DEPARTMENT OF ENERGY

10 CFR Part 431

[EERE–2020–BT–STD–0007]

RIN 1904–AE63

Energy Conservation Program: Energy Conservation Standards for Electric Motors

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

ACTION: Direct final rule.

SUMMARY: The Energy Policy and Conservation Act, as amended (''EPCA''), prescribes energy conservation standards for various consumer products and certain commercial and industrial equipment, including electric motors. EPCA also requires the U.S. Department of Energy (''DOE'') to periodically determine whether more-stringent, standards would be technologically feasible and economically justified, and would result in significant energy savings. In this direct final rule, DOE is adopting new and amended energy conservation standards for electric motors. It has determined that the new and amended 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 September 29, 2023, unless adverse comment is received by September 19, 2023. If adverse comments are received that DOE determines may provide a reasonable basis for withdrawal of the direct final rule, a timely withdrawal of this rule will be published in the **Federal Register**. If no such adverse comments are received, compliance with the new and amended standards established for electric motors in this direct final rule is required on and after June 1, 2027.

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 *www.regulations.gov/docket/EERE-2020-BT-STD-0007.* The docket web page contains instructions on how to access all documents, including public comments, in the docket.

For further information on how to submit a comment or review other public comments and the docket, contact the Appliance and Equipment Standards Program staff at (202) 287–1445 or by email: *ApplianceStandardsQuestions@ee.doe.gov.*

FOR FURTHER INFORMATION CONTACT:

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For further information on how to submit a comment, review other public comments and the docket, or participate in the public meeting, contact the Appliance and Equipment Standards Program staff at (202) 287–1445 or by email: *ApplianceStandardsQuestions@ee.doe.gov.*

SUPPLEMENTARY INFORMATION:

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I. Synopsis of the Direct Final Rule

The Energy Policy and Conservation Act, Public Law 94–163, as amended (''EPCA''),[1] authorizes DOE to regulate the energy efficiency of a number of consumer products and certain industrial equipment. (42 U.S.C. 6291–6317) Title III, Part C [2] of EPCA established the Energy Conservation Program for Certain Industrial Equipment. (42 U.S.C. 6311–6317). Such equipment includes electric motors, the subject of this rulemaking.

Pursuant to EPCA, any new or amended energy conservation standard must be designed to achieve the maximum improvement in energy efficiency that DOE determines is technologically feasible and economically justified. (42 U.S.C. 6316(a); 42 U.S.C. 6295(o)(2)(A)) Furthermore, the new or amended standard must result in a significant conservation of energy. (42 U.S.C. 6316(a); 42 U.S.C. 6295(o)(3)(B)) EPCA also provides that not later than 6 years after issuance of any final rule establishing or amending a standard, DOE must publish either a notice of determination that standards for the product do not need to be amended, or a notice of proposed rulemaking including new proposed energy conservation standards (proceeding to a final rule, as appropriate). (42 U.S.C. 6316(a); 42 U.S.C. 6295(m))

In light of the above and under the authority provided by 42 U.S.C. 6295(p)(4), DOE is issuing this direct final rule amending the energy conservation standards for electric motors. The amended standard levels in this document were submitted in a joint recommendation (the ''November 2022 Joint Recommendation'') [3] by the American Council for an Energy-Efficient Economy (''ACEEE''), Appliance Standards Awareness Project (''ASAP''), National Electrical Manufacturers Association (''NEMA''), Natural Resources Defense Council (''NRDC''), Northwest Energy Efficiency Alliance (''NEEA''), Pacific Gas & Electric Company (''PG&E''), San Diego Gas & Electric (''SDG&E''), and Southern California Edison (''SCE'') hereinafter referred to as ''the Electric Motors Working Group.'' In a letter comment submitted December 12, 2022, the New York State Energy Research and Development Authority (''NYSERDA'') expressed its support of the November 2022 Joint Recommendation and urged DOE to implement it in a timely manner. The November 2022 Joint Recommendation was preceded by the following DOE actions in this rulemaking and stakeholder comments thereon: May 2020 Early Assessment Review RFI (85 FR 30878 (May 21, 2020)); March 2022 Preliminary Analysis (87 FR 11650 (March 2, 2022)) and the Preliminary Analysis TSD (''March 2022 Prelim TSD''). See sections II.B.2 and II.B.3 for a detailed history of the current rulemaking and a discussion of the November 2022 Joint Recommendation.

After carefully considering the November 2022 Joint Recommendation, DOE determined that the recommendations contained therein are compliant with 42 U.S.C. 6295(o), as required by 42 U.S.C. 6295(p)(4)(A)(i) for the issuance of a direct final rule. As required by 42 U.S.C. 6295(p)(4)(A)(i), DOE is simultaneously publishing a NOPR proposing that the identical standard levels contained in this direct final rule be adopted. Consistent with the statute, DOE is providing a 110-day public comment period on the direct final rule. (42 U.S.C. 6295(p)(4)(B)) If DOE determines that any comments received provide a reasonable basis for withdrawal of the direct final rule under 42 U.S.C. 6295(o), DOE will continue the rulemaking under the simultaneously published NOPR. (42 U.S.C. 6295(p)(4)(C)) See section II.A for more details on DOE's statutory authority.

This direct final rule documents DOE's analyses to objectively and independently evaluate the energy savings potential, technological feasibility, and economic justification of the standard levels recommended in the November 2022 Joint Recommendation, as per the requirements of 42 U.S.C. 6295(o).

Ultimately, DOE found that the standard levels recommended in the November 2022 Joint Recommendation would result in significant energy savings and are technologically feasible and economically justified. Table I–1 through Table I–3 document the amended standards for electric motors. The amended standards correspond to the recommended trial standard level (''TSL'') 2 (as described in section V.A of this document) and are expressed in terms of nominal full-load efficiency. The amended standards are the same as those recommended by the Electric Motors Working Group. These standards apply to all products listed in through Table I–1 through Table I–3 and manufactured in, or imported into, the United States starting on June 1, 2027.

[1] All references to EPCA in this document refer to the statute as amended through the Energy Act of 2020, Public Law 116–260 (Dec. 27, 2020), which reflect the last statutory amendments that impact Parts A and A–1 of EPCA.

[2] For editorial reasons, upon codification in the U.S. Code, Part C was re-designated Part A–1.

[3] Joint comment response to the published Notification of a webinar and availability of preliminary technical support document; *www.regulations.gov/comment/EERE-2020-BT-STD-0007-0035.*

TABLE I–1—NOMINAL FULL-LOAD EFFICIENCIES OF NEMA DESIGN A, NEMA DESIGN B AND IEC DESIGN N, NE, NEY OR NY MOTORS (EXCLUDING FIRE PUMP ELECTRIC MOTORS AND AIR-OVER ELECTRIC MOTORS) AT 60 HZ

Motor horsepower/ standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/.75	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5/1.1	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0
2/1.5	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5
3/2.2	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5/3.7	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5/5.5	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10/7.5	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15/11	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20/15	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0
25/18.5	91.7	91.7	93.6	93.6	93.0	93.0	90.2	91.0
30/22	91.7	91.7	93.6	94.1	93.0	93.6	91.7	91.7
40/30	92.4	92.4	94.1	94.1	94.1	94.1	91.7	91.7
50/37	93.0	93.0	94.5	94.5	94.1	94.1	92.4	92.4
60/45	93.6	93.6	95.0	95.0	94.5	94.5	92.4	93.0
75/55	93.6	93.6	95.4	95.0	94.5	94.5	93.6	94.1
100/75	95.0	94.5	96.2	96.2	95.8	95.8	94.5	95.0
125/90	95.4	94.5	96.2	96.2	95.8	95.8	95.0	95.0
150/110	95.4	94.5	96.2	96.2	96.2	95.8	95.0	95.0
200/150	95.8	95.4	96.5	96.2	96.2	95.8	95.4	95.0
250/186	96.2	95.4	96.5	96.2	96.2	96.2	95.4	95.4
300/224	95.8	95.4	96.2	95.8	95.8	95.8		
350/261	95.8	95.4	96.2	95.8	95.8	95.8		
400/298	95.8	95.8	96.2	95.8				
450/336	95.8	96.2	96.2	96.2				
500/373	95.8	96.2	96.2	96.2				
550/410	95.8	96.2	96.2	96.2				
600/447	95.8	96.2	96.2	96.2				
650/485	95.8	96.2	96.2	96.2				
700/522	95.8	96.2	96.2	96.2				
750/559	95.8	96.2	96.2	96.2				

TABLE I–2—NOMINAL FULL-LOAD EFFICIENCIES OF NEMA DESIGN A, NEMA DESIGN B AND IEC DESIGN N, NE, NEY OR NY STANDARD FRAME SIZE AIR-OVER ELECTRIC MOTORS (EXCLUDING FIRE PUMP ELECTRIC MOTORS) AT 60 HZ

Motor horsepower/ standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/.75	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5/1.1	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0
2/1.5	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5
3/2.2	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5/3.7	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5/5.5	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10/7.5	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15/11	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20/15	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0
25/18.5	91.7	91.7	93.6	93.6	93.0	93.0	90.2	91.0
30/22	91.7	91.7	93.6	94.1	93.0	93.6	91.7	91.7
40/30	92.4	92.4	94.1	94.1	94.1	94.1	91.7	91.7
50/37	93.0	93.0	94.5	94.5	94.1	94.1	92.4	92.4
60/45	93.6	93.6	95.0	95.0	94.5	94.5	92.4	93.0
75/55	93.6	93.6	95.4	95.0	94.5	94.5	93.6	94.1
100/75	95.0	94.5	96.2	96.2	95.8	95.8	94.5	95.0
125/90	95.4	94.5	96.2	96.2	95.8	95.8	95.0	95.0
150/110	95.4	94.5	96.2	96.2	96.2	95.8	95.0	95.0
200/150	95.8	95.4	96.5	96.2	96.2	95.8	95.4	95.0
250/186	96.2	95.4	96.5	96.2	96.2	96.2	95.4	95.4

TABLE I–3—NOMINAL FULL-LOAD EFFICIENCIES OF NEMA DESIGN A, NEMA DESIGN B AND IEC DESIGN N, NE, NEY OR NY SPECIALIZED FRAME SIZE AIR-OVER ELECTRIC MOTORS (EXCLUDING FIRE PUMP ELECTRIC MOTORS) AT 60 HZ

Motor horsepower/ standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/.75	74.0	....	82.5	82.5	80.0	80.0	74.0	74.0
1.5/1.1	82.5	82.5	84.0	84.0	85.5	84.0	77.0	75.5
2/1.5	84.0	84.0	84.0	84.0	86.5	85.5	82.5	85.5
3/2.2	85.5	84.0	87.5	86.5	87.5	86.5	84.0	86.5
5/3.7	87.5	85.5	87.5	87.5	87.5	87.5	85.5	87.5
7.5/5.5	88.5	87.5	89.5	88.5	89.5	88.5	85.5	88.5
10/7.5	89.5	88.5	89.5	89.5	89.5	90.2	....	....
15/11	90.2	89.5	91.0	91.0	....	....	....	....
20/15	90.2	90.2	91.0	91.0	....	....	....	....

A. Benefits and Costs to Consumers

Table I–4 summarizes DOE's evaluation of the economic impacts of the adopted standards on consumers of electric motors, as measured by the average life-cycle cost (''LCC'') savings and the simple payback period (''PBP'').[4] The average LCC savings are positive for all representative units, and the PBP is less than the average lifetime of electric motors, which is estimated to be 13.6 years (see section V.B.1 of this document).

TABLE I–4—IMPACTS OF ADOPTED ENERGY CONSERVATION STANDARDS ON CONSUMERS OF ELECTRIC MOTORS

Equipment class group	Representative unit	Average LCC savings (2021$)	Simple payback period (years)
MEM, 1–500 hp, NEMA Design A and B	RU1	N/A	N/A
	RU2	N/A	N/A
	RU3	N/A	N/A
	RU4	567.1	4.1
	RU5	N/A	N/A
MEM, 501–750 hp, NEMA Design A and B above 500 hp	RU6	2,550.1	3.7
AO–MEM (Standard Frame Size)	RU7	57.6	4.0
	RU8	472.4	1.6
	RU9 *	....	....
	RU10	930.7	4.9
AO-Polyphase (Specialized Frame Size)	RU11	49.9	4.1

The entry ''N/A'' means not applicable because there is no change in the standard at certain TSLs.
* No impact because there are no shipments below the efficiency level corresponding to TSL1 and TSL2 for RU9.

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 (2023–2056). Using a real discount rate of 9.1 percent, DOE estimates that the INPV for manufacturers of electric motors in the case without new and amended standards is $5,023 million in 2021 dollars. Under the adopted standards, DOE estimates the change in INPV to range from −6.6 percent to −6.0 percent, which is approximately −$333 million to −$303 million. In order to bring products into compliance with new and amended standards, it is estimated that industry will incur total conversion costs of $468 million.

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

C. National Benefits and Costs[5]

DOE's analyses indicate that the adopted energy conservation standards for electric motors would save a significant amount of energy. Relative to the case without new and amended standards, the lifetime energy savings for electric motors purchased in the 30-year period that begins in the anticipated year of compliance with the new and amended standards (2027–2056) amount to 3.0 quadrillion British thermal units (''Btu''), or quads.[6] This represents a savings of 0.2 percent relative to the energy use of these products in the case without amended standards (referred to as the ''no-new-standards case'').

The cumulative net present value (''NPV'') of total consumer benefits of the standards for electric motors ranges from $2.23 billion (at a 7-percent discount rate) to $7.47 billion (at a 3-percent discount rate). This NPV

[4] The average LCC savings refer to consumers that are affected by a standard and are measured relative to the efficiency distribution in the no-new-standards case, which depicts the market in the compliance year in the absence of new or amended standards (see section IV.F.8 of this document). The simple PBP, which is designed to compare specific efficiency levels, is measured relative to the baseline product (see section IV.F.9 of this document).

[5] All monetary values in this document are expressed in 2021 dollars.

[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.2 of this document.

expresses the estimated total value of future operating-cost savings minus the estimated increased equipment and installation costs for electric motors purchased in 2027–2056.

In addition, the adopted standards for electric motors are projected to yield significant environmental benefits. DOE estimates that the adopted standards will result in cumulative emission reductions (over the same period as for energy savings) of 91.69 million metric tons (''Mt'')[7] of carbon dioxide (''CO_2''), 35.12 thousand tons of sulfur dioxide (''SO_2''), 148.74 thousand tons of nitrogen oxides (''NO_X''), 690.10 thousand tons of methane (''CH_4''), 0.82 thousand tons of nitrous oxide (''N_2O''), and 0.23 tons of mercury (''Hg'').[8] The estimated cumulative reduction in CO_2 emissions through 2030 amounts to 0.90 million Mt, which is equivalent to the emissions resulting from the annual electricity use of more than 0.15 million homes.

DOE estimates climate benefits from a reduction in greenhouse gases (GHG) using four different estimates of the social cost of CO_2 (''SC–CO_2''), the social cost of methane (''SC–CH_4''), and the social cost of nitrous oxide (''SC–N_2O''). Together these represent the social cost of GHG (SC–GHG). DOE used SC–GHG values based on the interim values developed by an Interagency Working Group on the Social Cost of Greenhouse Gases (IWG),[9] as discussed in section IV.K of this document. For presentational purposes, the climate benefits associated with the average SC–GHG at a 3-percent discount rate are $3.14 billion. DOE does not have a single central SC–GHG point estimate and it emphasizes the importance and value of considering the benefits calculated using all four SC–GHG estimates.

DOE also estimated health benefits from SO_2 and NO_X emissions reductions.[10] DOE estimated the present value of the health benefits would be $1.76 billion using a 7-percent discount rate, and $5.72 billion using a 3-percent discount rate.[11] DOE is currently only monetizing (for SO_2 and NO_X) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions.

Table I–5 summarizes the economic benefits and costs expected to result from the new and amended standards for electric motors. There are other important unquantified effects, including certain unquantified climate benefits, unquantified public health benefits from the reduction of toxic air pollutants and other emissions, unquantified energy security benefits, and distributional effects, among others.

TABLE I–5—SUMMARY OF ECONOMIC BENEFITS AND COSTS OF ADOPTED ENERGY CONSERVATION STANDARDS FOR ELECTRIC MOTORS

[TSL 2]

	Billion $2021
3% discount rate	
Consumer Operating Cost Savings	8.8
Climate Benefits *	3.1
Health Benefits **	5.7
Total Benefits †	17.7
Consumer Incremental Equipment Costs ‡	1.4
Net Benefits	16.3
7% discount rate	
Consumer Operating Cost Savings	3.0
Climate Benefits * (3% discount rate)	3.1
Health Benefits **	1.8
Total Benefits †	7.8
Consumer Incremental Equipment Costs ‡	0.7
Net Benefits	7.1

Note: This table presents the costs and benefits associated with product name shipped in 2027–2056. These results include benefits to consumers which accrue after 2027 from the products shipped in 2027–2056.

* Climate benefits are calculated using four different estimates of the SC–GHG (see section IV.L of this document). For presentational purposes of this table, the climate benefits associated with the average SC–GHG at a 3 percent discount rate are shown, but the Department does not have a single central SC–GHG point estimate, and it emphasizes the importance of considering the benefits calculated using all four SC–GHG estimates.

** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing (for SO_2 and NO_X) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. The health benefits are presented at real discount rates of 3 and 7 percent. See section IV.L of this document for more details.

[7] A metric ton is equivalent to 1.1 short tons. Results for emissions other than CO_2 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 2022* (''*AEO2022*''). *AEO2022* represents current federal and state legislation and final implementation of regulations as of the time of its preparation. See section IV.K of this document for further discussion of *AEO2022* assumptions that effect air pollutant emissions.

[9] See Interagency Working Group on Social Cost of Greenhouse Gases, Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide. Interim Estimates Under Executive Order 13990, Washington, DC, February 2021 (''February 2021 SC–GHG TSD''). *www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.*

[10] DOE estimated the monetized value of SO_2 and NO_X emissions reductions associated with electricity savings using benefit per ton estimates from the scientific literature. See section IV.L.2 of this document for further discussion.

[11] DOE estimates the economic value of these emissions reductions resulting from the considered TSLs for the purpose of complying with the requirements of Executive Order 12866.

† Total and net benefits include consumer, climate, and health benefits. For presentation purposes, total and net benefits for both the 3-percent and 7-percent cases are presented using the average SC–GHG with 3-percent discount rate, but the Department does not have a single central SC–GHG point estimate. DOE emphasizes the importance and value of considering the benefits calculated using all four SC–GHG estimates. See Table V–41 for net benefits using all four SC–GHG estimates. To monetize the benefits of reducing GHG emissions this analysis uses the interim estimates presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990* published in February 2021 by the Interagency Working Group on the Social Cost of Greenhouse Gases (IWG).

‡ Costs include incremental equipment costs as well as installation costs.

The benefits and costs of the standards can also be expressed in terms of annualized values. The monetary values for the total annualized net benefits are (1) the reduced consumer operating costs, minus (2) the increase in product purchase prices and installation costs, plus (3) the value of the benefits of GHG and NO_X and SO_2 emission reductions, all annualized.[12] The national operating 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 electric motors shipped in 2027–2056. The benefits associated with reduced emissions achieved as a result of the standards are also calculated based on the lifetime of electric motors shipped in 2027–2056.

Estimates of annualized benefits and costs of the adopted standards are shown in Table I–6. The results under the primary estimate are as follows.

Using a 7-percent discount rate for consumer benefits and costs and health benefits from reduced NO_X and SO_2 emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated cost of the standards adopted in this rule is $62.1 million per year in increased equipment costs, while the estimated annual benefits are $254.8 million in reduced equipment operating costs, $164.8 million in climate benefits, and $151.4 million in health benefits. In this case, the net benefit would amount to $508.9 million per year.

Using a 3-percent discount rate for all benefits and costs, the estimated cost of the standards is $71.0 million per year in increased equipment costs, while the estimated annual benefits are $463.6 million in reduced operating costs, $164.8 million in climate benefits, and $300.7 million in health benefits. In this case, the net benefit would amount to $858.2 million per year.

TABLE I–6—ANNUALIZED BENEFITS AND COSTS OF ADOPTED STANDARDS FOR ELECTRIC MOTORS

[TSL 2]

	Million 2021$/year		
	Primary estimate	Low-net-benefits estimate	High-net-benefits estimate
3% discount rate			
Consumer Operating Cost Savings	463.6	405.1	542.9
Climate Benefits *	164.8	148.0	186.5
Health Benefits **	300.7	269.5	341.0
Total Benefits †	929.1	822.5	1070.4
Consumer Incremental Equipment Costs ‡	71.0	73.7	73.0
Net Benefits	858.2	748.8	997.4
7% discount rate			
Consumer Operating Cost Savings	254.8	225.3	293.6
Climate Benefits * (3% discount rate)	164.8	148.0	186.5
Health Benefits **	151.4	137.1	169.5
Total Benefits †	571.0	510.4	649.6
Consumer Incremental Equipment Costs ‡	62.1	63.8	63.9
Net Benefits	508.9	446.6	585.6

Note: This table presents the costs and benefits associated with electric motors shipped in 2027–2056. These results include benefits to consumers which accrue after 2056 from the products shipped in 2027–2056.

* Climate benefits are calculated using four different estimates of the global SC–GHG (see section IV.L of this document). For presentational purposes of this table, the climate benefits associated with the average SC–GHG at a 3 percent discount rate are shown, but the Department does not have a single central SC–GHG point estimate, and it emphasizes the importance and value of considering the benefits calculated using all four SC–GHG estimates.

** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing (for SO_2 and NO_X) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. The health benefits are presented at real discount rates of 3 and 7 percent. See section IV.L of this document for more details.

[12] To convert the time-series of costs and benefits into annualized values, DOE calculated a present value in 2023, 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.,* 2030), and then discounted the present value from each year to 2023. Using the present value, DOE then calculated the fixed annual payment over a 30-year period, starting in the compliance year, that yields the same present value.

† Total and net benefits include consumer, climate, and health benefits. For presentation purposes, total and net benefits for both the 3-percent and 7-percent cases are presented using the average SC–GHG with 3-percent discount rate, but the Department does not have a single central SC–GHG point estimate. DOE emphasizes the importance and value of considering the benefits calculated using all four SC–GHG estimates. See Table V–41 for net benefits using all four SC–GHG estimates. To monetize the benefits of reducing GHG emissions this analysis uses the interim estimates presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990* published in February 2021 by the Interagency Working Group on the Social Cost of Greenhouse Gases (IWG).
‡ Costs include incremental equipment costs as well as installation costs.

DOE's analysis of the national impacts of the adopted standards is described in sections IV.H, V.B.3 and V.C of this document.

D. Conclusion

DOE has determined that the November 2022 Joint Recommendation containing recommendations with respect to energy conservation standards for electric motors was submitted jointly by interested persons that are fairly representative of relevant points of view, in accordance with 42 U.S.C. 6295(p)(4)(A). After considering the analysis and weighing the benefits and burdens, DOE has determined that the recommended standards are in accordance with 42 U.S.C. 6295(o), which contains the criteria for prescribing new or amended standards. Specifically, the Secretary has determined that the adoption of the recommended standards would result in the significant conservation of energy and is technologically feasible and economically justified. In determining whether the recommended standards are economically justified, the Secretary has determined that the benefits of the recommended standards exceed the burdens. Namely, the Secretary has concluded that the recommended standards, when considering the benefits of energy savings, positive NPV of consumer benefits, emission reductions, the estimated monetary value of the emissions reductions, and positive average LCC savings, would yield benefits outweighing the negative impacts on some consumers and on manufacturers, including the conversion costs that could result in a reduction in INPV for manufacturers.

Using a 7-percent discount rate for consumer benefits and costs and NO_X and SO_2 reduction benefits, and a 3-percent discount rate case for GHG social costs, the estimated cost of the standards for electric motors is $62.1 million per year in increased equipment and installation costs, while the estimated annual benefits are $254.8 million in reduced equipment operating costs, $164.8 million in climate benefits and $151.4 million in health benefits. The net benefit amounts to $508.9 million per year.

The significance of energy savings offered by a new or amended energy conservation standard cannot be determined without knowledge of the specific circumstances surrounding a given rulemaking.[13] For example, some covered products and equipment have most of their energy consumption occur during periods of peak energy demand. The impacts of these products on the energy infrastructure can be more pronounced than products with relatively constant demand. Accordingly, DOE evaluates the significance of energy savings on a case-by-case basis.

As previously mentioned, the standards are projected to result in estimated national energy savings of 3.0 quads (FFC), the equivalent of the primary annual energy use of 31 million homes. The NPV of consumer benefit for these projected energy savings is $2.2 billion using a discount rate of 7 percent, and $7.5 billion using a discount rate of 3 percent. The cumulative emission reductions associated with these energy savings are 91.69 Mt of CO_2, 35.12 thousand tons of SO_2, 148.74 thousand tons of NO_X, 690.10 thousand tons of CH_4, 0.82 thousand tons of N_2O, and 0.23 tons of Hg. The estimated monetary value of the climate benefits from reduced GHG emissions (associated with the average SC–GHG at a 3-percent discount rate) is $3.14 billion. The estimated monetary value of the health benefits from reduced SO_2 and NO_X emissions is $1.76 billion using a 7-percent discount rate, and $5.72 billion using a 3-percent discount rate. Based on these findings, DOE has determined the energy savings from the standard levels adopted in this DFR are ''significant'' within the meaning of 42 U.S.C. 6295(o)(3)(B). A more detailed discussion of the basis for these tentative conclusions is contained in the remainder of this document and the accompanying TSD.

Under the authority provided by 42 U.S.C. 6295(p)(4), DOE is issuing this direct final rule (''DFR'') amending the energy conservation standards for electric motors. Consistent with this authority, DOE is also publishing elsewhere in this **Federal Register** a notice of proposed rulemaking proposing standards that are identical to those contained in this direct final rule. See 42 U.S.C. 6295(p)(4)(A)(i).

II. Introduction

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

A. Authority

EPCA authorizes DOE to regulate the energy efficiency of a number of consumer products and certain industrial equipment. Title III, Part C[14] of EPCA added by Public Law 95–619, Title IV, section 441(a) (42 U.S.C. 6311–6317, as codified), established the Energy Conservation Program for Certain Industrial Equipment, which sets forth a variety of provisions designed to improve the energy efficiency of certain types of industrial equipment, including electric motors, the subject of this direct final rule. (42 U.S.C. 6311(1)(A)). The Energy Policy Act of 1992 (''EPACT 1992'') (Pub. L. 102–486 (Oct. 24, 1992)) further amended EPCA by establishing energy conservation standards and test procedures for certain commercial and industrial electric motors that are manufactured alone or as a component of another piece of equipment. In December 2007, Congress enacted the Energy Independence and Security Act of 2007 (''EISA 2007'') (Pub. L. 110–140 (Dec. 19, 2007). Section 313(b)(1) of EISA 2007 updated the energy conservation standards for those electric motors already covered by EPCA and established energy conservation standards for a larger scope of motors not previously covered by standards. (42 U.S.C. 6313(b)(2)) EISA 2007 also revised certain statutory definitions related to electric motors. *See* EISA 2007, sec. 313 (amending statutory definitions related to electric motors at 42 U.S.C. 6311(13)).

The energy conservation program under EPCA consists essentially of four parts: (1) testing, (2) labeling, (3) the establishment of Federal energy conservation standards, and (4) certification and enforcement procedures. Relevant provisions of EPCA include definitions (42 U.S.C.

[13] Procedures, Interpretations, and Policies for Consideration in New or Revised Energy Conservation Standards and Test Procedures for Consumer Products and Commercial/Industrial Equipment, 86 FR 70892, 70901 (Dec. 13, 2021).

[14] For editorial reasons, upon codification in the U.S. Code, Part C was redesignated Part A–1.

6311), test procedures (42 U.S.C. 6314), labeling provisions (42 U.S.C. 6315), energy conservation standards (42 U.S.C. 6313), and the authority to require information and reports from manufacturers (42 U.S.C. 6316; 42 U.S.C. 6296).

Federal energy efficiency requirements for covered equipment established under EPCA generally supersede State laws and regulations concerning energy conservation testing, labeling, and standards. (42 U.S.C. 6316(a) and (b); 42 U.S.C. 6297) DOE may, however, grant waivers of Federal preemption in limited instances for particular State laws or regulations, in accordance with the procedures and other provisions set forth under EPCA. (See 42 U.S.C. 6316(a) (applying the preemption waiver provisions of 42 U.S.C. 6297))

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. 6314(a), 42 U.S.C. 6295(o)(3)(A) and 42 U.S.C. 6295(r)) Manufacturers of covered equipment must use the Federal test procedures as the basis for: (1) certifying to DOE that their equipment complies with the applicable energy conservation standards adopted pursuant to EPCA (42 U.S.C. 6316(a); 42 U.S.C. 6295(s)), and (2) making representations about the efficiency of that equipment (42 U.S.C. 6314(d)). Similarly, DOE must use these test procedures to determine whether the equipment complies with relevant standards promulgated under EPCA. (42 U.S.C. 6316(a); 42 U.S.C. 6295(s)) The DOE test procedures for electric motors appear at title 10 of the Code of Federal Regulations (''CFR'') part 431, subpart B, appendix B.

EPCA further provides that, not later than 6 years after the issuance of any final rule establishing or amending a standard, DOE must publish either a notice of determination that standards for the product do not need to be amended, or a notice of proposed rulemaking including new proposed energy conservation standards (proceeding to a final rule, as appropriate). (42 U.S.C. 6316(a); 42 U.S.C. 6295(m)(1)) DOE must follow specific statutory criteria for prescribing new or amended standards for covered equipment, including electric motors. Any new or amended standard for a covered product must be designed to achieve the maximum improvement in energy efficiency that the Secretary of Energy determines is technologically feasible and economically justified. (42 U.S.C. 6316(a); 42 U.S.C. 6295(o)(2)(A) and 42 U.S.C. 6295(o)(3)(B)) Furthermore, DOE may not adopt any standard that would not result in the significant conservation of energy. (42 U.S.C. 6316(a); 42 U.S.C. 6295(o)(3))

Moreover, DOE may not prescribe a standard: (1) for certain products, including electric motors, if no test procedure has been established for the product, or (2) if DOE determines by rule that the standard is not technologically feasible or economically justified. (42 U.S.C. 6316(a); 42 U.S.C. 6295(o)(3)(A)–(B)) 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. 6316(a); 42 U.S.C. 6295(o)(2)(B)(i)) 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 (''Secretary'') considers relevant. (42 U.S.C. 6316(a); 42 U.S.C. 6295(o)(2)(B)(i)(I)–(VII))

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. 6316(a); 42 U.S.C. 6295(o)(2)(B)(iii))

EPCA, as codified, also contains what is known as 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. 6316(a); 42 U.S.C. 6295(o)(1)) 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. 6316(a); 42 U.S.C. 6295(o)(4))

Additionally, EPCA specifies 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 products that has the same function or intended use, if DOE determines that products within such group: (A) consume a different kind of energy from that consumed by other covered products within such type (or class); or (B) have a capacity or other performance-related feature which other products within such type (or class) do not have and such feature justifies a higher or lower standard. (42 U.S.C. 6316(a); 42 U.S.C. 6295(q)(1)) 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 such a 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. 6316(a); 42 U.S.C. 6295(q)(2))

Finally, EISA 2007 amended EPCA, in relevant part, to grant DOE authority to issue a final rule (*i.e.,* a ''direct final rule'' or ''DFR'') establishing an energy conservation standard on receipt of a statement submitted jointly by interested persons that are fairly representative of relevant points of view (including representatives of manufacturers of covered products, States, and efficiency advocates), as determined by the Secretary, that contains recommendations with respect to an energy or water conservation standard that are in accordance with the provisions of 42 U.S.C. 6295(o). (42 U.S.C. 6295(p)(4)) Pursuant to 42 U.S.C. 6295(p)(4), the Secretary must also determine whether a jointly-submitted recommendation for an energy or water conservation standard satisfies 42 U.S.C. 6295(o) or 42 U.S.C. 6313(a)(6)(B), as applicable.

The direct final rule must be published simultaneously with a NOPR that proposes an energy or water conservation standard that is identical to the standard established in the direct final rule, and DOE must provide a public comment period of at least 110 days on this proposal. (42 U.S.C. 6295(p)(4)(A)–(B)) Based on the comments received during this period, the direct final rule will either become effective, or DOE will withdraw it not later than 120 days after its issuance if (1) one or more adverse comments is received, and (2) DOE determines that those comments, when viewed in light of the rulemaking record related to the direct final rule, provide a reasonable basis for withdrawal of the direct final rule under 42 U.S.C. 6295(o), 42 U.S.C. 6313(a)(6)(B), or any other applicable law. (42 U.S.C. 6295(p)(4)(C)) Receipt of an alternative joint recommendation may also trigger a DOE withdrawal of the direct final rule in the same manner. *Id.* After withdrawing a direct final rule, DOE must proceed with the notice of proposed rulemaking published simultaneously with the direct final rule and publish in the **Federal Register** the reasons why the direct final rule was withdrawn. *Id.*

Typical of other rulemakings, it is the substance, rather than the quantity, of comments that will ultimately determine whether a direct final rule will be withdrawn. To this end, the substance of any adverse comment(s) received will be weighed against the anticipated benefits of the jointly-submitted recommendations and the likelihood that further consideration of the comment(s) would change the results of the rulemaking. DOE notes that, to the extent an adverse comment had been previously raised and addressed in the rulemaking proceeding, such a submission will not typically provide a basis for withdrawal of a direct final rule.

B. Background

1. Current Standards

In a final rule published on May 29, 2014, DOE prescribed the current energy conservation standards for electric motors manufactured on and after June 1, 2016. 79 FR 30934 (''May 2014 Final Rule''). These standards are set forth in DOE's regulations at 10 CFR 431.25 and are repeated in Table II–1, Table II–2, and Table II–3.

TABLE II–1—ENERGY CONSERVATION STANDARDS FOR NEMA DESIGN A, NEMA DESIGN B AND IEC DESIGN N MOTORS (EXCLUDING FIRE PUMP ELECTRIC MOTORS) AT 60 Hz

Motor horsepower/standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/.75	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5/1.1	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0
2/1.5	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5
3/2.2	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5/3.7	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5/5.5	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10/7.5	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15/11	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20/15	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0
25/18.5	91.7	91.7	93.6	93.6	93.0	93.0	90.2	91.0
30/22	91.7	91.7	93.6	94.1	93.0	93.6	91.7	91.7
40/30	92.4	92.4	94.1	94.1	94.1	94.1	91.7	91.7
50/37	93.0	93.0	94.5	94.5	94.1	94.1	92.4	92.4
60/45	93.6	93.6	95.0	95.0	94.5	94.5	92.4	93.0
75/55	93.6	93.6	95.4	95.0	94.5	94.5	93.6	94.1
100/75	94.1	93.6	95.4	95.4	95.0	95.0	93.6	94.1
125/90	95.0	94.1	95.4	95.4	95.0	95.0	94.1	94.1
150/110	95.0	94.1	95.8	95.8	95.8	95.4	94.1	94.1
200/150	95.4	95.0	96.2	95.8	95.8	95.4	94.5	94.1
250/186	95.8	95.0	96.2	95.8	95.8	95.8	95.0	95.0
300/224	95.8	95.4	96.2	95.8	95.8	95.8		
350/261	95.8	95.4	96.2	95.8	95.8	95.8		
400/298	95.8	95.8	96.2	95.8				
450/336	95.8	96.2	96.2	96.2				
500/373	95.8	96.2	96.2	96.2				

TABLE II–2—ENERGY CONSERVATION STANDARDS FOR NEMA DESIGN C AND IEC DESIGN H MOTORS AT 60 Hz

Motor horsepower/standard kilowatt equivalent	Nominal full-load efficiency (%)					
	4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/.75	85.5	85.5	82.5	82.5	75.5	75.5
1.5/1.1	86.5	86.5	87.5	86.5	78.5	77.0
2/1.5	86.5	86.5	88.5	87.5	84.0	86.5
3/2.2	89.5	89.5	89.5	88.5	85.5	87.5
5/3.7	89.5	89.5	89.5	89.5	86.5	88.5
7.5/5.5	91.7	91.0	91.0	90.2	86.5	89.5
10/7.5	91.7	91.7	91.0	91.7	89.5	90.2
15/11	92.4	93.0	91.7	91.7	89.5	90.2
20/15	93.0	93.0	91.7	92.4	90.2	91.0

TABLE II–2—ENERGY CONSERVATION STANDARDS FOR NEMA DESIGN C AND IEC DESIGN H MOTORS AT 60 Hz—Continued

Motor horsepower/standard kilowatt equivalent	Nominal full-load efficiency (%)					
	4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open
25/18.5	93.6	93.6	93.0	93.0	90.2	91.0
30/22	93.6	94.1	93.0	93.6	91.7	91.7
40/30	94.1	94.1	94.1	94.1	91.7	91.7
50/37	94.5	94.5	94.1	94.1	92.4	92.4
60/45	95.0	95.0	94.5	94.5	92.4	93.0
75/55	95.4	95.0	94.5	94.5	93.6	94.1
100/75	95.4	95.4	95.0	95.0	93.6	94.1
125/90	95.4	95.4	95.0	95.0	94.1	94.1
150/110	95.8	95.8	95.8	95.4	94.1	94.1
200/150	96.2	95.8	95.8	95.4	94.5	94.1

TABLE II–3—ENERGY CONSERVATION STANDARDS FOR FIRE PUMP ELECTRIC MOTORS AT 60 Hz

Motor horsepower/standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/.75	75.5	....	82.5	82.5	80.0	80.0	74.0	74.0
1.5/1.1	82.5	82.5	84.0	84.0	85.5	84.0	77.0	75.5
2/1.5	84.0	84.0	84.0	84.0	86.5	85.5	82.5	85.5
3/2.2	85.5	84.0	87.5	86.5	87.5	86.5	84.0	86.5
5/3.7	87.5	85.5	87.5	87.5	87.5	87.5	85.5	87.5
7.5/5.5	88.5	87.5	89.5	88.5	89.5	88.5	85.5	88.5
10/7.5	89.5	88.5	89.5	89.5	89.5	90.2	88.5	89.5
15/11	90.2	89.5	91.0	91.0	90.2	90.2	88.5	89.5
20/15	90.2	90.2	91.0	91.0	90.2	91.0	89.5	90.2
25/18.5	91.0	91.0	92.4	91.7	91.7	91.7	89.5	90.2
30/22	91.0	91.0	92.4	92.4	91.7	92.4	91.0	91.0
40/30	91.7	91.7	93.0	93.0	93.0	93.0	91.0	91.0
50/37	92.4	92.4	93.0	93.0	93.0	93.0	91.7	91.7
60/45	93.0	93.0	93.6	93.6	93.6	93.6	91.7	92.4
75/55	93.0	93.0	94.1	94.1	93.6	93.6	93.0	93.6
100/75	93.6	93.0	94.5	94.1	94.1	94.1	93.0	93.6
125/90	94.5	93.6	94.5	94.5	94.1	94.1	93.6	93.6
150/110	94.5	93.6	95.0	95.0	95.0	94.5	93.6	93.6
200/150	95.0	94.5	95.0	95.0	95.0	94.5	94.1	93.6
250/186	95.4	94.5	95.0	95.4	95.0	95.4	94.5	94.5
300/224	95.4	95.0	95.4	95.4	95.0	95.4	....	....
350/261	95.4	95.0	95.4	95.4	95.0	95.4	....	....
400/298	95.4	95.4	95.4	95.4	....	....	....	....
450/336	95.4	95.8	95.4	95.8	....	....	....	....
500/373	95.4	95.8	95.8	95.8	....	....	....	....

