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This document, concerning compressors is an action issued by the U.S. Department of Energy (DOE). Though it is not intended or expected, should any discrepancy occur between the document posted here and the document published in the Federal Register, the Federal Register publication controls.

The text of this rule is subject to correction based on the identification of errors as defined in 10 CFR 430.5 before publication in the Federal Register. Readers are requested to notify DOE by email at ApplianceStandardsQuestions@ee.doe.gov of any typographical or other errors, as described in such regulations, by no later than midnight on January 19, 2017, in order that DOE may make any necessary corrections in the regulatory text submitted to the Office of the Federal Register for publication.

[6450-01-P]

DEPARTMENT OF ENERGY

10 CFR Parts 429 and 431

[Docket Number EERE-2013-BT-STD-0040]

RIN 1904-AC83

**Energy Conservation Program: Energy Conservation Standards for Air
Compressors**

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

ACTION: 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. EPCA also authorizes DOE to establish standards for certain other types of industrial equipment, including air compressors. Such standards must be technologically feasible and economically justified, and must save a significant amount of energy. In this final rule, DOE is adopting new energy conservation standards for air compressors. It has determined that the adopted energy conservation standards for these products would result in significant conservation of energy, and are technologically feasible and economically justified.

DATES: The effective date of this rule is **[INSERT DATE 60 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER]**. Compliance with the new

standards established for compressors in this final rule is required on and after **[INSERT DATE 5 YEARS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER].**

ADDRESSES: The docket for this rulemaking, which includes 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 docket are listed in the www.regulations.gov index. However, not all documents listed in the index may be publicly available, such as information that is exempt from public disclosure.

The docket web page can be found at:
www.regulations.gov/docket?D=EERE-2013-BT-STD-0040. The docket web page contains simple instructions on how to access all documents, including public comments, in the docket.

For further information on how to review the docket, contact the Appliance and Equipment Standards Program staff at (202) 586-6636 or by email:
ApplianceStandardsQuestions@ee.doe.gov.

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VIII. Approval of the Office of the Secretary

I. Synopsis of the Final Rule

Title III of the Energy Policy and Conservation Act of 1975, as amended (“EPCA” or, in context, “the Act”), sets forth a variety of provisions designed to improve energy efficiency. (42 U.S.C. 6291, et seq.) Part C of Title III, which for editorial reasons was re-designated as Part A-1 upon incorporation into the U.S. Code (42 U.S.C. 6311–6317), establishes the “Energy Conservation Program for Certain Industrial Equipment.” EPCA provides that DOE may include a type of industrial equipment as covered equipment if it determines that to do so is necessary to carry out the purposes of Part A-1. (42 U.S.C 6312(b)). EPCA authorizes DOE to prescribe energy conservation standards for those types of industrial equipment which the Secretary classifies as covered equipment. (42 U.S.C 6314) On November 15, 2016, DOE published a final rule, which determined coverage for compressors is necessary to carry out the purposes of Part A-1 of Title III of EPCA (herein referred to as “notice of final determination”). 81 FR 79991

Pursuant to EPCA, any new or amended energy conservation standard must be designed to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A) and 6316(a)) Furthermore, the new or amended standard must result in a significant conservation of energy. (42 U.S.C. 6295(o)(3)(B) and 6316(a))

In accordance with these and other statutory provisions discussed in this document, DOE is adopting new energy conservation standards for compressors. The adopted standards, which are expressed in package isentropic efficiency (i.e., the ratio of the theoretical isentropic power required for a compression process to the actual power required for the same process), are shown in Table I.1. These standards apply to all compressors listed in Table I.1 and manufactured in, or imported into, the United States starting on **[INSERT DATE 5 YEARS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER]**.

In Table I.1, the term V_1 denotes the full-load actual volume flow rate of the compressor, in cubic feet per minute (“cfm”). Standard levels are expressed as a function of full-load actual volume flow rate for each equipment class, and may be calculated by inserting values from the rightmost two columns into the second leftmost column. Doing so yields an efficiency-denominated function of full-load actual volume flow rate.

Table I.1 Adopted Energy Conservation Standards for Air Compressors

| Equipment Class | Standard Level (Package isentropic efficiency) | η_{Regr} (Package isentropic efficiency Reference Curve) | d (Percentage Loss Reduction) |
|--|--|--|--|
| Rotary, lubricated, air-cooled, fixed-speed | $\eta_{\text{Regr}} + (1 - \eta_{\text{Regr}}) * (d/100)$ | $-0.00928 * \ln^2(.4719 * V_1) + 0.13911 * \ln(.4719 * V_1) + 0.27110$ | -15 |
| Rotary, lubricated, air-cooled, variable-speed | $\eta_{\text{Regr}} + (1 - \eta_{\text{Regr}}) * (d/100)$ | $-0.01549 * \ln^2(.4719 * V_1) + 0.21573 * \ln(.4719 * V_1) + 0.00905$ | -10 |
| Rotary, lubricated, liquid-cooled, fixed-speed | $.02349 + \eta_{\text{Regr}} + (1 - \eta_{\text{Regr}}) * (d/100)$ | $-0.00928 * \ln^2(.4719 * V_1) + 0.13911 * \ln(.4719 * V_1) + 0.27110$ | -15 |

| | | | |
|---|--|--|-----|
| Rotary, lubricated, liquid-cooled, variable-speed | $.02349 + \eta_{\text{Regr}} + (1 - \eta_{\text{Regr}}) * (d/100)$ | $-0.01549 * \ln^2(.4719 * V_1) + 0.21573 * \ln(.4719 * V_1) + 0.00905$ | -15 |
|---|--|--|-----|

A. Benefits and Costs to Consumers

Table I.2 presents DOE’s evaluation of the economic impacts of the proposed standards on consumers of air compressors, as measured by the average life-cycle cost (“LCC”) savings and the simple payback period (“PBP”).¹ The average LCC savings are positive for all equipment classes for which standards are being adopted, and the PBP is less than the average lifetime of air compressors; that lifetime is estimated to be approximately 13 years for the covered equipment classes.

Table I.2 Impacts of Adopted Energy Conservation Standards on Consumers of Air Compressors

| Equipment Class | Average LCC Savings 2015\$ | Simple Payback Period years |
|---|-----------------------------------|------------------------------------|
| Rotary Positive, Fixed Speed, Lubricated, Air Cooled (RP_FS_L_AC) | 8,002 | 2.4 |
| Rotary Positive, Fixed Speed, Lubricated, Liquid Cooled (RP_FS_L_WC) | 10,559 | 2.7 |
| Rotary Positive, Variable Speed, Lubricated, Air Cooled (RP_VS_L_AC) | 2,618 | 4.9 |
| Rotary Positive, Variable Speed, Lubricated, Liquid Cooled (RP_VS_L_WC) | 5,145 | 4.9 |

¹ The average LCC savings are measured relative to the no-new standards case 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.9). The simple PBP, which is designed to compare specific efficiency levels, is measured relative to the baseline model (see section IV.C.1.a).

DOE's analysis of the impacts of the adopted standards on consumers is described in section IV.F of this document.

B. Impact on Manufacturers

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 (2016–2051). Using a real discount rate of 8.7² percent, DOE estimates that the (INPV) for manufacturers of air compressors in the case without new standards is \$409.7 million in 2015\$. Under the adopted standards, DOE expects the change in INPV to range from -13.5 percent to -10.2 percent, which is approximately -\$55.1 million to -\$42.0 million. In order to bring products into compliance with adopted standards, DOE expects the industry to incur total conversion costs ranging from a high of \$121.3 million to \$98.1 million.³

² DOE estimated preliminary financial metrics, including the industry discount rate, based on publicly available financial information, including Securities and Exchange Commission (“SEC”) filings and S&P bond ratings. DOE presented the preliminary financial metrics to manufacturers in manufacturer impact analysis (“MIA”) interviews. DOE adjusted those values based on feedback from manufacturers. The complete set of financial metrics and more detail about the methodology can be found in chapter 12 of the final rule technical support document (“TSD”).

³ For the MIA, DOE modeled two standards-case conversion cost scenarios to represent uncertainty regarding the potential impacts on manufacturers following the implementation of energy conservation standards. More details about the methodology can be found in section IV.J.2 of this notice and in chapter 12 of the final rule TSD.

DOE’s analysis of the impacts of the adopted standards on manufacturers is described in section IV.J and section V.B.2 of this document.

C. National Benefits and Costs⁴

DOE’s analyses indicate that the adopted energy conservation standards for air compressors would save a significant amount of energy. Relative to the case without new standards (no new standards case), the lifetime energy savings for air compressors purchased in the 30-year period that begins in the anticipated first full year of compliance with the adopted standards (2022–2051)⁵ amount to 0.16 quadrillion British thermal units (“Btu”), or quads.⁶ This represents a savings of 0.6 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 air compressors ranges from \$0.2 billion (at a 7-percent discount rate) to \$0.4 billion (at a 3-percent discount rate). This NPV expresses the estimated total value of future operating-cost savings minus the estimated increased equipment costs for air compressors purchased in 2022–2051.

⁴ All monetary values in this document are expressed in 2015 dollars and, where appropriate, are discounted to 2016 unless explicitly stated otherwise.

⁵ The analysis uses January 1st, 2022, to represent the expected compliance date in late 2021. Therefore, the 30-year analysis period is referred to as 2022-2051 in this document.

⁶ 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.

In addition, the adopted standards for compressors are projected to yield significant environmental benefits. DOE estimates that the standards will result in cumulative emission reductions (over the same period as for energy savings) of 8.2 million metric tons (“Mt”)⁷ of carbon dioxide (CO₂), 6.5 thousand tons of sulfur dioxide (SO₂), 11.0 tons of nitrogen oxides (NO_x), 40.8 thousand tons of methane (CH₄), 0.1 thousand tons of nitrous oxide (N₂O), and 0.02 ton of mercury (Hg).⁸ The estimated cumulative reduction in CO₂ emissions through 2030 amounts to 0.9 Mt, which is equivalent to the emissions resulting from the annual electricity use of more than 95 thousand homes.

The value of the CO₂ reduction is calculated using a range of values per metric ton (“t”) of CO₂ (otherwise known as the “social cost of CO₂,” or “SC-CO₂”) developed by a Federal interagency working group.⁹ The derivation of the SC-CO₂ values is discussed in section IV.L.1. Using discount rates appropriate for each set of SC-CO₂ values, DOE estimates that the present value of the CO₂ emissions reduction is between \$0.05 billion and \$0.76 billion, with a value of \$0.25 billion using the central SC-CO₂ case represented by \$47.4/metric ton (t) in 2020.

⁷ A metric ton is equivalent to 1.1 short tons. Results for emissions other than CO₂ are presented in short tons.

⁸ DOE calculated emissions reductions relative to the no-new-standards-case, which reflects key assumptions in the *Annual Energy Outlook 2016* (AEO 2016). AEO 2016 represents current federal and state legislation and final implementation of regulations as of the end of February 2016. DOE is using the projection consistent with the cases described on page E-8 of *AEO 2016*.

⁹ United States Government–Interagency Working Group on Social Cost of Carbon. *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866*. May 2013. Revised July 2015. www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf.

DOE also calculated the value of the reduction in emissions of the non-CO₂ greenhouse gases, methane and nitrous oxide, using values for the social cost of methane (“SC-CH₄”) and the social cost of nitrous oxide (“SC-N₂O”) recently developed by the interagency working group.¹⁰ See section IV.L.2 for description of the methodology and the values used for DOE’s analysis. The estimated present value of the methane emissions reduction is between \$0.01 billion and \$0.11 billion, with a value of \$0.04 billion using the central SC-CH₄ case represented by \$1,353/t in 2020; and the estimated present value of the N₂O emissions reduction is between \$0.000 billion and \$0.003 billion, with a value of \$0.001 billion using the central SC-N₂O case, represented by \$16,916/t.

DOE also estimates the present value of the NO_x emissions reduction to be \$6.1 million using a 7-percent discount rate, and \$16.8 million using a 3-percent discount rate.¹¹ DOE is still investigating appropriate valuation of the reduction in other emissions, and therefore did not include any such values in the analysis for this final rule

¹⁰ United States Government–Interagency Working Group on Social Cost of Greenhouse Gases. Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866: Application of the Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide. August 2016. www.whitehouse.gov/sites/default/files/omb/inforeg/august_2016_sc_ch4_sc_n2o_addendum_final_8_26_16.pdf.

¹¹ DOE estimated the monetized value of NO_x emissions reductions associated with electricity savings using benefit per ton estimates from the Regulatory Impact Analysis for the Clean Power Plan Final Rule, published in August 2015 by EPA’s Office of Air Quality Planning and Standards. Available at www.epa.gov/cleanpowerplan/clean-power-plan-final-rule-regulatory-impact-analysis. See section IV.L.3 for further discussion. The U.S. Supreme Court has stayed the rule implementing the Clean Power Plan until the current litigation against it concludes. Chamber of Commerce, et al. v. EPA, et al., Order in Pending Case, West Virginia v. EPA, 136 S. Ct. 1000, 194 L. Ed. 2d 17 (2016). However, the benefit-per-ton estimates established in the Regulatory Impact Analysis for the Clean Power Plan are based on scientific studies that remain valid irrespective of the legal status of the Clean Power Plan. To be conservative, DOE is primarily using a national benefit-per-ton estimate for NO_x emitted from the

Table I.3 summarizes the economic benefits and costs expected to result from the adopted standards for air compressors

Table I.3 Summary of Economic Benefits and Costs of Adopted Energy Conservation Standards for Air Compressors*

| Category | Present Value billion 2015\$ | Discount Rate percent |
|--|------------------------------------|--------------------------|
| Benefits | | |
| Consumer Operating Cost Savings | 0.2 | 7 |
| | 0.6 | 3 |
| GHG Reduction (using avg. social costs at 5% discount rate)** | 0.1 | 5 |
| GHG Reduction (using avg. social costs at 3% discount rate)** | 0.3 | 3 |
| GHG Reduction (using avg. social costs at 2.5% discount rate)** | 0.5 | 2.5 |
| GHG Reduction (using 95 th percentile social costs at 3% discount rate)** | 0.9 | 3 |
| NO _x Reduction [†] | 0.006 | 7 |
| | 0.02 | 3 |
| Total Benefits [‡] | 0.5 | 7 |
| | 0.9 | 3 |
| Costs | | |
| Consumer Incremental Installed Costs ^{††} | 0.1 | 7 |
| | 0.2 | 3 |
| Total Net Benefits | | |
| Including GHG and NO _x Reduction Monetized Value [‡] | 0.5 | 7 |
| | 0.8 | 3 |

* This table presents the costs and benefits associated with compressors shipped in 2022–2051. These results include benefits to consumers that accrue after 2022 from the products shipped in 2022–2051.

** The interagency group selected four sets of SC-CO₂, SC-CH₄, and SC-N₂O values for use in regulatory analyses. Three sets of values are based on the average social costs from the integrated assessment models, at discount rates of 5-percent, 3-percent, and 2.5-percent. The fourth set, which represents the 95th percentile of the social cost distributions calculated using a 3-percent discount rate, is included to represent higher-than-expected impacts from climate change further out in the tails of the social cost distributions. The social cost values are emission year specific. The GHG reduction benefits are global benefits due to actions that occur domestically. See section IV.L for more details.

† DOE estimated the monetized value of NO_x emissions reductions associated with electricity savings using benefit per ton estimates from the Regulatory Impact Analysis for the Clean Power Plan Final Rule, published in August 2015 by EPA’s Office of Air Quality Planning and Standards. (Available at www.epa.gov/cleanpowerplan/clean-power-plan-

Electricity Generating Unit sector based on an the low-end estimates of premature mortality used by EPA. If the benefit-per-ton estimates were based on the high-end estimates, the values would be nearly two-and-a-half times larger. 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.

[final-rule-regulatory-impact-analysis](#).) See section IV.L.3 for further discussion. To be conservative, DOE is primarily using a national benefit-per-ton estimate for NOX emitted from the Electricity Generating Unit sector based on the low-end estimates of premature mortality used by EPA. If the benefit-per-ton estimates were based on the high-end estimates, the values would be nearly two-and-a-half times larger. 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.

‡ Total Benefits for both the 3-percent and 7-percent cases are presented using the average social costs with 3-percent discount rate.

†† The incremental installed costs include incremental equipment cost as well as installation costs. The costs account for the incremental variable and fixed costs incurred by manufacturers due to the proposed standards, some of which may be incurred in preparation for the rule.

The benefits and costs of the adopted standards for air compressors sold in 2022–2051 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 consumer operating costs, minus (2) the increases in product purchase prices and installation costs, plus (3) the value of the benefits of CO₂ and NO_x emission reductions, all annualized.¹²

The national operating cost savings are domestic private U.S. consumer monetary savings that occur as a result of purchasing the covered products and are measured for the lifetime of compressors shipped in 2022–2051. The benefits associated with reduced CO₂ emissions achieved as a result of the adopted standards are also calculated based on the lifetime of compressors shipped in 2022–2051. Because CO₂ emissions have a very long residence time in the atmosphere, the SC-CO₂ values for CO₂ emissions in future years reflect impacts that continue through 2300. The CO₂ reduction is a benefit that

¹² To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2016, 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 2016. The calculation uses discount rates of 3 and 7 percent for all costs and benefits except for the value of CO₂ 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 a 30-year period, starting in the compliance year, which yields the same present value.

accrues globally. DOE maintains that consideration of global benefits is appropriate because of the global nature of the climate change problem.

Estimates of annualized benefits and costs of the adopted standards are shown in Table I.4. The results under the primary estimate are as follows. Using a 7-percent discount rate for benefits and costs other than GHG reduction (for which DOE used average social costs with a 3-percent discount rate),¹³ the estimated cost of the standards in this rule is \$9.9 million per year in increased equipment costs, while the estimated annual benefits are \$28.1 million in reduced equipment operating costs, \$17.2 million in GHG reductions, and \$0.7 million in reduced NO_x emissions. In this case, the net benefit amounts to \$36 million per year. Using a 3-percent discount rate for all benefits and costs, the estimated cost of the standards is \$10.4 million per year in increased equipment costs, while the estimated annual benefits are \$36.8 million in reduced operating costs, \$17.2 million in GHG reductions, and \$1.0 million in reduced NO_x emissions. In this case, the net benefit amounts to \$45 million per year.

¹³ DOE used average social costs with a 3-percent discount rate because these values are considered as the “central” estimates by the interagency group.

Table I.4 Annualized Benefits and Costs of Adopted Standards for Compressors*

| | Discount Rate percent | Primary Estimate | Low-Net-Benefits Estimate | High-Net-Benefits Estimate |
|--|------------------------------|------------------|---------------------------|----------------------------|
| | | | | |
| Benefits | | | | |
| Consumer Operating Cost Savings | 7 | 28.1 | 24.8 | 35.1 |
| | 3 | 36.8 | 32.2 | 46.6 |
| GHG Reduction (using avg. social costs at 5% discount rate)** | 5 | 5.4 | 4.7 | 6.6 |
| GHG Reduction (using avg. social costs at 3% discount rate)** | 3 | 17.2 | 14.8 | 21.2 |
| GHG Reduction (using avg. social costs at 2.5% discount rate)** | 2.5 | 24.8 | 21.4 | 30.6 |
| GHG Reduction (using 95 th percentile social costs at 3% discount rate)** | 3 | 51.5 | 44.4 | 63.4 |
| NO _x Reduction [†] | 7 | 0.7 | 0.6 | 1.9 |
| | 3 | 1.0 | 0.9 | 2.8 |
| Total Benefits [‡] | 7 plus CO ₂ range | 34 to 80 | 30 to 70 | 44 to 100 |
| | 7 | 46 | 40 | 58 |
| | 3 plus CO ₂ range | 43 to 89 | 38 to 77 | 56 to 113 |
| | 3 | 55 | 48 | 71 |
| Costs | | | | |
| Consumer Incremental Equipment Costs ^{††} | 7 | 9.9 | 8.8 | 11.4 |
| | 3 | 10.4 | 9.3 | 12.0 |
| Net Benefits | | | | |
| Total [‡] | 7 plus CO ₂ range | 24 to 70 | 21 to 61 | 32 to 89 |
| | 7 | 36 | 31 | 47 |
| | 3 plus CO ₂ range | 33 to 79 | 28 to 68 | 44 to 101 |
| | 3 | 45 | 39 | 59 |

* This table presents the annualized costs and benefits associated with the considered compressors shipped in 2022–2051. These results include benefits to consumers which accrue after 2051 from the compressors purchased from 2022–2051. The incremental installed costs include incremental equipment cost as well as installation costs. The results account for the incremental variable and fixed costs incurred by manufacturers due to the adopted standards, some of which may be incurred in preparation for the rule. The GHG reduction benefits are global benefits due to actions that occur nationally. The Primary, Low Net Benefits, and High Net Benefits Estimates utilize projections of energy prices from the AEO 2016 Economic Growth cases. In addition, incremental product costs reflect constant prices 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.F. Note that the Benefits and Costs may not sum to the Net Benefits due to rounding.

** The interagency group selected four sets of SC-CO₂ SC-CH₄, and SC-N₂O values for use in regulatory analyses. Three sets of values are based on the average social costs from the integrated assessment models, at discount rates of 5 percent, 3 percent, and 2.5 percent. The fourth set, which represents the 95th percentile of the social cost distributions

calculated using a 3-percent discount rate, is included to represent higher-than-expected impacts from climate change further out in the tails of the social cost distributions. The social cost values are emission year specific. The GHG reduction benefits are global benefits due to actions that occur nationally. See section IV.L for more details.

† DOE estimated the monetized value of NO_x emissions reductions associated with electricity savings using benefit per ton estimates from the [Regulatory Impact Analysis for the Clean Power Plan Final Rule](#), published in August 2015 by EPA's Office of Air Quality Planning and Standards. (Available at www.epa.gov/cleanpowerplan/clean-power-plan-final-rule-regulatory-impact-analysis.) See section IV.L.3 for further discussion. For the Primary Estimate and Low Net Benefits Estimate, DOE used national benefit-per-ton estimates for NO_x emitted from the Electric Generating Unit sector based on an estimate of premature mortality used by EPA. For the High Net Benefits Estimate, the benefit-per-ton estimates were based on the Six Cities study (Lepuele *et al.*, 2011); these are nearly two-and-a-half times larger than those from the American Cancer Society ("ACS") study.

‡ Total Benefits for both the 3-percent and 7-percent cases are presented using the average social costs with 3-percent discount rate. In the rows labeled "7% plus GHG range" and "3% plus GHG 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 social cost values.

†† The incremental installed costs include incremental equipment cost as well as installation costs. The results account for the incremental variable and fixed costs incurred by manufacturers due to the proposed standards, some of which may be incurred in preparation for the rule.

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.

D. Conclusion

Based on the analyses culminating in this final rule, DOE finds the benefits of the standards (energy savings, consumer LCC savings, positive NPV of consumer benefit, and emission reductions) to the Nation outweigh the burdens (loss of INPV and LCC increases for some users of these products). DOE concludes that the standards in this final rule represent the maximum improvement in energy efficiency that is technologically feasible and economically justified, and will result in significant conservation of energy.

II. Introduction

The following section briefly discusses the statutory authority underlying this final rule, as well as some of the relevant historical background related to the establishment of standards for air compressors.

A. Authority

Title III of the Energy Policy and Conservation Act of 1975, as amended (“EPCA” or, in context, “the Act”), sets forth a variety of provisions designed to improve energy efficiency. (42 U.S.C. 6291, *et seq.*) Part C of Title III, which for editorial reasons was re-designated as Part A-1 upon incorporation into the U.S. Code (42 U.S.C. 6311–6317), establishes the “Energy Conservation Program for Certain Industrial Equipment.” EPCA provides that DOE may include a type of industrial equipment, including compressors, as covered equipment if it determines that to do so is necessary to carry out the purposes of Part A-1. (42 U.S.C. 6311(2)(B)(i) and 6312(b)). The purpose of Part A-1 is to improve the efficiency of electric motors and pumps and certain other industrial equipment in order to conserve the energy resources of the Nation. (42 U.S.C. 6312(a)). On November 15, 2016 DOE published a Notice of Final Determination of Coverage determining that compressors meet the statutory criteria for classifying industrial equipment as covered, because compressors are a type of industrial equipment (1) which in operation consume, or are designed to consume, energy; (2) are to a significant extent distributed in commerce for industrial or commercial use; and (3) are not covered under 42 U.S.C. 6291(a)(2). 81 FR 79991

Pursuant to EPCA, DOE's energy conservation program for covered products consists essentially of four parts: (1) testing; (2) labeling; (3) the establishment of Federal energy conservation standards; and (4) certification and enforcement procedures. For commercial and industrial products, DOE is primarily responsible for labeling requirements. 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 each covered product. (42 U.S.C. 6295(o)(3)(A), 6316(a) and 6314) Manufacturers of covered products must use the prescribed DOE test procedure as the basis for certifying to DOE that their products comply with the applicable energy conservation standards adopted under EPCA and when making representations to the public regarding the energy use or efficiency of those products. (42 U.S.C 6295(s), 6316(a) and 6314(d)) Similarly, DOE must use these test procedures to determine whether the products comply with standards adopted pursuant to EPCA. (42 U.S.C. 6295(s) and 6316(a)) DOE test procedures for compressors appear at title 10 of the Code of Federal Regulations ("CFR") part 431, subpart T, appendix A.

DOE follows specific statutory criteria for prescribing new or amended standards for covered equipment, including compressors. Any new or amended standard for a covered product must be designed to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. (42 U.S.C. 6316(a), and 6295(o)(2)(A)) Furthermore, DOE may not adopt any standard that would not result in the significant conservation of energy. (42 U.S.C. 6295(o)(3)(B) and 6316(a)) In deciding whether a proposed standard is economically justified, DOE must determine

whether the benefits of the standard exceed its burdens. (42 U.S.C. 6295(o)(2)(B)(i) and 6316(a)) DOE must make this determination after receiving comments on the proposed standard and by considering, to the greatest extent practicable, the following seven statutory factors:

(1) The economic impact of the standard on manufacturers and consumers of the 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 that are likely to result from the standard;

(3) The total projected amount of energy (or as applicable, water) 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 and water conservation; and

(7) Other factors the Secretary of Energy considers relevant.

(42 U.S.C. 6295(o)(2)(B)(i)(I)–(VII) and 6316(a))

Further, EPCA, as codified, establishes a rebuttable presumption that a standard is economically justified if the Secretary finds that the additional cost to the consumer of purchasing a product complying with an energy conservation standard level will be less

than three times the value of the energy savings during the first year that the consumer will receive as a result of the standard, as calculated under the applicable test procedure. (42 U.S.C. 6295(o)(2)(B)(iii) and 6316(a))

EPCA, as codified, also contains an “anti-backsliding” provision, which prevents the Secretary from prescribing any 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. 6295(o)(1) and 6316(a)) 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 in 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. 6295(o)(4) and 6316(a))

Additionally, 42 U.S.C. 6295(q)(1) and 6316(a) specify requirements when promulgating an energy conservation standard for a covered product that has two or more subcategories. DOE must specify a different standard level for a type or class of product that has the same function or intended use, if DOE determines that products within such group: (1) consume a different kind of energy from that consumed by other covered products within such type (or class); or (2) have a capacity or other performance-related feature that other products within such type (or class) do not have, and such feature justifies a higher or lower standard. (42 U.S.C. 6295(q)(1) and 6316(a)) In determining whether a performance-related feature justifies a different standard for a group of

products, DOE must consider such factors as the utility to the consumer of the feature and other factors DOE deems appropriate. Id. Any rule prescribing such a standard must include an explanation of the basis on which such higher or lower level was established. (42 U.S.C. 6295(q)(2) and 6316(a))

Federal energy conservation requirements generally supersede State laws or regulations concerning energy conservation testing, labeling, and standards. (42 U.S.C. 6297(a)–(c) and 6316(a)) DOE may, however, grant waivers of Federal preemption for particular State laws or regulations, in accordance with the procedures and other provisions set forth under 42 U.S.C. 6297(d) and 6316(a)).

B. Regulatory History for Compressors

Currently, there are no Federal energy conservation standards for air compressors. On December 31, 2012, DOE issued a Notice of Proposed Determination of Coverage (“2012 proposed determination of coverage”) that proposed to establish compressors as covered equipment on the basis that (1) DOE may only prescribe energy conservation standards for covered equipment; and (2) energy conservation standards for compressors would improve the efficiency of such equipment more than would be likely to occur in the absence of standards, so including compressors as covered equipment is necessary to carry out the purposes of Part A-1. 77 FR 76972 (Dec. 31, 2012). The 2012 proposed determination of coverage tentatively determined that the standards would likely satisfy the provisions of 42 U.S.C. 6312(B). On February 7, 2013, DOE published a notice reopening the comment period on the 2012 proposed determination of coverage. 78 FR 8998.

As noted above, on November 15 2016, DOE published a notice of final determination, which determined that coverage for compressors is necessary to carry out the purposes of Part A-1 of Title III of EPCA. 81 FR 79991.

On February 5, 2014, DOE published in the Federal Register a notice of public meeting, and provided a Framework document that addressed potential standards and test procedures for these products. 79 FR 6839. DOE held a public meeting to discuss the framework document on April 1, 2014. At this meeting, DOE discussed and received comments on the Framework document, which covered the analytical framework, models, and tools that DOE uses to evaluate potential standards; and all other issues raised relevant to the development of energy conservation standards for the different categories of compressors. On March 18, 2014, DOE extended the comment period. 79 FR 15061.

On May 5, 2016, DOE issued a notice of proposed rulemaking (“NOPR”) to propose test procedures for certain compressors. 87 FR 27220. On June 20, 2016, DOE held a public meeting to discuss the test procedure NOPR and receive comments from interested parties. On December 1, 2016, DOE issued a test procedure final rule that amends subpart T of Title 10 of the Code of Federal Regulations, part 431 (10 CFR part 431), and which contains definitions, materials incorporated by reference, and test procedures for determining the energy efficiency of certain varieties of compressors. The test procedure final rule also amended 10 CFR part 429 to establish sampling plans, representations requirements, and enforcement provisions for certain compressors.

On May 19, 2016, DOE published a notice of proposed rulemaking pertaining to energy conservation standards for compressors (“May 2016 NOPR”).¹⁴ 81 FR 31680.

DOE held a public meeting to discuss the May 2016 NOPR on June 20, 2016.

In this final rule, DOE responds to comments received from interested parties in response to the proposals presented in the May 2016 NOPR, either during the June 2016 NOPR public meeting or in subsequent written comments.¹⁵ In response to the May 2016 NOPR, DOE received 24 written comments in addition to the verbal comments made by interested parties during the June 2016 NOPR public meeting. The commenters included: the Alliance to Save Energy (ASE); the American Council for an Energy Efficient Economy (ACEEE); the Appliance Standards Awareness Project (ASAP); Atlas Copco AB (Atlas Copco); Castair; the U.S. Chamber of Commerce, representing 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 (API), the Association of Home Appliance Manufacturers, 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 collectively referred to as the “U.S. Chamber of Commerce” (U.S. Chamber of Commerce); the Compressed Air & Gas Institute (CAGI); Compressed Air Systems; Industrial Energy Consumers of America (IECA); Institute for Policy Integrity representing the Environmental Defense

¹⁴ Available at: www.regulations.gov/document?D=EERE-2013-BT-STD-0040-0038.

¹⁵ DOE notes that certain comments pertaining to the definition of “compressors” were addressed in the 2016 notice of final determination.

Fund, Institute for Policy Integrity at New York University School of Law, the Natural Resources Defense Council, and the Union of Concerned Scientists, collectively referred to as the “Joint Advocates” (Joint Advocates); Ingersoll Rand; Jenny Products, Kaeser Compressors; the Natural Resources Defense Council (NRDC); the Northeast Energy Efficiency Partnership (NEEP); the Northwest Energy Efficiency Alliance (NEEA); Michaels and Knappenberger, of the Center for the Study of Science, Cato Institute (Cato Institute); the Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), Southern California Edison (SCE), and Southern California Gas Company (SCGC), collectively referred to as the California Investor Owned Utilities (CA IOUs); the People’s Republic of China (P. R. China); Scales Industrial Technologies (Scales); Sullair; Saylor-Beall Manufacturing Company and Sullivan-Palatek, collectively referred to as “Sullivan-Palatek.” In this document, DOE identifies comments received in response to the May 2016 standard NOPR by the commenter, the number of document as listed in the docket maintained at www.regulations.gov (Docket No. EERE-2013-BT-STD-0040), and the page number of that document where the comment appears (for example: CAGI, No. 10 at p. 4). If a comment was made verbally during the NOPR public meeting, DOE specifically identifies those as being located in the NOPR public meeting transcript (for example: CAGI, public meeting transcript, No. 16 at p. 100). This final rule also contains certain relevant comments submitted in response to the compressors test procedure rulemaking (Docket No. Docket No. EERE-2014-BT-TP-0054) and the December 2012 proposed determination of coverage (Docket No. EERE-2012-BT-DET-0033); such comments will be identified with the appropriate docket number.

C. Process Rule

DOE notes that Appendix A established procedures, interpretations, and policies to guide DOE in the consideration and promulgation of new or revised appliance efficiency standards under EPCA. (See section 1 of 10 CFR 430 subpart C, appendix A) These procedures are a general guide to the steps DOE typically follows in promulgating energy conservation standards. The guidance recognizes that DOE can and will, on occasion, deviate from the typical process. (See 10 CFR part 430, subpart C, appendix A, section 14(a)) The guidance provides, among other things that DOE issues, final, modified test procedures for a given product prior to publication of the NOPR proposing energy conservation standards. In this particular instance, DOE deviated from its typical process and issued the energy conservation standards notice of proposed rulemaking prior to finalizing the test procedure. DOE believed this action was appropriate in this specific instance because DOE was proposing a commonly used industry test procedure methodology with few modifications. DOE developed the proposed energy conservation standards using representations for isentropic efficiency from manufacturers' CAGI datasheets that were developed consistent with the proposed test procedure methodology and are readily available on the market today. Thus, DOE believes that industry has a common understanding of the resulting efficiencies of different compressors designs being contemplated in the energy conservation standards rulemaking and could provide meaningful comments to DOE about the impacts of such standards. Based on the test procedure adopted in the December 2016 final rule, DOE remains confident that the timing deviation did not adversely impact the manufacturers ability to understand and provide reasonable comments on the proposed energy conservation standards rulemaking

due to the widespread availability of data consistent with DOE's test procedure and DOE's ability to take those comments into consideration in developing the final standard levels as included in this final rule.

III. General Discussion

A. Definitions

1. Definition of Covered Equipment

In the November 2016 notice of final determination, DOE adopted the following definition for compressor:

Compressor means a machine or apparatus that converts different types of energy into the potential energy of gas pressure for displacement and compression of gaseous media to any higher pressure values above atmospheric pressure and has a pressure ratio at full-load operating pressure greater than 1.3.

To support the definition of compressors, DOE adopts the following definition for pressure ratio at full-load operating pressure in the test procedure final rule:

Pressure ratio at full-load operating pressure means the ratio of discharge pressure to inlet pressure, determined at full-load operating pressure in accordance with the test procedures prescribed in 10 CFR 431.344.

DOE received comments on the definition of “compressor” in both the energy conservation standard and test procedure dockets. DOE addresses all comments related to the definition of compressor in the November 2016 notice of final determination.

2. Air- and Liquid-Cooled Compressors

In the energy conservation standards NOPR, DOE proposed the following definition for water-cooled compressors: a compressor that utilizes chilled water provided by an external system to cool both the compressed air and, if present, any auxiliary substance used to facilitate compression. DOE also proposed the following definition for air-cooled compressors: a compressor that utilizes air to cool both the compressed air and, if present, any auxiliary substance used to facilitate compression. 81 FR 31680, 31699 (May 19, 2016)

In response to the definition of water-cooled compressors in the energy conservation standards NOPR, Kaeser Compressors suggested replacing the term “chilled water” with “water” as the water is not always chilled. (Kaeser Compressors, Public Meeting Transcript, No. 0044 at pp. 22-23) Edison Electric Institute stated that the definition of water-cooled compressors does not account for compressors that use a combination of different fluids. (Edison Electric Institute, Public Meeting Transcript, No. 0044 at p. 23) Sullair commented that glycol cooling, which has a percentage of water, is an example in which the definition for water-cooled compressors fails to define all non-air cooling methods. (Sullair, No. 0056 at p. 13)

In response to commenters' concerns, DOE recognizes that the term "chilled water" may be unduly limiting. For this final rule, DOE is revising the term "water-cooled compressor" and its associated definition to refer to "liquid" instead of "chilled water." DOE believes that the term "liquid" is sufficiently broad to encompass the concerns raised by commenters. Omission of the term "chilled" similarly aids that objective, as it is not DOE's intent to limit the definition to compressors that use only chilled liquids.

Sullair also commented that compressors could have both liquid and air cooling (such as a closed-loop water system with a radiator and fan), and thus would represent a potential loophole to classify the compressor within an equipment class with a less-stringent standard. (Sullair, No. 0056 at pp. 13-14; Sullair, Public Meeting Transcript, No. 0044 at p. 23) DOE believes Sullair is referring to a scenario where a compressor with both liquid and air-cooling could be classified as an air-cooled compressor, rather than a liquid-cooled compressor, as the standards proposed in the energy conservation standards NOPR are less stringent for air-cooled equipment.

In response to Sullair's comment, DOE recognizes potential ambiguity between the definition of "air-cooled compressor" and "liquid-cooled compressor." Specifically, the definitions proposed in the energy conservation standards NOPR are not mutually exclusive, as a compressor could feasibly employ both liquid and air cooling in the same model. As a result, in this final rule, DOE is modifying the definition of "air-cooled compressor" to expressly exclude compressors that meet the definition of "liquid-cooled compressor." Doing so establishes mutual exclusivity among the equipment varieties,

ensuring that no compressors can meet the definition of both air-cooled and liquid-cooled compressors.

With respect to Sullair's specific example (a closed-loop water system with a radiator and fan), DOE clarifies that such a compressor would not meet the definition of "liquid-cooled compressor," because the coolant system is part of the compressor package and is not an external system. Specifically, the use of the term "provided by an external system" in the definition of liquid-cooled compressors means that the system that provides the liquid coolant is not integral to the compressor package, and the liquid coolant system energy consumption and power draw are not accounted for when the compressor is tested according to the DOE test procedure.

Further, in the test procedure final rule, DOE adopts a list of ancillary equipment that must be attached to the compressor during performance testing. DOE includes two lists; the first describes ancillary equipment that must be included on a unit when testing, regardless of whether it is distributed in commerce with the basic model under test; the second list contains ancillary equipment that is only required if it is distributed in commerce with the basic model under test. "Cooling fan(s) and motors" appear on the second list. However, there is no requirement that cooling equipment beyond "cooling fan(s) and motors," including equipment related to closed-loop liquid coolant circulation, be connected for testing purposes. As such, Sullair's specific example (a closed-loop water system with a radiator and fan within the package) is an air-cooled compressor and is tested with cooling fans engaged, but any water pumping equipment is not be required to be running.

Based on the discussion in this section, DOE is adopting the following, revised, definitions for liquid-cooled and air-cooled compressors.

“Liquid-cooled compressor” means a compressor that utilizes liquid coolant provided by an external system to cool both the compressed air and, if present, any auxiliary substance used to facilitate compression.

“Air-cooled compressor” means “a compressor that utilizes air to cool both the compressed air and, if present, any auxiliary substance used to facilitate compression, and that is not a liquid-cooled compressor.”

B. Scope of Energy Conservation Standards

In the energy conservation standards NOPR, DOE proposed to limit the scope of applicability of standards to compressors that meet the following criteria:

- are air compressors,
- are rotary compressors,
- are driven by a brushless electric motor,
- are distributed in commerce with a compressor motor nominal horsepower greater than or equal to 1 and less than or equal to 500 horsepower (“hp”),
and
- operate at a full-load operating pressure of greater than or equal to 31 and less than or equal to 225 pounds per square inch gauge (“psig”).

81 FR 31680, 31689-93 (May 19, 2016).

In the test procedure final rule, DOE limits the scope of test procedure applicability to compressors that meet the following criteria:

- are air compressors;
- are rotary compressors;
- are not liquid ring compressors;
- are driven by a brushless electric motor;
- are lubricated compressors;
- have a full-load operating pressure of 75–200 psig;
- are not designed and tested to the requirements of The American Petroleum Institute standard 619, “Rotary-Type Positive-Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries;” and
- have a capacity that is either:
 - 10–200 compressor motor nominal horsepower (hp), or
 - 35–1,250 full-load actual volume flow rate (cfm).

After considering comments received in response to the energy conservation standards NOPR, DOE is aligning the scope of energy conservation standards in this final rule to be similar, but less broad than the aforementioned scope of the test procedure final rule. The following sections, III.B.1 through III.B.8, discuss, in detail, each scope limitation, interested party comments, and DOE’s conclusions.

1. Equipment System Boundary

In the energy conservation standards NOPR, DOE proposed to limit the scope of the standards to “air compressors” that compress atmospheric air and consist of a bare compressor, driver(s), mechanical equipment to transfer energy from the driver to the bare compressor, and any ancillary equipment shipped in commerce with the compressor. DOE also proposed definitions for the terms “air compressor,” “bare compressor,” “driver,” “mechanical equipment,” and “ancillary equipment.” 81 FR 31680, 31688-31690 (May 19, 2016). DOE received comments on its proposal to limit the scope of the energy conservation standards to air compressors. These comments are discussed in detail below.

a. Air Compressor

Generally, DOE considered and responded to comments relating to the definition of the term “air compressor” in the test procedure final rule. Beyond those comments considered in the test procedure final rule, Scales Industrial Technologies commented that there are opportunities to improve the overall efficiency of a compressed air system on the demand side that should also be considered. (EERE-2014-BT-TP-0054, Scales Industrial Technologies, No. 0013 at p. 9)

In the energy conservation standards NOPR, DOE discussed the possibility of establishing standards at the “compressed air system” (“CAS”) level, but ultimately proposed standards at the packaged compressor level for the following reasons:

- each CAS is often unique to a specific installation;

- each CAS may include equipment from several different manufacturers; and
- a single CAS can include several different compressors, of different types, which may all have different full-load operating pressures. 81 FR 31680, 31689-31690 (May 19, 2016).

As discussed in the energy conservation standards NOPR, implementing a broader, CAS-based approach to compressor efficiency would require DOE to (1) establish a methodology for measuring losses in a given air-distribution network; and (2) assess what certification, compliance, or enforcement practices would be required for a large variety of system designs, and potential waiver criteria. For these reasons, in the energy conservation standards NOPR, DOE concluded that the CAS is not a viable equipment classification level for coverage. DOE recognizes the argument set forth by Scales Industrial Technologies and does not dispute the potential for savings beyond the compressor package. Nonetheless, the decision not to pursue standards at the CAS level was made, not due to absence of potential energy savings, but due to impracticality of creating a single standard and test procedure that would apply meaningfully to the great variety of air distribution systems. DOE continues to conclude that the CAS is not appropriate for this final rule.

Castair commented that the scope of the energy conservation standards should be limited only to air ends, stating that the assemblers of air compressors can do little to improve efficiency. (Castair, No. 0045 at p. 1)

In the energy conservation standards NOPR, DOE also discussed the possibility of establishing standards at the bare compressor level. Ultimately, DOE opted not to limit standards to the bare compressor, concluding that greater savings were available at the packaged compressor level. 81 FR 31680, 31689-31690 (May 19, 2016). In response to Castair’s comment, DOE notes that energy savings can be achieved through proper component selection (including the bare compressor and driver) and system design. For this reason, DOE maintains the approach proposed in the energy conservation standards NOPR and is applying standards at the compressor package level.

b. Ancillary Equipment

In the test procedure NOPR, DOE proposed using the term “ancillary equipment” to mean “any equipment distributed in commerce with an air compressor that is not a bare compressor, driver, or mechanical equipment.” 81 FR 31680, 31690 (May 19, 2016). In other words, it served as a catch-all for package components that did not fall into another category but were part of the package purchased by an end user.

In the test procedure final rule, DOE adopts a requirement different from what DOE proposed in the test procedure NOPR. DOE defines two lists of equipment; the first list includes items that must be attached during testing, and the second list includes items that must be attached during testing if the package is distributed in commerce configured as such. However, manufacturers may opt to test with additional equipment than is on the two lists, at their preference.

CAGI commented that the definition of ancillary equipment should be more specific and provided a list of ancillary equipment that is common and required for safe operation of a compressor. Ingersoll Rand, Kaeser Compressors, Mattei Compressors, Sullair, and Sullivan-Palatek supported the CAGI position and list. (CAGI, No. 0052 at pp. 6-8; Ingersoll Rand, No. 0055 at pp. 1, 4; Kaeser Compressors, No. 0053 at p.1; Mattei Compressors, No. 0063 at p. 2; Sullair, No. 0056 at pp. 1, 6; Sullivan-Palatek, No. 0051 at p.1) CAGI further commented that the list is almost identical to the European Union’s Lot 31 Draft Ecodesign Regulation (hereafter “Lot 31 draft regulation,” which is discussed in section IV.C.1.b) list of ancillary equipment, and clarified that manufacturers should provide missing ancillary equipment that is not installed on their compressor for compliance and enforcement testing. (CAGI, No. 0052 at pp. 6-8)

Atlas Copco commented that the definition of ancillary equipment as proposed in both the test procedure NOPR and the energy conservation standards NOPR is not consistent, as the DOE hoped, with the draft EU standards. Atlas Copco further stated that the definition as proposed penalizes manufacturers who efficiently include dryers within the design of the compressor package. Finally, Atlas Copco emphasizes the need for an equitable standard for defining ancillary equipment that allows for comparison across units, similar to the draft EU standards. (Atlas Copco, No. 0054 at p. 13)

DOE has considered and responded to the preceding comments in the test procedure final rule by adopting two lists to describe the minimum equipment configuration for compressor testing. The first list contains equipment that must be included on a unit when testing, regardless of whether it is distributed in commerce with

the basic model under test. This table aligns with many of the items that CAGI specified to be part of a standard package. The second list contains equipment that is only required if it is distributed in commerce with the basic model under test. DOE believes that it is impossible to require that items from this second list of ancillary equipment be connected for testing, as many basic models do not require some of this ancillary equipment to achieve their basic functionality and as adding such components would be impossible or impractical.

ASAP, ACEEE, NEEA, NRDC, NEEP, and ASE commented that DOE should independently investigate the energy consumption of ancillary equipment that manufacturers wish to exclude, such as dryers, as this equipment has a significant impact on air compressor energy efficiency. (ASAP, ACEEE, NEEA, NRDC, NEEP, and ASE, No. 0060 at p. 4)

Dryers and other unrequired ancillary equipment may consume significant energy in certain applications. However, because they are not universally included as part of a compressor package, DOE did not include them in the list of equipment required for testing. DOE may investigate the appropriateness of test procedures for air dryers and other unrequired ancillary equipment—either as part of a compressor, or separately—as part of future rulemakings.

2. Compression Principle: Rotary and Reciprocating Compressors

In the energy conservation standards NOPR, DOE analyzed rotary and reciprocating compressors as separate equipment classes, and concluded that each

provides a distinct utility that materially affects energy consumption. 81 FR 31680 at 31697-31698 (May 19, 2016). Ultimately, DOE did not propose energy conservation standards for reciprocating compressors because the energy conservation standards NOPR analyses showed that such proposed standards were not economically justified. 81 FR 31680.

As discussed in the energy conservation standards NOPR and during the accompanying public meeting, DOE performed the reciprocating compressor analyses based on a limited data set. Specifically, DOE had limited data characterizing reciprocating compressor performance, manufacturer selling price,¹⁶ and shipments in the U.S. market. 81 FR 31680 at 31707, 31717, 31724 (May 19, 2016). In the energy conservation standards NOPR, DOE put forth analysis based on the limited data that was available and requested both comment and better data from interested parties in order to strengthen its analysis.

In response, DOE received no quantitative reciprocating compressor data from commenters. Additionally, in the time since the energy conservation standards NOPR, DOE was unable to obtain, from other sources, any additional reciprocating compressor data. As discussed in the energy conservation standards NOPR, the availability of reciprocating compressor performance data is extremely limited. 81 FR 31680 at 31707 (May 19, 2016). This continues to remain true. Specifically, manufacturers of reciprocating compressors do not typically performance test their equipment or publish

¹⁶ DOE notes that it had retail price data from online retailers, but limited direct manufacturer selling price data. DOE did estimate manufacturer selling price from the retail price data using estimated markups.

performance information. Consequently, to collect the performance data required to establish energy conservation standards, DOE will need to work with manufacturers, independent labs, and/or other interested parties to test and gather such data. DOE may pursue such avenues in the future, however at this time DOE's performance data remains limited.

Sullivan-Palatek commented that because DOE does not have performance data on reciprocating compressors, it should delay any decision to combine or separate an equipment class until reciprocating data can be collected and analyzed. (Sullivan-Palatek, No. 0051 at p. 6)

In the absence of new quantitative data, DOE agrees with Sullivan-Palatek and is not confident that the reciprocating compressor data underlying the energy conservation standards NOPR analyses is sufficient to definitively conclude, in this final rule, that energy conservation standards for reciprocating compressors are not economically justifiable. Therefore, DOE is deferring consideration of energy conservation standards until it can obtain performance data to assess the possibility for economically justified energy savings for different categories of reciprocating compressors. DOE makes no determination regarding such savings in this final rule, and reiterates that reciprocating compressors remain as covered equipment.

Regarding reciprocating compressors, interested parties also provided comments related to equipment classes, potential energy savings, substitution risk, harmonization

with the European Union, and potential energy conservation standard levels. These topics are discussed in the following sections.

a. Equipment Classes

CAGI, Castair, and Compressed Air Systems agreed with DOE's conclusion that rotary and reciprocating compressors warranted separate equipment classes. (CAGI, Public Meeting Transcript, No. 0044 at p. 19; Compressed Air Systems, No. 0061 at p. 2) Specifically, Castair stated that the different designs of rotary and reciprocating equipment make the technologies better suited to continuous and intermittent demand cycles, respectively. (Castair, No. 0062 at p. 1)

DOE agrees with commenters that reciprocating and rotary compressors should be analyzed in separate equipment classes for the reasons presented in the energy conservations standards NOPR, and that they carry differential utility and ability to reach greater efficiencies. 81 FR 31680 at 31697-31698 (May 19, 2016). However, because DOE is not establishing energy conservation standards reciprocating compressors in this final rule, DOE will not be establishing formal equipment classes for reciprocating compressors in this final rule. DOE may consider CAGI's and Castair's remarks in any future rulemaking.

b. Energy Savings

ASAP and NEEA commented that the shipment data for reciprocating compressors led them to believe that a large amount of energy consumption is attributed to reciprocating compressors. ASAP asserted that by not setting standards for the

equipment class, DOE misses a significant opportunity to reduce the energy consumption of compressors. (ASAP, Public Meeting Transcript, No. 0044 at pp. 9-10; NEEA, Public Meeting Transcript, No. 0044 at p. 115) Additionally, ASAP, ACEEE, NEEA, NRDC, NEEP, and ASE commented that DOE should reduce the scope of compressor capacity to include only the large reciprocating compressors used in commercial and industrial applications, which do not have the low-duty cycles of the residential hobby compressors and, therefore, should produce a greater consumer benefit at the proposed standard levels. (ASAP, ACEEE, NEEA, NRDC, NEEP, ASE, No. 0060 at p. 2) The CA IOUs also cited the missed opportunity for “significant energy savings” as the reason to establish a standard for reciprocating compressors. (CA IOUs, No. 0059 at pp. 2-3)

DOE reiterates that it is not analyzing reciprocating compressors in this final rule due to a lack of data, but DOE may consider comments received in any future rulemaking.

c. Substitution Risk

ASAP, ACEEE, NRDC, NEEP, ASE, the CA IOUs, NEEA, and NWPC suggested that DOE establish standards for a subset of reciprocating compressors, with ASAP suggesting inclusion of large commercial and industrial reciprocating compressors, and NEEA and NWPC suggesting inclusion of reciprocating compressors from 20 to 100 compressor motor nominal horsepower. NEEA and NWPC further commented that the absence of energy conservation standards for reciprocating compressors between 20 and 100 compressor motor nominal horsepower would pose a

substitution risk due to the increased cost of rotary compressors subject to an energy conservation standard. (NEEA and NWPCC, No. 0057 at p. 2)

Atlas Copco commented that using a “technology approach” in establishing the scope of an energy conservation standards rule grants unfair advantage to unregulated technologies at the low and high ends of capacity ranges covered. Specifically, Atlas Copco asserted that turbo and piston compressors (if not included in the DOE test procedure and energy conservation standards) would realize the increased cost due to regulation, and therefore may gain popularity over the regulated rotary compressors. (Atlas Copco, No. 0054 at pp. 2, 11-12)

In response to Atlas Copco’s concerns regarding unfair competition, DOE notes that it adopts a smaller compressor motor nominal horsepower range in the test procedure final rule, and is also doing so in this energy conservation standards final rule. The new scope alleviates Atlas Copco’s concerns, as DOE’s research indicates that few reciprocating compressors are offered with a compressor motor nominal horsepower greater than 10 hp; section III.B.4 provides further discussion of this topic. In that section, DOE directly addresses Atlas Copco’s concerns and considers competition from unregulated compressor technologies in determining whether to reduce scope.

In response to NEEA and NWPCC, DOE reviewed marketing literature of major reciprocating compressor manufacturers, and found that the largest marketed reciprocating compressor available (between 75 and 200 psig) has 30 compressor motor nominal horsepower, with 20 compressor motor nominal horsepower being a more

typical upper limit.¹⁷ Additionally, based on confidential discussions with manufacturers, DOE believes that shipments of the available compressors with greater than or equal to 20 hp are extremely limited. For these reasons, DOE believes a substitution incentive is unlikely.

d. Harmonization with the European Union

Atlas Copco recommended that DOE base its regulation on standard air as defined by Lot 31, and noted that the Lot 31 regulation is “technology independent.” Atlas Copco clarified that Lot 31 defines categories for standard air compressors that group compressors based on three flow profiles: (1) fixed flow, (2) variable flow, and (3) intermittent use. Reciprocating compressors are typically in the intermittent use category. Atlas Copco notes that the intermittent use category may not be included in the Lot 31 draft regulation due to the small potential energy savings. (Atlas Copco, No. 0054 at p. 12)

In response to this comment, DOE first notes that the Lot 31 draft regulation on “standard air compressors” does not classify compressors by “fixed flow, variable flow and intermittent use.” Rather, the Lot 31 draft regulation establishes and defines two equipment groupings, “rotary standard” and “piston standard” air compressors, in a

¹⁷ See: www.quincycompressor.com/products/reciprocating-piston/, www.saylor-beall.com/base-mounted/, www.atlascopco.us/en-us/compressors/products/Air-compressor/Oil-injected-rotary-screw-air-compressor/LE-LT-industrial-oil-lubricated-piston-compressors, www.ingersollrandproducts.com/am-en/products/air/small-reciprocating-air-compressors/electric-driven-two-stage, http://usa.boge.com/artikel/Screw_Compressors/CL.jsp?msf=200%2C100%2C100, www.gardnerdenver.com/gdproducts/compressors/reciprocating/r-series-low-pressure-reciprocating-compressors/#13223.

similar manner to the equipment classes proposed in the energy conservation standards NOPR.¹⁸ Further, DOE evaluated all publicly available reports and information on the Lot 31 website,¹⁹ and found no mention of any regulatory approach that would define three sub-categories of fixed flow, variable flow and intermittent use. DOE recognizes that work to amend the Lot 31 draft regulation may be occurring in private. However, without any published or publicly available regulatory information, DOE does not believe it is appropriate to speculate on hypothetical decisions that the EU regulators may make.

