilize projections of energy prices from the *AEO 2015* Reference case, Low Economic Growth case, and High Economic Growth case, respectively. In addition, incremental equipment costs reflect a medium decline rate in the Primary Estimate, a low decline rate in the Low Benefits Estimate, and a high decline rate in the High Benefits Estimate. The methods used to derive projected price trends are explained in section IV.H.3.

** The CO_2 values represent global monetized values of the SCC, in 2014$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series incorporate an escalation factor.

† The $/ton values used for NO_X are described in section IV.L.2. DOE estimated the monetized value of NO_X emissions reductions using benefit per ton estimates from the *Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants,* published in June 2014 by EPA's Office of Air Quality Planning and Standards. (Available at: *http://www3.epa.gov/ttnecas1/regdata/RIAs/111dproposalRIAfinal0602.pdf.*) For DOE's Primary Estimate and Low Net Benefits Estimate, the agency is primarily using a national benefit-per-ton estimate for particulate matter emitted from the Electric Generating Unit sector based on an estimate of premature mortality derived from the ACS study (Krewski et al., 2009). For DOE's High Net Benefits Estimate, the benefit-per-ton estimates were based on the Six Cities study (Lepuele et al., 2011), which are nearly two-and-a-half times larger than those from the ACS study. Because of the sensitivity of the benefit-per-ton estimate to the geographical considerations of sources and receptors of emission, DOE intends to investigate refinements to the agency's current approach of one national estimate by assessing the regional approach taken by EPA's Regulatory Impact Analysis for the Clean Power Plan Final Rule.

†† Total Benefits for both the 3% and 7% cases are derived using the series corresponding to the average SCC with 3-percent discount rate ($40.0/t case. In the rows labeled "7% plus CO_2 range" and "3% plus CO_2 range," the operating cost and NO_X benefits are calculated using the labeled discount rate, and those values are added to the full range of CO_2 values.

VI. Procedural Issues and Regulatory Review

A. Review Under Executive Orders 12866 and 13563

Section 1(b)(1) of Executive Order 12866, ''Regulatory Planning and Review,'' 58 FR 51735 (Oct. 4, 1993), requires each agency to identify the problem that it intends to address, including, where applicable, the failures of private markets or public institutions that warrant new agency action, as well as to assess the significance of that problem. The problems that the adopted standards for CUACs/CUHPs and CWAFs are intended to address are as follows:

(1) Insufficient information and the high costs of gathering and analyzing relevant information lead some consumers to miss opportunities to make cost-effective investments in energy efficiency.

(2) In some cases, the benefits of more efficient equipment are not realized due to misaligned incentives between purchasers and users. An example of such a case is when the equipment purchase decision is made by a building contractor or building owner who does not pay the energy costs to operate that equipment.

(3) There are external benefits resulting from the improved energy efficiency of CWAFs that are not captured by the users of such equipment. These benefits include externalities related to public health, environmental protection and national energy security that are not reflected in energy prices, such as reduced emissions of air pollutants and greenhouse gases that impact human health and global warming. DOE attempts to qualify some of the external benefits through use of social cost of carbon values.

The Administrator of the Office of Information and Regulatory Affairs (''OIRA'') in the OMB has determined that the proposed regulatory action is a significant regulatory action under section (3)(f) of Executive Order 12866. Accordingly, pursuant to section 6(a)(3)(B) of the Order, DOE has provided to OIRA: (i) The text of the draft regulatory action, together with a reasonably detailed description of the need for the regulatory action and an explanation of how the regulatory action will meet that need; and (ii) An assessment of the potential costs and benefits of the regulatory action, including an explanation of the manner in which the regulatory action is consistent with a statutory mandate. DOE has included these documents in the rulemaking record.

In addition, the Administrator of OIRA has determined that the proposed regulatory action is an ''economically'' significant regulatory action under section (3)(f)(1) of Executive Order 12866. Accordingly, pursuant to section 6(a)(3)(C) of the Order, DOE has provided to OIRA an assessment, including the underlying analysis, of benefits and costs anticipated from the regulatory action, together with, to the extent feasible, a quantification of those costs; and an assessment, including the underlying analysis, of costs and benefits of potentially effective and reasonably feasible alternatives to the planned regulation, and an explanation why the planned regulatory action is preferable to the identified potential alternatives. These assessments can be found in the technical support documents for this rulemaking.

DOE has also reviewed this regulation pursuant to Executive Order 13563, issued on January 18, 2011. (76 FR 3281, Jan. 21, 2011) EO 13563 is supplemental to and explicitly reaffirms the principles, structures, and definitions governing regulatory review established in Executive Order 12866. To the extent permitted by law, agencies are required by Executive Order 13563 to: (1) Propose or adopt a regulation only upon a reasoned determination that its benefits justify its costs (recognizing that some benefits and costs are difficult to quantify); (2) tailor regulations to impose the least burden on society, consistent with obtaining regulatory objectives, taking into account, among other things, and to the extent practicable, the costs of cumulative regulations; (3) select, in choosing among alternative regulatory approaches, those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity); (4) to the extent feasible, specify performance objectives, rather than specifying the behavior or manner of compliance that regulated entities must adopt; and (5) identify and assess available alternatives to direct regulation, including providing economic incentives to encourage the desired behavior, such as user fees or marketable permits, or providing information upon which choices can be made by the public.

DOE emphasizes as well that Executive Order 13563 requires agencies to use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible. In its guidance, OIRA has emphasized that such techniques may include identifying changing future compliance costs that might result from technological innovation or anticipated behavioral changes. For the reasons stated in the preamble, DOE believes that this direct final rule is consistent with these principles, including the requirement that, to the extent permitted by law, benefits justify costs and that net benefits are maximized.

B. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*) requires preparation of a final regulatory flexibility analysis (''FRFA'') for any rule that by law must be proposed for public comment, unless the agency certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities. As required by Executive Order 13272, ''Proper Consideration of Small Entities in Agency Rulemaking,'' 67 FR 53461 (August 16, 2002), DOE published procedures and policies on February 19, 2003, to ensure that the potential impacts of its rules on small entities are properly considered during the rulemaking process. 68 FR 7990. DOE has made its procedures and policies available on the Office of the General Counsel's Web site (*http://energy.gov/gc/office-general-counsel*). DOE has prepared the following FRFA for the products that are the subject of this rulemaking.

For manufacturers of CUAC/CUHP and CWAF equipment, the Small Business Administration (''SBA'') has set a size threshold, which defines those entities classified as ''small businesses'' for the purposes of the statute. DOE used the SBA's small business size standards to determine whether any small entities would be subject to the requirements of the rule. See 13 CFR part 121. The size standards are listed by North American Industry Classification System (''NAICS'') code and industry description and are available at *http://www.sba.gov/category/navigation-structure/contracting/contracting-officials/small-business-size-standards*. Manufacturing of CUACs/CUHPs and CWAFs is classified under NAICS 333415, ''Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing.'' The SBA sets a threshold of 750 employees or less for an entity to be considered as a small business for this category.

1. Commercial Unitary Air Conditioners and Heat Pumps

a. Description of Estimated Number of Small Entities Regulated

To better assess the potential impacts of this rulemaking on small entities, DOE conducted a focused inquiry of the companies that could be small business manufacturers of equipment covered by this rulemaking. DOE conducted a market survey using available public information to identify potential small manufacturers. DOE's research involved industry trade association membership directories (including AHRI[8]), individual company Web sites, and market research tools (*e.g.,* Hoovers reports[9]) to create a list of companies that manufacture or sell CUAC/CUHP equipment covered by this rulemaking. DOE also asked industry representatives if they were aware of any other small manufacturers during manufacturer interviews. DOE reviewed publicly-available data and contacted companies on its list, as necessary, to determine whether they met the SBA's definition of a small business manufacturer. DOE screened out companies that do not offer equipment covered by this rulemaking, do not meet the definition of a ''small business,'' or are foreign-owned and operated.

DOE identified 12 CUAC/CUHP manufacturers who sell covered equipment in the U.S market. DOE determined that nine of these manufacturers were large and three met the SBA's ''small business'' definition.

b. Description and Estimate of Compliance Requirements

The first small manufacturer specialized in double-duct products. A review of its product literature and Web site showed that its only covered equipment were double-duct systems. Since this direct final rule does not amend the standards for double-duct equipment, this rule will not have an impact on this small manufacturer.

The second small manufacturer did not own any production assets for the covered equipment. The company outsourced the design and manufacture to a supplier. Thus, the small business would not face any capital conversion costs and very limited equipment conversion costs.

The third small manufacturer produced covered equipment that are subject to this direct final rule. Before issuing this final rule, DOE attempted to contact this small business manufacturer. However, the business chose not to participate in an MIA interview. Based on DOE's research, this third small manufacturer has three platforms with 11 models covered by the CUAC/CUHP rulemaking. However, it is difficult for DOE to discern the potential conversion costs required to comply with the direct final rule's standard since no IEER ratings were provided for these units.

Based on literature reviews, DOE believes this third small manufacturer specializes in custom and semi-custom products. This would suggest the manufacturer has less hard-tooling than their large competitors and their capital requirements would vary dramatically from the industy average. The company's capital conversion costs would likely be smaller in absolute dollars relative to large competitors. However, the small manufacturer would likely need to recover those costs over a lower volume of shipments.

2. Commercial Warm Air Furnaces

a. Description of Estimated Number of Small Entities Regulated

To better assess the potential impacts of this rulemaking on small entities, DOE conducted a focused inquiry of the companies that could be small business manufacturers of equipment covered by this rulemaking. DOE conducted a market survey using available public information to identify potential small manufacturers. DOE's research involved industry trade association membership directories (including AHRI[10]),

[8] Based on listings in the AHRI directory accessed on August 2, 2013 (Available at: *https://www.ahridirectory.org/ahridirectory/pages/home.aspx*).

[9] Hoovers | Company Information | Industry Information | Lists, D&B (2013) (Available at: *http://www.hoovers.com/*) (Last accessed April 3, 2013).

[10] Based on listings in the AHRI directory accessed on August 2, 2013 (Available at: *https://*

Continued

individual company Web sites, and market research tools (*e.g.,* Hoovers reports [11]) to create a list of companies that manufacture or sell CWAF equipment covered by this rulemaking. DOE also asked industry representatives if they were aware of any other small manufacturers during manufacturer interviews. DOE reviewed publicly-available data and contacted companies on its list, as necessary, to determine whether they met the SBA's definition of a small business manufacturer. DOE screened out companies that do not offer equipment covered by this rulemaking, do not meet the definition of a ''small business,'' or are foreign-owned and operated.

DOE identified 14 manufacturers of CWAFs sold in the U.S. market. DOE determined that eleven manufacturers were large and three manufacturers met the SBA's definition of a ''small business''.

Before issuing this document, DOE attempted to contact each small business CWAF equipment manufacturer it had identified. None of them, however, consented to formal interviews. DOE also attempted to obtain information about small business impacts while interviewing large manufacturers.

DOE identified one small gas-fired CWAF manufacturer and two small oil-fired CWAF manufacturers. The gas-fired CWAF manufacturer accounts for 17 of the 250 gas-fired CWAFs listings in the AHRI Directory,[12] or approximately 7 percent of the listings. This small manufacturer offers product exclusively at 80-percent TE, and at the recommended TSL, would need to update all equipment offerings to meet a standard of 82-percent TE. However, this position is not unique. There are also some large gas-fired CWAF manufacturers that would need to update all equipment offerings to meet the direct final rule's standard. From a design perspective, DOE believes that most gas-fired equipment lines on the market today can be upgraded to achieve the standard with increases in heat exchange surface area.