2. History of Standards Rulemaking for Electric Motors

In the May 2020 Early Assessment Review RFI, DOE stated that it was initiating an early assessment review to determine whether any new or amended standards would satisfy the relevant requirements of EPCA for a new or amended energy conservation standard for electric motors and sought information related to that effort. Specifically, DOE sought data and information that could enable the agency to determine whether DOE should propose a ''no new standard'' determination because a more stringent standard: (1) would not result in a significant savings of energy; (2) is not technologically feasible; (3) is not economically justified; or (4) any combination of the foregoing. 85 FR 30878, 30879.

On March 2, 2022, DOE published the preliminary analysis for electric motors. 87 FR 11650 (''March 2022 Preliminary Analysis''). In conjunction with the March 2022 Preliminary Analysis, DOE published a technical support document (''March 2022 Prelim TSD'') which presented the results of the in-depth technical analyses in the following areas: (1) Engineering; (2) markups to determine equipment price; (3) energy use; (4) life cycle cost (''LCC'') and payback period (''PBP''); and (5) national impacts. The results presented included the current scope of electric motors regulated at 10 CFR 431.25, in addition to an expanded scope of motors, including electric motors above 500 horsepower, air-over electric motors, and small, non-small-electric-motor, electric motors (''SNEM''). See Chapter 2 of the March 2022 Prelim TSD. DOE requested comment on a number of topics regarding the analysis presented.

DOE received comments in response to the March 2022 Preliminary Analysis from the interested parties listed in Table II–4.

TABLE II–4—MARCH 2022 PRELIMINARY ANALYSIS WRITTEN COMMENTS

Commenter(s)	Reference in this final rule	Docket No.	Commenter type
ABB Motors and Mechanical Inc	ABB	28	Manufacturer.
American Council for an Energy-Efficient Economy, Appliance Standards Awareness Project, National Electrical Manufacturers Association, Natural Resources Defense Council, Northwest Energy Efficiency Alliance, Pacific Gas & Electric Company, San Diego Gas & Electric, Southern California Edison.	Electric Motors Working Group.	35, 36	Working Group.
Appliance Standards Awareness Project, American Council for an Energy-Efficient Economy, Natural Resources Defense Council, New York State Energy Research and Development Authority.	Joint Advocates	27	Efficiency Organizations.
Association of Home Appliance Manufacturers; Air-Conditioning, Heating, and Refrigeration Institute.	AHAM and AHRI	25	Industry OEM Trade Association.
Air-Conditioning, Heating, and Refrigeration Institute	AHRI	26	Industry OEM Trade Association.
Pacific Gas and Electric Company (PG&E), San Diego Gas and Electric (SDG&E), and Southern California Edison (SCE).	CA IOUs	30	Utilities.
Daikin Comfort Technologies Manufacturing Company, L.P	Daikin	32	Manufacturer.
Electrical Apparatus Service Association, Inc	EASA	21	International Trade Association.
Hydraulics Institute	HI	31	Industry Pump Trade Association.
Lennox International	Lennox	29	Manufacturer.
Metglas, Inc	Metglas	24	Materials supplier.
Northwest Energy Efficiency Alliance	NEEA	33	Non-profit organization.
National Electrical Manufacturers Association (NEMA), Association of Home Appliance Manufacturers (AHAM), the Air-Conditioning, Heating, and Refrigeration Institute (AHRI), the Medical Imaging Technology Alliance (MITA), the Outdoor Power Equipment Institute (OPEI), Home Ventilating Institute (HVI) and the Power Tool Institute (PTI).	Joint Industry Stakeholders	23	Industry Trade Associations.
National Electrical Manufacturers Association	NEMA	22	Industry Trade Association.

By letter dated on November 15, 2022, DOE received a joint recommendation for energy conservation standards for electric motors (''November 2022 Joint Recommendation''). The November 2022 Joint Recommendation represented the motors industry, energy efficiency organizations and utilities (collectively, ''the Electric Motors Working Group'').[15] The November 2022 Joint Recommendation addressed energy conservation standards for medium electric motors that are 1–750 hp and polyphase, and air-over medium electric motors. On December 9, 2022, DOE received a supplemental letter to the November 2022 Joint Recommendation from the Electric Motors Working Group. The supplemental letter provided additional guidance on the recommended levels for open medium electric motors rated 100 hp to 250 hp, and a recommended compliance date for standards presented in the November 2022 Joint Recommendation.

A parenthetical reference at the end of a comment quotation or paraphrase provides the location of the item in the public record.[16]

3. Electric Motors Working Group Recommended Standard Levels

This section summarizes the standard levels recommended in the November 2022 Joint Recommendation and supplement by the Electric Motors Working Group and the subsequent procedural steps taken by DOE. Further discussion on scope is provided in section III.B of this document.

Recommendation #1: For NEMA Design A/B medium electric motors (''MEM'') rated up to 500 hp at 60Hz, standard levels as follows:

a. Less than 100 hp—remain at Premium LevelIE3 level [17]

b. 100–250 hp—increase to Super Premium/IE4 level,[18] aligning with European Union (''EU'') Ecodesign Directive 2019/1781 which requires IE4 levels for 75–200 kW motors.

c. Over 250 and up to 500 hp—remain at Premium Level/IE3 level

Separately, because the efficiencies for the IE4 level in IEC 60034–30–1:2014 do not distinguish between enclosed and open motors, the supplemental letter to the November 2022 Joint Recommendation recommended efficiencies for open motors based on the efficiencies for enclosed motors in the IEC standard. The supplemental letter stated that for some horsepower ratings, open motors have different minimum efficiencies which account for the different frame size at a given horsepower rating.

[15] The members of the Electric Motors Working Group included ACEEE, ASAP, NEMA, NRDC, NEEA, PG&E, SDG&E, and SCE.

[16] The parenthetical reference provides a reference for information located in the docket of DOE's rulemaking to develop energy conservation standards for electric motors. (Docket NO EERE–2020–BT–STD–0007, which is maintained at *www.regulations.gov*). The references are arranged as follows: (commenter name, comment docket ID number, page of that document).

[17] IE3 efficiency level refers to the 60 Hz efficiency values in Table 8 of IEC 60034–30–1:2014.

[18] IE4 efficiency level refers to the 60 Hz efficiency values in Table 10 of IEC 60034–30–1:2014.

Motor horsepower/standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
100/75	95.0	94.5	96.2	96.2	95.8	95.8	94.5	95.0
125/90	95.4	94.5	96.2	96.2	95.8	95.8	95.0	95.0
150/110	95.4	94.5	96.2	96.2	96.2	95.8	95.0	95.0
200/150	95.8	95.4	96.5	96.2	96.2	95.8	95.4	95.0
250/186	96.2	95.4	96.5	96.2	96.2	96.2	95.4	95.4

Premium efficiency level refers to the efficiency values in NEMA MG 1–2016 Tables 12–12. The current standards for NEMA Design A/B in Table 5 of 10 CFR 431.25 are at Premium efficiency. Accordingly, in this direct final rule, pursuant to the November 22 Joint Recommendation, the energy conservation standards for NEMA Design A/B medium electric motors (''MEM'') less than 100 hp and between 250 to 500 hp, remain at the current levels in 10 CFR 430.25. However, the energy conservation standards for such MEMs between 100 and 250 hp increase to the Super Premium/IE4 Level, which approximately represents a 20 percent reduction of losses over Premium/IE3. Table II–4 presents a comparison of the current and updated standards for MEMs between 100 and 250 hp.

TABLE II–4—CROSSWALK OF CURRENT AND NEW EFFICIENCY STANDARDS FOR MEMS 100–250 HP

Motor horsepower/standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
Current Standards in Table 5 of 10 CFR 431.25								
100/75	94.1	93.6	95.4	95.4	95.0	95.0	93.6	94.1
125/90	95.0	94.1	95.4	95.4	95.0	95.0	94.1	94.1
150/110	95.0	94.1	95.8	95.8	95.8	95.4	94.1	94.1
200/150	95.4	95.0	96.2	95.8	95.8	95.4	94.5	94.1
250/186	95.8	95.0	96.2	95.8	95.8	95.8	95.0	95.0
Updated Standards in this DFR, pursuant to the November 2022 Joint Recommendation								
100/75	95.0	94.5	96.2	96.2	95.8	95.8	94.5	95.0
125/90	95.4	94.5	96.2	96.2	95.8	95.8	95.0	95.0
150/110	95.4	94.5	96.2	96.2	96.2	95.8	95.0	95.0
200/150	95.8	95.4	96.5	96.2	96.2	95.8	95.4	95.0
250/186	96.2	95.4	96.5	96.2	96.2	96.2	95.4	95.4

Recommendation #2: For medium electric motors rated over 500 hp and up to 750 hp at 60 Hz, standard levels that correspond to IE3 levels for open and enclosed electric motors.

The current energy conservation standards for MEMs do not contain standards for MEMs with greater than 500 hp. However, in the May 2014 Final Rule, DOE noted that it may consider future regulation of motor types not regulated in the May 2014 Final Rule, including motors greater than 500 hp. *See* 79 FR 30946. As discussed more in section III.B of this document, DOE recently expanded the electric motor test procedure to include motors between 500 hp and 750 hp. Pursuant to the November 2022 Joint Recommendation, this direct final rule establishes standards for motors between 500 and 750 hp at levels consistent with IE3 levels for open and enclosed electric motors.

Recommendation #3: For air-over [19] medium electric motors (''AO–MEMs''), establish two equipment classes and corresponding energy conservation standards for AO MEMs: AO–MEMs in standard NEMA frame sizes and air-over motors in specialized NEMA frame sizes, with standard levels as follows:

a. Standard Frame Size AO–MEMs: For AO MEMs sold in standard NEMA frame sizes aligned with NEMA MG 1–2016, Table 13.2 (open motors) and Table 13.3 (enclosed motors), standard levels consistent with Recommendation #1 (*i.e.,* standard levels for NEMA MG 1 12–12 levels for motors rated less than 100 hp, IE4 levels for motors rated 100 to 250 hp, and MG 1 12–12 levels for motors rated over 250 hp).

b. Specialized Frame Size air-over electric motors: For air-over electric motors sold in smaller, specialized NEMA frame sizes, standard levels consistent with current fire pump efficiency levels (in Table 7 of 10 CFR 431.25), but with constraint on frame size as follows:

[19] *Air-over electric motor* means an electric motor that does not reach thermal equilibrium (*i.e.,* thermal stability), during a rated load temperature test according to section 2 of appendix B, without the application of forced cooling by a free flow of air from an external device not mechanically connected to the motor within the motor enclosure. 10 CFR 430.12.

HP/kW	2 Pole (maximum NEMA frame diameter)		4 Pole (maximum NEMA frame diameter)		6 Pole (maximum NEMA frame diameter)		8 Pole (maximum NEMA frame diameter)	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/.75	74 (48)	...	82.5 (48)	82.5 (48)	80 (48)	80 (48)	74 (140)	74 (140)
1.5/1.1	82.5 (48)	82.5 (48)	84 (48)	84 (48)	85.5 (140)	84 (140)	77 (140)	75.5 (140)
2/1.5	84 (48)	84 (48)	84 (48)	84 (48)	86.5 (140)	85.5 (140)	82.5 (180)	85.5 (180)
3/2.2	85.5 (140)	84 (48)	87.5 (140)	86.5 (140)	87.5 (180)	86.5 (180)	84 (180)	86.5 (180)
5/3.7	87.5 (140)	85.5 (140)	87.5 (140)	87.5 (140)	87.5 (180)	87.5 (180)	85.5 (210)	87.5 (210)
7.5/5.5	88.5 (180)	87.5 (140)	89.5 (180)	88.5 (180)	89.5 (210)	88.5 (210)	85.5 (210)	88.5 (210)
10/7.5	89.5 (180)	88.5 (180)	89.5 (180)	89.5 (180)	89.5 (210)	90.2 (210)	...	...
15/11	90.2 (210)	89.5 (180)	91 (210)	91 (210)	...	...	...	...
20/15	90.2 (210)	90.2 (210)	91 (210)	91 (210)	...	...	...	...

The current energy conservation standard for electric motors in 10 CFR 430.25 exempt air-over electric motors from the standards. 10 CFR 430.25(l). In the May 2014 Final Rule, DOE explained that this exemption was due to a lack of information at that time to support the establishment of a test method for air-over electric motors. *See* 79 FR 30946; 78 FR 38474. However, as discussed more in section III.B, DOE recently expanded the electric motor test procedure to include AO–MEMs. Accordingly, pursuant to the November 2022 Joint Recommendation, this direct final rule establishes 2 equipment classes for AO–MEMs (AO–MEMs in standard NEMA frame sizes, and those in specialized NEMA frame sizes) and corresponding standards based on the November 2022 Joint Recommendation. However, based on DOE's review of the market, DOE only observed AO–MEMs up to 250 hp. As such, in this direct final rule, DOE is only establishing standards for AO–MEMs up to 250 hp.

Recommendation #4: For synchronous and inverter-only electric motors, a recommendation to forego establishing standards until an updated test procedure is adopted that better captures the energy-saving benefits of these motors.

The current energy conservation standard for electric motors in 10 CFR 430.25 exempts inverter-only electric motors from the standards. 10 CFR 431.25(l). Similarly, the current energy conservation standards apply to AC induction motors, which do not include synchronous motors.[20] Accordingly, following this recommendation, this direct final rule continues to exempt these types of motors from the energy conservation standards.

Recommendation #5: For the recommended energy conservation standard levels, a compliance date of four (4) years from the date of publication of the final rule.

In the May 2014 Final Rule, DOE provided a 2-year compliance lead time based on the requirements of 42 U.S.C. 6313(b)(4)(B). See 79 FR 30944. DOE notes that EPCA generally requires a 3-year compliance lead time from the effective date of an amended standard under EPCA's 6-year lookback provisions. (42 U.S.C. 6316(a); 42 U.S.C. 6295(m)) However, EPCA's direct final rule provision (42 U.S.C. 6295(p)(4)) conveys upon DOE a substantive grant of rulemaking authority, thereby allowing stakeholders to negotiate over more aspects of the energy or water conservation standard, so long as the requirements of 42 U.S.C. 6295(o) are met. *See* 86 FR 70892, 70915. In the past, DOE has looked to joint recommendations to fill in necessary details that EPCA does not place upon the direct final rule process, including compliance periods. DOE's direct final rules have frequently utilized alternative compliance dates, while continuing to ensure that the standards in these rules represent the maximum improvement in energy efficiency that is technologically feasible and economically justified.

After carefully considering the November 2022 Joint Recommendation and supplement for amending the energy conservation standards for electric motors submitted by the Electric Motors Working Group, DOE has determined that these recommendations are in accordance with the statutory requirements of 42 U.S.C. 6295(p)(4) for the issuance of a direct final rule.

More specifically, these recommendations comprise a statement submitted by interested persons who are fairly representative of relevant points of view on this matter. In appendix A to subpart C of 10 CFR part 430 (''Appendix A''), DOE explained that to be ''fairly representative of relevant points of view,'' the group submitting a joint statement must, where appropriate, include larger concerns and small business in the regulated industry/manufacturer community, energy advocates, energy utilities, consumers, and States. However, it will be necessary to evaluate the meaning of ''fairly representative'' on a case-by-case basis, subject to the circumstances of a particular rulemaking, to determine whether fewer or additional parties must be part of a joint statement in order to be ''fairly representative of relevant points of view.'' Section 10 of appendix A. In reaching this determination, DOE took into consideration the fact that the Joint Recommendation was signed and submitted by a broad cross-section of interests, including a manufacturers' trade association, environmental and energy-efficiency advocacy organizations, and electric utility companies. NYSERDA, a state organization, also submitted a letter supporting the Joint Recommendation. DOE notes that these organizations include the relevant points of view specifically identified by Congress: manufacturers of covered products, States, and efficiency advocates. (42 U.S.C. 6295(p)(4)(A))

DOE also evaluated whether the recommendation satisfies 42 U.S.C. 6295(o), as applicable. In making this determination, DOE conducted an analysis to evaluate whether the potential energy conservation standards under consideration achieve the maximum improvement in energy efficiency that is technologically

[20] In the May 2014 Final Rule, DOE chose not to establish standards for inverter-only electric motors because of the then absence of a reliable and repeatable method to test them for efficiency, but DOE noted that if a test procedure became available, DOE may consider setting standards for inverter-only electric motors at that time. 79 FR 30945. DOE recently expanded the electric motor test procedure to include inverter-only and synchronous electric motors. *See* 87 FR 63600–63605. Similarly, DOE expanded the scope of the test procedure to include synchronous electric motors. 87 FR 63601–63605. However, pursuant to the November 2022 Joint Recommendation, DOE is not separately regulating inverter-only and synchronous electric motors in this direct final rule. Rather, DOE is only considering the substitution effects of switching to these electric motors if higher standards for MEMs are established. More discussion on inverter-only and synchronous electric motors may be found in sections IV.A and F of this document.

feasible and economically justified and result in significant energy conservation. The evaluation is the same comprehensive approach that DOE typically conducts whenever it considers potential energy conservation standards for a given type of product or equipment.

Upon review, the Secretary determined that the November 2022 Joint Recommendation comports with the standard-setting criteria set forth under 42 U.S.C. 6295(p)(4)(A). Accordingly, the Electric Motors Working Group recommended efficiency levels were included as the ''recommended TSL'' for electric motors (see section V.A for description of all of the considered TSLs). The details regarding how the Electric Motors Working Group-recommended TSLs comply with the standard-setting criteria are discussed and demonstrated in the relevant sections throughout this document.

In sum, as the relevant criteria under 42 U.S.C. 6295(p)(4) have been satisfied, the Secretary has determined that it is appropriate to adopt the Electric Motors Working Group-recommended amended energy conservation standards for Electric Motors through this direct final rule. Also, in accordance with the provisions described in section II.A of this document, DOE is simultaneously publishing a NOPR proposing that the identical standard levels contained in this direct final rule be adopted.

III. General Discussion

A. General Comments

This section summarizes general comments received from interested parties regarding rulemaking timing and process for the March 2022 Preliminary Analysis.

Lennox commented that long-standing DOE practice recognizes the benefit of establishing an appropriate test procedure before undertaking an energy conservation standards rulemaking. Lennox commented that the March 2022 Preliminary Analysis was issued in February 2022 while comments on the test procedure NOPR were due. As such, Lennox suggested that DOE cutting corners on the regulatory process undermines the accuracy and reliability of data contained in the March 2022 Preliminary Analysis TSD. (Lennox, No. 29 at p. 4–5) The Joint Industry Stakeholders commented that the process DOE is using for the electric motor test procedure and standards undermines the value of early stakeholder engagement. Specifically, they claimed that DOE is: (1) shortening comment periods; (2) overlapping comment periods; and (3) condensing the rulemaking process. The Joint Industry Stakeholders noted that DOE published the March 2022 Preliminary Analysis two months after issuing a proposed test procedure. Furthermore, the Joint Industry Stakeholders commented that there were numerous comments challenging DOE's proposed test procedure, which resulted in significant changes. They commented that manufacturers and others lack enough time with the proposed test procedure to fully understand or comment upon its impact on potential energy conservation standards, especially for SNEMs where they stated that DOE has done no testing. The Joint Industry Stakeholders commented that they recognize and support DOE's interest in moving rulemakings forward, especially rules such as the electric motor standards and test procedures, which have missed statutory deadlines. However, they stated that DOE should have released the proposed test procedure earlier so that DOE could receive feedback on the test procedure before proceeding with its resource-intensive preliminary analysis. (Joint Industry Stakeholders, No. 23 at p. 9–10)

Appendix A establishes procedures, interpretations, and policies to guide DOE in the consideration and promulgation of new or revised appliance energy conservation standards and test procedures under EPCA. DOE has maintained the process and timeline for the electric motors test procedure and energy conservation standards based on appendix A.

Appendix A requires that DOE provide for early input from stakeholders so that the initiation and direction of rulemaking is informed by comments from interested parties. Appendix A, section 1(a). As discussed in section II.B.2 of this document, DOE provided opportunity for comment for these energy conservation standards through the May 2020 Early Assessment Review RFI, which had a 30-day comment period, and the March 2022 Preliminary Analysis, which had a 60-day comment period. Further, DOE provided multiple opportunities for stakeholder comments and inputs through the test procedure rulemaking process; DOE published a request for information (85 FR 34111; June 3, 2020 ''June 2020 RFI''), which had a 45-day comment period, and DOE published a test procedure NOPR (86 FR 71710; December 17, 2021 ''December 2021 NOPR''), which originally had a 60-day comment period, which was extended to a 75-day comment period. 87 FR 6436. Even though some of these comment periods overlapped to some extent, DOE has nonetheless provided ample opportunity for stakeholder review and comments and has considered such comments and recommendations in this notice.

Appendix A also generally requires that test procedure rulemakings establishing methodologies used to evaluate proposed energy conservation standards will be finalized prior to publication of a NOPR proposing new or amended energy conservation standards. Appendix A, section 8(d)(1). Pursuant to 42 U.S.C. 6295(p)(4), published elsewhere in the **Federal Register** is a NOPR accompanying this direct final rule, which proposes standards identical to those in this direct final rule. On October 19, 2022, DOE published the electric motor test procedure final rule. (''October 2022 Final Rule''). Thus, in accordance with appendix A section 8(d)(1), the October 2022 Final Rule prior was published 180 days prior to publication of this energy conservations standards direct final rule and the accompanying NOPR.

B. Scope of Coverage and Equipment Classes

When evaluating and establishing energy conservation standards, DOE divides covered equipment into equipment classes by the type of energy used or by capacity or other performance-related features that justify differing standards. In making a determination 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. 6316(a); 42 U.S.C. 6295(q))

This document covers certain equipment meeting the definition of electric motors as defined in 10 CFR 431.12. Specifically, the definition for ''electric motor'' is ''a machine that converts electrical power into rotational mechanical power.'' *Id.* Electric motors are used in a wide range of applications in commercial building and in the industrial sector (*e.g.,* chemicals, primary metals, food, paper, plastic/rubber, petroleum refining, and wastewater), including: fans, compressors, pumps, material handling equipment, and material processing equipment.

Currently, DOE regulates medium electric motors (''MEMs'') falling into the NEMA Design A, NEMA Design B, NEMA Design C, and fire pump motor categories and those electric motors that meet the criteria specified at 10 CFR 431.25(g). 10 CFR 431.25(h)–(j). Section

431.25(g) specifies that the relevant standards apply only to electric motors, including partial electric motors, that satisfy the following criteria:

(1) Are single-speed, induction motors;
(2) Are rated for continuous duty (MG 1) operation or for duty type S1 (IEC)
(3) Contain a squirrel-cage (MG 1) or cage (IEC) rotor;
(4) Operate on polyphase alternating current 60-hertz sinusoidal line power;
(5) Are rated 600 volts or less;
(6) Have a 2-, 4-, 6-, or 8-pole configuration;
(7) Are built in a three-digit or four-digit NEMA frame size (or IEC metric equivalent), including those designs between two consecutive NEMA frame sizes (or IEC metric equivalent), or an enclosed 56 NEMA frame size (or IEC metric equivalent);
(8) Produce at least one horsepower (0.746 kW) but not greater than 500 horsepower (373 kW), and
(9) Meet all of the performance requirements of one of the following motor types: A NEMA Design A, B, or C motor or an IEC Design N, NE, NEY, NY or H, HE, HEY, HYmotor.[21]

10 CFR 431.25(g).

The definitions for NEMA Design A motors, NEMA Design B motors, NEMA Design C motors, fire pump electric motors, IEC Design N motor and IEC Design H motor, as well as ''E'' and ''Y'' designated IEC Design motors, are codified in 10 CFR 431.12. DOE has also currently exempted certain categories of motors from standards. The exemptions are as follows:

(1) Air-over electric motors;
(2) Component sets of an electric motor;
(3) Liquid-cooled electric motors;
(4) Submersible electric motors; and
(5) Inverter-only electric motors.

10 CFR 431.25(l)

On October 19, 2022, DOE published the electric motors test procedure final rule. 87 FR 63588 (''October 2022 Final Rule''). As part of the October 2022 Final Rule, DOE expanded the test procedure scope to additional categories of electric motors that currently do not have energy conservation standards. 87 FR 63588, 63593–63606. The expanded test procedure scope included the following:

- Electric motors having a rated horsepower above 500 and up to 750 hp that meets the criteria listed at § 431.25(g), with the exception of criteria § 431.25(g)(8) to air-over electric motors (''AO–MEMs''), and inverter-only electric motors;
- Small, non-Small-Electric Motor, Electric Motors (''SNEM''), which:

(a) Is not a small electric motor, as defined at § 431.442 and is not a dedicated pool pump motors as defined at § 431.483;
(b) Is rated for continuous duty (MG 1) operation or for duty type S1 (IEC);
(c) Operates on polyphase or single-phase alternating current 60-hertz (Hz) sinusoidal line power; or is used with an inverter that operates on polyphase or single-phase alternating current 60-hertz (Hz) sinusoidal line power;
(d) Is rated for 600 volts or less;
(e) Is a single-speed induction motor capable of operating without an inverter or is an inverter-only electric motor;
(f) Produces a rated motor horsepower greater than or equal to 0.25 horsepower (0.18 kW); and
(g) Is built in the following frame sizes: any two-, or three-digit NEMA frame size (or IEC equivalent) if the motor operates on single-phase power; any two-, or three-digit NEMA frame size (or IEC equivalent) if the motor operates on polyphase power, and has a rated motor horsepower less than 1 horsepower (0.75 kW); or a two-digit NEMA frame size (or IEC metric equivalent), if the motor operates on polyphase power, has a rated motor horsepower equal to or greater than 1 horsepower (0.75 kW), and is not an enclosed 56 NEMA frame size (or IEC metric equivalent).

- SNEMs that are air-over electric motors (''AO–SNEMs'') and inverter-only electric motors;
- Synchronous electric motors, which:

(a) Is not a dedicated pool pump motor as defined at § 431.483 or is not an air-over electric motor;
(b) Is a synchronous electric motor;
(c) Operates on polyphase or single-phase alternating current 60-hertz (Hz) sinusoidal line power; or is used with an inverter that operates on polyphase or single-phase alternating current 60-hertz (Hz) sinusoidal line power;
(d) Is rated 600 volts or less; and
(e) Produces at least 0.25 hp (0.18 kW) but not greater than 750 hp (559 kW).

- Synchronous electric motors that are inverter-only electric motors.

In the October 2022 Final Rule, DOE noted that, for these motors newly included within the scope of the test procedure for which there was no established energy conservation standard, manufacturers would not be required to use the test procedure to certify these motors to DOE until such time as a standard is established. 87 FR 63591.[22] Further, the October 2022 Final Rule continued to exclude the following categories of electric motors:

- inverter-only electric motors that are air-over electric motors;
- component sets of an electric motor;
- liquid-cooled electric motors; and
- submersible electric motors.

In the March 2022 Preliminary Analysis, DOE analyzed the additional motors now included within the scope of the test procedure after the October 2022 Final Rule.[23] See sections 2.2.1 and 2.2.3.2 of the March 2022 Prelim TSD. This included MEMs from 1–500 hp, AO–MEMs, SNEMs, and AO–SNEMs. However, consistent with the November 2022 Joint Recommendation, this direct final rule establishes new and amended standards for only a portion of the scope analyzed in the March 2022 Preliminary Analysis and included within the scope of the test procedure after the October 2022 Final Rule. Specifically, in this direct final rule, DOE is only amending standards for certain MEMs and establishing new standards for AO–MEMs and certain air-over polyphase motors. DOE may address in a future rulemaking energy conservation standards for electric motor equipment classes not addressed in this direct final rule. Table III–1 summarizes the equipment class groups (''ECG'') DOE established pursuant to the November 2022 Joint Recommendation and analyzed in this direct final rule. Further discussion on equipment classes is provided in section IV.A.3 of this document.

TABLE III–1—EQUIPMENT CLASS GROUPS CONSIDERED

ECG	ECG motor design type	Motor topology	Horsepower rating	Pole configuration	Enclosure
1	MEM 1–500 hp, NEMA Design A & B	Polyphase	1–500	2, 4, 6, 8	Open. Enclosed.

[21] DOE added the ''E'' and ''Y'' designations for IEC Design motors into § 431.25(g) in the October 2022 Final Rule. 87 FR 63596, 636597, 6306.

[22] However, manufacturers making voluntary representations respecting the energy consumption or cost of energy consumed by such motors are required to use the DOE test procedure for making such representations beginning 180 days following publication of the October 2022 Final Rule. *Id.*

[23] At the time, most of these motors had been proposed for inclusion in the scope of the test procedure in the December 2021 Test Procedure NOPR. 86 FR 71710.

TABLE III–1—EQUIPMENT CLASS GROUPS CONSIDERED—Continued

ECG	ECG motor design type	Motor topology	Horsepower rating	Pole configuration	Enclosure
2	MEM 501–750 hp, NEMA Design A & B	Polyphase	501–750	2, 4	Open. Enclosed.
3	AO–MEM (Standard Frame Size)	Polyphase	1–250	2, 4, 6, 8	Open. Enclosed.
4	AO–Polyphase (Specialized Frame Size)	Polyphase	1–20	2, 4, 6, 8	Open. Enclosed.

As described in section II.B.3 of this document, this direct final rule establishes new equipment classes for AO–MEMs, AO–polyphase motors, and MEMs between 500 and 750 hp, and amends the standards for the 100–250 hp MEMs equipment classes.

C. Test Procedure

EPCA sets forth generally applicable criteria and procedures for DOE's adoption and amendment of test procedures. (42 U.S.C. 6314(a)) Manufacturers of covered products must use these test procedures to certify to DOE that their product complies with energy conservation standards and to quantify the efficiency of their product. On October 19, 2022, DOE published the electric motor test procedure final rule. 87 FR 63588 (''October 2022 Final Rule''). As described previously, the October 2022 Final Rule expanded the types of motors included within the scope of the test procedure, including the new classes of electric motors for which DOE is establishing energy conservation standards in this final rule. DOE's test procedures for electric motors are currently prescribed at appendix B to subpart B of 10 CFR part 431 (''appendix B'').

DOE's energy conservation standards for electric motors are currently prescribed at 10 CFR 431.25. DOE's current energy conservation standards for electric motors are expressed in terms of nominal full-load efficiency.

D. Technological Feasibility

1. General

In each energy conservation standards rulemaking, DOE conducts a screening analysis based on information gathered on all current technology options and prototype designs that could improve the efficiency of the products or equipment that are the subject of the rulemaking. As the first step in such an analysis, DOE develops a list of technology options for consideration in consultation with manufacturers, design engineers, and other interested parties. DOE then determines which of those means for improving efficiency are technologically feasible. DOE considers technologies incorporated in commercially-available products or in working prototypes to be technologically feasible. 10 CFR 431.4; 10 CFR part 430, subpart C, appendix A, sections 6(c)(3)(i) and 7(b)(1) (''Appendix A'').

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; (3) adverse impacts on health or safety, and (4) unique-pathway proprietary technologies. Section 7(b)(2)–(5) of appendix A. Section IV.B of this document discusses the results of the screening analysis for electric motors, 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 direct final rule technical support document (''TSD'').

2. Maximum Technologically Feasible Levels

When DOE adopts an amended standard for a type or class of covered product, 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. 6316(a); 42 U.S.C. 6295(p)(1)) Accordingly, in the engineering analysis, DOE determined the maximum technologically feasible (''max-tech'') improvements in energy efficiency for electric motors, 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 III.C of this direct final rule and in chapter 5 of the direct final rule TSD.

E. Energy Savings

1. Determination of Savings

For each trial standard level (''TSL''), DOE projected energy savings from application of the TSL to electric motors purchased in the 30-year period that begins in the first year of compliance with the amended standards (2027–2056).[24] The savings are measured over the entire lifetime of electric motors 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 an equipment would likely evolve in the absence of new and amended energy conservation standards.

DOE used its national impact analysis (''NIA'') spreadsheet model to estimate national energy savings (''NES'') from potential amended or new standards for electric motors. The NIA spreadsheet model (described in section IV.H of this document) 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. DOE also calculates NES in terms of FFC energy savings. The FFC metric includes the energy consumed in extracting, processing, and transporting primary fuels (*i.e.,* coal, natural gas, petroleum fuels), and thus presents a more complete picture of the impacts of energy conservation standards.[25] DOE's

[24] Each TSL is composed of specific efficiency levels for each product class. The TSLs considered for this direct final rule are described in section V.A of this document. DOE also presents a sensitivity analysis that considers impacts for products shipped in a 9-year period.

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

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 document.

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 energy savings. (42 U.S.C. 6295(o)(3)(B))

The significance of energy savings offered by a new or amended energy conservation standard cannot be determined without knowledge of the specific circumstances surrounding a given rulemaking. For example, some covered products and equipment have most of their energy consumption occur during periods of peak energy demand. The impacts of these products on the energy infrastructure can be more pronounced than products with relatively constant demand.

Accordingly, DOE evaluates the significance of energy savings on a case-by-case basis, taking into account the significance of cumulative FFC national energy savings, the cumulative FFC emissions reductions, health benefits, and the need to confront the global climate crisis, among other factors.

As stated, the standard levels adopted in this direct final rule are projected to result in national energy savings of 3.0 quads, the equivalent of the electricity use of 31 million homes in one year. Based on the amount of FFC savings, the corresponding reduction in emissions, and need to confront the global climate crisis, DOE has determined the energy savings from the standard levels adopted in this direct final rule are ''significant'' within the meaning of 42 U.S.C. 6316(a); 42 U.S.C. 6295(o)(3)(B).

F. Economic Justification

1. Specific Criteria

As noted previously, EPCA provides seven factors to be evaluated in determining whether a potential energy conservation standard is economically justified. (42 U.S.C. 6316(a); 42 U.S.C. 6295(o)(2)(B)(i)(I)–(VII)) 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 a potential amended standard on manufacturers, DOE conducts an MIA, as discussed in section IV.J of this document. 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 industry-wide impacts analyzed include (1) INPV, which values the industry on the basis of expected future cash flows; (2) cash flows by year; (3) changes in revenue and income; and (4) other measures of impact, as appropriate. Second, DOE analyzes and reports the impacts on different 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 consumer costs and benefits expected to result from particular standards. DOE also evaluates the impacts of potential standards on identifiable subgroups of consumers that may be affected disproportionately by a 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. 6316(a); 42 U.S.C. 6295(o)(2)(B)(i)(II)) DOE conducts this comparison in its LCC and PBP analysis.

The LCC is the sum of the purchase price of an equipment(including its installation) and the operating costs (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 analysis, DOE assumes that consumers will purchase the covered products in the first year of compliance with new or amended standards. The LCC savings for the considered efficiency levels are calculated relative to the case that reflects projected market trends in the absence of new or amended standards. DOE's LCC and PBP analysis is discussed in further detail in section IV.F of this document.

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. 6316(a); 42 U.S.C. 6295(o)(2)(B)(i)(III)) As discussed in section IV.H of this document, DOE uses the NIA spreadsheet model 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. 6316(a); 42 U.S.C. 6295(o)(2)(B)(i)(IV)) Based on data available to DOE, the standards adopted in this document would not reduce the utility or performance of the products under consideration in this rulemaking.

e. Impact of Any Lessening of Competition

EPCA directs DOE to consider the impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from a standard. (42 U.S.C. 6316(a); 42 U.S.C. 6295(o)(2)(B)(i)(V)) 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 rule, together with an analysis of the nature and extent of the impact. (42 U.S.C. 6316(a); 42 U.S.C. 6295(o)(2)(B)(ii)) 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 energy conservation standards for electric motors are unlikely to have a significant adverse impact on competition. DOE is publishing the Attorney General's assessment at the end of this direct final rule.

f. Need for National Energy Conservation

DOE also considers the need for national energy and water conservation in determining whether a new or amended standard is economically justified. (42 U.S.C. 6316(a); 42 U.S.C. 6295(o)(2)(B)(i)(VI)) 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 of this document.

DOE maintains that environmental and public health benefits associated with the more efficient use of energy are important to take into account when considering the need for national energy conservation. The adopted standards 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 estimated emissions impacts are reported in section V.B.6 of this document. DOE also estimates the economic value of emissions reductions resulting from the considered TSLs, as discussed in section IV.L of this document.

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. 6316(a); 42 U.S.C. 6295(o)(2)(B)(i)(VII)) To the extent DOE identifies any relevant information regarding economic justification that does not fit into the other categories described previously, DOE could consider such information under ''other factors.''

2. Rebuttable Presumption

EPCA creates a rebuttable presumption that an energy conservation standard is economically justified if the additional cost to the equipment that meets the standard is less than three times the value of the first year's energy savings resulting from the standard, as calculated under the applicable DOE test procedure. (42 U.S.C. 6316(a); 42 U.S.C. 6295(o)(2)(B)(iii)) DOE's LCC and PBP analyses generate values used to calculate the effects that 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. 6316(a); 42 U.S.C. 6295(o)(2)(B)(i). 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 direct final rule.

IV. Methodology and Discussion of Related Comments

This section addresses the analyses DOE has performed for this rulemaking with regards to electric motors. Separate subsections address each component of DOE's analyses. In this direct final rule, DOE is only addressing comments and analysis specific to the scope of motors provided in the November 2022 Joint Recommendation. As such, any analysis and comments related to SNEMs and AO–SNEMs will be addressed in a separate NOPR.

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: *www.regulations.gov/docket/EERE-2020-BT-STD-0007.* Additionally, DOE used output from the latest version of the Energy Information Administration's (''EIA's'') *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 products concerned, including the purpose of the products, the industry structure, manufacturers, market characteristics, and technologies used in the products. 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 (1) a determination of the scope of the rulemaking and product classes, (2) manufacturers and industry structure, (3) existing efficiency programs, (4) shipments information, (5) market and industry trends; and (6) technologies or design options that could improve the energy efficiency of electric motors. The key findings of DOE's market assessment are summarized in the following sections. See chapter 3 of the direct final rule TSD for further discussion of the market and technology assessment.

1. Scope of Coverage

This document covers equipment meeting the definition of electric motors as defined in 10 CFR 431.12. Specifically, the definition for ''electric motor'' is ''a machine that converts electrical power into rotational mechanical power.'' *Id.*

In the March 2022 Preliminary Analysis, DOE presented analysis for the current scope of electric motors regulated at 10 CFR 431.25, as well as expanded scope proposed in the December 2021 test procedure NOPR, which included air-over electric motors and SNEMs. See Chapter 2 of the March 2022 Prelim TSD. Since, DOE has published the October 2022 Final Rule, which expanded the scope of the test procedures to include such motors, as discussed in detail in section III.B of this direct final rule.