As a result, DOE's proposal in the energy conservation standards NOPR to separate equipment classes for reciprocating and rotary compressors aligns with the current published version of the Lot 31 draft regulation,²⁰ as the Lot 31 draft regulation proposes different minimum energy efficiency requirements for rotary and reciprocating compressors. Atlas Copco's claim that the whole category of intermittent use could possibly be exempted because it has too little savings potential also supports DOE's conclusion in the energy conservation standards NOPR that reciprocating and rotary compressors each offer distinct utility that materially affects energy consumption, and that these differences necessitate separate equipment classes. 81 FR 31680 at 31697-31698 (May 19, 2016).

¹⁸ For copies of the EU draft regulation: www.regulations.gov/contentStreamer?documentId=EERE-2013-BT-STD-0040-0031&disposition=attachment&contentType=pdf

¹⁹ As viewed here: www.eco-compressors.eu/documents.htm

²⁰ For copies of the EU draft regulation: www.regulations.gov/contentStreamer?documentId=EERE-2013-BT-STD-0040-0031&disposition=attachment&contentType=pdf

e. Potential Standards for Reciprocating Compressors

ASAP, ACEEE, NRDC, NEEP, ASE, NEEA and NWPCC argued that establishing baseline standards for reciprocating compressors would both promote efficiency in the marketplace and generate test data for future rulemakings. (ASAP, Public Meeting Transcript, No. 0044 at p. 152; NEEA and NWPCC, No. 0057 at p. 2; ASAP, ACEEE, NEEA, NRDC, NEEP, ASE, No. 0060 at pp. 2-3)

DOE agrees that a baseline standard for reciprocating compressors would generate performance data. However, DOE reiterates that it lacks sufficient data to conclude whether any energy conservation standard, including a baseline standard, would be economically justified. Therefore, DOE is not analyzing reciprocating compressor in this final rule, but may do so in a future rulemaking.

3. Driver Style

In the energy conservation standards NOPR, DOE proposed to establish the scope of energy conservation standards using driver style as a differentiator. Specifically, DOE defined the scope of driver styles covered under the proposed standard by only including single-phase and three-phase brushless electric motors. 81 FR 31680 at 31691-31692 (May 19, 2016).

The following sections discuss the comments that DOE received regarding the scope of drivers proposed in the energy conservation standards NOPR.

a. Exclusion of Non-Electric Drivers

In the energy conservation standards NOPR, DOE proposed to align the scope of the energy conservation standards with the scope of applicability of the test procedure NOPR and not include engine-driven equipment in the scope. 81 FR 31680 at 31691 (May 19, 2016).

The Edison Electric Institute expressed disappointment that the NOPR was only focused on electric motors and was not more fuel-neutral with respect to compressor drivers, pointing out the savings potential for compressors driven by natural gas would be high, given their usage in 2015 was 0.86 quad. (Edison Electric Institute, Public Meeting Transcript, No. 0044 at p. 5)

In response to EEI's comment, engine-driven compressors were considered in the February 5, 2014 Framework document for compressors and discussed extensively in the May 5, 2016 test procedure NOPR. 79 FR 6839 and 81 FR 27220. Specifically, in the test procedure NOPR, DOE concluded that the inclusion of engine-driven compressors was not appropriate for various reasons, including their differing utility compared to electric compressors, their existing coverage under the U.S. Environmental Protection Agency's Tier 4 emissions regulations, and the limited test data available under Annex D of ISO 1217:2009 to verify suitability as a DOE test procedure. For these reasons, DOE noted that engine-driven compressors would more appropriately be considered as part of a future rulemaking. 81 FR 27220, 27229 (May 5, 2016).

DOE continues to conclude that engine-driven compressors are unique equipment with different performance, applications, and test requirements from compressors driven by electric motors. As a result, DOE continues to conclude engine-driven compressors would be more appropriate to address as part of a separate rulemaking specifically considering such equipment. DOE is limiting the scope of this final rule to only compressors driven by electric motors.

b. Exclusion of Brushed Motors

In the energy conservation standards NOPR, DOE proposed to align with the scope of applicability of the test procedure NOPR and only include those compressors that are driven by brushless motors in the scope. 81 FR 31680 at 31692 (May 19, 2016).

The CA IOUs commented that DOE should cover brushed motors in addition to brushless motors, citing the potential loophole of a market shift toward unregulated brushed motors and the higher potential for energy savings as reasons for their inclusion. (CA IOUs, No. 0059 at p. 3)

DOE reiterates that brushed motors are uncommon in compressors with significant potential energy savings (i.e., high operating hours) due to higher maintenance costs, short operating lives, significant acoustic noise, and electrical arcing. For these reasons, DOE concludes that brushed motors are not a viable substitution risk for compressors within the scope of the compressor test procedures. DOE is continuing to exclude compressors driven by brushed motors from the scope of this final rule.

c. Exclusion of Single-Phase Motors

In the energy conservation standards NOPR DOE proposed a standard that was applicable to both single- and three-phase rotary compressors, while acknowledging that compressors with single-phase motors may be less efficient. 81 FR 31680 at 31691-31692 (May 19, 2016).

Castair commented that single-phase motors should be excluded from the scope of the standard because of their small sales volume. Castair argued that single-phase compressors comprise a small portion of the market, three-phase compressor offerings are expanding, and customers that do not have three-phase power typically cannot afford to install three-phase power. (Castair, No. 0062 at p. 1) Sullair also recommended that DOE limit the scope of the energy conservation standards to compressors with compressor motor nominal horsepower greater than 10 hp, but only cited the simplicity of reducing the number of equipment classes and solving the issue of single-phase rotary compressors. (Sullair, No. 0056 at pp. 7-8)

Sullivan-Palatek suggested that DOE limit the scope of the energy conservation standard to compressors with compressor motor nominal horsepower greater than 10 hp.²¹ According to Sullivan-Palatek, limiting the scope of the energy conservation standard to compressors with compressor motor nominal horsepower greater than 10 hp would eliminate single-phase compressors from the scope of the standards and eliminate

²¹ Sullivan-Palatek's comment included recommendations for a scope of both greater than or equal to 10 nominal hp, and greater than 10 nominal hp.

the risk of product substitution of unregulated reciprocating and scroll compressors.
(Sullivan-Palatek, No. 0051 at p. 6; Sullivan-Palatek, No. 0051 at p. 7)

Sullair commented that, although single-phase and three-phase compressor packages are mostly identical, the motor and electrical equipment (e.g., the starter) differ. Sullair also stated that the customer decision in choosing a single-phase or three-phase compressor is driven by the electrical supply at the installation location; customers are not incentivized to purchase a single-phase motor as the installation cost is typically higher than an equivalent three-phase motor when three-phase power facility is available at the installation point. (Sullair, No. 0056 at pp. 7-8)

Ingersoll Rand requested that DOE exclude single-phase compressors if DOE intends to include compressors with a compressor motor nominal horsepower of less than 10 hp. Ingersoll Rand stated that single-phase compressors are purchased out of utility need and do not have the same energy efficiency potential as three-phase compressors in that compressor motor nominal horsepower range. Ingersoll Rand comments that regulating single-phase compressors under 10 nominal hp would penalize small businesses by requiring the purchase of a more expensive compressor, or requiring the conversion of its existing power supply to three-phase power. (Ingersoll Rand, No. 0055 at p. 5)

As discussed in section III.B.4, DOE is limiting the scope of this final rule to compressors with compressor motor nominal horsepower of 10 hp or greater. For compressor packages that are within this compressor motor nominal horsepower range

and available in single- and three-phase variations through online retailers, DOE found single-phase compressors offered at a similar price, or more expensive than comparable three-phase models. Additionally, DOE acknowledges Sullair's comment that, when three-phase power is available, installation costs for a single-phase compressors may be higher. Based on the similar prices DOE found through retailers, and the potential higher installation costs for single-phase compressors, DOE agrees with Sullair's comment that there is not an incentive to choose single-phase equipment instead of three-phase equipment. Therefore, DOE is limiting the scope of this final rule to compressors with three-phase motors. With the reduction of scope to include only three-phase compressors of 10 nominal hp or greater, Ingersoll Rand's concern regarding single-phase compressors of 10 nominal hp or less is no longer applicable.

DOE also received the following comments regarding the separation of equipment classes. Because single-phase compressors are not included within the scope of the standards established by this final rule, these comments are no longer relevant.

Castair, Compressed Air Systems, and Sullair both supported the creation of equipment classes based on motor phase count. Compressed Air Systems argued that single-phase compressors should be separated from three-phase compressors because there is little data available for single-phase compressors to make an informed decision. Furthermore, Compressed Air Systems argued that a single-phase compressor would not be able to meet a three-phase standard. (Compressed Air Systems, No. 0061 at p. 2)

Sullair made several arguments to support establishing equipment classes based on motor phase count. First, Sullair argued that the availability of premium efficiency single-phase motors is limited, resulting in difficulty in sourcing motors that would meet an energy efficiency standard. Sullair also stated that the customer decision in choosing a single-phase or three-phase compressor is driven by the electrical supply at the installation location; and as noted previously, customers are not incentivized to purchase a single-phase motor as the installation cost is typically higher than an equivalent three-phase motor, when three-phase power is in the facility. Finally, Sullair stated there is a risk of product substitution to unregulated single-phase products, such as reciprocating or scroll compressors, if DOE adopts one standard for single- and three-phase rotary compressors. Sullair argued that manufacturers will likely stop producing single-phase rotary compressors due to the unfair competitive disadvantage relative to competing technologies. (Sullair, No. 0056 at pp. 7-8; Sullair, Sullair, Public Meeting Transcript, No. 0044 at p. 60; Sullair, Public Meeting Transcript, No. 0044 at p. 27)

Sullivan-Palatek supported separating single-phase and three-phase compressors into two separate equipment classes, but also commented that limiting the scope would eliminate the need to create equipment classes for reciprocating and rotary compressors. (Sullivan-Palatek, No. 0051 at pp. 6-7)

With respect to consumer utility, a prime consideration in the establishment of equipment classes, Sullivan-Palatek stated that any application that can support three-phase power can also support single-phase power, but that the reverse is not true. (Sullivan-Palatek, Public Meeting Transcript, No. 0044 at p. 27)

As noted in this section, the matter of equipment classes by phase count is no longer applicable due to DOE's decision in limiting scope to compressors with three-phase motors. DOE may consider standards for single-phase equipment in a future rule.

4. Compressor Capacity

In the energy conservation standards NOPR, DOE proposed to limit the scope of compressors energy conservation standards to compressors with compressor motor nominal horsepower greater than or equal to 1, and less than or equal to 500 hp. In that NOPR, DOE also reasoned that the compressor industry typically used "nominal" motor horsepower as a descriptor of compressor capacity. 81 FR 31680 at 31692-31693 (May 19, 2016).

DOE received a number of comments in response to the proposed compressor capacity limitations. Commenters raised concerns regarding two facets of the compressor capacity scope: (1) the compressor motor nominal horsepower range included in the scope and (2) the coupling of compressor motor nominal horsepower and actual volume flow rate in the scope definition. These comments are discussed in sections III.B.4.a and III.B.4.b.

a. Compressor Motor Nominal Horsepower Range

Interested parties commented broadly on compressor motor nominal horsepower scope. ASAP, ACEEE, NEEA, NRDC, NEEP, ASE and the CA IOUs supported the proposed horsepower scope limitations. (ASAP, ACEEE, NEEA, NRDC, NEEP, ASE, No. 0060 at p. 4; CA IOUs, No. 0059 at p. 3)

CAGI suggested a compressor motor nominal horsepower range of 10 to 200 hp. (CAGI, No. 0052 at p. 9) Ingersoll Rand,²² Kaeser Compressors, Mattei Compressors, Sullair, and Sullivan-Palatek commented in support of CAGI's recommendations. (Ingersoll Rand, No. 0055 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullair, No. 0056 at pp. 1, 9-10; Sullivan-Palatek, No. 0051 at p. 1)

Scales Industrial Technologies suggested a compressor motor nominal horsepower scope of 15 hp to 200 or 250 hp. (EERE-2014-BT-TP-0054, Scales Industrial Technologies, No. 0013 at p. 3) Atlas Copco stated that it had no objection to inclusion of compressors of greater than 500 nominal hp, with no upper limit specified. (Atlas Copco, No. 0054 at p. 13)

Interested parties also provided a variety of specific rationales to support their recommendations. DOE grouped the specifics of interested party comments into six categories: data scarcity, substitution incentive, certification, consistency with the European Union, and energy savings. The following sections discuss these comments.

²² DOE notes that in response to the 2012 proposed determination of coverage, Ingersoll Rand commented that a number of small compressors (retail, consumer or commercial-based) are sold in the US market, but may not have a significant impact of energy savings if included in this rulemaking; further, the costs associated with coverage would have to be passed to the consumer as the profit margins are low for this type of compressor. (Docket No. EERE-2012-BT-DET-0033, Ingersoll Rand, No. 0004 at pp. 2-3) DOE views Ingersoll Rand's more recent 2016 test procedure NOPR comments as superseding the views presented in response to the 2012 proposed determination of coverage.

Data Scarcity

CAGI noted the scarcity of compressor data above a compressor motor nominal horsepower of 200 hp, citing that 200 hp is the upper limit of the CAGI Performance Verification Program. Ingersoll Rand, Kaeser Compressors, Mattei Compressors, Sullair, Sullivan-Palatek supported CAGI's position. (CAGI, No. 0052 at p. 9; CAGI, No. 0052 at p. 9; Ingersoll Rand, No. 0055 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullair, No. 0056 at p. 1; Sullivan-Palatek, No. 0051 at pp. 1, 6) The commenters argued that DOE's regression curves, which were used to establish efficiency levels and trial standard levels, were created with data that is not readily available for larger (above 200 nominal hp) or smaller (below 10 nominal hp) compressors, and that the regression curves are not appropriate above 200 nominal hp. In response to the 2012 proposed determination of coverage, NEEA commented that performance testing at horsepower levels below 15 was rare and that corresponding data is unreliable. (Docket No. EERE-2012-BT-DET-0033, NEEA, No. 0010 at p. 1).

Although compressors with a compressor motor nominal horsepower greater than 200 hp may publish performance data using CAGI data sheets, Sullair noted that these compressors do not formally participate in the Performance Verification Program and are not subject to independent testing, and the data associated with those compressors is posted voluntarily and not subject to verification. (EERE-2014-BT-TP-0054, Sullair, Public Meeting Transcript, No. 0016 at p. 52) As a result, DOE does not view such data as suitable to establish an energy conservation standard without further investigation. For this reason, and others outlined in the upcoming sections, DOE is not including compressors outside the range of 10-200 compressor motor nominal horsepower in the

scope this energy conservation standards final rule. DOE may explore standards for compressors outside the range of 10-200 compressor motor nominal horsepower, in a future rulemaking.

Substitution Incentive

CAGI, Sullair, Kaeser Compressors, and Sullivan-Palatek suggested a compressor motor nominal horsepower range of 10 to 200 hp. They reasoned that the proposed scope in the energy conservation standards NOPR would create an unfair competitive advantage for certain unregulated equipment below 10 nominal hp and over 200 nominal hp. They believe that this competitive advantage could translate to a risk of product substitution from unregulated equipment. The commenters specified scroll and reciprocating equipment as possible competition below 10 nominal hp and centrifugal equipment above 200 nominal hp. (CAGI, No. 0052 at p. 9; Kaeser Compressors, No. 0053 at p. 1; Sullair, No. 0056 at pp. 8-12; Sullair, Public Meeting Transcript, No. 0044 at pp. 129-130) Ingersoll Rand and Mattei Compressors commented in support of CAGI's recommendations. (Ingersoll Rand, No. 0055 at p. 1; Mattei Compressors, No. 0063 at p. 2)

DOE agrees that inclusion of small (less than 10 nominal hp) and larger (greater than 200 nominal hp) rotary compressors could create a competitive disadvantage for manufacturers of rotary compressors. Currently, without any energy conservation standards in place, rotary, centrifugal, reciprocating, and scroll compressors compete with each other over certain overlapping compressor motor nominal horsepower ranges. Adopting standards for rotary compressors alone, in these overlapping nominal

horsepower ranges, may disturb the competitive equilibrium. The costs associated with regulation may give the manufacturers of unregulated equipment (e.g., centrifugal, scroll, reciprocating) a competitive advantage, and allow them to incentivize end users to switch from a regulated (rotary) to an unregulated compressor, diminishing the impact of the proposed standard.

For this reason, and others outlined in the preceding and upcoming sections, DOE is not including compressors outside the range of 10 to 200 compressor motor nominal horsepower in the scope of this energy conservation standard final rule.

Certification, Sampling, and Enforcement

Commenters argued against standards for compressors with a compressor motor nominal horsepower greater than 200 hp because of substantial difficulty with sampling and enforcement. Basic models in this range are highly customized and carry low (and sometimes zero, over a period) production volumes. (CAGI, No. 0052 at p. 9; Sullair, No. 0056 at pp. 8-10) Sullair commented that testing costs for units of greater than 200 nominal hp are large relative to those of smaller compressors. (Sullair, Public Meeting Transcript, No. 0044 at pp. 129-130) Ingersoll Rand, Kaeser Compressors, Mattei Compressors, and Sullivan-Palatek commented in support of CAGI's recommendations. (Ingersoll Rand, No. 0055 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullivan-Palatek, No. 0051 at p. 1)

In arguing against standards for compressors of less than 10 nominal hp, Sullair cited the relatively high cost of certification and testing. Sullair argued the cost

certification and testing for this type of compressor may be more than 60 percent of the manufacturer selling price (“MSP”) of the compressor unit.(Sullair, No. 0056 at pp. 11-12)

In general, DOE agrees with the concerns that the representations, sampling, and enforcement provisions proposed in the test procedure NOPR may cause significant burden for compressors greater than 200 nominal hp, as many of the larger compressor motor nominal horsepower models are infrequently built and often unavailable for testing. However, regarding compressors of less than 10 nominal hp, DOE asserts that testing cost as a percentage of MSP is not an appropriate metric to evaluate the economic justification of test procedures or energy conservation standard. According to the test procedure final rule, each basic model must test a minimum of two unique models (or use an alternative efficiency determination method, “AEDM”) to determine compliance. DOE does not require performance or certification testing for all units distributed in commerce. The upfront costs associated with certifying a basic model amortize over all shipments of that basic model, and the ratio of initial testing cost to MSP have no bearing on the overall impact to manufacturers. DOE assesses the specific impacts of certification testing costs (and other upfront conversion costs) in detail in section IV.J.2.c.

For this reason, and others outlined in the preceding and upcoming sections, DOE is not including compressors with greater than 200 compressor motor nominal horsepower in the scope this energy conservation standards final rule.

Consistency with European Union

Atlas Copco expressed support for expanding the scope of covered compressor motor nominal horsepower to include all compressors above 500 hp, noting that this would be consistent with the draft EU standards for compressors, which proposed no upper limit of scope for coverage. (Atlas Copco, No. 0054 at p. 13)

Although the draft EU standards for compressors do not limit applicability based on motor power per se, DOE notes that the motor horsepower is constrained implicitly by the explicit limitations on pressure and flow. Interaction between flow and compressor motor nominal horsepower is discussed further in section III.B.4.b.

Generally, DOE recognizes the value of aligning requirements with other major regulatory bodies, but DOE will always evaluate alignment on a case-by-case basis. In this particular case, DOE does not view the harmonization benefit associated with coverage of compressor motor nominal horsepower levels greater than 200 as outweighing the burdens. The burdens, as discussed in the previous subsections, include risks of forming a standard based on insufficient data, creating market incentive to substitute to unregulated technologies less than 10 nominal hp or greater than 200 nominal hp, and imposing undue sampling and certification burden on low-volume compressor models. As a result, DOE does not find alignment with the European Union scope limitation to be appropriate in this case.

Energy Savings

In response to the test procedure NOPR, Sullair stated that the number of units and associated potential energy savings above 200 nominal hp are too small to warrant inclusion of those compressors within the test procedure applicability. (EERE-2014-BT-TP-0054, Sullair, No. 0006 at p. 2) In response to the energy conservation standards NOPR, CAGI and Sullair cited the relatively low number of shipments above 200 nominal hp as a reason to reduce the scope of the energy conservations standards. (CAGI No. 0052 at p. 9; Sullair, No. 0056 at pp. 9-10) Similarly, the People's Republic of China questioned the justification for including compressors with low compressor motor nominal horsepower and, consequently, a low potential for energy savings, into the scope of the standard. (EERE-2014-BT-TP-0054, P. R. China, No. 0019 at p. 3)

Other commenters argued that DOE should maintain the scope as proposed. ASAP, ACEEE, NEEA,²³ NRDC, NEEP, and ASE supported the proposed compressor motor nominal horsepower scope limitations. ASAP, ACEEE, NEEA, NRDC, NEEP and ASE stated that 5-percent and 7-percent of the fixed-speed and variable-speed compressor markets, respectively, would not be covered if the scope was limited to a maximum of 200 nominal hp. ASAP ACEEE, NEEA, NRDC, NEEP and ASE further commented that the higher nominal horsepower units represent even greater energy

²³ DOE notes that in response to the 2012 proposed determination of coverage, NEEA urged DOE to cover compressors <15 hp, stating that this range represented commodity-type compressors purchased without consideration of operating cost and, therefore, offering the opportunity for substantial energy savings. (NEEA, No. 0010 at p. 1) Further, NEEA stated that performance testing in this horsepower range was rare or unreliable. (Docket No. EERE-2012-BT-DET-0033, NEEA, No. 0010 at p. 1) DOE views NEEA's more recent 2016 test procedure NOPR comments as superseding the views presented in response to the 2012 proposed determination of coverage.

savings potential on a per-unit basis given their energy consumption. (ASAP, ACEEE, NEEA, NRDC, NEEP, ASE, No. 0060 at p. 4)

The CA IOUs supported the proposed range of 1-500 nominal hp, which aligns with the motors rulemaking, but encouraged DOE to expand the scope of coverage beyond 500 nominal hp to maximize the potential energy savings of the proposed rulemaking. (CA IOUs, No. 0059 at p. 3)

DOE evaluated the impact of reducing compressor motor nominal horsepower scope to the level recommended by CAGI, Kaeser Compressors, Ingersoll Rand, and Sullivan-Palatek (*i.e.*, 10-200 hp), and estimates that adopting this scope would retain 96.6 percent of the energy savings of the proposed 1-500 hp range. For compressors removed from scope at lower capacities, the low impacts are the result of smaller compressor capacities. For those removed from scope at the higher capacities, the low impacts are the result of extremely low shipments.

Conclusion

As noted previously in this section, DOE received multiple comments regarding the scope of compressor motor nominal horsepower that should be included in this final rule. CAGI, Kaeser Compressors, Ingersoll Rand, Mattei Compressors, Sullair, and Sullivan-Palatek recommended 10 to 200 nominal hp and Scales Industrial Technologies recommended 15 to 200 or 250 nominal hp. Alternatively, ASAP, ACEEE, NEEA, NRDC, NEEP, and ASE supported the proposed horsepower scope limitations, while

Atlas Copco and the CA IOUs stated that they had no objection to inclusion of compressors of greater than 500 nominal hp, with no upper limit specified.

In this section, DOE reviewed the recommendations and the justifications provided by commenter, and responded to each. In summary, the aforementioned data scarcity, substitution incentives, certification costs, and limited available shipments and energy savings for compressor outside the 10 to 200 compressor motor nominal horsepower range all contribute to DOE's decision to limit the scope of the energy conservation standards, in this final rule, to compressors of 10 to 200 nominal hp. In conjunction with the limit of compressor motor nominal horsepower range, DOE also establishes a limit on compressor full-load actual volume flow rate as discussed in section III.B.4.b.

b. Coupling of Compressor Motor Nominal Horsepower and Actual Volume Flow Rate in the Scope Definition

In addition to comments regarding potential horsepower limitations, CAGI and Sullair suggested establishing scope by limiting both compressor motor nominal horsepower and flow. In other words, a compressor would be subject to standards if it falls within either a given horsepower range or within a given flow range (or both). Specifically, CAGI supported an airflow limitation of 35 to 1,250 cfm, inclusive, while Sullair supported an airflow limitation of 30 to 1,250 cfm, inclusive. CAGI reasoned that an airflow range will prevent manufacturers possibly altering horsepower ratings at the margins in order to move compressors out of the scope of energy conservation standards. Sullair expanded upon this reasoning, and commented that a manufacturer may be

encouraged to add a nominally larger horsepower motor to circumvent the standards. (CAGI, No. 0052 at p. 9; Sullair, No. 0056 at pp. 9-10, 11-12, 13) Ingersoll Rand, Kaeser Compressors, Mattei Compressors, and Sullivan-Palatek commented in support of CAGI's recommendations. (Ingersoll Rand, No. 0055 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullivan-Palatek, No. 0051 at p. 1)

DOE agrees with CAGI and Sullair that, by not limiting flow rate, manufacturers could conceivably circumvent compressor regulations by using a motor of horsepower slightly greater than 200 hp. For example, two similar compressors, one with a 200 hp motor and one with a 225 hp motor, would supply nearly identical flow rates and pressure (i.e., utility) to the end user; however the one with the 225 hp motor would not be subject to proposed standards or proposed test procedures. In contrast, any alterations in flow rate would directly impact consumer utility.

A review of all available CAGI performance data sheets indicates that the flow rate ranges recommended by CAGI and Sullair are reasonable. The full-load actual volume flow rate range of 35 to 1,250 cfm, inclusive, is slightly broader than the compressor motor nominal horsepower range of 10 to 200 hp; i.e., the flow range encompasses slightly more compressors models. This aligns with the intent of the recommendations put forth by CAGI and Sullair. Specifically, the full-load actual volume flow rate range of 35 to 1,250 cfm includes 9.2-percent more fixed-speed compressors and 2.9-percent more variable-speed compressors in the scope the rulemaking.

For the reasons outlined in this section (i.e., reduction of circumvention risk and the reasonable nature of the ranges proposed), in this final rule, DOE adopts a coupled airflow and compressor motor nominal horsepower limit, as recommended by Sullair and CAGI. DOE notes that the recommendations from Sullair and CAGI are not completely aligned, with Sullair recommending a lower limit of 30 cfm and CAGI recommending a lower limit of 35 cfm. Given general support by Ingersoll Rand, Kaeser Compressors, and Sullivan-Palatek for CAGI's recommendations, DOE is adopting the higher limit of 35 cfm. Specifically, energy conservation standards apply to compressors with either a compressor motor nominal horsepower of 10 to 200 hp, or a full-load actual volume flow rate of 35 to 1,250 cfm.

5. Full-Load Operating Pressure

In the energy conservation standards NOPR, DOE proposed to limit the scope of the standard to compressors with full-load operating pressures between 31 psig and 225 psig. DOE chose the proposed full-load operating pressure scope to align with the test procedure NOPR, noting that equipment outside of that pressure range generally represents a low sales volume, specialized equipment type for applications that do not often overlap with what is generally considered in the market to be industrial air. 81 FR 31680 at 31693 (May 19, 2016). In the energy conservation standards NOPR, DOE also concluded that isentropic efficiency is approximately invariant with pressure over the pressure range under consideration and, as a result, DOE used data from equipment with full-load operating pressures between 31 and 225 psig to establish efficiency levels for each equipment class. 81 FR 31680 at 31705 (May 19, 2016). In the test procedure final rule, DOE restricts the scope of applicability of the test procedure to compressors with

full-load operating pressures between 75 and 200 psig. DOE may not establish energy conservation standards for equipment that does not have an established test procedure. For this reason, DOE may only consider energy conservation standards for equipment with full-load operating pressures between 75 and 200 psig in this final rule.

In response to DOE's energy conservation standards proposal, CAGI and Jenny Products commented that a pressure range between 75 and 200 psig is appropriate for the scope of the standard. Jenny Products stated that most air compressors are used in the 80-125 psig range, and that some are used in the 125-175 psig range; therefore a range of 75-200 psig would include almost all commercially available compressors built today. (EERE-2014-BT-TP-0054, Jenny Products, No. 0020 at p. 3) CAGI reasoned that package isentropic efficiency is relatively independent of pressure between 75 and 200 psig, and this range represents the largest segment of the industry. (CAGI, No. 0052 at pp. 9-10) CAGI's statement aligns with its comment on the breakdown of output pressures in the rotary compressors market, which was discussed in the NOPR as:

- Approximately 4.4 to 30 pounds per square inch gauge (psig) (pressure ratio greater than 1.3 and less than or equal to 3.0): The compressors industry generally refers to these products as blowers—a term DOE is considering defining as part of its fans and blowers rulemaking (Docket No. EERE-2013-BT-STD-0006). The majority of these units are typically distributed in commerce as bare compressors and do not include a driver, mechanical equipment, or controls.

- 31 to 79 psig (pressure ratio greater than 3.1 and less than or equal to 6.4): There are relatively few compressed air applications in this pressure range, contributing to both low product shipment volume and low annual energy consumption.
- 80 to 139 psig (pressure ratio greater than 6.4 and less than or equal to 10.5): This range represents the majority of general compressed air applications, shipments, and annual energy use.
- 140 to 215 psig (pressure ratio greater than 10.5 and less than or equal to 15.6): This range represents certain specialized applications, relatively lower sales volumes and annual energy consumption when compared to the 80 to 139 psig rotary compressor segment.
- Greater than 215 psig (pressure ratio greater than 15.6): This range represents even more specialized applications, which require highly engineered rotary compressors that vary based on each application. 81 FR 31680 at 31693 (May 19, 2016).

Ingersoll Rand, Kaeser Compressors, Mattei Compressors, Sullair, and Sullivan-Palatek commented in support of CAGI's recommendations. (Ingersoll Rand, No. 0055 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullair, No. 0056 at p. 1; Sullivan-Palatek, No. 0051 at p. 1)

Sullair commented that isentropic efficiency is independent of pressure across the range of 80-200 psig, which is nearly the same as the 75-200 range suggested by

Ingersoll Rand, Kaeser Compressors, Sullivan-Palatek, and by Sullair, itself, indirectly in support of CAGI's comments. (Sullair, No. 0056 at p. 15).

Alternatively, Atlas Copco suggested that 80 to 170 psig (7 to 15 bar) [sic] as range where the dependence of isentropic efficiency on outlet pressure is limited, which is in alignment with the limited pressure range covered by the EU Lot 31 draft regulation. (Atlas Copco, No. 0054 at pp. 19-20) However, DOE believes that Atlas Copco's unit conversions were inaccurate and thus, the suggested range does not align with the scope proposed in the EU Lot 31 draft regulation. Based these ambiguities, DOE cannot directly consider Atlas Copco's recommendation when considering the range where package isentropic efficiency can be considered independent of full-load operating pressure. For this reason, DOE defers to the recommendation of CAGI, Ingersoll Rand, Sullivan-Palatek, and Sullair, and concludes that package isentropic is relatively independent of full-load operating pressure at full-load operating pressures between 75 and 200 psig.

As a result, in this final rule, DOE is establishing the broadest scope of applicability of standards that is possible, under the current test procedure, i.e. a full-load operating pressure of 75 to 200 psig.

6. Lubricant Presence

In the energy conservation standards NOPR, DOE proposed to include lubricant-free compressors in the scope of the standards. However, DOE recognized differences in design, efficiency, cost, and utility for lubricant-free compressors when establishing

separate equipment classes for compressors based on lubricant presence. 81 FR 31680 at 31698 (May 19, 2016). DOE proposed, in the energy conservation standards NOPR, a “new standards at baseline” standard for lubricant-free compressors. This baseline would not have resulted in national energy savings, as reflected in the national impact analysis (“NIA”), but would have prevented potential new, less efficient equipment from the entering the market and potentially increasing future national energy consumption. 81 FR 31680 at 31736.

In the test procedure final rule, DOE excludes lubricant-free compressors from the scope of test procedures based on three general reasons: (1) the lack of applicability of the test method and metric proposed in the test procedure NOPR; (2) the desire to retain the opportunity to harmonize with the European Union regulatory process for the benefit of manufacturers and consumers; and (3) to avoid creating an incentive to substitute unregulated technologies (such as dynamic) for regulated lubricant-free compressors.

Because there is no test procedure for lubricant-free compressors, DOE cannot consider energy conservation standards for this equipment, in this final rule. DOE is making no determination of the technological feasibility or economic justification of potential standards for lubricant-free compressors in this final rule. DOE may evaluate standards for lubricant-free compressors in the future, if an appropriate test procedure can be developed.

Although DOE is unable to consider energy conservation standards for lubricant-free compressors, at this time, the following subsections summarize relevant interested

party comments. DOE may consider these comments if it chooses to pursue energy conservations for lubricant-free equipment in the future. In reviewing the comments, DOE observed that comments tended to fall into one of three groups. One group of comments focused on a lack of available performance data to inform the establishment of a standard. A second group focused on a possible unfair advantage conferred to substitute products outside of DOE's scope of standards. The final group of comments focused on the benefits of harmonizing standards with those proposed in the European Union.

Scarcity of Data

In response to the energy conservation standards NOPR, ASAP, ACEEE, NEEA, NRDC, NEEP, and ASE noted that lubricant-free compressors serve specialized applications and are less common, which makes establishing a standard difficult in the absence of data. However, ASAP, ACEEE, NEEA, NRDC, NEEP, and ASE suggested that DOE include lubricant-free compressors within the scope of the final rule, as the data gathered to certify these compressors will provide useful information for future rulemakings. To balance those two considerations, ASAP, ACEEE, NEEA, NRDC, NEEP and ASE suggested setting the energy conservation standards for lubricant-free compressors at efficiency level zero. (ASAP, ACEEE, NEEA, NRDC, NEEP, ASE, No. 0060 at p. 4)

Kaeser Compressors and Sullair also commented that there were a limited number of data points available for lubricant-free compressors, with Sullair commenting that there are few manufacturers of this type of equipment that participate in the CAGI Performance Verification Program. Kaeser Compressors further stated that the lack of

data makes the regression curves for the efficiency levels look possibly inaccurate toward the lower end of the covered airflow range, and that it preferred to wait until the EU finishes its assessment of lubricant-free compressors. (Kaeser Compressors, No. 0053 at p. 1; Kaeser Compressors, Public Meeting Transcript, No. 0044 at pp. 56-57; Sullair, Public Meeting Transcript, No. 0044 at pp. 31-32)

CAGI commented that DOE should exclude lubricant-free compressors in the scope of the final rule due to the limited compressor performance data available to inform a standard. (CAGI, No. 0052 at p. 12) Ingersoll Rand, Kaeser Compressors, Mattei Compressors, Sullair, and Sullivan-Palatek commented in support of CAGI's recommendations. (Ingersoll Rand, No. 0055 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullair, No. 0056 at p. 1; Sullivan-Palatek, No. 0051 at p. 1)

Substitution Incentive

CAGI commented that DOE should exclude lubricant-free compressors in the scope of the final rule in order to reduce risk of product substitution to unregulated technologies, such as dynamic compressors above a compressor motor nominal horsepower of 150 hp. (CAGI, No. 0052 at p. 12) Ingersoll Rand, Kaeser Compressors, Mattei Compressors, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0055 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullair, No. 0056 at p. 1; Sullivan-Palatek, No. 0051 at p. 1)

Harmonization with European Union

Ingersoll Rand commented that DOE should consider waiting to revise the efficiency levels for lubricant-free compressors until the draft EU standards for lubricant-free compressors are published. Ingersoll Rand also stated, however, that it did not oppose efficiency level zero, which DOE proposed in the energy conservation standards NOPR. (Ingersoll Rand, No. 0055 at p. 4)

CAGI also commented that DOE should exclude lubricant-free compressors in the scope of the final rule in order to preserve opportunity to align with EU once the EU establishes standards for lubricant-free compressors. (CAGI, No. 0052 at p. 12) Ingersoll Rand, Kaeser Compressors, Mattei Compressors, Sullair, and Sullivan-Palatek supported CAGI's comments. (Ingersoll Rand, No. 0055 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullair, No. 0056 at p. 1; Sullivan-Palatek, No. 0051 at p. 1)

Conclusion

As noted earlier in this section, DOE is not adopting standards for lubricant-free compressors because no test procedure exists. DOE is making no determination of the technological feasibility or economic justification of potential standards for lubricant-free compressors in this final rule. DOE may evaluate standards for lubricant-free compressors in a future rule.

7. Water-injected Compressors

DOE is aware that some compressors inject water into the compression chamber, in place of oil or other lubricants, in order to avoid risk of air contamination and to serve applications that require inherently clean air. In the energy conservation standards NOPR, DOE proposed to define “lubricated compressor” as “a compressor that introduces an auxiliary substance into the compression chamber during compression” and “auxiliary substance” as “any substance deliberately introduced into a compression process to aid in compression of a gas by any of the following: lubricating, sealing mechanical clearances, or absorbing heat.” In the energy conservation standards NOPR, DOE interpreted water to be an auxiliary substance. 81 FR 31680, 31698 (May 19, 2016).²⁴ Consequently, water-injected compressors would be classified as lubricated compressors.

In response to the energy conservation standards NOPR, Jenny Products commented that water screw compressors (also known as “water injected compressors”) are quite different from the compressors mentioned in the energy conservation standards NOPR proposal, and that DOE’s proposed standard attempt to lump too many compressors into a one size fits all model. (Jenny Products, No. 0058 at p. 2). Sullivan-Palatek also cited water screw compressors as an example of specialized technology that could be eliminated from the market if grouped with other lubricated compressors. Beyond these comments, DOE did not receive any specific evidence or data supporting the inclusion or exclusion of water-injected compressors.

²⁴ This definition was adopted, unchanged, in the test procedure final rule.

DOE performed research to better understand water-injected compressor technology and determine whether water-injection both provides consumer utility and inhibits the ability to reach higher efficiency levels.

Water-injected compressors operate similarly to conventional (i.e., oil or synthetic oil) lubricated compressors in that they introduce a liquid into the compression chamber to lubricate moving parts, seal mechanical clearances against the egress of air, and absorb heat. DOE understands the chief consumer utility of using water, in place of an oil- or synthetic oil-based auxiliary substance, is freedom from risk of output air contamination. Failure of a filter or other downstream oil removal apparatus does not permit oil to become present in the delivered air as no oil is present in the system. However, water and vapor are present and require removal. Because of the similar utility of an inherently oil-free process, water-injected compressors more often compete with lubricant-free compressors rather than lubricated compressors.

A limitation of replacing oil with water is that water tends to be more corrosive to many types of metals commonly used to construct compressors. This is particularly true if the water contains trace quantities of minerals, as does any water drawn from the environment or public water supply. To reduce corrosion, water-injected compressors employ advanced filtration (commonly, reverse osmosis) to create highly purified water for introduction into the compression process. The advanced filtration systems used by water-injected compressors may add nontrivial energy consumption to a compressor package and ultimately reduce efficiency. Reverse osmosis systems typically require creation of large pressure gradients and several stages of filtration. The filtration systems

may also contain elements to eliminate biological agents, of particular concern in medical applications.

Even with advanced filtration systems, water-injected compressors may require the use of more corrosion-resistant materials for any componentry downstream of the water injection site. These materials may be less resistant to mechanical deformation and exhibit diminished lifespan relative to conventional construction materials. As a result, designers tend to open mechanical clearances, as compared with conventionally lubricated compressors, in anticipation of mechanical deformation associated with less durable materials used to resist corrosion. Wider clearances allow more air leakage during operation, and ultimately reduce efficiency.

These modifications that alter efficiency – filtration, corrosion-resistant material, altered geometry – are also likely to add cost to a water-injected compressor, relative to a conventionally lubricated compressor of similar specification.

With respect to market share, DOE knows of only three manufacturers currently offering water-injected compressors in the United States market,²⁵ and DOE believes that shipments of water-injected compressors are very low, as compared to oil- or synthetic oil-injected compressors. As a result, DOE expects energy savings associated with water-injected compressors to be minimal.

²⁵ Sullivan-Palatek, Atlas Copco, and CompAir (a brand of Gardner Denver)

In conclusion, DOE's research indicates that water-injected compressors may provide additional end user utility, but with reduced ability to meet higher efficiency levels. As a result, water-injected compressors may warrant a separate equipment class from lubricated compressors. However, because no performance data is available to characterize water-injected compressors, DOE has no basis to establish a standard. As a result, DOE excludes water-injected compressors from the scope of this final rule. To clearly establish what is meant by the term, DOE is adopting a definition in this final rule. "Water-injected compressor" means "a lubricated compressor that uses injected water as an auxiliary substance."

8. Specialty Purpose Compressors

In the energy conservation standards NOPR, DOE did not explicitly exclude any categories of specialty compressors. DOE made no specific scope exclusion for what the compressor industry refers to as "customized" or "specialty-purpose" compressors. 81 FR 31680, 31690, 31693, 31696 (May 19, 2016). Although specialty compressors were not explicitly excluded, DOE expects that many would be effectively excluded by other scope limitations, including full-load operating pressure, compression principle, variety of gas compressed, capacity, driver variety, and lubricant presence.

DOE received comments with respect to customized and specialty-purpose compressors; generally, many commenters recommended that DOE expressly exclude customized and specialty-purpose compressors from the scope of the test procedure and energy conservation standards. Commenters provided information on what they viewed as customized and specialty-purpose compressors, as well as rationale for their

suggestions. In section III.B.8.a, DOE discusses comments related to compliance burden. In sections III.B.8.b through III.B.8.d DOE summarizes the remaining comments by topic. In section III.B.8.e, DOE provides a response to the comments discussed in sections III.B.8.b through III.B.8.d.

a. Compliance Burden

Atlas Copco and Sullair objected to the inclusion of customized compressors due to the burden of compliance for these low-volume units and noted that the customer modifications affect efficiency. Atlas Copco suggested use of a de minimis exception for low-volume compressors that would exclude them from the test procedure and energy conservation standard. (Atlas Copco, No. 0054 at pp. 14-15; Sullair, No. 0056 at p. 7)

The DOE test procedure allows manufacturers to use a testing-based sampling plan or AEDMs to determine the performance of a compressor. Manufacturers can use AEDMs to model the performance of compressors with lower sales volumes based on compressors with higher sales volumes, thereby reducing the burden of testing. DOE discusses and estimates all costs related to compliance with this final rule in section IV.J.

b. Limited Data

Jenny Products commented that specialty equipment was not addressed in the energy conservation standards NOPR and that limited data is available for this equipment. (Jenny Products, No. 0058 at p. 2) Sullivan-Palatek argued that specialty compressors rarely publish data sheets, and as a result, that DOE's proposed energy conservation standards do not reflect the existence of specialized compressors. (Sullivan-

Palatek, No. 0051 at pp. 4-5; EERE-2014-BT-TP-0054, Sullivan-Palatek, Public Meeting Transcript, No. 0016 at p. 115; EERE-2014-BT-TP-0054, Sullivan-Palatek, No. 0007 at p. 2)

Similarly, Sullair commented that the data used to form the efficiency levels proposed by DOE does not contain data from custom units and will drop the overall efficiency of the compressor population. (Sullair, Public Meeting Transcript, No. 0044 at p. 49) Sullair stated that the options for customized compressors (which are more frequently larger air compressors over 200 hp) are modifications that impact the compressor package efficiency but are required by the customer for use in a specific application. (Sullair, No. 0056 at p. 6)

c. Inability to Reach Higher Efficiency Levels

Sullivan-Palatek objected to the inclusion of special, custom, or low-volume models in the scope of energy conservation standards. (Sullivan-Palatek, No. 0051 at p. 5) Sullivan-Palatek argued that the number of product classes is too limited to reflect the variety of compressed air products, leading to an oversimplified standard that could make specialty products illegal and thus limit the number of configurations that can be offered to customers for hazardous duty or special weather applications. (Sullivan-Palatek, No. 0051 at p. 4) Castair commented that the proposed regulations will limit the customization of compressors for unique applications, which primarily affects small businesses. (Castair, No. 0045 at p. 1; EERE-2014-BT-TP-0054, Castair, No. 0018 at p. 1)

d. Examples of Specialties

CAGI provided examples of specific specializations, such as hazardous locations, breathing air, marine environments, ambient conditions above 45 degrees C or below 0 degrees C, and weather protection. (CAGI, No. 0052 at p. 8; Docket No. EERE-2014-BT-TP-0054, CAGI, No. 0010, p. 4) Ingersoll Rand, Kaeser Compressors, Mattei Compressors, Sullair, and Sullivan-Palatek commented in support of CAGI's recommendations. (Ingersoll Rand, No. 0055 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullair, No. 0056 at p. 1; Sullivan-Palatek, No. 0051 at p. 1)

Sullair agreed with CAGI's recommendation and provided additional examples of custom requirements, such as hazardous locations or corrosive environments (such as standards set by Atmosphères Explosibles ["ATEX"]²⁶, the American Petroleum Institute ["API"], the Mine Safety and Health Administration ["MSHA"], etc.), marine environments (e.g., American Bureau of Shipping ["ABS"]), alternate cooling methods (remote coolers, water-cooled, closed-loop cooling, etc.), ambient conditions exceeding 45 °C, ambient conditions below 5 °C, energy or heat recovery options, environmental protections (such as standards set by the National Electrical Manufacturers Association ["NEMA"], the International Electrotechnical Commission ["IEC"], etc.), and dimensional changes or enclosure modifications. (Sullair, No. 0056 at p. 7; Docket No. EERE-2014-BT-TP-0054, Sullair, No. 0006 at p. 8) Sullair noted that sump heating, extra

²⁶ATEX is the common industry phrasing for European Parliament and Council Directive 2014/34/EU of 26 February 2014, which governs equipment and protective systems intended for use in potentially explosive atmospheres. The term "ATEX" is a portmanteau of "atmosphères explosibles", French for "explosive atmospheres."

fans, and special marine applications where motors have to be built for ABS applications may increase energy consumption of the package. (Docket No. EERE-2014-BT-TP-0054, Sullair, Public Meeting Transcript, No. 0016 at p. 113) DOE considered the suggested industry standards in evaluating whether a particular specialty application warranted exclusion from energy conservation standards, and discusses the details in section III.B.8.e.

Jenny Products provided examples of specialty applications, such as explosion-proof applications, weather-proof applications, dental applications, and climate-control applications. (Jenny Products, No. 0058 at p. 2)

Sullivan-Palatek commented that compressor products usually start with the basic package, but often substitute nonstandard electric motors, controls or coolers along with adding numerous other options and features specified by the customer or required by the location where the compressor is installed. (Docket No. EERE-2014-BT-TP-0054, Sullivan-Palatek, No. 0007 at p. 2)

Atlas Copco provided examples of custom equipment, including customized liquid cooling systems, drive systems, safety systems, filtration systems, dryers, heaters, and air receiver/surge tanks. Atlas Copco also noted that each type of customization can have a significant impact on the energy efficiency of the total compressor system. (Docket No. EERE-2014-BT-TP-0054, Atlas Copco, No. 0009 at pp. 4-5)

e. Response to Comments

As discussed in the test procedure final rule, DOE incorporates CAGI's recommended list of equipment (with certain modifications) to define the minimum testing configuration for a compressor basic model. Consequently, customized or specialty-purpose equipment that is created by adding additional equipment to what the industry refers to as a standard or basic package compressor, would be tested without the additional equipment, and achieve the same rating as the basic package compressor it was derived from. For this reason, DOE finds no reason to expressly exclude from scope, any compressors that are created by adding additional equipment to the basic testing configuration specified in the test procedure.

Based on DOE's interpretation of interested party comments, two additional concerns remain: (1) specialty-purpose equipment that is created by modifying or replacing equipment on a standard package compressor, and (2) specialty-purpose equipment that is not derivative of other standard equipment. However, DOE notes that interested parties did not provide specific examples of specialty-purpose compressors models (i.e., basic models) that have been distributed into commerce, nor did they provide any direct or quantitative evidence that such compressors consume more energy and are more burdensome to certify than their "general-purpose" counterparts (beyond noting that more models may need to be certified). Regardless, given the interested party concerns, DOE performed research (using interested party comments as a starting point) to determine if any additional scope exclusions are warranted. Specifically, DOE was able to identify 11 applications and feature categories that could possibly be used to characterize specialty-purpose compressors in the compressor industry:

- 1) Corrosive Environments
- 2) Hazardous Environments
- 3) Extreme Temperatures
- 4) Marine Environments
- 5) Weather-protected
- 6) Mining Environments
- 7) Military Applications
- 8) Food Service Applications
- 9) Medical Air Applications (including dental)
- 10) Climate-control Applications
- 11) Petroleum, Gas, and Chemical Applications

Given the concerns raised by commenters, DOE established three criteria to help determine if exclusions are warranted for each of the aforementioned applications and feature categories. A compressor category must meet all three criteria to be considered for exclusion. The criteria are distinguishability, consumer utility, and material disadvantage.

The first criterion, distinguishability, is that compressors under consideration must be able to be distinguished from general-purpose compressors. In this case, to be distinguishable extends beyond being able to identify any difference whatsoever. Specifically, distinguishability is determined in the context of the test procedure. DOE's test procedure final rule contains instructions regarding compressor configuration during

testing. During a test, only specific, enumerated ancillary equipment is required to be connected to the compressor; manufacturers may remove non-required ancillary equipment if they chose to do so. If the specialized nature of a compressor arises from a non-required component of ancillary equipment, manufacturers have the option to remove its influence on compressor performance. In that scenario, the specialty compressor, from the perspective of the test procedure, has “collapsed” to a general-purpose unit with no remaining distinction. In considering whether a compressor meets the distinguishability criterion, DOE will assess whether the specialized nature of the compressor arises from ancillary equipment or configurations that would vanish under the specific provisions of DOE’s test.

As stated previously, DOE is incorporating CAGI’s recommended list of equipment (with certain modifications), so the only specialty-purpose compressors that could warrant exclusion are (1) those that are created by modifying or replacing equipment on a standard package compressor, and (2) specialty-purpose equipment that is not derivative of other standard equipment.

The second criterion, consumer utility, is that the specialty compressor must offer clear and unique utility to the end-user. If the specialty compressor can be easily substituted for a general-purpose compressor without significant consequence, unique consumer utility is not supplied. The criterion is also important for ensuring that exclusion would not create a substitution incentive for consumers to switch to non-regulated specialty equipment, as a means to reduce first-cost.

The final criterion, material disadvantage, is that a manufacturer must face greater difficulty, in some regard, in increasing the efficiency of the specialty compressors in question relative to general-purpose compressors. For example, due to extra componentry required to serve a specialty application, a specialty compressor manufacturer may face greater obstacles to improving efficiency than would a general-purpose compressor manufacturer. Alternatively, a compressor may be able to achieve greater efficiency without trouble but create some disproportionate burden to manufacturers, for example in testing or demonstrating compliance.

DOE performed research, using publicly available data, on each of the categories to determine if exclusions are warranted. In the following paragraphs, DOE discusses findings for each of the aforementioned 11 specialty applications.

Corrosive Environments

Corrosive environments can be damaging to both the external components of a compressor and the internal components, if corrosive agents are ingested with the air. DOE's research indicated that corrosive agents are found in wide range of varieties and severities. Certain corrosive agents may harm some materials but not others.

Compressors may be adapted to corrosive environments by using special materials, having special coatings, using additional intake air filtration, or using special or remote enclosures to isolate the compressor from the corrosive environment. However, most requirements for corrosive environments are customer-specific, making it difficult to create a generalized scope exclusion. Some end users also use general-purpose

compressors in a corrosive environment, opting to replace the compressor at an earlier interval instead of purchasing a more expensive compressor that can last longer in the corrosive environment.

Based on this information, DOE does not believe that all corrosive environment compressors meet the first criterion of distinguishability; however certain corrosive environment compressors utilizing special materials and/or coatings may be distinguishable.

DOE did find that certain corrosive environment compressors meet the second criterion of consumer utility. Although some consumers opt to simply replace compressors more frequently, this may be impractical in locations for which frequent replacement is impractical (e.g., a remote location) or for which downtime is intolerable. Further, some corrosive agents may significantly accelerate wear. As a result, measures employed to avert corrosive agents or resist their effect can be said to grant utility.

DOE does not find that such compressors meet the third criterion of material disadvantage. DOE was unable to find evidence that most compressors suited to corrosive environments would generally face disproportionate difficulty in reaching the same efficiency levels as general-purpose compressors. Specifically, DOE was unable to find evidence that identifiable components, such as special materials and coatings, affect efficiency. As a result, DOE does not find sufficient evidence that compressors suited to corrosive environments face disproportionate difficulty in reaching the same efficiency levels as general-purpose compressors. Furthermore, DOE found no evidence suggesting

corrosive environment compressors would be subject to disproportionate burden in testing or demonstrating compliance.

Because corrosive environment compressors do not meet the criteria of distinguishability and material disadvantage, DOE does not exclude them from the scope of this final rule.

Hazardous Environments

Hazardous environments include those in which there is the possibility of combustion or explosion. Compressors may be adapted to hazardous environments through modified electrical components and enclosures that protect against sparks and high temperatures. At least some of these components would need to be included as part of the basic package during testing. Several standards specify the type and level of precautions required for these environments, so certification with one or more of these could be a method for defining the scope of exclusion.

For these reasons, DOE finds that hazardous environment compressors to meet the first criterion of distinguishability. Hazardous environment compressors in the United States are designated as such by independent agencies such as UL, and given a rating that corresponds to the specific attributes of the hazardous environment for which the unit is being certified. Independent agencies, such as UL, certify that compressors are suitable for hazardous environments against the National Electrical Code (“NEC”), which is the common term for the National Fire Protection Association using a system of classes, zones, and groups of hazardous materials for which the equipment is being rated safe.

DOE examined standards set by Atmosphères Explosibles [“ATEX”]²⁷, but found that this designation is predominantly used in the European market and largely overlaps, in terms of the information it conveys to the consumer, with the NFPA 70 rating system.

DOE also found that hazardous environment compressors meet the second criterion of consumer utility. Using non-explosion-safe equipment, in hazardous environments, can create profound risk to life and property.

However, DOE does not find that hazardous environment compressor meet the third criterion of material disadvantage. DOE was unable to find evidence that compressors suited to hazardous environments would face disproportionate difficulty in reaching the same efficiency levels as general-purpose compressors. DOE believes that the modified electrical components and enclosures used in hazardous environments have little impact on energy use. Additionally, DOE found no evidence suggesting hazardous environment compressors would be subject to disproportionate burden in testing or demonstrating compliance.

Because hazardous environment compressors do not meet the criterion of material disadvantage, DOE does not exclude them from the scope of this final rule.