With respect to oil-fired small business CWAF manufacturers, the first of these entities DOE examined accounts for 11 of the 16 oil-fired CWAFs listings in the AHRI Directory. This manufacturer produces some of the most efficient products on the market at 92-percent TE. Similarly, the second small oil-fired manufacturer produces the most efficient non-condensing equipment on the market at 84-percent TE. These two small oil-fired manufacturers would unlikely be at a technological disadvantage relative to its competitors at the recommended TSL. It is possible the small manufacturers would have a competitive advantage given its technological lead and experience in the niche market of high-efficiency commercial oil-fired warm air furnaces.

Since CWAFs have relatively low sales volumes, and because the industry as a whole generally produces equipment at the baseline, DOE believes the average impacts will be similar for large and small business manufacturers. DOE was unable to identify any publicly available information that would lead to a conclusion that small manufacturers would be differentially impacted by this direct final rule. Therefore, DOE assumed that small business manufacturers would face similar conversion costs as larger businesses. However, the small CWAF manufacturers may need to allocate a greater portion of their technical resources or may need to access outside capital to support the transition to the direct final rule's standard.

3. Duplication, Overlap, and Conflict With Other Rules and Regulations

DOE is not aware of any rules or regulations that duplicate, overlap, or conflict with the rule being considered today.

4. Significant Alternatives to the Rule

The discussion above analyzes impacts on small businesses that would result from the direct final rule. In addition to the other TSLs being considered, the direct final rule TSDs analyzing the potential impacts from standards for CUACs/CUHPs and CWAFs include an analysis of the following policy alternatives: (1) No change in standard; (2) consumer rebates; (3) consumer tax credits; (4) manufacturer tax credits; (5) voluntary energy efficiency targets; and (6) bulk government purchases. While these alternatives may mitigate to some varying extent the economic impacts on small entities compared to the adopted standards, DOE does not intend to consider these alternatives further because in several cases, they would not be feasible to implement without authority and funding from Congress, and in all cases, DOE has determined that the energy savings of these alternatives are significantly smaller than those that are expected to result from adoption of the standards (0.2 percent to 2.4 percent of the energy savings from the adopted standards for CUACs/CUHPs, and less than 0.1 percent to 46 percent for CWAFs).[13] Accordingly, DOE is declining to adopt any of these alternatives and is adopting the standards set forth in this document. (See chapter 17 of the direct final rule TSDs for further detail on the policy alternatives DOE considered.)

Further, EPCA provides that a manufacturer whose annual gross revenue from all of its operations does not exceed $8,000,000 may apply for an exemption from all or part of an energy conservation standard for a period not longer than 24 months after the effective date of a final rule establishing the standard. Additionally, Section 504 of the Department of Energy Organization Act, 42 U.S.C. 7194, authorizes the Secretary to adjust a rule issued under EPCA in order to prevent ''special hardship, inequity, or unfair distribution of burdens'' that may be imposed on that manufacturer as a result of such rule. See 10 CFR part 430, subpart E, and part 1003 for additional details.

C. Review Under the Paperwork Reduction Act

Manufacturers of CUACs/CUHPs and CWAFs must certify to DOE that their equipment complies with any applicable energy conservation standards. In certifying compliance, manufacturers must test their equipment according to the DOE test procedures for CUACs/CUHPs and CWAFs, including any amendments adopted for those test procedures. DOE has established regulations for the certification and recordkeeping requirements for all covered consumer products and commercial equipment, including CUACs/CUHPs and CWAFs. 76 FR 12422 (March 7, 2011); 80 FR 5099 (Jan. 30, 2015). The collection-of-information requirement for certification and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act (''PRA''). This requirement has been approved by OMB under OMB control number 1910–1400. The public

www.ahridirectory.org/ahridirectory/pages/home.aspx).

[11] Hoovers | Company Information | Industry Information | Lists, D&B (2013) (Available at: *http://www.hoovers.com/*) (Last accessed April 3, 2013).

[12] The AHRI directory lists approximately 1,000 units. Many of these units are from the same model line, share the same chassis, and have the same level of performance, but have different heating capacities or installed product options. DOE consolidated the AHRI listing of CWAFs such that all units from the same model line and chassis are listed together as a single unit.

[13] Bulk government purchase have a small impact on CWAF energy use in the nation, while commercial consumer rebates could significantly impact energy use.

reporting burden for the certification is estimated to average 30 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB Control Number.

D. Review Under the National Environmental Policy Act of 1969

Pursuant to the National Environmental Policy Act of 1969 (''NEPA''), DOE has determined that the rule fits within the category of actions included in Categorical Exclusion (''CX'') B5.1 and otherwise meets the requirements for application of a CX. See 10 CFR part 1021, app. B, B5.1(b); § 1021.410(b) and app. B, B(1)–(5). The rule fits within the category of actions because it is a rulemaking that establishes energy conservation standards for consumer products or industrial equipment, and for which none of the exceptions identified in CX B5.1(b) apply. Therefore, DOE has made a CX determination for this rulemaking, and DOE does not need to prepare an Environmental Assessment or Environmental Impact Statement for this rule. DOE's CX determination for this rule is available at *http://energy.gov/nepa/categorical-exclusion-cx-determinations-cx.*

E. Review Under Executive Order 13132

Executive Order 13132, ''Federalism,'' 64 FR 43255 (August 10, 1999) imposes certain requirements on Federal agencies formulating and implementing policies or regulations that preempt State law or that have Federalism implications. The Executive Order requires agencies to examine the constitutional and statutory authority supporting any action that would limit the policymaking discretion of the States and to carefully assess the necessity for such actions. The Executive Order also requires agencies to have an accountable process to ensure meaningful and timely input by State and local officials in the development of regulatory policies that have Federalism implications. On March 14, 2000, DOE published a statement of policy describing the intergovernmental consultation process it will follow in the development of such regulations. 65 FR 13735. DOE has examined this direct final rule and has determined that it would not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. EPCA governs and prescribes Federal preemption of State regulations as to energy conservation for the equipment subject to this direct final rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297) Therefore, no further action is required by Executive Order 13132.