In response to the scope presented in the March 2022 Preliminary Analysis, DOE received a number of comments, which are discussed in the subsections below. In this direct final rule, DOE is only addressing comments and analysis specific to the scope of motors provided in the November 2022 Joint Recommendation, which includes MEMs and polyphase air-over electric motors.

a. Motor Used as a Component of a Covered Product or Equipment

Generally, Lennox noted that DOE should apply a finished-product approach to energy efficiency regulations. Specifically, Lennox commented that system performance standards of HVAC–R products include the energy used by the electric motors, and that increasing the stringency of component-level regulation does not have any efficiency benefit when the ultimate efficiency is measured at the systems level and manufacturers adjust other equipment parameters based on the overall system level of performance, offsetting increased motor costs by reducing other component costs and efficiencies to mitigate adverse financial impacts on consumers.[26] Lennox stated that mandating additional testing and certification of motors used in already-regulated HVAC–R products would not save energy and create needless testing, paperwork, and record-keeping requirements that raise consumer costs. (Lennox, No. 29 at p. 2–3) Lennox elaborated that the HVAC–R standards in place will drive more efficient design of relevant components, including motors, without unnecessary further regulation of components, and that the March 2022 Preliminary Analysis has not adequately accounted for these cumulative manufacturer burdens.[27] (Lennox, No. 29 at p. 6)

AHAM and AHRI strongly opposed DOE's plan to expand the existing scope of coverage of electric motors to include motors destined for particular applications in finished goods, and instead recommended that DOE should apply a finished-product approach to energy efficiency regulations. (AHAM, AHRI, No. 25 at p. 7–9) NEMA commented that further elevations to component efficiencies or changes to scope for electric motors energy conservation standards will lead to diminishing returns, and are therefore less practical, because previous electric motors rulemakings adequately addressed concerns for ''application and performance of existing equipment'' to the maximum extent practical. NEMA stated that DOE should allow application-dependent solutions like power drive systems to take over from minimum energy conservation standards as the most-appropriate and best-fit market transformation vehicles, but they must be selected and installed with due regard for their application-specific nature, which calls for ''other than regulatory action'' on the part of DOE. (NEMA, No. 22 at p. 26)

Daikin commented that they do not support the regulation of electric motors that are components of a covered equipment such as HVAC equipment. Daikin added that regulating embedded components creates both apparent and likely unforeseen issues. For HVAC manufacturers, Daikin commented that regulating components reduces design flexibility and may not result in optimal design for overall system performance. Daikin stated that standards for HVAC equipment are regularly evaluated by DOE to ensure regulations are aligned with the most cost-effective product for consumers, and HVAC manufacturers generally respond by producing a class of equipment at these federal minimum efficiency levels. As such, Daikin stated that regulating an embedded component will not improve the overall product's energy efficiency. (Daikin, No. 32 at p. 1)

On the other hand, the Joint Advocates commented in support of regulating electric motors that are components of covered equipment. The Joint Advocates stated that there is value in regulating the motors separately. The Joint Advocates agreed with DOE that different motor efficiency levels may be cost-effective for different covered products, and the presence of electric motors in covered equipment does not preclude the possibility of cost-effective energy standards for electric motors individually. Furthermore, the Joint Advocates commented that absent standards for motors that are used in covered equipment, consumers may get stuck with inefficient replacement motors. Finally, the Joint Advocates commented that motors used in covered equipment are often purchased by the original equipment manufacturer (''OEM'') from a motor manufacturer, and thus, exempting motors used in covered equipment would likely create enforcement challenges since it would be difficult to determine a given motor's end use application. (Joint Advocates, No. 27 at p. 5)

DOE understands that the majority of the concerns summarized in this section and provided separately by commenters stems from DOE potentially regulating SNEMs and AO–SNEMs. This direct final rule does not address SNEMs or AO–SNEMs as part of the scope. DOE may consider in a future rulemaking energy conservation standards for electric motor equipment classes not addressed in this direct final rule, including SNEMs and AO–SNEMs. If so, DOE will address these comments and concerns as part of any future rulemaking. As such, in this final rule, DOE is generally addressing comments regarding electric motors scope and what DOE has the authority to regulate.

As discussed in the October 2022 Final Rule, EPCA, as amended through EISA 2007, provides DOE with the authority to regulate the expanded scope of motors addressed in this rule. 87 FR 63588, 63596. Before the enactment of EISA 2007, EPCA defined the term ''electric motor'' as any motor that is a general purpose T-frame, single-speed, foot-mounting, polyphase squirrel-cage induction motor of the NEMA, Design A and B, continuous rated, operating on 230/460 volts and constant 60 Hertz line power as defined in NEMA Standards Publication MG1–1987. (*See* 42 U.S.C. 6311(13)(A) (2006)) Section 313(a)(2) of EISA 2007 removed that definition and the prior limits that narrowly defined what types of motors would be considered as electric motors. In its place, EISA 2007 inserted a new ''Electric motors'' heading, and created two new subtypes of electric motors: General purpose electric motor (subtype I) and general purpose electric motor (subtype II). (42 U.S.C. 6311(13)(A)–(B) (2011)) In addition, section 313(b)(2) of EISA 2007 established energy conservation standards for four types of electric motors: general purpose electric motors (subtype I) (*i.e.,* subtype I motors) with a power rating of 1 to 200 horsepower; fire pump motors; general purpose electric motor (subtype II) (*i.e.,* subtype II motors) with a power rating of 1 to 200 horsepower; and NEMA Design B, general purpose electric motors with a power rating of more than 200 horsepower, but less than or equal to 500 horsepower. (42 U.S.C. 6313(b)(2)) The term ''electric motor'' was left undefined. However, in a May 4, 2012 final rule amending the electric

[26] Lennox made these comments in the context of air-over and inverter-only motors included within HVACR products, requesting that DOE maintain the exemptions to the energy conservation standards for these motors contained in 10 CFR 431.25(l). (Lennox, No. 29 at p. 2) DOE addresses Lennox's comments regarding the exemption for these specific motors in sections IV.1.b and d of this document.

[27] Lennox also commented that DOE should continue exempting SEMs used as a component in covered equipment (specifically, HVACR equipment) from the energy conservation standards for electric motors, and that including SNEMs in the energy conversation standards for electric motors would circumvent Congressional intent to exempt from regulation small electric motors that are components of EPCA covered products and covered equipment. (Lennox, No. 29 at p. 3). As noted previously, DOE is not including SNEMs within the scope of this direct final rule. SNEMs may be addressed in a future rulemaking, and DOE will consider such comments in that rulemaking.

motors test procedure (the May 2012 Final Rule), DOE adopted the broader definition of ''electric motor'' currently found in 10 CFR 431.12 because DOE noted that the absence of a definition may cause confusion about which electric motors are required to comply with mandatory test procedures and energy conservation standards, and to provide DOE with the flexibility to set energy conservation standards for other types of electric motors without having to continuously update the definition of ''electric motors'' each time DOE sets energy conservation standards for a new subset of electric motors. 77 FR 26608, 26613.

The provisions of EPCA make clear that DOE may regulate electric motors ''alone or as a component of another piece of equipment.'' See 42 U.S.C. 6313(b)(1) & (2) (providing that standards for electric motors be applied to electric motors manufactured ''alone or as a component of another piece of equipment'') In contrast, Congress exempted small electric motors (SEMs) [28] that are a component of a covered product or a covered equipment from the standards that DOE was required to establish under 42 U.S.C. 6317(b). Congress did not, however, similarly restrict electric motors. Unlike SEMs, the statute does not limit DOE's authority to regulate an electric motor with respect to whether ''electric motors'' are stand-alone equipment items or components of a covered product or covered equipment. Rather, Congress specifically provided that DOE could regulate electric motors that are components of other covered equipment in the standards established by DOE.

Additionally, EPCA requires that any new or amended standard for a covered product must be designed to achieve the maximum improvement in energy efficiency that the Secretary of Energy determines is technologically feasible and economically justified. (42 U.S.C. 6316(a); 42 U.S.C. 6295(o)(2)(A) and 42 U.S.C. 6295(o)(3)(B)) In this direct final rule, DOE performs the necessary analyses to determine whether amended or new standards would meet the aforementioned criteria. Further, DOE has determined that the amended standards provide cost-effective standards that would result in the significant conservation of energy. Further discussion on double-counting as it relates to energy savings is provided in section IV.F of this document. Further discussion on the analytical results and DOE's justification is provided in section V.C of this document.

[28] Congress defined what equipment comprises a small electric motor (''SEM'')—specifically, ''a NEMA general purpose alternating current single-speed induction motor, built in a two-digit frame number series in accordance with NEMA Standards Publication MG1–1987.'' (42 U.S.C. 6311(13)(G)) (DOE clarified, at industry's urging, that the definition also includes motors that are IEC metric equivalents to the specified NEMA motors prescribed by the statute. *See* 74 FR 32059, 32061–32062; 10 CFR 431.442.

b. Air-Over Electric Motors

NEEA supported the inclusion of air-over electric motors in the scope of the standards, noting that including them will allow comparison of performance and informed purchase decisions. (NEEA, No. 33 at p. 2) The CA IOUs supported the inclusion of Totally Enclosed Air Over (''TEAO'') motors in the analysis. In addition, the CA IOUs commented that they support establishing standards for air-over motors that otherwise meet the description of regulated motors (*i.e.,* ''AO–MEM'') consistent with the levels for totally enclosed fan cooled (''TEFC'') electric motors. (CA IOUs, No. 30 at p. 1–2)

Lennox commented that DOE must continue the current electric motor exemptions specified in 10 CFR 431.25(l) for air-over, particularly when those motors are used in already-regulated HVACR products. (Lennox, No. 29 at p. 3) AHRI commented that air-over motors are explicitly exempted from regulation in 10 CFR 431.25(l), and that DOE has not overcome the challenges to include these exempted products, procedurally or technically. (AHRI, No. 26 at p. 1, 2)

DOE is covering air-over electric motors under its ''electric motors'' authority. (42 U.S.C. 6311(1)(A)) As previously discussed, the statute does not limit DOE's authority to regulate an electric motor with respect to whether they are stand-alone equipment items or as components of a covered product or covered equipment. See 42 U.S.C. 6313(b)(1) (providing that standards for electric motors be applied to electric motors manufactured ''alone or as a component of another piece of equipment'').

DOE's previous determination in the December 2013 Final Rule to exclude air-over electric motors from scope was due to insufficient information available to DOE at the time to support establishment of a test method. *See* 78 FR 75962, 75974–75975. Since that time, NEMA published a test standard for air-over motors in Section IV, ''Performance Standards Applying to All Machines,'' Part 34 ''Air-Over Motor Efficiency Test Method'' of NEMA MG 1–2016 (''NEMA Air-over Motor Efficiency Test Method''). The air-over method was originally published as part of the 2017 NEMA MG–1 Supplements and is also included in the latest version of NEMA MG 1–2016. In the October 2022 Final Rule, DOE used the aforementioned argument to include air-over electric motors into the test procedure scope and establish test procedures. *See* 87 FR 63588, 63597. In this direct final rule, DOE has analyzed the scope of electric motors based on the finalized test procedures from the October 2022 Final Rule, and amended energy conservation standards based on the November 2022 Joint Recommendation.

c. AC Induction Electric Motors Greater Than 500 Horsepower

NEEA commented in support of expanding the scope to include AC induction electric motors greater than 500 horsepower to identify their energy use, potential for energy savings, price, and prevalence in the market today. NEEA added that these motors consume a significant amount of energy, and that motor efficiency generally improves as a function of motor size, so it may be possible to establish higher efficiency standards for greater than 500 HP motors. (NEEA, No. 33 at p. 3)

NEMA stated that energy conservation standards for >500 HP motors would likely not be justified because of how tiny their market share is. It also stated that there are unique performance requirements applied to these motors that require custom designs that limit efficiency. NEMA stated that, at minimum, if a motor has one of the following special requirements, it should not be subject to standards; those special requirements are: <550 percent locked-rotor current, minimum locked rotor steady state supply voltage of <80 percent, ability to accelerate a moment of inertia greater than the moment of inertia defined by NEMA, ability to operate outside the range of -20 °C to +60 °C, ability to operate above 4,000 m above sea level, a load-torque envelope with a minimum torque of 25 percent of rated torque with a square shaped $T-n^2$ up to a max load, ability to start consecutively from cold three times or from hot two times, being a multi-speed motor, submersible, smoke extraction motor, explosion-proof motor, or a motor used in nuclear plants. (NEMA, No. 22 at p. 9–10)

Since the comments to the March 2022 Preliminary Analysis, the Electric Motors Working Group, which included NEEA and NEMA, recommended standards for medium electric motors rated over 500 hp and up to 750 hp at 60 Hz (Recommendation #2). The scope of medium electric motors includes those electric motors that currently meet

10 CFR 431.25(g), but expanded to include motor horsepower >500 hp but less than 750 hp. Accordingly, in this direct final rule, DOE is including the aforementioned scope of electric motors for consideration of new standards, based on the November 2022 Joint Recommendation. Specifically, in the November 2022 Joint Recommendation, the Electric Motors Working Group agreed on establishing efficiency levels corresponding to 60 Hz NEMA Premium levels for motors rated over 500 hp and up to 750 hp. The Electric Motors Working Group noted that extending the horsepower range of electric motors subject to energy conservation standards would be beneficial in aligning with EU Ecodesign Directive 2019/1781,[29] which covers motors up to 1000 kW (1341 hp) at NEMA Premium levels, and for which manufacturers are making investments to comply.

d. AC Induction Inverter-Only and Synchronous Electric Motors

NEEA commented in support of expanding the scope of standards to synchronous and inverter-only motors to identify their energy use, potential for energy savings, price, and prevalence in the market today. NEEA recommended to include these motors in the same equipment classes are induction motors. In addition, NEEA recommended not to establish stricter efficiency requirements for these motors based on full-load efficiency because these motors allow energy savings at part load conditions. (NEEA, No. 33 at p. 3) NEMA stated that synchronous motors should have their own equipment class until analysis concludes they are not needed. NEMA suggested DOE make an ''other than regulatory action'' to save energy at the application and reference NEMA Standard 10011–22 with regards to the power index. (NEMA, No. 22 at p. 8)

CA IOUs supported including inverter-only and synchronous electric motors, but in the same equipment class as currently regulated induction motors. The CA IOUs recommended convening an Appliance Standards and Rulemaking Federal Advisory Committee (''ASRAC'') Working Group to finalize a test procedure and part-load metric for these motors before finalizing a test procedure and energy conservation standards rulemaking. (CA IOUs, No. 30 at p. 2) The Joint Advocates also commented supporting analyzing synchronous motors jointly with currently covered motors and recommended that DOE also analyze synchronous motors jointly with relevant SNEM and AO motors. The Joint Advocates commented that synchronous motors represent the most efficient motors on the market and highlighted the potential energy savings opportunities facilitated by market shifts to synchronous motors. In addition, the Joint Advocates commented that the potential life-cycle cost savings associated with synchronous motor substitutions should be directly accounted for when evaluating potential amended standards for electric motors. (Joint Advocates, No. 27 at p. 2) Similarly, the CA IOUs also provided the following supporting data to show that synchronous and inverter-only electric motor are designed, marketed, capable, and are being used to replace induction motors: (1) manufacturer reference tables that promote the direct replacement of currently regulated induction motors with synchronous and inverter-only motors (2) data showing synchronous motor performance exceeding a best-in-class copper cage induction motor paired with a commercially available VFD (which the CA IOUs stated corroborates the PTSD savings estimates for synchronous electric motors), and (3) a summary of case studies docketed in response to the December 2021 test procedure NOPR. The CA IOUs commented that this supporting data demonstrates the use of synchronous and inverter-only motors in applications where National Electrical Manufacturers Association (NEMA) Design B motors are typically used. (CA IOUs, No. 30 at p. 2–3)

AHAM and AHRI commented that if DOE includes inverter-only and synchronous motors in the scope of the ECS, it should first publish a preliminary analysis or NODA for these motors before proceeding to a NOPR. (AHAM, AHRI, No. 25 at p. 2) Lennox commented that DOE imposing increased costs on inverter-only motors by additional regulation may inhibit HVACR manufacturer use of these motors in innovative applications. Further, Lennox commented that DOE ceasing its exemptions for inverter-only motors, and thereby unduly-burdening manufacturers and forcing higher HVACR product costs on consumers with component-level regulation, is particularly inappropriate during an ongoing pandemic where inflation has been at a 40-year high. (Lennox, No. 29 at p. 2–3) NEMA stated that by regulating synchronous motors, DOE is regulating both the required adjustable speed drive and the motor itself. It stated that this is unnecessary and poorly conceived, and that synchronous motors do not generally conform to the torque-speed curves required by NEMA and IEC Designs. (NEMA, No. 22 at p. 7) In addition, NEMA stated that inverter-only induction motors have characteristics warranting their own equipment class. It stated these motors are used exclusively for constant torque or constant HP applications and that certain applications have performance requirements like acceleration, deceleration, and overload capability for optimal control of a process. NEMA also stated that the performance requirements go beyond a single steady-state load condition that the test procedure uses, and that targeting a specific operating point's efficiency could restrict the other torque and thermal requirements of these motors. It also states that since the metric includes the losses of the inverter, these motors will have a lower maximum potential efficiency than typical induction motors. NEMA pointed to IEC 60034–30–2 as an example for efficiency values that pertain specifically to variable-speed motors. (NEMA, No. 22 at p. 8–9)

In this direct final rule, DOE is not separately regulating or establishing standards for inverter-only and synchronous electric motors. As a sensitivity analysis, DOE notes that it analyzed the impacts of potentially switching to these electric motors as a result of higher standards that will be finalized for MEMs 100–250 hp, NEMA Design A & B in this DFR; further discussion is provided in section IV.F of this document.

e. Submersible Electric Motors

NEEA and HI recommended excluding submersible motors from the scope of the standards due to the lack of repeatable and representative test procedures. (NEEA, No. 33 at p. 4; HI, No. 31 at p. 1) CA IOUs commented that they do not support including submersible electric motors, and that DOE should collaborate with industry stakeholders in developing a test procedure for this motor category. (CA IOUs, No. 30 at p. 2) Finally, NEMA stated that submersible electric motors should be removed from the rulemaking. (NEMA, No. 22 at p. 9) In the October 2022 Final Rule, DOE did not finalize a test method for submersible electric motors. *See* 87 FR 63588, 63605. Moreover, the November 2022 Joint Recommendation did not recommend energy conservation standards for submersible electric motors. Accordingly, submersible electric motors continue to be excluded

[29] In terms of standardized horsepowers, this would correspond to 100–250 hp when applying the guidance from 10 CFR 431.25(k) (and new section 10 CFR 431.25(q)).

from the test procedure and are not included in this standards direct final rule.

2. Test Procedure and Metric

DOE received comments regarding the test procedure and efficiency metric for electric motors subject to these energy conservation standards.

NEMA requested an SNOPR for the test procedure and requested that the energy conservation standards rulemaking not move forward until the test procedure is finished. (NEMA, No. 22 at p. 2). DOE published the electric motor test procedure final rule on October 19, 2022. 87 FR 63588.

NEEA commented that, until DOE revises their test procedure and efficiency metric to account for part-load operating conditions, they do not recommend that DOE establish stricter efficiency requirements for synchronous electric motors and inverter-only electric motors. (NEEA, No. 33 at p. 4,5) CA IOUs commented similarly, strongly encouraging DOE to adopt the use of a metric that is representative of part-load performance for inverter-only and synchronous electric motors. CA IOUs provided data in support of the use of a part-load metric for inverter-only and synchronous electric motor applications to better reflect how these motors operate in the field. (CA IOUs, No. 30 at p. 2) The Joint Advocates explained that inverter-only AC motors may not have a higher full-load efficiency than a comparable single-speed motor, but they may save energy by reducing motor speed and resulting input power at partial loads. Therefore, they commented that because the efficiency is evaluated only at full load, inverter-only motors would be at a disadvantage as the input losses associated with the inverter would be included in the efficiency calculation, but the potential energy savings resulting from its speed control capabilities would not be captured. (Joint Advocates, No. 27 at p. 3) NEMA commented that DOE should transition away from a single point efficiency metric and instead should develop a Power Index that incorporates the savings associated with power drive systems. NEMA commented that by applying a fixed speed efficiency testing at full load metric, the DOE misses the true opportunity for energy savings. NEMA explained that while at certain load points the motor losses might be a fraction (0.5 percent) lower, the application of a PDS would save 25–50 percent of power in the integral horsepower market and that these savings dwarf the 0.8 percent reduction associated with EL2. (NEMA, No. 22 at p. 5)

The currently prescribed test procedure in appendix B requires testing electric motors at full-load only. In the October 2022 Final Rule, DOE argued that variable-load applications primarily operate in a range where efficiency is relatively flat as a function of load, and therefore measuring the performance of these motors at full-load is representative of an average use cycle. *See* 87 FR 63588, 63620. Moreover, in this direct final rule, DOE is not proposing to separately regulate inverter-only and synchronous electric motors, but rather DOE is considering substitution effects to these motors for higher efficiency standards for MEMs.

Lennox commented that there would be insufficient testing facilities to accommodate significantly expanded motor product classes, such as DOE expanding motor regulations into SNEMs, air-over, synchronous or inverter-only motors, specifically in view of the proposal to require third-party laboratory testing. (Lennox, No. 29 at p. 5–6) The Joint Industry Stakeholders commented that DOE proposed that electric motors certified to the new test procedure could only be certified by 3rd party test labs, instead of certified labs in accordance with longstanding recognized practice. They stated that special and definite-purpose motors potentially classified as SNEM could not possibly be tested, redesigned, retested, certified, and made available for OEM use by the few third-party small electric motor certification bodies recognized by DOE today. (Joint Industry Stakeholders, No. 23 at p. 9) As discussed in section IV.A.1, in this direct final rule, DOE is only amending standards for certain MEMs and establishing standards for AO–MEMs and certain air-over polyphase motors. Further, DOE understands the Joint Industry Stakeholders comments to be directed at the proposals from the test procedure rulemaking. Since this proposal, DOE published the October 2022 Final Rule, where DOE decided to not adopt its proposal to require the use of an independent testing program, and to instead continue permitting the use of accredited labs as currently allowed through National Institute of Standards and Technology (''NIST'') and National Voluntary Laboratory Accreditation Program (''NVLAP'') accreditation. *See* 87 FR 62588, 63628–63629.

3. Equipment Classes

When evaluating and establishing energy conservation standards, DOE divides covered equipment into equipment classes by the type of energy used or by capacity or other performance-related features that justify differing standards. In making a determination 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. 6316(a); 42 U.S.C. 6295(q))

Due to the number of electric motor characteristics (*e.g.,* horsepower rating, pole configuration, and enclosure), in the March 2022 Preliminary Analysis, DOE used two constructs to help develop appropriate energy conservation standards for electric motors: ''equipment class'' and ''equipment class groups.'' An equipment class represents a unique combination of motor characteristics for which DOE is establishing a specific energy conservation standard. This includes permutations of electric motor design types (*i.e.,* NEMA Design A & B (and IEC equivalents)), standard horsepower ratings (*i.e.,* standard ratings from 1 to 500 horsepower), pole configurations (*i.e.,* 2–, 4–, 6–, or 8–pole), and enclosure types (*i.e.,* open or enclosed). An equipment class group (''ECG'') is a collection of electric motors that share a common design trait. Equipment class groups include motors over a range of horsepower ratings, enclosure types, and pole configurations. Essentially, each equipment class group is a collection of a large number of equipment classes with the same design trait. As such, in the March 2022 Preliminary Analysis, DOE presented equipment class groups based on electric motor design, motor topology, horsepower rating, pole configuration and enclosure type. See Chapters 2.3.1 and 3.2.2 of the March 2022 Preliminary Analysis TSD.

Further, although DOE acknowledged that synchronous electric motors, inverter-only electric motors and induction electric motors >500 hp and ≤750 hp would be within scope, DOE did not create separate equipment classes for these electric motors and did not evaluate separate energy conservation standards. (See Chapter 2.3.1.3 of the March 2022 Preliminary Analysis TSD) However, DOE did evaluate synchronous and inverter-only electric motors jointly with the induction motors because the motors did not have a performance-related feature that would justify a separate class. *Id.*

In response to the equipment classes, DOE received a number of comments, which are presented below. Comments regarding SNEM and AO–SNEM equipment classes will be addressed in a separate NOPR.

Regarding air-over motors, NEMA agreed that an air-over rating warrants a separate equipment class because these motors are often built in a smaller frame size to take advantage of the outside airflow. NEMA stated that these motors built in a smaller frame size are limited in their efficiency capability because less active material can fit in them. (NEMA, No. 22 at p. 7)

Since the comments to the March 2022 Preliminary Analysis TSD, the November 2022 Joint Recommendation specifically recommended that DOE establish two separate equipment classes for AO–MEMs, *i.e.,* standard frame AO–MEMs and specialized frame AO–MEMs, because of their different applications. The November 2022 Joint Recommendation identified standard frame AO–MEMs as AO–MEMs sold in standard NEMA frame sizes aligned with NEMA MG1, Table 13.2 and Table 13.3. In addition, the November 2022 Joint Recommendation identified specialized, smaller frame AO–MEMs as a group of motors for which the rated output exceeds the horsepower-frame size limits in the aforementioned NEMA MG1 tables. The Electric Motors Working Group noted that these motors are used in specialty applications where the design is optimized to meet space constraints and take advantage of higher-than-normal airflows, such as in agriculture applications. They also stated that because of the higher airflows, the motor operates at greater power densities than standard-frame motors, which therefore results in the motor being loaded to a slightly less efficient operating point. Accordingly, they recommended these motors be separated into their own equipment class. See November 2022 Joint Recommendation at 4–5.

Consistent with the November 2022 Joint Recommendation, in this direct final rule, DOE is separating the air-over equipment class into two equipment classes. As such, DOE is including ''AO–MEM (Standard frame size),'' and renaming ''Specialized Frame Size AO–MEMs'' (from the November 2022 Joint Recommendation) to ''AO–Polyphase (Specialized frame size)''. DOE notes that the frame size constraints from Recommendation 3.b. include frame sizes beyond those specifically in the AO–MEM scope; as discussed in section III.A, 10 CFR 431.25(g)(7) specifically states that a MEM built in a two-digit frame size would only be an enclosed 56 NEMA frame size (or IEC metric equivalent), whereas Recommendation 3.b. specifies maximum NEMA frame diameters at 48 NEMA frame size. Accordingly, to provide a more representative naming convention for these motors, DOE is using ''AO–Polyphase (Specialized frame size)'' in this direct final rule. DOE notes that only the naming convention is changed compared to the November 2022 Joint Recommendation; the scope of motors being represented continues to stay the same.

In addition, to clarify what is meant by ''standard frame size'' and ''specialized frame size,'' DOE is adding definitions in the CFR consistent with the recommendations from the November 2022 Joint Recommendation. Specifically, in this direct final rule, DOE is adding a definition for ''standard frame size'' as ''aligned with the specifications in NEMA MG 1–2016 section 13.2 for open motors, and NEMA MG 1–2016 section 13.3 for enclosed motors.'' Further, DOE is adding a definition for ''specialized frame size'' as ''means an electric motor frame size for which the rated output power of the motor exceeds the motor frame size limits specified for standard frame size. Specialized frame sizes have maximum diameters corresponding to the following NEMA Frame Sizes:''

Motor horsepower/standard kilowatt equivalent	Maximum NEMA frame diameter							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/.75	48	....	48	48	48	48	140	140
1.5/1.1	48	48	48	48	140	140	140	140
2/1.5	48	48	48	48	140	140	180	180
3/2.2	140	48	140	140	180	180	180	180
5/3.7	140	140	140	140	180	180	210	210
7.5/5.5	180	140	180	180	210	210	210	210
10/7.5	180	180	180	180	210	210	....	....
15/11	210	180	210	210	....	....	....	....
20/15	210	210	210	210	....	....	....	....

Regarding motors already covered at 10 CFR 431.25(g), NEMA stated that locked-rotor torque is not a typical design criterion used by end-users and that this value is already captured in the NEMA Design A, B, C etc. classification. NEMA also stated that locked-rotor torque is not a reliable means for determining energy efficiency. (NEMA, No. 22 at p. 6) DOE agrees with the statement and is therefore not incorporating locked-rotor torque as an equipment class identifier for MEMs currently covered at 10 CFR 431.25(g).

Regarding synchronous and inverter-only electric motors, NEEA recommended that DOE not create separate equipment classes because these motors are used in the same applications as their induction motor counterparts. (NEEA, No. 33 at p. 3) The Joint Advocates stated that while they agree that inverter-only induction electric motors do not have a unique performance-related feature or utility that justifies a separate class from non-inverter and inverter-capable motors, they were concerned that inverter-only motors may be at an unfair disadvantage relative to single-speed induction motors when efficiencies are evaluated only at full load. (Joint Advocates, No. 28 at p. 3) As discussed in section IV.A.1.d of this document, DOE is not separately regulating inverter-only and synchronous electric motors in this direct final rule. Rather, DOE is only considering the substitution effects of switching to these electric motors if higher standards for MEMs are established. Otherwise, comments regarding the test procedure and metric are addressed in section IV.A.2 of this document.

Therefore, Table IV–1 presents the ECGs considered in this direct final rule. The equipment class groups represent a total of 425 equipment classes.

TABLE IV–1—EQUIPMENT CLASS GROUPS CONSIDERED

ECG	ECG motor design type	Motor topology	Horsepower rating	Pole configuration	Enclosure
1	MEM 1–500 hp, NEMA Design A & B	Polyphase	1–500	2, 4, 6, 8	Open. Enclosed.
2	MEM 501–750 hp, NEMA Design A & B	Polyphase	501–750	2, 4	Open. Enclosed.
3	AO–MEM (Standard Frame Size)	Polyphase	1–250	2, 4, 6, 8	Open. Enclosed.
4	AO–Polyphase (Specialized Frame Size)	Polyphase	1–20	2, 4, 6, 8	Open. Enclosed.

4. Technology Options

In the March 2022 Preliminary Analysis market and technology assessment, DOE identified several technology options that were initially determined to improve the efficiency of electric motors, as measured by the DOE test procedure. Table IV–2 presents the technology options considered in the March 2022 Preliminary Analysis.

TABLE IV–2—MARCH 2022 PRELIMINARY ANALYSIS TECHNOLOGY OPTIONS TO INCREASE MOTOR EFFICIENCY

Type of loss to reduce	Technology option
Stator I2R Losses	Increase cross-sectional area of copper in stator slots Decrease the length of coil extensions
Rotor I2R Losses	Increase cross-sectional area of end rings. Increase cross-sectional area of rotor conductor bars. Use a die-cast copper rotor cage.
Core Losses	Use electrical steel laminations with lower losses. (watts/lb) Use thinner steel laminations. Increase stack length (*i.e.,* add electrical steel laminations).
Friction and Windage Losses	Optimize bearing and lubrication selection. Improve cooling system design.
Stray-Load Losses	Reduce skew on rotor cage. Improve rotor bar insulation.

In response to the technology options, DOE received several comments.

Regarding electrical steel, NEMA stated that newer grade steels are available but not in the high volumes required to replace today's production, and that many new grades are imported and subject to tariffs and delays. (NEMA, No. 22 at p. 10) NEMA argued that using lower-loss steel would not necessarily result in a more efficient electric motor. (NEMA, No. 22 at p. 10–13) Specifically, NEMA stated that processing of the steel during motor manufacturing could alter electrical steel performance. As an example, NEMA noted that thinner steels would deform more when punched than thicker grades. (NEMA, No. 22 at p. 11) Additionally, NEMA stated that different steel grades could have different heat transfer rates, which may affect motor operating temperature and, thus, efficiency. (NEMA, No. 22 at p. 11) NEMA provided certain test data illustrating its claims regarding the potential for steel loss and motor efficiency to diverge. (NEMA, No. 22 at p. 12) Relatedly, NEMA provided finite element model data illustrating magnetic flux density over the cross section of a 4-pole induction motor and noting the nonuniformity of the flux density values obtained, which NEMA observed could exceed the 1.5T-reference value commonly used by steel producers to rate their products. (NEMA, No. 22 at p. 13–14)

Losses generated in the electrical steel in the core of an induction motor can be significant and are classified as either hysteresis or eddy current losses. Hysteresis losses are caused by magnetic domains resisting reorientation to the alternating magnetic field. Eddy currents are physical currents that are induced in the steel laminations by the magnetic flux produced by the current in the windings. Both hysteresis and eddy current losses generate heat in the electrical steel.

In evaluating techniques used to reduce steel losses, DOE considered two types of material: conventional non-oriented electrical steel and ''non-conventional'' steels, which may contain high proportions of boron or cobalt or lack metal grain structure altogether. Conventional steels are more commonly used in electric motors manufactured today. The three types of steel that DOE classifies as ''conventional,'' include cold-rolled magnetic laminations, fully processed non-oriented electrical steel, and semi-processed non-oriented electrical steel. DOE does not model non-conventional electrical steels in its analysis of electric motors, including cobalt-based and amorphous steels. For additional details on DOE's software modeling and analysis of electrical steel performance, see chapter 3 of the direct final rule TSD.

DOE acknowledges the potential for increased non-oriented steel demand arising from a larger trend toward electrification of vehicles and equipment. However, DOE's research of publicly announced non-oriented electrical steel manufacturing capacity expansions [30] either currently underway

[30] *E.g.,* (1) US-based Cleveland-Cliffs doubles NOES capacity by 2023, adding 70 kilotons of annual capacity in response to customer demand.

(2) US-based Big River Steel (a subsidiary of United States Steel Corporation) announced plans to increase annual NOES production capacity by 200 kilotons by September 2023.

(3) JFE Steel reports plans to double NOES production capacity by the first half of the 2024 fiscal year, which begins in April 2024.

(4) Baoshan Iron & Steel (''Baosteel'', a subsidiary of China Baowu Steel Group) is reported to be expanding NOES production capacity by 500 kilotons by March 2023.

Continued

or planned for the near future suggests that steelmakers, both US-based and international, are anticipating increased demand and demonstrating willingness to increase supply accordingly.

Regarding tariffs on imported steels, DOE presented the costs for various steel grades to manufacturers during interviews and updated the costs based on input received. The input DOE received about steel prices incorporated changes in costs due to importing delays, tariffs, and global supply. Because the steel tariff applies to articles imported into the United States, it does not directly affect prices paid for steel in other nations, including those which manufacture motors sold in the US market.

Regarding the uncertain ability of lower-loss electrical steel to increase motor efficiency, electric motor manufacturers stated during confidential interviews that lower-loss steel would generally increase motor efficiency, even when considering the potential increase in steel loss that can arise during manufacturing. Accordingly, DOE considers lower-loss electrical steel to be an available option for improving motor efficiency in general, even if not in all possible motor designs. Electric motor manufacturers during confidential interviews did not report having constructed or tested electric motor designs using what appear to be the lowest-loss electrical steel grades available in the market. In cases, manufacturers reported unfamiliarity with the grades. As a result, DOE is not able to assess whether testing performed by manufacturers, including the example presented by NEMA (NEMA, No. 22 at p. 12), establishes a limitation on the degree of electric motor efficiency improvement possible through use of increasingly lower-loss electric steel.

Regarding the flux density map from finite element modeling provided by NEMA, it is reasonable to expect variation in flux density levels throughout both the motor laminations and over time, as NEMA observes. DOE's analysis does not assume a constant flux density would exist throughout an electric motor. Those variations would cause instantaneous, localized steel loss levels to vary accordingly, and depart from the manufacturer-rated values at a given, single reference value (1.5T, commonly for non-oriented electric steels). All grades of non-oriented electrical steel that DOE has identified share the property of increasing loss with increasing flux density. Thus, the flux density variation cited by NEMA would ostensibly exist for electrical steels generally; it would not be unique to lower-loss steel grades. Additionally, when evaluating use of a higher steel grade, manufacturers would likely optimize the design for the grade in question for any design likely to be built in significant volume. For DOE's modeling, DOE considered a conservative approach to represent performance of these lower-loss electrical steels, which is discussed further in section IV.C.1.c of this document.

Some production requirements associated with using lower-loss steel grades are understood and able to be accounted for with a cost. For example, increasing the silicon content of an alloy may increase resistivity (and thus, potentially reduce loss) but increase the hardness of the grade as a side effect. The comparatively harder steel may wear punching dies more rapidly, which would be likely to worsen the quality of the punched steel laminations more quickly if tooling were not replaced correspondingly more often or substituted with a harder tooling material. More frequent tooling replacement and harder tooling would be likely to add cost to the electric motor manufacturing process, which DOE accounts for in the manufacturer impact analysis.

Separately, NEMA also commented on another technology option that DOE considered. Specifically, NEMA stated that the benefits of reducing the length of the coil extensions are not clear. It noted that to reduce the I^2R loss, the mean length of each turn in the end coil region would have to be reduced during the coil winding stage but doing so would increase the difficulty of winding insertion due to increased crowding with adjacent coils. However, NEMA stated that if such a reduction in mean length was feasible, it is likely to have already been exploited to their full extent because it would reduce the amount of copper in the winding, and would also be a cost-saving measure. (NEMA, No. 22 at p. 3) DOE agrees that decreasing the length of the coil extensions in the stator slots of an electric motor reduces the resistive I^2R losses, and reduces the material cost of the electric motor because less copper is being used. DOE also agrees that there may be limited efficiency gains, if any, for most electric motors using this technology option. DOE understands that electric motors have been produced for many decades and that many manufacturers have improved their production techniques to the point where certain design parameters may already be fully optimized. However, DOE cannot conclude that this design parameter is fully optimized for all electric motors, and therefore maintains that this is a design parameter that affects efficiency and should be considered when designing an electric motor because it is a technology option that continues to be technologically feasible. DOE has previously made similar conclusions in the May 2014 Final Rule. *See* 79 FR 30934, 30960.

The CA IOUs strongly suggested that DOE update the maximum technology feasible for electric motors to include, at a minimum, the commercially available technology with the highest efficiency. The CA IOUs provided data for commercially available electric motors, as well as built and tested prototypes, that exceed the max-tech performance assumption in the March 2022 Preliminary Analysis. (CA IOUs, No. 30 at p. 3) For the analysis, DOE uses the maximum efficiency technology option to represent the design option which yields the highest energy efficiency that is technologically feasible within the scope of MEMs and air-over electric motors, which are all induction motors. In their comment, the CA IOU's present high efficiency motors that are all outside the scope of this direct final rule, such as permanent magnet synchronous motors, and electronically commutated motors. As such, DOE is not amending the maximum technology design option in this direct final rule.

Therefore, DOE maintains the same technology options from the March 2022 Preliminary Analysis in this direct final rule.

B. Screening Analysis

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

(8) *Technological feasibility.* Technologies that are not incorporated in commercial products or in commercially viable, existing prototypes will not be considered further.

(9) *Practicability to manufacture, install, and service.* If it is determined that mass production of a technology in commercial products and reliable installation and servicing of the technology 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.

(5) POSCO announced groundbreaking for a NOES production facility which will approximately quadruple high-efficiency NOES capacity to 400 kilotons by 2025.