²⁷ATEX is the common industry phrasing for European Parliament and Council Directive 2014/34/EU of 26 February 2014, which governs equipment and protective systems intended for use in potentially explosive atmospheres. The term “ATEX” is a portmanteau of “atmosphères explosibles”, French for “explosive atmospheres.”

Extreme Temperatures

CAGI and Sullair identified the need to exclude compressors used in extreme temperatures. (CAGI, No. 0010, p. 4; Sullair, No. 0006 at p. 8) For high extremes, both commenters identified temperatures above 45 °C. For low extremes, Sullair indicated temperatures below 5 °C, while CAGI indicated temperatures below 0 °C. DOE notes that CAGI and Sullair did not present any standardized tests or inspections that might be used to uniformly classify the acceptable temperature range for a compressor.

In the absence of that information, DOE performed research and found neither industry-accepted, standardized test methods to determine allowable operating temperature, nor any industry-accepted certification programs to classify compressors for extreme temperatures. DOE also researched what types of modification and components might be employed to adapt compressors for extremely high- and low-temperature environments. For lower temperatures, a variety of heating devices may be used to heat the compressor package in various ways – such equipment would not be required as a part of test procedure testing configuration and is, therefore, not a distinguishing feature.

In hotter environments, compressors may employ larger output air heat exchangers and associated fans. Unlike package heating and cooling, heat exchangers and fans would necessarily be part of the test configuration. However, manufacturers may employ larger heat exchangers and fans for a variety of reasons, e.g. recovering waste heat for use in space heating. Furthermore, heat exchanger and fan size (as compared to compressor capacity) is not a standardized feature across the compressor industry, with different manufacturers choosing different-sized components to meet their specific design

goals. Consequently, DOE is unable to establish a clear threshold to delineate larger heat exchangers and fans employed for high temperature applications. Furthermore, doing so would open a significant circumvention risk, as manufacturers could purposely substitute larger heat exchangers and fans in order to exclude compressors from regulation. For these reasons, DOE concludes that compressors designed for extreme temperature operation are not clearly distinguishable from general-purpose compressors.

Due to the difficulty in distinguishing compressors designed for extreme temperature operation from general-purpose compressors, DOE could not determine whether compressors designed for extreme temperature operation meet the second criterion of consumer utility, or the third criterion of material disadvantage. DOE adds that if a specialty purpose compressor fails to meet the first criterion of distinguishability, then it is unlikely that the specialty purpose compressor provides clear and unique utility to the end user that a general-purpose compressor would not provide. Similarly, if a specialty purpose compressor fails to meet the first criterion of distinguishability, then it is unlikely that the specialty purpose compressor has a material disadvantage compared to a general-purpose compressor. Consequently, DOE is unable to exclude these compressors from the scope of this final rule.

Marine Environments

Marine air compressors are intended for use aboard ships, offshore platforms, and similar environments. In general, DOE found this to be a very broad category of compressors. There are a wide variety of standards for these applications, but many of the requirements are customer-specific, making it difficult to clearly identify the scope for

exclusion. Marine compressors may be space constrained if installed on ships. However, this may not always be the case, and some marine environments may be able to utilize general-purpose compressors. Further, DOE found no way to distinguish clearly, from general-purpose compressors, those compressors specifically developed for constrained spaces. DOE's research found that other items, such as saltwater coolers, may be employed with marine air compressors, however, this equipment would not need to be included for testing. For these reasons, DOE does not find marine environment compressors to meet the first criterion of distinguishability.

Due to the difficulty in distinguishing marine environment compressors from general-purpose compressors, DOE could not determine whether marine environment compressors meet the second criterion of consumer utility, or the third criterion of material disadvantage. DOE adds that if a specialty purpose compressor fails to meet the first criterion of distinguishability, then it is unlikely that the specialty purpose compressor provides clear and unique utility to the end user that a general-purpose compressor would not provide. Similarly, if a specialty purpose compressor fails to meet the first criterion of distinguishability, then it is unlikely that the specialty purpose compressor has a material disadvantage compared to a general-purpose compressor. Because marine environment compressors do not meet the first criteria for consideration of exclusion, DOE does not exclude them from the scope of this final rule.

Weather-protected

Weather-protected compressors require features to prevent the ingress of water and debris, as well as accommodation for extreme temperatures in some cases. Design

accommodations related to extreme temperatures are discussed in that eponymous subsection of III.B.8.e and, therefore, the scope of this section is confined to those design accommodations related to aspects of weather-protection for reasons other than extreme temperature. DOE found that third-party standards exist for ingress protection of the electrical components. However, DOE could find no indication of a standard or certification for other aspects of weather protection, making it difficult to clearly identify a general scope for exclusion for all weather-protected equipment. However, DOE believes that certain weather-protected compressors (i.e., those with electrical components rated for ingress protection) meet the first criterion of distinguishability.

Similarly, DOE believes that certain weather-protected compressors (i.e., those with electrical components rated for ingress protection) meet the second criterion of consumer utility, as such equipment is designed to operate in environments where non-rated equipment cannot.

However, DOE does not find that weather-protected compressors meet the third criterion of material disadvantage. Most weather-protected compressors would generally not face disproportionate difficulty in reaching the same efficiency levels as general-purpose compressors. Some components added for weather protection, such as special electrical components, have little impact on energy use. As a result, DOE does not find evidence to suggest that weather-protected compressors face disproportionate difficulty in reaching the same efficiency levels as general-purpose compressors. DOE found no evidence suggesting weather-protected compressors would be subject to disproportionate burden in demonstrating compliance.

Because weather-protected compressors do not meet the third criteria for exclusion, DOE does not exclude them from the scope of this final rule.

Mining Environments

Mining environments can include both surface and subsurface mine compressor applications. There are some industry standards for these applications, for example those developed by the MSHA. However, DOE did not locate any which could be used to reliably designate compressors for mining environments. Furthermore, many of the design requirements for mining environment compressors are customer-specific, making it difficult to clearly identify the scope for exclusion. Some mining applications also use general-purpose compressors. For this reason, DOE does not find mining environment compressors to meet the first criterion of distinguishability. DOE was not able to determine that compressors for mining environments are always distinguishable from general-purpose compressors. There is no universally recognized designator.

Due to the difficulty in distinguishing mining environment compressors from general-purpose compressors, DOE could not determine whether mining environment compressors meet the second criterion of consumer utility, or the third criterion of material disadvantage. DOE adds that if a specialty purpose compressor fails to meet the first criterion of distinguishability, then it is unlikely that the specialty purpose compressor provides clear and unique utility to the end user that a general-purpose compressor would not provide. Similarly, if a specialty purpose compressor fails to meet the first criterion of distinguishability, then it is unlikely that the specialty purpose compressor has a material disadvantage compared to a general-purpose compressor.

Ultimately, because mining environment compressors do not meet the first criteria for consideration of exclusion, DOE does not exclude them from the scope of this final rule.

Military Applications

Compressors used in military applications have a wide range of applications. Many military applications use common commercial or industrial compressors. Other military applications, however, must meet extensive customer-specific requirements. These requirements can vary greatly with the customer, and there are no commonly used standards for compressors in military applications. This makes it difficult to clearly identify the scope for exclusion. For this reason, DOE does not find military compressors to meet the first criterion of distinguishability.

Due to the difficulty in distinguishing military compressors from general-purpose compressors, DOE could not determine whether military compressors meet the second criterion of consumer utility, or the third criterion of material disadvantage. DOE adds that if a specialty purpose compressor fails to meet the first criterion of distinguishability, then it is unlikely that the specialty purpose compressor provides clear and unique utility to the end user that a general-purpose compressor would not provide. Similarly, if a specialty purpose compressor fails to meet the first criterion of distinguishability, then it is unlikely that the specialty purpose compressor has a material disadvantage compared to a general-purpose compressor.

Ultimately, because military compressors do not meet the first criteria for consideration of exclusion, DOE does not exclude them from the scope of this final rule.

Food Service Applications

Food service applications can have requirements for air purity and for the use of food-grade lubricants. Food grade lubricants would need to be included for testing, so at least some compressors designed for food service applications would meet the first criterion of distinguishability.

DOE found that food service application compressors also met the second criterion of consumer utility. Without food grade lubricants, compressors would not be permitted to be used in food processing environments.

DOE does not find that food service application compressors meet the third criterion of material disadvantage. DOE found no evidence that food-grade lubricants, would impact efficiency. As a result, DOE does not find evidence to suggest that food service compressors face disproportionate difficulty in reaching the same efficiency levels as general-purpose compressors.

Because food service applications compressors do not meet the third criterion of material disadvantage, DOE does not exclude them from the scope of this final rule.

Medical Air Applications

Medical air applications can have requirements for air purity, which is rated according to ISO 8573-1,²⁸ and also included in the National Fire Protection Association Standard for Health Care Facilities (NFPA 99).²⁹ DOE notes that most medical air compressors are lubricant-free; as such, any lubricant-free medical air compressors are already excluded from this final rule. In lubricated compressors, high air purity is attained using a combination of filters and dryers added to the system after the compressor. These items are outside the basic compressor package, so a medical air compressor would collapse to a standard basic package for testing. For this reason, DOE does not find medical air application compressors to meet the first criterion of distinguishability.

Due to the difficulty in distinguishing medical air compressors from general-purpose compressors, DOE could not determine whether medical air compressors meet the second criterion of consumer utility, or the third criterion of material disadvantage. DOE adds that if a specialty purpose compressor fails to meet the first criterion of distinguishability, then it is unlikely that the specialty purpose compressor provides clear and unique utility to the end user that a general-purpose compressor would not provide. Similarly, if a specialty purpose compressor fails to meet the first criterion of distinguishability, then it is unlikely that the specialty purpose compressor has a material disadvantage compared to a general-purpose compressor.

²⁸ See: www.iso.org/iso/catalogue_detail.htm?csnumber=46418

²⁹ See: www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards?mode=code&code=99

Ultimately, because medical air compressors do not meet the first criteria for consideration of exclusion, DOE does not exclude them from the scope of this final rule.

Climate-control Applications

As noted in section III.B.8.d, Jenny Compressors argued that DOE should exclude climate control compressors. (Jenny Products, No. 0058 at p. 2) DOE reviewed available information for climate-control compressors and found that the most commonly advertised unique feature was an “oil carryover” of less than or equal to 2 parts per million (“ppm”).³⁰ DOE knows of one established standard for measurement of air purity, ISO 8573-1³¹. However, this standard expresses oil content using mg/m³, and would require conversion to ppm.

DOE reviewed compressors that are currently available for sale and marketed for climate-control applications. DOE found that all compressors currently listed as being for “climate-control” are reciprocating compressors. Because reciprocating compressors are not within the scope of this energy conservation standards rulemaking, DOE finds no reason to exclude climate-control compressors from this rulemaking.

³⁰ Gardner Denver: www.gardnerdenver.com/gdproducts/compressors/reciprocating/climate-control-low-pressure-reciprocating-compressors/#9816

Quincy: www.aavsales.com/pdfs/ClimateControl-Quincy.pdf

Champion: www.championpneumatic.com/assets/0/176/184/468/488/6ffe83-bd76-463c-9ebb-bce58e1489d7.pdf

CPR: www.cprindustries.com/climate-control-compressors.html

³¹ See: www.iso.org/iso/catalogue_detail.htm?csnumber=46418

Petroleum, Gas, and Chemical Applications

The American Petroleum Institute standard 619, “Rotary-Type Positive-Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries,” (API 619)³² specifies certain minimum requirements for compressors used in the petroleum, gas, and chemical industry. While API 619 contains many specific design requirements, it also indicates that customers must specify many design requirements themselves. As a result, compressors designed to meet API 619 requirements are not uniform; rather, they are, by definition, customized compressors. In addition to the design requirements, API 619 imposes rigorous testing, data reporting, and data retention requirements on manufacturers. For example, manufacturers are required to perform specific hydrostatic and operational mechanical vibration testing on each individual unit distributed in commerce. Furthermore, manufacturers must retain certain data for at least 20 years, such as certification of materials, test data and results, records of all heat treatment, results of quality control tests and inspections, and details of all repairs. Based on these testing, data reporting, and data retention requirements, DOE concludes that compressors designed and tested to the requirements of API 619 meet the first criterion of distinguishability. Specifically, DOE concludes that any manufacturer claiming a potential exclusion from energy conservation standards would be able to furnish test data proving that the compressor was designed and tested to API 619 (and associated customer-specific) requirements.

³² Available for purchase at: www.techstreet.com/standards/api-std-619?product_id=1757746

Based on DOE's assessment of API 619, DOE believes that the minimum design and testing requirements specified in API 619 are created to achieve, among other goals, safety and reliability in the petroleum, gas, and chemical industry. These requirements ensure that the compressor can be operated and maintained safely, in the safety-critical petroleum, gas, and chemical industry. Consequently, DOE concludes that compressors tested to, and meeting minimum design requirements of API 619 provide additional consumer utility.

At this time, DOE has insufficient evidence to conclusively determine if compressors meeting the minimum design and testing requirements specified in API 619 are at a material disadvantage, with respect to achievable compressors efficiency. However, given the role of API 619 in ensuring operational safety in the petroleum, gas, and chemical industry, DOE believes it is appropriate to exclude from the scope of energy conservation standards compressors meeting the minimum design and testing requirements specified in API 619. In other words, DOE finds that including compressors meeting the minimum design and testing requirements specified in API 619 may have adverse impacts on health or safety.

Furthermore, DOE believes that excluding compressors meeting the minimum design and testing requirements specified in API 619 will not create an appreciable risk of API 619 compressors being used in general purpose applications, due to the rigorous and burdensome requirements associated with complying with API 619. DOE may request that a manufacturer provide DOE with copies of the original design and test data

that were submitted in accordance with the requirements of API 619 as evidence that the compressor is designed and tested to API 619.

C. Test Procedure and Metric

This section discusses DOE's requirements with respect to test procedures and summarizes the test procedure for compressors adopted by DOE. EPCA sets forth generally applicable criteria and procedures for DOE's adoption and amendment of test procedures. (42 U.S.C. 6314) Manufacturers of covered equipment must use these test procedures to certify to DOE that their equipment complies with energy conservation standards and to quantify the efficiency of their equipment. (42 U.S.C 6295(s), 6316(a) and 6314(d)).

On May 5, 2016, DOE issued a notice of proposed rulemaking, to propose test procedures for certain compressors. 87 FR 27220. On June 20, 2016, DOE held a public meeting to discuss the test procedure NOPR and accept comments from interested parties. In December 2016, DOE issued a test procedure Final Rule, which establishes definitions, materials incorporated by reference, and test procedures for determining the energy efficiency of certain varieties of compressors in subpart T of Title 10 of the Code of Federal Regulations, Part 431 (10 CFR Part 431). The test procedure Final Rule also amends Title 10 CFR 429 to establish sampling plans, representations requirements, and enforcement provisions for certain compressors.

In the test procedure final rule, DOE prescribes a test procedure for measuring the full- and part-load package isentropic efficiency for certain varieties of rotary

compressors. The test procedure final rule is applicable to compressors that meet the following criteria:

- are air compressors;
- are rotary compressors;
- are not liquid ring compressors;
- are driven by a brushless electric motor;
- are lubricated compressors;
- have a full-load operating pressure of 75–200 psig;
- are not designed and tested to the requirements of The American Petroleum Institute standard 619, “Rotary-Type Positive-Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries;” and
- have a capacity that is either:
 - 10–200 compressor motor nominal horsepower (hp), or
 - 35–1,250 full-load actual volume flow rate (cfm).

For those applicable varieties of compressors, DOE prescribes methods to measure and calculate part- and full-load package isentropic efficiency by incorporating by reference sections of ISO 1217:2009(E), (ISO 1217:2009(E)), “Displacement compressors – Acceptance tests,” as amended through ISO 1217:2009(E)/Amd.1:2016.³³

³³ ISO 1217:2009(E)/Amd.1:2016 is titled “Calculation of isentropic efficiency and relationship with specific energy.”

DOE also provides additional testing instructions not included in ISO 1217:2009(E) in the test procedure final rule.

Full-load package isentropic efficiency is applicable to fixed-speed compressors, and calculated per section 3.6.1 of ISO 1217:2009(E). It is the ratio of isentropic power required for compression to real packaged compressor power input (both at full-load operating pressure and full-load actual volume flow rate). The test procedure final rule provides complete instructions on measuring and calculating each of these variables.

Part-load package isentropic efficiency is applicable to variable-speed compressors, and calculated as the weighted average of package isentropic efficiency at three reference load points 100-, 70-, and 40-percent of full-load actual volume flow rate). Package isentropic efficiency at each of these load points is calculated in a similar manner to full-load package isentropic efficiency, and the test procedure final rule provides complete instructions on all measurements and calculations needed for determining part-load package isentropic efficiency.

The test procedure final rule also contains specific methods to determine the full-load actual volume flow rate and full-load operating pressure of a compressor, both of which are necessary to test a compressor model and determine the applicable energy conservation standard for certain varieties of compressors in a repeatable way.

D. Impacts of Sampling Plan on Energy Conservation Standards Analysis

DOE defines, as part of the test procedure for compressors, the sampling requirements in part 429 of Chapter II, subchapter D of Title 10, Code of Federal Regulations. In accordance with section 429.63, manufacturers must determine the represented rating for each basic compressor model either by testing in conjunction with the applicable sampling provisions or by applying an AEDM. If the represented value is determined through testing, manufacturers must use a sample of not less than two units and any represented value of the full- or part-load package isentropic efficiency of a basic model must be calculated as the lower of (1) the mean of the test sample, and (2) the lower 95 percent confidence limit (“LCL”) divided by 0.95. DOE also establishes that package specific power, full-load actual volume flow rate, full-load operating pressure, and pressure ratio at full-load operating pressure must be represented as the mean of the test sample.

In the energy conservation standards NOPR, DOE directly calculated the full- or part-load isentropic efficiency of each compressor using values reported in the CAGI Performance Verification Program data sheets.³⁴ Ultimately, DOE used this performance data to establish efficiency levels for each equipment class. DOE assumed that the compressor performance data published as part of the CAGI Performance Verification Program represented the population mean for each compressor model.

³⁴ CAGI Performance Verification Program data sheets are discussed in section IV.C.1.a.

DOE received many comments from interested parties that were concerned that the data used to develop efficiency levels and ultimately propose energy conservation standards was not reflective of the sampling plan adopted in the test procedure final rule. Specifically, CAGI, Ingersoll Rand, and Sullivan-Palatek commented that the efficiency levels proposed by DOE do not consider the certification sampling plan proposed in the test procedure, stating that the use of the 95-percent lower confidence limit would result in a more conservative rating than what is currently represented on CAGI Performance Verification Program Data sheets. Commenters argued that DOE must adjust standard level, because the proposed standard level did not consider the impact of the sampling plan. (EERE-2014-BT-TP-0054, CAGI, No. 0010 at pp. 14, 15; Ingersoll Rand, No. 0055 at p. 2; EERE-2014-BT-TP-0054, Ingersoll Rand, No. 0011 at p. 2; Ingersoll Rand, Public Meeting Transcript, No. 0044 at p. 57; EERE-2014-BT-TP-0054, Ingersoll Rand, Public Meeting Transcript, No. 0016 at pp. 121-2; Sullivan-Palatek, No. 0051 at p. 4; EERE-2014-BT-TP-0054, Sullivan-Palatek, No. 0007 at pp. 2, 4) Sullair supported CAGI's comments regarding sampling. (EERE-2014-BT-TP-0054, Sullair, No. 0006 at p. 1) Sullivan-Palatek further commented that the proposed standards, if left without adjustment, place an extra level of performance above and beyond that required by the proposed standard. (EERE-2014-BT-TP-0054, Sullivan-Palatek, No. 0007 at p. 4)

DOE agrees with comments made by CAGI, Ingersoll Rand, Sullair, and Sullivan-Palatek that the industry's approach to testing in accordance with ISO 1217:2009 does not have the sampling and certification requirements that DOE adopts in the test procedure final rule. Further, DOE acknowledges that the data used to develop the efficiency levels presented in the energy conservation standards NOPR,

predominantly collected from publicly available data published in accordance with the CAGI Performance Verification Program, was not assessed for, or adjusted to account for, potential impacts of the test procedure sampling plan.

At the June 20, 2016 test procedure public meeting, DOE requested information regarding the process that manufacturers currently use to rate compressors. (EERE-2014-BT-TP-0054, DOE, Public Meeting Transcript, No. 0016 at pp. 42-43). DOE received feedback from Ingersoll Rand, Sullair, and Sullivan-Palatek indicating that they use a combination of test data and calculations. (EERE-2014-BT-TP-0054, Ingersoll Rand, Public Meeting Transcript, No. 0016 at pp. 44-45; EERE-2014-BT-TP-0054, Sullair, Public Meeting Transcript, No. 0016 at p. 43; EERE-2014-BT-TP-0054, Sullivan-Palatek, Public Meeting Transcript, No. 0016 at p. 44) However, DOE did not receive any specific performance test data or specific information on unit-to-unit variability, nor did DOE receive specific information on how a manufacturer arrives at a compressor rating (i.e., the sample mean of tested compressor).

In written comments, DOE did receive general information on the topic. Specifically, Ingersoll Rand noted that ISO 1217:2009(E) is designed to provide values closer to the population's "true mean," whereas DOE's proposed sampling plan is designed to give conservative results. (Ingersoll Rand, No. 0055 at p. 2) Similarly, CAGI stated that for any given basic compressor package model, one can expect there will be a distribution of efficiency around the "true mean" of the population. (EERE-2014-BT-TP-0054, CAGI, No. 0010 at pp. 12-13) Further, CAGI stated that they believe that current manufacturer rating programs are designed to provide values that are closer to the

population's "true mean" than does DOE's proposal. (EERE-2014-BT-TP-0054, CAGI, No. 0010 at p. 14)

Regarding the distribution of the test results, Ingersoll Rand and Sullivan-Palatek commented that the data used to form the efficiency levels proposed by DOE is reflective of a 5-percent enforcement tolerance under the CAGI Performance Verification Program. (Ingersoll Rand, No. 0055 at p. 2; Sullivan-Palatek, No. 0051 at p. 4; Sullivan-Palatek, Public Meeting Transcript, No. 0044 at p. 106) DOE interprets the 5-percent enforcement tolerance referred to by Ingersoll Rand and Sullivan-Palatek to reflect the 5-percent allowable variation in specific power allowed per Table C.2 of Annex C of ISO 1217:2009(E) for actual volume flow rates exceeding 0.250 cubic meters per second. DOE further assumes that this tolerance represents the bounds of the distribution of specific power for ISO 1217:2009(E).

To evaluate the effect of DOE's sampling plan in the test procedure final rule, DOE would prefer to have used the source data recorded in accordance with ISO 1217:2009(E) and directly calculate the certified value of full- or part-load isentropic efficiency for each compressor to develop the efficiency levels for each compressors as specified in the DOE test procedure. In the absence of source data, DOE would prefer to capture the variability of the CAGI Performance Verification Program data with detailed information of representative unit-to-unit variability. Unfortunately, DOE did not receive compressor test data with which DOE could directly calculate the certified full- or part-load isentropic efficiency (i.e., DOE does not have multiple tested values for each compressor basic model).

In the absence of receiving full test data or a detailed description of testing variability, DOE uses the feedback from manufacturers regarding the CAGI Performance Verification Program data to conduct a statistical analysis to assess the impact of the sampling plan in the test procedure final rule on package isentropic efficiency ratings. Specifically, DOE employs a Monte Carlo simulation of compressor ratings using Oracle Crystal Ball. A Monte Carlo simulation is a series of randomized trials that, after many repetitions, converges on a solution with a distribution of results. The resulting solution of a Monte Carlo analysis reflects the interactions between known “input” distributions; for the purposes of this analysis, the Monte Carlo analysis reflects the interaction between the distribution of specific power for each compressor, the known sampling plan in the compressors test procedure, and the resulting compressor package isentropic efficiency rating. The simulation calculates the full- or part-load package isentropic efficiency of each compressor by using the value of actual volume flow rate and compressor discharge pressure from the updated CAGI database along with the value of specific power (according to the assumed distribution of specific power) for each compressor in the test sample. From there, the simulation selects the lower of the (1) sample mean or (2) 95 percent LCL of the sample divided by 0.95 for each compressor basic model and stores the value as the “simulated” value of compressor full- or part-load isentropic efficiency for each trial. In addition, the Monte Carlo analysis stores the difference between the “simulated” and calculated mean-value³⁵ of full- or part-load isentropic efficiency for each compressor in the DOE database, for each trial. DOE calculates statistics on the

³⁵ The calculated mean value of full- or part-load isentropic efficiency is derived by direct calculations from reported values on the CAGI Performance Verification Program data sheets. As noted by manufacturer comments, the specific power of a compressor is assumed to represent the “true mean” or “population mean” of the represented compressor model.

simulation data to understand the likelihood and magnitude of a change in compressor rating under the DOE sampling and certification plan. Additional details of the calculations in the Monte Carlo simulation and a more comprehensive results section is in Chapter 5 of the TSD.

To construct a Monte Carlo simulation with the goal of understanding the impacts of the sampling plan on full- and part-load isentropic efficiency, DOE makes assumptions regarding the mean and statistical variation of specific power. As noted previously, DOE received information that the specific power data represented as a part of CAGI Performance Verification Program is representative of the “true mean” of a compressor model’s performance. As such, in the Monte Carlo model, DOE assumes that the specific power values represented on CAGI performance verification data sheets represent the population mean.

DOE also recognizes that the CAGI Performance Verification Program guarantees that the tested specific power performance of any participating compressor will be within the bounds of Table III.1.³⁶ Therefore, DOE assumes that the range of compressor specific power variation mirror the bounds of variation defined in Table III.1.³⁶

³⁶ International Organization for Standardization (ISO), ISO 1217 (E), Displacement compressors—Acceptance tests, International Organization for Standardization (ISO), 2009, Annex H, Table H.3.

Table III.1 Permissible Deviation of Specific Power and Isentropic Efficiency During Customer Acceptance Test for Electrically Driven Packaged Displacement Compressors*

| Volume Flow Rate at Specified Conditions* (m ³ /s)*10 ⁻³ | Specific Power Tolerances % | |
|---|--------------------------------|-------------|
| | Upper Limit | Lower Limit |
| 0 < v ≤ 8.3 | +8 | -8 |
| 8.3 < v ≤ 25 | +7 | -7 |
| 25 < v ≤ 250 | +6 | -6 |
| v > 250 | +5 | -5 |

* The column titles were edited from the source document for clarity.

With the mean and range of the test sample established, DOE needed to assume a statistical distribution centered about the mean and bounded by the allowable tolerance in Table III.1. DOE considered multiple distributions which could characterize tested compressor specific power. Specifically, DOE considered two general distributions: (1) a uniform distribution which assumed equal probability of values between the lower and upper limit of specific power variation as defined in Table III.1, and (2) a normal distribution.

Per Table C.2 of Annex C of ISO 1217:2009(E), the rationale for establishing a tolerance for specific power is to account for variation due to manufacturing and measurement tolerances. DOE interprets the statement to mean that the specific power tolerance accounts for unit-to-unit performance differences due to manufacturing tolerances as well as the inherent repeatability of the ISO 1217:2009(E) test procedure. A

literature review conducted by DOE found that a uniform probability distribution, which has an equal probability of values between the lower and upper tolerance, does not commonly represent distributions that have continuous outcomes (such as specific power). Alternatively, literature states that of the commonly occurring probability distributions, a normal distribution is the most appropriate choice to represent the probability of a continuous outcome that is a function of the interaction between random and independent variables.³⁷ Because the CAGI Performance Verification Program guarantees that performance and specific power is a function of random and independent variables, including manufacturing tolerances and test to test variation, it is much more likely that a normal probability distribution is the most representative of compressor specific power. For these reasons, a normal distribution is most appropriate to represent the unit-to-unit variability of compressor specific power. However, DOE explores the impact of this assumption as part of the sensitivity analysis and concludes that the assumption of a normal or uniform distribution, by itself, did not have an impact on the conclusion drawn from the analysis. A complete discussion of the sensitivity analysis can be found at the conclusion of this section.

With the distribution type selected, DOE then considered the standard deviation of the distribution. As previously stated, Table III.1 represents the allowable “enforcement tolerance” that CAGI uses as part of the Performance Verification Program. Because the CAGI Performance Verification Program guarantees performance within these tolerances, DOE concludes that, for all compressors that participate in this

³⁷ Tennett, Geoff. *Six Sigma: SPC and TQM in Manufacturing and Services*. 2001. Gower Publishing Company: Burlington, VT.

program, each unit distributed in commerce should achieve performance within these tolerances. Consequently, DOE assumes that the tolerance range specified in Table III.1 represents a range of plus or minus three standard deviations from the mean; i.e., 99.7-percent of test units will fall within that range specified in Table III.1. Functionally, this translates to a standard deviation of compressor specific power that represented one-third of the tolerance listed in Table III.1. As an example, if the tolerance for a compressor's represented specific power is ± 6 -percent, the standard deviation for the distribution of specific power for that compressor would be 2-percent of the compressor's specific power.

With DOE's establishing assumptions for the distribution of compressor specific power in the Monte Carlo simulation, the last remaining assumption is the number of units in the test sample to certify the full- and part-load isentropic efficiency for a compressor basic model. The test procedure final rule specifies a minimum sample size of two compressors is necessary to certify the full- or part-load isentropic efficiency of a basic model; there is no upper limit to the number of units that can be tested. DOE assumes that a manufacturer would test more than two units if the calculated full- or part-load isentropic efficiency (according to the sample plan) does not meet the expectations of the manufacturer. DOE recognizes that there is a practical limit to the number of units that can be tested and assumes that four units of each basic model are tested in the simulation, to calculate the full- and part-load package isentropic efficiency of the compressor. DOE explores the impact of this assumption as part of the sensitivity analysis and concludes that the assumption of testing three or four units, by itself, does

not have an impact on the results of the analysis. A complete discussion of the sensitivity analysis is in the conclusion of this section.³⁸

Based on the results of the Monte Carlo, DOE does not expect that, on average, the sampling plan will result in a lower certified full- or part-load package isentropic efficiency values, in comparison to the value calculated from the CAGI Performance Verification Program data sheets. Put differently, for each iteration of the Monte Carlo simulation, given a random sample of four units, the mean of the sample is nearly always lower than the 95th lower confidence interval divided by 0.95.

DOE also conducted a sensitivity analysis to understand the impact of two key assumptions: the number of units tested to certify the full- and part-load isentropic efficiency and the assumed shape of the specific power distribution. Specifically, DOE adjusted the number of units in the Monte Carlo analysis to reflect a sample size of three units and adjusted the distribution of compressor specific power to represent a uniform distribution. A uniform distribution is the most conservative assumption for the distribution of specific power; it provides an equal probability of a specific power value between the tolerance range permitted in Table III.1. The results of the sensitivity analysis for fixed-speed compressors and variable-speed compressors, expressed as the average change in certified rating (difference between the calculated and simulated mean-value), in points of efficiency, are in Table III.2 and Table III.3, respectively.

³⁸ The cost of testing four units to certify the full- or part-load package isentropic efficiency is accounted for in the Manufacturer Impact Analysis, section IV.J.2.c.

Table III.2 Sensitivity Analysis Results for Fixed-Speed Compressors: Average Change in Compressor Full- or Part-Load Package Isentropic Efficiency Rating

| Number of Units in Sample | Uniform Distribution of Specific Power | Normal Distribution of Specific Power |
|---------------------------|--|---------------------------------------|
| 3 | -0.7 Points | 0.0 Points |
| 4 | 0.0 Points | 0.0 Points |

Table III.3 Sensitivity Analysis Results for Variable-Speed Compressors: Average Change in Compressor Full- or Part-Load Package Isentropic Efficiency Rating

| Number of Units in Sample | Uniform Distribution of Specific Power | Normal Distribution of Specific Power |
|---------------------------|--|---------------------------------------|
| 3 | -0.7 points | 0.0 points |
| 4 | 0.0 points | 0.0 points |

Based on the results of the analysis, DOE expects that, for compressors participating in the CAGI Performance Verification Program and abiding by the tolerance in Table III.1, the sampling plan established in the test procedure will result in certified package isentropic efficiency values that represents the sample mean. Further, DOE reiterates that in the absence of test data or detailed information from manufacturers, a normal distribution best represents the unit-to-unit variability among compressors; however, the analysis shows that this assumption had little influence on the results of the sampling plan analysis. Additionally, DOE found that the results of the analysis are not sensitive to the assumption of testing four units, as the same conclusion is reached with a sample size of three units. Therefore, DOE concludes that while the assumptions that DOE made are grounded in reasoned logic and research, the results would be the same with a more conservative set of assumptions. For all of the reasons discussed in this

section, DOE concludes that no adjustments are necessary to the efficiency levels presented in the energy conservation standards NOPR.

E. Compliance Date

DOE has determined that any standards established by this rule will apply to compressors manufactured 5 years after the date on which any standard is published.³⁹ Therefore, the compliance date of this rule is [insert five years from publication date in the Federal Register].

F. 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. DOE then determines which of those means for improving efficiency are technologically feasible. DOE considers technologies

³⁹ EPCA specifies that the provisions of subsections (l) through (s) of section 42 U.S.C 6295 shall apply to any other type of industrial equipment which the Secretary classifies as covered equipment, which includes compressors. (42 U.S.C. 6316(a)) 42 U.S.C 6295(l)(2) states that any new or amended standard for any other type of consumer product which the Secretary classifies as a covered product shall not apply to products manufactured within five years after the publication of a final rule establishing such standard. This 5-year lead time also applies to other types of industrial equipment, such as compressors.

incorporated in commercially available products 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 product 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) Additionally, it is DOE policy not to include in its analysis any proprietary technology that is a unique pathway to achieving a certain efficiency level. Section IV.B of this notice discusses the results of the screening analysis for compressors, particularly the designs DOE considered, those it screened out, and those that are the basis for the standards considered in this rulemaking. For further details on the screening analysis for this rulemaking, see chapter 4 of the final rule TSD.

2. Maximum Technologically Feasible Levels

When DOE adopts a new or amended standard for a type or class of covered equipment, it must determine the maximum improvement in energy efficiency or maximum reduction in energy use that is technologically feasible for such product. (42 U.S.C. 6295(p)(1) and 6316(a)) Accordingly, in the engineering analysis, DOE determined the maximum technologically feasible (“max-tech”) improvements in energy efficiency for compressors, using the design parameters for the most efficient products available on the market or in working prototypes. The max-tech levels that DOE

determined for this rulemaking are described in section IV.C.5.b of this final rule and in chapter 5 of the final rule TSD.

G. Energy Savings

1. Determination of Savings

For each trial standard level (“TSL”), DOE projected energy savings from application of the TSL to compressors purchased in the 30-year period that begins in the first full year of compliance with the standards (2022–2051).⁴⁰ The savings are measured over the entire lifetime of products purchased in the 30-year analysis period. 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 product would likely evolve in the absence of energy conservation standards.

DOE used its national impact analysis spreadsheet models to estimate national energy savings (“NES”) from potential standards for compressors. The NIA spreadsheet model (described in section IV.H of this rule) calculates energy savings in terms of site energy, which is the energy directly consumed by products at the locations where they are used. For electricity, DOE reports national energy savings in terms of primary energy savings, which is the savings in the energy that is used to generate and transmit the site electricity. For natural gas, the primary energy savings are considered to be equal to the site energy savings. DOE also calculates NES in terms of full-fuel-cycle (“FFC”) energy

⁴⁰ DOE also presents a sensitivity analysis that considers impacts for products shipped in a 9-year period.

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.⁴¹ 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.2 of this notice.

2. Significance of Savings

To adopt any new or amended standards for a covered product, DOE must determine that such action would result in significant conservation of energy. (42 U.S.C. 6295(o)(3)(B) and 6316(a)) Although the term "significant" is not defined in the Act, the U.S. Court of Appeals, for the District of Columbia Circuit 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 are not "genuinely trivial." The energy savings for all the TSLs considered in this rulemaking, including the adopted standards, resulting in positive net benefits to the Nation, and are nontrivial, and, therefore, DOE considers them "significant" within the meaning of 42 U.S.C. 6295(o)(3)(B).

⁴¹ 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 (Aug. 17, 2012)

H. Economic Justification

1. Specific Criteria

As noted above, EPCA provides seven factors to evaluate in determining whether a potential energy conservation standard is economically justified. (42 U.S.C. 6295(o)(2)(B)(i)(I)-(VII) and 6316(a)) The following sections discuss how DOE has addressed each of those seven factors in this rulemaking.

a. Economic Impact on Manufacturers and Consumers

In determining the impacts of potential standards on manufacturers, DOE conducts a manufacturer impact analysis (“MIA”), as discussed in section IV.J. 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 a 30-year period. The industrywide impacts analyzed include (1) industry net present value (INPV), which values the industry based on 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 types 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 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 product 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. 6295(o)(2)(B)(i)(II) and 6316(a)) DOE conducts this comparison in its LCC and PBP analyses.

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 product. The LCC analysis requires a variety of inputs, such as product prices, product energy consumption, energy prices, maintenance and repair costs, product lifetime, and discount rates appropriate for consumers. To account for uncertainty and variability in specific inputs, such as product 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 consumers to recover the increased purchase cost (including installation) of a more efficient product 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 analyses, DOE assumes that consumers will purchase the covered products in the first full year of compliance with new standards. The LCC savings for the considered efficiency levels are calculated relative to the case that reflects projected market trends in the absence of new standards. DOE's LCC and PBP analyses are discussed in further detail in section IV.F.

c. Energy Savings

Although 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. 6295(o)(2)(B)(i)(III) and 6316(a)) As discussed in section IV.H, DOE uses the NIA spreadsheet models to project national energy savings.

d. Lessening of Utility or Performance of Products

In establishing product 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 products. (42 U.S.C. 6295(o)(2)(B)(i)(IV) and 6316) Based on data available to DOE, the standards adopted in this final rule would not reduce the utility or performance of the products subject to 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 standard. (42 U.S.C. 6295(o)(2)(B)(i)(V) and 6316(a)) It also directs the Attorney General to determine the impact, if any, of any lessening of competition likely to result from a standard and to transmit such determination 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. (42 U.S.C. 6295(o)(2)(B)(ii) and 6316(a)) To assist the Department of Justice (“DOJ”) in making such a determination, DOE transmitted copies of its proposed rule and the NOPR TSD to the Attorney General for review, with a request that the DOJ provide its determination on this issue. In its assessment letter responding to DOE, DOJ concluded that the proposed energy conservation standards for compressors are unlikely to have a significant adverse impact on competition. DOE is publishing the Attorney General’s assessment at the end of this final rule.

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. 6295(o)(2)(B)(i)(VI) and 6316(a)) The energy savings from the adopted standards 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 greenhouse gases (“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.8 of this notice. DOE also estimates the economic value of emissions reductions resulting from the considered TSLs, as discussed in section IV.L.

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. 6295(o)(2)(B)(i)(VII) and 6316(a)) To the extent interested parties submit any relevant information regarding economic justification that does not fit into the other categories described above, DOE could consider such information under “other factors.”

2. Rebuttable Presumption

As set forth in 42 U.S.C. 6295(o)(2)(B)(iii) and 6316(a), EPCA creates a rebuttable presumption that an energy conservation standard is economically justified if the additional cost to the consumer of a product 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. DOE’s LCC and PBP analyses

generate values used to calculate the effect potential new or 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 6316(a). 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 final rule.

I. Other Issues

1. Comments on the Proposed Standards

In the energy conservation standards NOPR, DOE proposed to establish energy conservation standards at TSL 2. However, DOE also noted that it was strongly considering TSL 3 due to its greater net benefits. 81 FR 31680 at 31683 (May 19, 2016). DOE received numerous, generalized comments related to its proposal; these comments are summarized in this section. All comments related to DOE's analyses and specific technical proposal are located in the appropriate subsections of sections III and IV.

a. Recommended Energy Conservation Standard Level

Ingersoll Rand supported TSL 2 and noted that the proposed standard level struck an appropriate balance between a more energy efficient marketplace and the increase in associated costs, leading to an economically justified rulemaking that maximizes

consumer benefits. (Ingersoll Rand, No. 0055 at pp. 2-3) Similarly, CAGI and Sullair commented that they support TSL 2, provided that DOE make adjustments to the standard that reflect CAGI's and Sullair's comments. (Sullair, No. 0056 at pp. 5-6; CAGI, No. 0052 at p. 3)

CAGI also stipulated that it would support TSL 2, provided that the trial standard level is technically feasible and economically justified after accounting for CAGI's other suggestions as well as the impact of the test procedure on assumed product compliance. (CAGI, No. 0052 at p. 3) Kaeser Compressors, Mattei Compressors, Sullair, and Sullivan-Palatek commented in support of CAGI's recommendations. (Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullair, No. 0056 at p. 1; Sullivan-Palatek, No. 0051 at p. 1)

The CA IOUs commented that they support TSL 2, but suggest that DOE adopt TSL 3 due to the higher benefits associated with TSL 3, such as increased energy savings, a simple payback period of 4.1 years or less for each equipment class, and reduced CO₂ emissions that assist California with meeting state greenhouse gas emissions goals. (CA IOUs, No. 0059 at pp. 1-2)

ASAP, ACEEE, NEEA, NRDC, NEEP, and ASE commented that they support TSL 3, noting that TSL 3 offered increased energy savings, increased NPV for consumers, and reduced CO₂ emissions when compared to TSL 2. (ASAP, ACEEE, NEEA, NRDC, NEEP, ASE, No. 0060 at pp. 1-2)

The CA IOUs, ASAP, ACEEE, NEEA, NRDC, NEEP, NWPCC, and ASE all commented that TSL 3 aligned closely with EU regulation, which consequently reduces the burden on manufacturers to comply with two standards when selling their products globally. (CA IOUs, No. 0059 at pp. 1-2; ASAP, ACEEE, NEEA, NRDC, NEEP, ASE, No. 0060 at pp. 1-2; NEEA and NWPCC, No. 0057 at p. 3)

Sullivan-Palatek commented that TSL 3 is an aggressive approach to setting initial conservation standards and suggested that DOE collect test data and observe the program prior to adopting a higher standard than TSL 2. (Sullivan-Palatek, No. 0051 at p. 5) Similarly, Ingersoll Rand did not support standards at TSL 3 and stated that standards at TSL 3 are not economically justified. (Ingersoll Rand, No. 0055 at pp. 2-3)

DOE discusses respective benefits and burdens of each TSL and, ultimately, presents reasoning for the TSL adopted as a standard in section V.C. DOE takes into consideration all of the factors mentioned by commenters, including consumer benefits, impacts to manufacturers, emissions reductions, and the benefits of harmonizing with the European Union.

Castair opposed standards at TSL 2. First Castair argued that electric motors are already subject to energy conservation standards and thus compressors do not need to be further regulated. Second, Castair commented that the compressor industry competes on the basis of efficiency, and therefore efficiency standards are not necessary. (Castair, No. 0062 at p. 2) Similarly, Jenny Products commented that more efficient compressors are

commercially available for all proposed equipment classes, which negates the need for an energy conservation standard for compressors. (Jenny Products, No. 0058 at p. 5)

In response to Castair and Jenny's comments, DOE notes that although some consumers may choose efficient compressors in the current market, they do not need to purchase efficient compressors. An energy conservation standard removes the lowest performing compressors from the market, and ensures that consumers receive, on average, economically justified energy savings. Consumers purchasing above that level voluntarily are unaffected. However, consumers who previously purchased below the standard level would be unable to do so, thus ensuring that consumers purchase more efficient equipment, which provides a corresponding improvement in life-cycle cost. While it is true that some compressor designs use motors that are currently subject to energy conservation standards, compressor manufacturers do not need to construct packages using motors within scope of standards. Moreover, a motor being subject to energy conservation standards does not preclude the possibility of finding economically justified savings at the compressor package level. There are many other opportunities to improve the efficiency of a compressor package beyond the driver.

Compressed Air Systems commented that DOE did not provide proof that (1) the proposed standards would improve efficiency over current designs, (2) the proposed standards were technically feasible, and (3) the proposed standards provide an economic benefit for consumers. Finally, Compressed Air Systems alleged that DOE did not collect sufficient data to support DOE's conclusions for the standards proposed in the NOPR. (Compressed Air Systems, No. 0061 at p. 1)

As discussed in section III.B.6, DOE acknowledges that it lacks sufficient data for certain varieties of compressors and is reducing the scope of this final rule appropriately. For the compressors that remain in scope, DOE maintains that sufficient data exists to support adoption of a standard under the provisions of EPCA, as amended. Specifically, DOE discusses efficiency improvement in section IV.C.4, technological feasibility in section III.F, and the economic benefits to consumers in section V.B.1.

b. Reciprocating Compressors

The CA IOUs suggested that DOE should consider EL 2 for reciprocating compressors in the standard adopted in the final rule. (CA IOUs, No. 0059 at pp. 1-2; CA IOUs, Public Meeting Transcript, No. 0044 at p. 152-153) As discussed in section III.B.2, DOE is excluding reciprocating compressors from the scope of this final rule. Therefore, no EL is selected.

2. Other Comments

The P. R. of China commented that DOE is obliged to share the data used to determine that energy conservation standards were justified in accordance with Article 2.5 of World Trade Organization Agreement on Technical Barriers to Trade.⁴² (P. R. China, No. 0049 at p. 32)

DOE discussed and documented its data, assessments, analysis, and rationale as part of the May 2016 energy conservation standards NOPR 81 FR 31680, this final rule,

⁴² Agreement on Technical Barriers to Trade, 1868 U.N.T.S. 120

and the associated TSDs. All relevant data and analysis has been publicly shared through the aforementioned documents.

CAGI also provided a general comment related to DOE's energy conservation standards NOPR proposal. CAGI commented that the most effective way to encourage efficiency is through improving the education and training of individuals who design compressed air demand and supply systems. CAGI argued that the proposed energy conservation standard for compressors diverts limited personnel and financial resources from education and training. (CAGI, No. 0052 at p. 3) Ingersoll Rand, Kaeser Compressors, Mattei Compressors, Sullair, and Sullivan-Palatek commented in support of CAGI's recommendations. (Ingersoll Rand, No. 0055 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullair, No. 0056 at p. 1; Sullivan-Palatek, No. 0051 at p. 1) Ingersoll Rand suggested that compressor package efficiency policy should include a regularly scheduled equipment maintenance program, and that efforts in compressed air system efficiency could lead to significant energy savings. (Docket No. EERE-2012-BT-DET-0033, Ingersoll Rand, No. 0004 at p. 3)

DOE notes that it addresses all individual suggestions provided by CAGI in this final rule, incorporating such suggestions where appropriate. DOE evaluates the benefits and burdens associated with all potential energy conservation standard levels in section V.C. In response to Ingersoll Rand's and CAGI's comments regarding training, maintenance, and education, DOE recognizes that although such efforts may save energy, they are beyond the extent of DOE's EPCA authority to require in an energy conservation standards rulemaking.

Sullivan-Palatek commented that DOE did not have access to performance data for models with variations; rather DOE used CAGI data sheets for basic model package compressors to develop efficiency levels. Sullivan-Palatek believes that developing a standard from basic model data and applying it to models with variations would be erroneous, as it is like comparing apples to oranges. (EERE-2014-BT-TP-0054, Sullivan-Palatek, No. 0007 at p. 2).

In response, DOE notes that, in the test procedure final rule, DOE incorporated CAGI's recommended list of equipment (which was supported by Sullivan-Palatek), with certain modifications, to define the minimum testing configuration for a compressor basic model. Consequently, basic model variants which add additional equipment to an existing basic model will be tested without the additional equipment, and achieve the same rating as the basic package compressor it was derived from. Furthermore, as discussed in section III.B.8, for equipment varieties currently distributed in commerce, DOE was unable to find evidence that variants created by substituting components from basic models would have a material disadvantage, with respect to energy efficiency. For these reasons, DOE believes that the efficiency levels established in this final rule are applicable to all compressors within the scope of this final rule.

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 this document. 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 projections 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 three spreadsheet tools are available on the DOE website for this rulemaking:

https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=6

3. Additionally, DOE used output from the latest version of the Energy Information Administration’s (“EIA”) Annual Energy Outlook (“AEO”) for the emissions and utility impact analyses.

A. Market and Technology Assessment

DOE develops information in the market and technology assessment that provides an overall picture of the market for the equipment concerned, including the purpose of the equipment, the industry structure, manufacturers, market characteristics, and technologies used in the equipment. This activity includes both quantitative and qualitative assessments based primarily on publicly available information. The subjects addressed in the market and technology assessment for this rulemaking include a determination of equipment classes and an assessment of technologies and design options that could improve the energy efficiency of compressors. Chapter 3 of the final rule TSD provides further discussion of these topics as well as discussions on definitions, scope of

coverage, test procedures, trade associations, manufacturers, shipments, regulatory and non-regulatory programs.

1. Equipment Classes

When evaluating and establishing energy conservation standards, DOE divides covered equipment into equipment classes by the type of energy used, by capacity, or other performance-related features that justify differing standards. In making a determination of whether a performance-related feature justifies a different standard, DOE must consider such factors as the utility of the feature to the consumer and other factors DOE determines are appropriate. (42 U.S.C. 6295(q) and 6316(a)). In the energy conservation standards NOPR for compressors, DOE proposed creating equipment classes based on the following factors:

- compression principle,
- lubricant presence,
- cooling method,
- motor speed type, and
- motor phase count. 81 FR 31680, 31697-700 (May 19, 2016).

After taking into consideration the changes to scope presented in section III.B, DOE is establishing fewer equipment classes than it proposed to establish in the energy conservation standards NOPR. In this final rule, the remaining equipment classes are differentiated only by motor speed range and cooling method. The following sections,

IV.A.1.a through IV.A.1.f, discuss these equipment class-setting factors, as well as those considered in the NOPR, in detail.

a. Compression Principle

In the energy conservation standards NOPR, DOE proposed to create equipment classes based on compression principle. Specifically, DOE proposed to create separate equipment classes for rotary compressors and reciprocating compressors on the basis that they have different achievable efficiencies and distinct utility to end users with different duty cycles. 81 FR 31680, 31697-8 (May 19, 2016).

As discussed in section III.B.2, DOE is including only rotary compressors within the scope of this rulemaking. Therefore, in this final rule DOE is not establishing separate equipment classes for reciprocating compressors.

b. Lubricant Presence

In the energy conservation standards NOPR, DOE proposed to create separate equipment classes for lubricated and lubricant-free compressors on the basis that lubricant-free compressors are less able to achieve higher efficiencies but offer utility to end users with applications requiring especially clean air. 81 FR 31680, 31698 (May 19, 2016).

As discussed in section III.B.4, DOE is not including lubricant-free compressors within the scope of this rulemaking. Therefore, in this final rule, DOE is not establishing separate equipment classes for lubricant-free compressors.

c. Motor Speed Range

In the energy conservation standards NOPR, DOE proposed to establish separate equipment classes for fixed-speed compressors and for variable-speed compressors on the basis that variable-speed compressors are generally less efficient at full-load than fixed-speed compressors, but variable-speed compressors offer additional utility in applications in which demand varies. Conversely, fixed-speed compressors are generally more efficient at full load, but do not offer the utility of reduced-speed operation to match variable demand. 81 FR 31680, 31699 (May 19, 2016).

In response to DOE's proposal, Atlas Copco supported separate equipment classes for fixed-speed and variable-speed compressors.⁴³ (Atlas Copco, No. 0054 at pp. 15-16)

DOE received no other comments regarding the creation of separate equipment classes for fixed-speed and variable-speed compressors. Therefore, in this final rule, DOE establishes separate equipment classes for fixed-speed and variable-speed compressors.

d. Number of Motor Phases

In the energy conservation standards NOPR, DOE proposed to divide single-phase and three-phase reciprocating compressors into separate equipment classes. DOE

⁴³ DOE notes that in this comment Atlas Copco also suggested that fixed-speed and variable-speed compressors should be tested and have results reported both for the full-load package isentropic efficiency as well as the part-load package isentropic efficiency. Atlas Copco argued that this would allow for comparisons across equipment classes and for variable-speed compressors that cannot reach 40-percent flow to calculate the cycle loss and, consequently, calculate the efficiency at 40-percent flow. DOE addressed this aspect of Atlas Copco's concerns in the test procedure final rule.

reasoned that compressors with a compressor motor nominal horsepower of less than 10 hp can be packaged with either single-phase or three-phase electric motors. Single-phase motors, while typically less efficient than three-phase motors, offer utility in applications with no access to three-phase power. 81 FR 31680, 31699-31700 (May 19, 2016).

In the energy conservation standards NOPR, DOE made no equipment class distinction between single- and three-phase rotary compressors because it was unable to obtain data on the performance of single-phase rotary equipment. As a result, DOE was unable to make a determination regarding whether single-phase equipment could reach the same performance levels as three-phase. DOE noted that single-phase rotary equipment accounted for very few annual shipments, but that if the applicable single-phase motors were less efficient and less expensive than their three-phase counterparts, then to create a separate standard without data would be to risk creating a substitution incentive. 81 FR 31680, 31699-31700 (May 19, 2016).

As discussed in section III.B.3.c, DOE does not believe that an incentive to substitute unregulated single-phase compressors is likely in the absence of standards because single-phase compressors are similar in price to comparable three-phase models, and single-phase compressors have potentially higher installation costs. As a result, DOE is limiting the scope of the energy conservation standards to three-phase compressors. Therefore, in this final rule, DOE is not establishing separate equipment classes based on phase count.

e. Variants of Rotary Compression Technology

In the energy conservation standards NOPR, DOE did not propose to establish equipment classes based on variants of rotary compression technology. 81 FR 31680 (May 19, 2016). For the purpose of this discussion, “variant” refers to a style of rotary compressor that is recognized by the industry as a distinct technology. “Rotary vane” and “rotary screw” are examples of rotary variants.

In response to the energy conservation standards NOPR, Jenny Products stated that vane compressors are inherently different than screw compressors, and that the only similarities between screw and vane compressors is that they are both rotary and positive-displacement. Jenny Products added that vane compressors should not be grouped with screw, piston or centrifugal compressors, and should instead have their own standard. Jenny products further noted that scroll compressors are different from the compressors that are mentioned in the energy conservations standards NOPR proposal and that the standard combines too many compressors into an overly general model. (Jenny Products, No. 0058 at p. 2) Sullivan-Palatek also commented that the NOPR proposal was overly general, with too few equipment classes to reflect the variety and specialization of products on the market. Sullivan-Palatek commented that this overgeneralization could make certain technologies illegal. As examples, Sullivan-Palatek mentioned scroll compressors and vane compressors. (Sullivan-Palatek, No. 0051 at p. 4) DOE clarifies that scroll compressors are not within the scope of this final rule because they are not rotary compressors; scroll compressors orbit⁴⁴ without changing angular position.

⁴⁴ For example, see: www.emersonclimate.com/en-us/products/compressors/scroll_compressors/pages/scroll_compressors.aspx

Further, scroll compressors on the market today are generally lubricant-free compressors, which are also not within the scope of this final rule.

In response to Jenny Products' and Sullivan-Palatek's comments on vane compressors, neither commenter provided any performance data or quantitative information to support the claim that vane compressors have significantly different utility and/or performance when compared to screw compressors.