F. Review Under Executive Order 12988

With respect to the review of existing regulations and the promulgation of new regulations, section 3(a) of Executive Order 12988, ''Civil Justice Reform,'' imposes on Federal agencies the general duty to adhere to the following requirements: (1) Eliminate drafting errors and ambiguity; (2) write regulations to minimize litigation; (3) provide a clear legal standard for affected conduct rather than a general standard; and (4) promote simplification and burden reduction. 61 FR 4729 (Feb. 7, 1996). Regarding the review required by section 3(a), section 3(b) of Executive Order 12988 specifically requires that Executive agencies make every reasonable effort to ensure that the regulation: (1) Clearly specifies the preemptive effect, if any; (2) clearly specifies any effect on existing Federal law or regulation; (3) provides a clear legal standard for affected conduct while promoting simplification and burden reduction; (4) specifies the retroactive effect, if any; (5) adequately defines key terms; and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. Section 3(c) of Executive Order 12988 requires Executive agencies to review regulations in light of applicable standards in section 3(a) and section 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, this direct final rule meets the relevant standards of Executive Order 12988.

G. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (''UMRA'') requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and Tribal governments and the private sector. Pub. L. 104–4, sec. 201 (codified at 2 U.S.C. 1531). For a regulatory action likely to result in a rule that may cause the expenditure by State, local, and Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of State, local, and Tribal governments on a ''significant intergovernmental mandate,'' and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect them. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820. DOE's policy statement is also available at *http://energy.gov/sites/prod/files/gcprod/documents/umra_97.pdf.*

DOE has concluded that this direct final rule may require expenditures of $100 million or more in any one year on the private sector. Such expenditures may include: (1) Investment in research and development and in capital expenditures by CUAC/CUHP and CWAF manufacturers in the years between the direct final rule and the compliance date for the new standards, and (2) incremental additional expenditures by consumers to purchase higher-efficiency CUACs/CUHPs and CWAFs.

Section 202 of UMRA authorizes a Federal agency to respond to the content requirements of UMRA in any other statement or analysis that accompanies the direct final rule. (2 U.S.C. 1532(c)) The content requirements of section 202(b) of UMRA relevant to a private sector mandate substantially overlap the economic analysis requirements that apply under section 325(o) of EPCA and Executive Order 12866. The **SUPPLEMENTARY INFORMATION** section of this document and the ''Regulatory Impact Analysis'' section of the TSD for this direct final rule respond to those requirements.

Under section 205 of UMRA, the Department is obligated to identify and consider a reasonable number of regulatory alternatives before promulgating a rule for which a written statement under section 202 is required. (2 U.S.C. 1535(a)) DOE is required to select from those alternatives the most cost-effective and least burdensome alternative that achieves the objectives of the rule unless DOE publishes an explanation for doing otherwise, or the selection of such an alternative is inconsistent with law. This direct final rule would establish amended energy conservation standards for CUACs/CUHPs and CWAFs that are designed to achieve the maximum improvement in energy efficiency that DOE has determined to be both technologically feasible and economically justified. A full discussion of the alternatives considered by DOE is presented in chapter 17 of the CUACs/CUHPs and CWAFs TSDs for this direct final rule.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105–277) requires Federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This direct final rule would not have any impact on the autonomy or integrity of the family as an institution. Accordingly, DOE has concluded that it is not necessary to prepare a Family Policymaking Assessment.

I. Review Under Executive Order 12630

Pursuant to Executive Order 12630, ''Governmental Actions and Interference with Constitutionally Protected Property Rights,'' 53 FR 8859 (March 18, 1988), DOE has determined that this direct final rule would not result in any takings that might require compensation under the Fifth Amendment to the U.S. Constitution.

J. Review Under the Treasury and General Government Appropriations Act, 2001

Section 515 of the Treasury and General Government Appropriations Act, 2001 (44 U.S.C. 3516, note) provides for Federal agencies to review most disseminations of information to the public under information quality guidelines established by each agency pursuant to general guidelines issued by OMB. OMB's guidelines were published at 67 FR 8452 (Feb. 22, 2002), and DOE's guidelines were published at 67 FR 62446 (Oct. 7, 2002). DOE has reviewed this direct final rule under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

K. Review Under Executive Order 13211

Executive Order 13211, ''Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use,'' 66 FR 28355 (May 22, 2001), requires Federal agencies to prepare and submit to OIRA at OMB, a Statement of Energy Effects for any significant energy action. A ''significant energy action'' is defined as any action by an agency that promulgates or is expected to lead to promulgation of a final rule, and that: (1) Is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy, or (3) is designated by the Administrator of OIRA as a significant energy action. For any significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

DOE has concluded that this regulatory action, which sets forth amended energy conservation standards for CUACs/CUHPs and CWAFs, is not a significant energy action because the standards are not likely to have a significant adverse effect on the supply, distribution, or use of energy, nor has it been designated as such by the Administrator at OIRA. Accordingly, DOE has not prepared a Statement of Energy Effects on this direct final rule.