(10) *Impacts on product utility.* If a technology is determined to have a significant adverse impact on the utility of the product to subgroups of consumers, or 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.

(11) *Safety of technologies.* If it is determined that a technology would have significant adverse impacts on health or safety, it will not be considered further.

(12) *Unique-pathway proprietary technologies.* If a technology has proprietary protection and represents a unique pathway to achieving a given efficiency level, it will not be considered further, due to the potential for monopolistic concerns.

10 CFR 431.4; 10 CFR part 430, subpart C, appendix A, sections 6(c)(3) and 7(b).

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

As part of the May 2022 Preliminary Analysis, DOE requested feedback, in part, on its screening analysis based on the five criteria described in this section. 87 FR 11650. The subsequent sections include comments from interested parties pertinent to the screening criteria, 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 March 2022 Prelim TSD, DOE screened out amorphous metal laminations and plastic bonded iron powder (''PBIP'') from the analysis. DOE requested further data on the feasibility of amorphous steel being used in electric motors at scale. See chapter 3 of the March 2022 Prelim TSD. In response, DOE received comments regarding the technologies excluded from this engineering analysis.

Metglas commented that they strongly disagree with the decision to exclude electric motors that use amorphous steel. Metglas stated that Hitachi Industrial Equipment Systems Co., Ltd. (Hitachi Sanki Systems) has commercially produced higher efficiency air compressors (IE5 class) with an amorphous metal-based motor since 2017. Metglas noted that Hitachi Ltd. is using novel motor topologies to optimize the use of amorphous foil in the fabrication process. Metglas claimed that other motor producers are actively designing amorphous metal-based motors, and while amorphous metal-based motors are certainly not predominant today, they do represent where the maximum technological feasibility efficiency levels can be set for electric motors. Metglas claimed the losses when using an amorphous metal stator have been shown to drop by more than 75 percent compared to a conventional non-oriented electrical steel, and that this allows for higher operational frequencies which reduces the overall motor size for the same output power. Furthermore, Metglas claimed higher efficiencies in other electrical appliances can be achieved with more efficient amorphous-based motors. (Metglas, No. 24 at p. 1) Metglas requested that DOE consider the maximum technical feasibility efficiency be based on the performance of amorphous metal containing motors, but understands that the DOE cannot set efficiency levels based on niche materials that have not been widely demonstrated on a commercial scale. (Metglas, No. 24 at p. 2) On the other hand, NEMA commented that amorphous steel is not a direct replacement for the current electrical steel that is in motors, and stated that this option is unproven since NEMA is not aware of any successful prototype motors using this steel. (NEMA, No. 22 at p. 14)

DOE reviewed the information submitted by Metglas and notes that the motors provided appear to all require an inverter to drive and are thus not in the scope of this direct final rule. DOE understands the potential benefits of using amorphous steel, particularly the reduction in core losses during operation, but was unable to identify any electric motors within the scope of this rule using amorphous steel. Additionally, as stated in the March 2022 Preliminary TSD, amorphous steel is a very brittle material which makes it difficult to punch into motor laminations. Amorphous steel may also be less structurally stiff, requiring additional mechanical support to implement. Finally, amorphous steel may entail greater acoustic noise levels, which may be unsuitable for some applications or require design compromises to mitigate. As such, with it not being definitive that amorphous steel is able to meet all the screening criteria, DOE is continuing to screen out amorphous metal in this direct final rule on the basis of technological feasibility.

Accordingly, consistent with the March 2022 Preliminary Analysis, DOE is continuing to screen out amorphous metal laminations and PBIP in this direct final rule.

2. Remaining Technologies

In the March 2022 Prelim TSD, DOE did not screen out the following technology options: Increasing cross-sectional area of copper in stator slots; decreasing the length of coil extensions; increasing cross-sectional area of end rings; increasing cross-sectional area of rotor conductor bars; using a die-cast copper rotor cage; using electrical steel laminations with lower losses (watts/lb); using thinner steel laminations; increasing stack length; optimizing bearing and lubrication selection; improving cooling system design; reducing skew on rotor cage; and improving rotor bar insulation. See chapter 3 of the March 2022 Prelim TSD.

Regarding copper die-cast rotors, NEMA commented in opposition of DOE's decision to not screen out copper die-cast rotors. NEMA stated that only one manufacturer offers NEMA Design A, B, or C motors with copper rotor cages, and that the largest horsepower offered of these motors was 20 HP. NEMA also stated that they are not practicable to manufacture because of added equipment requirements, higher energy costs to melt the copper, die lifespan that is 10 percent that of dies used for aluminum, and a casting piston life of only 500 rotors. NEMA also stated that the increased locked-rotor current due to the copper rotor would push certain motors out of NEMA Design B requirements and reduce consumer utility. NEMA finally stated that the higher melting point of copper (1084 deg C) vs. aluminum (660 deg C) poses health and safety issues for plant workers, and that DOE failed to rebut this claim with evidence in 2012. (NEMA, No. 22 at p. 4–5)

Aluminum is the most common material used today to create die-cast rotor bars for electric motors. Some manufacturers that focus on producing high-efficiency designs have started to offer electric motors with die-cast rotor bars made of copper. Copper offers better performance than aluminum because it has better electrical conductivity (*i.e.,* a lower electrical resistance). However, because copper also has a higher melting point than aluminum, the casting process becomes more difficult and is likely to increase both production time and cost.

DOE recognizes that assessing the technological feasibility of copper die-cast rotors in high-horsepower motors (above 30 HP) is made more complex by the fact that manufacturers do not offer them commercially. That could be for a variety of reasons, among them: (1) large copper die-cast rotors are physically impossible to construct; (2) they are possible to construct, but impossible to construct to required specifications, or (3) they are possible to construct to required specifications, but would require large capital investment to do so and would be so costly that few (if any) consumers would choose them. As stated in the March 2022 Preliminary TSD, electric motors incorporating copper die-cast rotor cages are already commercially available by large manufacturers for motors up to 30 horsepower.[31] As such, DOE does not have enough evidence to screen out copper die-cast rotors on the basis of practicability to manufacture, install, and service, or adverse impacts to equipment utility or availability. Additionally, DOE is hesitant to screen out copper die-cast rotors on the basis of technological feasibility because there is nothing to suggest the advantages associated with copper rotors would not occur beyond a certain size. Therefore, DOE's research into commercially available electric motors with copper die-cast rotors does not conclude that copper die-cast rotors are either: (1) physically impossible to construct, or (2) possible to construct, but impossible to construct to required specifications.

DOE considers a higher factory overhead markup (which includes all the indirect costs associated with production, indirect materials and energy use, taxes, and insurance) for copper die-cast rotors in the engineering analysis. See Chapter 5 of the direct final rule TSD. In addition, DOE understands that large capital investments may be needed for copper die-cast rotors, which is addressed as additional conversion costs in the manufacturer impact analysis (see section IV.J.4).

Regarding the higher melting point of copper versus aluminum (1085 degrees Celsius versus 660 degrees Celsius), although the increased temperature could theoretically affect the health or safety of plant workers, DOE does not believe that this potential impact is sufficiently adverse to screen out copper as a die cast material for rotor conductors. The process for die casting copper rotors involves risks similar to those of die casting aluminum. DOE believes that manufacturers who die-cast metal at 660 Celsius or 1085 Celsius (the respective temperatures required for aluminum and copper) would need to maintain strict safety protocols in both cases. DOE understands that many plants already work with molten aluminum die casting processes and believes that similar processes could be adopted for copper. Since DOE has not received any supporting data about the increased risks associated with copper die-casting versus aluminum die-casting, DOE is not screening out copper die-cast rotors from this direct final rule.

Otherwise, through a review of each technology, DOE concludes that all of the other identified technologies listed in section IV.A.4 met all five screening criteria to be examined further as design options in DOE's direct final rule analysis. The design options screened-in are consistent with the design options from the March 2022 Preliminary Analysis. 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). For additional details, see chapter 4 of the direct final rule TSD.

C. Engineering Analysis

The purpose of the engineering analysis is to establish the relationship between the efficiency and cost of electric motors. There are two elements to consider in the engineering analysis; the selection of efficiency levels to analyze (*i.e.,* the ''efficiency analysis'') and the determination of product cost at each efficiency level (*i.e.,* the ''cost analysis''). In determining the performance of higher-efficiency equipment, DOE considers technologies and design option combinations not eliminated by the screening analysis. For each equipment class, DOE estimates the baseline cost, as well as the incremental cost for the equipment at efficiency levels above the baseline. The output of the engineering analysis is a set of cost-efficiency ''curves'' that are used in downstream analyses (*i.e.,* the LCC and PBP analyses and the NIA).

1. Efficiency Analysis

DOE typically uses one of two approaches to develop energy efficiency levels for the engineering analysis: (1) relying on observed efficiency levels in the market (*i.e.,* the efficiency-level approach), or (2) determining the incremental efficiency improvements associated with incorporating specific design options to a baseline model (*i.e.,* the design-option approach). Using the efficiency-level approach, the efficiency levels established for the analysis are determined based on the market distribution of existing products (in other words, based on the range of efficiencies and efficiency level ''clusters'' that already exist on the market). Using the design option approach, the efficiency levels established for the analysis are determined through detailed engineering calculations and/or computer simulations of the efficiency improvements from implementing specific design options that have been identified in the technology assessment. DOE may also rely on a combination of these two approaches. For example, the efficiency-level approach (based on actual products on the market) may be extended using the design option approach to interpolate to define ''gap fill'' levels (to bridge large gaps between other identified efficiency levels) and/or to extrapolate to the max-tech level (particularly in cases where the max-tech level exceeds the maximum efficiency level currently available on the market).

In this rulemaking, DOE applied a combination of the efficiency-level approach and the design-option approach to establish efficiency levels to analyze. The design-option approach was used to characterize efficiency levels that are not available on the market but appear to be market solutions for those higher efficiency levels if sufficient demand existed. For the efficiency levels available on the market, sufficient performance data was publicly available to characterize these levels.

a. Representative Units Analyzed

Due to the large number of equipment classes, DOE did not directly analyze all equipment classes of electric motors considered in this direct final rule. Instead, DOE selected representative units based on two factors: (1) the quantity of motor models available within an equipment class and (2) the

[31] DOE is aware of two large manufacturers—Siemens and SEW-Eurodrive—that offer die-cast copper rotor motors up to 30-horsepower.

ability to scale to other equipment classes.

Table IV–3 presents the representative units DOE analyzed in the March 2022 Preliminary Analysis. DOE only analyzed NEMA Design B representative units.

TABLE IV–3—MARCH 2022 PRELIMINARY ANALYSIS REPRESENTATIVE UNITS ANALYZED

ECG/Design type	Representative unit horsepower (4 poles, enclosed)	Represented horsepower range (all poles, all enclosures)
MEM, NEMA Design B	5	1 ≤ hp ≤5.
	30	5 < hp ≤ 50.
	75	51 < hp ≤ 100.
	*150	101 < hp ≤ 200.
	*250	201 < hp ≤ 500.
AO–MEM, NEMA Design B	5	1 < hp ≤ 20.
	30	21 < hp ≤ 50.
	75	51 < hp ≤ 500.

* While these representative units were not directly analyzed in the engineering analysis, they were added to represent consumers of larger sized electric motors for the LCC and NIA analyses.

DOE received a comment regarding motor testing at higher efficiency levels. NEMA stated that DOE should test a greater number of representative units across all design types to better inform scaling assumptions, and that for higher efficiency levels, testing is more important than scaling. In addition, NEMA commented that DOE places too much reliance on untested models, scaling and interpolation. NEMA commented that the only appropriate way to evaluate non-represented equipment classes is to study them through testing (including prototype construction for testing, as appropriate). (NEMA, No. 22 at p. 15, 24)

DOE recognizes that scaling motor efficiencies is a complicated proposition that has the potential to result in efficiency standards that are not evenly stringent across all equipment classes. However, given the extremely high volume of horsepower rating, pole configuration, and enclosure combinations, DOE cannot feasibly analyze all of these variants directly, hence, the need for scaling.

For the analysis, DOE obtained electric motor performance data from a catalog reflecting electric motors currently available in the U.S. market and views this database as representative of the full range of motors that can be purchased. Specifically, DOE created a database which contains information regarding the characteristics of the motor (motor performance values like horsepower output, pole configuration, NEMA Design letter, etc.), and the full-load efficiency (''2022 Motor Database''). DOE collected performance data from online catalogs for four major motor manufacturers in 2022: ABB (which includes the manufacturer formerly known as Baldor Electric Company), Nidec Motor Corporation (which includes the US Motors brand), Regal-Beloit Corporation (which includes the Marathon and Leeson brands), and WEG Electric Motors Corporation.[32] Based on market information from the Low-Voltage Motors World Market Report,[33] DOE estimates that the four major motor manufacturers noted above comprise the majority of the U.S. motors market and are consistent with the motor brands considered in this direct final rule. In addition, DOE tested multiple motors and obtained test reports detailing the efficiency of these motors at their rated load, along with many other measurements and technical specifications, to inform the scaling relationships and efficiency analysis described in this direct final rule.

Using the 2022 Motor Database, and along with testing and modeling, DOE affirms that the scaling methodologies employed are accurate for the purposes of determining energy conservation standards, and therefore maintains the current scaling methodology. Further, the relationships used to scale between efficiency and a combination of horsepower, pole count, and enclosure are consistent with previously used and validated methods of scaling, which are based on Table 12–12 of NEMA MG 1–2016. For more detailed discussion on scaling, see section IV.C.4. Consequently, DOE has concluded that scaling is necessary and suitable for establishing appropriate efficiency levels for new or amended energy conservation standards for electric motors.

For this direct final rule, DOE updated several representative units based on the November 2022 Joint Recommendation. Overall, DOE updated the representative units to be based on both NEMA Design A and B instead of only NEMA Design B. The November 2022 Joint Recommendation specifically noted that to achieve IE4 levels, manufacturers would likely shift from NEMA Design B to NEMA Design A motors.

DOE notes that the one main difference between NEMA Design A and Design B is that Design A does not have a locked-rotor current limit. Locked-rotor current is the steady-state current applied to a motor, at its rated voltage, when the rotor is stationary. It is a critical design characteristic of induction motors because higher locked-rotor currents can negatively impact (or even damage) the starting circuit if the starting circuit is not equipped to handle the locked-rotor current. One of the ways to improve motor efficiency is to use lower core-loss electrical steel, but a common tradeoff of these low core-loss steels is a lower permeability[34] that requires the motor to have a higher locked-rotor current to meet the torque requirements of NEMA Design A and B. DOE analyzed a sample of over 3,000 NEMA Design A and B motors currently available on the market and found that

[32] ABB (Baldor-Reliance): Online Manufacturer Catalog, accessed March 22, 2022. Available at *https://www.baldor.com/catalog#category=2;* Nidec: Online Manufacturer Catalog, accessed April 8, 2022. Available at *ecatalog.motorboss.com/Catalog/Motors/ALL;* Regal (Marathon and Leeson): Online Manufacturer Catalog, accessed May 25, 2022. Available at *https://www.regalbeloit.com/Products/Faceted-Search?category=Motors&brand=Leeson,Marathon%20Motors;* WEG: Online Manufacturer Catalog, accessed March 22, 2022. Available at *http://catalog.wegelectric.com/.*

[33] Based on the OMDIA, Low-Voltage Motors Intelligence Service, Annual 2020 Analysis(OMDIA Report November 2020) Table 3: Market Share Estimates for Low-voltage Motors: Americas; Suppliers 'share of the Market:2019.

[34] The magnetic permeability of a material determines the magnitude of magnetic flux density in the material after a magnetic field is applied to it, and the magnetic flux density is proportional to the amount of torque generated in an electric motor.

over 50 percent of them are already at or above 90 percent of the NEMA Design B locked-rotor current limit. DOE notes that higher energy conservation standards could incentivize manufacturers to offer NEMA Design A motors in place of their Design B motors.

While it appears to be possible to design NEMA Design B motors that are at higher efficiency levels than current standards, these NEMA Design B motors would require some combination of longer stack lengths, wider core laminations, and/or higher slot fills, all of which could require additional equipment and retooling by the manufacturer. Because NEMA Design A and B motors are in the same equipment class, in the case of higher standards, manufacturers could opt to shift their offerings to NEMA Design A motors that do not require nearly the same magnitude of investment by the manufacturer. This shift to NEMA Design A offerings could result in additional installation costs, discussed in section IV.F.2. DOE's review of current motor catalogs suggests multiple manufacturers representing their IE4 motors as NEMA Design A.[35] As such, in this direct final rule, the representative unit designs include both NEMA Design A and Design B.

In addition, DOE updated the horsepowers analyzed, and the range of horsepowers each representative unit represents. First, DOE updated the MEM Design A/B 250 hp representative unit to 350 hp to better represent the horsepower range between 250 hp to 500 hp, which the Electric Motors Working Group recommended to remain at Premium Level/IE3 level (see Recommendation #1 in section II.B.3). Second, DOE added a MEM Design A/B representative unit at 600 hp to represent and analyze electric motors rated over 500 hp and up to 750 hp (see Recommendation #2 in section II.B.3). Third, DOE split the air-over equipment class into AO–MEM (Standard Frame Size) and AO–Polyphase (Specialized Frame Size), as discussed in section IV.A.3, and added the following representative units: (1) a representative unit to represent the horsepower range between 100 hp to 250 hp for AO–MEM (Standard Frame Size), which the Electric Motors Working Group recommended at Super Premium/IE4 level; and (2) a representative unit to represent the horsepower range between 1 hp to 20 hp for AO–Polyphase (Specialized Frame Size), which the Electric Motors Working Group recommended at fire pump level (see Recommendation #3 in section II.B.3). DOE notes that the 250 hp limit for AO–MEM (Standard Frame Size) corresponds to the horsepower output range observed in the 2022 Motor Database.

Otherwise, similar to the March 2022 Preliminary Analysis, DOE chose the horsepower ratings that constitute a high volume of motor models and approximate the middle of the range of covered horsepower ratings so that DOE could develop a reasonable scaling methodology. DOE did not vary the pole configuration of the representative classes it analyzed because analyzing the same pole configuration provided the strongest relationship upon which to base its scaling. Keeping as many design characteristics constant as possible enabled DOE to more accurately identify how design changes affect efficiency across horsepower ratings. For each motor topology, DOE directly analyzed the most common pole-configuration, which was 4-pole.

Table IV–4 presents the representative units analyzed, and the covered horsepower ranges for each of the representative units.

TABLE IV–4—REPRESENTATIVE UNITS ANALYZED

ECG	Representative unit (RU)	Representative unit horsepower (4 poles, enclosed)	Represented horsepower range (all poles, all enclosures)
MEM 1–500 hp, NEMA Design A & B	1	5	1 ≤ hp ≤ 5.
	2	30	5 < hp ≤ 20.
			20 < hp ≤ 50.
	3	75	50 < hp < 100.
	4	150	100 ≤ hp ≤ 250.
	5	350	250 < hp ≤ 500.
MEM 501–750 hp, NEMA Design A & B	6	600	500 < hp ≤ 750.
AO–MEM (Standard Frame Size)	7	5	1 ≤ hp ≤ 20.
	8	30	20 < hp ≤ 50.
	9	75	50 < hp < 100.
	10	150	100 ≤ hp ≤ 250.
AO–Polyphase (Specialized Frame Size)	11	5	1 ≤ hp ≤ 20.

b. Baseline Efficiency

For each equipment class, DOE generally selects a baseline model as a reference point for each class, and measures changes resulting from potential energy conservation standards against the baseline. The baseline model in each equipment class represents the characteristics of an equipment typical of that class (*e.g.,* capacity, physical size). Generally, a baseline model is one that just meets current energy conservation standards, or, if no standards are in place, the baseline is typically the most common or least efficient unit on the market.

In the March 2022 Preliminary Analysis, for current scope motors in 10 CFR 431.25, DOE used the current energy conservation standards in Table 5 of 10 CFR 431.25 as the baseline. For AO–MEMs, DOE used a baseline representing the lowest efficiencies available in the market based on catalog listings. See Chapter 5 of the March 2022 Prelim TSD. In response to the March 2022 Preliminary Analysis, DOE received comments on how the baseline efficiencies were established.

The Joint Advocates encouraged DOE to both clarify and refine the baseline efficiency levels for air-over electric motors. (Joint Advocates, No. 27 at pp. 2–3) Specifically, they commented that while the March 2022 Preliminary Analysis stated that the baseline

[35] ABB Product Brochure: NEMA Super-E Premium efficient motors. (Last accessed December 2, 2022.) *https://library.e.abb.com/public/e35d57ce4df3160285257d6d00720f51/9AKK106369_SuperE_1014_WEB.pdf.* WEG Super Premium Efficiency Catalog: *https://www.weg.net/catalog/weg/US/en/c/MT_1PHASE_LV_TEFC_W22_STANDARD/list?h=3a6a6e81.*

efficiency levels of the currently covered motors were the same as the air-over versions (See: EERE–2020–BT–STD–0007–0010, p. 5–7), Table 5.3.6 of the March 2022 Prelim TSD showed the baseline efficiency levels for the currently covered motors as EL1 for the air-over variants. Further, the Joint Advocates commented that the assumption that baseline air-over motors are less efficient than the baseline in the current standard for covered motors is supported by the 2015 Appliance Standards and Rulemaking Federal Advisory Committee (''ASRAC'') term sheet for fans and blowers,[36] which included default air-over motor efficiencies less than those shown in the March 2022 Preliminary Analysis. The Joint Advocates commented that they suspected that the lack of coverage for air-over motors means that there are available models that may be considerably less efficient than equivalent non-air-over motors. In addition, the Joint Advocates commented that the appropriate baseline efficiency levels for AO motors will depend heavily on the final AO motor test procedure. (Joint Advocates, No. 27 at pp. 2–3)

DOE notes that the Joint Advocates' statement that the baseline efficiency levels of currently covered motors are the same as the air-over versions in the March 2022 Prelim TSD is incorrect. The March 2022 Prelim TSD stated that, since AO motors are designed largely the same as non-AO motors, DOE used the same higher efficiency levels for AO MEM motors, and did not state that baseline efficiency levels of currently covered motors are the same as the air-over versions. This is shown in Table 5.3.6 and Table ES3.3.3 of the March 2022 Preliminary TSD, which also present the baseline efficiency for air-over motors as lower than the baseline for currently regulated motors.

Otherwise, DOE acknowledges that because air-over electric motors are not currently regulated, air-over electric motors will likely be less efficient than currently regulated non-air-over electric motors available on the market. In order to understand the efficiency of air-over electric motors currently available, DOE reviewed the 2022 Motor Database. With that, DOE confirmed that air-over electric motors were less efficient than currently regulated non-air-over electric motors and also noted that AO–MEMs were only available up to 250 hp. However, DOE did not identify baselines as low as what was considered in the 2015 ASRAC term sheet for fans and blowers; because DOE had current market data through the 2022 Motor Database, DOE decided to consider more up-to-date baseline efficiencies. As such, DOE maintained the engineering analysis for AO–MEMs from the March 2022 Preliminary Analysis.

The Joint Advocates commented that DOE's specification of a single target test temperature of 75 °C for all AO motors may not be representative. For example, the Joint Advocates commented that it is plausible that one or more of the AO motors that DOE tested may run at higher temperatures in the field, which would result in lower real-world efficiency. As such, they noted that artificially cooling a hotter running motor beyond realistic operating temperatures could result in AO motor efficiency ratings that are not representative both in comparison to other AO motors and the equivalent non-AO motors. Therefore, the Joint Advocates recommend that DOE analyze appropriate baseline efficiency levels for AO motors. (Joint Advocates, No. 27 at p. 3) In the October 2022 Final Rule, DOE addressed the single-target temperature concerns by specifying that the requirement to use a single target temperature of 75 °C only applies to air-over motors that do not have a specified temperature rise. As such, if the temperature rise is specified on the motor, such temperature rise will be used to determine the target temperature. 87 FR 63588, 63614.

Accordingly, in this direct final rule, DOE included the following baseline efficiencies, which are summarized below in Table IV–5:

For ECG 1, DOE used the current energy conservations standards in Table 5 of 10 CFR 431.25 to establish the baseline efficiency for each representative unit analyzed. The standards for this ECG align with Table 12–12 of NEMA MG 1–2016 ''Full-Load Efficiencies for 60 Hz Premium Efficiency . . .'' and is commonly referred to by industry as ''NEMA Premium'' or IE3 levels.

For ECGs 2 and 3, DOE used available catalog data to understand the efficiencies of motors offered. DOE observed that the lowest efficiencies at multiple horsepowers aligned with the efficiencies found in Table 12–11 of NEMA MG 1–2016 ''Full-Load Efficiencies of 60 Hz Energy-Efficient Motors''. These levels of efficiency are commonly referred to as ''fire pump electric motor levels'' since they largely correspond to the energy conservations standards for fire pump motors set out in Table 7 of 10 CFR 431.25. As such, DOE set the baseline for ECGs 2 and 3 in line with fire pump electric motor levels.

For ECG 4, during the electric motor working group negotiations it was discussed that catalog data would not accurately represent the efficiencies of these ''specialized'' frame size motors since they are designed be placed in larger equipment based on manufacturer specifications, and not typically sold through publicly available catalogs. DOE understands that given a fixed horsepower output, reducing frame size will restrict the potential for efficiency improvements in a motor and may make improvements in efficiency more expensive compared to a larger motor. Because the electric motors in ECG 4 are smaller versions of those in ECG 3, DOE assumed that the baseline efficiency for ECG 4 would be an offset version of the baseline of ECG 3. DOE decided to quantify the offset in terms of 'NEMA bands' because these bands are commonly used by industry when describing motor efficiency. One NEMA band represents a 10 percent reduction in motor losses from the previous efficiency value; Table 12–10 of NEMA MG 1–2016 specifies the list of selectable efficiency values. DOE received feedback from manufacturers that they typically design motors in increments of 20 percent loss differences or more because of motor efficiency test variability and marketing clarity. This 20 percent loss is consistent with the IE level designations, in that each IE level that is included in IEC 60034–30–1:2014, starting from IE1 (lowest efficiency) to IE4 (highest efficiency), is approximately in increments of 20 percent loss difference. As such, DOE assumed the baseline for ECG 4 would be 2 NEMA bands (or 20 percent loss difference) lower than the baseline of ECG 3 due to reduced size of ECG 4 motors. This baseline corresponds with the IE1 level, the lowest level defined by IEC 60034–30–1:2014.

[36] See EERE–2013–BT–STD–0006–0179, p. 18, *www.regulations.gov/document/EERE-2013-BT-STD-0006-0179.*

TABLE IV–5—BASELINE EFFICIENCIES ANALYZED

ECG	ECG motor design type	RU	Description
1	MEM 1–500 hp, NEMA Design A & B	1	NEMA Premium/IE3.
		2	
		3	
		4	
		5	
2	MEM 501–750 hp, NEMA Design A & B	6	Fire Pump.
3	AO–MEM (Standard Frame Size)	7	Fire Pump.
		8	
		9	
		10	
4	AO–Polyphase (Specialized Frame Size)	11	2 NEMA bands below Fire Pump.

c. Higher Efficiency Levels

As part of DOE's analysis, the maximum available efficiency level is the highest efficiency unit currently available on the market. DOE also defines a ''max-tech'' efficiency level to represent the maximum possible efficiency for a given product.

In the March 2022 Preliminary Analysis, DOE established the higher efficiency levels by shifting the baseline efficiencies up a certain number of NEMA bands. For ECG 1, EL 1 represented a 1 NEMA band increase over baseline efficiency, EL 2 a 2 NEMA band increase, and so on until max-tech. For ECG 3 of this direct final rule (referred to as ''AO–MEMs'' in the March 2022 Preliminary Analysis), EL 1 was NEMA Premium because this ECG had a lower baseline at fire pump levels. EL 2 was 1 NEMA band above premium, EL 3 was 2 NEMA bands above NEMA Premium, and the max-tech was the same as ECG 1. See Chapter 5 of the March 2022 Prelim TSD.

In response to the March 2022 Preliminary Analysis, DOE received comments regarding the analysis used to determine efficiencies at higher levels.

NEMA stated that any performance modeling done by DOE should rely on multiple tested models rather than a single unverified motor performance model (NEMA, No. 22 at p. 2–3). NEMA also stated that building and testing models with high enough volumes to ensure repeatability is the only way to prove the performance of a new steel. (NEMA, No. 22 at p. 11,13)

While DOE acknowledges that testing individual models is the most ideal way to gather performance data for electric motors, given the extremely high volume of horsepower rating, pole configuration, and enclosure combinations, DOE cannot feasibly analyze all of these variations directly, hence, the need for scaling and modeling. Accordingly, DOE retained an electric motors subject matter expert (''SME'') with significant experience in terms of both design and related software, who prepared a set of electric motor designs with increasing efficiency.

DOE concurs that modeling is not an exact equivalent to testing in all regards, and that relative to physical motor units, modeled results may over- or -underestimate performance. That prototyping and testing of production runs are important motor tools does not imply, however, that properly modeled motors would carry no predictive power and could not be of value in estimating electric motor performance. Through confidential interviews of electric motor manufacturers, DOE learned that performance modeling, along with prototyping, is a central element in modern electric motor development. Therefore, DOE does not find justification to abandon modeling as an analytical practice. DOE pairs and informs modeled results using physical testing and teardown of motors purchased on the market, and from performance data collected in the 2022 Motor Database, as detailed in chapter 5 of the direct final rule TSD. The motors that were torn down represented a range of horsepowers, and had efficiencies rated at 2 to 3 NEMA bands above their respective standards. As new designs were created, DOE's SME ensured that the critical performance characteristics that define a NEMA design letter (*e.g.,* locked-rotor torque, breakdown torque, pull-up torque, and locked-rotor currents) were maintained.

As an example on how the modeling was informed by teardowns, DOE's SME used lamination diameters measured during the teardowns as limits for the software models. After establishing baseline models, DOE used the motor design software to incorporate design options (generated in the market and technology assessment and screening analysis) to increase motor efficiency all the way up to the max-tech design. This procedure has been utilized to inform scaling relationships in previous rulemakings, and as such, DOE is continuing to use motor performance modeling as the basis of its efficiency analysis in this direct final rule.

In recognition of the potential for electrical steel quality to vary and of modeled results to diverge from test results of production electric motor designs, DOE opted to use a conservative approach when modeling the performance of electrical steels by using the guaranteed maximum core loss values for various steel grades in place of ''average'' or ''typical'' core loss per pound values. Purchasers of electrical steel cannot rely on a given sample of electrical steel exceeding (*i.e.,* carrying lower loss) the guaranteed loss. However, on a larger scale the steel performance would be expected to converge to the average if steel manufacturers are accurately representing their products.

Separately, NEMA stated that the inrush current of multiple models exceeds the NEMA Design B and C locked-rotor current limits for the following representative units: 5HP, Design B; 5HP, Design C; and 50 HP, Design C. (NEMA, No. 22 at p. 3) NEMA also stated that in order to comply with the test procedure, motors may become NEMA Design A motors with higher inrush current, and that this higher current could create safety issues on other components and would require upgrades and modifications to electrical components of the motor. It stated that not being able to satisfy NEMA Design B requirements would present a loss of consumer utility. (NEMA, No. 22 at p. 2)

DOE disagrees with NEMA's claim that the test procedure rule would require a change in motor design to comply with standards. DOE understands NEMA's comment to relate to the changes to the represented value formula (currently in 10 CFR 429.64) proposed in the test procedure NOPR (86 FR 71710, December 17, 2021). DOE addressed concerns regarding the updates to the test procedure in the October 2022 Final Rule; specifically, DOE noted that while DOE proposed changes in the formulas used to determine the represented value of a basic model, DOE did not propose to change how the compliance of a given basic model is determined. As such, DOE concluded that the compliance or noncompliance of a basic model would remain unchanged by the publication of this final rule, and therefore, disagreed with NEMA that basic model redesigns would be required to ensure compliance. 87 FR 63588, 63631–63633

As for the representative unit designs not complying with NEMA Design B locked-rotor current requirements, DOE agrees and notes that the voltages specified for those units in the March 2022 Preliminary TSD were incorrect and will be corrected in the TSD of this direct final rule. With that voltage correction, the locked-rotor current units for the mentioned representative units fell within NEMA Design B limits. However, as discussed in section IV.C.1.a, DOE is considering NEMA Design A at higher efficiency levels.

As such, for this direct final rule, DOE considered several design options for higher efficiencies: improved electrical steel for the stator and rotor, using die-cast copper rotors, increasing stack length, and any other applicable design options remaining after the screening analysis when improving electric motor efficiency from the baseline level up to a max-tech level. As each of these design options are added, the manufacturer's cost generally increases and the electric motor's efficiency improves. DOE worked with an SME to develop the highest efficiency levels technologically feasible for each representative unit analyzed, and used a combination of electric motor software design programs and SME input to develop these levels. The SME also checked his designs against tear-down data and calibrated his software using the relevant test results. DOE notes that for all efficiency levels of directly modeled representative units, the frame size was constrained to that of the baseline unit. DOE also notes that the full-load speed of the simulated motors did not stay the same throughout all efficiency levels. Depending on the materials used to meet a given efficiency level, the full-load speed of the motor may increase compared to a lower efficiency model, but for the representative units analyzed this was not always the case. See chapter 5 of the TSD for more details on the full-load speeds of modeled units.

For the max-tech efficiencies in the engineering analysis, DOE considered 35H210 silicon steel, which has the lowest theoretical maximum core loss of all steels considered in this engineering analysis, and the thinnest practical thickness for use in motor laminations. In addition, the max-tech efficiency designs all use die-cast copper rotors, because copper offers better performance than aluminum since it has better electrical conductivity (*i.e.,* a lower electrical resistance), leading to a higher-efficiency design. The max-tech designs also have the highest possible slot fill, maximizing the number of motor laminations that can fit inside the motor. Further details are provided in Chapter 5 of the direct final rule TSD.

For intermediate efficiency levels that were higher than an ECG's baseline but not the max-tech efficiency considered, DOE used different approaches to establish these levels depending on the ECG, as discussed in the next few paragraphs.

For ECG 1, EL 1 was set at IE4 levels (also referred to as NEMA Super-Premium) after receiving feedback during the electric motor working group negotiations that this should be the first EL considered above current standards (in 10 CFR 431.25, IE3 or ''NEMA Premium''), consistent with the progression of the IE levels to represent efficiency, when available. IE4 levels correspond to the efficiency values in Table 10 of IEC 60034–30–1:2014,''Nominal efficiency limits (percentage) for 60 Hz IE4''. DOE notes that the efficiencies at IE4 levels are varying magnitudes above current standard levels, but are typically either 1 or 2 NEMA bands higher depending on pole configuration and horsepower output. Next, DOE defined EL 2 as 2 NEMA bands above current standards and EL 3 as 3 NEMA bands above current standards. For RU1, RU2 and RU5, EL 1 efficiency is the same as EL 2 efficiency because the IE4 efficiencies are the same as the efficiencies at 2 NEMA bands above current standard levels.

When possible, DOE opted to set the intermediate efficiency levels at industry-recognized levels of efficiency like NEMA Premium or IE4. For ECGs 2 and 3, EL 1 was set at current standards since the baseline for these ECGs was lower than current standards. EL 2 was then set at IE4 levels, and EL 3 set at 2 NEMA bands above current standard levels. For RU6, RU7 and RU8, EL 2 efficiency is the same as EL 3 efficiency because the IE4 efficiencies are the same as the efficiencies at 2 NEMA bands above current standards.

For ECG 4, DOE again opted to set the intermediate efficiency levels at industry-recognized levels. Therefore, EL 1 was set at fire pump electric motor levels, EL 2 at current standards or NEMA Premium, and EL 3 at IE4 levels. For RU11, the max-tech efficiency is the same as EL 3 efficiency at IE4.

Table IV–6 presents a summary of the description of the higher efficiency levels analyzed in this direct final rule. For additional details on the efficiency levels, see chapter 5 of the direct final rule TSD.

TABLE IV–6—HIGHER EFFICIENCIES ANALYZED

ECG	RUs	EL0/Baseline	EL1	EL2	EL3	EL4
1	1 through 5	Premium/IE3	Super Premium/IE4	2 NEMA bands above Premium.	3 NEMA bands above Premium.	Max-tech
2	6	Fire pump	Premium/IE3	Super Premium/IE4	2 NEMA bands above Premium.	Max-tech
3	7 through 10	Fire pump	Premium/IE3	Super Premium/IE4	2 NEMA bands above Premium.	Max-tech
4	11	2 NEMA Bands below Fire pump.	Fire pump	Premium/IE3	Super Premium/IE4	Max-tech

2. Cost Analysis

The cost analysis portion of the engineering analysis is conducted using one or a combination of cost approaches. The selection of cost approach depends on a suite of factors, including the availability and reliability of public information, characteristics of the regulated product, the availability and timeliness of purchasing the equipment on the market. The cost approaches are summarized as follows:

• Physical teardowns: Under this approach, DOE physically dismantles a commercially available product, component-by-component, to develop a detailed bill of materials for the product.

• Catalog teardowns: In lieu of physically deconstructing a product, DOE identifies each component using parts diagrams (available from manufacturer websites or appliance repair websites, for example) to develop the bill of materials for the product.

• Price surveys: If neither a physical nor catalog teardown is feasible (for example, for tightly integrated products such as fluorescent lamps, which are infeasible to disassemble and for which parts diagrams are unavailable) or cost-prohibitive and otherwise impractical (*e.g.* large commercial boilers), DOE conducts price surveys using publicly available pricing data published on major online retailer websites and/or by soliciting prices from distributors and other commercial channels.

In the March 2022 Preliminary Analysis, DOE conducted the analysis using a combination of physical teardowns and software modeling. DOE contracted a professional motor laboratory to disassemble various electric motors and record what types of materials were present and how much of each material was present, recorded in a final bill of materials (''BOM''). To supplement the physical teardowns, software modeling by an SME was also used to generate BOMs for select efficiency levels of directly analyzed representative units. The resulting bill of materials provides the basis for the manufacturer production cost (''MPC'') estimates. See Chapter 5 of the March 2022 Prelim TSD.

In response to the March 2022 Preliminary Analysis, DOE received a number of comments. First, DOE received a comment regarding labor rates and markups used in the engineering analysis. ABB commented that the tabulated cost of labor used in Table 2.5.17 of the March 2022 Prelim TSD does not accurately reflect the current labor market. ABB added that the U.S. labor markets have tightened significantly over the past 12 months, and as a result labor rates have increased significantly. Therefore, ABB commented that they believe the labor rates shown in the table are outdated and need to be revised with current rates. Regarding the magnitude of the factory markup in Table 2.5.17 in the March 2022 Prelim TSD, ABB also commented that they believe that 30 percent is a more accurate estimate than the 15 percent mentioned, and that using the 15 percent markup would result in an underestimation of the cost impacts of factory overhead. (ABB, No. 28 at p. 1)

Regarding labor rates and markups, DOE used the same hourly labor rate for all electric motors analyzed. DOE determined the unburdened labor rate by using the 2007 Economic Census of Industry, and since the March 2022 Preliminary Analysis, updated the labor rate to dollar year 2021 using producer price index (''PPI'') data.[37] DOE understands this method of calculation accounts for changes in the labor market because the PPI data contains information from the current market. In addition, several markups were applied to this hourly rate to obtain a fully burdened rate, which is representative of the labor costs associated with manufacturing electric motors. The markups applied to the base labor cost per hour include indirect production, overhead, fringe, and assembly labor up-time costs. Finally, DOE also incorporated input from manufacturers during interviews on domestic and foreign labor rates to inform the labor cost values used in the engineering analysis in this direct final rule. As such, DOE concludes that the updates to the labor rates since the March 2022 Preliminary Analysis accurately represent current labor market.