In the absence of quantitative information from commenters, DOE reviewed publicly available performance data for rotary vane compressors to determine if differences in performance exist between vane and screw compressors.⁴⁵ DOE found that only one vane compressor manufacturer currently participates in the CAGI Performance Verification Program; as a result, all available vane compressor data is associated with this manufacturer. For comparison, eight unique rotary compressor manufacturers currently participate in the CAGI Performance Verification Program.⁴⁶

DOE found that the available fixed-speed vane compressors perform similarly to fixed-speed screw compressors. For example, of 29 in-scope fixed-speed vane compressors for which data was available, 86-percent were able to reach EL 2;⁴⁷ in

⁴⁵ The performance data was obtained from data sheets published through the CAGI Performance Verification Program: www.cagi.org/performance-verification/

⁴⁶ For a list of manufacturers currently participating in the CAGI Performance Verification Program, please visit this website: www.cagi.org/performance-verification/data-sheets.aspx. Note that Chicago Pneumatic and Quincy are subsidiaries of Atlas Copco.

⁴⁷ EL 2 represents the standard level proposed for this equipment in the energy conservation standards NOPR. See section IV.C.5 for more information on efficiency levels.

comparison, 84-percent of fixed-speed screw compressors were able to reach EL 2. Further, for this same set of fixed-speed vane compressors, 55-percent were able to reach EL 3;⁴⁸ in comparison, 53-percent of fixed-speed screw compressors were able to reach EL 3.⁴⁹ Given the comparable performance of rotary screw and rotary vane compressors, DOE finds no justification to establish a separate equipment class for these two variants of rotary compressors. Consequently, in this final rule, DOE makes no change to its NOPR proposal and does not adopt a separate equipment class for vane compressors.

f. Cooling Method

In the energy conservation standards NOPR, DOE proposed creating separate equipment classes for air- and liquid-cooled compressors. DOE discussed the utility of each cooling method, as well as the efficiency differences between the two cooling methods, as reasons to separate compressors based on cooling method. 81 FR 31680, 31699 (May 19, 2016). The following subsections summarize interested party comments related to DOE's proposal.

Utility

NEEA, NWPCC and Sullair stated that the cooling method offers utility wherein air-cooled equipment can be used where water may not be available. (NEEA and NWPCC, No. 0057 at p. 3; Sullair, No. 0056 at pp. 13-14) Compressed Air Systems also supported the creation of equipment classes and stated that the water cooler requires no

⁴⁸ EL 3 represents the approximate middle of the market, with respect to efficiency. See section IV.C.5 for more information on efficiency levels.

⁴⁹ See chapter 3 of the TSD for more information on this analysis.

electrical energy from the package and, as a result, that the same standard would not be applicable to both cooling methods. (Compressed Air Systems, No. 0061 at p. 2)

Alternatively, CAGI stated that the decision on cooling method is based on site-specific capabilities and it is not appropriate to separate air- and liquid-cooled compressors into equipment classes. (CAGI, No. 0052 at p. 10; CAGI, Public Meeting Transcript, No. 0044 at p. 22) This position was supported by ASAP based on information provided by industry at the public meeting. (ASAP, Public Meeting Transcript, No. 0044 at p. 24) Ingersoll Rand, Kaeser Compressors, Mattei Compressors, Sullair and Sullivan-Palatek supported CAGI's comment that it is not appropriate to separate compressors into equipment classes. (Ingersoll Rand, No. 0055 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullair, No. 0056 at p. 1; Sullivan-Palatek, No. 0051 at p. 1)

Pursuant to EPCA, DOE must consider such factors as the utility of the feature to the consumer and other factors DOE determines are appropriate. (42 U.S.C. 6295(q) and 6316(a)) DOE shares the view of commenters arguing that cooling method offers utility to the end user. Whereas air-cooled compressors may shed heat to the ambient environment, liquid-cooled compressors require a source of cooling liquid from an external system, which not all applications may have. Conversely, compressors operating in warm environments may be thermally limited and unable to operate at full capacity, and end users may improve compressor performance by opting for liquid cooling if the possibility exists. In either case, cooling method offers utility to the consumer.

Performance

ASAP, the CA IOUs and Edison Electric Institute supported the creation of equipment classes by cooling method, with the CA IOUs arguing that combining the two equipment classes would effectively lower the standard for liquid-cooled compressors. (CA IOUs, No. 0059 at pp. 3-4) ASAP and Edison Electric Institute further commented that a single efficiency level for both cooling methods would result in the elimination of air-cooled compressors, which are less efficient, from the market. (NEEA and NWPCC, No. 0057 at p. 3; Edison Electric Institute, Public Meeting Transcript, No. 0044 at pp. 23-24)

Sullair suggested that DOE merge the liquid-cooled equipment class with the air-cooled equipment class and apply the proposed standards of the air-cooled class; liquid-cooled compressors are low volume and tend to have better efficiency than air-cooled compressors. (Sullair, No. 0056 at pp. 13-14) Similarly, Sullivan-Palatek commented that liquid-cooled compressors are produced in low volumes and, as such, should not have their own equipment class and should be held to the air-cooled compressor standards. (Sullivan-Palatek, No. 0051 at p. 6; Sullivan-Palatek, Public Meeting Transcript, No. 0044 at p. 24) Sullair also noted that liquid-cooled compressors are generally more efficient than air-cooled compressors and would not encounter difficulty in meeting standards derived from air-cooled compressors. Furthermore, Sullair noted that integration with other infrastructure such as heat recovery could be discouraged because the liquid-cooled standard is more stringent. (Sullair, No. 0056 at pp. 13-14)

Atlas Copco pointed out that the efficiency difference between cooling methods for lubricated compressors is small, which is why the draft EU standards for compressors propose the same standard levels for air-cooled and liquid-cooled lubricated compressors. (Atlas Copco, Public Meeting Transcript, No. 0044 at pp. 24-25)

CAGI commented that the efficiency of a compressor is not dictated by cooling method and, thus, compressors should not be separated into equipment classes based on cooling method. (CAGI, No. 0052 at p. 10; CAGI, Public Meeting Transcript, No. 0044 at p. 22) Ingersoll Rand, Kaeser Compressors, Mattei Compressors, Sullair, and Sullivan-Palatek commented in support of CAGI's recommendations. (Ingersoll Rand, No. 0055 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullair, No. 0056 at p. 1; Sullivan-Palatek, No. 0051 at p. 1)

DOE shares ASAP, the CA IOUs, Edison Electric Institute, Atlas Copco, Sullivan-Palatek and Sullair's viewpoint that cooling method does affect efficiency. In doing so, DOE disputes CAGI's claim that compressor efficiency is unaffected by cooling method if measured at the package level, as specified by DOE's test procedure final rule. Specifically, air-cooled compressors may employ additional fans or other energy-consuming technology that could be superfluous for a liquid-cooled compressor. The effect of air cooling on energy consumption appears directly in the CAGI Performance Verification Program data, which indicates that liquid-cooled compressors achieve greater isentropic efficiencies than air-cooled compressors of otherwise equivalent design. DOE discusses the relationship between the package isentropic efficiencies of air- and liquid-cooled compressors in section IV.C.5.a.

In specific response to Sullair's comment, DOE does not anticipate that an end user's decision to employ heat recovery will be affected by energy conservation standards for liquid-cooled compressors. Instead, DOE believes an end user's decision will continue to be made based on whether the application site has use for waste heat. Specifically, in the energy conservation NOPR, DOE proposed efficiency levels for liquid-cooled compressors that conservatively accounted for this difference in efficiency.⁵⁰ 81 FR 31680, 31710-31711 (May 19, 2016). Further, according to the testing configuration established in the test procedure final rule, DOE does not require manufacturers to install heat recovery equipment during certification testing. For these reasons, DOE concludes that the efficiency levels established in the NOPR provide no advantage or disadvantage to liquid-cooled systems that employ heat recovery equipment.

Based on the aforementioned discussion of differences in efficiency and utility between air-cooled and liquid-cooled compressors, DOE concludes that separate equipment classes are warranted and justified, and DOE is adopting separate equipment classes for air- and liquid-cooled compressors in this final rule.

Substitution Risk

Sullair noted that certain cooling designs, such as hybrid systems, would be difficult to classify, leading to loopholes. (Sullair, No. 0056 at pp. 13-14) CAGI stated that an end user's decision on cooling method is based on site-specific capabilities.

⁵⁰ See section 5.7.5.1 of the NOPR TSD here: www.regulations.gov/document?D=EERE-2013-BT-STD-0040-0037

(CAGI, No. 0052 at p. 10; CAGI, Public Meeting Transcript, No. 0044 at p. 22) This position was supported by ASAP based on information provided by industry at the public meeting. (ASAP, Public Meeting Transcript, No. 0044 at p. 24) Ingersoll Rand, Kaeser Compressors, Mattei Compressors, Sullair, and Sullivan-Palatek commented in support of CAGI's recommendations. (Ingersoll Rand, No. 0055 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullair, No. 0056 at p. 1; Sullivan-Palatek, No. 0051 at p. 1)

DOE acknowledges Sullair's concern that certain equipment may be of hybrid design, and is updating its definitions for the final rule to address those cases so that an incentive to substitute such equipment does not arise. See III.A.2 for details. DOE interprets CAGI's and ASAP's arguments to mean that an end user's choice of cooling method is made largely due to site-specific factors and infers that substitution is unlikely to occur, especially at the standard levels adopted in this final rule. Therefore, DOE continues to believe that it is appropriate to establish separate equipment classes and corresponding standards, as is done in this final rule.

Certification and Compliance Burden

In response to the energy conservation standards NOPR, Sullair commented that certifying based on cooling method would be burdensome to two different equipment classes and suggested that DOE merge the liquid-cooled equipment class with the air-cooled equipment class and apply the proposed standards of the air-cooled class. (Sullair, No. 0056 at pp. 13-14)

DOE disagrees that separate equipment classes for liquid-cooled and air-cooled compressors would lead to significant increases in compliance burden. The DOE test procedure allows manufacturers to use a testing-based sampling plan or AEDMs to determine the performance of a compressor. Manufacturers can use AEDMs to model the performance of compressors with lower sales volumes based on compressors with higher sales volumes, thereby reducing the burden of testing. In the case of liquid-cooled and air-cooled compressors, the similarities between models, as noted by Sullivan-Palatek, would allow for relatively straightforward modeling of liquid-cooled models based on test data from otherwise-similar air-cooled models.

Additionally, in the test procedure final rule, DOE defines basic model to mean all units of a class of compressors manufactured by one manufacturer, having the same primary energy source, the same compressor motor nominal horsepower, and essentially identical electrical, physical, and functional (or pneumatic) characteristics that affect energy consumption and energy efficiency. 81 FR 27220, 27243 (May 5, 2016). As discussed previously, air- and liquid-cooled compressors clearly have different characteristics that affect energy consumption and efficiency. Consequently, even if liquid- and air-cooled compressors were combined into a single equipment class, as requested by commenters, analogous liquid- and air-cooled compressors would be classified as separate basic models and thus require separate certification. Therefore, combining air- and liquid cooled compressors into one equipment class will not reduce the incremental testing burden.

g. List of Equipment Classes

In the energy conservation standards NOPR, DOE proposed a list of equipment classes and associated equipment class designations. 81 FR 31680, 31700 (May 19, 2016). Based on the discussion in this section, and the scope of this final rule as discussed in section III.B, there are four equipment classes in this final rule. DOE’s list of equipment classes for this final rule is provided in Table IV.1.

Table IV.1 List of Equipment Classes

| Compressor type | Lubrication type | Cooling method | Driver type | Motor phase | Equipment class designation |
|------------------------|-------------------------|-----------------------|--------------------|--------------------|------------------------------------|
| Rotary | Lubricated | Air-cooled | Fixed-speed | Three-phase | RP_FS_L_AC |
| | | Liquid-cooled | | | RP_FS_L_WC |
| | | Air-cooled | Variable-speed | | RP_VS_L_AC |
| | | Liquid-cooled | | | RP_VS_L_WC |

2. Technology Options

In the energy conservation standards NOPR, DOE discussed design options as in three general categories, rather than as independent individual strategies. This is because technology options are, in some cases, able to be deployed independently (e.g., cooling fan efficiency), and in other cases require coordination (e.g., using a more efficient motor). Instead of a bottom-up approach, wherein DOE could attempt to assign a characteristic improvement to each technology option, DOE proposed a top-down approach, wherein the primary consideration is the overall package efficiency and the associated overall cost required to achieve that efficiency. Instead of independent options,

DOE generally considered all efficiency improvement to come from a package redesign. This package redesign can be thought of as including three broad categories of improvements:

- multi-staging;
- air-end improvement; and
- auxiliary component improvement. 81 FR 31680, 31701-3 (May 19, 2016).

DOE received no comment in response to its characterization of compressor technology options. As a result, in this final rule, DOE is making no changes to its characterization of compressor technology options. The following sections summarize the package redesign options that were originally discussed in the energy conservation standards NOPR. (81 FR 31680, 31701-31703)

a. Multi-Staging

Compressors ingest air at ambient conditions and compress it to a higher pressure required by the specific application. Compressors can perform this compression in one or multiple stages, where a stage corresponds to a single air-end and offers the opportunity for heat removal before the next stage. Units that compress the air from ambient to the specified design pressure of the compressor in one stage are referred to as single-stage compressors, while units that use multiple stage are referred to as multistage compressors.

The act of compression generates inherent heat in a gas. If the process occurs quickly enough to limit the transfer of that heat to the environment, the compression is known as “adiabatic.” By contrast, compression may be performed slowly, such that heat flows from the gas at the same rate at which it is generated and such that the temperature of the gas never exceeds that of the environment. This process is called “isothermal.” DOE notes that a hotter gas is conceptually “harder” to compress; the compressor must overcome the heat energy present in the gas in order to continue the compression process. As a result, compression to a given volume requires less work if performed isothermally. “Real” (i.e., not idealized in any respect) compressors are neither adiabatic nor isothermal, and dissipate some portion of compressive heat during the process. If a compressor is able to dissipate more heat, the resulting act of compression becomes easier and the compressor requires less input energy.

Multi-stage compressors are specifically designed to take advantage of this principle and split the compression process into two or more stages (each performed using a single air-end) to allow heat removal between the stages using a heat-exchange device sometimes called an “intercooler.” The more stages used, the closer the compressor behavior comes to the isothermal ideal. Eventually, however, the benefits to adding further stages diminish; gains from each marginal stage are countered by the inherent inefficiencies of using smaller compressor units. Depending on the specific pressure involved, the optimal number of stages may vary widely. Most standard industrial air applications, however, do not use more than two stages.

In response to the 2012 proposed determination of coverage, Ingersoll Rand stated that two-stage compression technology can offer an improvement in efficiency of 12- to 15-percent when compared to single-stage compression. (Docket No. EERE-2012-BT-DET-0033, Ingersoll Rand, No. 0004 at pp. 3-4). DOE considers multistaging to be a valid path to higher efficiency, and has included performance data from single-stage and multistage compressors alike in its analysis.

b. Air-End Improvement

The efficiency of any given air-end depends upon a number of factors, including:

- rated compressor output capacity;
- compression chamber geometry;
- operating speed;
- surface finish;
- manufacturing precision; and
- designed equipment tolerances.

Each individual air-end has a best-efficiency operating point based upon the characteristics listed. However, because air-ends can operate at multiple flow rates, manufacturers commonly utilize a given air-end in multiple compressor packages to reduce overall costs. This results in air-ends operating outside of the best-efficiency point. Using one air-end in multiple compressor packages reduces the total number of air-ends a manufacturer needs to provide across the entire market, reducing costs at the price of reduced efficiency for those packages operating outside of the best efficiency point for

the air-end. However, a manufacturer could redesign and optimize air-ends for any given flow rate and discharge pressure, increasing the overall efficiency of the compressor package.

Manufacturers can use two viable design pathways to increase compressor efficiency via air-end improvement. The first is to enhance a given air-end design's properties that affect efficiency, which could include manufacturing precision, surface finish, mechanical design clearances, and overall aerodynamic efficiency. The second is to more appropriately match air-ends and applications by building an overall larger number of air-end designs. As a result, a given air-end will be used less frequently in applications requiring it to operate further from its optimal operating point. These two practices may be employed independently or jointly; the option that is prioritized will depend on the specifics of a manufacturer's equipment line and the ultimate efficiency level sought.

c. Auxiliary Component Improvement

As discussed in the previous section, compressor manufacturers normally use one air-end in multiple compressor packages that are designed to operate at different discharge pressures and flow rates. Each compressor package consists of multiple design features that affect package efficiency, including valves, piping system, motor, capacity controls, fans, fan motors, filtration, drains, and driers. This equipment, for example, may control the flow of air, moisture, or oil, or the temperature and humidity of output air, or regulate temperature and other operating parameters. Compressor manufacturers do not

normally provide end users with the option to replace any individual part of a compressor package to increase efficiency, as each feature also has a direct effect on compressor performance. However, improving the operating characteristics of any of these “auxiliary” parts may offer a chance to improve the overall efficiency of the compressor package.

For example, package isentropic efficiency can be increased by reducing the internal pressure drop of the package using improved valves and pipe systems, or by improving the efficiency of (1) both the drive and fan motors (if present), (2) the fan, itself (if present), (3) condensate drains, (4) both air and lubricant filters, and (5) controls. The improvement must be considered relative to a starting point, however. Even if the modifications could be deployed independently of each other, and not all can, the spread of efficiencies available in the market likely already reflects the more cost-effective choice for improving efficiency at any given point. Perhaps one manufacturer, by virtue of features of its product lines, finds that reaching a given efficiency level in a particular equipment class is most cost-effectively done by improving Technology X. Another may find that it is more cost effective to improve Technology Y. Both could be correct because each may have had a different starting point. Adding to this difficulty in ascertaining exactly when a given technology should be deployed (as with a bottom-up technology option approach) is the manufacturing reality that it is not cost-effective to offer an infinite number of combinations and equipment sizes. Perhaps a compressor of output level between two others would most optimally use a fan sized specifically for that compressor. Because it is not cost effective for that compressor’s manufacturer to stock another fan size, however, the compressor ends up sub-optimally using a fan either

slightly too large or slightly too small, both at some cost to efficiency. Thus, less may be learned by scrutinizing the design choices of a specific model than is learned by considering the overall spread of costs and efficiencies available in the market at large.

Because the compressor packages function as an ensemble of complementary parts, changing one part often leads to changing others. A special case may come with more-efficient electric motors. Compressors normally use induction motors, which generally vary operating speed as efficiency is improved. Using a more efficient (but otherwise identical) induction motor without considering the rest of the compressor design could be counterproductive if the gains in motor efficiency were more than offset by subsequent loss in performance of the air-end and other parts. DOE's proposal assumes that the best-performing compressors on the market are built using the most-efficient available electric motors that are suited to the task. However, it could not confirm instances of a manufacturer using "super premium" or "IE4" induction motors, which appear to only recently have been made available commercially.⁵¹ The terms "super premium" and "IE4" have been used in the United States and in Europe, respectively, to describe the motor industry's next tier of efficiency. Possible reasons for this include the motors not being suitable for use in compressors, manufacturers still exploring the relatively new motors and not yet having introduced equipment redesigned to make use of them, or that manufacturers are already, using the motors in the most efficient compressor offerings.

⁵¹ One manufacturer, for example, describes its IE4 offerings here: www.regulations.gov/#!documentDetail;D=EERE-2013-BT-STD-0040-0033

As an example of the influence of auxiliary componentry on compressor efficiency, in the test procedure final rule, DOE presents two lists of ancillary equipment to describe compressor configuration requirements. The first includes ancillary equipment that must be included as part of a compressor package when testing, regardless of whether it is distributed in commerce with the basic model under test; the second list contains ancillary equipment that is only required if it is distributed in commerce with the basic model under test. Any ancillary equipment on these lists may affect efficiency, and these lists illustrate the set of ancillary equipment that needs to function harmoniously for the package to perform well.

Table IV.2 List of Equipment Required During Test

| Equipment | Fixed-speed rotary air compressors | Variable-speed rotary air compressors |
|--|---|--|
| Driver | Yes | Yes |
| Bare compressors | Yes | Yes |
| Inlet filter | Yes | Yes |
| Inlet valve | Yes | Yes |
| Minimum pressure check valve / backflow check valve | Yes | Yes |
| Lubricant separator | Yes | Yes |
| Air piping | Yes | Yes |
| Lubricant piping | Yes | Yes |
| Lubricant filter | Yes | Yes |
| Lubricant cooler | Yes | Yes |
| Thermostatic valve | Yes | Yes |
| Electrical switchgear or frequency converter for the driver | Yes | Not applicable* |
| Device to control the speed of the driver (e.g., variable-speed drive) | Not applicable** | Yes |
| Compressed air cooler(s) | Yes | Yes |
| Pressure switch, pressure transducer, or similar pressure-control device | Yes | Yes |
| Moisture separator and drain | Yes | Yes |

*This category is not applicable to variable-speed rotary air compressors

** This category is not applicable to fixed-speed rotary air compressors

Table IV.3 List of Equipment Required During Test, if Distributed in Commerce with the Basic Model

| Equipment | Fixed-speed rotary air compressors | Variable-speed rotary air compressors |
|--|------------------------------------|---------------------------------------|
| Cooling fan(s) and motors | Yes | Yes |
| Mechanical equipment | Yes | Yes |
| Lubricant pump | Yes | Yes |
| Interstage cooler | Yes | Yes |
| Electronic or electrical controls and user interface | Yes | Yes |
| All protective and safety devices | Yes | Yes |

B. Screening Analysis

DOE uses the following four screening criteria to determine which technology options are suitable for further consideration in an energy conservation standards rulemaking:

- 1) Technological feasibility. Technologies that are not incorporated in commercial products or in working prototypes will not be considered further.

- 2) Practicability to manufacture, install, and service. If it is determined that mass production and reliable installation and servicing of a technology in commercial products could not be achieved on the scale necessary to serve the relevant market at the time of the projected compliance date of the standard, then that technology will not be considered further.

- 3) Impacts on product utility or product availability. If it is determined that a technology would have significant adverse impact on the utility of the product to significant subgroups of consumers or would result in the unavailability of

any covered product type with performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as products generally available in the United States at the time, it will not be considered further.

- 4) Adverse impacts on health or safety. If it is determined that a technology would have significant adverse impacts on health or safety, it will not be considered further.

10 CFR part 430, subpart C, appendix A, 4(a)(4) and 5(b)

In sum, if DOE determines that a technology, or a combination of technologies, fails to meet one or more of the above four criteria, it will be excluded from further consideration in the engineering analysis. The reasons for eliminating any technology are discussed below.

The subsequent sections include DOE's evaluation of each technology option against the screening analysis criteria, and whether DOE determined that a technology option should be excluded ("screened out") based on the screening criteria.

1. Screened-Out Technologies

In the energy conservation standards NOPR, DOE was not able to identify technology options that would fail the screening criteria. 81 FR 31680, 31703 (May 19, 2016). DOE received no comments related to the technology options and screening

analysis presented in the energy conservation standards NOPR. As a result, DOE is making no changes to its screening analysis in this final rule.

2. Remaining Technologies

Through a review of each technology, DOE concludes that all of the other identified technologies listed in section IV.A.1.g met all four screening criteria. In summary, DOE did not screen out the following technology options:

- multi-staging
- air-end improvement
- auxiliary component improvement

DOE determined that these technology options are technologically feasible because they are being used, or have previously been used, in commercially available products or working prototypes. DOE also finds that all of the remaining technology options meet the other screening criteria (i.e., practicable to manufacture, install, and service and do not result in adverse impacts on consumer utility, product availability, health, or safety).

C. Engineering Analysis

In the engineering analysis, DOE describes the relationship between manufacturer selling price (MSP) and improved compressor package isentropic efficiency. This relationship serves as the basis for cost-benefit calculations for individual end users, manufacturers, and the Nation. DOE conducted the engineering analysis for this rulemaking using an efficiency level approach. The efficiency level approach uses

estimates of costs and efficiencies of equipment available on the market at distinct efficiency levels to develop the cost-efficiency relationship. The efficiency levels in this analysis range from that of the least-efficient compressor sold today (i.e., the baseline) to the maximum technologically feasible efficiency level. At each efficiency level examined, DOE determines the MSP; this relationship is referred to as a cost-efficiency curve.

In the following sections, DOE summarizes the engineering analysis presented in the NOPR, addresses potential changes to the analysis resulting from the test procedure final rule, discusses comments received, presents analytical changes in response to comments, and summarizes the cost-efficiency results passed to the downstream economic analyses.

1. Summary of Data Sources

In the energy conservation standards NOPR, DOE discussed several sources of data that it used in the engineering analysis. Specifically, DOE discussed the CAGI Performance Verification Program data, the European Union Lot 31 Ecodesign Preparatory Study on Electric Motor Systems / Compressors (hereafter “Lot 31 study,” which is discussed in section IV.C.1.b), confidential U.S. MSP data, and the online retailer price database; these sources are discussed in the following sections. Chapter 5 of the final rule TSD contains further detail on these data sources, beyond what is discussed in this document.

a. CAGI Performance Verification Program Data

CAGI's Performance Verification Program provides manufacturers a standardized test method and performance data reporting format for rotary compressors. In the energy conservation standards NOPR, DOE compiled the information contained in every CAGI Performance Verification data sheet available from the websites of individual manufacturers into one database, and referred to this as the "CAGI database" throughout the NOPR.⁵² As part of this final rule, DOE compiled information from newly available CAGI data sheets, as well as updated data sheets from the same compressor models, and compiled them into a new database; this is referred to as the "updated CAGI database" in this final rule.

b. European Union Lot 31 Study

As described in the energy conservation standards NOPR, the European Union Ecodesign directive established a framework under which manufacturers of energy-using products are obliged to reduce the energy consumption and other negative environmental impacts occurring throughout the product life cycle.⁵³ Air compressors were examined in the Lot 31 study. Lot 31 published a final report in June 2014⁵⁴ and a draft regulation for standards for air compressors ("Lot 31 draft regulation").⁵⁵ 81 FR 31680, 31700-31701 (May 19, 2016).

⁵² For more information regarding CAGI's Performance Verification Program, please see: www.cagi.org/performance-verification/

⁵³ Source: www.eceee.org/ecodesign/products/Compressors

⁵⁴ For copies of the Lot 31 Final Report on Compressors, please go to: www.regulations.gov/#!documentDetail;D=EERE-2013-BT-STD-0040-0031

⁵⁵ For copies of the EU draft regulation: www.regulations.gov/contentStreamer?documentId=EERE-2013-BT-STD-0040-0031&disposition=attachment&contentType=pdf

In the energy conservation standards NOPR engineering analysis, DOE used several relationships developed in the Lot 31 study. The first relationship represented the market average package isentropic efficiency, as a function of output flow, for each compressor variety; this relationship is referred to herein as the “Lot 31 regression curve.” The second relationship, the “Lot 31 regulation curve,” was scaled from each Lot 31 regression curve using “d-values.” The d-values describe the percent reduction in losses from the regression curve, and establish a Lot 31 regulation curve. 81 FR 31680, 31704 (May 19, 2016).

The Lot 31 study also established relationships among compressor package isentropic efficiency, output flow rate, and list selling price for each compressor variety. List price represents the price paid by the final customer, and can be scaled to estimate MSP by using a constant markup factor. These relationships are referred to as “Lot 31 MSP-flow-efficiency relationships” in the NOPR and this final rule. In this final rule, DOE continues to reference the aforementioned relationships from the Lot 31 study, without any modifications. 81 FR 31680, 31704 (May 19, 2016).

c. Confidential MSP and Performance Data

For the energy conservation standards NOPR analysis, DOE’s contractor collected MSP and performance data for a range of compressor sizes and equipment classes from manufacturers. This data is confidential and subject to a nondisclosure agreement between the DOE contractor and the manufacturers. Data collected included pressure, flow rate, compressor motor nominal horsepower, full-load input power (in kilowatts), motor efficiency, package specific power, and MSP for individual compressor

models. Throughout the NOPR and this final rule, these values are referred to as the “confidential U.S. MSP data.” 81 FR 31680, 31704 (May 19, 2016). This data is unchanged from the energy conservation standards NOPR.

d. Public Price Data

In the energy conservation standards NOPR, DOE used a database of prices from online retailers, referred to as the “online retailer price database.” 81 FR 31680, 31704 (May 19, 2016). DOE did not use this database in this final rule, because it was used to develop relationships for reciprocating compressors, which are not analyzed as part of this final rule.

2. Impacts of Test Procedure on Source Data

Ingersoll Rand and Kaeser Compressors commented that the publicly available data and data submitted by manufacturers to the department represent what they consider a “standard” compressor package, which does not encompass all of the ancillary equipment defined in the test procedure. (EERE-2014-BT-TP-0054, Ingersoll Rand, Public Meeting Transcript, No. 0016 at p. 36; Kaeser Compressors, Public Meeting Transcript, No. 0044 at p. 49)

DOE made several modifications in the test procedure final rule, such that the set of compressor ancillary equipment required for testing are now explicitly specified. As discussed in the test procedure final rule, the equipment configuration for testing now aligns with current industry practice. Therefore, in this final rule, DOE is basing analysis on the updated CAGI database without modification.

Additionally, DOE received many comments from interested parties that were concerned that the data DOE used to develop efficiency levels and ultimately propose energy conservation standards was not reflective of the sampling plan adopted in the test procedure final rule. DOE notes that these comments are directly addressed in section III.D of this final rule.

3. Representative Equipment

In the energy conservation standards NOPR, DOE selected representative pressures as the basis for developing the relationship between manufacturer selling price and package isentropic efficiency. Specifically, DOE chose 125 psig for the rotary equipment classes and 175 psig for the reciprocating equipment classes because they represented the majority of equipment in the CAGI database and online retailer database, respectively. 81 FR 31680, 31704-31705 (May 19, 2016).

Sullair commented that it agreed with the proposed representative pressures, but clarified that the pressures listed on CAGI data sheets is not a proxy for the market. Sullair further stated that the bulk of the market is at 100 and 125 psig. (Sullair, Public Meeting Transcript, No. 0044 at p. 42) DOE agrees with Sullair that availability of compressor models at certain pressures does not represent shipments by pressure. However, as discussed in the energy conservation standards NOPR, DOE used the data sheets to determine a representative pressure for the engineering analysis, which was the most common pressure available. The representative pressure and data used to determine it does not to represent a market distribution or a specific percentage of shipments at that representative pressure. Based on the support from Sullair's comment and for the reasons

presented in the energy conservation standards NOPR, DOE retains in this final rule the representative discharge pressure of 125 psig as a basis for determining MSP-efficiency relationships for rotary compressors.

Kaeser Compressors and Ingersoll Rand commented that reciprocating compressors run cyclically, typically starting at 125 psig and stopping at 175 psig. (Kaeser Compressors, Public Meeting Transcript, No. 0044 at p. 43; Ingersoll Rand, Public Meeting Transcript, No. 0044 at p. 44) Ingersoll Rand expanded on their comment, stating that it would be more appropriate to choose a much lower representative pressure than the “start” pressure of 175 psig. (Ingersoll Rand, Public Meeting Transcript, No. 0044 at pp. 45-46)

Compressed Air Systems commented that reciprocating compressors can operate at a range of pressures and selecting one pressure to evaluate its efficiency may be inappropriate as that is not how the compressors designed to operate. (Compressed Air Systems, Public Meeting Transcript, No. 0044 at pp. 43-44) Compressed Air Systems stated that testing compressors at the representative pressure of 175 psig may be unsafe for some compressors to do safely. (Compressed Air Systems, No. 0061 at p. 3)

As discussed in section III.B.2, DOE is excluding reciprocating compressors from the scope of this final rule, and therefore is not asserting any conclusions regarding representative equipment configurations for reciprocating compressors at this time. DOE will consider the aforementioned input if it analyzes standards for reciprocating compressors in a future rulemaking.

4. Design Options and Available Energy Efficiency Improvements

In the energy conservation standards NOPR, DOE identified package redesign as the primary design option available to improve compressor package isentropic efficiency and described multi-staging, air-end improvement, and auxiliary component improvement as specialized cases of package redesign. 81 FR 31680, 31705 (May 19, 2016). As discussed in section IV.B in this final rule, package redesign remains the only design option considered in this engineering analysis. Consistent with the energy conservation standards NOPR, in this final rule, DOE is using an efficiency level approach, focusing on the total efficiency observed at various price levels rather than attempting to quantify the impact on package isentropic efficiency of all of the subcomponents that form a compressor package.

5. Efficiency Levels

In the energy conservation standards NOPR, DOE established and analyzed six efficiency levels and a baseline to assess the relationship between MSP and package isentropic efficiency. 81 FR 31680, 31705 (May 19, 2016). In this final rule, the engineering analysis remains generally the same as presented in the energy conservation standards NOPR. However, the following sections describe specific modifications to the NOPR analysis that DOE made in response to interested party comments.

a. Air-Cooled and Liquid-Cooled Scaling Relationships

In the energy conservation standards NOPR, DOE proposed efficiency levels for liquid-cooled equipment classes established by scaling analogous air-cooled efficiency levels. DOE developed this scaling relationship using the CAGI database and accounted

for the differences in package isentropic efficiency due to the lack of a fan motor in liquid-cooled equipment. 81 FR 31680, 31710 (May 19, 2016).

Sullair commented that DOE's approach to scale liquid-cooled equipment classes from air-cooled using a fixed variable may not be accurate at high and low compressor motor nominal horsepower ranges. (Sullair, Public Meeting Transcript, No. 0044 at pp. 59-60) In response to Sullair's comment, DOE notes that it reduced the compressor motor nominal horsepower scope of the final rule to 10 to 200 hp, as described in section III.B.4.a. Sullair was specifically concerned with the scaling at high and low compressor motor nominal horsepower ranges, including compressors less than 10 nominal hp and greater than 200 nominal hp, which are no longer within scope. For the remaining scope, 10 to 200 nominal hp, DOE examined pairs of air-cooled and liquid-cooled compressors from the updated CAGI database and did not find a strong relationship between the difference in package isentropic efficiency and flow rate. The results of this analysis are provided in chapter 5 of the final rule TSD. For these reasons, DOE maintains the methodology for efficiency level scaling relationships between air-cooled and liquid-cooled equipment classes in this final rule.

Finally, DOE re-evaluated the constant used for the scaling relationships using the updated CAGI database. DOE found similar results that supported the relationship and constant scaling factor proposed in the NOPR, and therefore maintains the scaling relationships proposed in the NOPR. The results of this analysis are provided in chapter 5 of the final rule TSD.

b. Baseline, Max-Tech, and Efficiency levels

For all equipment classes, the baseline efficiency level characterizes the lowest efficiency equipment present in the market for each equipment class. DOE established baselines in the energy conservation standards NOPR, described by their d-values, for each equipment class using the CAGI database. 81 FR 31680, 31705-31713 (May 19, 2016). DOE received no comments regarding baseline efficiency levels presented in the energy conservation standards NOPR. As noted in section IV.C.1.b, DOE updated the CAGI database using the most recent available data and subsequently re-evaluated the d-values used for the baseline of each equipment class. DOE compared the baselines proposed in the NOPR to the updated CAGI database, and concluded that the baselines accurately represent the new data. Therefore, DOE adopts the baselines used in the NOPR for all equipment classes. The results of this analysis are provided in chapter 5 of the final rule TSD.

For all equipment classes, the max-tech efficiency level (EL 6) represents the highest efficiency level possible for an equipment class. DOE established max-tech efficiency levels, represented by d-values, for each equipment class using the CAGI database in the NOPR. 81 FR 31680, 31705-31713 (May 19, 2016). DOE received no comments regarding max-tech efficiency levels presented in the energy conservation standards NOPR. As noted in section IV.C.1.b, DOE updated the CAGI database and subsequently re-evaluated the d-values used for the max-tech efficiency level of each equipment class. DOE compared the max-tech efficiency levels proposed in the NOPR to the updated CAGI database and concluded that the max-tech efficiency levels accurately represent the new data. Therefore, DOE adopts the max-tech efficiency levels used in the

NOPR for all equipment classes. The results of this analysis are provided in chapter 5 of the final rule TSD.

DOE received no comments regarding the intermediate efficiency levels presented in the energy conservation standards NOPR. As such, DOE is making no changes to the d-values for ELs 1, 2, 3, 4, and 5 presented in the energy conservation standards NOPR. Chapter 5 of the final rule TSD contains a detailed discussion of baseline, max-tech and efficiency levels.

c. Efficiency Level Relationships

In the energy conservation standards NOPR, DOE proposed equations for efficiency levels based on an analysis of public data, in a manner consistent with the Lot 31 draft regulation for air compressors. DOE summarized the efficiency levels for each equipment class with the following information: an equation for the regression curve, an equation for the efficiency levels, and a d-value used in the equation for efficiency levels. 81 FR 31680, 31705-31713 (May 19, 2016).

DOE received overarching comments regarding the efficiency levels proposed in the energy conservation standards NOPR. Specifically, CAGI and Sullair commented that there was an error in the formula presented at the public meeting. The formulae on these pages include the term $\ln(X)^2$, but should state $\ln^2(X)$. (CAGI, No. 0052 at p. 11; Sullair, No. 0056 at p. 17; Sullair, Public Meeting Transcript, No. 0044 at p. 15; Sullair, Public Meeting Transcript, No. 0044 at p. 148) Ingersoll Rand, Kaeser Compressors, Mattei Compressors, and Sullivan-Palatek commented in support of CAGI's recommendations.

(Ingersoll Rand, No. 0055 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullivan-Palatek, No. 0051 at p. 1)

DOE agrees with CAGI and Sullair's comment and notes that the comments point out a typographical error in the NOPR equation structure, which, when corrected, represents the intent of the equations. Therefore, the equations presented in this final rule have been modified to address the typographical error, but these changes have no impact on the analytical results in this final rule.

Additionally, CAGI and Sullair stated that DOE based the efficiency level equations presented in the NOPR on the Lot 31 draft regulation for air compressors, but rounded and truncated some equations coefficients. CAGI and Sullair further stated that the rounding creates a situation where a compressor may meet one proposed efficiency standard, but fail the other. CAGI and Sullair recommend aligning the coefficients in the efficiency level equations with the equations in the Lot 31 draft regulation to prevent this potential issue. (CAGI, No. 0052 at p. 12; Sullair, Public Meeting Transcript, No. 0044 at p. 16; Sullair, No. 0056 at p. 17) Ingersoll Rand, Kaeser Compressors, Mattei Compressors, and Sullivan-Palatek commented in support of CAGI's recommendations. (Ingersoll Rand, No. 0055 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullivan-Palatek, No. 0051 at p. 1)

DOE examined the equations in the Lot 31 draft regulation and found that coefficients used were all reported to the thousandth (i.e., 0.001) and varied between 3 and 5 significant digits. In the energy conservation standards NOPR, DOE presented

equations for efficiency levels with 3 significant digits. DOE also notes that in the test procedure final rule, all calculations of package isentropic efficiency must be rounded to the thousandth (i.e., 0.001). DOE's original intent was to align with the equations used in the Lot 31 draft regulation, and DOE is modifying the equations in this final rule to include all significant digits presented in the Lot 31 draft regulation equations. DOE notes that the original, unrounded and untruncated Lot 31 draft regulation equations were used in DOE's energy conservation standards NOPR analysis. As such, this is a typographical change to the presentation of the equations in the regulatory text, and thus this change has no impact on the analytical results in this final rule.

Sullivan-Palatek commented that the efficiency level equations presented in the energy conservation standards NOPR did not seem reasonable, stating that the package isentropic efficiency of a given compressor would not consistently rise with respect to compressor motor nominal horsepower. Sullivan-Palatek suggested that the efficiency level curves should begin to flatten at 100 to 150 nominal hp, meaning that the package isentropic efficiency for a given efficiency level would remain flat beyond 100 or 150 nominal hp. (EERE-2014-BT-TP-0054, Sullivan-Palatek, No. 0007 at p. 3; EERE-2014-BT-TP-0054, Sullivan-Palatek, Public Meeting Transcript, No. 0016 at p. 51)

Additionally, the People's Republic of China noted that it was unreasonable to use a single efficiency curve spanning the range of 1-500 nominal hp as a considered regulation. The People's Republic of China requested that DOE provide the data used to develop this curve in accordance with Article 2.5 of World Trade Organization Agreement on Technical Barriers to Trade, which permits a World trade Organization

member to request another member to provide technical justification for a regulation.⁵⁶
(P. R. China, No. 0049 at p. 3)

In response to the comments from Sullivan-Palatek and the People's Republic of China, the efficiency levels analyzed in this final rule are all based on Lot 31 regression curves, which were created from empirical data. Specifically, the Lot 31 regression curves were created from CAGI Performance Verification Program data. Further, in the energy conservation standards NOPR, DOE independently confirmed that regressions of the CAGI database performance data would result in curves similar to the Lot 31 regression curves. 81 FR 31680, 31706-31707 (May 19, 2016). DOE notes that Sullivan-Palatek did not provide any supporting data or justification as to why they believed the regression curve shape was incorrect. Additionally, no other interested parties commented on the regression curve shape. For these reasons, in this final rule, DOE makes no further adjustments to the shape of the efficiency level curves.

CAGI and Sullair commented that Table 1 in the May 19, 2016 energy conservation standards NOPR (81 FR at 31767) contains an error for the rotary, lubricated, air-cooled, variable-speed compressor equipment class d-value of -10. CAGI and Sullair believe this value should be -15 to align with the rotary, lubricated, water-cooled, variable-speed compressor equipment class d-value. (CAGI, No. 0052 at p. 11; Sullair, No. 0056 at p. 17) Ingersoll Rand, Kaeser Compressors, Mattei Compressors, and Sullivan-Palatek commented in support of CAGI's recommendations. (Ingersoll Rand,

⁵⁶ Agreement on Technical Barriers to Trade, 1868 U.N.T.S. 120

No. 0055 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullivan-Palatek, No. 0051 at p. 1) DOE notes that the d-values in Table 1 of the NOPR align with the corresponding EL 2 analyzed in the NOPR engineering analysis. EL 2 for these two equipment classes do not have the same d-value because DOE determined that they have different baseline d-values, based on data in the CAGI database. This results in a different d-value for EL 2, which DOE described as two-thirds of the way between the baseline and EL 3 in the energy conservation standards NOPR. 81 FR at 31706 (May 19, 2016). Therefore, DOE concludes that no error was present, and does not make any modifications based on this comment from CAGI and Sullair.

Beyond the changes discussed in this section, DOE uses the same efficiency level relationships proposed in the energy conservation standards NOPR for this final rule. The following sections present the efficiency levels for equipment classes analyzed in this final rule and discuss specific comments from interested parties. As discussed in section III.B, certain air compressors that DOE analyzed in the energy conservation standards NOPR are no longer within the scope of this final rule. Therefore, DOE is only presenting engineering analysis results for equipment within the scope of this rule. Specifically, DOE is only presenting engineering analysis results for fixed- and variable-speed, lubricated, rotary, three-phase compressors within the scope of this rule. Chapter 5 of the final rule TSD contains a detailed discussion of all efficiency level relationships.

RP FS L AC

The regression curve for the rotary, lubricated, air-cooled, fixed-speed equipment class is unchanged from the energy conservation standards NOPR, except for the typographical corrections noted in this section, and is as follows:

$$\begin{aligned}\eta_{Isen_Regr_RP_FS_L_AC} \\ &= -0.00928 \times \ln^2(0.4719 \times V_1) + 0.13911 \times \ln(0.4719 \times V_1) \\ &+ 0.27110\end{aligned}$$

Equation 1

Where:

$\eta_{Isen_Regr_RP_FS_L_AC}$ = regression curve package isentropic efficiency for the rotary, lubricated, air-cooled, fixed-speed equipment class, and

V_1 = full-load actual volume flow rate (cubic feet per minute).

The efficiency levels for the rotary, lubricated, air-cooled, fixed-speed equipment class are unchanged from the energy conservation standards NOPR. All efficiency levels, are defined by the following equation, in conjunction with the d-values in Table IV.4.

$$\eta_{Isen_STD_RP_FS_L_AC} = \eta_{Isen_Regr_RP_FS_L_AC} + (1 - \eta_{Isen_Regr_RP_FS_L_AC}) \times d/100$$

Equation 2

Where:

$\eta_{Isen_STD_RP_FS_L_AC}$ = package isentropic efficiency for the rotary, lubricated, air-cooled, fixed-speed equipment class, for a selected efficiency level,

$\eta_{Isen_Regr_RP_FS_L_AC}$ = regression curve package isentropic efficiency for the rotary, lubricated, air-cooled, fixed-speed equipment class, and

d = d-value for each proposed efficiency level, as specified in Table IV.4

Table IV.4 Efficiency Levels Analyzed for Rotary, Lubricated, Air-Cooled, Fixed-Speed, Three-Phase

| Efficiency Level | d-Value |
|------------------|---------|
| Baseline | -49 |
| EL 1 | -30 |
| EL 2 | -15 |
| EL 3 | 0 |
| EL 4 | 5 |
| EL 5 | 13 |
| EL 6 | 30 |

RP FS L WC

The efficiency levels for the rotary, lubricated, liquid-cooled, fixed-speed equipment class are derived from the rotary, lubricated, air-cooled, fixed-speed equipment class.

The efficiency levels for the rotary, lubricated, liquid-cooled, fixed-speed equipment class are unchanged from the energy conservation standards NOPR. All

efficiency levels are defined by the following equation, in conjunction with the d-values in Table IV.5.

$$\eta_{Isen_STD_RP_FS_L_WC} = 0.02349 + \eta_{Isen_Regr_RP_FS_L_AC} + (1 - \eta_{Isen_Regr_RP_FS_L_AC}) \times d/100$$

Equation 3

Where:

$\eta_{Isen_STD_RP_FS_L_WC}$ = package isentropic efficiency for the rotary, lubricated, liquid-cooled, fixed-speed equipment class, for a selected efficiency level,

$\eta_{Isen_Regr_RP_FS_L_AC}$ = regression curve package isentropic efficiency for the rotary, lubricated, air-cooled, fixed-speed equipment class, and

d = d-value for each proposed efficiency level, as specified in Table IV.5.

Table IV.5 Efficiency Levels Analyzed for Rotary, Lubricated, Liquid-Cooled, Fixed-Speed, Three-Phase

| Efficiency Level | d-Value |
|------------------|---------|
| Baseline | -49 |
| EL 1 | -30 |
| EL 2 | -15 |
| EL 3 | 0 |
| EL 4 | 5 |
| EL 5 | 13 |
| EL 6 | 30 |

RP VS L AC

The regression curve for the rotary, lubricated, air-cooled, variable-speed equipment class is unchanged from the energy conservation standards NOPR, except for the typographical corrections noted in this section, and is as follows:

$$\begin{aligned}\eta_{Isen_Regr_RP_VS_L_AC} \\ &= -0.01549 \times \ln^2(0.4719 \times V_1) + 0.21573 \times \ln(0.4719 \times V_1) \\ &+ 0.00905\end{aligned}$$

Equation 4

Where:

$\eta_{Isen_Regr_RP_VS_L_AC}$ = regression curve package isentropic efficiency for the rotary, lubricated, air-cooled, variable-speed equipment class, and

V_1 = full-load actual volume flow rate (cubic feet per minute).

The efficiency levels for the rotary, lubricated, air-cooled, variable-speed equipment class are unchanged from the energy conservation standards NOPR. All efficiency levels are defined by the following equation, in conjunction with the d-values in Table IV.6.

$$\eta_{Isen_STD_RP_VS_L_AC} = \eta_{Isen_Regr_RP_VS_L_AC} + (1 - \eta_{Isen_Regr_RP_VS_L_AC}) \times d/100$$

Equation 5

Where:

$\eta_{Isen_STD_RP_VS_L_AC}$ = package isentropic efficiency for the rotary, lubricated, air-cooled, variable-speed equipment class, for a selected efficiency level,

$\eta_{Isen_Regr_RP_VS_L_AC}$ = regression curve package isentropic efficiency for the rotary, lubricated, air-cooled, variable-speed equipment class, and

d = d-value for each proposed efficiency level, as specified in Table IV.6.

Table IV.6 Efficiency Levels Analyzed for Rotary, Lubricated, Air-Cooled, Variable- Speed, Three-Phase

| Efficiency Level | d-Value |
|-------------------------|----------------|
| Baseline | -30 |
| EL 1 | -20 |
| EL 2 | -10 |
| EL 3 | 0 |
| EL 4 | 5 |
| EL 5 | 15 |
| EL 6 | 33 |

RP VS L WC

The efficiency levels for the rotary, lubricated, liquid-cooled, variable-speed equipment class are derived from the rotary, lubricated, air-cooled, variable-speed equipment class.

The efficiency levels for the rotary, lubricated, liquid-cooled, variable-speed equipment class are unchanged from the energy conservation standards NOPR. All efficiency levels are defined by the following equation, in conjunction with the d-values in Table IV.7:

$$\begin{aligned} \eta_{Isen_STD_RP_VS_L_WC} &= 0.02349 + \eta_{Isen_Regr_RP_VS_L_AC} + (1 - \eta_{Isen_Regr_RP_VS_L_AC}) \\ &\times d/100 \end{aligned}$$

Equation 6

Where:

$\eta_{Isen_STD_RP_VS_L_WC}$ = package isentropic efficiency for the rotary, lubricated, liquid-cooled, variable-speed equipment class, for a selected efficiency level,

$\eta_{Isen_Regr_RP_VS_L_AC}$ = regression curve package isentropic efficiency for the rotary, lubricated, air-cooled, variable-speed equipment class, and

d = d-value for each proposed efficiency level, as specified in Table IV.7.

Table IV.7 Efficiency Levels Analyzed for Rotary, Lubricated, Liquid-Cooled, Variable-Speed, Three-Phase

| Efficiency Level | d-Value |
|------------------|---------|
| Baseline | -45 |
| EL 1 | -30 |
| EL 2 | -15 |
| EL 3 | 0 |
| EL 4 | 5 |
| EL 5 | 15 |
| EL 6 | 34 |

6. Manufacturer Selling Price

In the energy conservation standards NOPR, DOE’s general approach was to collect public and confidential manufacturer selling price data (in U.S. dollars) for compressors distributed in commerce in the United States, in order to scale relationships

established in the Lot 31 study to the U.S. market. 81 FR 31680 at 31703-31704, 31713-31718 (May 19, 2016). The following sections discuss interested party comments related to MSP of lubricant-free equipment (section IV.C.6.a), potential overestimation of MSP and its impact on analyses (section IV.C.6.b), the unchanged relationship between air-cooled and liquid-cooled MSP (section IV.C.6.c), and a summary of MSP results (section IV.C.6.d).

a. MSP of Lubricant-Free Equipment Classes

In the energy conservation standards NOPR, DOE analyzed lubricant-free equipment classes. DOE developed a relationship between MSP for lubricated and lubricant-free equipment classes and requested comment on the relationship.

In response, CAGI commented that scaling the MSP of lubricated, air-cooled equipment to determine the MSP of lubricant-free, air-cooled equipment is not justified as there is no proven relationship between lubricant-free MSP and lubricated MSP. (CAGI, No. 0052 at pp. 10-11) Ingersoll Rand, Kaeser Compressors, Mattei Compressors, Sullair, and Sullivan-Palatek commented in support of CAGI's recommendations. (Ingersoll Rand, No. 0055 at p. 1; Kaeser Compressors, No. 0053 at p. 1; Mattei Compressors, No. 0063 at p. 2; Sullair, No. 0056 at p. 1; Sullivan-Palatek, No. 0051 at p. 1)

As discussed in section III.B.4, DOE is excluding lubricant-free compressors from the scope of this final rule, and therefore DOE is not asserting any conclusions regarding MSP for lubricant-free compressors at this time.

b. Potential Overestimation of MSP due to Non-Efficiency-Related Equipment

Sullivan-Palatek stated that customers who order more efficient compressors typically require other optional non-efficiency-related ancillary equipment, which artificially inflates the cost of the more efficient equipment. (Sullivan-Palatek, Public Meeting Transcript, No. 0044 at pp. 63-64; Sullivan-Palatek, Public Meeting Transcript, No. 0044 at p. 67; Sullivan-Palatek, Public Meeting Transcript, No. 0044 at p. 68) Ingersoll Rand supported Sullivan-Palatek's comments. (Ingersoll Rand, Public Meeting Transcript, No. 0044 at pp. 67-68)

In the energy conservation standards NOPR, DOE established MSP-flow-efficiency relationships using the Lot 31 study of MSP-flow-efficiency relationships, and MSPs for compressor packages sold in the United States. As discussed in the NOPR, DOE scaled the Lot 31 study's absolute equipment MSPs to a magnitude that represents MSPs offered in the U.S. market, but maintained the incremental MSP trends established in the Lot 31 study. 81 FR 31680 at 31715 (May 19, 2016). The Lot 31 MSP-flow-efficiency relationships were developed using cost data that was confined to basic packages only, any packages with additional features, such as "active cooling" were omitted to reduce complexity of the analysis.⁵⁷ Additionally, the Lot 31 study explained that some basic packages have more opportunities to upgrade functions in the future and are more expensive because they have space and material for potential future upgrades.⁵⁸ These descriptions indicate that there may be some small costs included in the Lot 31

⁵⁷ See the Lot 31 Ecodesign Preparatory Study on Compressors Task 7 section 2.4.1 here: www.regulations.gov/#!documentDetail;D=EERE-2013-BT-STD-0040-0031

⁵⁸ Ibid.

MSP-flow-efficiency relationships that are not related to efficiency improvements (e.g., costs for extra space in the package for optional components). DOE scaled the Lot 31 MSP-flow-efficiency relationships using U.S. prices of basic compressor packages, as distributed in commerce. In alignment with the Lot 31 study, DOE did not explicitly exclude any costs from more efficient models. Therefore, the MSPs presented in the NOPR engineering analysis represent the total price of the basic package, as distributed in commerce, which is consistent with the Lot 31 methodology.

As discussed in the energy conservation standards NOPR, DOE leveraged the Lot 31 MSP-flow-efficiency relationship because it is based on an analysis which was publicly vetted through the European Union regulation process. At this time (and at the time of the NOPR analysis), no additional data is available that would allow DOE to parse out the impact of certain ancillary equipment on the Lot 31 MSP-flow-efficiency relationship.

DOE understands that the potential slight overestimation of MSP at higher efficiency levels due to non-efficiency-related equipment could affect the results of DOE's analyses. Therefore, DOE has assessed the potential impacts of including costs of optional ancillary equipment that do not affect package isentropic efficiency in the outputs of the engineering analysis. Specifically, potential overestimation of MSP at higher efficiency levels is most likely to produce conservative results at higher efficiency levels, as it overestimates the cost to increase package isentropic efficiency. If incremental MSPs in the NOPR are overestimated, then it follows that corresponding consumer benefits presented in the NOPR are underestimated. In the energy conservation

standards NOPR, DOE presented consumer benefits that were positive above the proposed standard level, and revising any potentially overestimated incremental MSPs would only increase the benefits of these levels. 81 FR 31680, 31737-31744 (May 19, 2016). As explained in the NOPR, DOE proposed TSL 2 after walking down to a potential reduction in INPV for manufacturers that DOE concluded was economically justified. Consumer and national benefits were positive from TSL 2 through max-tech for all equipment classes considered in this final rule. 81 FR at 31753-31755. Revising any potentially, slightly overestimated incremental MSPs (to lower values) at higher efficiency levels would increase NOPR estimated consumer benefits, with little impact on NOPR-estimated reduction in INPV for manufacturers and, therefore, not change the justification for the standard proposed in the NOPR.