L. Review Under the Information Quality Bulletin for Peer Review

On December 16, 2004, OMB, in consultation with the Office of Science and Technology Policy (OSTP), issued its Final Information Quality Bulletin for Peer Review (the Bulletin). 70 FR 2664 (Jan. 14, 2005). The Bulletin establishes that certain scientific information shall be peer reviewed by qualified specialists before it is disseminated by the Federal Government, including influential scientific information related to agency regulatory actions. The purpose of the bulletin is to enhance the quality and credibility of the Government's scientific information. Under the Bulletin, the energy conservation standards rulemaking analyses are ''influential scientific information,'' which the Bulletin defines as ''scientific information the agency reasonably can determine will have, or does have, a clear and substantial impact on important public policies or private sector decisions.'' *Id.* at FR 2667.

In response to OMB's Bulletin, DOE conducted formal in-progress peer reviews of the energy conservation standards development process and analyses and has prepared a Peer Review Report pertaining to the energy conservation standards rulemaking analyses. Generation of this report involved a rigorous, formal, and documented evaluation using objective criteria and qualified and independent reviewers to make a judgment as to the technical/scientific/business merit, the actual or anticipated results, and the productivity and management effectiveness of programs and/or projects. The ''Energy Conservation Standards Rulemaking Peer Review Report'' dated February 2007 has been disseminated and is available at the following Web site: *www1.eere.energy.gov/buildings/appliance_standards/peer_review.html*.

M. Congressional Notification

As required by 5 U.S.C. 801, DOE will report to Congress on the promulgation of this direct final rule prior to its effective date. The report will state that it has been determined that the rule is a ''major rule'' as defined by 5 U.S.C. 804(2). DOE also will submit the supporting analyses to the Comproller General in the U.S. Government Accountability Office (''GAO'') and make them available to each House of Congress.

VII. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this direct final rule.

List of Subjects in 10 CFR Part 431

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Intergovernmental relations, Reporting and recordkeeping requirements, Small businesses.

Issued in Washington, DC, on December 17, 2015.

David T. Danielson,

Assistant Secretary, Energy Efficiency and Renewable Energy.

For the reasons set forth in the preamble, DOE amends part 431 of chapter II, subchapter D, of title 10 of the Code of Federal Regulations, as set forth below:

PART 431—ENERGY EFFICIENCY PROGRAM FOR CERTAIN COMMERCIAL AND INDUSTRIAL EQUIPMENT

■ 1. The authority citation for part 431 continues to read as follows:

Authority: 42 U.S.C. 6291–6317.

■ 2. Section 431.77 is revised to read as follows:

§ 431.77 Energy conservation standards and their effective dates.

(a) *Gas-fired commercial warm air furnaces.* Each gas-fired commercial warm air furnace must meet the following energy efficiency standard levels:

(1) For gas-fired commercial warm air furnaces manufactured starting on January 1, 1994, until January 1, 2023, the TE at the maximum rated capacity (rated maximum input) must be not less than 80 percent; and

(2) For gas-fired commercial warm air furnaces manufactured starting on January 1, 2023, the TE at the maximum rated capacity (rated maximum input) must be not less than 81 percent.

(b) *Oil-fired commercial warm air furnaces.* Each oil-fired commercial warm air furnace must meet the following energy efficiency standard levels:

(1) For oil-fired commercial warm air furnaces manufactured starting on January 1, 1994, until January 1, 2023, the TE at the maximum rated capacity (rated maximum input) must be not less than 81 percent; and

(2) For oil-fired commercial warm air furnaces manufactured starting on January 1, 2023, the TE at the maximum rated capacity (rated maximum input) must be not less than 82 percent.

■ 3. Section 431.92 is amended by adding the definition of ''Double-duct air conditioner or heat pump means air-cooled commercial package air conditioning and heating equipment'' in alphabetical order to read as follows:

§ 431.92 Definitions concerning commercial air conditioners and heat pumps.

* * * * *

Double-duct air conditioner or heat pump means air-cooled commercial package air conditioning and heating equipment that—

(1) Is either a horizontal single package or split-system unit; or a vertical unit that consists of two components that may be shipped or installed either connected or split;

(2) Is intended for indoor installation with ducting of outdoor air from the building exterior to and from the unit, as evidenced by the unit and/or all of its components being non-weatherized, including the absence of any marking (or listing) indicating compliance with UL 1995, ''Heating and Cooling Equipment,'' or any other equivalent requirements for outdoor use;

(3)(i) If it is a horizontal unit, a complete unit has a maximum height of 35 inches; (ii) If it is a vertical unit, a complete unit has a maximum depth of 35 inches; and

(4) Has a rated cooling capacity greater than or equal to 65,000 Btu/h and up to 300,000 Btu/h.

* * * * *

■ 4. Section 431.97 is amended by:

■ a. Redesignating Tables 5 through 11 as Tables 7 through 13;

■ b. Revising paragraph (b) and the introductory text of paragraph (c);

■ c. In paragraph (d)(1) introductory text, removing ''Table 7'' and adding in its place ''Table 9'';

■ d. In paragraph (d)(2) introductory text, removing ''Table 8'' and adding in its place ''Table 10''; and

■ e. In paragraph (d)(3) introductory text, removing ''Table 9'' and adding in its place ''Table 11''.

The revisions read as follows:

§ 431.97 Energy efficiency standards and their compliance dates.

* * * * *

(b) Each commercial air conditioner or heat pump (not including single package vertical air conditioners and single package vertical heat pumps, packaged terminal air conditioners and packaged terminal heat pumps, computer room air conditioners, and variable refrigerant flow systems) manufactured starting on the compliance date listed in the corresponding table must meet the applicable minimum energy efficiency standard level(s) set forth in Tables 1 through 6 of this section.