Regarding the overhead markup, DOE notes that in the March 2022 Preliminary Analysis, an overhead markup of 30 percent was applied to the unburdened labor rate in line with ABB's recommendation. The 15 percent factory overheard markup referenced in ABB's comment is a separate markup applied to the material cost of a motor, not related to the labor markup of concern. In addition, the factory overhead markup was increased to 20 percent when copper die-casting was used in the rotor. DOE presented the range of factory overhead markups in manufacturer interviews, and either received little feedback, or generally supportive comments from manufacturers. Accordingly, DOE concludes that the factory overhead markups used in the March 2022 Preliminary Analysis sufficiently characterizes the markups used for the cost analysis.

DOE also received a comment regarding material prices. NEMA commented referring DOE to a Department of Commerce study from October 2020 for perspective on conductor prices. NEMA also stated that DOE should update its information to 2022 data and pricing. (NEMA, No. 22 at p. 16) DOE reviewed the Department of Commerce study referenced by NEMA and did not find any specific material pricing information regarding copper or aluminum, the two conductors that this engineering analysis focuses on. In the direct final rule, DOE determined conductor prices based on producer price indices[38] and manufacturer input obtained through interviews.

Regarding the dollar year used for the analysis, DOE usually uses the most recent completed year before the publication of any rulemaking document when presenting pricing information and data to reduce the impact of month-to-month material pricing volatility. However, due to recent pricing volatility as a result of global supply chain issues, DOE is presenting pricing information as a 5-year average price so that the price results can be extrapolated more accurately for use in future years. As such, DOE presents all costs and pricing information as a 5-year average of the years 2017 to 2021 in this direct final rule.

Finally, DOE also received a comment regarding how costs would need to be updated because of the stack length increase. NEMA commented that the stack lengths of motors in Table 2.5.13 of the March 2022 Preliminary Analysis TSD appear to be longer than what would fit in a typical motor housing and stated that DOE needs to consider the cost of redesigning the motor to accommodate the larger stack and all costs of changing the production line. NEMA stated that certain stack lengths may be so long that they are not able to be machine wound, and instead would use the more labor-intensive process of hand winding. NEMA commented that the increased labor requirements would push manufacturers to move production to facilities with lower cost of labor outside of the US and would reduce US jobs. Finally, NEMA stated that the conversion costs of using thinner steels did not capture the conversion costs of using longer stack lengths. NEMA also stated that end-use motor application redesign should be accounted for as well. (NEMA, No. 22 at p. 17)

DOE notes that NEMA did not identify specific units that would have to be hand-wound because of their stack lengths. A given winding machine may have a limit of how long of a stack it can wind, but DOE understands that if the

[37] NAICS code 335312 ''Motor and generator manufacturing'' production workers hours and wages.

[38] Producer Price Index by Commodity: Metals and Metal Products: Copper Wire and Cable (WPU10260314): *https://fred.stlouisfed.org/series/WPU10260314*; Producer Price Index by Commodity: Metals and Metal Products: Extruded Aluminum Rod, Bar, and Other Extruded Shapes (WPU10250162): *https://fred.stlouisfed.org/series/WPU10250162.*

stack length increased beyond this limit, a manufacturer could use the next sized winding machine that they may already use for larger horsepower motors. However, in this direct final rule, DOE is not adopting a standard level that would require motors to be hand-wound, and as such does not find that there will be a push to offshore US manufacturing of electric motors for the standards being finalized. However, separately DOE also performs a manufacturer impact analysis to quantify the costs incurred by the manufacturer to redesign regulated equipment at each efficiency level; see discussion in section IV.J.

Accordingly, in this direct final rule, DOE continues to use the approach from the March 2022 Preliminary Analysis by determining costs using a combination of physical teardowns and software modeling. In addition, as part of this direct final rule, DOE supplemented other critical inputs to the MPC estimate, including material prices assumed, scrap costs, overhead costs, and conversion costs incurred by the manufacturer, using information provided by manufacturers under a nondisclosure agreement through both manufacturer interviews and the Electric Motors Working Group. Through these nondisclosure agreements, DOE solicited and received feedback on inputs like: motor starter costs associated with NEMA Design A motors, recent electrical steel prices by grade, and the MPCs of both Design A and Design B motors at different efficiency levels and rated motor output. See chapter 5 of the direct final rule TSD for more detail on the scrap, overhead, and conversion costs as well as material prices used.

Finally, to account for manufacturers' non-production costs and profit margin, DOE applies a non-production cost multiplier (the manufacturer markup) to the MPC. The resulting manufacturer selling price (''MSP'') is the price at which the manufacturer distributes a unit into commerce. DOE developed an average manufacturer markup by examining the annual Securities and Exchange Commission (SEC) 10–K reports filed by publicly-traded manufacturers primarily engaged in electric motor manufacturing and whose combined product range includes electric motors. For motors with a rated output power of 5 or less horsepower, DOE used a non-production markup of 37 percent. For motors rated above 5 horsepower, DOE used a non-production markup of 45 percent.

3. Cost-Efficiency Results

The results of the engineering analysis are reported as cost-efficiency data (or ''curves'') in the form of MSP (in dollars) versus full-load efficiency (in %), which form the basis for subsequent analysis. DOE developed eleven curves representing the four equipment class groups. The methodology for developing the curves started with determining the full-load efficiency and MPCs for baseline motors. Above the baseline, DOE implemented various combinations of design options to achieve each efficiency level. Design options were implemented until all available technologies were employed (*i.e.,* at a max-tech level). To account for manufacturers' non-production costs and profit margin, DOE applies a manufacturer markup to the MPC, resulting in the MSP. See Table IV–7 for the final results. See TSD Chapter 5 for additional detail on the engineering analysis.

TABLE IV–7—COST-EFFICIENCY RESULTS

RU	HP	Pole	Enclosure	Full-load efficiency (%)					MSP (2021$)				
				EL0	EL1	EL2	EL3	EL4	EL0	EL1	EL2	EL3	EL4
1	5	4	Enclosed	89.50	91.00	91.00	91.70	92.40	$340.95	$424.52	$424.52	$459.91	$614.47
2	30	4	Enclosed	93.60	94.50	94.50	95.00	95.40	1,331.45	1,792.24	1,792.24	1,928.42	1,999.62
3	75	4	Enclosed	95.40	95.80	96.20	96.50	96.80	3,724.25	4,577.13	4,943.96	5,219.07	5,541.73
4	150	4	Enclosed	95.80	96.20	96.50	96.80	97.10	6,181.17	6,378.33	8,205.53	8,662.15	9,197.66
5	350	4	Enclosed	96.20	96.80	96.80	97.10	97.40	12,874.60	15,313.54	15,313.54	18,042.15	19,157.57
6	600	4	Enclosed	95.80	96.20	96.80	96.80	97.40	19,711.60	20,532.73	24,422.41	24,422.41	30,552.96
7	5	4	Enclosed	87.50	89.50	91.00	91.00	92.40	304.59	332.96	414.57	414.57	554.40
8	30	4	Enclosed	92.40	93.60	94.50	94.50	95.40	1,281.82	1,326.36	1,785.38	1,785.38	1,975.97
9	75	4	Enclosed	94.10	95.40	95.80	96.20	96.80	3,097.87	3,703.79	4,551.99	4,910.11	5,510.57
10	150	4	Enclosed	95.00	95.80	96.20	96.50	97.10	5,352.67	6,199.20	6,396.94	8,229.47	8,687.42
11	5	4	Enclosed	85.50	87.50	89.50	91.00	91.00	304.59	332.96	414.57	554.40	554.40

In this direct final rule, DOE also added a scenario to account for the fact that some consumers may choose to purchase a synchronous electric motor (out of scope of this direct final rule) rather than a more efficient NEMA Design A or B electric motor or select to purchase a VFD in combination with a compliant electric motor. As such, DOE costed out the price of a synchronous electric motor and a VFD to analyze for this substitution; further discussion on this analysis is provided in Chapter 5 of the direct final rule TSD.

4. Scaling Methodology

Due to the large number of equipment classes, DOE was not able to perform a detailed engineering analysis on each one. Instead, DOE focused its analysis on the representative units and scaled the results to equipment classes not directly analyzed in the engineering analysis. In the March 2022 Preliminary Analysis, DOE used the current standards at 10 CFR 431.25 as a basis to scale the efficiency of the representative units to all other equipment classes. In order to scale for efficiency levels above baseline, the efficiencies for the representative units were shifted up or down by however many NEMA bands, because these bands are commonly used by industry when describing motor efficiency, that efficiency level was above current standards.

In response to the preliminary analysis, NEMA disagreed that a given enclosed motor could meet the same or higher efficiency standards as an open motor. NEMA stated that Part 13 of NEMA MG1 specifies, for many ratings, their standard frame size to be smaller than an enclosed motor of the same frame size. NEMA provided an example of a 7.5 hp, 575V, 2 pole standard NEMA Design A/B motor and state that an open enclosure motor is standard as a 184T frame whereas an enclosed would be a 213T frame. NEMA stated that the ratings for which the standard frame size is the same for an open or enclosed enclosure, the efficiency capability of the open motor is expected to be equal or greater than an enclosed motor because of the reduced windage losses and potentially lower operating temperature. NEMA noted that the specific utility lost by switching from an open motor to an enclosed one would be having to move to a physically larger motor and mounting dimensions for certain ratings. NEMA stated that the efficiency ratings of NEMA 12–12 is higher for open motors at some ratings, higher for enclosed at others, and in some cases equal in order to retain this utility of having a smaller motor for a given application. (NEMA, No. 22 at p. 6)

DOE acknowledges that the efficiencies would be different for open and enclosed motors for the scope of electric motors being considered in this direct final rule. As such, DOE considered separate efficiencies for open and enclosed motors; although DOE only analyzed enclosed motor representative units as part of the analysis, for the full range of efficiencies being considered for the downstream analysis, DOE considered different efficiencies for open and enclosed. DOE based the relationship between enclosed and open motor efficiencies on Table 5 of 10 CFR 431.25. Specifically, DOE quantified the offset between enclosed and open motor efficiencies for each pole and horsepower combination in terms of NEMA bands. DOE used the same offset to determine the open motor efficiencies from the enclosed motor efficiencies for the full range of pole and horsepower combinations being considered for each ECG and efficiency level analyzed.

In this direct final rule, to scale across horsepower, pole configuration, and enclosure, DOE again relied on industry-recognized levels of efficiency when possible, or shifted forms of these levels. For example: when an efficiency level for a representative unit was NEMA Premium, Table 12–12 of NEMA MG 1–2016 was used to determine the efficiency of all the non-representative unit equipment classes. This method of scaling was also done for IE4 levels of efficiency, electric motor fire pump levels, and shifted versions of NEMA Premium (see Table IV–10 for description of efficiency levels analyzed). DOE relied on industry-recognized levels because they sufficiently capture the effects of enclosure, pole configuration, frame size, and horsepower on motor efficiency.

D. Markups Analysis

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

In the March 2022 Preliminary Analysis, DOE identified distribution channels for MEM 1–500 hp, NEMA Design A and B and AO–MEM (Standard Frame Size) and their respective market shares (*i.e.,* percentage of sales going through each channel). For these electric motors, the main parties in the distribution chain are OEMs, equipment or motor wholesalers, retailers, and contractors. In response to the March 2022 Preliminary Analysis, DOE did not receive any comment on the distribution channels identified. Therefore, DOE retained these distribution channels for MEM 1–500 hp, NEMA Design A and B and AO–MEM (Standard Frame Size) in the direct final rule. For electric motors above 500 hp and up to 750 hp (''MEM 501–750 hp, NEMA Design A & B''), DOE applied the same distribution channels. For and AO–polyphase (specialized frame size) electric motors which are typically sold through OEMs, DOE assumed that these motors are only sold through distribution channels that include OEMs.

DOE developed baseline and incremental markups for each actor in the distribution chain. Baseline markups are applied to the price of products with baseline efficiency, while incremental markups are applied to the difference in price between baseline and higher-efficiency models (the incremental cost increase). The incremental markup is typically less than the baseline markup and is designed to maintain similar per-unit operating profit before and after new or amended standards.[39]

In the March 2022 Preliminary Analysis, DOE relied on economic data from the U.S. Census Bureau and on 2020 RS Means Electrical Cost Data to estimate average baseline and incremental markups. Specifically, DOE estimated the OEM markups for electric motors based on financial data of different sets of OEMs that use respective electric motors from the latest 2019 Annual Survey of Manufactures.[40] The relevant sets of OEMs identified were listed in Table 6.4.2 of the March 2022 Prelim TSD, using six-digit code level North American Industry Classification System (NAICS). Further, DOE collected information regarding sales taxes from the Sales Tax Clearinghouse.[41] See chapter 6 of the March 2022 Prelim TSD.

In response to the March 2022 Preliminary Analysis, NEMA commented that Table 6.4.2 of the March 2022 Prelim TSD should be replaced by Table IV.3 of the Import Data Declaration Proposed Rule.[42] (NEMA, No. 22 at p. 18)

Table IV.3 of the Import Data Declaration Proposed Rule provides a list of five-digit code level NAICS.[43] DOE reviewed the corresponding six-digit code level NAICS and identified the following additional NAICS code as relevant in the context of OEMs incorporating electric motors in their equipment: 333999 ''All other miscellaneous general Purpose machinery manufacturing''. Other NAICS codes were either already included in the March 2022 Preliminary Analysis or were did not correspond to OEMs incorporating electric motors subject to this DFR in their equipment.

For the direct final rule, DOE revised the OEM baseline and incremental markups calculation to account for this additional NAICS code. In addition, DOE relied on updated data from the economic data from the U.S. Census Bureau and on 2022 RS Means Electrical Cost Data, and the Sales Tax Clearinghouse.

Chapter 6 of the direct final rule TSD provides details on DOE's development of markups for electric motors.

E. Energy Use Analysis

The purpose of the energy use analysis is to determine the annual energy consumption of electric motors at different efficiencies for a representative sample of commercial, industrial, and agricultural consumers, and to assess the energy savings potential of increased electric motor efficiency. The energy use analysis estimates the range of energy use of electric motors in the field (*i.e.,* as they are actually used by consumers). For each consumer in the sample, the energy use is calculated by multiplying the annual average motor input power by the annual operating hours. The

[39] Because the projected price of standards-compliant products is typically higher than the price of baseline products, using the same markup for the incremental cost and the baseline cost would result in higher per-unit operating profit. While such an outcome is possible, DOE maintains that in markets that are reasonably competitive it is unlikely that standards would lead to a sustainable increase in profitability in the long run.

[40] U.S. Census Bureau. 2019 Annual Survey of Manufactures (ASM): Statistics for Industry Groups and Industries. (Last accessed March 23, 2021.) *www.census.gov/programs-surveys/asm.html.*

[41] Sales Tax Clearinghouse Inc. State Sales Tax Rates Along with Combined Average City and County Rates. July 2021. (Last accessed July 1, 2021.) *thestc.com/STrates.stm.*

[42] NEMA also provided the following link: *www.regulations.gov/document/EERE-2015-BT-CE-0019-0001*

[43] Each five-digit code level NAICS includes several six-digit code level NAICS.

energy use analysis provides the basis for other analyses DOE performed, particularly assessments of the energy savings and the savings in consumer operating costs that could result from adoption of amended or new standards.

1. Consumer Sample

In the March 2022 Preliminary Analysis, DOE created a consumer sample to represent consumers of electric motors in the commercial, industrial, and agricultural sectors. DOE used the sample to determine electric motor annual energy consumption as well as for conducting the LCC and PBP analyses. Each consumer in the sample was assigned a sector, an application, and a region. The sector and application determine the usage profile of the electric motor and the economic characteristics of the motor owner vary by sector and region. DOE primarily relied on data from the 2018 Commercial Building Energy Consumption Survey (''CBECS''), the 2018 Manufacturing Energy Consumption Survey (''MECS''), the 2013 Farm and Ranch Irrigation Survey, and a DOE–AMO report ''U.S. Industrial and Commercial Motor System Market Assessment Report Volume 1: Characteristics of the Installed Base'' (''MSMA'' or ''DOE–AMO report'').[44] See chapter 7 of the March 2022 Prelim TSD.

In response to DOE's requests for feedback regarding the consumer sample, NEMA referred to the MSMA report (NEMA, No. 22 at p. 19) As previously described, DOE relied on information from the MSMA report to inform its consumer sample. DOE did not receive any additional comments related to the consumer sample developed in the preliminary analysis and retained the same approach for this direct final rule. In addition, for electric motors above 500 hp and up to 750 hp, and AO–polyphase specialized frame size electric motors, DOE applied the same consumer sample.

2. Motor Input Power

In the March 2022 Preliminary Analysis, DOE calculated the motor input power as the sum of (1) the electric motor's rated horsepower multiplied by its operating load (*i.e.,* the motor output power), and (2) the losses at the operating load (*i.e.,* part-load losses). DOE estimated distributions of motor average annual operating load by application and sector based on information from the MSMA report. DOE determined the part-load losses using outputs from the engineering analysis (full-load efficiency at each efficiency level) and published part-load efficiency information from 2016 and 2020 catalog data from several manufacturers to model motor part-load losses as a function of the motor's operating load. See chapter 7 of the March 2022 Prelim TSD.

In response to DOE's requests for feedback regarding distributions of average annual operating load by application and sector, NEMA referred to the MSMA report (NEMA, No. 22 at p. 19) As previously described, DOE relied on information from the MSMA report to characterize average annual operating loads. DOE did not receive any additional comments related to the distributions of operating loads developed in the March 2022 Preliminary Analysis and retained the same approach for this DFR.

DOE did not receive any comments on its approach to determine part-load losses and retained the same methodology for this DFR. However, DOE updated its analysis to account for more recent part-load efficiency information from the 2022 Motor Database. In addition, for electric motors larger than 500 hp and up to 750 hp, and AO–polyphase specialized frame size electric motors, DOE applied the same approach for establishing motor part-load losses and motor input power.

3. Annual Operating Hours

In the March 2022 Preliminary Analysis, DOE used information from the MSMA report to establish distributions of motor annual hours of operation by application for the commercial and industrial sectors. The MSMA report provided average, mean, median, minimum, maximum, and quartile boundaries for annual operating hours across industrial and commercial sectors by application and showed no significant difference in average annual hours of operation between horsepower ranges. DOE used this information to develop application-specific statistical distributions of annual operating hours in the commercial and industrial sectors. See chapter 7 of the March 2022 Prelim TSD.

For electric motors used in the agricultural sector (which were not included in the MSMA report), DOE derived statistical distributions of annual operating hours of irrigation pumps by region using data from the 2013 Census of Agriculture Farm and Ranch Irrigation Survey.

In response to DOE's requests for feedback regarding distributions of average annual operating hours by application and sector, NEMA referred to the DOE MSMA report. (NEMA, No. 22 at p. 20) As previously described, DOE relied on information from the MSMA report to inform its distributions of annual operating hours in the commercial and industrial sectors. For the agricultural sector, which was not included in the MSMA report, DOE relied on additional data sources as previously described. DOE did not receive any additional comments related to the distributions of operating hours developed in the March 2022 Preliminary Analysis and retained the same approach for this final rule. In addition for electric motors larger than 500 hp, DOE also relied on data from the MSMA report to develop operating hours.

4. Impact of Electric Motor Speed

Any increase in operating speeds as the efficiency of the motor is increased could affect the energy saving benefits of more efficient motors in certain variable torque applications (*i.e.,* fans, pumps, and compressors) due to the cubic relation between speed and power requirements (*i.e.,* ''affinity law''). In the March 2022 Preliminary Analysis, DOE accounted for any changes in the motor's rated speed with an increase in efficiency levels, based on the speed information by EL provided in the engineering analysis. Based on information from a European motor study,[45] DOE assumed that 20 percent of consumers with fan, pump, and air compressor applications would be negatively impacted by higher operating speeds. See chapter 7 of the March 2022 Prelim TSD.

The Joint Advocates requested clarifications regarding how DOE accounted for the impact of the increased motor speed on the energy use, as well as how motor slip[46] was

[44] Prakash Rao et al., ''U.S. Industrial and Commercial Motor System Market Assessment Report Volume 1: Characteristics of the Installed Base,'' January 12, 2021, *doi.org/10.2172/1760267.*

[45] ''EuP–LOT–30–Task–7–Jun–2014.Pdf,'' accessed April 26, 2021, *www.eup-network.de/fileadmin/user_upload/EuP-LOT-30-Task-7-Jun-2014.pdf.* The European motor study estimated, as a ''worst case scenario,'' that up to 40 percent of consumers purchasing motors for replacement applications may not see any decrease or increase in energy use due to this impact and did not incorporate any change in energy use with increased speed. In addition, the European motor study also predicts that any energy use impact will be reduced over time because new motor driven equipment would be designed to take account of this change in speed. Therefore, the study did not incorporate this effect in the analysis (*i.e.,* 0 percent of negatively impacted consumers). In the absence of additional data to estimate the percentage of consumers that may be negatively impacted in the compliance year, DOE relied on the mid-point value of 20 percent.

[46] The motor slip is the difference between the motor's synchronous speed and actual speed which is lower than the synchronous speed). At higher

Continued

incorporated into the energy use analysis. (Joint Advocates, No. 27 at p. 4–5)

DOE described the method and assumptions used to calculate the impact of higher speeds (*i.e.,* lower slip) by EL on the energy use in section 7.2.2.1 of the March 2022 Prelim TSD. In the direct final rule TSD, DOE provided additional details on the methodology and equations used as part of Appendix 7A.

NEMA commented that nearly 100 percent of fans, pumps and compressors using electric motors would be negatively impacted by an increase in speed. In addition, NEMA commented that it would take up to two years for OEMs to redesign and recertify an equipment with a motor that has higher speed and provided an example calculation to illustrate the impacts of higher speed operation. (NEMA, No. 22 at pp. 20–21, 49) The Joint Industry Stakeholders commented that DOE should consider the full impact of higher speed motors by taking into account new products as well as replacement. The Joint Industry Stakeholders commented that if lower speed motors are no longer available, appliances may be forced to incorporate higher speed motors which may cause short-cycling in HVAC and refrigeration applications and result in negative impacts in other appliances. (Joint Industry Stakeholders, No. 23 at pp. 8–9)

In this direct final rule, DOE included the effect of increased speeds in the energy use calculation for all equipment classes. DOE reviewed information related to pump, fans, and compressor applications and notes that: (1) seven to 20 percent of motors used in these applications are paired with VFDs which allow the user to adjust the speed of the motor; [47] (2) approximately half of fans operate with belts which also allow the user to adjust the speed of the driven fan; [48] (3) some applications would benefit from increase in speeds as the work would be completed at a higher load in less operating hours (*e.g.* pump filling water tank faster at increased speed); (4) not all fans, pumps and compressors are variable torque loads to which the affinity laws applies. Therefore, less than 100 percent of motors in these applications would experience an increase in energy use as a result of an increase in speed. In addition, as described in the European motor study, the increase in speed would primarily impact replacement motors installed in applications that previously operated with a lower speed motor. For these reasons, DOE determined that assuming that 100 percent of fans, pumps and compressors using electric motors would be negatively impacted by an increase in speed would not be representative. DOE continues to rely on a 20 percent assumption used in the March 2022 Preliminary Analysis. In addition, DOE incorporated a sensitivity analysis allowing the user to consider this effect following scenarios described in Appendix 7–A of the TSD.

Chapter 7 of the direct final rule TSD provides details on DOE's energy use analysis for electric motors.

F. Life-Cycle Cost and Payback Period Analysis

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

- The LCC is the total consumer expense of an appliance or product over the life of that product, 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 product.
- 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 at higher efficiency levels by the change in annual operating cost for the year that amended or new standards are assumed to take effect.

For any given efficiency level, DOE measures the change in LCC relative to the LCC in the no-new-standards case, which reflects the estimated efficiency distribution of electric motors 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 product.

For each considered efficiency level in each product class, DOE calculated the LCC and PBP for a nationally representative set of consumers. As stated previously, DOE developed consumer samples from various data sources (see section IV.E.1 of this document). For each sample consumer, DOE determined the energy consumption for the electric motor and the appropriate energy price. By developing a representative sample of consumers, the analysis captured the variability in energy consumption and energy prices associated with the use of electric motors.

Inputs to the calculation of total installed cost include the cost of the product—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, product lifetimes, and discount rates. DOE created distributions of values for product 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 electric motor user samples. The model calculated the LCC and PBP for products at each efficiency level for 10,000 consumer per simulation run. The analytical results include a distribution of 10,000 data points showing the range of LCC savings for a given efficiency level relative to the no-new-standards case efficiency distribution. In performing an iteration of the Monte Carlo simulation for a given consumer, product efficiency is chosen based on its probability. If the chosen product efficiency is greater than or equal to the efficiency of the standard level under consideration, the LCC and PBP calculation reveals that a consumer is not impacted by the standard level. By accounting for consumers who already purchase more-efficient products, DOE avoids overstating the potential benefits from increasing product efficiency.

DOE calculated the LCC and PBP for all consumers of electric motors as if each were to purchase a new product in the first year of required compliance with new or amended standards. DOE

ELs, the speed of a given motor may increase and the motor slip may decrease.

[47] See Figure 64 and Figure 71 of the MSMA report.

[48] See 2016 Fan Notice of Data Availability, 81 FR 75742 (November 1, 2016). LCC spreadsheet, ''LCC sample'' worksheet, ''Belt vs. direct driven fan distribution'' available at *www.regulations.gov/document/EERE-2013-BT-STD-0006-0190.*

expects the direct final rule to publish in the first half of 2023. Therefore, DOE used 2027 as the year of compliance with any new or amended standards for electric motors based on the recommended 4 year compliance period after the direct final rule publication.

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

TABLE IV–8—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 a constant price trend to project equipment costs based on historical data.
Installation Costs	Installation costs vary by EL. Used input from NEMA and engineering analysis to determine installation costs.
Annual Energy Use	Motor input power multiplied by annual operating hours per year. *Variability:* Primarily based on the MSMA report, 2018 CBECS, 2018 MECS, and 2013 Farm and Ranch Irrigation Survey.
Energy Prices	*Electricity:* Based on EEI Typical Bills and Average Rates Reports data for 2021. *Variability:* Regional energy prices determined for four census regions.
Energy Price Trends	Based on AEO 2022 price projections.
Repair and Maintenance Costs	Repair costs based on Vaughen 2021, varies by EL Assumed no change in maintenance costs with efficiency level.
Equipment Lifetime	*Average:* 11.8–33.6 years depending on the equipment class group and horsepower considered. Shipments-weighted average lifetime is 13.6.
Discount Rates	Calculated as the weighted average cost of capital for entities purchasing electric motors. Primary data source was Damodaran Online.
Compliance Date	2027.

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

In response to the preliminary analysis, the Joint Stakeholders commented that double-regulation has no corresponding consumer benefits in the form of reduced power consumption given the appliance regulations being unchanged and the fact that a more efficient motor does not necessarily translate to a more efficient product when incorporated into a finished good. The Joint Stakeholders commented that to potentially increase the cost of an OEM product, without a corresponding energy savings would mean a net loss for consumers and negative national impacts. The Joint Industry Stakeholders noted that the DOE used operating hours for the following categories of equipment: air compressors, refrigeration compressors, fans and blowers, pumps material handling, material processing, other, and agricultural pumps. Of these, the Joint Stakeholders noted that electric motors used in air compressors, refrigeration compressors, fans and blowers, pumps and agricultural pumps are already regulated to some extent and that DOE made no apparent effort to account for this and deduct a significant portion of those estimated hours (Joint Industry Stakeholders, No. 23 at p. 5) Lennox commented that DOE must accurately assess, and avoid double-counting, energy savings when assessing potential efficiency improvements from motors used in already-regulated HVAC equipment. Lennox commented that it is unclear in the LCC and payback periods analysis if DOE accounted for double regulation and eliminated energy savings already achieved from system-level HVACR regulation. (Lennox, No. 29 at p. 4) HI commented that there is a potential for duplicate accounting of energy savings when regulating motors in general. In addition, there is a potential for other motor product efficiencies to be counted twice such as the use of inverter-only products in pumps when the DOE calculates savings in their evaluations (one for inverter only motors, and another for pumps using those motors). (HI, No. 31 at p. 1) NEMA commented that many of the proposed additions to scope are accompanied by erroneous claims of potential energy savings, owing to the fact that the added motors are components to other regulated appliances and devices. They commented that their review of the document shows instances where the DOE is anticipating energy savings on products that will be used in other covered products, suggesting the potentially significant overstatement of potential energy savings benefits. (NEMA, No. 22 at p. 5)

As highlighted in a previous DOE report, motor energy savings potential and opportunities for higher efficiency electric motors in commercial and residential equipment would result in overall energy savings.[49] In addition, some manufacturers advertise electric motors as resulting in energy savings in HVAC equipment.[50] Therefore, DOE disagrees with the Joint Industry Stakeholders that an increase in motor efficiency would not necessarily result in a more efficient equipment when incorporated into a given equipment. In addition, DOE's analysis ensures the LCC and NIA analysis do not result in double-counting of energy savings by accounting for consumers who already purchase more-efficient products and calculating LCC and energy savings relative to a no-new standards case efficiency distribution. See Section IV.F.8 for more details. DOE applies the same approach in other equipment rulemakings, and evaluates energy savings relative to a no-new standards case efficiency distribution that accounts for consumers who already purchase more-efficient equipment incorporating more efficient motors. As such, any future analysis in support of energy conservation standards for equipment incorporating motors would also account for equipment that already incorporate more-efficient electric

[49] U.S. DOE Building technology Office, Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in residential and Commercial Equipment, December 2013. Available at: *www.energy.gov/eere/buildings/downloads/motor-energy-savings-potential-report*

[50] See for example Nidec and ABB: *acim.nidec.com/motors/usmotors/industry-applications/hvac; bit.ly/3wEIQyu*

motors and would not result in any double counting of energy savings resulting from motor efficiency improvements.

In the direct final rule TSD, DOE added a scenario to account for the fact that some consumers may choose to purchase a synchronous electric motor (out of scope of this direct final rule) rather than a more efficient NEMA Design A or B electric motor or select to purchase a VFD in combination with a compliant electric motor. DOE developed a consumer choice model to estimate the percentage of consumers that would purchase a synchronous electric motor based on the payback period of such investment. See Appendix 8–D for more details on this analysis. DOE notes that there is uncertainty as to which rate such substitution would occur and did not incorporate this scenario as part of the reference analysis.

1. Equipment Cost

To calculate consumer product costs, DOE multiplied the MSPs developed in the engineering analysis by the distribution channel markups described previously (along with sales taxes). DOE used different markups for baseline products and higher-efficiency products, because DOE applies an incremental markup to the increase in MSP associated with higher-efficiency products.

Economic literature and historical data suggest that the real costs of many products may trend downward over time according to ''learning'' or ''experience'' curves. Experience curve analysis implicitly includes factors such as efficiencies in labor, capital investment, automation, materials prices, distribution, and economies of scale at an industry-wide level. To derive a price trend for electric motors, DOE obtained historical PPI data for integral horsepower motors and generators manufacturing spanning the time period 1969–2021 from the Bureau of Labor Statistics' (''BLS'').[51] The PPI data reflect nominal prices, adjusted for electric motor quality changes. An inflation-adjusted (deflated) price index for integral horsepower motors and generators manufacturing was calculated by dividing the PPI series by the implicit price deflator for Gross Domestic Product. The deflated price index for integral horsepower motors was found to align with the copper, steel and aluminum deflated price indices. DOE believes that the extent to how these trends will continue in the future is very uncertain. Therefore, DOE relied on a constant price assumption as the default price factor index to project future electric motor prices.

DOE did not receive any comments on price trends in response to the preliminary analysis and followed the same methodology in the direct final rule.

2. Installation Cost

Installation cost includes labor, overhead, and any miscellaneous materials and parts needed to install the product. In the March 2022 Preliminary Analysis, DOE considered that all motors would remain NEMA Design B as efficiency increased, and DOE found no evidence that installation costs would be impacted with increased efficiency levels. Therefore, in the March 2022 Preliminary Analysis, DOE did not incorporate changes in installation costs for motors that are more efficient than baseline equipment. DOE assumed there was no variation in installation costs between a baseline efficiency motor and a higher efficiency motor except in terms of shipping costs. These shipping costs were based on weight data from the engineering analysis for the representative units. See chapter 8 of the March 2022 Prelim TSD.

In response to the preliminary analysis, EASA stated that there is no simple or reliable method to estimate the installation time and costs for synchronous motors under 100 hp because they are typically embedded into a machine like a fan or compressor. EASA further commented that submersible motors do not have a simple or reliable method to estimate their installation costs because of the physically connected piping that would require more time to install than a typical motor. EASA commented that inverter-only motors probably do not require additional time and cost to install compared to non-inverter motor unless they require additional wiring for feedback devices and sensors or mitigation of harmonics. (EASA, No. 21 at pp. 3–4)

DOE is not including synchronous electric motors, submersible electric motors, and inverter-only motors in the scope of this direct final rule.

EASA commented that motors above 500 hp have additional rigging costs during installation because of their size and sometimes difficult to access locations. EASA stated that there is not a simple or reliable method to estimate the installation time and costs for this size of motor. (EASA, No. 21 at p. 3) NEMA commented that DOE should include costs for rigging (hoisting) for larger motors due to their extreme weight. As rated horsepower increases, so too does the expense and time to move them safely. (NEMA, No. 22 at p. 22)

DOE agrees that at a given efficiency level, the installation costs will vary as a function of the motor's weight. However, DOE did not find evidence that rigging costs (for a given motor size) would be impacted with increased efficiency levels as the variations in weights by EL are not significant enough to change the equipment and labor required to hoist the motor as compared to the baseline.

EASA commented that if a motor is replaced with a physically larger frame, the replacement would have higher installation costs because of the added complexity of modifying the mounting setup to accommodate the larger motor, and in some case would be impossible. (EASA, No. 21 at p. 2–3)

As noted in section IV.C of this document, DOE fixed the frame size which remains the same across efficiency levels. Therefore, DOE did not account for any changes in installation costs due to changes in frame sizes in this direct final rule.

In addition, as noted in IV.C.1.a, in this direct final rule, DOE revised the engineering approach, and assumed that higher efficiency motors above the baseline would meet the characteristics of a NEMA A motors and have higher inrush currents. Therefore, based on input from NEMA, DOE estimated the additional installation costs associated with the higher inrush current at efficiency levels above baseline, and incorporated these costs in the analysis.

3. Annual Energy Consumption

For each sampled consumer, DOE determined the energy consumption for an electric motor at different efficiency levels using the approach described previously in section IV.E of this document.

4. Energy Prices

Because marginal electricity price more accurately captures the incremental savings associated with a change in energy use from higher efficiency, it provides a better representation of incremental change in consumer costs than average electricity prices. Therefore, DOE applied average electricity prices for the energy use of the product purchased in the no-new-standards case, and marginal electricity prices for the incremental change in energy use associated with the other efficiency levels considered.

[51] Serie PCU3353123353121 for integral horsepower motors and generators manufacturing; *www.bls.gov/ppi/.*

DOE derived electricity prices in 2021 using data from EEI Typical Bills and Average Rates reports. Based upon comprehensive, industry-wide surveys, this semi-annual report presents typical monthly electric bills and average kilowatt-hour costs to the customer as charged by investor-owned utilities. For all sectors, DOE calculated electricity prices using the methodology described in Coughlin and Beraki (2019).[52]

DOE's methodology allows electricity prices to vary by sector, region and season. In the analysis, variability in electricity prices is chosen to be consistent with the way the consumer economic and energy use characteristics are defined in the LCC analysis. For electric motors, DOE relied on variability by region and sector. See chapter 8 of the final rule TSD for details.

To estimate energy prices in future years, DOE multiplied the 2021 energy prices by the projection of annual average price changes for each sector from the Reference case in *AEO2022,* which has an end year of 2050.[53] To estimate price trends after 2050, DOE used the 2050 electricity prices, held constant.

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

In the March 2022 Preliminary Analysis, for the maintenance costs, DOE did not find data indicating a variation in maintenance costs between baseline efficiency and higher efficiency motors. The cost of replacing bearings, which is the most common maintenance practice, is constant across efficiency levels. Therefore, DOE did not include maintenance costs in the LCC analysis. See chapter 8 of the March 2022 Prelim TSD.

DOE did not receive any comments related to maintenance costs and retained the same approach in this direct final rule.

DOE defines motor repair as including rewinding and reconditioning. In the March 2022 Preliminary Analysis, DOE estimated repair costs as a function of efficiency based on data from 2021 Vaughen's National Average Prices. Based on these data, DOE estimated the repair costs for baseline electric motors, and used a 15 percent repair cost increase per NEMA efficiency band increase. In addition, DOE considered that electric motors at or below 20 horsepower were not repaired. DOE also assumed that electric motors with a horsepower greater than 20 and less than or equal to 100 horsepower are repaired once over their lifetime, while electric motors with a horsepower greater than 100 and less than or equal to 500 are repaired twice over their lifetime. DOE also assumed that all electric motors above 20 horsepower would be repaired at least one, regardless of the sampled lifetime. As a sensitivity analysis, DOE also considered an alternative scenario where motors are repaired only upon meeting certain lifetime criteria. See chapter 8 of the March 2022 Prelim TSD.

In response to the March 2022 Preliminary Analysis, EASA and NEMA stated that DOE may have overlooked non-rewinding repairs like bearing changes and stated that these repairs occur 5–7 times more often than rewinds regardless of motor output power. (EASA, No. 21 at p. 3; NEMA, No. 22 at p. 21) As noted previously, DOE defines motor repair as including rewinding and reconditioning. Other non-rewinding related practices such as bearing replacement were considered as part of the maintenance costs.

EASA commented that a higher efficiency motor may require more material (*e.g.* copper magnet wire) and more labor to rewind windings with the higher slot fill that is typical of high efficiency designs. EASA also state that section 2.8.5 of the preliminary analysis TSD attributes a 15 percent increase in repair cost due to higher efficiency which contradicts Table 2.8.1 of the preliminary analysis TSD that states ''assumed no change with efficiency level'' for repair costs. (EASA, No. 21 at pp. 3–4) NEMA commented that as efficiency increases, the rate of hand winding increases. Repairing hand-wound motors may take longer as they are usually would by hand to accomplish very tight stacking. Rewinding such motors will take longer and cost more than random wound designs (NEMA, No. 22 at p. 22) NEMA also commented that the discussion on section 2.8.5 of the preliminary analysis TSD contradicted the summary table 2.8.1. of the preliminary analysis TSD (NEMA, No. 22 at p. 22)

As noted by NEMA and EASA, more efficient motors are more expensive to repair. In the March 2022 Preliminary Analysis, DOE estimated the repair costs for baseline electric motors, and used a 15 percent repair cost increase per NEMA efficiency band increase to characterize the increase in repair costs with increased electric motor efficiency. In this direct final rule, DOE continues to apply an increase in repair costs at higher efficiency, and because the increase is directly related to the increase in material costs, DOE assumed the repair costs would increase similarly to the MSP instead of applying a 15 percent increase per NEMA efficiency band increase. DOE notes a typographical error in Table 2.8.1 of the preliminary analysis TSD. In that Table, DOE omitted to describe the repair cost assumption, and the statement only applies to the maintenance costs.