Further, as discussed previously, DOE based the MSPs trends in the energy conservation standards NOPR on trends established in Lot 31 study. DOE does not have cost data which could be used to evaluate how costs of more efficient compressor packages may increase due to non-efficiency-related items. Additionally, commenters did not provide any quantitative data related to this.

Consequently, based on the potential minimal impact of revising MSP-flow-efficiency relationships according to Sullivan-Palatek's comment, and the lack of available cost data to do so, DOE is adopting in this final rule the MSP-flow-efficiency relationships as proposed in the energy conservation standards NOPR.

c. Air-Cooled and Liquid-Cooled MSP Relationships

In the energy conservation standards NOPR, DOE used MSPs for air-cooled equipment classes to represent MSPs for liquid-cooled equipment classes. DOE reasoned that any difference in incremental MSP between air- and liquid-cooled compressors would not be significant, when compared to the incremental MSP of the greater package. Consequently, DOE concluded that the incremental cost and price of efficiency would be the same for both air-cooled and liquid-cooled equipment classes at each efficiency level. 81 FR 31680 at 31716-31717 (May 19, 2016). As discussed in section IV.A.1.f, DOE maintains separate equipment classes for air-cooled and liquid-cooled equipment in this final rule.

In response to the NOPR, Sullair commented that generally there is an analogous air-cooled and liquid-cooled compressor for lubricated equipment, and when ignoring the cost of the cooling system, the manufacturer production cost (“MPC”) for each is the same. This mirrors the assumption made in DOE’s energy conservation standards NOPR analysis. However, Sullair added that DOE’s assumption that the incremental cost of efficiency for air-cooled and water-cooled equipment classes are equal may not work because air-cooled equipment can improve package isentropic efficiency by using premium efficiency fan motors, while liquid-cooled equipment cannot. (Sullair, Public Meeting Transcript, No. 0044 at pp. 65-66)

DOE acknowledges that air-cooled equipment has a technology option that is not available to liquid-cooled equipment (i.e., more-efficient fan motors). In response, DOE assessed the impact of its assumption that any difference in incremental MSP between air- and liquid-cooled systems would not be significant when compared to the incremental MSP of the greater package.

In the energy conservation standards NOPR, DOE derived MSP at each air-cooled efficiency level from empirical pricing data. It is therefore reasonable to assume that the MSP at the baseline level represents compressors with low efficiency fan motors. At each subsequent efficiency level, the likelihood of improved efficiency fan motors increases. As a result, it is reasonable to assume that the empirically based MSPs at each subsequent efficiency level already represent compressors with fan motors of increasing efficiency.

In the energy conservation standards NOPR, DOE established efficiency levels for liquid-cooled compressors at a uniform 2.35 package isentropic efficiency points above the analogous air-cooled efficiency level. As discussed in section IV.C.5.a and the energy conservation standards NOPR, this increase of 2.35 package isentropic efficiency points represents the average difference in package isentropic efficiency between 269 pairs of analogous fixed-speed air-cooled and liquid-cooled models. The air- and liquid-cooled pairs in this analysis represented the range of fan motor efficiency available on the market. Following the logic established by Sullair's comment, theoretically, pairs with lower efficiency fan motors should have greater differences in package isentropic efficiency, and pairs with higher efficiency fan motors should have smaller differences in package isentropic efficiency. Thus, if DOE is to precisely account for improvements in

fan motor efficiency (while using the same incremental MSPs for air- and liquid-cooled efficiency levels), the increase in package isentropic efficiency between air- and liquid-cooled compressors should be slightly more than 2.35 at baseline and slightly less than 2.35 at max-tech. Such an adjustment would result in liquid-cooled compressors gaining slightly less package isentropic efficiency between each efficiency level, when compared to air-cooled compressors. However, the increase in MSP at each efficiency level would be the same for both air- and liquid-cooled compressors.

DOE quantified the impact of the aforementioned relationship. Data within the updated CAGI database show that most fan motors are less than five percent the size of the compresses motor (e.g., a compressor with a 100 hp motor typically has a fan motor less than 5 hp). One common air-cooled configuration in the updated CAGI database, for example, is a compressor with a compressor motor nominal horsepower of 100 hp and a 3 hp fan motor. The efficiency of 3 hp fan motors typically range from 81.5- to 89.5-percent. With all else held constant, DOE estimates that upgrading from the least efficient fan motor to the most efficient would increase package isentropic efficiency by approximately 0.20 percentage points for a 100 nominal hp compressor. DOE also assessed a 200 nominal hp compressor with a 10 hp fan motor, and found a similar result: package isentropic efficiency increased by approximately 0.18 percentage points. DOE examined this impact for 25 nominal hp compressors, as well. Based on the updated CAGI database, DOE found that 1 hp fan motor are typically associated with 25 nominal hp compressors, and these fan motors ranged from 65.0- to 85.5-percent efficient. This range resulted in an increase in package isentropic efficiency of approximately 0.78

percentage points. Chapter 5 of the final rule TSD contains a detailed discussion of the impact of fan motor efficiency on package isentropic efficiency.

Practically, if DOE were to apply this result to the analysis for a compressor with a compressor motor nominal horsepower of 25 hp, the air- to liquid-cooled offset would range from 2.74 at baseline to 1.96 at max-tech (a range of 0.78 percentage points identified in 25 nominal hp compressors); instead of being a constant 2.35 package isentropic efficiency points. At EL 2, (the standard level proposed in the energy conservation standards NOPR) the offset would be approximately 2.47 points of package isentropic efficiency.⁵⁹

For compressors with a compressor motor nominal horsepower of 100 hp, the air- to liquid-cooled offset would range from 2.45 at baseline to 2.25 at max-tech (a range of 0.20 percentage points identified in 100 nominal hp compressors); instead of being a constant 2.35 package isentropic efficiency points. At EL 2 the offset would be approximately 2.38 percentage points of package isentropic efficiency.⁶⁰ Compressor with a motor nominal horsepower of 200 hp would have an almost identical offset, based on DOE's analysis.

⁵⁹ DOE estimated the offset for 25 hp compressors at EL 2 by linearly interpolating between the offsets and d-values at baseline and EL 3. As such, DOE estimates that the package isentropic efficiency offset should be 2.47 at EL 2, by interpolating between 2.74 (baseline) and 2.35 (EL 3). Chapter 5 of the final rule TSD contains details on this calculation.

⁶⁰ DOE estimated the offset for 100 hp compressors at EL 2 by linearly interpolating between the offsets and d-values at baseline and EL 3. As such, DOE estimates that the package isentropic efficiency offset should be 2.38 at EL 2, by interpolating between 2.45 (baseline) and 2.35 (EL 3). Chapter 5 of the final rule TSD contains details on this calculation.

DOE asserts that the potential changes to the package isentropic efficiency offset at EL 2, for the example compressors with a compressor motor nominal horsepower of 25, 100, and 200 hp, are very small, and will result in negligible impact on downstream analyses. Specifically, this analysis showed that package isentropic efficiency, for EL 2, for liquid-cooled equipment classes, should be slightly higher (i.e., more stringent) than what was analyzed in the NOPR, while maintaining the same MSP. Revising EL 2 for liquid-cooled equipment classes to be more stringent would increase NOPR estimated consumer benefits, which are positive from TSL 2 through max-tech for all equipment classes considered in this final rule. 81 FR at 31753-31755.

Further, revising EL 2 for liquid-cooled equipment classes to be more stringent would have a negligible impact on the estimated reduction in INPV for manufacturers. Specifically, in this scenario, MSP (one of the key inputs to calculating INPV) does not change. With a slightly more stringent EL 2, DOE expects only negligible changes in the number of models failing and shipment estimates (other key inputs to calculating INPV), because the potential change to the efficiency level is so small. As explained in the NOPR, DOE proposed TSL 2 after walking down to a potential reduction in INPV for manufacturers that DOE concluded was economically justified. Therefore, the potential impact of revising EL 2 does not change the justification for the standard proposed in the NOPR.

Further, DOE's analysis shows that efficiency levels above EL 3 for liquid-cooled equipment classes should be slightly lower (i.e., less stringent) than what was analyzed in the NOPR. Therefore, the NOPR analyses would have shown slightly less economic

benefits if EL 3 were revised. However, economic benefits were significantly positive at these higher ELs, and ultimately DOE walked down below these levels based on INPV impacts, which similarly to EL 2 would have negligible changes.

As such, DOE maintains its assertion that any difference in incremental MSP between air- and liquid-cooled systems would not be significant, when compared to the incremental MSP of the greater package. Furthermore, implementing such changes, with rigor, adds significant complexity to DOE’s analysis, with little-to-no increase in analytical resolution. For these reasons, for this final rule, DOE maintains the relationships between air- and liquid-cooled compressors, for EL 1 through EL 6, as established in the energy conservation standards NOPR.

d. Summary of Manufacturer Selling Price Relationships

Based on the discussions in sections IV.C.6.a, IV.C.6.b, and IV.C.6.c, DOE is adopting the MSP-flow-efficiency relationships in the following sections in this final rule. DOE notes that the relationships for these equipment classes are unchanged from the NOPR analysis. 81 FR 31680, 31714-31717 (May 19, 2016).

RP FS L AC

The MSP-flow-efficiency relationship for the rotary, lubricated, air-cooled, fixed-speed equipment class is as follows:

$$MSP_{RP_FS_L_AC} = 0.820 \times [(4.72 \times V_1 + 2500) + (136.88 \times V_1 + 10000) \times \eta_{Isen_STD_RP_FS_L_AC}^3]$$

Equation 7

Where:

$MSP_{RP_FS_L_AC}$ = manufacturer selling price for the rotary, lubricated, air-cooled, fixed-speed equipment class at a selected efficiency level and full-load actual volume flow rate,

$\eta_{Isen_STD_RP_FS_L_AC}$ = package isentropic efficiency for the rotary, lubricated, air-cooled, fixed-speed equipment class, for a selected efficiency level and full-load actual volume flow rate, and

V_1 = full-load actual volume flow rate (cubic feet per minute).

MSP for each efficiency level for the rotary, lubricated, air-cooled, fixed-speed equipment class is presented in Table IV.8 at representative full-load actual volume flow rates.

Table IV.8 Representative MSPs for the RP_FS_L_AC Equipment Class

| Efficiency Level | Full-Load Actual Volume Flow Rate (cfm) | | | | | |
|------------------|---|---------|----------|----------|----------|----------|
| | 20* | 50 | 100 | 200 | 500 | 1,000 |
| Baseline | \$2,437 | \$3,350 | \$4,975 | \$8,517 | \$20,350 | \$41,492 |
| EL 1 | \$2,784 | \$4,007 | \$6,039 | \$10,319 | \$24,243 | \$48,764 |
| EL 2 | \$3,192 | \$4,680 | \$7,063 | \$11,983 | \$27,719 | \$55,158 |
| EL 3 | \$3,742 | \$5,506 | \$8,264 | \$13,877 | \$31,572 | \$62,159 |
| EL 4 | \$3,960 | \$5,818 | \$8,707 | \$14,562 | \$32,943 | \$64,633 |
| EL 5 | \$4,349 | \$6,357 | \$9,460 | \$15,716 | \$35,230 | \$68,739 |
| EL 6 | \$5,349 | \$7,677 | \$11,257 | \$18,414 | \$40,484 | \$78,091 |

* 20 cfm is outside of the scope of this final rule, however the MSP at this point was used for interpolation purposes in downstream analyses.

RP_FS_L_WC

As discussed in section IV.C.6.a, DOE uses the MSP for air-cooled equipment classes to represent MSP for liquid-cooled equipment classes. Therefore, the MSP-flow-efficiency relationship for the rotary, lubricated, liquid-cooled, fixed-speed equipment class is the same as the as the rotary, lubricated, air-cooled, fixed-speed equipment class. The MSP for each efficiency level for the rotary, lubricated, liquid-cooled, fixed-speed equipment class is presented in Table IV.9 at representative full-load actual volume flow rates.

Table IV.9 Representative MSPs for the RP_FS_L_WC Equipment Class

| Efficiency Level | Full-Load Actual Volume Flow Rate (cfm) | | | | | |
|------------------|---|---------|----------|----------|----------|----------|
| | 20 | 50 | 100 | 200 | 500 | 1,000 |
| Baseline | \$2,437 | \$3,350 | \$4,975 | \$8,517 | \$20,350 | \$41,492 |
| EL 1 | \$2,784 | \$4,007 | \$6,039 | \$10,319 | \$24,243 | \$48,764 |
| EL 2 | \$3,192 | \$4,680 | \$7,063 | \$11,983 | \$27,719 | \$55,158 |
| EL 3 | \$3,742 | \$5,506 | \$8,264 | \$13,877 | \$31,572 | \$62,159 |
| EL 4 | \$3,960 | \$5,818 | \$8,707 | \$14,562 | \$32,943 | \$64,633 |
| EL 5 | \$4,349 | \$6,357 | \$9,460 | \$15,716 | \$35,230 | \$68,739 |
| EL 6 | \$5,349 | \$7,677 | \$11,257 | \$18,414 | \$40,484 | \$78,091 |

RP_VS_L_AC

The MSP-flow-efficiency relationship for the rotary, lubricated, air-cooled, variable-speed equipment class is as follows:

$$MSP_{RP_VS_L_AC} = 1.302 \times [(4.72 \times V_1 + 2500) + (136.88 \times V_1 + 10000) \times \eta_{Isen_STD_RP_VS_L_AC}^3]$$

Equation 8

Where:

$MSP_{RP_VS_L_AC}$ = manufacturer selling price for the rotary, lubricated, air-cooled, variable-speed equipment class at a selected efficiency level and full-load actual volume flow rate,

$\eta_{Isen_STD_RP_VS_L_AC}$ = package isentropic efficiency for the rotary, lubricated, air-cooled, variable-speed equipment class, for a selected efficiency level and full-load actual volume flow rate, and

V_1 = full-load actual volume flow rate (cubic feet per minute).

MSP for each efficiency level for the rotary, lubricated, air-cooled, variable-speed equipment class is presented in Table IV.10 at representative full-load actual volume flow rates.

Table IV.10 Representative MSPs for the RP_VS_L_AC Equipment Class

| Efficiency Level | Full-Load Actual Volume Flow Rate (cfm) | | | | | |
|------------------|---|----------|----------|----------|----------|-----------|
| | 20 | 50 | 100 | 200 | 500 | 1,000 |
| Baseline | \$3,606 | \$4,935 | \$7,577 | \$13,526 | \$33,464 | \$68,234 |
| EL 1 | \$3,818 | \$5,474 | \$8,526 | \$15,189 | \$37,092 | \$75,013 |
| EL 2 | \$4,131 | \$6,139 | \$9,624 | \$17,044 | \$41,031 | \$82,293 |
| EL 3 | \$4,565 | \$6,943 | \$10,883 | \$19,101 | \$45,292 | \$90,093 |
| EL 4 | \$4,834 | \$7,401 | \$11,576 | \$20,209 | \$47,548 | \$94,193 |
| EL 5 | \$5,488 | \$8,437 | \$13,097 | \$22,590 | \$52,317 | \$102,806 |
| EL 6 | \$7,109 | \$10,743 | \$16,314 | \$27,461 | \$61,802 | \$119,743 |

RP VS L WC

As discussed in section IV.C.6.a, DOE uses the MSP for air-cooled equipment classes to represent MSP for liquid-cooled equipment classes. Therefore the MSP-flow-efficiency relationship for the rotary, lubricated, liquid-cooled, variable-speed equipment class is the same as the as the rotary, lubricated, air-cooled, variable-speed equipment class. The MSP for each efficiency level for the rotary, lubricated, liquid-cooled, variable-speed equipment class is presented in Table IV.11 at representative full-load actual volume flow rates.

Table IV.11 Representative MSPs for the RP_VS_L_WC Equipment Class

| Efficiency Level | Full-Load Actual Volume Flow Rate (cfm) | | | | | |
|------------------|---|----------|----------|----------|----------|-----------|
| | 20 | 50 | 100 | 200 | 500 | 1,000 |
| Baseline | \$3,436 | \$4,332 | \$6,410 | \$11,370 | \$28,574 | \$58,968 |
| EL 1 | \$3,606 | \$4,935 | \$7,577 | \$13,526 | \$33,464 | \$68,234 |
| EL 2 | \$3,960 | \$5,790 | \$9,056 | \$16,092 | \$39,022 | \$78,589 |
| EL 3 | \$4,565 | \$6,943 | \$10,883 | \$19,101 | \$45,292 | \$90,093 |
| EL 4 | \$4,834 | \$7,401 | \$11,576 | \$20,209 | \$47,548 | \$94,193 |
| EL 5 | \$5,488 | \$8,437 | \$13,097 | \$22,590 | \$52,317 | \$102,806 |
| EL 6 | \$7,218 | \$10,889 | \$16,512 | \$27,755 | \$62,364 | \$120,739 |

7. Manufacturer Production Cost

In the energy conservation standards NOPR, DOE estimated manufacturer markups based on confidential data gathered during interviews with manufacturers. The markups help to differentiate the manufacturer production cost from the manufacturer selling price of compressors and feed into downstream analyses such as the Manufacturer Impact Analysis. 81 FR 31680, 31718 (May 19, 2016).

In response to DOE's analysis, Atlas Copco commented that there is a large variation in the markups from manufacturer production cost to manufacturer selling price for global and U.S. manufacturers, because global manufacturers may elect to assemble some compressors at non-U.S. facilities. (Atlas Copco, Public Meeting Transcript, No. 0044 at p. 72)

DOE agrees with Atlas Copco's comment that there is variation in markups between different manufacturers. As noted in the NOPR, DOE developed the baseline markup estimates based on confidential data obtained during confidential manufacturer interviews from both global and U.S. based manufacturers. 81 FR 31680, 31718 (May 19, 2016). The markups are intended to represent the industry average, and DOE acknowledges that any individual manufacturer may have different markups.

Additionally, DOE did not receive any new information that could be used to revise the NOPR values for baseline markup estimates or breakdown for manufacturer production cost (MPC) for compressors. Therefore, in this final rule, DOE adopts the estimates for baseline markup estimates and breakdown for MPC for compressors presented in the NOPR.

8. Other Analytical Outputs

In the energy conservation standards NOPR, DOE calculated values for full-load power and no-load power for use in cost-benefit calculations for individual end users, manufacturers, and the Nation. Full-load power was calculated for each equipment class using the formula proposed for package isentropic efficiency in the test procedure NOPR

and the outputs of package isentropic efficiency, full-load actual volume flow rate, and pressure from the engineering analysis. DOE used the CAGI database to establish a relationship and calculate values for no-load power based on full-load power. 81 FR 31680, 31718 (May 19, 2016).

DOE received no comments regarding the other analytical outputs discussed in this section. Thus, for the reasons discussed in the energy conservation standards NOPR, in this final rule DOE does not modify the other analytical outputs of the engineering analysis from the NOPR. Chapter 5 of the final rule TSD contains a detailed discussion of these outputs.

D. Markups Analysis

The markups analysis develops appropriate markups (e.g., retailer markups, distributor markups, contractor markups) in the distribution chain and in sales taxes to convert the MSP estimates derived in the engineering analysis to end user prices. The end user prices are then used in the LCC and PBP analyses and in the manufacturer impact analysis. At each step in the distribution channel, companies mark up the price of the equipment to cover business costs and profit margin. For compressors, the main distribution channels are (1) manufacturers directly to end users, (2) manufacturers to distributors to end users, (3) manufacturers to contractors to end users, and (4) manufacturers to end users through other means. Table IV.12 shows the estimated market shares of each channel, based on compressor capacity.

Table IV.12 Compressors Distribution Chain

| Channel Structure | | | | Lubricated Rotary Positive Compressors | |
|-------------------|------------------------------|------------|------|--|----------------|
| | | | | < 500 cfm % | ≥ 500 cfm % |
| Manufacturer | | | User | 7.5 | 20.0 |
| Manufacturer | Distributor/Manufacturer Rep | | User | 85.0 | 77.5 |
| Manufacturer | Distributor/Manufacturer Rep | Contractor | User | 5.0 | 2.5 |
| Manufacturer | Other | | User | 2.5 | 0.0 |
| Total | | | | 100 | 100 |

DOE developed separate markups for baseline equipment (baseline markups) and for the incremental cost of more-efficient equipment (incremental markups). Incremental markups are coefficients that relate the change in the MSP of higher efficiency models to the change in the sales price.

To develop markups for the parties involved in the distribution of compressors, DOE utilized several sources, including: (1) the U.S. Census Bureau 2007 Economic Census Manufacturing Industry Series (NAICS 33 Series)⁶¹ to develop original equipment manufacturer markups; (2) the U.S. Census Bureau 2012 Annual Wholesale Trade Survey, Machinery, Equipment, and Supplies Merchant Wholesalers⁶² to develop distributor markups; and (3) 2013 RS Means Electrical Cost Data⁶³ to develop mechanical contractor markups.

⁶¹ U.S. Census Bureau (2007). Economic Census Manufacturing Industry Series (NAICS 33 Series). www.census.gov/manufacturing/asm

⁶² U.S. Census Bureau (2012). Annual Wholesale Trade Survey, Machinery, Equipment, and Supplies Merchant Wholesalers (NAICS 4238). www.census.gov/wholesale/index.html

⁶³ RS Means (2013), Electrical Cost Data, 36th Annual Edition (Available at: www.rsmeans.com).

In addition to the markups, DOE derived State and local taxes from data provided by the Sales Tax Clearinghouse. This data represents weighted-average taxes that include county and city rates. DOE derived shipment-weighted-average tax values for each region considered in the analysis.

CAGI commented that it found no errors with DOE's distribution channel and markups assumptions presented in the NOPR. (CAGI, No. 044 Public Meeting Transcript, at p. 94). DOE received no other comments to this approach, therefore; DOE is maintaining the same approach for the final rule as it did in the NOPR.

Chapter 6 of the NOPR TSD provides details on DOE's development of markups for compressors.

E. Energy Use Analysis

The purpose of the energy use analysis is to determine the annual energy consumption of air compressors at different efficiencies in representative U.S. manufacturing and commercial facilities, and to assess the energy savings potential of increased air compressor efficiency. The energy use analysis estimates the range of energy use of air compressors in the field (*i.e.*, as they are actually used by end users). The energy use analysis provides the basis for other analyses DOE performed, particularly assessments of the energy savings and the savings in end user operating costs that could result from adoption of new standards.

Annual energy use of air compressors depends on the utilization of the equipment, which is influenced by air compressor application, annual hours of operation, load profiles, capacity controls, and compressor capacity. DOE calculates the annual energy use as the sum of input power at each load point multiplied by the annual operating hours at each respective load point.

1. Applications

Air compressors operate in response to system demands in three general ways, or applications. DOE determined these applications after examining available field assessment data from two database sources: (1) a database of motor nameplate and field data compiled by the Washington State University (“WSU”) Extension Energy Program, Applied Proactive Technologies (“APT”), and New York State Energy Research and Development Authority (“NYSERDA”) (“WSU/NYSERDA database”)⁶⁴ and (2) the Northwest Industrial Motor Database.⁶⁵ Based on the distribution of compressor-specific assessments found in these databases, DOE defined three application types to capture statistical variations in air demand and control strategies. DOE defined the three application types as follows:

Trim: Compressors equipped with controls configured to serve fluctuating air demand. The trim application represents either the operation of an individual compressor,

⁶⁴ The motors database is composed of information gathered by WSU and APT during 123 industrial motor surveys or assessments: 11 motor assessments were conducted between 2005 and 2011 and occurred in industrial plants; 112 industrial motor surveys were conducted between 2005 and 2011 and were funded by NYSERDA and conducted in New York State.

⁶⁵ Northwest Industrial Motor Database Summary, 2009, Strategic Energy Group.

or a compressor within a compressor plant, that serves the fluctuating portion of the demand.

Base load: Compressors equipped with controls configured to serve steady-state air demands. The base-load application represents a compressor within a compressor plant that serves the constant portion of fluctuating demand, while the remaining fluctuating portion of demand covered by a trim application.⁶⁶

Intermittent: Compressors equipped with controls configured to serve sporadic loads. For example, these could be operated as back-up compressors for either base-load or trim compressors, or as a dedicated air compressor to a specific process such as sand blasting or fermentation.

Table IV.13 shows the estimated distribution of air compressor application.

Table IV.13 Distribution of Air Compressors by Application

| Application | Probability % |
|--------------------|--------------------------|
| Trim | 50 |
| Base-load | 28 |
| Intermittent | 22 |

CAGI commented that based on experience, more than 28-percent of compressors in the field are operating at full usage as base-load compressors. CAGI further

⁶⁶ Air demand (in cfm) can vary considerably during plant operations. A portion of this air demand may be steady-state, driving equipment that is run constantly, while the remaining portion may be fluctuating.

commented that rotary compressors are not designed for intermittent use. (CAGI, No. 0044 at p. 82; CAGI, No. 0052 at pp. 5-6) Ingersoll Rand, Kaeser Compressors, Mattei Compressors, Sullair, and Sullivan-Palatek commented in support of CAGI's recommendations. (Ingersoll Rand, No. 0055 at p.1; Kaeser Compressors, No. 0053 at p.1; Mattei Compressors, No. 0063 at p. 2; Sullair, No. 0056 at p.1; Sullivan-Palatek, No. 0051 at p.1) While CAGI may feel that more than 28-percent of compressors operating in the field are base-load compressors, they did not offer an alternative value. DOE acknowledges that rotary compressors they may not be designed for intermittent use, DOE undemands that rotary compressors may be used in an intermittent fashion in the field. DOE acknowledges that the definition of these applications does have similarities with the way compressors are marketed and distributed in commerce. They are not meant to be literal representations of these occurrences; instead, they are labels used to categorize the statistical variation of the wide range of conditions in which compressors operate in the field.

2. Annual Hours of Operation

In the NOPR DOE constructed a probability distribution of average annual hours of operation ("AHO") for each of the three application types based on NYSERDA and WSU system assessments data discussed previously, and on the Lot 31 study.

Several stakeholders commented that the annual hours of operation used in the NOPR analysis were too high, resulting in an overstatement of potential savings. Sullivan-Palatek commented that the annual hours of operation were overstated, by as much as a factor of three, and that as compressor capacity (in hp) increases, so do the

hours of operation. (Sullivan-Palatek, No. 044 Public Meeting Transcript at pp 84-85) Atlas Copco commented that the annual hours of operation were overstated for some equipment categories by a factor of two. (Atlas Copco, No. 0054 at pp. 4-5) Jenny Products commented that the annual hours of operations were overstated by a factor of two. (Jenny Products, No. 0058 at p. 3) Ingersoll Rand commented that the annual hours of operation were overstated, and agreed with the distribution of annual hours of operation provided by CAGI. (Ingersoll Rand, No. 0055 at pp. 3-4) Sullair commented that the annual hours of operation were skewed toward compressors operated by heavier industries, and not likely operated by single-shift operations. (Sullivan-Palatek, No. 0044 Public Meeting Transcript at p. 85) Compressed Air Systems commented that annual hours of operation were overstated by 50- to 75- percent (Compressed Air Systems, No. 0061 at p. 5), and that 80- percent of compressors under 250 hp operate 8 to 10 hours per workday. (Compressed Air Systems, No. 0044 at p. 88) Compressed Air Systems agreed that compressors rated at lower capacities would be used less (fewer hours of operation) than those with higher capacities. (Compressed Air Systems, No. 0061 at p. 3) Jenny Products commented that most compressors operate at 2,000 hours per year based on single shift, 8 hours per day, 5 days per week, 50 weeks per year. (Jenny Products, No. 0058 at p. 3) CAGI commented that the operating hours per year is between 2,800 and 4,600 hours. CAGI also provided a distribution of average annual operating hours. (CAGI, No. 0052 at pp. 4-5) Kaeser Compressors and Mattei Compressors commented in support of CAGI's recommendations. (Kaeser Compressors, No. 0053 at p.1; Mattei Compressors, No. 0063 at p. 2)

The distribution AHO provided by CAGI in response to the NOPR were skewed toward higher operating hours than those estimated by DOE. The weighted averages of the distribution provided by CAGI and DOE’s NOPR analysis are 5,166 and 4,081, respectively. Table IV.14 shows the AHO distribution used by DOE in the NOPR compared to that submitted by CAGI.

Table IV.14 Comparison of Annual Hours of Operation

| Annual Hours of Operation | % of Total Compressors | |
|---------------------------|------------------------|----------|
| | CAGI | DOE NOPR |
| <1000 | 5.6 | 2.4 |
| 1000-2000 | 5.0 | 17.1 |
| 2001-3000 | 12.2 | 9.0 |
| 3001-4000 | 12.1 | 20.4 |
| 4001-5000 | 12.7 | 17.1 |
| 500-6000 | 11.3 | 19.0 |
| 6001-7000 | 11.2 | 8.2 |
| 7001-8000 | 10.2 | 4.6 |
| >8000 | 19.6 | 2.1 |

CAGI’s comments did not indicate how AHO changes with compressor capacity. However, Atlas Copco’s comment did show how AHO changes by compressor capacity. (Atlas Copco, No. 0054 Appendix B, at p.2) In response to the analysis provided by Atlas Copco, DOE adjusted average AHO by capacity for the final rule. Table IV.15 shows the average AHO at each capacity range used in this final rule.

Table IV.15 Average Annual Hours of Operation by Compressors Capacity

| Full-Load Actual Volume Flow Rate (cfm) | DOE AHO |
|--|----------------|
| ≥ 35 to < 50 | 3,385 |
| ≥ 50 to < 100 | 3,238 |
| ≥ 100 to < 200 | 3,308 |
| ≥ 200 to < 300 | 3,346 |
| ≥ 500 to < 1000 | 3,726 |
| ≥ 1,000 to < 1250 | 4,248 |

3. Load Profiles

Information on typical load profiles for compressors is not available in the public domain. DOE reviewed resources provided by stakeholders, as well as sample compressed air system assessments of commercial and industrial customers. Given the lack of data, DOE developed several load profiles based on how typical compressor applications would likely be employed in the field. Each compressor load profile is approximated by weights that specify the percentage of time the compressor operates at one of four load points: 20-, 40-, 70-, and 100-percent of its duty point airflow.⁶⁷ Load profiles are then mapped to each application type to capture compressor operation in the field. The four load profile types are described below.

Flat-load profile: represents a constant maximum airflow demand. All annual hours of operation are assigned to the duty point airflow. The flat-load profile is used for most base-load applications, and for intermittent applications to represent the event where

⁶⁷ DOE assumes that 20-percent is the lowest point at which a compressor will operate before it can be cycled by capacity controls into its Stop or Unload status. See chapter 7 of the TSD for more information on capacity controls.

an intermittent compressor is operating in a base-load role. It can also represent a situation where intermittent demand has been attenuated due to the inclusion of appropriately sized secondary (demand) air receiver storage to the compressed air system.

High-load profile: represents a high fraction of annual operating hours spent at, or near the maximum airflow demand. The annual hours of operation are distributed across the higher airflow load points. The high-load profile is used to represent most trim applications, and some base-load applications.

Low-load profile: represents a low fraction of annual operating hours spent at maximum air flow. Annual hours of operation are distributed across the lower airflow load points. Low-load profile, although undesirable, occurs if a single compressor is supplying airflow to a range of tools, with only a small fraction of operating hours at which all of these tools are operating. This profile is used with both trim and intermittent applications.

Even-load profile: represents an even distribution of annual operating hours spent at each airflow load point. This load profile is a characteristic of trim or intermittent applications.

Table IV.16 shows the percentage of annual operating hours at each of the load points described above for the four load profiles. Table IV.17 shows the assumed probability of each type of load profile being selected for each application type.

Table IV.16 Fraction of Annual Operating Hours as a Fraction of Rated Airflow

| Load Point | Load Profile | | | |
|------------|--------------|------|-----|-------|
| | Flat | High | Low | Even |
| 20% | 0% | 0% | 30% | 0% |
| 40% | 0% | 10% | 30% | 33.3% |
| 70% | 0% | 40% | 30% | 33.3% |
| 100% | 100% | 50% | 10% | 33.3% |

Table IV.17 Distribution of Load Profiles by Application

| Application | Load Profile | Load Profile Probability |
|--------------|--------------|--------------------------|
| Trim | Flat | - |
| | Even | 40% |
| | Low | 40% |
| | High | 20% |
| Base-load | Flat | 80% |
| | Even | - |
| | Low | - |
| | High | 20% |
| Intermittent | Flat | 30% |
| | Even | 20% |
| | Low | 20% |
| | High | 30% |

4. Capacity Control Strategies

Facility demands for compressed air rarely match a compressor's rated air capacity. To account for this discrepancy, some form of compressed air control strategy is necessary. Some forms of capacity control only apply to certain compressor designs

and are effective over a limited range of a compressor's capacity. In addition, some capacity controls can be used in combination. As the capacity is regulated, the power required for the compressor to meet the airflow demand will change depending on the chosen control strategy. Chapter 7 of the final rule TSD describes the implemented control in detail with mathematical models for each of the following control strategies: Start/Stop, Load/Unload (2-step), Inlet Valve Modulation, and Variable Displacement. DOE also included the following combined control strategies: Inlet Valve Modulation/Unload, Variable Displacement/Unload, and Multi-step/Unload. DOE modeled these control strategies largely on the following sources: Analysis Methodology Manual for AIRMaster Compressed Air System Audit and Analysis Software,⁶⁸ CAGI's Compressed Air and Gas Handbook,⁶⁹ and Compressed Air System Controls.⁷⁰

a. Load/Unload

Sullair commented that for compressors with a compressor motor nominal horsepower over 10 hp, stop control is not available without load/unload controls. Further, Sullair commented that there is no variable displacement without variable displacement unload. (Sullair, LLC, No. 0044 at pp. 97) Consequently, DOE updated its analysis and removed start/stop without load/unload for compressors rated over 10 nominal hp and included load/unload with all variable displacement compressors.

⁶⁸ Wheeler, G. M., Bessey, E. G. & McGill, R. D. Analysis Methodology Manual for AIRMaster Compressed Air System Audit and Analysis Software, 1997.

⁶⁹ McCulloh, D. M. Compressed Air and Gas Handbook. Compressed Air and Gas Institute (CAGI), 2003. at <www.cagi.org>

⁷⁰ Compressed Air Challenge, U.S. DOE, Compressed Air System Controls, 1998, at <www.compressedairchallenge.org/library/factsheets/factsheet06.pdf>

Atlas Copco submitted average results, by capacity, showing the average number of running hours per year, and load ratios of a sample of lubricated air compressors in a draft report.⁷¹ (Atlas Copco, No. 0054 Appendix B, at p. 3) From these results DOE was able to adjust the number of hours per year that compressors spend in the unload control state. In the NOPR DOE assumed a fixed 20-percent of time for rotary screw lubricated compressors. The adjusted average value used in this final rule is 40-percent. When applied to the energy use analysis, this results in 40-percent of a compressor's annual operating hours spent in the unload control state.

b. Cycle Energy Requirement

Atlas Copco submitted a second internal report⁷² that presented an approach to quantify the energy use of a compressor in the following operating states: (1) when the compressor is in its unloaded control state and transitions into delivering air; and (2) when the compressor stops delivering air and transitions into its unloaded control state (this is also known as “blow-down”). (Atlas Copco, No. 0054 Annex A, at pp. 5 - 9) The approach for determining this energy use, called “cycle energy requirement” (“CER”), is described in Atlas Copco's comment. (Atlas Copco, No. 0054 Appendix B, at p. 1) Although this approach bears interest, it has not been peer reviewed or accepted by industry. Further, the reports lack the necessary information needed to model the described transitional states. Additionally, Atlas Copco submitted a technical report⁷³ indicating that it is possible for a compressor to fractionally cycle through these stages.

⁷¹ Wouters, C., Measurement Principle on Cycle Losses, Atlas Copco, November, 2015

⁷² Wouters, C., Air Compressors Total Energy Consumption, Atlas Copco, August, 2016

⁷³ Van Nederkassel, L., The Relation between the Compressor Installation and its Energy Efficiency, Section 2-2, Compressors, Compressed Air and Vacuum Technology Association, September 2004.

(Atlas Copco, No. 0054 Annex B, at p. 1) However, the report does not include metrics on the number of cycles that are at each fraction of these stages. For DOE to apply the proposed CER approach in the energy use analysis, these inputs would be required. While DOE acknowledges that energy is used during the transitional stages outlined in the CER approach, at this time neither DOE nor industry have sufficient information to determine the CER of baseline equipment, or to estimate the decrease in CER as compressor efficiency increases. As such, DOE cannot ascertain the impacts of the submitted approach. Given the uncertainty surrounding this methodology, and given the lack of supporting information, DOE elected not to use the CER methodology for this final rule.

F. Life-Cycle Cost and Payback Period Analyses

DOE conducted LCC and PBP analyses to evaluate the economic impacts on individual end users of potential energy conservation standards for air compressors. The effect of new or amended energy conservation standards on individual end users usually involves a reduction in operating cost and an increase in purchase cost. DOE used the following two metrics to measure end-user impacts:

- The LCC is the total end user expense of an appliance or 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 is the estimated amount of time (in years) it takes end users 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-standards case, which reflects the estimated efficiency distribution of air compressors 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 a nationally representative set of air compressors. DOE used data from the NYSERDA and Northwest Industrial Motor Database databases, Lot 31 study and acquired system assessments to define each air compressor's application, load profile, annual hours of operation, and combination of employed controls. For each of the considered air compressors, DOE determined the energy consumption and the appropriate electricity price, thus capturing the variability in energy consumption and energy prices associated with the use of air compressors.

Inputs to the calculation of total installed cost include equipment costs—which includes MPCs, manufacturer markups, retailer and distributor 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, with probabilities attached to each value, to account for their uncertainty and variability.

The computer model DOE uses to calculate the LCC and PBP 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 air compressor end user sample. The model calculated the LCC and PBP for equipment at each efficiency level for 10,000 end users per simulation run.

DOE calculated the LCC and PBP for all end users as if each were to purchase a new equipment in the expected year of compliance with a new standard. DOE has determined that any standards would apply to air compressors manufactured five years after the date on which any standard is published.⁷⁴ Table IV.18 summarizes 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 model, and

⁷⁴ EPCA specifies that the provisions of subsections (l) through (s) of section 42 U.S.C 6295 shall apply to any other type of industrial equipment which the Secretary classifies as covered equipment, which includes compressors. (42 U.S.C. 6316(a)) 42 U.S.C 6295(l)(2) states that any new or amended standard for any other type of consumer product which the Secretary classifies as a covered product shall not apply to products manufactured within five years after the publication of a final rule establishing such standard. This five-year lead time also applies to other types of industrial equipment, such as compressors.

of all the inputs to the LCC and PBP analyses, are contained in chapter 8 of the final rule TSD and its appendices.

Table IV.18 Summary of Inputs and Methods for the LCC and PBP Analysis*

| Inputs | Source/Method |
|------------------------------|--|
| Equipment Cost | Derived by multiplying MPCs by manufacturer and retailer markups and sales tax, as appropriate. Used historical data to derive a price-scaling index to project equipment costs. |
| Installation Costs | Baseline installation cost determined with data from stakeholders. Assumed no change with efficiency level. |
| Annual Energy Use | The total annual energy use multiplied by the hours per year. Average number of hours based on field data calibrated to data submitted by stakeholders. |
| Energy Prices | Electricity: Marginal prices derived from EEI. ⁷⁵ |
| Energy Price Trends | Based on <u>AEO 2016</u> price projections. |
| Repair and Maintenance Costs | Assumed no change with efficiency level. |
| Equipment Lifetime | Assumed average lifetime of 12.5 years for rotary. |
| Discount Rates | Approach involves identifying all possible debt or asset classes that might be used to purchase air compressors. Primary data source was the Damodaran Online. |
| Compliance Date | Late 2021 (2022 for analysis purposes) |

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

1. Equipment Cost

To calculate end user equipment costs, DOE multiplied the MSPs 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

⁷⁵ Edison Electric Institute (EEI), Typical Bills and Average Rates Report Summer, and Winger (2014).

associated with higher efficiency equipment. As explained in section IV.D, DOE assumed that compressors are delivered by the manufacturer through one of four distribution channels. The overall markups used in the LCC analysis are weighted averages of all of the relevant distribution channel markups.

To project an equipment price trend for the final rule, DOE derived an inflation-adjusted index of the Producer Price Index for air and gas compressor equipment manufacturers over the period 1984-2013.⁷⁶ These data shows a slight decrease from 1989 through 2004. Since 2004, however, there has been an increase in the price index. Given the relatively slow global economic activity in 2009 through 2013, the extent to which a future trend can be predicted based on the last decade is uncertain. Because the observed data does not provide a firm basis for projecting future cost trends for compressor equipment, DOE used a constant price assumption as the default trend to project future compressor prices from 2022. Thus, prices projected for the LCC and PBP analyses are equal to the 2014 values for each efficiency level in each equipment class.

DOE received no adverse comments on its NOPR equipment cost estimates, and maintained the same approach for the final rule.

2. Installation Cost

Installation cost includes labor, overhead, and any miscellaneous materials and parts needed to install the equipment. In the NOPR, DOE requested information on

⁷⁶ Series ID PCU333911333911; www.bls.gov/ppi/.

whether installation costs would be expected to change with efficiency. Sullair responded that some high efficiency technologies would preclude installation into existing harsh industrial climates and would necessitate the construction of a clean room. (Sullair, LLC, No. 0044 at pp. 106-107) However, Sullair did not specify which high efficiency technologies would make the construction of a clean room for installation necessary, nor did Sullair indicate at which efficiency level this may become an issue. The range of equipment efficiencies presented in this final rule are currently available as “general purpose” compressors that are designed to be operated without the need of a clean room.

Ingersoll Rand commented that water-cooled compressors would have higher installation costs than air-cooled equipment. (Ingersoll Rand, No. 044 Public Meeting Transcript at pp. 107-108) For the final rule, compressors using liquid- and air-cooled cooling systems are considered separate equipment classes, and are not considered potential replacements for one another in the LCC analysis. DOE recognizes that installations cost would be different for water- versus air-cooled compressors, but for equipment using the same cooling method, DOE does not expect installation costs to change with increased efficiency.

Atlas Copco responded that differences in installation costs would depend on what DOE considers as part of the equipment standard package. (Atlas Copco, No. 044 Public Meeting Transcript at p. 109) For the equipment defined as the standard package

for the final rule, DOE does not expect installation cost to change as efficiency increases.⁷⁷

In conclusion, DOE does not expect installation cost to change with increased efficiency, so DOE did not include installation costs for this final rule.

3. Annual Energy Consumption

For each sampled compressor, DOE determined the energy consumption for an air compressor at different efficiency levels using the approach described above in section IV.E of this document.

4. Energy Prices

DOE derived average and marginal annual non-residential (commercial and industrial) electricity prices at the National level using data from EIA's Form EIA-861 database (based on "Annual Electric Power Industry Report"),⁷⁸ EEI Typical Bills and Average Rates Reports,⁷⁹ and information from utility tariffs. Electricity tariffs for non-residential end users can be very complex, with the principal difference from residential rates being the incorporation of demand charges. The presence of demand charges means that two end users with the same monthly electricity consumption may have very different bills, depending on their peak demand. For this final rule analysis, DOE used marginal electricity prices to estimate the impact of demand charges for end users of air

⁷⁷ The equipment defined as part of the standard package are discussed in section IV.C.2

⁷⁸ Available at: www.eia.doe.gov/cneaf/electricity/page/eia861.html.

⁷⁹ Edison Electric Institute. *Typical Bills and Average Rates Report*. Winter 2014 published April 2014, Summer 2014 published October 2014: Washington, D.C. (Last accessed June 2, 2015.) www.eei.org/resourcesandmedia/products/Pages/Products.aspx.

compressors. The methodology used to calculate the marginal electricity rates is described in appendix 8B of the final rule TSD.

EEI noted that by using marginal electricity prices, which are sometimes higher than average electricity prices, DOE might be overstating the value of electricity savings for equipment operated outside of peak hours. (Edison Electric Institute, No. 0044 at pp. 99-100) DOE assumes that compressors operating at low load factors are operated during normal business hours. As a result, demand is coincident with peak hours, which has higher costs per-unit energy than non-peak hours. EEI did not offer any data to support its conjecture and, therefore, DOE maintained the electricity price methodology it used in the NOPR for this final rule.

To estimate energy prices in future years, DOE multiplied the average national energy prices by the projections of annual change in national-average commercial and industrial electricity prices in AEO 2016, which has an end year of 2040.⁸⁰ To estimate price trends after 2040, DOE used the average annual rate of change in prices from 2020 to 2040.

5. Maintenance and Repair Costs

Repair costs are associated with repairing or replacing product components that have failed in an appliance; maintenance costs are associated with maintaining the operation of the product. Typically, small incremental increases in product efficiency

⁸⁰ U.S. Department of Energy, Energy Information Administration, Annual Energy Outlook 2016 with Projections to 2040 (Available at: <www.eia.gov/forecasts/aeo/>). AEO 2016

produce no, or only minor, changes in repair and maintenance costs compared to baseline efficiency products.

Compressed Air Systems stated that maintenance costs would be higher for more efficient equipment due to the need for more frequent service. (Compressed Air Systems, No. 0061 at p. 3) Compressed Air Systems did not provide any rationale for this increase in service. In the absence of information to indicate what would drive the need for additional service, or at which efficiency level DOE may need to consider an increase in repair or maintenance costs, or other drivers that would trigger higher repair or maintenance costs for more efficient equipment, DOE has maintained the same approach as the NOPR and not estimated repair or maintenance costs for this analysis.

6. Equipment Lifetime

DOE defines equipment lifetime as the age when a given air compressor is retired from service. For this analysis, DOE continued to use an estimated average lifetime of 13 years for the compressors examined in this rulemaking, with a minimum and maximum of 4 and 35 years, respectively

DOE estimated average lifetime by equipment class based existing literature and used these estimates to develop statistical distributions. DOE defines two types of lifetime: (1) mechanical lifetime, that is the total lifetime hours of operation (including routine maintenance and repairs); and (2) service lifetime, that is the number of years the consumer owns and uses the unit, and is equal to the mechanical lifetime divided by the annual hours of operation. The service lifetime is the direct input to the LCC. DOE

presented the minimum, average, and maximum equipment lifetimes estimates in the NOPR notice and at the NOPR public meeting. FR 81 71723.

Sullivan-Palatek stated that they believed that DOE overstated the average life expectancy because DOE did not consider compressors removed from service when a plant closes or when an upgrade to more capacity is needed. (Sullivan-Palatek, No. 0051 at p. 3) Compressed Air Systems stated that it agreed with the lifetime DOE presented in the NOPR. (Compressed Air Systems, No. 0061 at p. 3)

DOE reflects the uncertainty of equipment service lifetimes in the LCC analysis for equipment by using probability distributions described above. DOE maintains that the distribution of compressor lifetimes that it used captures situations such as those mentioned by Sullivan-Palatek. For this final rule, DOE maintained its approach from the NOPR and based equipment lifetimes on information published in the Lot31 study.⁸¹

Sullivan-Palatek commented that equipment life is affected by the number of hours used, maintenance, installation and duty cycle. (Sullivan-Palatek, No. 0051 at p. 7) DOE used a distribution of lifetimes to capture the variability of lifetimes of compressors in the field. Because air compressors with more annual operating hours tend to have shorter lifetimes in years, DOE used a distribution of lifetime in hours to allow for a negative correlation between annual operating hours and lifetime in years. Due to the overall decreases in annual operating hours described in section IV.E.2, the estimated

⁸¹ [Ecodesign Preparatory Study on Electric Motor Systems/Compressors](http://www.regulations.gov/#!documentDetail;D=EERE-2013-BT-STD-0040-0031); 2014; Prepared for the European Commission by Van Holsteijn en Kemna B.V. (VHK); ENER/C3/413-2010-LOT 31-SI2.612161; www.regulations.gov/#!documentDetail;D=EERE-2013-BT-STD-0040-0031

average air compressor lifetime increased slightly from the NOPR (an average of 12.5 years) to the final rule (an average of 13.3 years).

Compressed Air Systems speculated that air compressors meeting the DOE standards may have a lower life expectancy as performance degradation will be more difficult to prevent. (Compressed Air Systems, No. 0061 at p. 3) Compressed Air Systems did not provide any evidence that would provide a basis for using different lifetimes for higher-efficiency compressors. DOE maintained the approach in the NOPR of using the same lifetime distribution for all considered efficiency levels.

Chapter 8 of the final rule TSD contains a detailed discussion of equipment lifetimes.

7. Discount Rates

The discount rate is the rate at which future expenditures 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 the cost of capital is the weighted-average 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.⁸² DOE estimated a separate distribution of weighted-average cost of capital for each business sector that purchases compressors. More details regarding DOE's estimates of end-user discount rates are provided in chapter 8 of the final rule TSD.

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

To accurately estimate the share of end users that would be affected by a potential energy conservation standard at a particular efficiency level, DOE's LCC analysis considered the projected distribution (i.e., market shares) of equipment efficiencies that end users purchase in the no-new-standards case (i.e., the case without new energy conservation standards). To estimate the efficiency distribution of air compressors for 2021, DOE examined the frequency of efficiencies made available under CAGI's voluntary testing program for each equipment class (CAGI database), and the distribution of efficiencies of shipments used in the pumps rulemaking,⁸³ scaled to the capacity range of compressors. DOE found the distribution for both samples to be similar, with the distribution of efficiencies of shipments for pumps skewed slightly toward higher efficiencies. DOE continued to use the re-scaled distribution of pump efficiencies, as it did in the NOPR, as it is based on the efficiencies of shipments of a durable industrial

⁸² Damodaran Online, The Data Page: Cost of Capital by Industry Sector, 2001-2013. (Last accessed March, 2014.) See: <http://pages.stern.nyu.edu/~adamodar/>.

⁸³ U.S. Department of Energy. Energy Efficiency and Renewable Energy Office. Energy Conservation Program: Energy Conservation Standards for Pumps; Notice of proposed rulemaking. 2015. See: www.regulations.gov/#!documentDetail;D=EERE-2011-BT-STD-0031-0040

product, rather than the frequency of efficiency of an entry in a catalog, and thus better reflects end user choice.

The estimated market shares for the no-new-standards case efficiency distribution for air compressors are shown in Table IV.19. See chapter 8 of the final rule TSD for further information on the derivation of the efficiency distributions.

Table IV.19 Distribution of Compressor Efficiencies in the No-New-Standards Case

| Efficiency Level (EL) | Average of Probability % | |
|-----------------------|--------------------------|---------------|
| | Air-cooled | Liquid-cooled |
| 0 | 12% | 12% |
| 1 | 16% | 16% |
| 2 | 16% | 16% |
| 3 | 18% | 18% |
| 4 | 6% | 6% |
| 5 | 11% | 11% |
| 6 | 22% | 22% |

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 products, compared to baseline products, through energy cost savings. Payback periods are expressed in years. Payback periods that exceed the life of the product 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 product and the change in the first-year annual operating expenditures relative to the baseline. The PBP calculation uses the same inputs as the LCC analysis, but does not include the discount rate.

As noted above, EPCA, as amended, establishes a rebuttable presumption that a standard is economically justified if the Secretary finds that the additional cost to the consumer of purchasing a product 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 calculated under the applicable test procedure. (42 U.S.C. 6295(o)(2)(B)(iii) and 6316(a)) For each considered efficiency level, DOE determined the value of the first year's energy savings by calculating the energy savings in accordance with the applicable DOE test procedure, and multiplying those savings by the average energy price projection for the year in which compliance with the standards would be required.

G. Shipments Analysis

DOE uses projections of annual equipment shipments to calculate the national impacts of potential energy conservation standards on energy use, NPV, and future manufacturer cash flows.⁸⁴ The shipments model takes an accounting approach, tracking market shares of each equipment class and the vintage of units in the stock. Stock accounting uses equipment shipments as inputs to estimate the age distribution of in-service equipment stocks for all years. The age distribution of in-service equipment

⁸⁴ DOE uses data on manufacturer shipments as a proxy for national sales, as aggregate data on sales is lacking. In general one would expect a close correspondence between shipments and sales.

stocks is a key input to calculations of both the NES and NPV, because operating costs for any year depend on the age distribution of the stock.

For the NOPR analysis, DOE received recent shipments data for rotary compressors from a number of stakeholders and subject matter experts. DOE received no adverse comments regarding the shipments projections presented in the NOPR of the equipment covered in this final rule, so DOE did not revise its overall approach to the shipments analysis for this final rule.

The 2013 shipments estimates were disaggregated by compressor capacity in cubic feet per minute (“cfm”). To project future shipments of air compressors, DOE scaled the 2013 values using macroeconomic forecasts for Value of Total Manufacturing Shipments, and Commercial Floor Space trend from AEO 2016 for industrial and commercial sectors, respectively.

Air compressors are used widely in both commercial and manufacturing/industrial sectors. DOE was not able to locate any information indicating what fraction of equipment is used in either sector. For the NOPR, DOE assumed that industrial/manufacturing processes require a greater volume of compressed air than commercial processes. Due to higher electrical load requirements in the industrial/manufacturing sector than in the commercial sector, DOE assumed that compressors greater than 50 cfm capacity are mainly used in manufacturing, and that compressors equal to or less than 50 cfm capacity are mainly used in commercial buildings.

Sullivan-Palatek stated that DOE should not assume a hard break between commercial and industrial compressor at 50 cfm. Rather there is a gradual “blend” as capacity increases. (Sullivan-Palatek, No. 044 Public Meeting Transcript at pp. 111-112) DOE agreed with this assessment and revised its distribution between industrial and commercial sectors by applying a more gradual shift as capacity increases. The assumed distribution of compressors to the commercial sector by capacity covered in this final rule are shown in Table IV.20.

Table IV.20 Distribution of Compressors to the Commercial Sector by Capacity

| Full-Load Actual Volume Flow Rate (cfm) | Share of Shipments % | | | |
|---|----------------------|------------|------------|------------|
| | RP_FS_L_AC | RP_FS_L_WC | RP_VS_L_AC | RP_VS_L_WC |
| ≥ 35 to < 50 | 63 | 63 | 63 | 63 |
| ≥ 50 to < 100 | 31 | 31 | 31 | 31 |
| ≥ 100 to < 200 | 6 | 6 | 6 | 6 |
| ≥ 200 to < 300 | 0 | 0 | 0 | 0 |
| ≥ 500 to < 1000 | 0 | 0 | 0 | 0 |
| ≥ 1,000 to < 1250 | 0 | 0 | 0 | 0 |

For rotary equipment classes, DOE used CAGI test data for air compressors collected directly from manufacturers to distribute shipments into the different cooling type equipment classes. The equipment classes and their estimated market shares are shown in Table IV.21. DOE used the same shares for all years in the projection.