TABLE 1 TO § 431.97—MINIMUM COOLING EFFICIENCY STANDARDS FOR AIR CONDITIONING AND HEATING EQUIPMENT

[Not including single package vertical air conditioners and single package vertical heat pumps, packaged terminal air conditioners and packaged terminal heat pumps, computer room air conditioners, and variable refrigerant flow multi-split air conditioners and heat pumps]

Equipment type	Cooling capacity	Subcategory	Heating type	Efficiency level	Compliance date: Equipment manufactured starting on . . .
Small Commercial Package Air Conditioning and Heating Equipment (Air-Cooled, 3-Phase, Split-System).	<65,000 Btu/h	AC	All	SEER = 13	June 16, 2008.
		HP	All	SEER = 13	June 16, 2008.[1]
Small Commercial Package Air Conditioning and Heating Equipment (Air-Cooled, 3-Phase, Single-Package).	<65,000 Btu/h	AC	All	SEER = 13	June 16, 2008.[1]
		HP	All	SEER = 13	June 16, 2008.[1]
Small Commercial Package Air Conditioning and Heating Equipment (Air-Cooled).	≥65,000 Btu/h and <135,000 Btu/h.	AC	No Heating or Electric Resistance Heating.	EER = 11.2	January 1, 2010.[2]
			All Other Types of Heating	EER = 11.0	January 1, 2010.[2]
		HP	No Heating or Electric Resistance Heating.	EER = 11.0	January 1, 2010.[2]
			All Other Types of Heating	EER = 10.8	January 1, 2010.[2]
Large Commercial Package Air Conditioning and Heating Equipment (Air-Cooled).	≥135,000 Btu/h and <240,000 Btu/h.	AC	No Heating or Electric Resistance Heating.	EER = 11.0	January 1, 2010.[2]
			All Other Types of Heating	EER = 10.8	January 1, 2010.[2]
		HP	No Heating or Electric Resistance Heating.	EER = 10.6	January 1, 2010.[2]
			All Other Types of Heating	EER = 10.4	January 1, 2010.[2]

TABLE 1 TO § 431.97—MINIMUM COOLING EFFICIENCY STANDARDS FOR AIR CONDITIONING AND HEATING EQUIPMENT—Continued

[Not including single package vertical air conditioners and single package vertical heat pumps, packaged terminal air conditioners and packaged terminal heat pumps, computer room air conditioners, and variable refrigerant flow multi-split air conditioners and heat pumps]

Equipment type	Cooling capacity	Subcategory	Heating type	Efficiency level	Compliance date: Equipment manufactured starting on . . .
Very Large Commercial Package Air Conditioning and Heating Equipment (Air-Cooled).	≥240,000 Btu/h and <760,000 Btu/h.	AC	No Heating or Electric Resistance Heating.	EER = 10.0	January 1, 2010.[2]
			All Other Types of Heating	EER = 9.8	January 1, 2010.[2]
		HP	No Heating or Electric Resistance Heating.	EER = 9.5	January 1, 2010.[2]
			All Other Types of Heating	EER = 9.3	January 1, 2010.[2]
Small Commercial Package Air Conditioning and Heating Equipment (Water-Cooled).	<65,000 Btu/h	AC	All	EER = 12.1	October 29, 2003.
	≥65,000 Btu/h and <135,000 Btu/h.	AC	No Heating or Electric Resistance Heating.	EER = 12.1	June 1, 2013.
			All Other Types of Heating	EER = 11.9	June 1, 2013.
Large Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled).	≥135,000 Btu/h and <240,000 Btu/h.	AC	No Heating or Electric Resistance Heating.	EER = 12.5	June 1, 2014.
			All Other Types of Heating	EER = 12.3	June 1, 2014.
Very Large Commercial Package Air-Conditioning and Heating Equipment (Water-Cooled).	≥240,000 Btu/h and <760,000 Btu/h.	AC	No Heating or Electric Resistance Heating.	EER = 12.4	June 1, 2014.
			All Other Types of Heating	EER = 12.2	June 1, 2014.
Small Commercial Package Air-Conditioning and Heating Equipment (Evaporatively-Cooled).	<65,000 Btu/h	AC	All	EER = 12.1	October 29, 2003.
	≥65,000 Btu/h and <135,000 Btu/h.	AC	No Heating or Electric Resistance Heating.	EER = 12.1	June 1, 2013.
			All Other Types of Heating	EER = 11.9	June 1, 2013.
Large Commercial Package Air-Conditioning and Heating Equipment (Evaporatively-Cooled).	≥135,000 Btu/h and <240,000 Btu/h.	AC	No Heating or Electric Resistance Heating.	EER = 12.0	June 1, 2014.
			All Other Types of Heating	EER = 11.8	June 1, 2014.
Very Large Commercial Package Air Conditioning and Heating Equipment (Evaporatively-Cooled).	≥240,000 Btu/h and <760,000 Btu/h.	AC	No Heating or Electric Resistance Heating.	EER = 11.9	June 1, 2014.
			All Other Types of Heating	EER = 11.7	June 1, 2014.
Small Commercial Package Air-Conditioning and Heating Equipment (Water-Source: Water-to-Air, Water-Loop).	<17,000 Btu/h	HP	All	EER = 11.2	October 29, 2003.[3]
	≥17,000 Btu/h and <65,000 Btu/h.	HP	All	EER = 12.0	October 29, 2003.[3]
	≥65,000 Btu/h and <135,000 Btu/h.	HP	All	EER = 12.0	October 29, 2003.[3]

[1] And manufactured before January 1, 2017. See Table 3 of this section for updated efficiency standards.
[2] And manufactured before January 1, 2018. See Table 3 of this section for updated efficiency standards.
[3] And manufactured before October 9, 2015. See Table 3 of this section for updated efficiency standards.