EASA and NEMA commented that they believe 20 horsepower is not a valid breakpoint for a repair/replace decision on electric motors. In practice, EASA and NEMA commented that the horsepower breakpoint may be as high as 100 horsepower on motors readily available from stock. Also, special OEM motors and IEC motors that may be unavailable from inventory may be rewound more often than other motors and in lower power ratings due to need to keep equipment in service. (EASA, No. 21 at p. 2; NEMA, No. 22 at p. 21) EASA provided data from 2017–2021 regarding 11,000 technical inquiries they received about rewinding motors. The data showed that 32 percent, 29 percent, 31 percent and 8 percent of inquiries related to motors with horsepower below 20, between 20 and 100 hp, between 100–500 hp, and greater than 500 hp, respectively. (EASA, No. 21 at p. 2) EASA commented that getting substantive data on repair likelihood would require polling a large sample of end-users and providing them with the definition of repair given in 8.3.3. of the preliminary analysis TSD.[54] (EASA, No. 21 at p. 4)

Since the publication of the March 2022 Preliminary Analysis, DOE reviewed additional information related to repair practices. DOE found that although a breakpoint of 20 hp reflects the breakpoint below which the repair cost for is equivalent to or exceeds the cost of a new motor, the decision to repair or replace the motor is not only based on a cost effectiveness criteria.[55] Specifically, in most facilities the cost of lost production or customer

[52] Coughlin, K. and B. Beraki. 2019. Non-residential Electricity Prices: A Review of Data Sources and Estimation Methods. Lawrence Berkeley National Lab. Berkeley, CA. Report No. LBNL–2001203. *https://ees.lbl.gov/publications/non-residential-electricity-prices.*

[53] U.S. Energy Information Administration. *Annual Energy Outlook 2022.* 2022. Washington, DC (Last accessed June 1, 2022.) *https://www.eia.gov/outlooks/aeo/index.php.*

[54] DOE defined a motor repair as repair as including rewinding and reconditioning

[55] ''US Department of Energy, Advanced Manufacturing Office, Premium Efficiency Motor Selection and Application Guide,'' February 2014, *www.energy.gov/sites/prod/files/2014/04/f15/amo_motors_handbook_web.pdf.*

inconvenience from downtime outweighs any cost differences between repairing or replacing a failed motor. As noted by EASA, the need to keep the equipment in service also affects the repair or replace decision. In addition, when replacing a motor, another major concern is stock availability. Most motors under 100 hp will typically be available on the shelf at the facility while larger and specialty motors will not.[56] Based on this additional information, DOE updated the repair breakpoint from 20 hp to 100 hp. As such DOE considered that electric motors below 100 hp would not be repaired while motors above 100 hp would be repaired at least once. In addition, DOE revised the analysis to consider that specialty electric motors, which are less likely to be in stock would be repaired regardless of their size.

The Joint Advocates observed that for several representative units of currently-covered motors, the lifetime operating costs increased at higher EL and commented that DOE should review the repair assumptions and costs to ensure that operating costs at higher ELs are not over-estimated. Specifically, the Joint Advocates commented that DOE should use the alternative scenario, wherein a motor is only assumed to be repaired if that motor's projected lifetime is greater than half of the average motor lifetime. The Joint Advocates commented that this alternative approach is similar to that used in the analysis for motor replacements in the direct final rule for dedicated-purpose pool pumps[57] and would result in LCCs that are more reflective of real-world repair/replacement decisions. (Joint Advocates, No. 27 at p. 3–4)

In this direct final rule, DOE revised the repair assumptions to align with the alternative scenario presented in the March 2022 Preliminary Analysis. As noted by the Joint Advocates, this scenario, which assumes that motors with longer lifetimes would be repaired more often is more representative of industry practice.

6. Equipment Lifetime

In the March 2022 Preliminary Analysis, for electric motors regulated at 10 CFR 431.25, DOE estimated the average mechanical lifetime of electric motors (*i.e.,* the total number of hours an electric motor operates throughout its lifetime) and used different values depending on the electric motor's horsepower. For NEMA Design A and B electric motors, and AO MEMs, DOE established sector-specific average motor lifetime estimates to account for differences in maintenance practices and field usage conditions. In addition, DOE applied a maximum lifetime of 30 years as used in the May 2014 Final Rule. DOE then developed Weibull distributions of mechanical lifetimes. The lifetime in years for a sampled electric motor is calculated by dividing the sampled mechanical lifetime by the sampled annual operating hours of the electric motor. This model produces a negative correlation between annual hours of operation and electric motor lifetime. Electric motors operated many hours per year are likely to be retired sooner than electric motors that are used for only a few hours per year. In addition, DOE considered that electric motors of less than or equal to 75 horsepower are most likely to be embedded in a piece of equipment (*i.e.,* an application). For such applications, DOE developed Weibull distributions of application lifetimes expressed in years and compared the sampled motor mechanical lifetime (in years) with the sampled application lifetime. DOE assumed that the electric motor would be retired at the earlier of the two lifetimes. See chapter 8 of the March 2022 Prelim TSD.

In response to the March 2022 Preliminary Analysis, NEMA commented that the lifetimes assigned to the representative units appear to be sufficiently accurate. (NEMA, No. 22 at p. 22). The CA IOUs recommended higher maximum lifetimes for NEMA Designs A and B electric motors beyond 30 years and provided data to justify a higher maximum lifetime. Specifically, the CA IOUs referenced the MSMA report which shows that 5.4 percent of motors with legible nameplate were older than 30 years, including 3.4 percent of motors rated 101 to 500 hp which had lifetimes of at least 50 years. The CA IOUs also cited the Swiss EASY program which showed motors of 40 years still in operation. Finally the CA IOUs cited the ''Energy-Efficient Motor Systems: A Handbook on Technology, Program, and Policy Opportunities'' which references average lifetimes of 30 years for motors larger than 50 hp. (CA IOUs, No. 30 at p. 3)

DOE reviewed the data provided by the CA IOUs. As noted by the CA IOUs, the maximum lifetime of 30 years assumed in the March 2022 Preliminary Analysis is not representative as some motors are reported to have a lifetime exceeding 50 years. In this direct final rule, DOE revised the maximum lifetime of NEMA Designs A and B electric motors and AO MEMs from 30 years to 60 years based on information from the MSMA report which showed motors still in operation after 50 years.

7. Discount Rates

In the calculation of LCC, DOE applies discount rates appropriate to consumers to estimate the present value of future operating cost savings. DOE estimated a distribution of discount rates for electric motors based on the opportunity cost of consumer funds.

DOE applies weighted average discount rates calculated from consumer debt and asset data, rather than marginal or implicit discount rates.[58] The LCC analysis estimates net present value over the lifetime of the product, so the appropriate discount rate will reflect the general opportunity cost of household funds, taking this time scale into account. Given the long time horizon modeled in the LCC analysis, the application of a marginal interest rate associated with an initial source of funds is inaccurate. Regardless of the method of purchase, consumers are expected to continue to rebalance their debt and asset holdings over the LCC analysis period, based on the restrictions consumers face in their debt payment requirements and the relative size of the interest rates available on debts and assets. DOE estimates the aggregate impact of this rebalancing using the historical distribution of debts and assets.

To establish commercial and industrial discount rates, DOE estimated the weighted-average cost of capital using data from Damodaran Online.[59] The weighted-average cost of capital is commonly used to estimate the present value of cash flows to be derived from a typical company project or investment. Most companies use both debt and equity capital to fund investments, so their cost of capital is the weighted average of the cost to the firm of equity and debt financing. DOE estimated the cost of equity using the

[56] Bonneville Power Administration, ''Quality Electric Motor Repair, a Guidebook for Electric Utilities'' *digital.library.unt.edu/ark:/67531/metadc665937/m2/1/high_res_d/237370.pdf.*

[57] See 82 FR 5650 (January 18, 2017).

[58] The implicit discount rate is inferred from a consumer purchase decision between two otherwise identical goods with different first cost and operating cost. It is the interest rate that equates the increment of first cost to the difference in net present value of lifetime operating cost, incorporating the influence of several factors: transaction costs; risk premiums and response to uncertainty; time preferences; interest rates at which a consumer is able to borrow or lend. The implicit discount rate is not appropriate for the LCC analysis because it reflects a range of factors that influence consumer purchase decisions, rather than the opportunity cost of the funds that are used in purchases.

[59] Damodaran, A. *Data Page: Historical Returns on Stocks, Bonds and Bills-United States.* 2021. (Last accessed April 26, 2022.) *pages.stern.nyu.edu/~adamodar/.*

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 average commercial, industrial, and agricultural discount rates in 2022 are 6.8 percent, 7.2 percent, and 7.1 percent respectively.

In response to the March 2022 Preliminary Analysis, DOE did not receive any comments on discount rates.

See chapter 8 of the direct final rule TSD for further details on the development of consumer discount rates.

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

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

In the March 2022 Preliminary Analysis, to estimate the energy efficiency distribution of electric motors for 2027, DOE relied on model counts by efficiency from the 2016 and 2020 Manufacturer Catalog Data and assumed no changes in electric motor efficiency over time. In some cases where DOE did not have enough models with efficiency information within a single horsepower range, DOE aggregated horsepower ranges. In addition for certain AO–SNEM electric motors, DOE did not find enough models with efficiency information to develop a distribution and used the efficiency distributions of the corresponding non-AO equipment class instead. In the March 2022 Preliminary Analysis, DOE used a Monte Carlo simulation to draw from the efficiency distributions and randomly assign an efficiency to the electric motor purchased by each sample household in the no-new-standards case. The resulting percent shares within the sample match the market shares in the efficiency distributions. See chapter 8 of the March 2022 Prelim TSD.

NEMA disagreed with the DOE estimates for AO MEMs efficiency distributions and commented that these distributions were modeled/estimated, rather than gathered properly and accurately through testing and other means. NEMA commented that DOE should not develop estimates and interpolations and instead finalize test procedures. NEMA added that energy efficiency information does not exist because Federal test procedures for some of these motors have not been established. (NEMA, No. 22 at p. 23)

DOE notes that NEMA did not provide any data to support alternative efficiency distributions. In the absence of such data, DOE relied on model counts by efficiency from manufacturer Catalog Data and updated the data to reflect 2022 catalog offerings (using the 2022 Motor Database). For AO Polyphase specialized frame electric motors, DOE did not find any catalog data to characterize their efficiency distributions and assumed all motors were at the baseline, because the OEM market is cost-driven. As such these motors are typically built on a first-cost basis and are not optimized for efficiency.[60] In addition, the electric motors test procedure, which relies on industry test methods published in 2016,[61] was finalized on October 19, 2022. 87 FR 63588 For air-over motors, DOE believes manufacturers currently use the industry test methods (which were adopted in the October 2022 Final Rule) to evaluate the efficiency of electric motors as reported in their catalogs, which is in line with the DOE test procedure as finalized.

As previously noted, in the March 2022 Preliminary Analysis, DOE assumed no changes in electric motor efficiency over time. DOE did not receive any comment on this assumption and retain the same approach in this direct final rule: to estimate the energy efficiency distribution of electric motors for 2027, DOE assumed no changes in electric motor efficiency over time. The estimated market shares for the no-new-standards case for electric motors are shown in Table IV–9 by equipment class group and horsepower range.

TABLE IV–9—NO-NEW STANDARDS CASE EFFICIENCY DISTRIBUTIONS IN THE COMPLIANCE YEAR

Equipment class group	Horsepower range	EL0 (%)	EL1 (%)	EL2 (%)	EL3 (%)	EL4 (%)
MEM 1–500 hp, NEMA Design A and B	1 ≤ hp ≤ 5	79.8	18.8	0.0	0.9	0.6
	5 < hp ≤ 20	93.9	5.4	0.0	0.5	0.1
	20 < hp ≤ 50	93.9	5.4	0.0	0.5	0.1
	50 < hp <100	89.6	1.2	6.7	2.5	0.0
	100 ≤ hp ≤ 250	85.9	7.0	6.5	0.6	0.0
	250 < hp ≤ 500	91.9	8.1	0.0	0.0	0.0
MEM 501–750 hp, NEMA Design A & B	500 < hp ≤ 750	10.5	73.7	15.8	0.0	0.0
AO–MEM (Standard Frame Size)	1 ≤ hp ≤ 20	33.3	64.3	2.3	0.0	0.0
	20 < hp ≤ 50	10.3	89.7	0.0	0.0	0.0
	50 < hp < 100	0.0	100.0	0.0	0.0	0.0
	100 ≤ hp ≤ 250	16.7	75.0	8.3	0.0	0.0
AO–Polyphase (Specialized Frame Size)	1 ≤ hp ≤ 20	100	0	0	0	0

* May not sum to 100% due to rounding.

The existence of market failures in the commercial and industrial sectors is well supported by the economics literature and by a number of case studies as discussed in the remainder of this section. DOE did not receive any comments specific to the random assignment of no-new-standards case efficiencies (sampled from the developed efficiency distribution) in the LCC model and continued to rely on the same approach to reflect market failures in the motor market, as noted in the following examples. First, a recognized problem in commercial settings is the

[60] See, Almeida, Anibal T., et al. 2008. *EuP Lot 11 Motors, Ecodesign Assessment of Energy Using Products.* s.l.: ISR-University of Coimbra for the European Commission Directorate General for Mobility and Transport, 2008. (p.117). Available at: *circabc.europa.eu/sd/d/62415be2-3d5a-4b3f-b29a-d1760f4dc11a/Lot11Motors1-8final28-04-08.pdf.*

[61] NEMA Standards Publication MG 1–2016, ''Motors and Generators: Air-Over Motor Efficiency Test Method Section IV Part 34'', *www.nema.org/docs/default-source/standards-document-library/part-34-addition-to-mg1-2016-watermarkd91d7834-cf4f-4a87-b86f-bef96b7dad54.pdf?sfvrsn=cbf1386d_3.*

principal-agent problem, where the building owner (or building developer) selects the equipment and the tenant (or subsequent building owner) pays for energy costs.[62] [63] In the case of electric motors, for many companies, the energy bills are paid for the company as a whole and not allocated to individual departments. This practice provides maintenance and engineering staff little incentives to pursue energy saving investments because the savings in energy bills provide little benefits to the decision-making maintenance and engineering staff. (Nadel et al.) [64] Second, the nature of the organizational structure and design can influence priorities for capital budgeting, resulting in choices that do not necessarily maximize profitability.[65] In the case of electric motors, within manufacturing as a whole, motor system energy costs constitute less than 1 percent of total operating costs and energy efficiency has a low level of priority among capital investment and operating objectives. (Xenergy,[66] Nadel et al.) Third, there are asymmetric information and other potential market failures in financial markets in general, which can affect decisions by firms with regard to their choice among alternative investment options, with energy efficiency being one such option.[67] In the case of electric motors, Xenergy identified the lack of information concerning the nature of motor system efficiency measures—their benefits, costs, and implementation procedures—as a principal barrier to their adoption. In addition, Almeida [68] reports that the attitude of electric motor end-user is characterized by bounded rationality where they adopt 'rule of thumb' routines because of the complexity of market structure which makes it difficult for motors end-users to get all the information they need to make an optimum decision concerning allocation of resources. The rule of thumb is to buy the same type and brand as the failed motor from the nearest retailer. Almeida adds that the same problem of bounded rationality exists when end-users purchase electric motors incorporated in larger equipment. In general, end-users are only concerned about the overall performance of a machine, and energy efficiency is rarely a key factor in this performance. Motor selection is therefore often left to the OEM, which are not responsible for energy costs and prioritize price and reliability.

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

9. Payback Period Analysis

The payback period is the amount of time it takes the consumer to recover the additional installed cost of more-efficient 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, except that discount rates are not needed.

As noted previously, EPCA 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)) 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 new or amended standards would be required.

G. Shipments Analysis

DOE uses projections of annual product shipments to calculate the national impacts of potential amended or new energy conservation standards on energy use, NPV, and future manufacturer cash flows.[69] The shipments model takes an accounting approach, tracking market shares of each product class and the vintage of units in the stock. Stock accounting uses product shipments as inputs to estimate the age distribution of in-service product stocks for all years. The age distribution of in-service product 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.

In the March 2022 Preliminary Analysis, DOE estimated shipments in the base year (2020). DOE estimated the shipments of NEMA Design A and B electric motors regulated under 10 CFR 431.25 to be approximately 4.5 million units in 2020 based on data from the 2019 Low-Voltage Motors, World Market Report, and on the share of low-voltage motors that are subject to the electric motors energy conservation standards. DOE estimated the total shipments AO–MEMs in 2020 to be 240,000 units. For electric motors regulated under 10 CFR 431.25, DOE developed a distribution of shipments by equipment class group, horsepower, enclosure, and poles based on data from manufacturer interviews. For AO–MEMs, DOE relied on model counts from the 2020 and 2016/2020 Manufacturer Catalog Data. DOE also provided shipments estimates for additional categories of electric motors not analyzed in the preliminary analysis such as electric motors with horsepower greater than 500 hp. See chapter 9 of the March 2022 Prelim TSD.

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Hubbard R.G. and Kashyap A. (1992). ''Internal Net Worth and the Investment Process: An Application to U.S. Agriculture,'' *Journal of Political Economy,* 100, 506–534.

[68] de Almeida, E.L.F. (1998). ''Energy efficiency and the limits of market forces: The example of the electric motor market in France'', *Energy Policy,* 26(8), 643–653.

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

NEMA commented that shipments for motors above 500 hp were over-estimated (NEMA, No. 22 at p. 24) During the electric motor working group negotiations, NEMA provided an estimate of 250—400 units sold per year. NEMA also provided an estimate of 180,000 units for AO MEMs, and 20,000 units for AO polyphase specialized frame size electric motors. In this direct final rule, DOE is including electric motors with horsepower greater than 500 hp and relied on NEMA's input to estimate shipments to 375 units in the base year. For AO MEMs and AO polyphase specialized frame size electric motors, DOE revised the total shipments to align with NEMA's estimate and revised the distribution of shipments by horsepower range based on model counts from the 2022 Motor Database. DOE did not receive any additional comments related to the base year shipments estimates and retained the values estimated in the March 2022 Preliminary Analysis for NEMA Design A and B motors between 1—500 hp.

In the March 2022 Preliminary Analysis, for NEMA A and B electric motors which are primarily used in the industry and commercial sectors, DOE projected shipments in the no-new standards case under the assumption that long-term growth of electric motor shipments will be driven by long-term growth of fixed investments. DOE relied on the AEO 2021 forecast of fixed investments through 2050 to inform its shipments projection. For the years beyond 2050, DOE assumed that fixed investment growth will follow the same growth trend as GDP, which DOE projected for years after 2050 based on the GDP forecast provided by AEO 2021. For AO–MEM electric motors, which are typically lower horsepower motors, DOE projected shipments using the following sector-specific market drivers from AEO 2021: commercial building floor space, housing numbers, and value of manufacturing activity for the commercial, residential, and industrial sector, respectively. In addition, DOE kept the distribution of shipments by equipment class group/horsepower range constant across the analysis period. Finally, in each standard case, DOE accounted for the possibility that some consumers may choose to purchase a synchronous electric motor (out of scope of this preliminary analysis) rather than a more efficient NEMA Design A or B electric motor. DOE developed a consumer choice model to estimate the percentage of consumers that would purchase a synchronous electric motor based on the payback period of such investment.

In response to the March 2022 Preliminary Analysis, NEMA commented that they do not anticipate horsepower shifts from technology changes. NEMA also noted that, as an example, increased emission requirements for stationary diesel pump drivers will increase demand for larger 200 hp and above electric motors. (NEMA, No. 22 at p. 24) NEMA did not provide any additional comments regarding shipments projections. DOE did not receive any additional comments related to shipments and retained the same methodology as in the preliminary analysis and updated the analysis to reflect AEO 2022. DOE applied the same shipments trends to electric motors above 500 hp.

With respect to synchronous motors, NEMA commented that in section 2.9.5 of the March 2022 Prelim TSD, DOE notes that synchronous motors are less efficient than their Design A or B counterparts, which NEMA does not agree with. Furthermore, NEMA stated that a focus on single point efficiency at full load misses the benefit synchronous motors provide (variable load and reduced speed operation). (NEMA, No. 22 at p. 24)

DOE clarifies that Table 2.9.5 of the March 2022 Preliminary Analysis TSD did not provide information related to the efficiency of synchronous motors. Instead, Table 2.9.5 of the March 2022 Prelim TSD presented the percentage of consumer that would select a synchronous motor over a compliant induction motor in each considered standard level case. In addition, as noted by NEMA, synchronous motors offer additional energy savings benefits through variable load and reduced speed operation and DOE accounted for these savings in the preliminary analysis by applying a reduction of energy of 30 percent based on information from a previous DOE study.[70] (See section 9.4 of the March 2022 Prelim TSD).

The Electric Motors Working Group stated that to achieve IE4 efficiency levels, manufacturers would likely shift from NEMA Design B to NEMA Design A motors. This shift may result in the increased adoption of variable frequency drives (VFDs), which would significantly increase energy savings. Furthermore, while DOE's March 2022 Preliminary Analysis looked only at substitutions to synchronous motors up to 100 hp, the increased adoption of VFDs (paired with an IE4 motor) would also be relevant at higher horsepower levels. The Electric Motors Working Group therefore encouraged DOE to include this VFD substitution in its analysis and added that with these substitutions, DOE's updated analysis will show the recommended efficiency levels to be cost effective. The Electric Motors Working Group did not provide estimates regarding the rate at which this substitution would occur.

In the direct final rule TSD, DOE added a scenario to account for the fact that some consumers may choose to purchase a synchronous electric motor (out of scope of this direct final rule) rather than a more efficient NEMA Design A or B electric motor or select to purchase a VFD in combination with a compliant electric motor. Similar to the approach used in the March 2022 Preliminary Analysis, DOE developed a consumer choice model to estimate the percentage of consumers that would purchase a synchronous electric motor based on the payback period of such investment. DOE notes that there is uncertainty as to which rate such substitution would occur and did not incorporate this scenario as part of the reference analysis. To support the payback calculation, DOE accounted for the total installed costs and annual operating costs of a synchronous motor and of a VFD in combination with a compliant electric motor. In addition, DOE updated its previous estimate of energy use reduction resulting from variable load and reduced speed operation based on a more recent study. See appendix 8–D of the DFR TSD for more details on this analysis.

NEMA added that comparing a synchronous motor and drive combination to an induction motor is not an apples-to-apples comparison and should be avoided. NEMA stated that the application of motor-drive systems are application dependent. NEMA stated that programs which encourage and facilitate power drive system installations in the field and during planning are the appropriate vehicles for market transformation, not point-of-sale regulations such as those in question of the PTSD. NEMA stated that DOE should defer to and encourage those programs as appropriate ''other than regulatory'' actions for market transformation. (NEMA, No. 22 at p. 24)

DOE notes that NEMA is a member of the Electric Motors Working Group and jointly commented that DOE should consider that some consumers may select to purchase a synchronous motor and drive combination or a VFD combined with a compliant motor. As noted, DOE analyzed this scenario as a

[70] U.S Department of Energy. United States Industrial Electric Motor Systems Market Opportunities Assessment. 2002.

sensitivity analysis and the reference scenario did not include this potential market shift to synchronous motors and VFD usage.

NEMA commented that legacy induction motors are being replaced by PDS (or power drive systems) consisting of a motor and controls/drives as a means to dramatically reduce power and integrate motor driven systems into sophisticated control schemes that continuously monitor processes managing flow, pressure, etc., to reduce operating costs and emissions. (NEMA, No. 22 at p. 23) As noted by NEMA, advanced technology electric motors that are combined with a drive are now available on the market and could be used in the same applications as the electric motors analyzed in this direct final rule. However, DOE estimates these PDS currently represent a small fraction of the market.[71] Further, NEMA did not provide data to quantitatively estimate the rate at which such PDS would replace legacy induction motors. As such DOE did not include such impact in the reference scenario. Instead, DOE accounted for the potential switch from induction motors to PDS as a sensitivity scenario. See Appendix 8–C and 10–D for more details. In addition, as another sensitivity analysis, DOE also projected shipments in a low growth scenario which assumed lower shipments compared to the reference scenario. See Chapter 9 of the direct final rule for more details.

H. National Impact Analysis

The NIA assesses the national energy savings (''NES'') and the NPV from a national perspective of total consumer costs and savings that would be expected to result from new or amended standards at specific efficiency levels.[72] (''Consumer'' in this context refers to consumers of the product being regulated.) DOE calculates the NES and NPV for the potential standard levels considered based on projections of annual product shipments, along with the annual energy consumption and total installed cost data from the energy use and LCC analyses. For the present analysis, DOE projected the energy savings, operating cost savings, product costs, and NPV of consumer benefits over the lifetime of electric motors sold from 2027 through 2056.

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

In its analysis, DOE analyzes the energy and economic impacts of a potential standard on all equipment classes aggregated by horsepower range and equipment class group. For NEMA Design A and B electric motors regulated under 10 CFR 431.25, inputs for non-representative equipment classes (*i.e.,* those not analyzed in the engineering, energy-use, and LCC analyses) are scaled using inputs for the analyzed representative equipment classes.[73] For AO–MEMs and electric motors above 500 hp, DOE used the results of the representative units without any scaling due to the smaller size of horsepower ranges associated for each representative unit, and lower shipments of motors at larger horsepower ratings.

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–10 summarizes the inputs and methods DOE used for the NIA analysis for the direct final rule. Discussion of these inputs and methods follows the table. See chapter 10 of the direct final rule TSD for further details.

TABLE IV–10—SUMMARY OF INPUTS AND METHODS FOR THE NATIONAL IMPACT ANALYSIS

Inputs	Method
Shipments	Annual shipments from shipments model.
Compliance Date of Standard	2027.
Efficiency Trends	No-new-standards case: constant trend Standard cases: constant trend.
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 product prices based on historical data (constant trend).
Repair and Maintenance Cost per Unit	Maintenance costs: Do not change with efficiency level. Repair costs: Changes with efficiency level.
Electricity Price	Estimated average and marginal electricity prices from the LCC analysis based on EEI data.
Electricity Price Trends	*AEO2022* projections (to 2050) and extrapolation thereafter.
Energy Site-to-Primary and FFC Conversion	A time-series conversion factor based on *AEO2022.*
Discount Rate	3 percent and 7 percent.
Present Year	2023.

1. Equipment Efficiency Trends

A key component of the NIA is the trend in energy efficiency projected for the no-new-standards case and each of the standards cases. Section IV.F.8 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 year of anticipated compliance with an amended or new standard. To project the trend in efficiency absent amended standards for electric motors over the

[71] DOE estimates the market share of advanced technology motors to be less than 1 percent based on information from OMDIA, Low-Voltage Motors Intelligence Service, Annual 2020 Analysis (OMDIA Report November 2020).

[72] The NIA accounts for impacts in the 50 states and U.S. territories.

[73] For example, results from representative unit 1 (NEMA Design A and B electric motors, 5-horsepower, 4-pole, enclosed) were scaled based by HP and weight to represent all NEMA Design A and B electric motor equipment classes between 1 and 5 horsepower. DOE then used shipments weighted-average results to represent the 1–5 HP range.

entire shipments projection period, similar to what was done in the March 2022 preliminary Analysis, DOE applied a constant trend. The approach is further described in chapter 10 of the direct final rule TSD.

For the standards cases, similar to what was done in the March 2022 preliminary Analysis, DOE used a ''roll-up'' scenario to establish the shipment-weighted efficiency for the year that standards are assumed to become effective (2027). In this scenario, the market shares of products in the no-new-standards case that do not meet the standard under consideration would ''roll up'' to meet the new standard level, and the market share of products above the standard would remain unchanged.

To develop standards case efficiency trends after 2027, DOE assumed no change over the forecast period.

DOE did not receive any comments on the projected efficiency trends.

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 or amended energy conservation standards. DOE calculated the national energy consumption by multiplying the number of units (stock) of each product (by vintage or age) by the unit energy consumption (also by vintage). 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 *AEO2022.* Cumulative energy savings are the sum of the NES for each year over the timeframe of the analysis.

Use of higher-efficiency products is sometimes associated with a direct rebound effect, which refers to an increase in utilization of the product due to the increase in efficiency. For example, when a consumer realizes that a more-efficient electric motor used for cooling will lower the electricity bill, that person may opt for increased comfort in the building by using the equipment more, thereby negating a portion of the energy savings. In commercial buildings, however, the person owning the equipment (*i.e.,* the building owner) is usually not the person operating the equipment (*i.e.,* the renter). Because the operator usually does not own the equipment, that person will not have the operating cost information necessary to influence their operation of the equipment. Therefore, DOE believes that a rebound effect is unlikely to occur in commercial buildings. In the industrial and agricultural sectors, DOE believes that electric motors are likely to be operated whenever needed for the required process or service, so a rebound effect is also unlikely to occur in the industrial and agricultural sectors.

In addition, electric motors are components of larger equipment or systems and DOE has determined that a change in motor efficiency alone would not increase the utilization of that equipment or system. DOE did not find any data on the rebound effect specific to electric motors and did not receive any comments supporting the inclusion of a rebound effect for electric motors. DOE did not apply a rebound effect for electric motors.

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 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 sector [74] 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 10B of the direct final rule TSD.

[74] For more information on NEMS, refer to *The National Energy Modeling System: An Overview 2018,* DOE/EIA–0581(2018), April 2019. Available at *www.eia.gov/outlooks/aeo/nems/documentation/* (last accessed July 26, 2022).

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 developed equipment price trends based on historical PPI data. DOE applied the same trends (*i.e.,* constant price trend) to project prices for each equipment class at each considered efficiency level.

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 electric motors. In addition to the default price trend, DOE considered two product price sensitivity cases: (1) a high price decline case and (2) a low price decline case based on historical PPI data. The derivation of these price trends and the results of these sensitivity cases are described in appendix 10–C of the direct final rule TSD.

The operating cost savings are electricity cost savings and any changes in repair costs, which are calculated using the estimated energy savings in each year and the projected electricity price as well as using the lifetime repair costs estimates from the LCC. To estimate electricity prices in future years, in each sector (commercial, industrial and agriculture), DOE multiplied the sector-specific average electricity prices by the projection of annual national-average electricity price changes in the Reference case from *AEO2022,* which has an end year of 2050. To estimate price trends after 2050, DOE used the 2050 electricity prices, held constant. DOE then used a weighted-average trend across all sectors in the NIA. As part of the NIA, DOE also analyzed scenarios that used inputs from variants of the *AEO2022* Reference case that have lower and higher economic growth. Those cases have lower and higher energy price trends compared to the Reference case. NIA results based on these cases are presented in appendix 10C of the direct 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 direct 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.[75] The discount rates for the determination of NPV are in contrast to the discount rates used in the LCC analysis, which are designed to reflect a consumer's perspective. The 7-percent real value is an estimate of the average before-tax rate of return to private capital in the U.S. economy. The 3-percent real value represents the ''social rate of time preference,'' which is the rate at which society discounts 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 on identifiable subgroups of consumers that may be disproportionately affected by a new or amended national standard. 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 direct final rule, DOE analyzed the impacts of the considered standard levels on one subgroup: small businesses.

DOE used the LCC and PBP spreadsheet model to estimate the impacts of the considered efficiency levels on this subgroup. Chapter 11 in the direct 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 and amended energy conservation standards on manufacturers of electric motors 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 and amended 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 Government Regulatory Impact Model (''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, product shipments, manufacturer markups, and investments in 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 and amended standards, the GRIM estimates a range of possible impacts under different manufacturer 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 direct 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 electric motors manufacturing industry based on the market and technology assessment, preliminary manufacturer interviews, and publicly-available information. This included a top-down analysis of electric motors 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 electric motors manufacturing industry, including company filings of form 10–K from the SEC,[76] corporate annual reports, the U.S. Census Bureau's ''*Economic Census*,''[77] and reports from D&B Hoover.[78]

In Phase 2 of the MIA, DOE prepared a framework industry cash-flow analysis to quantify the potential impacts of new and amended energy conservation standards. 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: (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 electric motors 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 conducted structured, detailed interviews with representative manufacturers. During these interviews, DOE discussed engineering, manufacturing, procurement, and financial topics to validate assumptions used in the GRIM and to identify key issues or concerns. See section IV.J.3 of this document for a description of the key issues raised by manufacturers during the interviews. As part of Phase 3, DOE also evaluated subgroups of manufacturers that may be disproportionately impacted by new and amended standards or that may not be accurately represented by the average cost assumptions used to develop the industry cash flow analysis. Such

[75] United States Office of Management and Budget. *Circular A–4: Regulatory Analysis.* September 17, 2003. Section E. Available at *georgewbush-whitehouse.archives.gov/omb/memoranda/m03-21.html* (last accessed July 26, 2022).

[76] *www.sec.gov/edgar.*

[77] *www.census.gov/programs-surveys/asm/data/tables.html.*

[78] *app.avention.com.*

manufacturer subgroups may include small business manufacturers, low-volume manufacturers (''LVMs''), niche players, and/or manufacturers exhibiting a cost structure that largely differs from the industry average. DOE identified one subgroup for a separate impact analysis: small business manufacturers. The small business subgroup is discussed in section VI.B, ''Review under the Regulatory Flexibility Act'' and in chapter 12 of the direct 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 and amended 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 new and amended energy conservation standards. The GRIM spreadsheet uses the inputs to arrive at a series of annual cash flows, beginning in 2023 (the base year of the analysis) and continuing to 2056. DOE calculated INPVs by summing the stream of annual discounted cash flows during this period. For manufacturers of electric motors, DOE used a real discount rate of 9.1 percent, which was used in the May 2014 Final Rule and then asked for feedback on this value 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 and amended energy conservation standards 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 and subsequent Working Group meetings. 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 direct final rule TSD.

a. Manufacturer Production Costs

Manufacturing more efficient equipment is typically more expensive than manufacturing baseline equipment due to the use of more complex components, which are typically more costly than baseline components. The changes in the MPCs of the covered equipment can affect the revenues, gross margins, and cash flow of the industry.

DOE conducted the engineering analysis using a combination of physical teardowns and software modeling. DOE contracted a professional motor laboratory to disassemble various electric motors and record what types of materials were present and how much of each material was present, recorded in a final bill of materials (''BOM''). To supplement the physical teardowns, software modeling by a subject matter expert (''SME'') was also used to generate BOMs for select efficiency levels of directly analyzed representative units.

For a complete description of the MPCs, see chapter 5 of the direct final rule TSD.

b. Shipments Projections

The GRIM estimates manufacturer revenues based on total unit shipment projections 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 2023 (the base year) to 2056 (the end year of the analysis period). See chapter 9 of the direct final rule TSD for additional details.

c. Product and Capital Conversion Costs

New and amended energy conservation standards 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 equipment class. For the MIA, DOE classified these conversion costs into two major groups: (1) product conversion costs; and (2) capital conversion costs. Product conversion costs are investments in research, development, testing, marketing, and other non-capitalized costs necessary to make equipment designs comply with new amended 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 equipment designs can be fabricated and assembled.

DOE calculated the product and capital conversion costs using bottom-up approach based on feedback from manufacturers during manufacturer interviews. During manufacturer interviews, DOE asked manufacturers questions regarding the estimated product and capital conversion costs needed to produce electric motors within an equipment class at each specific EL. DOE used the feedback provided from manufacturers to estimate the approximate amount of engineering time, testing costs and capital equipment that would be purchased to redesign a single frame size to each EL. Some of the types of capital conversion costs manufacturers identified were the purchase of lamination die sets, winding machines, frame casts, and assembly equipment as well as other retooling costs. The two main types of product conversion costs manufacturers shared with DOE during interviews were number of engineer hours necessary to re-engineer frames to meet higher efficiency standards and the testing costs to comply with higher efficiency standards.

DOE then took average values (*i.e.,* costs or number of hours) based on the range of responses given by manufacturers for each product and capital conversion costs necessary for a manufacturer to increase the efficiency of one frame size to a specific EL. DOE multiplied the conversion costs associated with manufacturing a single frame size at each EL by the number of frames each interviewed manufacturer produces. DOE finally scaled this number based on the market share of the manufacturers DOE interviewed, to arrive at industry wide bottom-up product and capital conversion cost estimates for each representative unit at each EL.

In response to the May 2020 Early Assessment Review RFI, NEMA stated that if DOE decides to pursue revision of energy conservation standards for electric motors, DOE should revisit its analyses and assumptions for the product and capital conversion costs used in the May 2014 Final Rule. (NEMA, No. 4 at p. 3) Additionally, in response to the March 2022 Preliminary Analysis EASA agreed with NEMA's comment that DOE should revise the analyses for product and capital conversion costs (EASA, No. 21 at p. 5) After the publication of the March 2022 Preliminary Analysis, DOE interviewed manufacturers to gather information regarding the product and capital conversion costs used in this NOPR analysis. DOE relied on the information gathered during these manufacturer interviews to create the product and capital conversion cost estimated used in this direct final rule analysis.

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

d. Markup Scenarios

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

Under the preservation of gross margin scenario, DOE applied a single uniform ''gross margin percentage'' across all efficiency levels, which assumes that manufacturers would be able to maintain the same amount of profit as a percentage of revenues at all efficiency levels within an equipment class. In this manufacturer markup scenario, electric motor manufacturers fully pass on any additional MPC increase due to standards to their consumers. DOE used a manufacturer markup of 1.37 for all electric motors covered by this rulemaking with less than or equal to 5 hp, and a manufacturer markup or 1.45 for all electric motors covered by this rulemaking greater than 5 hp. DOE used these same manufacturer markups for all TSLs in the preservation of gross margin scenario. This manufacturer markup scenario represents the upper-bound of manufacturer INPV and is the manufacturer markup scenario used to calculate the economic impacts on consumers.

Under the preservation of operating profit scenario, DOE modeled a situation in which manufacturers are not able to increase per-unit operating profit in proportion to increases in MPCs. Under this scenario, as MPCs increase, manufacturers reduce the manufacturer margins to maintain a cost competitive offering in the market. However, in this scenario manufacturers maintain their total operating profit in absolute dollars in the standards case, despite higher product costs and investment. Therefore, gross margin (as a percentage) shrinks in the standards cases. This manufacturer markup scenario represents the lower-bound to industry profitability under new and amended energy conservation standards.

A comparison of industry financial impacts under the two markup scenarios is presented in section V.B.2.a of this document.