Table IV.21 Share of Shipments by Equipment Class

| Equipment Class | Description | Market Share % |
|-----------------|--|----------------|
| RP_FS_L_AC | Rotary Screw, Fixed-Speed, Lubricated, Air Cooled | 70 |
| RP_FS_L_WC | Rotary Screw, Fixed-Speed, Lubricated, Liquid-Cooled | 13 |
| RP_VS_L_AC | Rotary Screw, Variable-Speed, Lubricated, Air Cooled | 15 |

DOE recognizes that an increase in equipment price resulting from energy conservation standards may affect end-user decisions making regarding whether to purchase a new compressor, a refurbished one, or repair an existing failed unit. DOE has not found any information in the literature that indicates a demand price elasticity for commercial and industrial firms. In the NOPR, DOE used a medium elasticity of -0.5 for commercial customers, and a lower elasticity (-0.25) for industrial customers.⁸⁵ DOE used a lower elasticity for industrial customers because these customers are likely to place greater value on the reliability and efficiency provided by new equipment over the alternative of purchasing used equipment. DOE received no comments on its assumed purchase price elasticities presented in the NOPR analysis, and maintained these assumptions for this final rule.

H. National Impact Analysis

The NIA assesses the national energy savings and the national net present value from a national perspective of total consumer costs and savings expected to result from new or amended standards at specific efficiency levels. (“Consumer” in this context refers to consumers of the covered equipment.) DOE calculates the NES and NPV for the potential standard levels considered based on projections of annual equipment shipments,

⁸⁵ A price elasticity of -0.5 means that for every 1 percent increase in price, the demand for the product (i.e., shipments) would decline by 0.5 percent. An elasticity of 1 indicates very high elasticity of demand, whereas an elasticity of zero indicates no elasticity of demand. Elasticities are considered constant over time.

along with the annual energy consumption and total installed cost data from the energy use and LCC analyses.⁸⁶ For the present analysis, DOE projected the energy savings, operating cost savings, equipment costs, and NPV of consumer benefits over the lifetime of air compressors sold from 2022 through 2051.

DOE evaluates the impacts of potential standards for compressors by comparing a case without such standards with standards-case projections. For the no-new-standards case, DOE considers historical trends in efficiency and various forces that are likely to affect the mix of efficiencies over time. 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.22 summarizes the inputs and methods DOE used for the NIA analysis for this final rule. Discussion of these inputs and methods follows the table. See chapter 10 of the final rule TSD for further details.

Table IV.22 Summary of Inputs and Methods for the National Impact Analysis

| Inputs | Method |
|---------------|--|
| Shipments | Annual shipments from shipments model. |

⁸⁶ For the NIA, DOE adjusts the installed cost data from the LCC analysis to exclude sales tax, which is a transfer.

| | |
|---|--|
| Compliance Date of Standard | Late 2021 (assumed Jan. 1, 2022 for analysis) |
| Efficiency Trends | No-new-standards case: constant market shares. |
| Annual Energy Consumption per Unit | Annual weighted-average values are a function of energy use at each TSL. |
| Total Installed Cost per Unit | Annual weighted-average values are a function of cost at each TSL. Incorporates projection of future equipment prices based on historical data. |
| Annual Energy Cost per Unit | Annual weighted-average values as a function of the annual energy consumption per unit and energy prices. |
| Repair and Maintenance Cost per Unit | Annual values do not change with efficiency level. |
| Energy Prices | <u>AEO 2016</u> projections (to 2040) and extrapolation thereafter. |
| Energy Site-to-Primary and FFC Conversion | Site-to-Primary: A time-series conversion factor based on <u>AEO 2016</u> . FFC: Utilizes data and projections published in <u>AEO 2016</u> . |
| Discount Rate | Three and seven percent. |
| Present Year | 2016. |

1. Equipment Efficiency Trends

A key component of the NIA is the trend in energy efficiency projected for the no-new-standards case and for each of the standards cases. Section IV.F.1 of this document describes how DOE developed an energy efficiency distribution for the no-new-standards case (which yields a shipment-weighted average efficiency) for each of the considered equipment classes for the first full year of anticipated compliance with a new standard.

For the NOPR, DOE examined data on the number of air compressor designs by efficiency for 2006 through 2015 from manufacturer performance test reports. However, DOE could determine no clear trend from the examination of the data, and DOE had no

data indicating what percentage of shipments are attributed to these more-efficient air compressors. Therefore, DOE did not apply a trend over time to air compressor efficiency.

CAGI commented that it was not plausible to assume that that there is no change, over time, in the market share of more efficient equipment, and that it would be difficult to arrive at an exact figure. (CAGI, No. 0052 at p. 11)

For the reasons described above, DOE maintained the approach from the NOPR for his final rule and did not apply a trend over time to air compressor efficiency in the no-new-standards case. However, DOE examined two scenarios where the efficiency of the market shifts to higher efficiency equipment over time. In the first scenario, the market shifts to higher efficiency levels at a rate of 0.5 percent each year; in the second scenario, the rate is 1 percent per year. The results of these scenarios can be found in appendix 10D of the final rule TSD.

For each standards case, DOE used a “roll-up” scenario to establish the market shares by efficiency level for the year that compliance would be required with new standards (i.e., late 2021). While DOE could not determine a clear trend in efficiency improvement over time, nor could DOE identify any clear drivers for energy efficiency. DOE does acknowledge that the range of compressor efficiencies in the market varies widely, with the majority of equipment sold above baseline efficiency in the no-new-standards case. This distribution of efficiencies is in Table IV.19 where The no-new-standards case DOE estimated that 88 percent of equipment sold is above baseline

efficiency. Therefore, after the compliance year, DOE maintained consistency with the no-new-standards case and assumed no change in efficiency.

2. National Energy Savings

The national energy savings analysis involves a comparison of national energy consumption of the considered products between each potential standards case (TSL) and the case with no new 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). DOE calculated annual NES based on the difference in national energy consumption for the no-new-standards case and for each higher efficiency standard case. DOE estimated energy consumption and savings based on site energy and converted the electricity consumption and savings to primary energy (*i.e.*, the energy consumed by power plants to generate site electricity) using annual conversion factors derived from [AEO 2016](#). Cumulative energy savings are the sum of the NES for each year over the timeframe of the analysis.

The site-to-primary energy conversion factors are estimated by sector and end-use. As there is no specific end-use for compressors for either the commercial or industrial sectors, in the NOPR DOE used conversion factors for refrigeration as a proxy because refrigeration has the potential to operate constantly as some compressors do in the field.

Edison Electric Institute commented that using the site-to-source conversion factors for refrigerators as a proxy was incorrect, as most compressors do not operate like

refrigerators. (EEI, Public Meeting Transcript, No. 0044 at p. 144) In response to this comment, for the final rule, DOE instead used an average of site-to-source conversion for all industrial and commercial end-uses.

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 greenhouse gas and other emissions in the national impact analyses and emissions analyses included in future energy conservation standards rulemakings. 76 FR 51281 (Aug. 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 National Energy Modeling System ("NEMS") is the most appropriate tool for its FFC analysis and its intention to use NEMS for that purpose. 77 FR 49701 (Aug. 17, 2012). NEMS is a public domain, multi-sector, partial equilibrium model of the U.S. energy sector⁸⁷ that EIA uses to prepare its Annual Energy Outlook. The FFC factors incorporate losses in production and delivery in the case of natural gas (including fugitive emissions) and additional energy used to produce and deliver the various fuels used by power plants. The approach used, for deriving FFC measures of energy use and emissions, is described in appendix 10A of the final rule TSD.

⁸⁷ For more information on NEMS, refer to The National Energy Modeling System: An Overview 2009, DOE/EIA-0581(2009), October 2009. Available at www.eia.gov/forecasts/aeo/index.cfm.

3. Net Present Value Analysis

The inputs for determining the NPV of the total costs and benefits experienced by consumers are (1) total annual installed cost, (2) total annual operating costs (energy costs and repair and maintenance costs), and (3) a discount factor to calculate the present value of costs and savings. DOE calculates net savings 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 each product shipped during the projection period.

As discussed in section IV.F.1 of this document, DOE does not find a firm basis to project a trend in air compressor prices, so DOE used constant real prices as the default. To evaluate the effect of uncertainty regarding the price trend estimates, DOE investigated the impact of different product price projections on the consumer NPV for the considered TSLs for air compressors. In addition to the default price trend, DOE considered two equipment price sensitivity cases: (1) a high price decline case based on Air and Gas Compressor Manufacturer historical Producer Price Index (“PPI”) series⁸⁸ and (2) a low price decline case based on AEO 2016 industrial equipment price trend. The derivation of these price trends and the results of these sensitivity cases are described in appendix 10C of the final rule TSD.

The operating cost savings are energy cost savings, which are calculated using the estimated energy savings in each year and the projected price of the appropriate form of

⁸⁸ U.S. Department of Labour, Bureau of Labor Statistics, Air & gas compressors, ex. compressors for ice making, refrigeration, or a/c equipment, Series ID: PCU33391233391211Z

energy. To estimate energy prices in future years, DOE multiplied the average regional energy prices by a projection of annual national-average commercial and industrial energy price changes consistent with the cases described on page E-8 in AEO 2016,⁸⁹ which has an end year of 2040. To estimate price trends after 2040, DOE used the average annual rate of change in prices from 2020 through 2040. As part of the NIA, DOE also analyzed scenarios that used inputs from variants of the AEO 2016 case that have lower and higher economic growth. Those cases have lower and higher energy price trends and the NIA results based on these cases are presented in appendix 10C of the final rule TSD.

In calculating the NPV, DOE multiplies the net savings in future years by a discount factor to determine their present value. For this final rule, DOE estimated the NPV of consumer benefits using both a 3-percent and a 7-percent real discount rate. DOE uses these discount rates in accordance with guidance provided by the Office of Management and Budget (“OMB”) to Federal agencies on the development of regulatory analysis.⁹⁰ 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

⁸⁹ U.S. Department of Energy–Energy Information Administration. Annual Energy Outlook 2016 with Projections to 2040. Washington, DC. Available at www.eia.gov/forecasts/aeo/. The standards finalized in this rulemaking will take effect before the requirements of the Clean Power Plan (CPP) as modeled in the AEO 2016 Reference case, putting downward pressure on electricity prices relative to that case. Consequently, DOE used the more conservative price projections found in the AEO 2016 No-CPP case.

⁹⁰ United States Office of Management and Budget. Circular A-4: Regulatory Analysis. September 17, 2003. Section E. Available at www.whitehouse.gov/omb/memoranda/m03-21.html.

preference,” which is the rate at which society discounts future consumption flows to their present value.

I. Consumer Subgroup Analysis

In analyzing the potential impact of new or amended energy conservation standards on consumers, DOE evaluates the impact of the new or amended standard on identifiable subgroups of consumers that may be disproportionately affected. The purpose of a subgroup analysis is to determine the extent of any such disproportional impacts. DOE evaluates impacts on particular subgroups of consumers by analyzing the LCC impacts and PBP for those particular consumers from alternative standard levels. For this final rule, DOE analyzed the impacts of the considered standard levels on small business consumers. DOE used the LCC and PBP spreadsheet model to estimate the impacts of the considered efficiency levels on this subgroup. Chapter 11 in the final rule TSD describes the consumer subgroup analysis.

J. Manufacturer Impact Analysis

1. Overview

DOE performed an MIA to estimate the financial impacts of new energy conservation standards on manufacturers of compressors and to estimate the potential impacts of such standards on employment and manufacturing capacity. The MIA has both quantitative and qualitative aspects and includes analyses of projected industry cash flows, the INPV, investments in research and development (“R&D”) and manufacturing capital, and domestic manufacturing employment. Additionally, the MIA seeks to determine how new energy conservation standards might affect manufacturing

employment, capacity, and competition, as well as how standards contribute to overall regulatory burden. Finally, the MIA serves to identify any disproportionate impacts on manufacturer subgroups, including small business manufacturers.

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 include data on the industry cost structure, unit production costs, unit shipments, manufacturer markups, and investments in research and development (R&D) and manufacturing capital required to produce compliant products. The key GRIM outputs are the INPV, which is the sum of industry annual cash flows over the analysis period, discounted using the industry-weighted average cost of capital, and the impact to domestic manufacturing employment. The model uses standard accounting principles to estimate the impacts of more-stringent energy conservation standards on a given industry by comparing changes in INPV and domestic manufacturing employment between a no-new-standards case and the various standards cases (TSLs). To capture the uncertainty relating to manufacturer pricing strategies following new standards, the GRIM estimates a range of possible impacts under different markup scenarios.

The qualitative part of the MIA addresses manufacturer characteristics and market trends. Specifically, the MIA considers such factors as a potential standard's impact on manufacturing capacity, competition within the industry, the cumulative impact of other DOE and non-DOE regulations, and impacts on manufacturer subgroups. The complete MIA is outlined in chapter 12 of the final rule TSD.

DOE conducted the MIA for this rulemaking in three phases. In Phase 1 of the MIA, DOE prepared a profile of the compressor manufacturing industry based on the market and technology assessment, preliminary manufacturer interviews, and publicly available information. This included a top-down analysis of compressor manufacturers that DOE used to derive preliminary financial inputs for the GRIM (e.g., revenues; materials, labor, overhead, and depreciation expenses; selling, general, and administrative expenses (“SG&A”); and R&D expenses). DOE also used public sources of information to further calibrate its initial characterization of the compressor manufacturing industry, including company filings of form 10-K from the SEC,⁹¹ corporate annual reports, the U.S. Census Bureau’s “Economic Census”⁹² and Hoover’s reports to conduct this analysis.⁹³

In Phase 2 of the MIA, DOE prepared a framework industry cash-flow analysis to quantify the potential impacts of new energy conservation standards on compressors. The GRIM uses several factors to determine a series of annual cash flows starting with the announcement of the standard and extending over a 30-year period following the compliance date of the standard. These factors include annual expected revenues, costs of sales, SG&A and R&D expenses, taxes, and capital expenditures. In general, energy conservation standards can affect manufacturer cash flow in three distinct ways:

⁹¹ U.S. Securities and Exchange Commission, Annual 10-K Reports (Various Years) (Available at: www.sec.gov/edgar/searchedgar/companysearch.html).

⁹² U.S. Census Bureau, Annual Survey of Manufacturers: General Statistics: Statistics for Industry Groups and Industries (2014) (Available at: <http://factfinder2.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t>).

⁹³ Hoovers Inc. Company Profiles, Various Companies (Available at: www.hoovers.com).

(1) creating a need for increased investment, (2) raising production costs per unit, and (3) altering revenue due to higher per-unit prices and changes in sales volumes.

In addition, during Phase 2, DOE developed interview guides to distribute to manufacturers of compressors in order to develop other key GRIM inputs, including product and capital conversion costs, and to gather additional information on the anticipated effects of energy conservation standards on revenues, direct employment, capital assets, industry competitiveness, and subgroup impacts.

In Phase 3 of the MIA, DOE evaluated subgroups of manufacturers that may be disproportionately impacted by energy conservation standards or that may not be represented accurately 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 greatly differs from the industry average could be more negatively affected. DOE identified one subgroup for a separate impact analysis: small business manufacturers. The small business subgroup is discussed in section VII.B, “Review under the Regulatory Flexibility Act” and in chapter 12 of the final rule TSD.

2. Government Regulatory Impact Model and Key Inputs

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 uses a standard, annual discounted cash-flow analysis 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 a

new energy conservation standard. The GRIM spreadsheet uses the inputs to arrive at a series of annual cash flows, beginning in 2016 (the reference year of the analysis) and continuing to 2051 (the end of the analysis period). DOE calculated INPVs by summing the stream of annual discounted cash flows during this period. For manufacturers of compressors, DOE used a real discount rate of 8.7-percent, which was derived from industry financials and then modified according to feedback received during manufacturer interviews.

The GRIM calculates cash flows using standard accounting principles and compares changes in INPV between the 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 new energy conservation standard on manufacturers. As discussed previously, DOE developed critical GRIM inputs using a number of sources, including publicly available data, results of the engineering analysis, and information gathered from industry stakeholders during the course of manufacturer interviews. The GRIM results are presented 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 final rule TSD.

a. 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 costlier than baseline components. The changes in the manufacturer production cost (MPC) of the analyzed equipment can affect the revenues, gross margins,

and cash flow of the industry, making the equipment cost data key GRIM inputs for DOE's analysis.

Costs associated with the MPC includes raw materials and purchased components, production labor, factory overhead, and production equipment depreciation. In the MIA, DOE used the MPCs for each efficiency level calculated in the engineering analysis, as described in section IV.C.7 and further detailed in chapter 5 of the final rule TSD.

b. Shipments Projections

The GRIM estimates manufacturer revenues based on total unit shipment projects and the distribution of those shipments by efficiency level. Changes in sales volumes and efficiency mix over time can significantly affect manufacturer finances. For this analysis, the GRIM uses the NIA's annual shipment projections derived from the shipments analysis from 2016 to 2051. The shipments model divides the shipments of compressors into specific market segments. The model starts from a historical reference year and calculates retirements and shipments by market segment for each year of the analysis period. This approach produces an estimate of the total product stock, broken down by age or vintage, in each year of the analysis period. In addition, the product stock efficiency distribution is calculated for the no-new-standards case and for each standards case for each equipment class. The NIA shipments forecasts are, in part, based on a roll-up scenario. The forecast assumes that a product in the no-new-standards case that does not meet the standard under consideration would "roll up" to meet the new standard

beginning in the compliance year of 2022. See section IV.G of this document and chapter 9 of the final rule TSD for additional details.

c. Product and Capital Conversion Costs

New energy conservation standards for compressors could cause manufacturers to incur 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 product 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 investments in research, development, testing, marketing, and other non-capitalized costs necessary to make product designs comply with new energy conservation standards. Capital conversion costs are investments in property, plant, and equipment necessary to adapt or change existing production facilities such that new compliant product designs can be fabricated and assembled. To evaluate the level of capital conversion costs manufacturers would likely incur to comply with new energy conservation standards, DOE used manufacturer interviews to gather data on the anticipated level of capital investment that would be required at each efficiency level. Based on equipment listings, provided by the engineering analysis, DOE developed industry average capital expenditure by weighting manufacturer feedback based on model offerings as a proxy for market-share. DOE supplemented manufacturer comments and tailored its analyses with information obtained during engineering analysis described in chapter 5 of the final rule TSD.

DOE assessed the product conversion costs at each considered efficiency level by integrating data from quantitative and qualitative sources. DOE received feedback regarding the potential costs of each efficiency level from multiple manufacturers to estimate product conversion costs (e.g., R&D expenditures, certification costs). DOE combined this information with product listings to estimate how much manufacturers would have to spend on product development and product testing at each efficiency level. Manufacturer data was aggregated to better reflect the industry as a whole and to protect confidential information.

Ultimately, for the MIA, DOE modeled two standards-case conversion cost scenarios to represent uncertainty regarding the potential impacts on manufacturers following the implementation of energy conservation standards. These scenarios and figures used in the GRIM are further discussed in chapter 12 of the final rule TSD.

d. Markup Scenarios

As discussed previously, MSPs include direct manufacturing production costs (i.e., labor, materials, and overhead estimated in DOE's MPCs) and all non-production costs (i.e., SG&A, R&D, and interest), along with profit. To calculate the MSPs in the GRIM, DOE applied a baseline manufacturer markup to the MPCs estimated in the engineering analysis for each product class and efficiency level in both the no-new-standards case and the standards case.

With a baseline markup, DOE applied a uniform "gross margin percentage" for each equipment class, across all efficiency levels. This 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, the absolute dollar markup will increase as well. As discussed in section V.B.2.a, DOE estimated the average non-production cost baseline markup—which includes SG&A expenses, R&D expenses, interest, and profit—to be 1.35 for lubricated rotary compressors. For the purpose of this final rule analysis, the GRIM only analyzed lubricated, rotary compressors. All results in the MIA are presented for lubricated rotary compressors only. Additional details on markups can be found in chapter 12 of the final rule TSD.

3. Discussion of Comments

During the notice of proposed rulemaking public meeting, interested parties commented on the assumptions and results of the analyses. Verbal and written comments addressed several topics, including concerns regarding EU harmonization, testing impacts, impacts on packagers, and small business impacts.

a. EU Harmonization

Several stakeholders commented that DOE should consider the cumulative regulatory burden of simultaneous energy conservation standards that the industry is currently facing, particularly with the European Union's standards. In a joint comment, stakeholders stated that DOE should refine its analysis to include the cost effectiveness of full harmonization with the pending EU Compressor energy efficiency standards. Some manufacturers have already begun preparations for the proposed EU standard.

Additionally, stakeholders commented that DOE should analyze the returns from the

increased scale of production and a shared learning curve with international standards harmonization to consider the differential cost of development for products designed to comply. If U.S. and EU standards are not harmonized, these manufacturers noted they would either have to carry a greater number of equipment lines to comply with efficiency standards in both domestic and European markets, or sell a single set of high efficiency equipment in both markets. Either option will be cumbersome for manufacturers.

(ASAP; ACEEE; NEEA; NRDC; NEEP; ASE, No. 60 at p. 3)

On the other hand, Sullivan-Palatek commented that some manufacturers only have U.S. operations and cannot take advantage of harmonizing with EU standards. Therefore, it would not be beneficial for all manufacturers to harmonize with EU standards. (Sullivan-Palatek, Public Meeting Transcript No. 44 at p. 127)

In response, DOE acknowledges that harmonization with EU standards would reduce cumulative regulatory burden for some manufacturers. In the test procedure final rule, DOE excluded non-lubricated rotary compressors from the scope of test procedures in part to help manufacturers harmonize with the EU's standards. In this final rule, DOE modeled a low conversion cost scenario that accounts for potential synergies with the potential EU standard. In this scenario, industry has lower total conversion costs based synergies with the EU Standards, as proposed in EU's "Lot 31" analysis, which set air compressor standards for both reciprocating and rotary air compressors. As such, EU standards were considered as a factor in DOE's analysis. Further, to account for feedback that harmonization with EU standards would not be beneficial to industry, DOE modeled

a high conversion cost scenario that reflects higher level of investments by manufacturers.

b. Testing Impacts

Sullivan-Palatek and Castair stated that a complex sampling and compliance program is a burden to such a low-volume specialty industry, particularly due to the staff, software and testing facilities required. These commenters were concerned that the test procedure, even with AEDMs, do not align with current testing methods used by the industry over the past 10 years. (Sullivan-Palatek, Public Meeting Transcript No. 0044 at p. 154-155; Castair, No. 45 at pp. 1-2) To address comments raised in both the test procedure rulemaking and the standards rulemaking, DOE amended the compressor test procedure to align as closely as possible to ISO 1217:2009 in order to reduce manufacturer burden. With these modifications, the test methods established in the final rule are intended to produce results equivalent to those produced historically under ISO 1217:2009. Consequently, if historical test data is consistent with values that will be generated when testing with the test methods established in this final rule, then manufacturers may use this data for the purposes of representing any metrics subject to representations requirements. (DOE, Public Meeting Transcript, No. 0016 at p. 136)

Jenny Products and Compressed Air Systems commented that the high cost to comply with the test procedure and standard would place a significant burden on small manufacturers. (Jenny Products, No. 58 at p. 5; Compressed Air Systems, No. 61 at p. 4) Additionally, Jenny and CAGI raised concerns that the testing process would require

technical resources that would come at the expense of other priorities, such as customer service. (Jenny Products, No. 58 at p. 5; CAGI, No. 52 at p. 3)

Compressed Air Systems noted that testing four to five units based on the NOPR test procedure could cost up to \$125,000 for a manufacturer. Most domestic small air compressor manufacturers produce small quantities of each model offered, which is a heavy cost burden to smaller companies with limited access to capital. (Compressed Air Systems, No. 61 at p. 4)

DOE understands the commenter's concerns about the scope of the test procedure as defined in the test procedure NOPR, which included many low-shipment volume or custom compressor models. In the test procedure final rule, DOE takes two key steps to address commenters' concerns and to reduce the burden of testing, especially for low-volume equipment. First, DOE significantly limits the scope of the test procedure final rule, as compared to the scope proposed in the test procedure NOPR. Second, DOE adopts provisions allowing the use of an alternative efficiency determination method (AEDM), in lieu of testing.

The revised scope aligns with the scope recommended by CAGI and other manufacturers. Further, the 10 to 200 hp scope established in the test procedure final rule falls within the scope of the CAGI Performance Verification Program for rotary compressors. A complete discussion can be found in the test procedure final rule.

In addition, the test procedure final rule adopts provisions allowing for the use of AEDMs. AEDMs are mathematical calculations or models that manufacturers may use to predict the energy efficiency or energy consumption characteristics of a basic model. The use of AEDMs are intended to reduce the need for physical testing and to reduce the overall testing burden for manufacturers.

c. Impacts on Packagers

During the NOPR public meeting, Sullivan-Palatek and Compressed Air Systems stated that packagers would incur engineering expenses as a result of the standard. They requested DOE incorporate cost estimates for packagers to comply with the standard in the revised analysis. (Compressed Air Systems; Sullivan-Palatek, Public Meeting Transcript No. 44 at p. 138-140) In written comments, Jenny Products stated that DOE should include in its cost estimate engineering redesign and certification costs for packagers. Jenny Products stated that the redesign of air ends by OEMs will only partially help packagers meet the standard. (Jenny Products, No. 58 at p. 4) In written comments, Sullivan-Palatek estimated packagers could have engineering redesign costs that exceed \$1 million per company, depending on the number of models they offer. (Sullivan-Palatek, No. 51 at p. 1-2) Additionally, Castair requested that American air compressor packagers be exempt from this regulation (Castair, No. 18 at p. 2). (CAGI, No. 52 at p. 3) (Sullivan-Palatek, No. 51 at p. 2)

Sullivan-Palatek commented that contrary to DOE's assumption, this standard will result in significant production redesign costs for compressor packagers. They argue that the cost to packagers could in fact exceed \$1 million per company because many of

the energy gains required by this standard come not only from air end redesign, but also from packaging. (Sullivan-Palatek, No. 51 at p. 1-2) Additionally, Castair requested that American air compressor packagers be exempt from this regulation (Castair, No. 18 at p. 2).(CAGI, No. 52 at p. 3)

Although DOE is not exempting packagers from the analysis, DOE has revised its analysis to calculate and include costs associated with packagers in its final rule analysis. DOE estimates that packagers will incur between \$10.5 and \$15.2 million in total engineering redesign costs to comply with the energy conservation standards of this final rule. As such, DOE has included this cost to packagers in total conversion costs estimated at TSL 2, which are between \$98.1 million and \$121.3 million for the industry. Details of the conversion cost methodology are described in chapter 12 of the final rule TSD.

d. Small Business Impacts

Many manufacturers stated that small businesses will be negatively affected by the proposed regulation compared to their larger multinational counterparts. Sullivan-Palatek stated that it is difficult for small businesses to access capital compared to their larger competitors. (Sullivan-Palatek, Public Meeting Transcript No. 44 at p. 141-143) A few manufacturers also noted that a stringent standard can cause a disproportionate cost burden to small business. This burden will likely cause many small businesses to exit the rotary compressor business or to be acquired by larger companies. (Sullivan-Palatek, No. 51 at p. 2-9) (Castair, No. 52 at p. 3) (Compressed Air Systems, No. 61 at p. 4) Often times, these small businesses, both manufacturers and packagers, employ specialized

workers that may not be able to find a new job where they can use their skills. (Sullivan-Palatek, No. 51 at p. 9; Castair, No. 45 at p. 1; CAGI, No. 52 at p. 3)

Consistent with the requirements of the Regulatory Flexibility Act (5 U.S.C. 601, et seq.), as amended, the Department analyzed the expected impacts of an energy conservation standard on small business compressor manufacturers directly regulated by DOE's standards. DOE understands that small manufacturers may be significantly affected by an energy conservation standard. These impacts are discussed in detail in section VII.B. Furthermore, DOE analyzes the impacts of a compressors energy conservation standard on domestic direct employment in section V.B.2.b.

Additionally, Sullivan-Palatek questioned how a smaller firm, such as their own, with the same number of models requiring conversion as a large manufacturer, would have fewer conversion costs. The company requested an independent analysis by the Department of Justice. (Sullivan-Palatek, No. 51 at p. 8-9)

In the NOPR, DOE reported an average conversion cost for small manufacturers. Depending on the number of models offered and equipment efficiencies, small manufacturers may find that their conversion costs fall either above or below the small business average. In the NOPR and final rule analyses, DOE identified two small OEMs. For those two small OEMs, DOE identified 23 failing models or models that do not comply with the standard. DOE notes that 21 of the 23 failing models are manufactured by one small business OEM, which is Sullivan-Palatek. Sullivan-Palatek has a

significant portion of failing models is above the industry average failure rate. A more detailed analysis of small business impacts can be found in section VI.B.

During the notice of proposed rulemaking public meeting, DOE cautioned stakeholders that Small Business Administration (“SBA”) size standards may shift before the final rule is published. Sullair and CAGI commented that with an increased size standard, from 500 employees to 1,000 employees, the number of OEMs identified would increase as well. (CAGI, Public Meeting Transcript No. 44 at p. 141; Sullair, Public Meeting Transcript No. 44 at p. 140)

For the compressor manufacturing industry, the SBA sets size threshold, which defines those entities classified as small businesses for the purpose of this statute. Compressor manufacturers are classified under NAICS 333912, “Air and Gas Compressor Manufacturing.” During the NOPR stage, the SBA set a threshold of 500 employees or less for an entity to be considered as a small business in this industry. In February 2016, as codified in 13 CFR part 121, the SBA changed size standards for NAICS code 333912 to 1,000 employees or less. Therefore, for the purpose of this final rule, DOE has identified 22 small manufacturers that meet the employee threshold defined by the SBA. The manufacturer impact analysis and regulatory flexibility analysis have been updated in the final rule to reflect the changes in SBA size standards.

Manufacturers stated that there are between 10-100 more small businesses affected by this rulemaking that were not previously identified by DOE during the NOPR

stage. With a number of small businesses unidentified, many were not notified or contacted for feedback prior to the regulation. Jenny Products noted DOE did not contact them during the NOPR stage. (Sullivan-Palatek, No. 51 at p. 1-2; Jenny Products, No. 58 at p. 4-5; Compressed Air Systems, No. 61 at p. 2; Castair, No. 45 at p. 2) In a written comment, Compressed Air Systems provided a list of sixteen potential small businesses that could be affected by this final rule. They also noted that while DOE's analysis shows that most units manufactured by small businesses can comply with the standards of this final rule, small businesses will still face high burdens testing each model. (Compressed Air Systems, No. 61 at p. 2-5) As such, Compressed Air Systems asked that DOE conduct a more thorough survey of domestic small businesses to understand how a stringent standard will lessen their ability to remain competitive in the market. (Compressed Air Systems, No. 61 at p. 2-5)

DOE recognizes that small manufacturers may be substantially impacted by energy conservation standards. Again, DOE notes in the Regulatory Flexibility Act, section VI.B of this final rule notice, that small manufacturers are not expected to face significantly higher conversion costs than their larger competitors. In response to the list of manufacturers provided by Compressed Air Systems, DOE reviewed this list and identified two additional entities that produce covered equipment. Of these two entities, one was a large manufacturer and the other was a domestic small business that packages and assembles covered equipment. DOE has updated its manufacturer count and analyses to reflect these additions. During the NOPR stage, DOE attempted to contact all

small manufacturers identified at the time, including Jenny Products. Only two small manufacturers chose to participate in interviews with DOE.

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 CO₂, NO_x, SO₂, and Hg. The second component estimates the impacts of potential standards on emissions of two additional greenhouse gases, CH₄ and N₂O, 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.

The analysis of power sector emissions uses marginal emissions factors that were derived from data in AEO 2016, as described in section IV.M. Details of the methodology are described in the appendices to chapters 13 and 15 of the final rule TSD.

Combustion emissions of CH₄ and N₂O are estimated using emissions intensity factors published by the EPA—GHG Emissions Factors Hub.⁹⁴ The FFC upstream emissions are estimated based on the methodology described in chapter 15 of the final rule TSD. The upstream emissions include both emissions from fuel combustion during

⁹⁴ Available at www2.epa.gov/climateleadership/center-corporate-climate-leadership-ghg-emission-factors-hub.

extraction, processing, and transportation of fuel, and “fugitive” emissions (direct leakage to the atmosphere) of CH₄ and CO₂.

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.

The AEO incorporates the projected impacts of existing air quality regulations on emissions. AEO 2016 generally represents current legislation and environmental regulations, including recent government actions, for which implementing regulations were available as of February 29, 2016. DOE’s estimation of impacts accounts for the presence of the emissions control programs discussed in the following paragraphs.

SO₂ 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 SO₂ for affected EGUs in the 48 contiguous States and the District of Columbia (D.C.). (42 U.S.C. 7651 et seq.) SO₂ emissions from 28 eastern States and D.C. 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.⁹⁵ In 2011, EPA issued a replacement for CAIR, the Cross-State Air Pollution Rule (“CSAPR”). 76 FR

⁹⁵ See North Carolina v. EPA, 531 F.3d 896 (D.C. Cir. 2008), modified on rehearing, 550 F.3d 1176 (D.C. Cir. 2008).

48208 (Aug. 8, 2011). On August 21, 2012, the D.C. Circuit issued a decision to vacate CSAPR,⁹⁶ and the court ordered EPA to continue administering CAIR. On April 29, 2014, the U.S. Supreme Court reversed the judgment of the D.C. Circuit and remanded the case for further proceedings consistent with the Supreme Court's opinion.⁹⁷ On October 23, 2014, the D.C. Circuit lifted the stay of CSAPR.⁹⁸ Pursuant to this action, CSAPR went into effect (and CAIR ceased to be in effect) as of January 1, 2015.⁹⁹ AEO 2016 incorporates implementation of CSAPR.

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 SO₂ emission allowances resulting from the lower electricity demand caused by the adoption of an efficiency standard could be used to permit offsetting increases in SO₂ emissions by any regulated EGU. In past years, DOE recognized that there was uncertainty about the effects of efficiency standards on SO₂ emissions covered by the existing cap-and-trade system, but it concluded that negligible reductions in power sector SO₂ emissions would occur as a result of standards.

Beginning in 2016, however, SO₂ emissions will fall as a result of the Mercury and Air Toxics Standards (“MATS”) for power plants. 77 FR 9304 (Feb. 16, 2012). In

⁹⁶ See EME Homer City Generation, L.P. v. EPA, 696 F.3d 7 (D.C. Cir. 2012).

⁹⁷ See EPA v. EME Homer City Generation, L.P. 134 S. Ct. 1584 (U.S. 2014). The Supreme Court held in part that EPA’s methodology for quantifying emissions that must be eliminated in certain States due to their impacts in other downwind States was based on a permissible, workable, and equitable interpretation of the Clean Air Act provision that provides statutory authority for CSAPR.

⁹⁸ See EME Homer City Generation, L.P. v. EPA, Order (D.C. Cir. filed October 23, 2014) (No. 11-1302).

⁹⁹ On July 28, 2015, the D.C. Circuit issued its opinion regarding the remaining issues raised with respect to CSAPR that were remanded by the Supreme Court. The D.C. Circuit largely upheld CSAPR but remanded to EPA without vacatur certain States’ emission budgets for reconsideration. EME Homer City Generation, LP v. EPA, 795 F.3d 118 (D.C. Cir. 2015).

the MATS final rule, EPA established a standard for hydrogen chloride as a surrogate for acid gas hazardous air pollutants (“HAP”), and also established a standard for SO₂ (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, SO₂ 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 2016 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 SO₂ emissions. Under the MATS, emissions will be far below the cap established by CSPAR, so it is unlikely that excess SO₂ emissions allowances resulting from the lower electricity demand will be needed or used to permit offsetting increases in SO₂ emissions by any regulated EGU.¹⁰⁰ Because reduced electricity demand (and therefore reduced SO₂ emissions) will no longer be used to offset increases in SO₂ emissions elsewhere, DOE believes that energy conservation standards that decrease electricity generation will generally reduce SO₂ emissions in 2016 and beyond.

¹⁰⁰ DOE notes that on June 29, 2015, the U.S. Supreme Court ruled that the EPA erred when the agency concluded that cost did not need to be considered in the finding that regulation of hazardous air pollutants from coal- and oil-fired electric utility steam generating units (“EGUs”) is appropriate and necessary under section 112 of the Clean Air Act (“CAA”). Michigan v. EPA, 135 S. Ct. 2699 (2015). The Supreme Court did not vacate the MATS rule, and DOE has tentatively determined that the Court’s decision on the MATS rule does not change the assumptions regarding the impact of energy conservation standards on SO₂ emissions. Further, the Court’s decision does not change the impact of the energy conservation standards on mercury emissions. The EPA, in response to the U.S. Supreme Court’s direction, has now considered cost in evaluating whether it is appropriate and necessary to regulate coal- and oil-fired EGUs under the CAA. EPA concluded in its final supplemental finding that a consideration of cost does not alter the EPA’s previous determination that regulation of hazardous air pollutants, including mercury, from coal- and oil-fired EGUs, is appropriate and necessary. 79 Fed. Reg. 24420 (April 25, 2016). The MATS rule remains in effect, but litigation is pending in the D.C. Circuit Court of Appeals over EPA’s final supplemental finding MATS rule.

CSAPR established a cap on NO_x emissions in 28 eastern States and the District of Columbia. Energy conservation standards are expected to have little effect on NO_x emissions in those States covered by CSAPR 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 (Hg) 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 2016, 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 CO₂, CH₄, N₂O and NO_x that are expected to result from each of the TSLs considered. In order 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 projection period for each TSL. This section summarizes the basis for the values used for monetizing the emissions benefits and presents the values considered in this final rule.

1. Social Cost of Carbon

The Social Cost of Carbon (“SC-CO₂”) 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 SC-CO₂ are provided in dollars per metric ton of CO₂. A domestic SC-CO₂ value is meant to reflect the value of damages in the United States resulting from a unit change in CO₂ emissions, while a global SC-CO₂ value is meant to reflect the value of damages worldwide.

Under section 1(b)(6) 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 SC-CO₂ estimates presented here is to allow agencies to incorporate the monetized social benefits of reducing CO₂ emissions into 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 SC-CO₂ estimates, technical experts from numerous agencies met on a regular basis to consider public comments, explore the technical literature in relevant fields, and to discuss key model

inputs and assumptions. The main objective of this process was to develop a range of SC-CO₂ 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 SC-CO₂ estimates used in the rulemaking process.

a. Monetizing Carbon Dioxide Emissions

When attempting to assess the incremental economic impacts of CO₂ emissions, the analyst faces a number of challenges. A report from the National Research Council¹⁰¹ 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, SC-CO₂ estimates can be useful in estimating the social benefits of reducing CO₂ emissions. Although any numerical estimate of the benefits of reducing carbon dioxide emissions is subject to some uncertainty, that does not relieve DOE of its obligation to attempt to factor those benefits into its cost-benefit analysis. Moreover, the Interagency Working Group

¹⁰¹ National Research Council. Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use. 2009. National Academies Press: Washington, DC.

(“IWG”) SC-CO₂ estimates are supported by the existing scientific and economic literature. As a result, DOE has relied on the IWG SC-CO₂ estimates in quantifying the social benefits of reducing CO₂ emissions. DOE estimates the benefits from reduced (or costs from increased) emissions in any future year by multiplying the change in emissions in that year by the SC-CO₂ 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 current SC-CO₂ values reflect the IWG’s best assessment, based on current data, of the societal effect of CO₂ emissions. The IWG 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.

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 CO₂ emissions. The interagency group did not undertake any original analysis. Instead, it combined SC-CO₂ 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 that represented the

first sustained interagency effort within the U.S. government to develop an SC-CO₂ estimate for use in regulatory analysis. The results of this preliminary effort were presented in several proposed and final rules issued by DOE and other agencies.

b. Current Approach and Key Assumptions

After the release of the interim values, the IWG reconvened on a regular basis to generate improved SC-CO₂ estimates. Specifically, the IWG considered public comments and further explored the technical literature in relevant fields. It relied on three integrated assessment models (“IAM”) commonly used to estimate the SC-CO₂: 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 SC-CO₂ 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 IWG 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 IWG selected four sets of SC-CO₂ values for use in regulatory analyses. Three sets of values are based on the average SC-CO₂ from the three integrated assessment models, at discount rates of 2.5-, 3-, and 5-percent. The fourth set, which represents the 95th percentile SC-CO₂ 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 SC-CO₂ distribution. The values grow in real terms over time. Additionally, the IWG determined that a range of values from 7- percent to 23- percent should be used to adjust the global SC-CO₂ to calculate domestic effects,¹⁰² although preference is given to consideration of the global benefits of reducing CO₂ emissions. Table IV-23 presents the values in the 2010 IWG report.¹⁰³

Table IV-23 Annual SCC Values from 2010 IWG Report (2007\$ per Metric Ton CO₂)

| Year | Discount Rate and Statistic | | | |
|------|-----------------------------|---------|---------|-----------------------------|
| | 5% | 3% | 2.5% | 3% |
| | Average | Average | Average | 95 th 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 |

¹⁰² 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.

¹⁰³ United States Government–Interagency Working Group on Social Cost of Carbon. Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. February 2010. www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf.

| | | | | |
|------|------|------|------|-------|
| 2050 | 15.7 | 44.9 | 65.0 | 136.2 |
|------|------|------|------|-------|

In 2013 the IWG released an update (which was revised in July 2015) that contained SC-CO₂ values that were generated using the most recent versions of the three integrated assessment models that have been published in the peer-reviewed literature.¹⁰⁴ DOE used these values for this final rule. Table IV-24 shows the four sets of SC-CO₂ estimates from the 2013 interagency update (revised July 2015) in 5-year increments from 2010 through 2050. The full set of annual SC-CO₂ estimates from 2010 through 2050 is reported in appendix 14A of the final rule TSD. The central value that emerges is the average SC-CO₂ across models at the 3-percent discount rate. However, for purposes of capturing the uncertainties involved in regulatory impact analysis, the IWG emphasizes the importance of including all four sets of SC-CO₂ values.

**Table IV-24 Annual SC-CO₂ Values from 2013 IWG Update (Revised July 2015)
(2007\$ per Metric Ton CO₂)**

| Year | Discount Rate and Statistic | | | |
|------|-----------------------------|---------|---------|-----------------------------|
| | 5% | 3% | 2.5% | 3% |
| | Average | Average | Average | 95 th 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 |

¹⁰⁴ United States Government–Interagency Working Group on Social Cost of Carbon. Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. May 2013. Revised July 2015. www.whitehouse.gov/sites/default/files/omb/inforeg/scc-tds-final-july-2015.pdf.

It is important to recognize that a number of key uncertainties remain, and that current SC-CO₂ 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 SC-CO₂. 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.

DOE converted the values from the 2013 interagency report (revised July 2015) to 2015\$ using the implicit price deflator for gross domestic product (“GDP”) from the Bureau of Economic Analysis. For each of the four sets of SC-CO₂ cases, the values for emissions in 2020 are \$13.5, \$47.4, \$69.9, and \$139 per metric ton avoided (values expressed in 2015\$). DOE derived values after 2050 based on the trend in 2010–2050 in each of the four cases in the interagency update.

DOE multiplied the CO₂ emissions reduction estimated for each year by the SC-CO₂ 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 SC-CO₂ values in each case.

DOE received several comments on the development of and the use of the SCC values in its analyses. 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. (U.S. Chamber of Commerce, No. 0050 at p. 4) The Cato Institute stated that the current SCC estimates are discordant with the best scientific literature on the equilibrium climate sensitivity and the fertilization effect of carbon dioxide, and are based upon the output of integrated assessment models that have little utility because of their great uncertainties. The Cato Institute stated that until the SCC values are corrected, the SCC should be barred from use in this and all other Federal rulemakings. (Cato Institute, No. 0043 at pp. 1-2) IECA stated that before DOE applies any SCC estimate in its rulemaking, DOE must correct the methodological flaws that commenters have raised about the IWG's SCC estimate. IECA referenced a U.S. Government Accountability Office report that highlights severe uncertainties in SCC values. (IECA, No. 0048 at p. 2)

In contrast, the Joint Advocates stated that only a partial accounting of the costs of climate change (those most easily monetized) can be provided, which inevitably involves incorporating elements of uncertainty. The Joint Advocates commented that accounting for the economic harms caused by climate change is a critical component of sound benefit-cost analyses of regulations that directly or indirectly limit greenhouse

gases. The Joint Advocates stated that several Executive Orders direct Federal agencies to consider non-economic costs and benefits, such as environmental and public health impacts. (Joint Advocates, No. 0047 at pp. 2-3) Furthermore, the Joint Advocates argued that without an SCC estimate, regulators would by default be using a value of zero for the benefits of reducing carbon pollution, thereby implying that carbon pollution has no costs. The Joint Advocates stated that it would be arbitrary for a Federal agency to weigh the societal benefits and costs of a rule with significant carbon pollution effects but to assign no value at all to the considerable benefits of reducing carbon pollution. (Joint Advocates, No. 0047 at p. 3)

The Joint Advocates stated that assessment and use of the integrated assessment models (IAM) in developing the SCC values has been transparent. The Joint Advocates further noted that repeated opportunities for public comment demonstrate that the IWG's SCC estimates were developed and are being used transparently. (Joint Advocates, No. 0047 at p. 4) The Joint Advocates stated that (1) the IAMs used reflect the best available, peer-reviewed science to quantify the benefits of carbon emission reductions; (2) uncertainty is not a valid reason for rejecting the SCC analysis, and (3) the IWG was rigorous in addressing uncertainty inherent in estimating the economic cost of pollution. (Joint Advocates, No. 0047 at pp. 5, 17-18, 18-19) The Joint Advocates added that the increase in the SCC estimate in the 2013 update reflects the growing scientific and economic research on the risks and costs of climate change, but is still very likely an underestimate of the SCC. (Joint Advocates, No. 0047 at p. 4)

In response to the comments on the SCC, 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 IWG's reports, 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. The GAO report mentioned by IECA noted that the working group's processes and methods used consensus-based decision making, relied on existing academic literature and models, and took steps to disclose limitations and incorporate new information.¹⁰⁵ Although uncertainties remain, the revised SCC values 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.¹⁰⁶ DOE notes that not using SCC estimates because of uncertainty would be tantamount to

¹⁰⁵ www.gao.gov/products/GAO-14-663. (Last accessed Sept. 22, 2016)

¹⁰⁶ In November 2013, OMB announced a new opportunity for public comment on the interagency technical support document underlying the revised SCC estimates. In July 2015, OMB published a detailed summary and formal response to the many comments that were received. See 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.

assuming that the benefits of reduced carbon emissions are zero, which is inappropriate. Furthermore, the commenters have not offered alternative estimates of the SCC that they believe are more accurate.

IECA stated that the social cost of carbon places U.S. manufacturing at a distinct competitive disadvantage. IECA added that the higher SCC cost drives manufacturing companies offshore and increases imports of more carbon-intensive manufactured goods. (IECA, No. 0048 at pp. 1-2) The SCC is not a cost imposed on any manufacturers. It is simply a metric that Federal agencies use to estimate the societal benefits of policy actions that reduce CO₂ emissions.

IECA stated that the SCC estimates must be made consistent with OMB Circular A-4, and noted that it uses a lower discount rate than recommended by OMB Circular A-4 and values global benefits rather than solely U.S. domestic benefits. (IECA, No. 0048 at p. 5) The Cato Institute also stated that the SCC approach is at odds with existing OMB guidelines for preparing regulatory analyses. (Cato Institute, No. 0043 at p. 1)

OMB Circular A-4 provides two suggested discount rates for use in regulatory analysis: 3-percent and 7-percent. Circular A-4 states that the 3 percent discount rate is appropriate for "regulation [that] primarily and directly affects private consumption (e.g., through higher consumer prices for goods and services)." The interagency working group that developed the SCC values for use by Federal agencies examined the economics literature and concluded that the consumption rate of interest is the correct concept to use in evaluating the net social costs of a marginal change in CO₂ emissions, as the impacts

of climate change are measured in consumption-equivalent units in the three models used to estimate the SCC. The interagency working group chose to use three discount rates to span a plausible range of constant discount rates: 2.5-, 3-, and 5-percent per year. The central value, 3-percent, is consistent with estimates provided in the economics literature and OMB's Circular A-4 guidance for the consumption rate of interest.

Regarding the use of global SCC values, DOE's analysis estimates both global and domestic benefits of CO₂ emissions reductions. Following the recommendation of the IWG, DOE places more focus on a global measure of SCC. 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.

IECA stated that the social cost of carbon value is unrealistically high in comparison to carbon market prices. (IECA, No. 0048 at p. 3) The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year, whereas carbon trading prices in existing markets are simply a function of the demand and supply of tradable permits in those markets. Such prices depend on the arrangements in specific carbon markets, and bear no necessary relation to the damages associated with an incremental increase in carbon emissions.

2. Social Cost of Methane and Nitrous Oxide

The Joint Advocates stated that EPA and other agencies have begun using a methodology developed to specifically measure the social cost of methane in recent proposed rulemakings, and recommended that DOE should use the social cost of methane metric to more accurately reflect the true benefits of energy conservation standards. They stated that the methodology in the study used to develop the social cost of methane provides reasonable estimates that reflect updated evidence and provide consistency with the Government's accepted methodology for estimating the SCC. (Joint Advocates, No. 0047 at pp. 19-20)

While carbon dioxide is the most prevalent greenhouse gas emitted into the atmosphere, other GHGs are also important contributors. These include methane and nitrous oxide. Global warming potential values ("GWPs") are often used to convert

emissions of non-CO₂ GHGs to CO₂-equivalents to facilitate comparison of policies and inventories involving different GHGs. While GWPs allow for some useful comparisons across gases on a physical basis, using the social cost of carbon to value the damages associated with changes in CO₂-equivalent emissions is not optimal. This is because non-CO₂ GHGs differ not just in their potential to absorb infrared radiation over a given time frame, but also in the temporal pathway of their impact on radiative forcing, which is relevant for estimating their social cost but not reflected in the GWP. Physical impacts other than temperature change also vary across gases in ways that are not captured by GWP.

In light of these limitations and the paucity of peer-reviewed estimates of the social cost of non-CO₂ gases in the literature, the 2010 SCC Technical Support Document did not include an estimate of the social cost of non-CO₂ GHGs and did not endorse the use of GWP to approximate the value of non-CO₂ emission changes in regulatory analysis. Instead, the IWG noted that more work was needed to link non-CO₂ GHG emission changes to economic impacts.

Since that time, new estimates of the social cost of non-CO₂ GHG emissions have been developed in the scientific literature, and a recent study by Marten *et al.* (2015) provided the first set of published estimates for the social cost of CH₄ and N₂O emissions that are consistent with the methodology and modeling assumptions

underlying the IWG SC-CO₂ estimates.¹⁰⁷ Specifically, Marten et al. used the same set of three integrated assessment models, five socioeconomic and emissions scenarios, equilibrium climate sensitivity distribution, three constant discount rates, and the aggregation approach used by the IWG to develop the SC-CO₂ estimates. An addendum to the IWG’s Technical Support Document on Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866 summarizes the Marten et al. methodology and presents the SC-CH₄ and SC-N₂O estimates from that study as a way for agencies to incorporate the social benefits of reducing CH₄ and N₂O emissions into benefit-cost analyses of regulatory actions that have small, or “marginal,” impacts on cumulative global emissions.¹⁰⁸

The methodology and estimates described in the addendum have undergone multiple stages of peer review and their use in regulatory analysis has been subject to public comment. The estimates are presented with an acknowledgement of the limitations and 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, just as the IWG has committed to do for the SC-CO₂. The OMB has determined that the use of the Marten et al. estimates in regulatory analysis is consistent

¹⁰⁷ Marten, A.L., Kopits, E.A., Griffiths, C.W., Newbold, S.C., and A. Wolverton. 2015. Incremental CH₄ and N₂O Mitigation Benefits Consistent with the U.S. Government’s SC-CO₂ Estimates. Climate Policy. 15(2): 272-298 (published online, 2014).

¹⁰⁸ United States Government–Interagency Working Group on Social Cost of Greenhouse Gases. Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866: Application of the Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide. August 2016. www.whitehouse.gov/sites/default/files/omb/inforeg/august_2016_sc_ch4_sc_n2o_addendum_final_8_26_16.pdf.

with the requirements of OMB's Information Quality Guidelines Bulletin for Peer Review and OMB Circular A-4.

The SC-CH₄ and SC-N₂O estimates are presented in Table IV-25. Following the same approach as with the SC-CO₂, values for 2010, 2020, 2030, 2040, and 2050 are calculated by combining all outputs from all scenarios and models for a given discount rate. Values for the years in between are calculated using linear interpolation. The full set of annual SC-CH₄ and SC-N₂O estimates between 2010 and 2050 is reported in appendix 14-A of the final rule TSD. DOE derived values after 2050 based on the trend in 2010–2050 in each of the four cases in the IWG addendum.

Table IV-25 Annual SC-CH₄ and SC-N₂O Estimates from 2016 IWG Addendum (2007\$ per Metric Ton)

| Year | SC-CH ₄ | | | | SC-N ₂ O | | | |
|------|-----------------------------|---------|---------|-----------------------------|-----------------------------|---------|---------|-----------------------------|
| | Discount Rate and Statistic | | | | Discount Rate and Statistic | | | |
| | 5% | 3% | 2.5% | 3% | 5% | 3% | 2.5 % | 3% |
| | Average | Average | Average | 95 th percentile | Average | Average | Average | 95 th percentile |
| 2010 | 370 | 870 | 1,200 | 2,400 | 3,400 | 12,000 | 18,000 | 31,000 |
| 2015 | 450 | 1,000 | 1,400 | 2,800 | 4,000 | 13,000 | 20,000 | 35,000 |
| 2020 | 540 | 1,200 | 1,600 | 3,200 | 4,700 | 15,000 | 22,000 | 39,000 |
| 2025 | 650 | 1,400 | 1,800 | 3,700 | 5,500 | 17,000 | 24,000 | 44,000 |
| 2030 | 760 | 1,600 | 2,000 | 4,200 | 6,300 | 19,000 | 27,000 | 49,000 |
| 2035 | 900 | 1,800 | 2,300 | 4,900 | 7,400 | 21,000 | 29,000 | 55,000 |
| 2040 | 1,000 | 2,000 | 2,600 | 5,500 | 8,400 | 23,000 | 32,000 | 60,000 |
| 2045 | 1,200 | 2,300 | 2,800 | 6,100 | 9,500 | 25,000 | 34,000 | 66,000 |
| 2050 | 1,300 | 2,500 | 3,100 | 6,700 | 11,000 | 27,000 | 37,000 | 72,000 |

DOE multiplied the CH₄ and N₂O emissions reduction estimated for each year by the SC-CH₄ and SC-N₂O estimates 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 SC-CH₄ and SC-N₂O estimates in each case.

3. Social Cost of Other Air Pollutants

As noted previously, DOE estimated how the considered energy conservation standards would reduce power sector NO_x emissions in those 22 States not affected by CSAPR.