TABLE 2 TO § 431.97—MINIMUM HEATING EFFICIENCY STANDARDS FOR AIR CONDITIONING AND HEATING EQUIPMENT [HEAT PUMPS]

[Not including single package vertical air conditioners and single package vertical heat pumps, packaged terminal air conditioners and packaged terminal heat pumps, computer room air conditioners, variable refrigerant flow multi-split air conditioners and heat pumps, and double-duct air-cooled commercial package air conditioning and heating equipment]

Equipment type	Cooling capacity	Efficiency level	Compliance date: Equipment manufactured starting on . . .
Small Commercial Package Air Conditioning and Heating Equipment (Air-Cooled, 3-Phase, Split-System).	<65,000 Btu/h	HSPF = 7.7	June 16, 2008.[1]
Small Commercial Pacakage Air-Conditioning and Heating Equipment (Air-Cooled, 3-Phase, Single-Package).	<65,000 Btu/h	HSPF = 7.7	June 16, 2008.[1]
Small Commercial Package Air Conditioning and Heating Equipment (Air-Cooled).	≥65,000 Btu/h and <135,000 Btu/h.	COP = 3.3	January 1, 2010.[2]
Large Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled).	≥135,000 Btu/h and <240,000 Btu/h.	COP = 3.2	January 1, 2010.[2]
Very Large Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled).	≥240,000 Btu/h and <760,000 Btu/h.	COP = 3.2	January 1, 2010.[2]
Small Commercial Packaged Air Conditioning and Heating Equipment (Water-Source: Water-to-Air, Water-Loop).	<135,000 Btu/h	COP = 4.2	October 29, 2003.

[1] And manufactured before January 1, 2017. See Table 4 of this section for updated heating efficiency standards.
[2] And manufactured before January 1, 2018. See Table 4 of this section for updated heating efficiency standards.

TABLE 3 TO § 431.97—UPDATES TO THE MINIMUM COOLING EFFICIENCY STANDARDS FOR AIR CONDITIONING AND HEATING EQUIPMENT

[Not including single package vertical air conditioners and single package vertical heat pumps, packaged terminal air conditioners and packaged terminal heat pumps, computer room air conditioners, variable refrigerant flow multi-split air conditioners and heat pumps, and double-duct air-cooled commercial package air conditioning and heating equipment]

Equipment type	Cooling capacity	Subcategory	Heating type	Efficiency level	Compliance date: Equipment manufactured starting on . . .
Small Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled).	≥65,000 Btu/h and <135,000 Btu/h.	AC	Electric Resistance Heating or No Heating.	IEER = 12.9 IEER = 14.8	January 1, 2018.[1] January 1, 2023.
			All Other Types of Heating	IEER = 12.7 IEER = 14.6	January 1, 2018.[1] January 1, 2023.
		HP	Electric Resistance Heating or No Heating.	IEER = 12.2 IEER = 14.1	January 1, 2018.[1] January 1, 2023.
			All Other Types of Heating	IEER = 12.0 IEER = 13.9	January 1, 2018.[1] January 1, 2023.
Large Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled).	≥135,000 Btu/h and <240,000 Btu/h.	AC	Electric Resistance Heating or No Heating.	IEER = 12.4 IEER = 14.2	January 1, 2018.[1] January 1, 2023.
			All Other Types of Heating	IEER = 12.2 IEER = 14.0	January 1, 2018.[1] January 1, 2023.
		HP	Electric Resistance Heating or No Heating.	IEER = 11.6 IEER = 13.5	January 1, 2018.[1] January 1, 2023.
			All Other Types of Heating	IEER = 11.4 IEER = 13.3	January 1, 2018.[1] January 1, 2023.
Very Large Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled).	≥240,000 Btu/h and <760,000 Btu/h.	AC	Electric Resistance Heating or No Heating.	IEER = 11.6 IEER = 13.2	January 1, 2018.[1] January 1, 2023.
			All Other Types of Heating	IEER = 11.4 IEER = 13.0	January 1, 2018.[1] January 1, 2023.
		HP	Electric Resistance Heating or No Heating.	IEER = 10.6 IEER = 12.5	January 1, 2018.[1] January 1, 2023.
			All Other Types of Heating	IEER = 10.4 IEER = 12.3	January 1, 2018.[1] January 1, 2023.
Small Commercial Package Air-Conditioning and Heating Equipment (Air-Cooled, 3-Phase, Split-System).	<65,000 Btu/h	AC	All	SEER = 13.0	June 16, 2008.
		HP	All	SEER = 14.0	January 1, 2017.
Small Commercial Package Air-Conditioning and Heating Equipment (Air-Cooled, 3-Phase, Single-Package).	<65,000Btu/h	AC	All	SEER = 14.0	January 1, 2017.
		HP	All	SEER = 14.0	January 1, 2017.

TABLE 3 TO § 431.97—UPDATES TO THE MINIMUM COOLING EFFICIENCY STANDARDS FOR AIR CONDITIONING AND HEATING EQUIPMENT—Continued

[Not including single package vertical air conditioners and single package vertical heat pumps, packaged terminal air conditioners and packaged terminal heat pumps, computer room air conditioners, variable refrigerant flow multi-split air conditioners and heat pumps, and double-duct air-cooled commercial package air conditioning and heating equipment]

Equipment type	Cooling capacity	Subcategory	Heating type	Efficiency level	Compliance date: Equipment manufactured starting on . . .
Small Commercial Packaged Air-Conditioning and Heating Equipment (Water Source: Water-to-Air, Water-Loop).	<17,000 Btu/h	HP	All	EER = 12.2	October 9, 2015.
	≥17,000 Btu/h and <65,000 Btu/h.	HP	All	EER = 13.0	October 9, 2015.
	≥65,000 Btu/h and <135,000Btu/h.	HP	All	EER = 13.0	October 9, 2015.