3. Manufacturer Interviews

DOE conducted additional interviews with manufacturers following the publication of the March 2022 Prelim TSD in preparation for this NOPR analysis. In interviews, DOE asked manufacturers to describe their major concerns regarding this rulemaking. The following section highlights manufacturer concerns that helped inform the projected potential impacts of anew and amended standard on the industry. Manufacturer interviews are conducted under non-disclosure agreements (''NDAs''), so DOE does not document these discussions in the same way that it does public comments in the comment summaries and DOE's responses throughout the rest of this document.

During these interviews, most manufacturers stated that even manufacturing a single electric motor to an efficiency level above IE 4 (or IE 4 equivalent efficiency levels) would require a significant level of investments. Further, most manufacturers also stated that it would be impossible to manufacturer a complete line of electric motors spanning all horsepower covered by this rulemaking regardless of the costs associated with this task. Increasing the efficiency of any electric motor to an efficiency level above IE 4 would require each manufacturer to make a significant capital investment to retool their entire production line. It would also require manufacturers to completely redesign almost every electric motor configuration offered, which could take more than a decade of engineering time.

DOE examines a range of efficiency levels for covered equipment when determining whether to amend or establish energy conservation standards, including the level that represents the most energy-efficient combination of design options. In this analysis for NEMA Design A and B electric motors between 1 and 500 hp, EL 1 is associated with an IE 4 equivalent efficiency level and EL 2, EL 3, and EL 4 (max-tech) represent efficiency levels above IE 4. DOE understands the level of burden placed on electric motor manufacturers if energy conservation standards require any electric motors to meet energy conservation standards set above IE 4 equivalent levels. These investments (in the form of conversion costs) are accounted for in the MIA and displayed in section V.B.2.a.

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 CO_2, NO_X, SO_2, and Hg. The second component estimates the impacts of potential standards on emissions of two additional greenhouse gases, CH_4 and N_2O, as well as the reductions in emissions of other gases due to ''upstream'' activities in the fuel production chain. These upstream activities comprise extraction, processing, and transporting fuels to the site of combustion.

The analysis of electric power sector emissions of CO_2, NO_X, SO_2, and Hg uses emissions factors intended to represent the marginal impacts of the change in electricity consumption associated with amended or new standards. The methodology is based on results published for the *AEO,* including a set of side cases that implement a variety of efficiency-related policies. The methodology is described in appendix 13A in the direct final rule TSD. The analysis presented in this notice uses projections from *AEO2022.* Power sector emissions of CH_4 and N_2O from fuel combustion are estimated using Emission Factors for Greenhouse Gas Inventories published by the Environmental Protection Agency (EPA).[79]

FFC upstream emissions, which include emissions from fuel combustion during extraction, processing, and transportation of fuels, and ''fugitive''

[79] Available at *www.epa.gov/sites/production/files/2021-04/documents/emission-factors_apr2021.pdf* (last accessed July 12, 2021).

emissions (direct leakage to the atmosphere) of CH_4 and CO_2, are estimated based on the methodology described in chapter 15 of the direct final rule TSD.

The emissions intensity factors are expressed in terms of physical units per MWh or MMBtu of site energy savings. For power sector emissions, specific emissions intensity factors are calculated by sector and end use. Total emissions reductions are estimated using the energy savings calculated in the national impact analysis.

1. Air Quality Regulations Incorporated in DOE's Analysis

DOE's no-new-standards case for the electric power sector reflects the *AEO,* which incorporates the projected impacts of existing air quality regulations on emissions. *AEO2022* generally represents current legislation and environmental regulations, including recent government actions, that were in place at the time of preparation of *AEO2022,* including the emissions control programs discussed in the following paragraphs.[80]

SO_2 emissions from affected electric generating units (''EGUs'') are subject to nationwide and regional emissions cap-and-trade programs. Title IV of the Clean Air Act sets an annual emissions cap on SO_2 for affected EGUs in the 48 contiguous States and the District of Columbia (''DC''). (42 U.S.C. 7651 *et seq.*) SO_2 emissions from numerous States in the eastern half of the United States are also limited under the Cross-State Air Pollution Rule (''CSAPR''). 76 FR 48208 (Aug. 8, 2011). CSAPR requires these States to reduce certain emissions, including annual SO_2 emissions, and went into effect as of January 1, 2015.[81] *AEO2022* incorporates implementation of CSAPR, including the update to the CSAPR ozone season program emission budgets and target dates issued in 2016. 81 FR 74504 (Oct. 26, 2016). Compliance with CSAPR is flexible among EGUs and is enforced through the use of tradable emissions allowances. Under existing EPA regulations, for states subject to SO_2 emissions limits under CSAPR, any excess SO_2 emissions allowances resulting from the lower electricity demand caused by the adoption of an efficiency standard could be used to permit offsetting increases in SO_2 emissions by another regulated EGU.

However, beginning in 2016, SO_2 emissions began to fall as a result of the Mercury and Air Toxics Standards (''MATS'') for power plants. 77 FR 9304 (Feb. 16, 2012). The final rule establishes power plant emission standards for mercury, acid gases, and non-mercury metallic toxic pollutants. In order to continue operating, coal plants must have either flue gas desulfurization or dry sorbent injection systems installed. Both technologies, which are used to reduce acid gas emissions, also reduce SO_2 emissions. Because of the emissions reductions under the MATS, it is unlikely that excess SO_2 emissions allowances resulting from the lower electricity demand would be needed or used to permit offsetting increases in SO_2 emissions by another regulated EGU. Therefore, energy conservation standards that decrease electricity generation will generally reduce SO_2 emissions. DOE estimated SO_2 emissions reduction using emissions factors based on *AEO2022.*

CSAPR also established limits on NO_X emissions for numerous States in the eastern half of the United States. Energy conservation standards would have little effect on NO_X emissions in those States covered by CSAPR emissions limits if excess NO_X emissions allowances resulting from the lower electricity demand could be used to permit offsetting increases in NO_X emissions from other EGUs. In such case, NO_X emissions would remain near the limit even if electricity generation goes down. Depending on the configuration of the power sector in the different regions and the need for allowances, however, NO_X emissions might not remain at the limit in the case of lower electricity demand. That would mean that standards might reduce NO_X emissions in covered States. Despite this possibility, DOE has chosen to be conservative in its analysis and has maintained the assumption that standards will not reduce NO_X emissions in States covered by CSAPR. Standards would be expected to reduce NO_X emissions in the States not covered by CSAPR. DOE used *AEO2022* data to derive NO_X emissions factors for the group of States not covered by CSAPR.

The MATS limit mercury emissions from power plants, but they do not include emissions caps and, as such, DOE's energy conservation standards would be expected to slightly reduce Hg emissions. DOE estimated mercury emissions reduction using emissions factors based on *AEO2022,* which incorporates the MATS.

NEMA commented that DOE does not adequately examine or account for the significant impacts from ever-increasing investment in and use of renewable energy sources and associated decrease in emissions. (NEMA, No. 22 at p. 25)

DOE acknowledges that increasing use of renewable electricity sources could reduce CO_2 emissions and likely other emissions from the power sector faster than could have been expected when *AEO2022* was prepared. Nevertheless, DOE has used *AEO2022* for the purposes of quantifying emissions as DOE believes it continues to be the most appropriate projection at this time for such purposes.

L. Monetizing Emissions Impacts

As part of the development of this direct final rule, for the purpose of complying with the requirements of Executive Order 12866, DOE considered the estimated monetary benefits from the reduced emissions of CO_2, CH_4, N_2O, NO_X, and SO_2 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 direct final rule.

To monetize the benefits of reducing GHG emissions this analysis uses the interim estimates presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990* published in February 2021 by the Interagency Working Group on the Social Cost of Greenhouse Gases (IWG). DOE requests comment on how to address the climate benefits and other non-monetized effects of the proposal.

1. Monetization of Greenhouse Gas Emissions

DOE estimates the monetized benefits of the reductions in emissions of CO_2, CH_4, and N_2O by using a measure of the SC of each pollutant (*e.g.,* SC–CO_2).

[80] For further information, see the Assumptions to AEO2022 report that sets forth the major assumptions used to generate the projections in the Annual Energy Outlook. Available at *www.eia.gov/outlooks/aeo/assumptions/* (last accessed June 22, 2022).

[81] CSAPR requires states to address annual emissions of SO_2 and NO_X, precursors to the formation of fine particulate matter ($PM_{2.5}$) pollution, in order to address the interstate transport of pollution with respect to the 1997 and 2006 $PM_{2.5}$ National Ambient Air Quality Standards (''NAAQS''). CSAPR also requires certain states to address the ozone season (May–September) emissions of NO_X, a precursor to the formation of ozone pollution, in order to address the interstate transport of ozone pollution with respect to the 1997 ozone NAAQS. 76 FR 48208 (Aug. 8, 2011). EPA subsequently issued a supplemental rule that included an additional five states in the CSAPR ozone season program; 76 FR 80760 (Dec. 27, 2011) (Supplemental Rule).

These estimates represent the monetary value of the net harm to society associated with a marginal increase in emissions of these pollutants in a given year, or the benefit of avoiding that increase. These estimates are intended to include (but are not limited to) climate-change-related changes in net agricultural productivity, human health, property damages from increased flood risk, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services.

DOE exercises its own judgment in presenting monetized climate benefits as recommended by applicable Executive orders, and DOE would reach the same conclusion presented in this direct final rule in the absence of the social cost of greenhouse gases. That is, the social costs of greenhouse gases, whether measured using the February 2021 interim estimates presented by the Interagency Working Group on the Social Cost of Greenhouse Gases or by another means, did not affect the rule ultimately adopted by DOE.

DOE estimated the global social benefits of CO_2, CH_4, and N_2O reductions (*i.e.,* SC–GHGs) using the estimates presented in the Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990, published in February 2021 by the IWG. The SC–GHGs is the monetary value of the net harm to society associated with a marginal increase in emissions in a given year, or the benefit of avoiding that increase. In principle, SC–GHGs includes the value of all climate change impacts, including (but not limited to) changes in net agricultural productivity, human health effects, property damage from increased flood risk and natural disasters, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services. The SC–GHGs therefore, reflects the societal value of reducing emissions of the gas in question by one metric ton. The SC–GHGs is the theoretically appropriate value to use in conducting benefit-cost analyses of policies that affect CO_2, N_2O and CH_4 emissions. As a member of the IWG involved in the development of the February 2021 SC–GHG TSD, DOE agrees that the interim SC–GHG estimates represent the most appropriate estimate of the SC–GHG until revised estimates have been developed reflecting the latest, peer-reviewed science.

The SC–GHGs estimates presented here were developed over many years, using transparent process, peer-reviewed methodologies, the best science available at the time of that process, and with input from the public. Specifically, in 2009, the IWG, that included the DOE and other executive branch agencies and offices was established to ensure that agencies were using the best available science and to promote consistency in the social cost of carbon (SC–CO_2) values used across agencies. The IWG published SC–CO_2 estimates in 2010 that were developed from an ensemble of three widely cited integrated assessment models (IAMs) that estimate global climate damages using highly aggregated representations of climate processes and the global economy combined into a single modeling framework. The three IAMs were run using a common set of input assumptions in each model for future population, economic, and CO_2 emissions growth, as well as equilibrium climate sensitivity—a measure of the globally averaged temperature response to increased atmospheric CO_2 concentrations. These estimates were updated in 2013 based on new versions of each IAM. In August 2016 the IWG published estimates of the social cost of methane (SC–CH_4) and nitrous oxide (SC–N_2O) using methodologies that are consistent with the methodology underlying the SC–CO_2 estimates. The modeling approach that extends the IWG SC–CO_2 methodology to non-CO_2 GHGs has undergone multiple stages of peer review. The SC–CH_4 and SC–N_2O estimates were developed by Marten *et al.*[82] and underwent a standard double-blind peer review process prior to journal publication. In 2015, as part of the response to public comments received to a 2013 solicitation for comments on the SC–CO_2 estimates, the IWG announced a National Academies of Sciences, Engineering, and Medicine review of the SC–CO_2 estimates to offer advice on how to approach future updates to ensure that the estimates continue to reflect the best available science and methodologies. In January 2017, the National Academies released their final report, Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide, and recommended specific criteria for future updates to the SC–CO_2 estimates, a modeling framework to satisfy the specified criteria, and both near-term updates and longer-term research needs pertaining to various components of the estimation process (National Academies, 2017).[83] Shortly thereafter, in March 2017, President Trump issued Executive Order 13783, which disbanded the IWG, withdrew the previous TSDs, and directed agencies to ensure SC–CO_2 estimates used in regulatory analyses are consistent with the guidance contained in OMB's Circular A–4, ''including with respect to the consideration of domestic versus international impacts and the consideration of appropriate discount rates'' (Executive Order (''E.O.'') 13783, section 5(c)). Benefit-cost analyses following E.O. 13783 used SC–GHG estimates that attempted to focus on the U.S.-specific share of climate change damages as estimated by the models and were calculated using two discount rates recommended by Circular A–4, 3 percent and 7 percent. All other methodological decisions and model versions used in SC–GHG calculations remained the same as those used by the IWG in 2010 and 2013, respectively.

On January 20, 2021, President Biden issued Executive Order 13990, which re-established the IWG and directed it to ensure that the U.S. Government's estimates of the social cost of carbon and other greenhouse gases reflect the best available science and the recommendations of the National Academies (2017). The IWG was tasked with first reviewing the SC–GHG estimates currently used in Federal analyses and publishing interim estimates within 30 days of the E.O. that reflect the full impact of GHG emissions, including by taking global damages into account. The interim SC–GHG estimates published in February 2021 are used here to estimate the climate benefits for this direct final rule. The E.O. instructs the IWG to undertake a fuller update of the SC–GHG estimates by January 2022 that takes into consideration the advice of the National Academies (2017) and other recent scientific literature. The February 2021 SC–GHG TSD provides a complete discussion of the IWG's initial review conducted under E.O.13990. In particular, the IWG found that the SC–GHG estimates used under E.O. 13783 fail to reflect the full impact of GHG emissions in multiple ways.

First, the IWG found that the SC–GHG estimates used under E.O. 13783 fail to fully capture many climate impacts that affect the welfare of U.S. citizens and residents, and those impacts are better reflected by global measures of the SC–GHG. Examples of omitted effects from

[82] Marten, A.L., E.A. Kopits, C.W. Griffiths, S.C. Newbold, and A. Wolverton. Incremental CH_4 and N_2O mitigation benefits consistent with the U.S. Government's SC–CO_2 estimates. *Climate Policy.* 2015. 15(2): pp. 272–298.

[83] National Academies of Sciences, Engineering, and Medicine. *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide.* 2017. The National Academies Press: Washington, DC.

the E.O. 13783 estimates include direct effects on U.S. citizens, assets, and investments located abroad, supply chains, U.S. military assets and interests abroad, and tourism, and spillover pathways such as economic and political destabilization and global migration that can lead to adverse impacts on U.S. national security, public health, and humanitarian concerns. In addition, assessing the benefits of U.S. GHG mitigation activities requires consideration of how those actions may affect mitigation activities by other countries, as those international mitigation actions will provide a benefit to U.S. citizens and residents by mitigating climate impacts that affect U.S. citizens and residents. A wide range of scientific and economic experts have emphasized the issue of reciprocity as support for considering global damages of GHG emissions. If the United States does not consider impacts on other countries, it is difficult to convince other countries to consider the impacts of their emissions on the United States. The only way to achieve an efficient allocation of resources for emissions reduction on a global basis—and so benefit the U.S. and its citizens—is for all countries to base their policies on global estimates of damages. As a member of the IWG involved in the development of the February 2021 SC–GHG TSD, DOE agrees with this assessment and, therefore, in this direct final rule DOE centers attention on a global measure of SC–GHG. This approach is the same as that taken in DOE regulatory analyses from 2012 through 2016. A robust estimate of climate damages that accrue only to U.S. citizens and residents does not currently exist in the literature. As explained in the February 2021 TSD, existing estimates are both incomplete and an underestimate of total damages that accrue to the citizens and residents of the U.S. because they do not fully capture the regional interactions and spillovers discussed above, nor do they include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature. As noted in the February 2021 SC–GHG TSD, the IWG will continue to review developments in the literature, including more robust methodologies for estimating a U.S.-specific SC–GHG value, and explore ways to better inform the public of the full range of carbon impacts. As a member of the IWG, DOE will continue to follow developments in the literature pertaining to this issue

Second, the IWG found that the use of the social rate of return on capital (7 percent under current OMB Circular A–4 guidance) to discount the future benefits of reducing GHG emissions inappropriately underestimates the impacts of climate change for the purposes of estimating the SC–GHG. Consistent with the findings of the National Academies (2017) and the economic literature, the IWG continued to conclude that the consumption rate of interest is the theoretically appropriate discount rate in an intergenerational context,[84] and recommended that discount rate uncertainty and relevant aspects of intergenerational ethical considerations be accounted for in selecting future discount rates.

Furthermore, the damage estimates developed for use in the SC–GHG are estimated in consumption-equivalent terms, and so an application of OMB Circular A–4's guidance for regulatory analysis would then use the consumption discount rate to calculate the SC–GHG. DOE agrees with this assessment and will continue to follow developments in the literature pertaining to this issue. DOE also notes that while OMB Circular A–4, as published in 2003, recommends using 3% and 7% discount rates as ''default'' values, Circular A–4 also reminds agencies that ''different regulations may call for different emphases in the analysis, depending on the nature and complexity of the regulatory issues and the sensitivity of the benefit and cost estimates to the key assumptions.'' On discounting, Circular A–4 recognizes that ''special ethical considerations arise when comparing benefits and costs across generations,'' and Circular A–4 acknowledges that analyses may appropriately ''discount future costs and consumption benefits . . . at a lower rate than for intragenerational analysis.'' In the 2015 Response to Comments on the Social Cost of Carbon for Regulatory Impact Analysis, OMB, DOE, and the other IWG members recognized that ''Circular A–4 is a living document'' and ''the use of 7 percent is not considered appropriate for intergenerational discounting. There is wide support for this view in the academic literature, and it is recognized in Circular A–4 itself.'' Thus, DOE concludes that a 7% discount rate is not appropriate to apply to value the social cost of greenhouse gases in the analysis presented in this analysis.

To calculate the present and annualized values of climate benefits, DOE uses the same discount rate as the rate used to discount the value of damages from future GHG emissions, for internal consistency. That approach to discounting follows the same approach that the February 2021 TSD recommends ''to ensure internal consistency—*i.e.,* future damages from climate change using the SC–GHG at 2.5 percent should be discounted to the base year of the analysis using the same 2.5 percent rate.'' DOE has also consulted the National Academies' 2017 recommendations on how SC–GHG estimates can ''be combined in RIAs with other cost and benefits estimates that may use different discount rates.'' The National Academies reviewed several options, including ''presenting all discount rate combinations of other costs and benefits with [SC–GHG] estimates.''

As a member of the IWG involved in the development of the February 2021 SC–GHG TSD, DOE agrees with the above assessment and will continue to follow developments in the literature pertaining to this issue. While the IWG works to assess how best to incorporate the latest, peer reviewed science to develop an updated set of SC–GHG estimates, it set the interim estimates to be the most recent estimates developed by the IWG prior to the group being disbanded in 2017. The estimates rely on the same models and harmonized inputs and are calculated using a range of discount rates. As explained in the February 2021 SC–GHG TSD, the IWG has recommended that agencies revert to the same set of four values drawn from the SC–GHG distributions based on three discount rates as were used in regulatory analyses between 2010 and 2016 and were subject to public comment. For each discount rate, the IWG combined the distributions across models and socioeconomic emissions scenarios (applying equal weight to

[84] Interagency Working Group on Social Cost of Carbon. *Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866.* 2010. United States Government. (Last accessed April 15, 2022.) *www.epa.gov/sites/default/files/2016-12/documents/scc_tsd_2010.pdf;* Interagency Working Group on Social Cost of Carbon. *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.* 2013. (Last accessed April 15, 2022.) *www.federalregister.gov/documents/2013/11/26/2013-28242/technical-support-document-technical-update-of-the-social-cost-of-carbon-for-regulatory-impact;* Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. Technical Support Document: Technical Update on the Social Cost of Carbon for Regulatory Impact Analysis-Under Executive Order 12866. August 2016. (Last accessed January 18, 2022.) *www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf;* Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. 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. (Last accessed January 18, 2022.) *www.epa.gov/sites/default/files/2016-12/documents/addendum_to_sc-ghg_tsd_august_2016.pdf.*

each) and then selected a set of four values recommended for use in benefit-cost analyses: an average value resulting from the model runs for each of three discount rates (2.5 percent, 3 percent, and 5 percent), plus a fourth value, selected as the 95th percentile of estimates based on a 3 percent discount rate. The fourth value was included to provide information on potentially higher-than-expected economic impacts from climate change. As explained in the February 2021 SC–GHG TSD, and DOE agrees, this update reflects the immediate need to have an operational SC–GHG for use in regulatory benefit-cost analyses and other applications that was developed using a transparent process, peer-reviewed methodologies, and the science available at the time of that process. Those estimates were subject to public comment in the context of dozens of proposed rulemakings as well as in a dedicated public comment period in 2013.

There are a number of limitations and uncertainties associated with the SC–GHG estimates. First, the current scientific and economic understanding of discounting approaches suggests discount rates appropriate for intergenerational analysis in the context of climate change are likely to be less than 3 percent, near 2 percent or lower.[85] Second, the IAMs used to produce these interim estimates do not include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature and the science underlying their ''damage functions''—*i.e.,* the core parts of the IAMs that map global mean temperature changes and other physical impacts of climate change into economic (both market and nonmarket) damages—lags behind the most recent research. For example, limitations include the incomplete treatment of catastrophic and non-catastrophic impacts in the integrated assessment models, their incomplete treatment of adaptation and technological change, the incomplete way in which inter-regional and intersectoral linkages are modeled, uncertainty in the extrapolation of damages to high temperatures, and inadequate representation of the relationship between the discount rate and uncertainty in economic growth over long time horizons. Likewise, the socioeconomic and emissions scenarios used as inputs to the models do not reflect new information from the last decade of scenario generation or the full range of projections. The modeling limitations do not all work in the same direction in terms of their influence on the SC–CO_2 estimates. However, as discussed in the February 2021 TSD, the IWG has recommended that, taken together, the limitations suggest that the interim SC–GHG estimates used in this final rule likely underestimate the damages from GHG emissions. DOE concurs with this assessment.

DOE's derivations of the SC–GHG (*i.e.,* SC–CO_2, SC–N_2O, and SC–CH_4) values used for this direct final rule are discussed in the following sections, and the results of DOE's analyses estimating the benefits of the reductions in emissions of these pollutants are presented in section V.B.6 of this document.

NEMA disagrees with DOE's approach for estimating monetary benefits associated with emissions reductions. NEMA commented that this topic is too convoluted and subjective to be included in a rulemaking analysis for electric motor standards.(NEMA, No. 22 at p. 25)

As previously stated, as part of the development of this direct final rule, for the purpose of complying with the requirements of Executive Order 12866, DOE considered the estimated monetary benefits from the reduced emissions of CO_2, CH_4, N_2O, NO_X, and SO_2 that are expected to result from each of the TSLs considered.

a. Social Cost of Carbon

The SC–CO_2 values used for this direct final rule were generated using the values presented in the 2021 update from the IWG's February 2021 TSD. Table IV–11 shows the updated sets of SC–CO_2 estimates from the latest interagency update in 5-year increments from 2020 to 2050. The full set of annual values used is presented in Appendix 14–A of the direct final rule TSD. For purposes of capturing the uncertainties involved in regulatory impact analysis, DOE has determined it is appropriate include all four sets of SC–CO_2 values, as recommended by the IWG.[86]

TABLE IV–11—ANNUAL SC–CO_2 VALUES FROM 2021 INTERAGENCY UPDATE, 2020–2050

[2020$ per metric ton CO_2]

Year	Discount rate			
	5% Average	3% Average	2.5% Average	3% 95th percentile
2020	14	51	76	152
2025	17	56	83	169
2030	19	62	89	187
2035	22	67	96	206
2040	25	73	103	225
2045	28	79	110	242
2050	32	85	116	260

For 2051 to 2070, DOE used SC–CO_2 estimates published by EPA, adjusted to 2020$.[87] These estimates are based on methods, assumptions, and parameters identical to the 2020–2050 estimates published by the IWG. DOE expects additional climate benefits to accrue for any longer-life electric motors after 2070, but a lack of available SC–CO_2 estimates for emissions years beyond 2070 prevents DOE from monetizing these potential benefits in this analysis.

[85] Interagency Working Group on Social Cost of Greenhouse Gases (IWG). 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. February. United States Government. Available at: *www.whitehouse.gov/briefing-room/blog/2021/02/26/a-return-to-science-evidence-based-estimates-of-the-benefits-of-reducing-climate-pollution/.*

[86] For example, the February 2021 TSD discusses how the understanding of discounting approaches suggests that discount rates appropriate for intergenerational analysis in the context of climate change may be lower than 3 percent.

[87] See EPA, *Revised 2023 and Later Model Year Light-Duty Vehicle GHG Emissions Standards: Regulatory Impact Analysis,* Washington, DC, December 2021. Available at: *www.epa.gov/system/files/documents/2021-12/420r21028.pdf* (last accessed January 13, 2022).

DOE multiplied the CO_2 emissions reduction estimated for each year by the SC–CO_2 value for that year in each of the four cases. DOE adjusted the values to 2021$ using the implicit price deflator for gross domestic product (''GDP'') from the Bureau of Economic Analysis. 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–CO_2 values in each case.

b. Social Cost of Methane and Nitrous Oxide

The SC–CH_4 and SC–N_2O values used for this direct final rule were based on the values developed for in the February 2021 TSD. Table IV–12 shows the updated sets of SC–CH_4 and SC–N_2O estimates from the latest interagency update in 5-year increments from 2020 to 2050. The full set of annual values used is presented in Appendix 14–A of the direct final rule TSD. To capture the uncertainties involved in regulatory impact analysis, DOE has determined it is appropriate to include all four sets of SC–CH_4 and SC–N_2O values, as recommended by the IWG.

TABLE IV–12—ANNUAL SC–CH_4 AND SC–N_2O VALUES FROM 2021 INTERAGENCY UPDATE, 2020–2050

[2020$ per metric ton]

Year	SC–CH_4				SC–N_2O			
	Discount rate and statistic				Discount rate and statistic			
	5% Average	3% Average	2.5% Average	3% 95th percentile	5% Average	3% Average	2.5% Average	3% 95th percentile
2020	670	1,500	2,000	3,900	5,800	18,000	27,000	48,000
2025	800	1,700	2,200	4,500	6,800	21,000	30,000	54,000
2030	940	2,000	2,500	5,200	7,800	23,000	33,000	60,000
2035	1,100	2,200	2,800	6,000	9,000	25,000	36,000	67,000
2040	1,300	2,500	3,100	6,700	10,000	28,000	39,000	74,000
2045	1,500	2,800	3,500	7,500	12,000	30,000	42,000	81,000
2050	1,700	3,100	3,800	8,200	13,000	33,000	45,000	88,000

DOE multiplied the CH_4 and N_2O emissions reduction estimated for each year by the SC–CH_4 and SC–N_2O estimates for that year in each of the cases. To calculate a present value of the stream of monetary values, DOE discounted the values in each of the cases using the specific discount rate that had been used to obtain the SC–CH_4 and SC–N_2O estimates in each case.

2. Monetization of Other Emissions Impacts

For the direct final rule, DOE estimated the monetized value of NO_X and SO_2 emissions reductions from electricity generation using benefit per ton estimates for that sector from the EPA's Benefits Mapping and Analysis Program.[88] DOE used EPA's values for $PM_{2.5}$-related benefits associated with NO_X and SO_2 and for ozone-related benefits associated with NO_X for 2025 and 2030, and 2040, calculated with discount rates of 3 percent and 7 percent. DOE used linear interpolation to define values for the years not given in the 2025 to 2040 range; for years beyond 2040 the values are held constant. DOE derived values specific to the sector for electric motors using a method described in appendix 14B of the direct final rule TSD.

DOE multiplied the site 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.

M. Utility Impact Analysis

The utility impact analysis estimates the changes in installed electrical capacity and generation projected to result for each considered TSL. The analysis is based on published output from the NEMS associated with *AEO2022*. 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 in the *AEO2022* Reference case and various side cases. Details of the methodology are provided in the appendices to chapters [13] and [15] of the direct final rule 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 potential new or amended energy conservation standards.

N. Employment Impact Analysis

DOE considers employment impacts in the domestic economy as one factor in selecting a standard. Employment impacts from new or amended energy conservation standards include both direct and indirect impacts. Direct employment impacts are any changes in the number of employees of manufacturers of the products subject to standards, their suppliers, and related service firms. The MIA addresses those impacts. Indirect employment impacts are changes in national employment that occur due to the shift in expenditures and capital investment caused by the purchase and operation of more-efficient appliances. Indirect employment impacts from standards consist of the net jobs created or eliminated in the national economy, other than in the manufacturing sector being regulated, caused by (1) reduced spending by 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

[88] *Estimating the Benefit per Ton of Reducing $PM_{2.5}$ Precursors from 21 Sectors. www.epa.gov/benmap/estimating-benefit-ton-reducing-pm25-precursors-21-sectors.*

activity in different sectors of the economy, as well as the jobs created elsewhere in the economy by this same economic activity. Data from BLS indicate that expenditures in the utility sector generally create fewer jobs (both directly and indirectly) than expenditures in other sectors of the economy.[89] 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 suggest 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 direct final rule using an input/output model of the U.S. economy called Impact of Sector Energy Technologies version 4 (''ImSET'').[90] ImSET is a special-purpose version of the ''U.S. Benchmark National Input-Output'' (''I–O'') model, which was designed to estimate the national employment and income effects of energy-saving technologies. The ImSET software includes a computer- based I–O model having structural coefficients that characterize economic flows among 187 sectors most relevant to industrial, commercial, and residential building energy use.

NEMA commented that the proposed approach for assessing national employment impacts appears to be sufficient. (NEMA, No. 22 at p. 25)

DOE notes that ImSET is not a general equilibrium forecasting model, and that 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 (2027–2031), where these uncertainties are reduced. For more details on the employment impact analysis, see chapter 16 of the direct 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 electric motors. It addresses the TSLs examined by DOE, the projected impacts of each of these levels if adopted as energy conservation standards for electric motors, and the standards levels that DOE is proposing to adopt in this direct final rule. Additional details regarding DOE's analyses are contained in the direct final rule TSD supporting this document.

A. Trial Standard Levels

In general, DOE typically evaluates potential amended standards for products and equipment by grouping individual efficiency levels for each class into TSLs. Use of TSLs allows DOE to identify and consider manufacturer cost interactions between equipment classes, to the extent that there are such interactions, and market cross elasticity from consumer purchasing decisions that may change when different standard levels are set.

In the analysis conducted for this direct final rule, DOE analyzed the benefits and burdens of four TSLs for electric motors. DOE developed TSLs that combine efficiency levels for each analyzed equipment class group by horsepower range. DOE presents the results for the TSLs in this document, while the results for all efficiency levels that DOE analyzed are in the direct final rule TSD.

Table V.1 presents the TSLs and the corresponding efficiency levels that DOE has identified for potential amended energy conservation standards for electric motors. Table V.2 presents the corresponding description of the levels.

TSL 4 represents the maximum technologically feasible (''max-tech'') energy efficiency for all equipment class groups and is constructed with the same efficiency level for all equipment class groups (*i.e.,* EL 4). (See Table IV–6 in section IV.C.1.c for a breakdown of ELs 1–4 for each ECG).

TSL 3 represents a level corresponding to the IE4 level for each equipment class group (*i.e.,* the industry standard efficiency classification above NEMA Premium/I3), except for AO–polyphase specialized frame size electric motors, where it corresponds to a lower level of efficiency (*i.e.,* NEMA Premium/I3 level) due to the physical limitation of these electric motors.

TSL 2 represents the levels recommended by the November 2022 Joint Recommendation. For currently regulated electric motors (*i.e.,* MEM, 1–500 hp, NEMA Design A and B motors), this TSL represents no changes in the current standard (*i.e.,* NEMA Premium/IE3 level, EL0), except for currently regulated motors in the 100 to 250 hp range where TSL 2 is set at an EL corresponding to the IE4 level (*i.e.,* the industry standard efficiency classification above NEMA Premium/IE3, EL1).[91] At TSL 2, MEM 501–750 hp, NEMA Design A and B electric motors are set at the NEMA Premium level (EL1). For AO–MEM standard frame size, TSL 2 is similarly constructed using the efficiency levels corresponding to the NEMA Premium/IE3 level (EL1), except in the 100 to 250 hp range of AO–MEM standard frame size motors, where it is equivalent to the IE4 level (EL2). For AO–polyphase specialized frame electric motors, TSL 2 represents the fire pump electric motor level (EL1), which is the industry standard efficiency classification approximately two bands below NEMA Premium/IE3.

TSL1 represents a level below the recommended level. TSL1 represents a level where the currently non-regulated electric motors would be subject to the same standards as currently regulated motors (*i.e.,* NEMA Premium level), except for AO–polyphase specialized frame size electric motors, where it corresponds to a lower level of efficiency (*i.e.,* fire pump electric motor level) due to the physical limitation of these electric motors. For currently regulated electric motors (*i.e.,* MEM, 1–500 hp, NEMA Design A and B motors), this TSL would represent no changes in the current standard.

[89] 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* (last accessed September 30, 2022).

[90] Livingston, O.V., S.R. Bender, M.J. Scott, and R.W. Schultz. *ImSET 4.0: Impact of Sector Energy Technologies Model Description and User Guide.* 2015. Pacific Northwest National Laboratory: Richland, WA. PNNL–24563.

[91] As noted, this TSL would harmonize with the current European energy conservation standards (compliance date July, 2023). See *eur-lex.europa.eu/eli/reg/2019/1781/oj.*

TABLE V.1—TRIAL STANDARD LEVELS FOR ELECTRIC MOTORS

Equipment class group	Horsepower range	Trial standard level 1	Trial standard level 2	Trial standard level 3	Trial standard level 4
		Efficiency level			
MEM, 1–500 hp, NEMA Design A and B	1 ≤ hp ≤ 5	0	0	1	4
	5 < hp ≤ 20	0	0	1	4
	20 < hp ≤ 50	0	0	1	4
	50 < hp <100	0	0	1	4
	100 ≤ hp ≤ 250	0	1	1	4
	250 < hp ≤ 500	0	0	1	4
MEM, 501–750 hp, NEMA Design A and B	500 < hp ≤ 750	1	1	2	4
AO–MEM (Standard Frame Size)	1 ≤ hp ≤ 20	1	1	2	4
	20 < hp ≤ 50	1	1	2	4
	50 < hp < 100	1	1	2	4
	100 ≤ hp ≤ 250	1	2	2	4
AO–Polyphase (Specialized Frame Size)	1 ≤ hp ≤ 20	1	1	2	4

TABLE V.2—DESCRIPTION OF TRIAL STANDARD LEVELS FOR ELECTRIC MOTORS

ECG	Horsepower range	Trial standard level 1	Trial standard level 2	Trial standard level 3	Trial standard level 4
		Efficiency level description			
		NEMA premium *	Recommended	IE4 *	Max-tech
MEM, 1–500 hp, NEMA Design A and B.	1 ≤ hp ≤ 5	Premium/IE3	Premium/IE3	Super Premium/IE4	Max-tech.
	5 < hp ≤ 20	Premium/IE3	Premium/IE3	Super Premium/IE4	Max-tech.
	20 < hp ≤ 50	Premium/IE3	Premium/IE3	Super Premium/IE4	Max-tech.
	50 < hp <100	Premium/IE3	Premium/IE3	Super Premium/IE4	Max-tech.
	100 ≤ hp ≤ 250	Premium/IE3	Super Premium/IE4	Super Premium/IE4	Max-tech.
	250 < hp ≤ 500	Premium/IE3	Premium/IE3	Super Premium/IE4	Max-tech.
MEM, 501–750 hp, NEMA Design A and B.	500 < hp ≤ 750	Premium/IE3	Premium/IE3	Super Premium/IE4	Max-tech.
AO–MEM (Standard Frame Size).	1 ≤ hp ≤ 20	Premium/IE3	Premium/IE3	Super Premium/IE4	Max-tech.
	20 < hp ≤ 50	Premium/IE3	Premium/IE3	Super Premium/IE4	Max-tech.
	50 < hp < 100	Premium/IE3	Premium/IE3	Super Premium/IE4	Max-tech.
	100 ≤ hp ≤ 250	Premium/IE3	Super Premium/IE4	Super Premium/IE4	Max-tech.
AO–Polyphase (Specialized Frame Size).	1 ≤ hp ≤ 20	Fire pump	Fire pump	Premium/IE3	Max-tech.

* Except for AO–Polyphase (Specialized Frame Size) electric motors where the efficiency level corresponds to a lower efficiency.

DOE constructed the TSLs for this direct final rule to include ELs representative of ELs with similar characteristics (*i.e.,* using similar technologies and/or efficiencies, and having roughly comparable equipment availability). The use of representative ELs provided for greater distinction between the TSLs. While representative ELs were included in the TSLs, DOE considered all efficiency levels as part of its analysis.[92] In constructing the TSLs, DOE did not consider EL3 because the average LCC savings at EL3 were negative for all representative units, with a majority of consumers experiencing net cost as shown in section V.B.1.a of this document. Similarly, DOE did not consider a TSL with EL2 for the MEM, 1–500 hp, NEMA Design A and B electric motors because the average LCC savings at EL 2 were negative for each of the representative units analyzed, with a majority of consumers experiencing net cost as shown in section V.B.1.a of this document.

[92] Efficiency levels that were analyzed for this final rule are discussed in section IV.C of this document. Results by efficiency level are presented in TSD chapter 8.

B. Economic Justification and Energy Savings

1. Economic Impacts on Individual Consumers

DOE analyzed the economic impacts on electric motors consumers by looking at the effects that new and amended standards at each TSL would have on the LCC and PBP. DOE also examined the impacts of potential standards on selected consumer subgroups. These analyses are discussed in the following sections.

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 direct final rule TSD provides detailed information on the LCC and PBP analyses.

As described in Table IV–4 of this document, the analysis focuses on 11 representative units identified in the engineering analysis. Table V–3 through Table V–24 show the LCC and PBP results for the TSLs considered for each representative unit. In the first of each pair of tables, the simple payback is measured relative to the baseline product. In the second table, impacts are measured relative to the efficiency distribution in the no-new-standards case in the compliance year (see section IV.F.8 of this document). 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–3—AVERAGE LCC AND PBP RESULTS FOR MEM, NEMA DESIGN A AND B; 5 hp, 4 POLES, ENCLOSED

[RU1]

TSL	Efficiency level	Average costs (2021$)				Simple payback (years)	Average lifetime (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC		
1–2	Baseline	1,185.5	789.9	5,754.2	6,939.6		12.6
3	EL1	1,356.8	779.7	5,684.8	7,041.6	16.7	12.6
	EL2 *	1,356.8	779.7	5,684.8	7,041.6	16.7	12.6
	EL3	1,408.0	773.7	5,643.8	7,051.8	13.7	12.6
4	EL4	1,620.1	768.5	5,616.7	7,236.8	20.3	12.6

* EL1 = EL2.