DOE estimated the monetized value of NO_x emissions reductions from electricity generation using benefit per ton estimates from the Regulatory Impact Analysis for the Clean Power Plan Final Rule, published in August 2015 by EPA's Office of Air Quality Planning and Standards.¹⁰⁹ The report includes high and low values for NO_x (as PM_{2.5}) for 2020, 2025, and 2030 using discount rates of 3-percent and 7-percent; these values are presented in appendix 14B of the final rule TSD. DOE primarily relied on the low estimates to be conservative.¹¹⁰ The national average low values for 2020 (in 2015\$) are \$3,187/ton at 3-percent discount rate and \$2,869/ton at 7-percent discount rate. DOE developed values specific to the sector for compressors using a method described in

¹⁰⁹ Available at www.epa.gov/cleanpowerplan/clean-power-plan-final-rule-regulatory-impact-analysis. See Tables 4A-3, 4A-4, and 4A-5 in the report. The U.S. Supreme Court has stayed the rule implementing the Clean Power Plan until the current litigation against it concludes. Chamber of Commerce, et al. v. EPA, et al., Order in Pending Case, 577 U.S. ____ (2016). However, the benefit-per-ton estimates established in the Regulatory Impact Analysis for the Clean Power Plan are based on scientific studies that remain valid irrespective of the legal status of the Clean Power Plan.

¹¹⁰ For the monetized NO_x benefits associated with PM_{2.5}, the related benefits are primarily based on an estimate of premature mortality used by EPA. If the benefit-per-ton estimates were based on the high-end estimates, the values would be nearly two-and-a-half times larger. Using the lower value is more conservative when making the policy decision concerning whether a particular standard level is economically 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 final rule TSD for citations for the studies mentioned above.)

appendix 14B of the final rule TSD. For this analysis DOE used linear interpolation to define values for the years between 2020 and 2025 and between 2025 and 2030; for years beyond 2030 the value is held constant.

DOE multiplied the emissions reduction (in 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 is evaluating appropriate monetization of reduction in other 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 generation 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 is based on published output from the NEMS associated with AEO 2016. NEMS produces the AEO Reference case, as well as a number of side cases that estimate the economy-wide impacts of changes to energy supply and demand. For the current analysis, impacts are quantified by comparing the levels of electricity sector generation, installed capacity, fuel consumption and emissions consistent with the projections described on page E-8 of AEO 2016 and various side cases. Details of the methodology are provided in the appendices to chapters 13 and 15 of the final rule TSD.

The output of this analysis is a set of time-dependent coefficients that capture 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 savings 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 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 consumers on energy, (2) reduced spending on new energy supply by the utility industry, (3) increased consumer spending on the products to which the new standards apply and other goods and services, 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”). 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 indicates that capital expenditures in the utility sector generally create fewer jobs (both directly and indirectly) than expenditures in other sectors of the economy.¹¹¹ 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 suggests that 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 final rule using an input/output model of the U.S. economy called Impact of Sector Energy Technologies version 4 (“ImSET”).¹¹² 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

¹¹¹ See U.S. Department of Commerce–Bureau of Economic Analysis. Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMS II). 1997. U.S. Government Printing Office: Washington, DC. Available at www.bea.gov/scb/pdf/regional/perinc/meth/rims2.pdf.

¹¹² Livingston, OV, SR Bender, MJ Scott, and RW Schultz (2015). ImSET 4.0: Impact of Sector Energy Technologies Model Description and User’s Guide. Pacific Northwest National Laboratory. PNNL-24563

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 used ImSET only to generate results for near-term timeframes (2027), where these uncertainties are reduced. For more details on the employment impact analysis, see chapter 16 of the final rule TSD.

V. Analytical Results and Conclusions

The following section addresses the results from DOE's analyses with respect to the considered energy conservation standards for compressors. It addresses the TSLs examined by DOE, the projected impacts of each of these levels if adopted as energy conservation standards for compressors, and the standards levels that DOE is adopting in this final rule. Additional details regarding DOE's analyses are contained in the final rule TSD supporting this notice.

A. Trial Standard Levels

DOE analyzed the benefits and burdens of six TSLs for compressors. These TSLs were developed by combining specific efficiency levels for each of the equipment classes

analyzed by DOE. DOE presents the results for the TSLs in this document, while the results for all efficiency levels that DOE analyzed are in the final rule TSD.

Table V.1 presents the TSLs and the corresponding efficiency levels for compressors. TSL 6 represents the maximum technologically feasible (“max-tech”) energy efficiency for all product classes. TSLs increase directly with the analyzed ELs, from EL 1 through max-tech (EL 6). TSL 3 is of significance because it represents a combination of efficiency levels that is equivalent to the draft EU second tier minimum energy efficiency requirement for rotary lubricated air compressors.¹¹³

Table V.1 Trial Standard Level to Efficiency Level Mapping

| Trial Standard Level | Efficiency Level (EL) | | | |
|----------------------|-----------------------|------------|------------|------------|
| | RP_FS_L_AC | RP_FS_L_WC | RP_VS_L_AC | RP_VS_L_WC |
| TSL 1 | EL 1 | EL 1 | EL 1 | EL 1 |
| TSL 2 | EL 2 | EL 2 | EL 2 | EL 2 |
| TSL 3 | EL 3 | EL 3 | EL 3 | EL 3 |
| TSL 4 | EL 4 | EL 4 | EL 4 | EL 4 |
| TSL 5 | EL 5 | EL 5 | EL 5 | EL 5 |
| TSL 6 | EL 6 | EL 6 | EL 6 | EL 6 |

B. Economic Justification and Energy Savings

1. Economic Impacts on Individual Consumers

DOE analyzed the economic impacts on compressors consumers by looking at the effects potential standards at each TSL would have on the LCC and PBP. DOE also

¹¹³ For more information regarding the draft regulation see: www.eup-network.de/product-groups/overview-ecodesign/

examined the impacts of potential standards on selected 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 price increases 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 final rule TSD provides detailed information on the LCC and PBP analyses.

The following tables show the LCC and PBP results for the TSLs considered for compressors. 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 in the no-new-standards case in the compliance year. Because some consumers purchase products with higher efficiency in the no-new-standards case, the average savings are less than the difference between the average LCC of the baseline product and the average LCC at each TSL. The savings refer only to consumers who are affected by a standard at a given TSL. Those who already purchase a product with efficiency at or above a given TSL are not affected. Consumers for whom the LCC increases at a given TSL experience a net cost.

Table V.2 Average LCC and PBP Results for RP_FS_L_AC

| TSL | Efficiency Level | Average Costs 2015\$ | | | | Simple Payback years | Average Lifetime years |
|-----|------------------|-------------------------|-----------------------------|-------------------------|---------|----------------------|------------------------|
| | | Installed Cost | First Year's Operating Cost | Lifetime Operating Cost | LCC | | |
| -- | Baseline | 21,698 | 12,793 | 105,575 | 127,273 | -- | 12.9 |
| 1 | 1 | 21,989 | 12,645 | 104,358 | 126,347 | 2.0 | 12.9 |
| 2 | 2 | 22,602 | 12,420 | 102,511 | 125,113 | 2.4 | 12.9 |
| 3 | 3 | 23,782 | 12,081 | 99,730 | 123,512 | 2.9 | 12.9 |
| 4 | 4 | 24,342 | 11,945 | 98,604 | 122,947 | 3.1 | 12.9 |
| 5 | 5 | 25,380 | 11,715 | 96,714 | 122,094 | 3.4 | 12.9 |
| 6 | 6 | 28,232 | 11,189 | 92,379 | 120,611 | 4.1 | 12.9 |

Note: The results for each TSL are calculated assuming that all consumers use equipment at that efficiency level. The PBP is measured relative to the baseline product.

Table V.3 Average LCC Savings Relative to the No-New-Standards Case for RP_FS_L_AC

| TSL | Efficiency Level | Life-Cycle Cost Savings | |
|-----|------------------|--------------------------------|---|
| | | Average LCC Savings* 2015\$ | Percent of Consumers that Experience Net Cost |
| 1 | 1 | 7,882 | 0 |
| 2 | 2 | 8,002 | 1 |
| 3 | 3 | 7,377 | 3 |
| 4 | 4 | 7,192 | 4 |
| 5 | 5 | 7,849 | 7 |
| 6 | 6 | 8,604 | 14 |

* The savings represent the average LCC for affected consumers.

Table V.4 Average LCC and PBP Results for RP_FS_L_WC

| TSL | Efficiency Level | Average Costs 2015\$ | | | | Simple Payback years | Average Lifetime years |
|-----|------------------|-------------------------|-----------------------------|-------------------------|---------|----------------------|------------------------|
| | | Installed Cost | First Year's Operating Cost | Lifetime Operating Cost | LCC | | |
| -- | Baseline | 37,548 | 24,433 | 204,247 | 241,795 | -- | 13.4 |
| 1 | 1 | 38,047 | 24,215 | 202,410 | 240,457 | 2.3 | 13.4 |
| 2 | 2 | 39,262 | 23,792 | 198,860 | 238,122 | 2.7 | 13.4 |
| 3 | 3 | 41,078 | 23,279 | 194,542 | 235,620 | 3.1 | 13.4 |
| 4 | 4 | 42,014 | 23,047 | 192,604 | 234,618 | 3.2 | 13.4 |
| 5 | 5 | 43,725 | 22,658 | 189,352 | 233,077 | 3.5 | 13.4 |
| 6 | 6 | 48,328 | 21,764 | 181,888 | 230,216 | 4.0 | 13.4 |

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline product.

Table V.5 Average LCC Savings Relative to the No-New-Standards Case for RP_FS_L_WC

| TSL | Efficiency Level | Life-Cycle Cost Savings | |
|-----|------------------|---------------------------------------|---|
| | | Average LCC Savings* <u>2015\$</u> | Percent of Consumers that Experience Net Cost |
| 1 | 1 | 11,644 | 0 |
| 2 | 2 | 10,559 | 1 |
| 3 | 3 | 14,398 | 2 |
| 4 | 4 | 11,615 | 5 |
| 5 | 5 | 12,907 | 7 |
| 6 | 6 | 14,684 | 12 |

* The savings represent the average LCC for affected consumers.

Table V.6 Average LCC and PBP Results for RP_VS_L_AC

| TSL | Efficiency Level | Average Costs <u>2015\$</u> | | | | Simple Payback <u>years</u> | Average Lifetime <u>years</u> |
|-----|------------------|--------------------------------|-----------------------------|-------------------------|---------|--------------------------------|----------------------------------|
| | | Installed Cost | First Year's Operating Cost | Lifetime Operating Cost | LCC | | |
| -- | Baseline | 37,068 | 11,363 | 93,018 | 130,086 | -- | 13.2 |
| 1 | 1 | 37,379 | 11,289 | 92,436 | 129,815 | 4.2 | 13.2 |
| 2 | 2 | 38,176 | 11,135 | 91,195 | 129,371 | 4.9 | 13.2 |
| 3 | 3 | 39,786 | 10,878 | 89,121 | 128,907 | 5.6 | 13.2 |
| 4 | 4 | 40,852 | 10,730 | 87,923 | 128,775 | 6.0 | 13.2 |
| 5 | 5 | 43,353 | 10,427 | 85,462 | 128,815 | 6.7 | 13.2 |
| 6 | 6 | 49,259 | 9,862 | 80,859 | 130,119 | 8.1 | 13.2 |

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline product.

Table V.7 Average LCC Savings Relative to the No-New-Standards Case for RP_VS_L_AC

| TSL | Efficiency Level | Life-Cycle Cost Savings | |
|-----|------------------|---------------------------------------|---|
| | | Average LCC Savings* <u>2015\$</u> | Percent of Consumers that Experience Net Cost |
| 1 | 1 | 2,343 | 2 |
| 2 | 2 | 2,618 | 6 |
| 3 | 3 | 2,248 | 17 |
| 4 | 4 | 2,130 | 23 |
| 5 | 5 | 1,885 | 31 |
| 6 | 6 | -41 | 48 |

* The savings represent the average LCC for affected consumers.

Table V.8 Average LCC and PBP Results for RP_VS_L_WC

| TSL | Efficiency Level | Average Costs 2015\$ | | | | Simple Payback years | Average Lifetime years |
|-----|------------------|-------------------------|-----------------------------|-------------------------|---------|-------------------------|---------------------------|
| | | Installed Cost | First Year's Operating Cost | Lifetime Operating Cost | LCC | | |
| -- | Baseline | 58,996 | 19,522 | 161,662 | 220,658 | -- | 13.5 |
| 1 | 1 | 59,644 | 19,361 | 160,316 | 219,959 | 4.0 | 13.5 |
| 2 | 2 | 61,546 | 18,996 | 157,279 | 218,825 | 4.9 | 13.5 |
| 3 | 3 | 64,746 | 18,513 | 153,269 | 218,015 | 5.7 | 13.5 |
| 4 | 4 | 66,394 | 18,298 | 151,492 | 217,886 | 6.0 | 13.5 |
| 5 | 5 | 70,200 | 17,855 | 147,820 | 218,020 | 6.7 | 13.5 |
| 6 | 6 | 79,660 | 16,960 | 140,401 | 220,061 | 8.1 | 13.5 |

Note: The results for each TSL are calculated assuming that all consumers use products at that efficiency level. The PBP is measured relative to the baseline product.

Table V.9 Average LCC Savings Relative to the No-New-Standards Case for RP_VS_L_WC

| TSL | Efficiency Level | Life-Cycle Cost Savings | |
|-----|------------------|--------------------------------|---|
| | | Average LCC Savings* 2015\$ | Percent of Consumers that Experience Net Cost |
| 1 | 1 | 6,199 | 1 |
| 2 | 2 | 5,145 | 8 |
| 3 | 3 | 6,118 | 14 |
| 4 | 4 | 4,496 | 25 |
| 5 | 5 | 3,918 | 32 |
| 6 | 6 | 754 | 48 |

* 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 that purchase compressors. Table V.10 compares the average LCC savings and PBP at each efficiency level for the consumer subgroups, along with the average LCC savings for the entire consumer sample. In most cases, the average LCC

savings and PBP small businesses that purchase compressors at the considered efficiency levels are not substantially different from the average for all consumers. Chapter 11 of the final rule TSD presents the complete LCC and PBP results for the subgroups.

Table V.10 Comparison of LCC Savings and PBP for Consumer Subgroups and All Consumers

| Equipment Class | Consumer Group | TSL 1 | TSL 2 | TSL 3 | TSL 4 | TSL 5 | TSL 6 |
|---|-----------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Average Life-Cycle Cost Savings (2015\$) | | | | | | | |
| RP_FS_L_AC | All Consumers | 7,882 | 8,002 | 7,377 | 7,192 | 7,849 | 8,604 |
| | Small Businesses | 6,284 | 6,423 | 5,885 | 5,709 | 6,143 | 6,451 |
| RP_FS_L_WC | All Consumers | 11,644 | 10,559 | 14,398 | 11,615 | 12,907 | 14,684 |
| | Small Businesses | 9,904 | 8,593 | 11,413 | 9,130 | 9,999 | 10,972 |
| RP_VS_L_AC | All Consumers | 2,343 | 2,618 | 2,248 | 2,130 | 1,885 | -41 |
| | Small Businesses | 1,860 | 1,910 | 1,424 | 1,200 | 602 | -1,850 |
| RP_VS_L_WC | All Consumers | 6,199 | 5,145 | 6,118 | 4,496 | 3,918 | 754 |
| | Small Businesses | 4,422 | 3,468 | 3,539 | 2,312 | 1,206 | -2,781 |
| Simple Payback Period <u>years</u> | | | | | | | |
| RP_FS_L_AC | All Consumers | 2.0 | 2.4 | 2.9 | 3.1 | 3.4 | 4.1 |
| | Small Businesses | 2.0 | 2.5 | 3.0 | 3.2 | 3.5 | 4.1 |
| RP_FS_L_WC | All Consumers | 2.3 | 2.7 | 3.1 | 3.2 | 3.5 | 4.0 |
| | Small Businesses | 2.3 | 2.7 | 3.1 | 3.3 | 3.6 | 4.1 |
| RP_VS_L_AC | All Consumers | 4.2 | 4.9 | 5.6 | 6.0 | 6.7 | 8.1 |

| | | | | | | | |
|---------|---------------------|-----|-----|-----|-----|-----|-----|
| | Small Businesses | 4.2 | 4.9 | 5.7 | 6.1 | 6.8 | 8.2 |
| RP_VS_L | All Consumers | 4.1 | 4.9 | 5.8 | 6.1 | 6.8 | 8.2 |
| WC | Small Businesses | 4.1 | 4.9 | 5.8 | 6.1 | 6.8 | 8.2 |

c. Rebuttable Presumption Payback

As discussed in section III.H.2, U.S.C. 6295(o)(2)(B)(iii) establishes a rebuttable presumption that an energy conservation standard is economically justified if the increased purchase cost for a product that meets the standard is less than three times the value of the first-year energy savings resulting from the standard. In calculating a rebuttable presumption payback period for each of the considered TSLs, DOE used discrete values, and, as required by EPCA, based the energy use calculation on the DOE test procedure for compressors. In contrast, the PBPs presented previously were calculated using distributions that reflect the range of energy use in the field.

Table V.11 presents the rebuttable-presumption payback periods for the considered TSLs for compressors. While DOE examined the rebuttable-presumption criterion, it 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. 6295(o)(2)(B)(i), that considers the full range of impacts to the consumer, manufacturer, Nation, and environment. The results of that analysis serve as the basis for DOE to definitively evaluate the economic justification for a potential standard level, thereby supporting or rebutting the results of any preliminary determination of economic justification.

Table V.11 Rebuttable-Presumption Payback Periods

| Equipment Class | Trial Standard Level | | | | | |
|-----------------|----------------------|-----|-----|-----|-----|-----|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| RP_FS_L_AC | 1.9 | 2.4 | 2.9 | 3.0 | 3.3 | 4.0 |
| RP_FS_L_WC | 2.2 | 2.6 | 3.0 | 3.2 | 3.4 | 4.0 |
| RP_VS_L_AC | 4.7 | 5.5 | 5.9 | 6.7 | 7.6 | 9.1 |
| RP_VS_L_WC | 4.6 | 5.4 | 5.5 | 6.8 | 7.6 | 9.1 |

2. Economic Impacts on Manufacturers

DOE performed an MIA to estimate the impact of new energy conservation standards on manufacturers of compressors. The next section describes the expected impacts on manufacturers at each considered TSL. Chapter 12 of the final rule TSD explains the analysis in further detail.

a. Industry Cash Flow Analysis Results

In this section, DOE provides GRIM results from the analysis, which examines changes in the industry that would result from a standard. Table V.12 and Table V.13 illustrates the estimated financial impacts (represented by changes in INPV) of new energy conservation standards on manufacturers of compressors, as well as the conversion costs that DOE estimates manufacturers of compressors would incur at each TSL. DOE notes that the GRIM and resulting industry cash flow analysis considered only lubricated rotary equipment classes, as DOE is not establishing standards for reciprocating equipment or lubricant-free rotary equipment. For further discussion on DOE's proposal for reciprocating compressors, see section V.C.

As discussed in section IV.J.2, DOE modeled two different conversion cost scenarios to evaluate the range of cash flow impacts on the compressor industry: (1) a low conversion cost scenario; and (2) a high conversion cost scenario.

Specifically, the two scenarios explore uncertainty in conversion costs, as they relate to the draft EU minimum energy efficiency standards for air compressors. During confidential interviews, multiple manufacturers indicated that they sell similar equipment in the U.S. and the EU. They also indicated that if the EU adopted the draft standard for air compressors, the efficiency of some equipment sold in the U.S. would be improved by windfall. As such, when the EU standard takes effect, which would be phased in from 2018 to 2020, a significant amount of globally marketed equipment would already exhibit improved efficiency, regardless of a DOE standard. However, because the EU standard is not yet adopted, DOE chose to use a scenario analysis to evaluate its potential impacts on conversion costs.

The low conversion cost scenario assumes that manufacturers active in the EU market will not face additional product conversion costs to adapt to a U.S. standard that is at or below the draft EU level (EL 3 and TSL 3). If the U.S. standard is above the EU level, these manufacturers would still incur full redesign costs. In the high conversion cost scenario, all manufacturers face full product conversion costs, regardless of an EU regulation. DOE notes that manufacturers that are not active in the EU market will face the same conversion costs, regardless of the scenario.

To evaluate the magnitude of each product and capital conversion cost scenario, DOE relied on cost estimates provided by representative manufacturers as well as estimates and appraisals provided by consultants familiar with air compressor and general industrial manufacturing.

Additional details on the conversion cost scenarios can be found in chapter 12 of this final rule TSD.

In the following discussion, the INPV results refer to the difference in industry value between the no-new-standards case “business as usual” and each standards case resulting from the sum of discounted cash flows from 2016 to 2051. To provide perspective on the short-run cash flow impact, DOE includes in the discussion of results a comparison of free cash flow between the no-new-standards case and the standards case at each TSL in the year before standards would take effect. This figure provides an understanding of the magnitude of required conversion costs related to cash flows generated by the industry in the no-new-standards case. Table V.12 and Table V.13 present INPV results under the low and high conversion cost scenarios. The low conversion cost scenario represents the least severe set of impacts while the high conversion cost scenario represents the most severe set of impacts. Markups do not vary with conversion cost scenarios.

Table V.12 Manufacturer Impact Analysis Results for Compressors: Low Conversion Cost Scenario

| | Units | No New Standard Case | Trial Standard Level* | | | | | |
|---------------------------------|----------|----------------------|-----------------------|---------|---------|---------|---------|----------|
| | | | 1 | 2 | 3 | 4 | 5 | 6 |
| INPV | 2015\$M | 409.7 | 389.0 | 367.8 | 262.0 | 149.2 | 98.4 | 70.0 |
| Change in INPV | 2015\$M | - | (20.7) | (42.0) | (147.8) | (260.5) | (311.3) | (339.8) |
| | % | - | (5.1) | (10.2) | (36.1) | (63.6) | (76.0) | (82.9) |
| Product Conversion Costs | 2015\$M | - | 41.2 | 74.4 | 206.7 | 355.5 | 426.5 | 496.1 |
| Capital Conversion Costs | 2015\$M | - | 6.1 | 23.7 | 73.8 | 98.0 | 119.1 | 140.4 |
| Total Conversion Costs | 2015\$M | - | 47.3 | 98.1 | 280.5 | 453.5 | 545.6 | 636.4 |
| Free Cash Flow | 2015\$M | 25.2 | 8.8 | (10.1) | (89.9) | (166.4) | (207.2) | (247.4) |
| | % Change | - | (65.1) | (140.0) | (456.8) | (760.6) | (922.6) | (1082.4) |

*Parentheses indicate negative values.

Table V.13 Manufacturer Impact Analysis Results for Compressors: High Conversion Cost Scenario

| | Units | No New Standard Case | Trial Standard Level* | | | | | |
|---------------------------------|----------|----------------------|-----------------------|---------|---------|---------|---------|----------|
| | | | 1 | 2 | 3 | 4 | 5 | 6 |
| INPV | 2015\$M | 409.7 | 384.8 | 354.6 | 204.6 | 136.6 | 83.2 | 52.0 |
| Change in INPV | 2015\$M | - | (25.0) | (55.1) | (205.2) | (273.1) | (326.6) | (357.7) |
| | % | - | (6.1) | (13.5) | (50.1) | (66.7) | (79.7) | (87.3) |
| Product Conversion Costs | 2015\$M | - | 49.3 | 97.6 | 289.9 | 373.6 | 448.5 | 521.9 |
| Capital Conversion Costs | 2015\$M | - | 6.1 | 23.7 | 73.8 | 98.0 | 119.1 | 140.4 |
| Total Conversion Costs | 2015\$M | - | 55.4 | 121.3 | 363.7 | 471.6 | 567.6 | 662.3 |
| Free Cash Flow | 2015\$M | 25.2 | 6.1 | (19.2) | (126.6) | (174.4) | (216.9) | (258.8) |
| | % Change | - | (75.7) | (176.3) | (602.4) | (792.3) | (961.1) | (1127.6) |

*Parentheses indicate negative values.

TSL 1 represents EL 1 for lubricated rotary compressors. At TSL 1, DOE estimates the impacts on INPV to range from -\$25.0 million to -\$20.7 million, or a change of -6.1-percent to -5.1-percent. Industry free cash flow is estimated to change by -\$19.1 million to -\$16.4 million, or a change of -75.7-percent to -65.1-percent compared to the no-new-standards case value of \$25.2 million in the year before the compliance date (2021). DOE estimates industry conversion costs of as high as \$55.4 million to \$47.3 million at TSL 1.

TSL 2 represents EL 2 lubricated rotary compressors. At TSL 2, DOE estimates impacts on INPV to range from -\$55.1 million to -\$42.0 million, or a change in INPV of -

13.5-percent to -10.2-percent. At this level, industry free cash flow is estimated to change by -\$44.4 million to -\$35.3 million, or a change of -176.3-percent to -140.0-percent compared to the no-new-standards case value of \$25.2 million in the year before the compliance date (2021). DOE estimates industry conversion costs of as high as \$121.3 million to \$98.1 million at TSL 2.

TSL 3 represents EL 3 for lubricated rotary compressors. At TSL 3, DOE estimates impacts on INPV of -\$205.2 million to -\$147.8 million, or a change in INPV of -50.1-percent to -36.1-percent. At this level, industry free cash flow is estimated to change by -\$151.7 million to -\$115.1 million, or a change of -602.4-percent to -456.8-percent compared to the no-new-standards case value of \$25.2 million in the year before the compliance date (2021). DOE estimates industry conversion costs of as high as \$363.7 million to \$280.5 million at TSL 3.

TSL 4 represents EL 4 for lubricated rotary compressors. At TSL 4, DOE estimates impacts on INPV of -\$273.1 million to -\$260.5, or a change in INPV of -66.7-percent to -63.6-percent. At this level, industry free cash flow is estimated to change by -\$199.6 million to -\$191.6 million, or a change of -792.3-percent to -760.6-percent compared to the no-new-standards case value of \$25.2 million in the year before the compliance date (2021). DOE estimates industry conversion costs of as high as \$471.6 million to \$453.5 million at TSL 4.

TSL 5 represents EL 5 for lubricated rotary compressors. At TSL 5, DOE estimates impacts on INPV of -\$326.6 million to -\$311.3, or a change in INPV of -79.7-

percent to -76.0-percent. Industry free cash flow is estimated to change by -\$242.1 million to -\$232.4 million or a change of -961.1-percent to -922.6-percent compared to the no-new-standards case value of \$25.2 million in the year before the compliance date (2021). DOE estimates industry conversion costs of as high as \$567.6 million to \$545.6 million at TSL 5.

TSL 6 represents EL 6 for lubricated rotary compressors. At TSL 6, DOE estimates impacts on INPV of -\$357.7 to -\$339.8 million, or a change in INPV of -87.3-percent to -82.9-percent. Industry free cash flow is estimated to change by -\$284.0 million to -\$272.6 million, or a change of -1,127.6-percent to -1,082.4-percent compared to the no-new-standards case value of \$25.2 million in the year before the compliance date (2021). DOE estimates industry conversion costs of as high as \$662.3 to \$636.4 million at TSL 6.

b. Direct Impacts on Employment

To quantitatively assess the potential impacts of new energy conservation standards on direct employment in the compressor industry, DOE used the GRIM to estimate the domestic labor expenditures and number of direct employees in the no-new-standards case and in each of the standards cases during the analysis period. DOE used statistical data from the U.S. Census Bureau's 2014 ASM, 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 equipment 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 2014 Annual Survey of Manufacturers ("ASM")). The production worker estimates in this section only cover workers up to the line-supervisor level who are directly involved in fabricating and assembling equipment within an OEM facility. Workers performing services that are closely associated with production operations, such as materials handling tasks using forklifts, are also included as production labor.

To calculate non-production workers, the GRIM assumes non-production workers account for 42-percent of direct employment, which is a ratio derived from 2014 ASM data. The direct employment impacts calculated in the GRIM are the sum of the changes in the number of domestic production and non-production workers resulting from the new energy conservation standards for compressors, as compared to the no-new-standards case. In general, more-efficiency compressors are complex and more labor intensive. Per-unit labor requirements and production time requirements increase with higher energy conservation standards.

To estimate an upper bound to employment change, DOE assumes all domestic manufacturers would choose to continue producing equipment in the U.S. and would not

move production to foreign countries. To estimate a lower bound to employment, DOE considers the case where all manufacturers choose to relocate production of failing rotary compressors with a compressor motor nominal horsepower under 50 hp overseas rather than make the necessary conversions at domestic production facilities. A complete description of the assumptions used to generate these upper and lower bounds can be found in chapter 12 of the NOPR TSD.

In the absence of energy conservation standards, DOE estimates that the rotary air compressors industry would employ 1,313 domestic production workers and 962 domestic non-production workers in 2022, the year of compliance. Table V.14 shows the range of impacts of potential energy conservation standards on U.S. production workers of air compressors.

At the NOPR stage, DOE estimated 1,417 production workers in the no-new-standards case for the compressor industry in 2022. For the final rule, DOE updated its analysis based on 2014 U.S. Census data, the updated engineering analysis, and the updated shipments analysis. DOE's revised final rule analysis forecasts that the industry will employ 2,275 production and non-production workers in the compressor industry in 2022 in the absence of new energy conservation standards. DOE estimates that approximately 50-percent of rotary air compressors sold in the United States are manufactured domestically. The final rule analysis presents an updated set of direct employment impacts that range from a net loss of 1,256 to a gain of 42 jobs at the standard level. Therefore, DOE's analysis agrees with the statements from the industry that there is a risk of decreasing the number of manufacturing jobs related to the covered

equipment. Table V.14 shows the range of impacts of new energy conservation standards of this final rule on U.S. production workers of compressors.

Table V.14 Potential Changes in the Compressors Direct Employment in 2022

| | Trial Standard Level* | | | | | | |
|--|-----------------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | No-New-Standards Case | 1 | 2 | 3 | 4 | 5 | 6 |
| Number of Domestic Production Workers | 1,313 | 1,225 to 1,343 | 1,059 to 1,391 | 654 to 1,468 | 434 to 1,507 | 219 to 1,580 | 28 to 1,776 |
| Change in Domestic Production Workers | - | (88) to 30 | (254) to 78 | (659) to 155 | (878) to 194 | (1,094) to 267 | (1,285) to 463 |
| Domestic Direct Employment** | 2,275 | 2,123 to 2,327 | 1,835 to 2,410 | 1,133 to 2,544 | 753 to 2,611 | 379 to 2,738 | 49 to 3,078 |
| Potential Changes in Direct Employment | - | (152) to 52 | (439) to 135 | (1,142) to 269 | (1,522) to 336 | (1,896) to 463 | (2,226) to 803 |

* DOE presents a range of potential employment impacts. Numbers in parentheses indicate negative numbers.

** This field presents impacts on domestic direct employment, which aggregates production and non-production workers. Based on ASM census data, DOE assumed the ratio of production to non-production employees stays consistent across all analyzed TSLs, which is 42 percent non-production workers.

At the upper end of the range, all examined TSLs show positive impacts on domestic employment levels. Producing more-efficient compressors tends to require more labor, and DOE estimates that if compressor manufacturers chose to keep their current production in the U.S., domestic employment could increase at each TSL.

The lower end of the range represents the maximum decrease in the number of U.S. production workers that could result from an energy conservation standard. In interviews, manufacturers stated that the domestic compressor industry has seen limited migration to foreign production facilities. While many compressors are currently manufactured in foreign production facilities, this is more often the result of the global

operations of many manufacturers, rather than off-shoring of former U.S. production. However, manufacturers that currently produce in the U.S. have indicated they could potentially shift some production of some covered equipment to foreign facilities in order to take advantage of lower labor costs and/or global economies of scale, if standards erode the economic benefits of manufacturing domestically. Manufacturers also stated that smaller, lower compressor motor nominal horsepower compressors, rather than larger, higher nominal horsepower compressors, are more likely to shift to foreign production. Given the uncertainty surrounding potential off-shoring decisions, manufacturers were unable to pinpoint a specific nominal horsepower cutoff for “lower horsepower compressors.” However, based on qualitative discussions with manufacturers, DOE estimates that 50 nominal hp is an appropriate cutoff to represent “lower horsepower compressors.” As a result, the lower bound of direct employment impacts assumes manufacturers choose to relocate production of failing rotary compressors under 50 nominal hp overseas rather than make the necessary conversions at domestic production facilities.

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 final rule TSD.

c. Impacts on Manufacturing Capacity

In interviews, manufacturers of compressors did not indicate that new energy conservation standards would significantly constrain manufacturing production capacity. However, as discussed in section IV.J of the NOPR, manufacturers expressed concern

that they may face a bottleneck in the redesign process. In other words, manufacturers felt that if they could complete their redesigns within the compliance period, then they would not have a problem obtaining sufficient floor space, equipment, and manufacturing labor to meet the shipment demands of the market, following an energy conservation standard.

Manufacturers indicated that most experienced compressor design engineers are already employed within the industry, which limits their ability to rapidly expand their research and development teams if faced with a high volume of required compressor redesigns. Consequently, manufacturers typically commented that standard levels at or above the equivalent of TSL 3 could cause engineering constraints which might create time delays in complying with new standards. DOE notes that manufacturers typically discussed this constraint with respect to a three-year compliance period. In this final rule, however, DOE is establishing a standard level at TSL 2, in conjunction with a five-year compliance period.

d. Impacts on Subgroups of Manufacturers

As discussed previously, using average cost assumptions to develop an industry cash flow estimate is not adequate for assessing differential impacts among subgroups of manufacturers. The rule could affect small manufacturers, niche players, or manufacturers exhibiting a cost structure that differs largely from the industry average, differently. DOE used the results of the industry characterization to group manufacturers exhibiting similar characteristics. Specifically, DOE identified small business manufacturers as a subgroup for a separate impact analysis.

For the small business subgroup 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 30840, 30849 (May 15, 2000), as amended at 65 FR 53533, 53544 (September 5, 2000), and codified at 13 CFR part 121.) To be categorized as a small business manufacturer of compressors under North American Industry Classification System (“NAICS”) code 333912, “Air and Gas Compressor Manufacturing,” a compressor manufacturer and its affiliates may employ a maximum of 1,000 employees. The 1,000-employee threshold includes all employees in a business’s parent company and any other subsidiaries. Based on this classification, DOE identified 15 manufacturers of rotary air compressors. The small business subgroup analysis is discussed in section VII.B of this document and in chapter 12 of the NOPR TSD.

e. Cumulative Regulatory Burden

One aspect of assessing manufacturer burden involves looking at the cumulative impact of multiple DOE standards and at the regulatory actions of other Federal agencies and States that affect the manufacturers of a covered product or equipment. While any one regulation may not impose a significant burden on manufacturers, the combined effects of several existing or impending regulations may have serious consequences for some manufacturers, groups of manufacturers, or an entire industry. 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.

For the cumulative regulatory burden analysis, DOE looks at other regulations that could affect compressor manufacturers during the compliance period, from 2016 to 2022, or those that will take effect approximately three years after the 2022 compliance date of new energy conservation standards for this equipment. The compliance years and expected industry conversion costs of relevant energy conservation standards are indicated in Table V.15. Included in the table are Federal regulations that have compliance dates beyond the range of DOE's analysis.

Table V.15 Compliance Dates and Expected Conversion Expenses of Federal Energy Conservation Standards Affecting Compressor Manufacturers

| Federal Energy Conservation Standard | Number of Manufacturers* | Number of Manufacturers Affected from This Final Rule** | Approx. Standards Year | Industry Conversion Costs (Millions \$) | Industry Conversion Costs / Revenue*** |
|--|---------------------------------|--|-------------------------------|--|---|
| Commercial Refrigeration Equipment 79 FR 17725 (March 28, 2014) | 54 | 1 | 2017 | 184.0 (2012\$) | 1.5% |
| Commercial Packaged Air Conditioners and Heat Pumps (Air-Cooled) 81 FR 2420 (January 15, 2016) | 13 | 1 | 2018 and 2023 | 520.8 (2014\$) | 4.4% |
| Automatic Commercial Ice Makers 80 FR 4645 (January 28, 2015) | 16 | 1 | 2018 | 25.1 (2013\$) | 2.3% |
| External Power Supplies and Battery Chargers 81 FR 38266 (June 13, 2016) | 30 | 2 | 2018 | 19.5 (2013\$) | Less than 1% |
| Uninterruptible Power Supplies† 81 FR 52196 (August 5, 2016) | 48 | 1 | 2019 | 20.0 (2015\$) | Less than 1% |
| Residential Furnace Fans 79 FR 38129 (July 3, 2014) | 38 | 1 | 2019 | 40.6 (2014\$) | 1.6% |
| Commercial Packaged Boilers† 81 FR 15836 (March 24, 2016) | 45 | 1 | 2022 | 27.5 (2014\$) | 2.3% |
| Residential Furnaces† 80 FR 13120 (September 2, 2016) | 13 | 1 | 2022 | 54.7 (2015\$) | 1% |
| Central Air Conditioners and Heat Pumps† 80 FR 52206 (August 25, 2015) | 30 | 1 | 2023 | 342.6 (2015\$) | Less than 1% |
| Commercial Warm Air Furnaces 81 FR 2420 (January 15, 2016) | 14 | 1 | 2023 | 7.5 to 22.2 (2014\$)†† | 1.7% to 5.2%†† |

*This column presents the total number of manufacturers identified in the energy conservation standard rule contributing to cumulative regulatory burden.

**This column presents the number of manufacturers producing compressor equipment that are also listed as manufacturers in the listed energy conservation standard contributing to cumulative regulatory burden.

***This column presents conversion costs as a percentage of cumulative revenue for the industry during the conversion period. The conversion period is the timeframe over which manufacturers must make conversion costs investments and lasts from the announcement year of the final rule to the standards year of the final rule. This period typically ranges from 3 to 5 years, depending on the energy conservation standard.

†The final rule for this energy conservation standard has not been published. The compliance date and analysis of conversion costs have not been finalized at this time. (If a value is provided for total industry conversion expense, this value represents an estimate from the NOPR.)

††Low and high conversion cost scenarios were analyzed as part of this Direct Final Rule. The range of estimated conversion expenses presented here reflects those two scenarios.

DOE also identified other regulatory burdens that will affect manufacturers of compressors, such as international energy conservation standards and EPA Tier IV emission regulation.

International Energy Conservation Standards

Compressor manufacturers that sell equipment outside of the United States are subject to several international energy conservation standards. In 2015, the European Union introduced energy efficiency regulation for compressors, which included standards for reciprocating and rotary air compressors. Several stakeholders cited concerns regarding DOE's less stringent standard for rotary compressors compared to the EU's current standard. For the test procedure final rule, DOE excludes lubricated compressors from the scope of test procedures in part to help manufacturers harmonize with the EU's regulatory standards for compressors.

EPA Tier IV Emission Regulation

In 2014, the EPA adopted multiple tiers of emissions standards, including Tier IV regulation, which falls under a comprehensive national program to reduce emissions from non-road diesel engines by integrating engine and fuel controls as a system to gain the greatest emission reductions. To meet Tier IV emission standards, engine manufacturers will be required to produce new engines with advanced emission control technologies. DOE received comments from Sullivan-Palatek stating concerns resulting from Tier IV regulation. Due to the EPA emission standards, many product voids have resulted that may take years to repair since manufacturers are still bearing the cost of this regulation. Sullivan-Palatek also stated that the destruction of product demand caused by the Tier IV regulation due to substantially higher costs and complex maintenance for end customers has been burdensome for the industry. Because customers have the option to operate and repair at least two decades of used compressors rather than purchasing new machines, the US market for the Tier IV portable compressors has declined by about 70% .(Sullivan-Palatek, No. 51 at p. 8)

In response, DOE does not include rulemakings in its cumulative regulatory analysis that take effect more than three years before or after the effective date of this final rule standard. Therefore, there may be other standards required of manufacturers that were excluded from the cumulative regulatory burden analysis. As outlined in appendix A to 10 CFR 430, subpart C, DOE considers other significant product-specific regulations that will take effect within three years of the effective date of the standard

under consideration and will affect significantly the same manufacturers. (Section 10(g)(2), 10 CFR 430, subpart C, appendix A.)

3. National Impact Analysis

This section presents DOE’s estimates of the national energy savings and the NPV of consumer benefits that would result from each of the TSLs considered as potential new standards.

a. Significance of Energy Savings

To estimate the energy savings attributable to potential standards for compressors, DOE compared their energy consumption under the no-new-standards case to their anticipated energy consumption under each TSL. The savings are measured over the entire lifetime of products purchased in the 30-year period that begins in the year of anticipated compliance with new standards (2022–2051). Table V.16 presents DOE’s projections of the national energy savings for each TSL considered for compressors. The savings were calculated using the approach described in section IV.H of this document.

Table V.16 Cumulative National Energy Savings for compressors; 30 Years of Shipments (2022–2051)

| | Trial Standard Level | | | | | |
|----------------|----------------------|------|------|------|------|------|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| | <u>quads</u> | | | | | |
| Primary energy | 0.03 | 0.15 | 0.43 | 0.59 | 0.87 | 1.59 |
| FFC energy | 0.03 | 0.16 | 0.45 | 0.61 | 0.91 | 1.66 |

OMB Circular A-4¹¹⁴ 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 9 years, rather than 30 years of product shipments. The choice of a 9-year period is a proxy for the timeline in U.S.C 6295(m) and 6316(a) for the review of certain energy conservation standards and potential revision of and compliance with such revised standards.¹¹⁵ The review timeframe established in U.S.C 6295(m) and 6316(a) is generally not synchronized with the product lifetime, product manufacturing cycles, or other factors specific to compressors. 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 9-year analytical period are presented in Table V.17. The impacts are counted over the lifetime of compressors purchased in 2022–2030.

¹¹⁴ U.S. Office of Management and Budget. Circular A-4: Regulatory Analysis. September 17, 2003. www.whitehouse.gov/omb/circulars_a004_a-4/.

¹¹⁵ Section 325(m) of EPCA 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 products, the compliance period is 5 years rather than 3 years.

Table V.17 Cumulative National Energy Savings for compressors; 9 Years of Shipments (2022–2030)

| | Trial Standard Level | | | | | |
|----------------|----------------------|------|------|------|------|------|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| | <u>quads</u> | | | | | |
| Primary energy | 0.01 | 0.04 | 0.11 | 0.15 | 0.22 | 0.40 |
| FFC energy | 0.01 | 0.04 | 0.11 | 0.15 | 0.23 | 0.41 |

b. Net Present Value of Consumer Costs and Benefits

DOE estimated the cumulative NPV of the total costs and savings for consumers that would result from the TSLs considered for compressors. In accordance with OMB’s guidelines on regulatory analysis,¹¹⁶ DOE calculated NPV using both a 7-percent and a 3-percent real discount rate. Table V.18 shows the consumer NPV results with impacts counted over the lifetime of products purchased in 2022-2051.

Table V.18 Cumulative Net Present Value of Consumer Benefits for compressors; 30 Years of Shipments (2022–2051)

| Discount Rate | Trial Standard Level <u>billion 2015\$</u> | | | | | |
|---------------|---|-----|-----|-----|-----|-----|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 3 percent | 0.1 | 0.4 | 1.2 | 1.5 | 2.1 | 3.3 |
| 7 percent | 0.0 | 0.2 | 0.4 | 0.5 | 0.7 | 1.0 |

The NPV results based on the aforementioned 9-year analytical period are presented in Table V.19. The impacts are counted over the lifetime of products purchased in 2022-2030. As mentioned previously, such results are presented for

¹¹⁶ U.S. Office of Management and Budget. Circular A-4: Regulatory Analysis. September 17, 2003. www.whitehouse.gov/omb/circulars_a004_a-4/.

informational purposes only and are not indicative of any change in DOE’s analytical methodology or decision criteria.

Table V.19 Cumulative Net Present Value of Consumer Benefits for compressors; 9 Years of Shipments (2022–2030)

| Discount Rate | Trial Standard Level billion 2015\$ | | | | | |
|---------------|--|-----|-----|-----|-----|-----|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 3 percent | 0.0 | 0.2 | 0.4 | 0.5 | 0.7 | 1.1 |
| 7 percent | 0.0 | 0.1 | 0.2 | 0.2 | 0.3 | 0.5 |

The above results reflect the use of a default constant trend to estimate the change in price for compressors over the analysis period (see section IV.F.1 of this document). 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 10B of the final rule TSD. In the high-price-decline case, the NPV of consumer benefits is higher than in the default case. In the low-price-decline case, the NPV of consumer benefits is lower than in the default case.

c. Indirect Impacts on Employment

DOE expects that energy conservation standards for compressors will reduce energy expenditures for consumers of those products, 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. As described in section IV.N of this document, DOE used an input/output model of the U.S. economy to estimate indirect employment impacts of the TSLs that DOE considered. 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 near-term timeframes (2022–2027), 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 final rule TSD presents detailed results regarding anticipated indirect employment impacts.

4. Impact on Utility or Performance of Products

As discussed in section III.H.1.d of this notice, DOE has concludes that the standards adopted in this final rule will not lessen the utility or performance of the compressors under consideration in this rulemaking. Manufacturers of these products currently offer units that meet or exceed the adopted standards.

5. Impact of Any Lessening of Competition

DOE considered any lessening of competition that would be likely to result from new or amended standards. As discussed in section III.H.1.e, EPCA 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 DOJ with copies of the

NOPR and the TSD for review. In its assessment letter responding to DOE, DOJ concludes that the proposed energy conservation standards for compressors are unlikely to have a significant adverse impact on competition. DOE is publishing the Attorney General's assessment at the end of this 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 final rule TSD 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 energy conservation standards for compressors is expected to yield environmental benefits in the form of reduced emissions of certain air pollutants and greenhouse gases. Table V.20 provides DOE's estimate of cumulative emissions reductions expected to result from the TSLs considered in this rulemaking. The table includes both power sector emissions and upstream emissions. The emissions were calculated using the method discussed in section IV.K. DOE reports annual emissions reductions for each TSL in chapter 13 of the final rule TSD.

Table V.20 Cumulative Emissions Reduction for Compressors Shipped in 2022–2051

| | Trial Standard Level | | | | | |
|---------------------------------------|----------------------|------|-------|-------|-------|-------|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Power Sector Emissions | | | | | | |
| CO ₂ (million metric tons) | 1.5 | 7.8 | 21.9 | 29.8 | 44.1 | 80.5 |
| SO ₂ (thousand tons) | 1.3 | 6.5 | 18.2 | 24.8 | 36.7 | 67.0 |
| NO _x (thousand tons) | 0.9 | 4.5 | 12.7 | 17.3 | 25.6 | 46.8 |
| Hg (tons) | 0.00 | 0.02 | 0.06 | 0.08 | 0.12 | 0.22 |
| CH ₄ (thousand tons) | 0.2 | 0.8 | 2.4 | 3.2 | 4.8 | 8.7 |
| N ₂ O (thousand tons) | 0.0 | 0.1 | 0.3 | 0.5 | 0.7 | 1.2 |
| Upstream Emissions | | | | | | |
| CO ₂ (million metric tons) | 0.1 | 0.4 | 1.2 | 1.7 | 2.5 | 4.6 |
| SO ₂ (thousand tons) | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.5 |
| NO _x (thousand tons) | 1.3 | 6.5 | 18.3 | 24.8 | 36.8 | 67.2 |
| Hg (tons) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CH ₄ (thousand tons) | 7.9 | 39.9 | 112.8 | 153.3 | 227.3 | 414.7 |
| N ₂ O (thousand tons) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total FFC Emissions | | | | | | |
| CO ₂ (million metric tons) | 1.6 | 8.2 | 23.1 | 31.4 | 46.6 | 85.1 |
| SO ₂ (thousand tons) | 1.3 | 6.5 | 18.4 | 25.0 | 37.0 | 67.6 |
| NO _x (thousand tons) | 2.2 | 11.0 | 31.0 | 42.1 | 62.5 | 114.0 |
| Hg (tons) | 0.00 | 0.02 | 0.06 | 0.08 | 0.12 | 0.22 |
| CH ₄ (thousand tons) | 8.1 | 40.8 | 115.2 | 156.5 | 232.0 | 423.5 |
| N ₂ O (thousand tons) | 0.0 | 0.1 | 0.3 | 0.5 | 0.7 | 1.3 |

As part of the analysis for this rule, DOE estimated monetary benefits likely to result from the reduced emissions of CO₂ for each of the considered TSLs for compressors. As discussed in section IV.L of this document, DOE used the most recent values for the SC-CO₂ developed by the interagency working group. The four sets of SC-CO₂ values correspond to the average values from distributions that use a 5-percent discount rate, a 3-percent discount rate, and a 2.5-percent discount rate, and the 95th-percentile values from a distribution that uses a 3-percent discount rate. The actual SC-CO₂ values used for emissions in each year are presented in appendix 14A of the final rule TSD.

Table V.21 presents the global value of the CO₂ emissions reduction at each TSL. 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 final rule TSD.

Table V.21 Present Value of GHG Emissions Reduction for Compressors Shipped in 2022–2051

| Trial Standard Level | SC-CO ₂ Case | | | |
|----------------------|---------------------------|---------------------------|-----------------------------|-----------------------------------|
| | 5% Discount Rate, Average | 3% Discount Rate, Average | 2.5% Discount Rate, Average | 3% Discount Rate, 95th Percentile |
| | million 2015\$ | | | |
| 1 | 10.5 | 49.5 | 79.2 | 150.9 |
| 2 | 52.8 | 250.0 | 400.4 | 762.2 |
| 3 | 149.2 | 706.1 | 1131.2 | 2153.2 |
| 4 | 202.7 | 959.4 | 1536.8 | 2925.4 |
| 5 | 300.6 | 1422.4 | 2278.6 | 4337.3 |
| 6 | 548.5 | 2595.7 | 4158.1 | 7915.0 |

* For each of the four cases, the corresponding SCC value for emissions in 2020 is \$13.5, \$47.4, \$63.2, and \$118 per metric ton (2015\$). The values are for CO₂ only (i.e., not CO_{2eq} of other greenhouse gases).

As discussed in section IV.L.2, DOE estimated monetary benefits likely to result from the reduced emissions of methane and N₂O that DOE estimated for each of the considered TSLs for compressors. DOE used the recent values for the SC-CH₄ and SC-N₂O developed by the interagency working group. Table V-22 presents the value of the CH₄ emissions reduction at each TSL, and Table V-23 presents the value of the N₂O emissions reduction at each TSL.

Table V-22 Present Value of Methane Emissions Reduction for Compressors Shipped in 2022–2051

| TSL | SC-CH ₄ Case | | | |
|-----|---------------------------|---------------------------|-----------------------------|---|
| | 5% Discount Rate, Average | 3% Discount Rate, Average | 2.5% Discount Rate, Average | 3% Discount Rate, 95 th Percentile |
| | million 2015\$ | | | |
| 1 | 2.3 | 7.8 | 11.2 | 20.9 |
| 2 | 11.8 | 39.4 | 56.5 | 105.4 |
| 3 | 33.4 | 111.4 | 159.7 | 297.6 |
| 4 | 45.4 | 151.3 | 217.0 | 404.3 |
| 5 | 67.3 | 224.3 | 321.7 | 599.5 |
| 6 | 122.9 | 409.3 | 587.0 | 1094.0 |

Table V-23 Present Value of Nitrous Oxide Emissions Reduction for Compressors Shipped in 2022–2051

| TSL | SC-N ₂ O Case | | | |
|-----|---------------------------|---------------------------|-----------------------------|---|
| | 5% Discount Rate, Average | 3% Discount Rate, Average | 2.5% Discount Rate, Average | 3% Discount Rate, 95 th Percentile |
| | million 2015\$ | | | |
| 1 | 0.1 | 0.3 | 0.4 | 0.7 |
| 2 | 0.3 | 1.3 | 2.1 | 3.5 |
| 3 | 0.8 | 3.7 | 5.9 | 9.9 |
| 4 | 1.1 | 5.0 | 8.0 | 13.4 |
| 5 | 1.7 | 7.4 | 11.9 | 19.9 |
| 6 | 3.1 | 13.6 | 21.7 | 36.2 |

DOE is well aware that scientific and economic knowledge about the contribution of CO₂ 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 GHG 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 CO₂ 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. 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 resulting from the interagency review process. DOE notes, however, that the adopted standards would be economically justified even without inclusion of monetized benefits of reduced GHG emissions.

DOE also estimated the monetary value of the economic benefits associated with NO_x emissions reductions anticipated to result from the considered TSLs for compressors. The dollar-per-ton values that DOE used are discussed in section IV.L of this document. Table V.24 presents the present value for NO_x emissions reduction for each TSL calculated using 7-percent and 3-percent discount rates. This table presents results that use the low benefit-per-ton values, which reflect DOE’s primary estimate.

Table V.24 Estimates of Present Value of NO_x Emissions Reduction for Compressors Shipped in 2022–2051*

| TSL | 3% Discount Rate | 7% Discount Rate |
|-----|-----------------------|------------------|
| | million 2015\$ | |
| 1 | 3.3 | 1.2 |
| 2 | 16.8 | 6.1 |
| 3 | 47.4 | 17.4 |
| 4 | 64.4 | 23.6 |
| 5 | 95.5 | 35.0 |
| 6 | 174.3 | 63.8 |

* Results are based on the low benefit-per-ton values.

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. 6295(o)(2)(B)(i)(VII) and 6316(a)) No other factors were considered in this analysis.

8. Summary of National Economic Impacts

Table V.25 presents the NPV values that result from adding the estimates of the potential economic benefits resulting from reduced GHG and NO_x emissions to the NPV of consumer savings calculated for each TSL considered in this rulemaking.

Table V.25 Consumer NPV Combined with Present Value of Benefits from Emissions Reductions

| TSL | Consumer NPV and Low NO _x Values at 3% Discount Rate Added with: | | | |
|-----|---|------------------------------------|--------------------------------------|--|
| | GHG 5% Discount Rate, Average Case | GHG 3% Discount Rate, Average Case | GHG 2.5% Discount Rate, Average Case | GHG 3% Discount Rate, 95 th Percentile Case |
| | billion 2015\$ | | | |
| 1 | 0.11 | 0.16 | 0.19 | 0.27 |
| 2 | 0.53 | 0.75 | 0.92 | 1.33 |
| 3 | 1.38 | 2.02 | 2.50 | 3.66 |
| 4 | 1.82 | 2.68 | 3.33 | 4.91 |
| 5 | 2.55 | 3.83 | 4.79 | 7.13 |
| 6 | 4.11 | 6.46 | 8.20 | 12.48 |
| TSL | Consumer NPV and Low NO _x Values at 7% Discount Rate Added with: | | | |
| | GHG 5% Discount Rate, Average Case | GHG 3% Discount Rate, Average Case | GHG 3% Discount Rate, Average Case | GHG 3% Discount Rate, 95 th Percentile Case |
| | billion 2015\$ | | | |
| 1 | 0.05 | 0.09 | 0.13 | 0.21 |
| 2 | 0.23 | 0.46 | 0.63 | 1.04 |
| 3 | 0.60 | 1.24 | 1.71 | 2.88 |
| 4 | 0.78 | 1.65 | 2.30 | 3.88 |
| 5 | 1.09 | 2.37 | 3.33 | 5.67 |
| 6 | 1.72 | 4.06 | 5.81 | 10.09 |

Note: The GHG benefits include the estimated benefits for reductions in CO₂, CH₄, and N₂O emissions using the four sets of SC-CO₂, SC-CH₄, and SC-N₂O values developed by the interagency working group.