[1] And manufactured before January 1, 2023.

TABLE 4 TO § 431.97—UPDATES TO THE MINIMUM HEATING EFFICIENCY STANDARDS FOR AIR-COOLED AIR CONDITIONING AND HEATING EQUIPMENT [HEAT PUMPS]

[Not including single package vertical air conditioners and single package vertical heat pumps, packaged terminal air conditioners and packaged terminal heat pumps, computer room air conditioners, variable refrigerant flow multi-split air conditioners and heat pumps, and double-duct air-cooled commercial package air conditioning and heating equipment]

Equipment type	Cooling capacity	Efficiency level.[1]	Compliance date: Equipment manufactured starting on . . .
Small Commercial Package Air Conditioning and Heating Equipment (Air-Cooled, 3-Phase, Split-Sytem).	<65,000 Btu/h	HSPF = 8.2	January 1, 2017.
Small Commercial Package Air Conditioning and Heating Equipment (Air-Cooled, 3-Phase, Single Package).	<65,000 Btu/h	HSPF = 8.0	January 1, 2017.
Small Commercial Package Air Conditioning and Heating Equipment (Water-Source: Water-to-Air, Water-Loop).	<135,000 Btu/h	COP = 4.3	October 9, 2015.
Small Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled).	≥65,000 Btu/h and <135,000 Btu/h	COP = 3.3	January 1, 2018.[2]
		COP = 3.4	January 1, 2023.
Large Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled).	≥135,000 Btu/h and <240,000 Btu/h	COP = 3.2	January 1, 2018.[2]
		COP = 3.3	January 1, 2023.
Very Large Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled).	≥240,000 Btu/h and <760,000 Btu/h	COP = 3.2	January 1, 2018.

[1] For units tested using the relevant AHRI Standards, all COP values must be rated at 47 °F outdoor dry-bulb temperature for air-cooled equipment.

[2] And manufactured before January 1, 2023.

TABLE 5 TO § 431.97—MINIMUM COOLING EFFICIENCY STANDARDS FOR DOUBLE-DUCT AIR-CONDITIONING AND HEATING EQUIPMENT

Equipment type	Cooling capacity	Subcategory	Heating type	Efficiency level	Compliance date: Equipment manufactured starting on . . .
Small Double-Duct Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled).	≥65,000 Btu/h and <135,000 Btu/h.	AC	Electric Resistance Heating or No Heating.	EER = 11.2	January 1, 2010.
			All Other Types of Heating	EER = 11.0	January 1, 2010.
		HP	Electric Resistance Heating or No Heating.	EER = 11.0	January 1, 2010.
			All Other Types of Heating	EER = 10.8	January 1, 2010.
Large Commercial Double-Duct Packaged Air Conditioning and Heating Equipment (Air-Cooled).	≥135,000 Btu/h and <240,000 Btu/h.	AC	Electric Resistance Heating or No Heating.	EER = 11.0	January 1, 2010.
			All Other Types of Heating	EER = 10.8	January 1, 2010.
		HP	Electric Resistance Heating or No Heating.	EER = 10.6	January 1, 2010.
			All Other Types of Heating	EER = 10.4	January 1, 2010.
Very Large Double-Duct Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled).	≥240,000 Btu/h and <300,000 Btu/h.	AC	Electric Resistance Heating or No Heating.	EER = 10.0	January 1, 2010.

TABLE 5 TO § 431.97—MINIMUM COOLING EFFICIENCY STANDARDS FOR DOUBLE-DUCT AIR-CONDITIONING AND HEATING EQUIPMENT—Continued

Equipment type	Cooling capacity	Subcategory	Heating type	Efficiency level	Compliance date: Equipment manufactured starting on . . .
			All Other Types of Heating	EER = 9.8	January 1, 2010.
		HP	Electric Resistance Heating or No Heating.	EER = 9.5	January 1, 2010.
			All Other Types of Heating	EER = 9.3	January 1, 2010.

TABLE 6 TO § 431.97—MINIMUM HEATING EFFICIENCY STANDARDS FOR DOUBLE-DUCT AIR-COOLED AIR CONDITIONING AND HEATING EQUIPMENT

[Heat pumps]

Equipment type	Cooling capacity	Heating type	Efficiency level [1]	Compliance date: Equipment manufactured starting on . . .
Small Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled).	≥65,000 Btu/h and <135,000 Btu/h.	Electric Resistance Heating or No Heating.	COP = 3.3	January 1, 2010.
		All Other Types of Heating	COP = 3.3	January 1, 2010.
Large Commercial Packaged Air-Conditioning and Heating Equipment (Air-Cooled).	≥135,000 Btu/h and <240,000 Btu/h.	Electric Resistance Heating or No Heating.	COP = 3.2	January 1, 2010.
		All Other Types of Heating	COP = 3.2	January 1, 2010.
Very Large Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled).	≥240,000 Btu/h and <300,000 Btu/h.	Electric Resistance Heating or No Heating.	COP = 3.2	January 1, 2010.
		All Other Types of Heating	COP = 3.2	January 1, 2010.

[1] For units tested using the relevant AHRI Standards, all COP values must be rated at 47 °F outdoor dry-bulb temperature for air-cooled equipment.

(c) Each packaged terminal air conditioner (PTAC) and packaged terminal heat pump (PTHP) manufactured starting on January 1, 1994, but before October 8, 2012 (for standard size PTACs and PTHPs) and before October 7, 2010 (for non-standard size PTACs and PTHPs) must meet the applicable minimum energy efficiency standard level(s) set forth in Table 7 of this section. Each standard size PTAC and PTHP manufactured starting on October 8, 2012, and each non-standard size PTAC and PTHP manufactured starting on October 7, 2010, must meet the applicable minimum energy efficiency standard level(s) set forth in Table 6 of this section.

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