The national operating cost savings are domestic U.S. monetary savings that occur as a result of purchasing the covered compressors, and are measured for the

lifetime of products shipped in 2022–2051. The benefits associated with reduced GHG emissions achieved as a result of the adopted standards are also calculated based on the lifetime of compressors shipped in 2022–2051. However, the GHG reduction is a benefit that accrues globally. Because CO₂ emissions have a very long residence time in the atmosphere, the SC-CO₂ values for future emissions reflect climate-related impacts that continue through 2300.

C. Conclusion

When considering new or amended energy conservation standards, the standards that DOE adopts for any type (or class) of covered product must be designed to achieve the maximum improvement in energy efficiency that the Secretary determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A) and 6316(a)) 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. 6295(o)(2)(B)(i) and 6316(a)) The new or amended standard must also result in significant conservation of energy. (42 U.S.C. 6295(o)(3)(B) and 6316(a))

For this final rule, DOE considered the impacts of standards for compressors 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. These include the impacts on identifiable subgroups of consumers who may be disproportionately affected by a national standard and impacts on employment.

1. Benefits and Burdens of TSLs Considered for Compressors Standards

Table V.26 and Table V.27 summarize the quantitative impacts estimated for each TSL for compressors. The national impacts are measured over the lifetime of compressors purchased in the 30-year period that begins in the anticipated year of compliance with new standards (2022–2051). The energy savings, emissions reductions, and value of emissions reductions refer to full-fuel-cycle results. The efficiency levels contained in each TSL are described in section V.A of this notice.

Table V.26 Summary of Analytical Results for Compressors TSLs: National Impacts

| Category | TSL 1 | TSL 2 | TSL 3 | TSL 4 | TSL 5 | TSL 6 |
|--|----------------|----------------|----------------|----------------|----------------|----------------|
| Cumulative FFC National Energy Savings (quads) | | | | | | |
| quads | 0.03 | 0.16 | 0.45 | 0.61 | 0.91 | 1.66 |
| NPV of Consumer Costs and Benefits (billion 2015\$) | | | | | | |
| 3% discount rate | 0.10 | 0.45 | 1.15 | 1.50 | 2.08 | 3.26 |
| 7% discount rate | 0.04 | 0.16 | 0.40 | 0.51 | 0.68 | 0.98 |
| Cumulative FFC Emissions Reduction | | | | | | |
| CO ₂ (million metric tons) | 1.6 | 8.2 | 23.1 | 31.4 | 46.6 | 85.1 |
| SO ₂ (thousand tons) | 1.3 | 6.5 | 18.4 | 25.0 | 37.0 | 67.6 |
| NO _x (thousand tons) | 2.2 | 11.0 | 31.0 | 42.1 | 62.5 | 114.0 |
| Hg (tons) | 0.00 | 0.02 | 0.06 | 0.08 | 0.12 | 0.22 |
| CH ₄ (thousand tons) | 8.1 | 40.8 | 115.2 | 156.5 | 232.0 | 423.5 |
| N ₂ O (thousand tons) | 0.0 | 0.1 | 0.3 | 0.5 | 0.7 | 1.3 |
| Value of Emissions Reduction | | | | | | |
| CO ₂ (billion 2015\$)* | 0.01 to 0.15 | 0.05 to 0.76 | 0.15 to 2.15 | 0.20 to 2.93 | 0.30 to 4.34 | 0.55 to 7.91 |
| CH ₄ (billion 2015\$) | 0.00 to 0.02 | 0.01 to 0.11 | 0.03 to 0.30 | 0.05 to 0.40 | 0.07 to 0.60 | 0.12 to 1.09 |
| N ₂ O (billion 2015\$) | 0.000 to 0.001 | 0.000 to 0.003 | 0.001 to 0.010 | 0.001 to 0.013 | 0.002 to 0.020 | 0.003 to 0.036 |
| NO _x – 3% discount rate (million 2015\$) | 3.3 to 7.5 | 16.8 to 37.9 | 47.4 to 107.1 | 64.4 to 145.5 | 95.5 to 215.7 | 174.3 to 393.6 |
| NO _x – 7% discount rate (million 2015\$) | 1.2 to 2.8 | 6.1 to 13.9 | 17.4 to 39.3 | 23.6 to 53.4 | 35.0 to 79.1 | 63.8 to 144.3 |

Parentheses indicate negative (-) values.

* Range of the economic value of CO₂ reductions is based on estimates of the global benefit of reduced CO₂ emissions.

Table V.27 Summary of Analytical Results for Compressors TSLs: Manufacturer and Consumer Impacts

| Category | TSL 1 | TSL 2 | TSL 3 | TSL 4 | TSL 5 | TSL 6 |
|---|----------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| Manufacturer Impacts | | | | | | |
| Industry NPV (<u>million 2015\$</u>) (No-new-standards case INPV = 409.7) | 384.8 to 389.0 | 354.6 to 367.8 | 204.6 to 262.0 | 136.6 to 149.2 | 83.2 to 98.4 | 52.0 to 70.0 |
| Industry NPV (<u>% change</u>) | (6.1) to (5.1) | (13.5) to (10.2) | (50.1) to (36.1) | (66.7) to (63.6) | (79.7) to (76.0) | (87.3) to (82.9) |
| Consumer Average LCC Savings (2015\$) | | | | | | |
| RP_FS_L_AC | 7,882 | 8,002 | 7,377 | 7,192 | 7,849 | 8,604 |
| RP_FS_L_WC | 11,644 | 10,559 | 14,398 | 11,615 | 12,907 | 14,684 |
| RP_VS_L_AC | 2,343 | 2,618 | 2,248 | 2,130 | 1,885 | (41) |
| RP_VS_L_WC | 6,199 | 5,145 | 6,118 | 4,496 | 3,918 | 754 |
| Shipment-Weighted Average* | 8,172 | 8,086 | 8,225 | 7,599 | 8,293 | 9,011 |
| Consumer Simple PBP (years) | | | | | | |
| RP_FS_L_AC | 2.0 | 2.4 | 2.9 | 3.1 | 3.4 | 4.1 |
| RP_FS_L_WC | 2.3 | 2.7 | 3.1 | 3.2 | 3.5 | 4.1 |
| RP_VS_L_AC | 4.2 | 4.9 | 5.6 | 6.0 | 6.7 | 8.1 |
| RP_VS_L_WC | 4.0 | 4.9 | 5.7 | 6.0 | 6.7 | 8.1 |
| Shipment-Weighted Average* | 2.2 | 2.6 | 3.1 | 3.3 | 3.6 | 4.4 |
| Percent of Consumers that Experience a Net Cost | | | | | | |
| RP_FS_L_AC | 0 | 1 | 3 | 4 | 7 | 14 |
| RP_FS_L_WC | 0 | 1 | 2 | 5 | 7 | 12 |
| RP_VS_L_AC | 2 | 6 | 17 | 23 | 31 | 48 |
| RP_VS_L_WC | 1 | 8 | 14 | 25 | 32 | 48 |
| Shipment-Weighted Average* | 0 | 1 | 4 | 5 | 9 | 16 |

Parentheses indicate negative (-) values.

* Weighted by shares of each equipment class in total projected shipments in 2022

DOE first considered TSL 6, which represents the max-tech efficiency level. TSL 6 would save 1.66 quads of energy, an amount DOE considers significant. Under TSL 6, the NPV of consumer benefit would be 0.98 billion using a discount rate of 7-percent, and 3.26 billion using a discount rate of 3-percent.

The cumulative emissions reductions at TSL 6 are 85.1 Mt of CO₂, 67.6 thousand tons of SO₂, 114.0 thousand tons of NO_x, 0.22 ton of Hg, 423.5 thousand tons of CH₄, and 1.3 thousand tons of N₂O. The estimated monetary value of the GHG emissions reduction at TSL 6 ranges from \$548 million to \$7,915 million for CO₂, from \$123 million to \$1,094 million for CH₄, and from \$3.1 million to \$36.2 million for N₂O. The estimated monetary value of the NO_x emissions reduction at TSL 6 is \$64 million using a 7-percent discount rate and \$174 million using a 3-percent discount rate.

At TSL 6, the average LCC impact is a savings of \$8,604 for RP_FS_L_AC, \$14,684 for RP_FS_L_WC, -\$41 for RP_VS_L_AC, and \$4754 for RP_VS_L_WC.¹¹⁷ The simple payback period is 4.1 years for RP_FS_L_AC and RP_FS_L_WC, and 8.1 years for RP_VS_L_AC, and RP_VS_L_WC. The fraction of consumers experiencing a net LCC cost is 14-percent for RP_FS_L_AC, 12-percent for RP_FS_L_WC, 48-percent for RP_VS_L_AC, and RP_VS_L_WC.

At TSL 6, the projected change in INPV is a decrease of \$357.7 million to \$339.8 million. This corresponds to a net loss of 87.3-percent to 82.9-percent in INPV for manufacturers.

The Secretary concludes that at TSL 6 for compressors, the benefits of energy savings, emission reductions, and the estimated monetary value of the emissions reductions are outweighed by the negative NPV of consumer benefits, the economic

¹¹⁷ For the definition of each product class code, see Table I.2.

burden on some consumers, and the significant burden on the industry, including the conversion costs and profit margin impacts that could result in a large reduction in INPV. Consequently, the Secretary has concluded that TSL 6 is not economically justified.

DOE then considered TSL 5, which would save 0.91 quad of energy, an amount DOE considers significant. Under TSL 5, the NPV of consumer benefit would be \$0.68 billion using a discount rate of 7-percent, and \$2.08 billion using a discount rate of 3-percent.

The cumulative emissions reductions at TSL 5 are 46.6 Mt of CO₂, 37.0 thousand tons of SO₂, 62.5 thousand tons of NO_x, 0.12 ton of Hg, 232.0 thousand tons of CH₄, and 0.7 thousand tons of N₂O. The estimated monetary value of the GHG emissions reduction at TSL 5 ranges from \$301 million to \$4,337 million for CO₂, from \$67 million to \$599 million for CH₄, and from \$1.7 million to \$19.9 million for N₂O. The estimated monetary value of the NO_x emissions reduction at TSL 5 is \$35 million using a 7-percent discount rate and \$95 million using a 3-percent discount rate.

At TSL 5, the average LCC impact is a savings of \$7,849 for RP_FS_L_AC, \$12,907 for RP_FS_L_WC, \$1,885 for RP_VS_L_AC, and \$3,918 for RP_VS_L_WC. The simple payback period is 3.4 years for RP_FS_L_AC, 3.5 years for RP_FS_L_WC, and 6.7 years for RP_VS_L_AC, and RP_VS_L_WC. The fraction of consumers experiencing a net LCC cost is 7-percent for RP_FS_L_AC and RP_FS_L_WC, 31-percent for RP_VS_L_AC, and 32-percent for RP_VS_L_WC.

At TSL 5, the projected change in INPV is a decrease of \$326.6 million to \$311.3 million. This corresponds to a net loss of 79.7-percent to 76.0-percent in INPV for manufacturers.

Based on this analysis, DOE concludes that at TSL 5, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, and the estimated monetary value of the emissions reductions are outweighed by the economic burden on some consumers, and significant burden on the industry, including the conversion costs and profit margin impacts that could result in a large reduction in INPV. Consequently, DOE has concluded that TSL 5 is not economically justified.

DOE then considered TSL 4, which would save an estimated 0.61 quad of energy, an amount DOE considers significant. Under TSL 4, the NPV of consumer benefit would be \$1.50 billion using a discount rate of 7-percent, and \$0.51 billion using a discount rate of 3-percent.

The cumulative emissions reductions at TSL 4 are 31.4 Mt of CO₂, 25.0 thousand tons of SO₂, 42.1 thousand tons of NO_x, 0.08 ton of Hg, 156.5 thousand tons of CH₄, and 0.3 thousand tons of N₂O. The estimated monetary value of the GHG emissions reduction at TSL 4 ranges from \$203 million to \$2,925 million for CO₂, from \$45 million to \$404 million for CH₄, and from \$1.1 million to \$13.4 million for N₂O. The estimated monetary value of the NO_x emissions reduction at TSL 4 is \$24 million using a 7-percent discount rate and \$64 million using a 3-percent discount rate.

At TSL 4, the average LCC impact is a savings of \$7,192 for RP_FS_L_AC, \$11,615 for RP_FS_L_WC, \$2,130 for RP_VS_L_AC, and \$4,496 for RP_VS_L_WC. The simple payback period is 3.1 years for RP_FS_L_AC, 3.2 for RP_FS_L_WC, 6.0 years for RP_VS_L_AC, and RP_VS_L_WC. The fraction of consumers experiencing a net LCC cost is 4-percent for RP_FS_L_AC, 5-percent for RP_FS_L_WC, 23 percent for RP_VS_L_AC, and 25 percent for RP_VS_L_WC.

At TSL 4, the projected change in INPV ranges from a decrease of \$273.1 million to 260.5 million. This correspond to a net loss in INPV of 66.7-percent to 63.6-percent for manufacturers.

The Secretary concludes that at TSL 4 for compressors, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, and the estimated monetary value of the emissions reductions are 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 4 is not economically justified.

DOE then considered TSL 3, which would save an estimated 0.45 quads of energy, an amount DOE considers significant. Under TSL 3, the NPV of consumer benefit would be \$1.15 billion using a discount rate of 7-percent, and \$0.40 billion using a discount rate of 3-percent.

The cumulative emissions reductions at TSL 3 are 23.1 Mt of CO₂, 18.4 thousand tons of SO₂, 31.0 thousand tons of NO_x, 0.06 ton of Hg, 115.2 thousand tons of CH₄, and 0.3 thousand tons of N₂O. The estimated monetary value of the GHG emissions reduction at TSL 3 ranges from \$149 million to \$2, 153 million for CO₂, from \$33 million to \$298 million for CH₄, and from \$0.8 million to \$9.9 million for N₂O. The estimated monetary value of the NO_x emissions reduction at TSL 4 is \$17 million using a 7-percent discount rate and \$47 million using a 3-percent discount rate.

At TSL 3, the average LCC impact is a savings of \$7,377 for RP_FS_L_AC, \$14,398 for RP_FS_L_WC, \$2,248 for RP_VS_L_AC, and \$6,118 for RP_VS_L_WC. The simple payback period is 2.9 years for RP_FS_L_AC, 3.1 for RP_FS_L_WC, 5.6 years for RP_VS_L_AC, and 5.7 years for RP_VS_L_WC. The fraction of consumers experiencing a net LCC cost is 3-percent for RP_FS_L_AC, 2 percent for RP_FS_L_WC, 17-percent for RP_VS_L_AC, and 14-percent for RP_VS_L_WC.

At TSL 3, the projected change in INPV ranges from a decrease of \$205.2 million to a decrease of \$147.8 million. This corresponds to a net loss of INPV of 50.1-percent and 36.1-percent, respectively.

The Secretary concludes that at TSL 3 for compressors, the benefits of energy savings, positive NPV of consumer benefits, emission reductions, and the estimated monetary value of the emissions reductions are 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 TSL 2, which would save an estimated 0.16 quad of energy, an amount DOE considers significant. Under TSL 2, the NPV of consumer benefit would be \$0.45 billion using a discount rate of 7-percent, and \$0.16 billion using a discount rate of 3-percent.

The cumulative emissions reductions at TSL 2 are 8.2 Mt of CO₂, 6.5 thousand tons of SO₂, 11.0 thousand tons of NO_x, 0.02 tons of Hg, 40.8 thousand tons of CH₄, and 0.1 thousand tons of N₂O. The estimated monetary value of the GHG emissions reduction at TSL 2 ranges from \$53 million to \$762 million for CO₂, from \$25 million to \$220 million for CH₄, and from \$0.3 million to \$3.5 million for N₂O. The estimated monetary value of the NO_x emissions reduction at TSL 2 is \$6 million using a 7-percent discount rate and \$17 million using a 3-percent discount rate.

At TSL 2, the average LCC impact is a savings of \$8,002 for RP_FS_L_AC, \$10,559 for RP_FS_L_WC, \$2,618 for RP_VS_L_AC, and \$5,145 for RP_VS_L_WC. The simple payback period is 2.4 years for RP_FS_L_AC, 2.7 for RP_FS_L_WC, and 4.9 years for RP_VS_L_AC and RP_VS_L_WC. The fraction of consumers experiencing a net LCC cost is 1 percent for RP_FS_L_AC and RP_FS_L_WC, 6-percent for RP_VS_L_AC, and 8-percent for RP_VS_L_WC.

At TSL 2, the projected change in INPV ranges from a decrease of \$55.1 million to a decrease of \$42.0 million. This corresponds to a net loss of INPV of 13.5-percent and 10.2-percent, respectively.

After considering the analysis and weighing the benefits and burdens, the Secretary has concluded that at TSL 2 for compressors, 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 outweigh the negative impacts on some consumers and on manufacturers, including the conversion costs that could result in a reduction in INPV for manufacturers. Accordingly, the Secretary has concluded that TSL 2 would offer the maximum improvement in efficiency that is technologically feasible and economically justified, and would result in the significant conservation of energy.

Therefore, based on the above considerations, DOE adopts the energy conservation standards for compressors at TSL 2. The new energy conservation standards for compressors, which are expressed as package isentropic efficiency, are shown in Table V.28.

Table V.28 Energy Conservation Standards for Compressors

| Equipment Class | Standard Level (Package isentropic efficiency) | η_{Regr} (Package isentropic efficiency Reference Curve) | d (Percentage Loss Reduction) |
|---|---|---|--------------------------------------|
| Rotary, lubricated, air-cooled, fixed-speed | $\eta_{Regr} + (1 - \eta_{Regr}) * (d/100)$ | $-0.00928 * \ln^2(.4719 * V_1) + 0.13911 * \ln(.4719 * V_1) + 0.27110$ | -15 |
| Rotary, lubricated, | $\eta_{Regr} + (1 - \eta_{Regr}) * (d/100)$ | $-0.01549 * \ln^2(.4719 * V_1) + 0.21573 * \ln(.4719 * V_1) + 0.00905$ | -10 |

| | | | |
|--|--|--|-----|
| air-cooled, variable- speed | | | |
| Rotary, lubricated, liquid- cooled, fixed-speed | $.02349 + \eta_{\text{Regr}} + (1 - \eta_{\text{Regr}}) * (d/100)$ | $-0.00928 * \ln^2(.4719 * V_1) + 0.13911 * \ln(.4719 * V_1) + 0.27110$ | -15 |
| Rotary, lubricated, liquid- cooled, variable- speed | $.02349 + \eta_{\text{Regr}} + (1 - \eta_{\text{Regr}}) * (d/100)$ | $-0.01549 * \ln^2(.4719 * V_1) + 0.21573 * \ln(.4719 * V_1) + 0.00905$ | -15 |

2. Annualized Benefits and Costs of the Adopted Standards

The benefits and costs of the adopted standards can also be expressed in terms of annualized values. The annualized net benefit is (1) the annualized national economic value (expressed in 2015\$) of the benefits from operating products that meet the adopted standards (consisting primarily of operating cost savings from using less energy), minus increases in product purchase costs, plus (2) the annualized monetary value of the benefits of GHG and NO_x emission reductions.

Table V.29 shows the annualized values for compressors under TSL 2, expressed in 2015\$. The results under the primary estimate are as follows.

Using a 7-percent discount rate for benefits and costs other than GHG reduction (for which DOE used average social costs with a 3-percent discount rate),¹¹⁸ the estimated cost of the standards in this rule is \$9.9 million per year in increased equipment

¹¹⁸ DOE used average social costs with a 3-percent discount rate because these values are considered as the “central” estimates by the interagency group.

costs, while the estimated annual benefits are \$28.1 million in reduced equipment operating costs, \$17.2 million in GHG reductions, and \$0.7 million in reduced NO_x emissions. In this case, the net benefit amounts to \$36 million per year. Using a 3-percent discount rate for all benefits and costs, the estimated cost of the standards is \$10.4 million per year in increased equipment costs, while the estimated annual benefits are \$36.8 million in reduced operating costs, \$17.2 million in GHG reductions, and \$1.0 million in reduced NO_x emissions. In this case, the net benefit amounts to \$45 million per year.

Table V.29 Annualized Benefits and Costs of Adopted Standards for Compressors*

| | Discount Rate percent | Primary Estimate | Low-Net-Benefits Estimate | High-Net-Benefits Estimate |
|--|------------------------------|------------------|---------------------------|----------------------------|
| | | | | |
| Benefits | | | | |
| Consumer Operating Cost Savings | 7 | 28.1 | 24.8 | 35.1 |
| | 3 | 36.8 | 32.2 | 46.6 |
| GHG Reduction (using avg. social costs at 5% discount rate)** | 5 | 5.4 | 4.7 | 6.6 |
| GHG Reduction (using avg. social costs at 3% discount rate)** | 3 | 17.2 | 14.8 | 21.2 |
| GHG Reduction (using avg. social costs at 2.5% discount rate)** | 2.5 | 24.8 | 21.4 | 30.6 |
| GHG Reduction (using 95 th percentile social costs at 3% discount rate)** | 3 | 51.5 | 44.4 | 63.4 |
| NO _x Reduction [†] | 7 | 0.7 | 0.6 | 1.9 |
| | 3 | 1.0 | 0.9 | 2.8 |
| Total Benefits [‡] | 7 plus CO ₂ range | 34 to 80 | 30 to 70 | 44 to 100 |
| | 7 | 46 | 40 | 58 |
| | 3 plus CO ₂ range | 43 to 89 | 38 to 77 | 56 to 113 |
| | 3 | 55 | 48 | 71 |
| Costs | | | | |
| Consumer Incremental Equipment Costs ^{††} | 7 | 9.9 | 8.8 | 11.4 |
| | 3 | 10.4 | 9.3 | 12.0 |
| Net Benefits | | | | |
| Total [‡] | 7 plus CO ₂ range | 24 to 70 | 21 to 61 | 32 to 89 |
| | 7 | 36 | 31 | 47 |
| | 3 plus CO ₂ range | 33 to 79 | 28 to 68 | 44 to 101 |
| | 3 | 45 | 39 | 59 |

* This table presents the annualized costs and benefits associated with the considered compressors shipped in 2022–2051. These results include benefits to consumers which accrue after 2051 from the compressors purchased from 2022–2051. The incremental installed costs include incremental equipment cost as well as installation costs. The results account for the incremental variable and fixed costs incurred by manufacturers due to the adopted standards, some of which may be incurred in preparation for the rule. The GHG reduction benefits are global benefits due to actions that occur nationally. The Primary, Low Net Benefits, and High Net Benefits Estimates utilize projections of energy prices from the AEO 2016 Economic Growth cases. In addition, incremental product costs reflect constant prices 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.F. Note that the Benefits and Costs may not sum to the Net Benefits due to rounding.

** The interagency group selected four sets of SC-CO₂ SC-CH₄, and SC-N₂O values for use in regulatory analyses. Three sets of values are based on the average social costs from the integrated assessment models, at discount rates of 5-percent, 3-percent, and 2.5-percent. The fourth set, which represents the 95th percentile of the social cost distributions

calculated using a 3-percent discount rate, is included to represent higher-than-expected impacts from climate change further out in the tails of the social cost distributions. The social cost values are emission year specific. The GHG reduction benefits are global benefits due to actions that occur nationally. See section IV.L for more details.

† DOE estimated the monetized value of NO_x emissions reductions associated with electricity savings using benefit per ton estimates from the [Regulatory Impact Analysis for the Clean Power Plan Final Rule](#), published in August 2015 by EPA's Office of Air Quality Planning and Standards. (Available at www.epa.gov/cleanpowerplan/clean-power-plan-final-rule-regulatory-impact-analysis.) See section IV.L.3 for further discussion. For the Primary Estimate and Low Net Benefits Estimate, DOE used national benefit-per-ton estimates for NO_x emitted from the Electric Generating Unit sector based on an estimate of premature mortality used by EPA. For the High Net Benefits Estimate, the benefit-per-ton estimates were based on the Six Cities study (Lepuele [et al.](#), 2011); these are nearly two-and-a-half times larger than those from the American Cancer Society ("ACS") study.

‡ Total Benefits for both the 3-percent and 7-percent cases are presented using the average social costs with 3-percent discount rate. In the rows labeled "7% plus GHG range" and "3% plus GHG 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 social cost values.

†† The incremental installed costs include incremental equipment cost as well as installation costs. The results account for the incremental variable and fixed costs incurred by manufacturers due to the proposed standards, some of which may be incurred in preparation for the rule.

VI. Certification Requirements

In the energy conservation standards NOPR, DOE proposed to adopt reporting requirements in a new section 429.63(b) within subpart B of 10 CFR part 429. Consistent with other types of covered products and equipment, the proposed section (10 CFR 429.63(b)) would specify that the general certification reporting requirements contained in 10 CFR 429.12 apply to compressors. The additional requirements proposed in 10 CFR 429.63 would require manufacturers to include the following data (to be made public) in the certification reports:

- full-load package isentropic efficiency or part-load package isentropic efficiency, as applicable (dimensionless);
- full-load actual volume flow rate (in cubic feet per minute);
- compressor motor nominal horsepower (in horsepower);

- full-load operating pressure (in pounds per square inch, gauge);
- maximum full-flow operating pressure (in pounds per square inch, gauge);
and
- pressure ratio (dimensionless).

81 FR 31680, 31757-31758 (May 19, 2016).

The Code of Federal Regulations, under 10 CFR § 429.12(b), already requires reporting of manufacturer name, model number(s), and equipment class for all covered products and equipment.

With respect to reporting model number(s), in the NOPR DOE proposed that a certification report must include a basic model number and the manufacturer's (individual) model number(s). DOE went on to explain that a manufacturer's model number (individual model number) is the identifier used by a manufacturer to uniquely identify what is commonly considered a "model" in industry – all units of a particular design. The manufacturer's (individual) model number typically appears on the product nameplate, in product catalogs and in other product advertising literature. In contrast, the basic model number is a number used by the manufacturer to indicate to DOE how the manufacturer has grouped its individual models for the purposes of testing and rating. Many manufacturers choose to use a model number that is similar to the individual model numbers in the basic model, but that is not required. The manufacturer's individual

model number(s) in each basic model must reference not only the bare compressor, but also any motor and controls with which the compressor is being rated. 81 FR 31680, 31758 (May 19, 2016).

DOE received no comments in response to its proposal for certification requirements. However, requirements in the test procedure final rule regarding compressor configuration during testing necessitate the addition of two certification requirements to this final rule.

The test procedure final rule included two lists of ancillary equipment. The first list, presented in Table IV.2, contains ancillary equipment that must be included on a compressor package during testing, regardless of whether that ancillary equipment is distributed in commerce with the basic model under test. The second list, presented in Table IV.3, contains ancillary equipment that is required to be included for testing only if the ancillary equipment is distributed in commerce with the basic model under test. The test procedure final rule requires that if a compressor is distributed in commerce without an item from Table IV.2, the compressor's manufacturer must provide an appropriate item to be installed for compliance testing. Additionally, the test procedure specifies that ancillary equipment (other than that listed in Table IV.2 and Table IV.3) may be installed for the test if it is distributed in commerce with the compressor, but this additional ancillary equipment is not required.

To support these testing provisions, in this final rule, DOE is requiring manufacturers to report information regarding any pieces of ancillary equipment that

manufacturers install for testing,¹¹⁹ but that are not part of the compressor package, as distributed in commerce. The reporting of this information will allow DOE to replicate, for any possible compliance and enforcement testing, the testing configuration used by manufacturers during their certification testing. DOE believes this to be important, as the specified additional ancillary equipment installed for test may significantly affect the energy consumption of the tested unit.

As a result, the total of data required to be included in the certification reports is now as follows:

- full-load package isentropic efficiency or part-load package isentropic efficiency, as applicable (dimensionless)
- full-load actual volume flow rate (in cubic feet per minute)
- compressor motor nominal horsepower (in horsepower)
- full-load operating pressure (in pounds per square inch, gauge)
- maximum full-flow operating pressure (in pounds per square inch, gauge)
- pressure ratio at full-load operating pressure (dimensionless)

¹¹⁹ I.e., in order to comply with the requirement that a tested compressor package include all ancillary equipment listed in Table IV.2

- For any ancillary equipment that is installed for testing, but that is not part of the compressor package, as distributed in commerce (per the requirements of 10 CFR part 431, subpart T, appendix A, section I(B)(4)), the following must be reported:
 - A general description of the ancillary equipment, based on the list provided in the first column of Table 1 of 10 CFR part 431, subpart T, appendix A, section I(B)(4)
 - The manufacturer of the ancillary equipment
 - The brand of the ancillary equipment (if different from the manufacturer)
 - The model number of the ancillary equipment
 - The serial number of the ancillary equipment (if applicable)
 - The following electrical characteristics, if applicable:
 - Input Voltage
 - Number of Phases
 - Input Frequency

- The following mechanical characteristics, if applicable:
 - Size of any connections
 - Type of any connections

- Installation instructions for the ancillary equipment, accompanied by photos that clearly illustrate the ancillary equipment, as installed on compressor package. Instructions and photo(s) to be provided in portable document format (i.e., a PDF file).

VII. 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 compressors are intended to address are as follows:

- (1) Insufficient information and the high costs of gathering and analyzing relevant information leads 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 occurs when a building contractor or building owner makes the purchasing decision but does not pay the energy costs.
- (3) There are external benefits resulting from improved energy efficiency of products or equipment 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 quantify 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 regulatory action in this document is not a significant regulatory action under section (3)(f) of Executive Order 12866. Section 6(a)(3)(A) of the Executive Order states that absent a material change in the development of the planned regulatory action, regulatory action not designated as significant will not be subject to review under section 6(a)(3) unless, within 10 working days of receipt of DOE’s list of planned regulatory actions, the Administrator of OIRA notifies the agency that OIRA has determined that a planned regulation is a significant regulatory action within the meaning of the Executive order. Accordingly, DOE has not submitted this final rule for review by OIRA. 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.

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 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 an initial regulatory flexibility analysis (“IRFA”) and 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 (Aug. 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 website (<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 compressors, the 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 the North American Industry Classification System (NAICS) code and industry description and are available at www.sba.gov/sites/default/files/files/Size_Standards_Table.pdf. Manufacturing of compressors is classified under NAICS 333912, “Air and Gas Compressor Manufacturing.” The SBA sets a threshold of 1,000 employees or fewer for an entity to be considered as a small business for this category.

1. Need for, Objectives of, and Legal Basis, for Rule

As described in section II.A above, Title III of the Energy Policy and Conservation Act of 1975 (EPCA or the Act) sets forth a variety of provisions designed to improve energy efficiency. (42 U.S.C. 6291, *et seq.*) Part C of Title III, which for editorial reasons was re-designated as Part A-1 upon incorporation into the U.S. Code (42 U.S.C. 6311–6317), establishes the “Energy Conservation Program for Certain Industrial Equipment.” EPCA provides that DOE may include a type of industrial equipment, including compressors, as covered equipment if it determines that to do so is necessary to carry out the purposes of Part A-1. (42 U.S. 6311(2)(B)(i) and 6312(b)). The purpose of Part A-1 is to improve the efficiency of electric motors and pumps and certain other industrial equipment in order to conserve the energy resources of the Nation. (42 U.S.C 6312(a)). DOE determined that compressors meet the statutory criteria for classifying industrial equipment as covered, as Compressors are a type of industrial equipment (1)

which in operation consumes, or is designed to consume, energy; (2) are to a significant extent distributed in commerce for industrial or commercial use; and (3) are not covered under 42 U.S.C. 6291(a)(2).

2. Significant Issues Raised in Response to the IRFA

Many manufacturers stated that small businesses would be negatively affected by the proposed regulation compared to their larger multinational counterparts. Sullivan-Palatek stated it is difficult for their small business, and other small businesses, to access capital compared to their larger competitors. (Sullivan-Palatek, Public Meeting Transcript No. 44 at p. 141-143) A few manufacturers also noted that a stringent standard can cause a heavy cost burden that will likely cause many small businesses to exit the rotary compressor business or become acquired by larger companies. (Sullivan-Palatek, No. 51 at p. 2-9; Castair, No. 52 at p. 3; Compressed Air Systems, No. 61 at p. 4) Often times, these small businesses, both manufacturers and packagers, employ specialized workers that may not be able to find a new job where they can use their skills. (Sullivan-Palatek, No. 51 at p. 9; Castair, No. 45 at p. 1; CAGI, No. 52 at p. 3)

Further, Compressed Air Systems noted that testing four to five units based on the NOPR test procedure could cost up to \$125,000 for a manufacturer. Most domestic small air compressor manufacturers produce small quantities of each model offered, which is a heavy cost burden to smaller companies with limited access to capital. (Compressed Air Systems, No. 61 at p. 4)

Consistent with the requirements of the Regulatory Flexibility Act (5 U.S.C. 601, et seq.), as amended, the Department analyzes the expected impacts of an energy conservation standard on small business compressor manufacturers directly regulated by DOE's standards. DOE understands that some small manufacturers may be disproportionately affected by an energy conservation standard, and these impacts are discussed in detail in section VII.B.4. DOE agrees that small businesses may not have the same access to capital compared to their larger competitors. Furthermore, DOE analyzes the impacts of a compressors energy conservation standard on domestic direct employment in section V.B.2.b. Further, DOE acknowledges the commenter's concerns about the scope of the test procedure as defined in the test procedure NOPR, which included many low-shipment volume or custom compressor models. DOE took two key steps to address commenters' concerns and reduce the burden of testing, especially for low-volume equipment, in the test procedure final rule: (1) DOE is significantly limiting the scope of the test procedure final rule, as compared to the scope proposed in the test procedure NOPR, and (2) DOE adopted provisions allowing the use of an AEDM, in lieu of testing.

Additionally, Sullivan-Palatek recalls that in the NOPR, DOE identified two small business OEMs and 13 large OEMs. Sullivan-Palatek also stated that DOE's NOPR analysis concluded that, on average, small businesses will incur \$3.95 million to \$5.15 million in conversion costs per company. Meanwhile, large businesses will incur, on average, \$6.02 million to \$7.85 million in conversion costs per company. Sullivan-Palatek questioned why DOE assumes a smaller firm, such as their own, with the same

number of models requiring conversion will incur a lesser cost than a large business. As such, they requested an independent analysis by the Department of Justice. (Sullivan-Palatek, No. 51 at p. 8-9)

DOE understands that small manufacturers will have varying degrees of burden when complying with a compressors energy conservation standard. Depending on the number of models offered and equipment efficiency offerings, small manufacturers may find that their conversion costs either fall above or below the small business average. Typically, larger manufacturers have broader equipment offerings than their smaller competitors, which means they are likely to incur higher redesign costs to bring more products into compliance. However, DOE notes that one small business OEM had a higher percentage of failing models at TSL 2. This small business OEM may incur disproportionate impacts relative to the industry because their percentage of failing models is above the industry average.

During the notice of proposed rulemaking public meeting, DOE cautioned stakeholders that SBA size standards may shift before the final rule is published. Sullair and CAGI commented that with an increased size standard, from 500 employees to 1,000 employees, the number of OEMs identified would increase as well. (CAGI, Public Meeting Transcript No. 44 at p. 141; Sullair, Public Meeting Transcript No. 44 at p. 140)

For the compressor manufacturing industry, the Small Business Administration (SBA) sets size threshold, which defines those entities classified as small businesses for

the purpose of this statute. Compressor manufacturers are classified under NAICS 333912, “Air and Gas Compressor Manufacturing.” During the NOPR stage, the SBA set a threshold of 500 employees or less for an entity to be considered as a small business in this industry. In February 2016, as codified in 13 CFR part 121, the SBA changed size standards for NAICS code 333912 to 1,000 employees or less. Therefore, for the purpose of this final rule, DOE has identified 22 small manufacturers that meet the employee threshold defined by the SBA. The manufacturer impact analysis and regulatory flexibility analysis have been updated in the final rule to reflect the changes in SBA size standards.

Manufacturers stated that there are between 10-100 more small businesses affected by this rulemaking that were not previously identified by DOE during the NOPR stage. With a number of small businesses unidentified, many were not notified or contacted for feedback prior to the regulation. Further, Jenny Products and Compressed Air Systems commented that the high cost to comply with the test procedure and standard would place a significant burden on small manufacturers. (Sullivan-Palatek, No. 51 at p. 1-2; Jenny Products, No. 58 at p. 4-5; Compressed Air Systems, No. 61 at p. 2-4; Castair, No. 45 at p. 2) In a written comment, Compressed Air Systems provided a list of sixteen potential small businesses that could be affected by this final rule standard. It also noted that while DOE’s analysis shows that most units manufactured by small businesses can comply with this final rule, small businesses will still face high burdens testing each model. (Compressed Air Systems, No. 61 at p. 2-5) However, Jenny Products confirmed that their company will not be able to comply with this final rule standard. (Jenny

Products, No. 58 at p. 6) As a result, Compressed Air Systems asked that DOE conduct a more thorough survey of domestic small businesses to understand how a stringent standard will lessen their ability to remain competitive in the market. (Compressed Air Systems, No. 61 at p. 2-5)

DOE recognizes that small manufacturers may be substantially impacted by energy conservation standards. Again, DOE notes in the Regulatory Flexibility Act, section VI.B of this final rule notice, that small manufacturers are not expected to face significantly higher conversion costs than their larger competitors. In response to the list of manufacturers provided by Compressed Air Systems, DOE reviewed this list and identified two additional entities that produce covered equipment. Of these two entities, one was a large manufacturer and the other was a domestic small business that packages and assembles covered equipment. DOE has updated its manufacturer count and analyses to reflect these additions.

3. Description on Estimated Number of Small Entities Affected

For manufacturers of compressors, 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 www.sba.gov/sites/default/files/files/Size_Standards_Table.pdf. Manufacturing of compressors is classified under NAICS 333912, “Air and Gas Compressor

Manufacturing” The SBA sets a threshold of 1,000 employees or fewer for an entity to be considered as a small business for this category.

To identify and estimate the number of small business manufacturers of equipment within the scope of this rulemaking, DOE conducted a market survey using available public information. DOE’s research involved industry trade association membership directories (including CAGI), individual company and online retailer websites, and market research tools (e.g., Hoovers reports) to create a list of companies that manufacture equipment covered by this rulemaking. DOE presented its list to manufacturers in MIA interviews and asked industry representatives if they were aware of any other small manufacturers during manufacturer interviews and at DOE public meetings. DOE reviewed publicly-available data and contacted select 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 within the scope of this rulemaking, do not meet the definition of a “small business,” or are foreign-owned and operated.

DOE identified 22 manufacturers of lubricated rotary compressor equipment sold in the United States and within the scope of this rulemaking. Seven of these manufacturers were under the 1,000-employee threshold defined by the SBA to qualify as a small business and are domestic companies.

Within the compressor industry, manufacturers are classified into two categories; original equipment manufacturers (“OEMs”) and compressor packagers. OEMs

manufacture their own air-ends and assemble them with other components to create complete package compressors. Packagers assemble motors and other accessories with air-ends purchased from other companies, resulting in a complete compressor.

Within the rotary air compressor industry, DOE identified 22 manufacturers; 15 are OEMs and seven are packagers of compressors. Of the 22 total manufacturers, seven large OEMs supply approximately 80 percent of shipments and revenues. Of the seven domestic small businesses identified, DOE's research indicates that two are OEMs and five are packagers.

4. Description and Estimate of Compliance Requirements Including Differences in Cost, if Any, for Different Groups of Small Entities

Because DOE proposes to establish standards for only lubricated rotary equipment, this section will only focus on the estimated impacts to the seven domestic small manufacturers of rotary compressors.

Of the seven domestic small rotary compressor manufacturers identified, DOE's research indicates that two are OEMs and five are packagers. Whereas OEMs would be expected to incur significant redesign and capital conversion costs in order to comply with new standards, packagers would not. Unlike OEMs, packagers would not face significant capital conversion costs, as the processes they use to assemble completed packages from purchased air-ends and components is not expected to change. Packagers

are also not expected to face significant product redesign costs, as the burden of engineering and redesigning the air-end and other key components would reside with OEMs. However, as manufacturers OEMs and packagers are both expected to incur new compliance and testing costs, as any new energy conservation standard would require their equipment to be tested and certified to the standard, using a DOE test procedure.

As a result of these efforts, the following discussion of domestic small business impacts considers capital, redesign, and compliance cost impacts facing rotary OEMs, while only considering redesign and compliance cost impacts for rotary packagers.

DOE identified two small business OEMs producing lubricated rotary compressors. Based on equipment listings data in the CAGI database, small business OEMs comprise approximately three percent of industry listings. Excluding testing costs, DOE estimates that the average failing compressor model will cost between \$0.29 million and \$0.38 million in product and capital conversion costs. Using the CAGI database and manufacturer websites, DOE identified 23 failing models manufactured by small business OEMs. Therefore, DOE estimates that product and capital conversion costs, excluding testing costs, for small businesses to range from \$6.6 million to \$8.7 million. DOE notes that 21 of the 23 failing models are manufactured by one small business OEM. This small business OEM may incur disproportionate impacts relative to the industry because their percentage of failing models is above the industry average.

DOE identified five small business packagers producing lubricated rotary compressors. DOE estimates that the average packager will incur between \$1.5 million and \$2.2 million in engineering redesign costs at TSL 2. DOE was unable to obtain equipment performance data for packagers. During the NOPR stage, DOE estimated the total number of rotary models in the industry by scaling the model counts in the CAGI database by CAGI's estimated market share; 85 percent. In the final rule analysis, DOE updated the CAGI database with additional manufacturers and models. The CAGI database model count increased by approximately five percent and therefore, for the purposes of the final rule analysis, DOE estimates that packagers represent approximately 10 percent of industry models. Therefore, DOE calculated the industry testing cost to packagers at approximately \$2.3 million. Further, using publicly available information, DOE calculated the average annual revenue of a small business packager at \$14.5 million. With a conversion period of five years, 2017 to 2021, the average small business packager would have to commit between 2.5 percent and 3.5 percent of their conversion period revenue to cover the estimated engineering redesign and testing costs at TSL 2.

DOE's conversion cost estimates were derived from total industry conversion costs discussed previously in section IV.J.2.c. DOE notes that the ranges shown here relate to the two conversion cost scenarios investigated in section IV.J.2.c.

However, as noted in section V.B.2, the GRIM free cash flow results in 2021 indicated that some manufacturers may need to access the capital markets in order to fund conversion costs directly related to the proposed standard. Given that small

manufacturers may have greater difficulty securing outside capital¹²⁰ and that the necessary conversion costs are not insignificant to the size of a small business, it is possible the domestic small OEMs may be forced to retire a greater portion of product models than large competitors. In addition, smaller companies often have a higher cost of borrowing due to higher risk on the part of investors, largely attributed to lower cash flows and lower per unit profitability. In these cases, small manufacturers may observe higher costs of debt than larger manufacturers.

5. Significant Alternatives to the Rule

The discussion in the previous section analyzes impacts on small businesses that would result from the adopted standards, represented by TSL 2. In reviewing alternatives to the adopted standards, DOE examined energy conservation standards set at lower efficiency levels. While TSL 1 would reduce the impacts on small business manufacturers, it would come at the expense of a reduction in energy savings. TSL 1 achieves 81 percent less energy savings compared to the energy savings at TSL 2.

DOE believes that establishing standards at TSL 2 balances the benefits of the energy savings at TSL 2 with the potential burdens placed on compressors manufacturers, including small business manufacturers. Accordingly, DOE is not adopting one of the

¹²⁰ Simon, Ruth, and Angus Loten, "Small-Business Lending Is Slow to Recover," *Wall Street Journal*, August 14, 2014. Accessed August 2014, available at <http://online.wsj.com/articles/small-business-lending-is-slow-to-recover-1408329562>.

other TSLs considered in the analysis, or the other policy alternatives examined as part of the regulatory impact analysis and included in chapter 17 of the final rule TSD.

Additional compliance flexibilities may be available through other means. EPCA provides that a manufacturer whose annual gross revenue from all of its operations does not exceed \$8 million 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, provides authority for 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. Manufacturers should refer to 10 CFR part 430, subpart E, and part 1003 for additional details.

C. Review Under the Paperwork Reduction Act

Manufacturers of compressors must certify to DOE that their products comply with any applicable energy conservation standards. In certifying compliance, manufacturers must test their products according to the DOE test procedures for compressors, 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 compressors. 76 FR 12422 (March 7, 2011); 80 FR 5099 (Jan. 30, 2015). The collection-of-information requirement for the 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. Public 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 (“NEPA”) of 1969, 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 this 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. DOE has applied Categorical Exclusion B5.1 – Actions to conserve energy or water, as the final determination for this rulemaking and, therefore, 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 (Aug. 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 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 products that are the subject of this 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(d)) Therefore, no further action is required by Executive Order 13132.

F. Review Under Executive Order 12988

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). 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 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.

This rule does not contain a Federal intergovernmental mandate, nor is it expected to require expenditures of \$100 million or more in any one year by the private sector. As a result, the analytical requirements of UMRA do not apply.

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 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 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 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 new energy conservation standards for compressors, 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 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:

www.energy.gov/eere/buildings/peer-review.

M. Congressional Notification

As required by 5 U.S.C. 801, DOE will report to Congress on the promulgation of this 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).

VIII. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this final rule.

List of Subjects

10 CFR Part 429

Confidential business information, Energy conservation, Household appliances, Imports, Reporting and recordkeeping requirements.

10 CFR Part 431

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Incorporation by reference, Intergovernmental relations, Small businesses.

Issued in Washington, DC, on December 5, 2016.



David J. Friedman
Acting Assistant Secretary
Energy Efficiency and Renewable Energy

For the reasons set forth in the preamble, DOE amends parts 429 and 431 of chapter II, subchapter D, of title 10 of the Code of Federal Regulations, as set forth below:

**PART 429 - CERTIFICATION, COMPLIANCE, AND ENFORCEMENT FOR
CONSUMER PRODUCTS AND COMMERCIAL AND INDUSTRIAL
EQUIPMENT**

1. The authority citation for part 429 continues to read as follows:

Authority: 42 U.S.C. 6291–6317; 28 U.S.C. 2461 note.

2. Section 429.12 is amended by revising paragraph (b)(13) to read as follows:

§429.12 General requirements applicable to certification reports.

* * * * *

(b) * * *

(13) Product specific information listed in §§429.14 through 429.63 of this chapter.

* * * * *

3. Section 429.63 is amended by adding paragraph (b) to read as follows:

§429.63 Compressors.

* * * * *

(b) Certification reports.

(1) The requirements of §429.12 are applicable to compressors; and

(2) Pursuant to §429.12(b)(13), a certification report will include the following public product-specific information:

(i) Full-load package isentropic efficiency or part-load package isentropic efficiency, as applicable (dimensionless).

(ii) Full-load actual volume flow rate (in cubic feet per minute).

(iii) Compressor motor nominal horsepower (in horsepower).

(iv) Full-load operating pressure (in pounds per square inch, gauge).

(v) Maximum full-flow operating pressure (in pounds per square inch, gauge).

(vi) Pressure ratio at full-load operating pressure (dimensionless).

(vii) For any ancillary equipment that is installed for test, but is not part of the compressor package as distributed in commerce (per the requirements of 10 CFR part 431, subpart T, appendix A, section I(B)(4)), the following must be reported:

(A) A general description of the ancillary equipment, based on the list provided in the first column of Table 1 of 10 CFR part 431, subpart T, appendix A, section I(B)(4)

(B) The manufacturer of the ancillary equipment

(C) The brand of the ancillary equipment (if different from the manufacturer)

(D) The model number of the ancillary equipment

(E) The serial number of the ancillary equipment (if applicable)

(F) The following electrical characteristics, if applicable:

(1) Input Voltage

(2) Number of Phases

(3) Input Frequency

(G) The following mechanical characteristics, if applicable:

(1) Size of any connections

(2) Type of any connections

(H) Installation instructions for the ancillary equipment, accompanied by photos that clearly illustrate the ancillary equipment, as installed on compressor package. Instructions and photo(s) to be provided in portable document format (i.e., a PDF file).

4. Section 429.71 is amended by adding paragraph (e) to read as follows:

§429.71 Maintenance of records.

* * * * *

(e) When considering if a compressor is subject to energy conservation standards under part 431, DOE may need to determine if a compressors was designed and tested to the requirements set forth in the American Petroleum Institute standard 619, “Rotary-Type Positive-Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries” (API 619). In this case, DOE may request that a manufacturer provide DOE with copies of the original requirements and test data that were submitted to the purchaser of the compressor, in accordance with API 619.

**PART 431 - ENERGY CONSERVATION PROGRAM FOR CERTAIN
COMMERCIAL AND INDUSTRIAL EQUIPMENT**

5. The authority citation for part 431 continues to read as follows:

Authority: 42 U.S.C. 6291-6317; 28 U.S.C. 2461 note.

6. Section 431.342 is amended by adding, in alphabetical order, definitions for “Air-cooled compressor”, “Liquid-cooled compressor” and “Water-injected lubricated compressor” to read as follows:

§ 431.342 Definitions concerning compressors.

* * * * *

Air-cooled compressor means a compressor that utilizes air to cool both the compressed air and, if present, any auxiliary substance used to facilitate compression, and that is not a liquid-cooled compressor.

* * * * *

Liquid-cooled compressor means a compressor that utilizes liquid coolant provided by an external system to cool both the compressed air and, if present, any auxiliary substance used to facilitate compression.

* * * * *

Water-injected lubricated compressor means a lubricated compressor that uses injected water as an auxiliary substance.

7. Add § 431.345 to read as follows:

§431.345 Energy conservation standards and effective dates.

(a) Each compressor that is manufactured starting on **[INSERT DATE FIVE YEARS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER]** and that:

- (1) Is an air compressor,
- (2) Is a rotary compressor,
- (3) Is not a liquid ring compressor,
- (4) Is driven by a brushless electric motor,
- (5) Is a lubricated compressor,

(6) Has a full-load operating pressure greater than or equal to 75 pounds per square inch gauge (psig) and less than or equal to 200 psig,

(7) Is not designed and tested to the requirements of The American Petroleum Institute standard 619, “Rotary-Type Positive-Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries,”

(8) Has full-load actual volume flow rate greater than or equal to 35 cubic feet per minute (cfm), or is distributed in commerce with a compressor motor nominal horsepower greater than or equal to 10 horsepower (hp),

(9) Has a full-load actual volume flow rate less than or equal to 1,250 cfm, or is distributed in commerce with a compressor motor nominal horsepower less than or equal to 200 hp,

(10) Is driven by a three-phase electric motor,

(11) Is manufactured alone or as a component of another piece of equipment; and

(12) Is in one of the equipment classes listed in the Table 1, must have a full-load package isentropic efficiency or part-load package isentropic efficiency that is not less than the appropriate “Minimum Package Isentropic Efficiency” value listed in Table 1 of this section.

TABLE 1—ENERGY CONSERVATION STANDARDS FOR CERTAIN COMPRESSORS

| Equipment Class | Minimum Package Isentropic Efficiency | η_{Regr} (package isentropic efficiency reference curve) | d (Percentage Loss Reduction) |
|--|--|--|--|
| Rotary, lubricated, air-cooled, fixed-speed compressor | $\eta_{\text{Regr}} + (1 - \eta_{\text{Regr}}) * (d/100)$ | $-0.00928 * \ln^2(.4719 * V_1) + 0.13911 * \ln(.4719 * V_1) + 0.27110$ | -15 |
| Rotary, lubricated, air-cooled, variable-speed compressor | $\eta_{\text{Regr}} + (1 - \eta_{\text{Regr}}) * (d/100)$ | $-0.01549 * \ln^2(.4719 * V_1) + 0.21573 * \ln(.4719 * V_1) + 0.00905$ | -10 |
| Rotary, lubricated, liquid-cooled, fixed-speed compressor | $.02349 + \eta_{\text{Regr}} + (1 - \eta_{\text{Regr}}) * (d/100)$ | $-0.00928 * \ln^2(.4719 * V_1) + 0.13911 * \ln(.4719 * V_1) + 0.27110$ | -15 |
| Rotary, lubricated, liquid-cooled, variable-speed compressor | $.02349 + \eta_{\text{Regr}} + (1 - \eta_{\text{Regr}}) * (d/100)$ | $-0.01549 * \ln^2(.4719 * V_1) + 0.21573 * \ln(.4719 * V_1) + 0.00905$ | -15 |

(b) Instructions for the use of Table 1 of this section:

- (1) To determine the standard level a compressor must meet, the correct equipment class must be identified. The descriptions are in the first column (“Equipment Class”); definitions for these descriptions are found in §431.342.
- (2) The second column (“Minimum Package Isentropic Efficiency”) contains the applicable energy conservation standard level, provided in terms of package isentropic efficiency.
- (3) For “Fixed-speed compressor” equipment classes, the relevant Package Isentropic Efficiency is Full-load Package Isentropic Efficiency. For “Variable-speed compressor” equipment classes, the relevant Package Isentropic Efficiency is Part-load Package Isentropic Efficiency. Both Full- and Part-load Package Isentropic Efficiency are determined in accordance with the test procedure in §431.344.
- (4) The second column (“Minimum Package Isentropic Efficiency”) references the third column (“ η_{Regr} ”), also a function of full-load actual volume flow rate, and the fourth column (“d”). The equations are provided separately to maintain consistency with the language of the preamble and analysis.
- (5) The second and third columns contain the term V_1 , which denotes compressor full-load actual volume flow rate, given in terms of cubic feet per minute (“cfm”) and determined in accordance with the test procedure in §431.344.

Note: The following letter will not appear in the Code of Federal Regulations.

U.S. DEPARTMENT OF JUSTICE

Antitrust Division

Renata B. Hesse

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(202) 514-2401 / (202) 616-2645 (Fax)

July 18, 2016

Anne Harkavy

Deputy General Counsel for Litigation, Regulation and Enforcement

U.S. Department of Energy Washington, DC 20585

Re: Energy Conservation Standards for Compressors; Doc. No. EERE-2013-BT-STD-0040

Dear Deputy General Counsel Harkavy:

I am responding to your May 19, 2016, letter seeking the views of the Attorney General about the potential impact on competition of proposed energy conservation

standards for compressors. Your request was submitted under Section 325(o)(2)(B)(i)(V) of the Energy Policy and Conservation Act, as amended (ECPA), 42 U.S.C. 6295(o)(2)(B)(i)(V), which requires the Attorney General to make a determination of the impact of any lessening of competition that is likely to result from the imposition of proposed energy conservation standards. The Attorney General's responsibility for responding to requests from other departments about the effect of a program on competition has been delegated to the head of the Antitrust Division in 28 CFR § 0.40(g).

In conducting its analysis, the Antitrust Division examines whether a proposed standard may lessen competition, for example, by substantially limiting consumer choice or increasing industry concentration. A lessening of competition could result in higher prices to manufacturers and consumers.

We have reviewed the proposed standards contained in the Notice of Proposed Rulemaking (81 Fed. Reg. 31680, May 19, 2016) and the related technical support documents. We have also reviewed supplementary information submitted to the Attorney General by the Department of Energy, as well as materials presented at the public meeting held on the proposed standards on June 20, 2016, and conducted interviews with industry members.

Based on the information currently available, we do not believe that the proposed energy conservation standards for compressors are likely to have a significant adverse impact on competition.

Sincerely,

Renata B. Hesse