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–4—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR MEM, NEMA DESIGN A AND B; 5 hp, 4 POLES, ENCLOSED

[RU1]

TSL	Efficiency level	Life-cycle cost savings	
		Average LCC savings ** (2021$)	Percent of consumers that experience net cost
1–2	Baseline	N/A	N/A
3	EL1	−101.8	64.1
	EL2 *	−101.8	64.1
	EL3	−92.3	76.4
4	EL4	−276.4	95.9

The entry "N/A" means not applicable because there is no change in the standard at certain TSLs.

* EL1 = EL2.

** The savings represent the average LCC for affected consumers.

TABLE V–5—AVERAGE LCC AND PBP RESULTS FOR MEM, NEMA DESIGN A AND B; 30 hp, 4 POLES, ENCLOSED

[RU2]

TSL	Efficiency level	Average costs (2021$)				Simple payback (years)	Average lifetime (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC		
1–2	Baseline	3,274.2	4,568.5	37,700.8	40,975.0		14.1
3	EL1	3,964.7	4,523.7	37,347.1	41,311.9	15.4	14.1
	EL2 *	3,964.7	4,523.7	37,347.1	41,311.9	15.4	14.1
	EL3	4,175.1	4,502.3	37,174.6	41,349.7	13.6	14.1
4	EL4	4,277.2	4,484.2	37,026.9	41,304.1	11.9	14.1

* EL1 = EL2.

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–6—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR MEM, NEMA DESIGN A AND B; 30 hp, 4 POLES, ENCLOSED

[RU2]

TSL	Efficiency level	Life-cycle cost savings	
		Average LCC savings ** (2021$)	Percent of consumers that experience net cost
1–2	Baseline	N/A	N/A
3	EL1	−336.9	82.2
	EL2 *	−336.9	82.2
	EL3	−356.9	81.1
4	EL4	−309.4	75.0

The entry "N/A" means not applicable because there is no change in the standard at certain TSLs.
* EL1 = EL2.
** The savings represent the average LCC for affected consumers.

TABLE V–7—AVERAGE LCC AND PBP RESULTS FOR MEM, NEMA DESIGN A AND B; 75 hp, 4 POLES, ENCLOSED

[RU3]

TSL	Efficiency level	Average costs (2021$)				Simple payback (years)	Average lifetime (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC		
1–2	Baseline	8,046.4	10,021.1	83,400.1	91,446.5		14.2
3	EL1	9,288.2	9,979.9	83,074.6	92,362.8	30.2	14.2
	EL2	9,811.9	9,956.1	82,879.4	92,691.3	27.2	14.2
	EL3	10,177.1	9,925.6	82,631.4	92,808.5	22.3	14.2
4	EL4	10,636.4	9,895.3	82,386.0	93,022.4	20.6	14.2

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–8—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR MEM, NEMA DESIGN A AND B; 75 hp, 4 POLES, ENCLOSED

[RU3]

TSL	Efficiency level	Life-cycle cost savings	
		Average LCC savings * (2021$)	Percent of consumers that experience net cost
1–2	Baseline	N/A	N/A
3	EL1	−916.7	88.4
	EL2	−1,229.6	86.0
	EL3	−1,258.0	89.0
4	EL4	−1,439.6	90.5

The entry "N/A" means not applicable because there is no change in the standard at certain TSLs.
* The savings represent the average LCC for affected consumers.

TABLE V–9—AVERAGE LCC AND PBP RESULTS FOR MEM, NEMA DESIGN A AND B; 150 hp, 4 POLES, ENCLOSED

[RU4]

TSL	Efficiency level	Average costs (2021$)				Simple payback (years)	Average lifetime (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC		
1	Baseline	13,066.4	20,576.9	243,710.9	256,777.2		33.4
2–3	EL1	13,414.0	20,492.3	242,797.2	256,211.3	4.1	33.4
	EL2	15,941.3	20,467.3	243,214.8	259,156.1	26.2	33.4
	EL3	16,547.4	20,404.6	242,661.3	259,208.7	20.2	33.4
4	EL4	17,308.4	20,342.2	242,143.9	259,452.3	18.1	33.4

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–10—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR MEM, NEMA DESIGN A AND B; 150 hp, 4 POLES, ENCLOSED

[RU4]

TSL	Efficiency level	Life-cycle cost savings	
		Average LCC savings* (2021$)	Percent of consumers that experience net cost
1	Baseline	N/A	N/A
2–3	EL1	567.1	20.2
	EL2	−2,424.3	90.1
	EL3	−2,314.5	90.3
4	EL4	−2,541.1	89.1

The entry "N/A" means not applicable because there is no change in the standard at certain TSLs.
* The savings represent the average LCC for affected consumers.

TABLE V–11—AVERAGE LCC AND PBP RESULTS FOR MEM, NEMA DESIGN A AND B; 350 hp, 4 POLES, ENCLOSED

[RU5]

TSL	Efficiency level	Average costs (2021$)				Simple payback (years)	Average lifetime (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC		
1–2	Baseline	26,409.6	47,899.8	563,544.0	589,953.6		33.4
3	EL1	29,815.6	47,610.1	561,091.1	590,906.6	11.8	33.4
	EL2*	29,815.6	47,610.1	561,091.1	590,906.6	11.8	33.4
	EL3	33,572.3	47,548.0	561,385.2	594,957.5	20.4	33.4
4	EL4	35,153.9	47,405.2	560,142.3	595,296.2	17.7	33.4

* EL1 = EL2.
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–12—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR MEM, NEMA DESIGN A AND B; 350 hp, 4 POLES, ENCLOSED

[RU5]

TSL	Efficiency level	Life-cycle cost savings	
		Average LCC savings** (2021$)	Percent of consumers that experience net cost
1–2	Baseline	N/A	N/A
3	EL1	−945.5	66.9
	EL2*	−945.5	66.9
	EL3	−4,918.5	92.4
4	EL4	−5,257.2	89.0

The entry "N/A" means not applicable because there is no change in the standard at certain TSLs.
* EL1 = EL2.
** The savings represent the average LCC for affected consumers.

TABLE V–13—AVERAGE LCC AND PBP RESULTS FOR MEM, NEMA DESIGN A AND B; 600 hp, 4 POLES, ENCLOSED

[RU6]

TSL	Efficiency level	Average costs (2021$)				Simple payback (years)	Average lifetime (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC		
	Baseline	40,229.5	83,393.4	980,309.1	1,020,538.6		33.5
1–2	EL1	41,466.0	83,054.7	976,644.0	1,018,109.9	3.7	33.5
3	EL2	46,889.6	82,698.8	973,798.2	1,020,687.7	9.6	33.5
	EL3*	46,889.6	82,698.8	973,798.2	1,020,687.7	9.6	33.5
4	EL4	55,293.3	82,201.3	970,160.6	1,025,454.0	12.6	33.5

* EL2 = EL3.
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–14—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR MEM, NEMA DESIGN A AND B; 600 hp, 4 POLES, ENCLOSED

[RU6]

TSL	Efficiency level	Life-cycle cost savings	
		Average LCC savings ** (2021$)	Percent of consumers that experience net cost
	Baseline		
1–2	EL1	2,550.1	2.1
3	EL2	−2,287.8	58.3
	EL3 *	−2,287.8	58.3
4	EL4	−6,710.3	83.2

* EL2 = EL3.
** The savings represent the average LCC for affected consumers.

TABLE V–15—AVERAGE LCC AND PBP RESULTS FOR AO MEM (STANDARD FRAME SIZE); 5 hp, 4 POLES, ENCLOSED

[RU7]

TSL	Efficiency level	Average costs (2021$)				Simple payback (years)	Average lifetime (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC		
	Baseline	1,126.0	992.2	6,734.4	7,860.4		11.8
1–2	EL1	1,214.2	970.4	6,589.4	7,803.6	4.0	11.8
3	EL2	1,331.6	960.7	6,531.3	7,862.8	6.5	11.8
	EL3	1,331.6	960.7	6,531.3	7,862.8	6.5	11.8
4	EL4	1,525.2	947.7	6,455.8	7,981.0	9.0	11.8

* EL3 = EL2.
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–16—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR AO MEM (STANDARD FRAME SIZE); 5 hp, 4 POLES, ENCLOSED

[RU7]

TSL	Efficiency level	Life-cycle cost savings	
		Average LCC savings ** (2021$)	Percent of consumers that experience net cost
	Baseline		
1–2	EL1	57.6	10.3
3	EL2	−39.2	62.9
	EL3 *	−39.2	62.9
4	EL4	−156.5	80.7

* EL2 = EL3.
** The savings represent the average LCC for affected consumers.

TABLE V–17—AVERAGE LCC AND PBP RESULTS FOR AO MEM (STANDARD FRAME SIZE); 30 hp, 4 POLES, ENCLOSED

[RU8]

TSL	Efficiency level	Average costs (2021$)				Simple payback (years)	Average lifetime (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC		
	Baseline	3,186.7	5,553.3	44,668.1	47,854.8		13.7
1–2	EL1	3,302.6	5,482.2	44,098.8	47,401.4	1.6	13.7
3	EL2	3,925.6	5,428.3	43,681.1	47,606.7	5.9	13.7
	EL3 *	3,925.6	5,428.3	43,681.1	47,606.7	5.9	13.7
4	EL4	4,214.4	5,384.7	43,337.1	47,551.4	6.1	13.7

* EL3 = EL2.
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–18—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR AO MEM (STANDARD FRAME SIZE); 30 hp, 4 POLES, ENCLOSED

[RU8]

TSL	Efficiency level	Life-cycle cost savings	
		Average LCC savings** (2021$)	Percent of consumers that experience net cost
	Baseline		
1–2	EL1	472.4	0.9
3	EL2	−160.8	73.9
	EL3*	−160.8	73.9
4	EL4	−105.5	64.5

* EL2 = EL3.

** The savings represent the average LCC for affected consumers.

TABLE V–19—AVERAGE LCC AND PBP RESULTS FOR AO MEM (STANDARD FRAME SIZE); 75 hp, 4 POLES, ENCLOSED

[RU9]

TSL	Efficiency level	Average costs (2021$)				Simple payback (years)	Average lifetime (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC		
	Baseline	6,905.6	13,470.2	104,380.5	111,286.0		13.3
1–2	EL1	7,850.5	13,291.7	103,149.1	110,999.7	5.3	13.3
3	EL2	8,995.7	13,237.8	102,934.5	111,930.2	9.0	13.3
	EL3	9,505.8	13,227.0	102,934.8	112,440.6	10.7	13.3
4	EL4	10,331.4	13,147.4	102,463.3	112,794.6	10.6	13.3

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–20—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR AO MEM (STANDARD FRAME SIZE); 75 hp, 4 POLES, ENCLOSED

[RU9]

TSL	Efficiency level	Life-cycle cost savings	
		Average LCC savings** (2021$)	Percent of consumers that experience net cost
	Baseline		
1–2	EL1*		
3	EL2	−930.5	99.9
	EL3	−1,441.0	98.4
4	EL4	−1,795.0	96.4

* No savings at EL1 as there are no shipments at the baseline for RU9. See Table IV–9 of this document.

** The savings represent the average LCC for affected consumers.

TABLE V–21—AVERAGE LCC AND PBP RESULTS FOR AO MEM (STANDARD FRAME SIZE); 150 hp, 4 POLES, ENCLOSED

[RU10]

TSL	Efficiency level	Average costs (2021$)				Simple payback (years)	Average lifetime (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC		
	Baseline	11,557.8	26,565.2	296,595.2	308,153.0		31.4
1	EL1	12,862.9	26,349.5	294,637.7	307,500.7	6.1	31.4
2–3	EL2	13,119.9	26,243.0	293,559.4	306,679.3	4.9	31.4
	EL3*	15,651.8	26,253.2	294,598.5	310,250.3	13.1	31.4
4	EL4	16,290.6	26,095.5	293,085.9	309,376.5	10.1	31.4

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.

* At EL3, for RU10, the increase in motor speed compared to the baseline is greater than the increase in motor speed at EL2 compared to the baseline (see section IV.C.1.c of this document). The additional energy use due to the increase in motor speed at EL3 results in lower energy savings and higher operating costs at EL3 compared to EL2. See section IV.E.4 of this document for a detailed explanation of the impact of speed.

TABLE V–22—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR AO MEM (STANDARD FRAME SIZE); 150 hp, 4 POLES, ENCLOSED

[RU10]

TSL	Efficiency level	Life-cycle cost savings	
		Average LCC savings * (2021$)	Percent of consumers that experience net cost
	Baseline		
1	EL1	608.8	6.3
2–3	EL2	930.7	11.7
	EL3	−2,720.3	93.7
4	EL4	−1,846.6	79.0

* The savings represent the average LCC for affected consumers.

TABLE V–23—AVERAGE LCC AND PBP RESULTS FOR POLYPHASE (SPECIALIZED FRAME SIZE); 5 hp, 4 POLES, ENCLOSED

[RU11]

TSL	Efficiency level	Average costs (2021$)				Simple payback (years)	Average Lifetime (years)
		Installed cost	First year's operating cost	Lifetime operating cost	LCC		
	Baseline	1,134.3	993.4	6,899.6	8,033.9		11.9
1–2	EL1	1,225.1	971.1	6,758.9	7,984.0	4.1	11.9
3	EL2	1,342.9	956.1	6,688.5	8,031.3	5.6	11.9
	EL3	1,539.1	942.1	6,648.0	8,187.0	7.9	11.9
4	EL4 *	1,539.1	942.1	6,648.0	8,187.0	7.9	11.9

* EL3 = EL4.

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–24—AVERAGE LCC SAVINGS RELATIVE TO THE NO-NEW-STANDARDS CASE FOR AO–POLYPHASE (SPECIALIZED FRAME SIZE); 5 hp, 4 POLES, ENCLOSED

[RU11]

TSL	Efficiency level	Life-cycle cost savings	
		Average LCC savings * (2021$)	Percent of consumers that experience net cost
	Baseline		
1–2	EL1	49.9	32.1
3	EL2	2.5	53.4
	EL3	−153.2	74.5
4	EL4 *	−153.2	74.5

* EL3 = EL4.

** The savings represent the average LCC for affected consumers.

b. Consumer Subgroup Analysis

In the consumer subgroup analysis, DOE estimated the impact of the considered TSLs on small businesses. Table V–25 compares the average LCC savings and PBP at each efficiency level for the consumer subgroups with similar metrics for the entire consumer sample for electric motors. For the subgroup analysis, the only input change to the LCC calculation is the discount rate applied. Therefore, the simple paybacks remain identical for small businesses compared to the whole sample. In all cases, the average LCC savings and PBP for small businesses at the considered efficiency levels are reduced compared to the average for all consumers. Chapter 11 of the direct final rule TSD presents the complete LCC and PBP results for the subgroups.

TABLE V–25—COMPARISON OF LCC SAVINGS AND PBP FOR SMALL BUSINESS CONSUMER SUBGROUPS AND ALL CONSUMERS

TSL	EL	Average LCC savings* (2021$)		Simple payback (years)	
		Small businesses	All businesses	Small businesses	All businesses
MEM, NEMA Design A and B; 5 hp, 4 poles, enclosed (RU1)					
1–2	0	N/A	N/A	N/A	N/A
3	1	−108.5	−101.8	16.7	16.7
	2	−108.5	−101.8	16.7	16.7
	3	−101.7	−92.3	13.3	13.3
4	4	−288.0	−276.4	20.7	20.7
MEM, NEMA Design A and B; 30 hp, 4 poles, enclosed (RU2)					
1–2	0	N/A	N/A	N/A	N/A
3	1	−376.7	−336.9	15.4	15.4
	2	−376.7	−336.9	15.4	15.4
	3	−414.2	−356.9	13.6	13.6
4	4	−383.3	−309.4	11.8	11.8
MEM, NEMA Design A and B; 75 hp, 4 poles, enclosed (RU3)					
1–2	0	N/A	N/A	N/A	N/A
3	1	−954.2	−916.7	30.3	30.3
	2	−1,290.1	−1229.6	27.1	27.1
	3	−1,342.9	−1258.0	22.0	22.0
4	4	−1,550.9	−1439.6	20.3	20.3
MEM, NEMA Design A and B; 150 hp, 4 poles, enclosed (RU4)					
1	0	N/A	N/A	N/A	N/A
2–3	1	398.4	567.1	4.1	4.1
	2	−2,471.1	−2424.3	27.6	27.6
	3	−2,454.5	−2314.5	20.5	20.5
4	4	−2,768.0	−2541.1	18.2	18.2
MEM, NEMA Design A and B; 350 hp, 4 poles, enclosed (RU5)					
1–2	0	N/A	N/A	N/A	N/A
3	1	−1,362.7	−945.5	11.7	11.7
	2	−1,362.7	−945.5	11.7	11.7
	3	−5,206.4	−4918.5	20.9	20.9
4	4	−5,758.3	−5257.2	17.9	17.9
MEM, NEMA Design A and B; 600 hp, 4 poles, enclosed (RU6)					
	0	....	....	....	....
1–2	1	1,865.7	2550.1	3.6	3.6
3	2	−2,854.2	−2287.8	14.1	14.1
	3	−2,854.2	−2287.8	14.1	14.1
4	4	−7,771.5	−6710.3	15.8	15.8
AO–MEM (Standard Frame Size); 5 hp, 4 poles, enclosed (RU7)					
	0	....	....	....	....
1–2	1	44.1	57.6	4.0	4.0
3	2	−49.0	−39.2	8.6	8.6
	3	−49.0	−39.2	8.6	8.6
4	4	−172.7	−156.5	11.4	11.4
AO–MEM (Standard Frame Size); 30 hp, 4 poles, enclosed (RU8)					
	0	....	....	....	....
1–2	1	407.9	472.4	1.6	1.6
3	2	−213.1	−160.8	10.4	10.4
	3	−213.1	−160.8	10.4	10.4
4	4	−196.1	−105.5	8.8	8.8
AO–MEM (Standard Frame Size); 75 hp, 4 poles, enclosed (RU9)					
	0	....	....	....	....
1–2	*1	....	....	....	....

TABLE V–25—COMPARISON OF LCC SAVINGS AND PBP FOR SMALL BUSINESS CONSUMER SUBGROUPS AND ALL CONSUMERS—Continued

TSL	EL	Average LCC savings * (2021$)		Simple payback (years)	
		Small businesses	All businesses	Small businesses	All businesses
3	2	−947.0	−930.5	21.2	21.2
	3	−1,454.5	−1,441.0	25.6	25.6
4	4	−1,854.7	−1795.0	17.2	17.2
AO–MEM (Standard Frame Size); 150 hp, 4 poles, enclosed (RU10)					
	0	....	....	....	....
1	1	292.7	608.8	6.1	6.1
2–3	2	691.0	930.7	3.4	3.4
	3	−2,732.4	−2720.3	24.5	24.5
4	4	−2,111.7	−1846.6	13	13
AO–Polyphase (Specialized Frame Size); 5 hp, 4 poles, enclosed (RU11)					
	0	....	....	....	....
1–2	1	37.0	49.9	4.1	4.1
3	2	−16.1	2.5	5.6	5.6
	3	−173.9	−153.2	7.9	7.9
4	4	−173.9	−153.2	7.9	7.9

The entry "N/A" means not applicable because there is no change in the standard at certain TSLs.
* No savings at EL1 as there are no shipments at the baseline for RU9. See Table IV–9 of this document.

c. Rebuttable Presumption Payback

As discussed in section III.F.2, EPCA establishes a rebuttable presumption that an energy conservation standard is economically justified if the increased purchase cost for 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 electric motors. In contrast, the PBPs presented in section V.B.1.a were calculated using distributions that reflect the range of energy use in the field.

Table V–26 presents the rebuttable-presumption payback periods for the considered TSLs for electric motors. While DOE examined the rebuttable-presumption criterion, it considered whether the standard levels considered for the direct final 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–26—REBUTTABLE-PRESUMPTION PAYBACK PERIODS

Representative unit	Rebuttable payback period (years)			
	TSL 1	TSL 2	TSL 3	TSL 4
MEM, NEMA Design A and B; 5 hp, 4 poles, enclosed (RU1)	N/A	N/A	12.6	15.1
MEM, NEMA Design A and B; 30 hp, 4 poles, enclosed (RU2)	N/A	N/A	11.4	8.8
MEM, NEMA Design A and B; 75 hp, 4 poles, enclosed (RU3)	N/A	N/A	21.6	14.9
MEM, NEMA Design A and B; 150 hp, 4 poles, enclosed (RU4)	N/A	3.0	3.0	12.9
MEM, NEMA Design A and B; 350 hp, 4 poles, enclosed (RU5)	N/A	N/A	8.5	12.9
MEM, NEMA Design A and B; 600 hp, 4 poles, enclosed (RU6)	2.7	2.7	6.9	9.2
AO–MEM (Standard Frame Size); 5 hp, 4 poles, enclosed (RU7)	3.1	3.1	5.0	6.9
AO–MEM (Standard Frame Size); 30 hp, 4 poles, enclosed (RU8)	1.2	1.2	4.5	4.6
AO–MEM (Standard Frame Size); 75 hp, 4 poles, enclosed (RU9) *	....	....	6.6	7.8
AO–MEM (Standard Frame Size); 150 hp, 4 poles, enclosed (RU10)	4.4	3.5	3.5	7.3
AO–Polyphase (Specialized Frame Size); 5 hp, 4 poles, enclosed (RU11)	3.1	3.1	4.2	5.9

The entry "N/A" means not applicable because there is no change in the standard at certain TSLs.
* No payback at TSL1 and TSL2 (EL1) as there are no shipments at the baseline for RU9. See Table IV–9 of this document.

2. Economic Impacts on Manufacturers

DOE performed an MIA to estimate the impact of new and amended energy conservation standards on manufacturers of electric motors. The following section describes the expected impacts on manufacturers at each considered TSL. Chapter 12 of the direct 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. The following tables summarize the estimated financial impacts (represented by changes in INPV) of potential new and amended energy conservation standards on manufacturers of electric motors, as well as the conversion costs that DOE estimates manufacturers of electric motors would incur at each TSL.

To evaluate the range of cash flow impacts on the electric motor industry, DOE modeled two manufacturer markup scenarios that correspond to the range of possible market responses to new and amended standards. Each manufacturer markup scenario results in a unique set of cash flows and corresponding INPVs at each TSL.

In the following discussion, the INPV results refer to the difference in industry value between the no-new-standards case and the standards cases that result from the sum of discounted cash flows from the reference year (2023) through the end of the analysis period (2056). The results also discuss the difference in cash flows between the no-new standards case and the standards cases in the year before the estimated compliance date for new and amended energy conservation standards. This figure represents the size of the required conversion costs relative to the cash flow generated by the electric motor industry in the absence of new and amended energy conservation standards.

To assess the upper (less severe) end of the range of potential impacts on electric motors manufacturers, DOE modeled a preservation of gross margin scenario. This scenario assumes that in the standards cases, electric motor manufacturers will be able to pass along all the higher MPCs required for more efficient equipment to their customers. Specifically, the industry will be able to maintain its average no-new-standards case gross margin (as a percentage of revenue) despite the higher production costs in the standards cases. In general, the larger the MPC increases, the less likely manufacturers are to achieve the cash flow from operations calculated in this scenario because it is less likely that manufacturers will be able to fully markup these larger production cost increases.

To assess the lower (more severe) end of the range of potential impacts on the electric motor manufacturers, DOE modeled a preservation of operating profit scenario. This scenario represents the lower end of the range of impacts on manufacturers because no additional operating profit is earned on the higher MPCs, eroding profit margins as a percentage of total revenue.

TABLE V–27—MANUFACTURER IMPACT ANALYSIS FOR ELECTRIC MOTORS—PRESERVATION OF GROSS MARGIN SCENARIO

	Units	No-new-standards case	Trial standard level			
			1	2	3	4
INPV	*2021$ millions*	5,023	4,899	4,720	4,681	(3,840)
Change in INPV	*2021$ millions*		(124)	(303)	(342)	(8,863)
	%		(2.5)	(6.0)	(6.8)	(176.4)
Product Conversion Costs	*2021$ millions*		159	296	870	6,285
Capital Conversion Costs	*2021$ millions*		31	173	748	7,231
Total Conversion Costs	*2021$ millions*		190	468	1,618	13,516

TABLE V–28—MANUFACTURER IMPACT ANALYSIS FOR ELECTRIC MOTORS—PRESERVATION OF OPERATING PROFIT SCENARIO

	Units	No-new-standards case	Trial standard level			
			1	2	3	4
INPV	*2021$ millions*	5,023	4,896	4,690	3,659	(6,066)
Change in INPV	*2021$ millions*		(127)	(333)	(1,364)	(11,090)
	%		(2.5)	(6.6)	(27.2)	(220.8)
Product Conversion Costs	*2021$ millions*		159	296	870	6,285
Capital Conversion Costs	*2021$ millions*		31	173	748	7,231
Total Conversion Costs	*2021$ millions*		190	468	1,618	13,516

TSL 1 sets the efficiency level at baseline for all MEM, 1–500 hp, NEMA Design A and B; and at EL 1 for all MEM, 501–750 hp, NEMA Design A and B, for all AO–MEM 1–250 hp (standard frame size), and for all AO–Polyphase 1–20 hp (specialized frame size). At TSL 1, DOE estimates impacts on INPV will range from −$127 million to −$124 million, which represents a change in INPV of approximately −2.5 percent (for both values, when rounded to the nearest tenth of a percent). At TSL 1, industry free cash flow (operating cash flow minus capital expenditures) is estimated to decrease to $272 million, or a drop of 21 percent, compared to the no-new-standards case value of $343 million in 2026, the year leading up to the compliance date of new and amended energy conservation standards.

In the absence of new or amended energy conservation standards, DOE estimates that all MEM, 1–500 hp, NEMA Design A and B; 90 percent of MEM, 501–750 hp, NEMA Design A and B; 73 percent of the AO–MEM 1–250 hp (standard frame size); and none of the AO–Polyphase 1–20 hp (specialized frame size) shipments will meet or exceed the ELs required at TSL 1 in 2027, the compliance year of new and amended standards.

DOE does not expect manufacturers to incur any product or capital conversion costs for MEM, 1–500 hp, NEMA Design A and B at TSL 1, since standards are set at baseline at TSL 1 for these electric motors. For the rest of the electric motors covered by this rulemaking, DOE estimates that manufacturers will incur approximately $159 million in product conversion costs and approximately $31 million in capital conversion costs. Product conversion costs primarily include engineering time to redesign non-compliance electric motor models and to re-test these newly redesigned models to meet the standards set at TSL 1. Capital conversion costs include the purchase of lamination die sets, winding machines, frame casts, and assembly equipment as well as other retooling costs for MEM, 501–750 hp, NEMA Design A and B and for all AO–MEM 1–250 hp (standard frame size) and all AO–Polyphase 1–20 hp (specialized frame size) electric motors covered by this rulemaking.

At TSL 1, under the preservation of gross margin scenario, the shipment weighted average MPC increases slightly by approximately 0.1 percent relative to the no-new-standards case MPC. This slight price increase is outweighed by the $190 million in total conversion costs estimated at TSL 1, resulting in slightly negative INPV impacts at TSL 1 under the preservation of gross margin scenario.

Under the preservation of operating profit scenario, manufacturers earn the same nominal operating profit as would be earned in the no-new-standards case, but manufacturers do not earn additional profit from their investments. The slight increase in the shipment weighted average MPC results in a slightly lower average manufacturer margin. This slightly lower average manufacturer margin and the $190 million in total conversion costs result in slightly negative INPV impacts at TSL 1 under the preservation of operating profit scenario.

TSL 2 sets the efficiency level at baseline for all MEM, 1–99 hp and 251–500 hp, NEMA Design A and B; at EL 1 for all MEM, 100–250 hp and 501–750 hp, NEMA Design A and B, for all AO–MEM 1–99 hp (standard frame size), and for all AO–Polyphase 1–20 hp (specialized frame size); and at EL 2 for all AO–MEM 100–250 hp (standard frame size). At TSL 2, DOE estimates impacts on INPV will range from −$333 million to −$303 million, which represents a change in INPV of approximately −6.6 percent to −6.0 percent, respectively. At TSL 2, industry free cash flow (operating cash flow minus capital expenditures) is estimated to decrease to $160 million, or a drop of 53 percent, compared to the no-new-standards case value of $343 million in 2026, the year leading up to the compliance date of new and amended energy conservation standards.

In the absence of new or amended energy conservation standards, DOE estimates that all MEM, 1–99 hp and 251–500 hp, NEMA Design A and B; 14 percent of all MEM, 100–250 hp, NEMA Design A and B; 90 percent of all MEM, 501–750, NEMA Design A and B; 72 percent of all AO–MEM 1–99 hp (standard frame size); 8 percent of all AO–MEM 100–250 hp (standard frame size); and none of the AO–Polyphase 1–20 hp (specialized frame size) shipments will meet or exceed the ELs required at TSL 2 in 2027, the compliance year of new and amended standards.

DOE does not expect manufacturers to incur any product or capital conversion costs for MEM, 1–99 hp and 250–500 hp, NEMA Design A and B at TSL 2, since standards are set at baseline at TSL 2 for these electric motors. For the rest of the electric motors covered by this rulemaking, DOE estimates that manufacturers will incur approximately $296 million in product conversion costs and approximately $173 million in capital conversion costs. Product conversion costs primarily include engineering time to redesign non-compliance electric motor models and to re-test these newly redesigned models to meet the standards set at TSL 2. Capital conversion costs include the purchase of lamination die sets, winding machines, frame casts, and assembly equipment as well as other retooling costs for MEM, 100–250 hp and 501–750 hp, NEMA Design A and B and for all AO–MEM 1–250 hp (standard frame size) and all AO–Polyphase 1–20 hp (specialized frame size) electric motors covered by this rulemaking.

At TSL 2, under the preservation of gross margin scenario, the shipment weighted average MPC increases slightly by approximately 0.7 percent relative to the no-new-standards case MPC. This slight price increase is outweighed by the $468 million in total conversion costs estimated at TSL 2, resulting in moderately negative INPV impacts at TSL 2 under the preservation of gross margin scenario.

Under the preservation of operating profit scenario, manufacturers earn the same nominal operating profit as would be earned in the no-new-standards case, but manufacturers do not earn additional profit from their investments. The slight increase in the shipment weighted average MPC results in a slightly lower average manufacturer margin. This slightly lower average manufacturer margin and the $468 million in total conversion costs result in moderately negative INPV impacts at TSL 2 under the preservation of operating profit scenario.

TSL 3 sets the efficiency level at EL 1 for all MEM, 1–500 hp, NEMA Design A and B; and at EL 2 for all MEM, 501–750 hp, NEMA Design A and B, for all AO–MEM 1–250 hp (standard frame size), and for all AO–Polyphase 1–20 hp (specialized frame size). At TSL 3, DOE estimates impacts on INPV will range from −$1,364 million to −$342 million, which represents a change in INPV of approximately −27.2 percent to −6.8 percent, respectively. At TSL 3, industry free cash flow (operating cash flow minus capital expenditures) is estimated to decrease to −$303 million, or a drop of 189 percent, compared to the no-new-standards case value of $343 million in 2026, the year leading up to the compliance date of new and amended energy conservation standards.

In the absence of new or amended energy conservation standards, DOE estimates that 14 percent of all MEM, 1–500 hp, NEMA Design A and B; 16 percent of all MEM, 501–750 hp, NEMA Design A and B; 2 percent of all AO–MEM 1–250 hp (standard frame size); and none of the AO–Polyphase 1–20 hp (specialized frame size) shipments will meet or exceed the ELs required at TSL 3 in 2027, the compliance year of new and amended standards.

The majority of electric motors covered by this rulemaking will need to be redesigned at TSL 3. DOE estimates that manufacturers will have to make significant investments in their manufacturing production equipment and the engineering resources dedicated to redesigning electric motor models. DOE estimates that manufacturers will incur approximately $870 million in product conversion costs and approximately $748 million in capital conversion costs.

At TSL 3, under the preservation of gross margin scenario, the shipment weighted average MPC increases significantly by approximately 22.0 percent relative to the no-new-standards case MPC. This price increase is outweighed by the $1,618 million in total conversion costs estimated at TSL 3, resulting in moderately negative INPV impacts at TSL 3 under the preservation of gross margin scenario.

Under the preservation of operating profit scenario, manufacturers earn the same nominal operating profit as would be earned in the no-new-standards case, but manufacturers do not earn additional profit from their investments. The increase in the shipment weighted average MPC results in a significantly lower average manufacturer margin, compared to the no-new-standards case manufacturer margin. This lower average manufacturer margin and the $1,618 million in total conversion costs result in significantly negative INPV impacts at TSL 3 under the preservation of operating profit scenario.

TSL 4 sets the efficiency level at EL 4 (max-tech) for all electric motors covered by this rulemaking. At TSL 4, DOE estimates impacts on INPV will range from −$11,090 million to −$8,863 million, which represents a change in INPV of approximately −220.8 percent to −176.4 percent, respectively. At TSL 4, industry free cash flow (operating cash flow minus capital expenditures) is estimated to decrease to −$5,634 million, or a drop of 1,745 percent, compared to the no-new-standards case value of $343 million in 2026, the year leading up to the compliance date of new and amended energy conservation standards.

In the absence of new or amended energy conservation standards, DOE estimates that less than 1 percent of all MEM, 1–50 hp, NEMA Design A and B; none of the MEM, 51–750 hp, NEMA Design A and B; none of the AO–MEM 1–250 hp (standard frame size); and none of the AO–Polyphase 1–20 hp (specialized frame size) shipments will meet the ELs required at TSL 4 in 2027, the compliance year of new and amended standards.

Almost all electric motors covered by this rulemaking will need to be redesigned at TSL 4. DOE estimates that manufacturers will have to make significant investments in their manufacturing production equipment and the engineering resources dedicated to redesigning electric motor models. DOE estimates that manufacturers will incur approximately $6,285 million in product conversion costs and approximately $7,231 million in capital conversion costs. The significant increase in product and capital conversion costs is because DOE assumes that electric motor manufacturers will need to use die-cast copper rotors for most, if not all, electric motors manufactured to meet this TSL. This technology requires a significant level of investment because the majority of the existing electric motor production machinery would need to be replaced or significantly modified.

At TSL 4, under the preservation of gross margin scenario, the shipment weighted average MPC increases significantly by approximately 49.5 percent relative to the no-new-standards case MPC. This price increase is significantly outweighed by the $13,516 million in total conversion costs estimated at TSL 4, resulting in significantly negative INPV impacts at TSL 4 under the preservation of gross margin scenario.

Under the preservation of operating profit scenario, manufacturers earn the same nominal operating profit as would be earned in the no-new-standards case, but manufacturers do not earn additional profit from their investments. The increase in the shipment weighted average MPC results in a lower average manufacturer margin, compared to the no-new-standards case manufacturer margin. This lower average manufacturer margin and the $13,516 million in total conversion costs result in significantly negative INPV impacts at TSL 4 under the preservation of operating profit scenario.

b. Direct Impacts on Employment

To quantitatively assess the potential impacts of new and amended energy conservation standards on direct employment in the electric motors 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 2021 Annual Survey of Manufacturers (''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 involved with the manufacturing of electric motors 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.

In the GRIM, DOE used the labor content of each piece of equipment and the MPCs to estimate the annual labor expenditures of the industry. DOE used Census data and interviews with manufacturers to estimate the portion of the total labor expenditures attributable to domestic labor.

The production worker estimates in this employment section cover only workers up to the line-supervisor level who are directly involved in fabricating and assembling an electric motor within a motor facility. Workers performing services that are closely associated with production operations, such as material handling with a forklift, are also included as production labor. DOE's estimates account for only production workers who manufacture the specific equipment covered by this rulemaking. For example, a worker on an electric motor line manufacturing a fractional horsepower motor (*i.e.,* a motor with less than one horsepower) would not be included with this estimate of the number of electric motor workers, since fractional motors are not covered by this rulemaking.

The employment impacts shown in Table V–29 represent the potential production employment impact resulting from new and amended energy conservation standards. The upper bound of the results estimates the maximum change in the number of production workers that could occur after compliance with new and amended energy conservation standards when assuming that manufacturers continue to produce the same scope of covered equipment in the same production facilities. It also assumes that domestic production does not shift to lower-labor-cost countries. Because there is a real risk of manufacturers evaluating sourcing decisions in response to new and amended energy conservation standards, the lower bound of the employment results includes the estimated total number of U.S. production workers in the industry who could lose their jobs if some existing electric motor production was moved outside of the U.S. While the results present a range of employment impacts following 2027, this section also include qualitative discussions of the likelihood of negative employment impacts at the various TSLs. Finally, the employment impacts shown are independent of the indirect employment impacts from the broader U.S. economy, which are documented in chapter 16 of the direct final rule TSD.

Based on 2021 ASM data and interviews with manufacturers, DOE estimates approximately 15 percent of electric motors covered by this rulemaking sold in the U.S. are manufactured domestically. Using this assumption, DOE estimates that in the absence of new and amended energy conservation standards, there would be approximately 1,242 domestic production workers involved in manufacturing all electric motors covered by this rulemaking in 2027. Table V–29 shows the range of potential impacts of new and amended energy conservation standards on U.S. production workers involved in the production of electric motors covered by this rulemaking.

TABLE V–29—POTENTIAL CHANGES IN THE NUMBER OF DOMESTIC ELECTRIC MOTOR WORKERS

	No-new-standards case	Trial standard level			
		1	2	3	4
Domestic Production Workers in 2027	1,242	1,243	1,250	1,515	1,857

TABLE V–29—POTENTIAL CHANGES IN THE NUMBER OF DOMESTIC ELECTRIC MOTOR WORKERS—Continued

	No-new-standards case	Trial standard level			
		1	2	3	4
Domestic Non-Production Workers in 2027	712	712	712	712	712
Total Domestic Employment in 2027	1,954	1,955	1,962	2,227	2,569
Potential Changes in Total Domestic Employment in 2027 *		(2)–1	(13)–8	(432)–273	(1,201)–615

* DOE presents a range of potential impacts. Numbers in parentheses indicate negative values.

At the upper end of the range, all examined TSLs show an increase in the number of domestic production workers for electric motors. The upper end of the range represents a scenario where manufacturers increase production hiring due to the increase in the labor associated with adding the required components and additional labor (*e.g.,* hand winding, etc.) to make electric motors more efficient. However, as previously stated, this assumes that in addition to hiring more production employees, all existing domestic production would remain in the United States and not shift to lower labor-cost countries.

At the lower end of the range, all examined TSLs show a decrease in domestic production employment. In response to the March 2022 Preliminary TSD NEMA stated that increasing component prices can drive production offshore when tariffs only apply to raw materials and not finished goods. (NEMA, No. 22 at p. 16). The lower end of the domestic employment range assumes that some electric motor domestic production employment may shift to lower labor-cost countries in response to energy conservation standards. DOE estimated this lower bound potential change in domestic employment based on the percent change in the MPC at each TSL.

c. Impacts on Manufacturing Capacity

During manufacturer interviews and during meetings supporting the November 2022 Joint Recommendation, most manufacturers stated that any standards requiring efficiency levels higher than IE4 (also referred to as NEMA Super-Premium) [93] would severely disrupt manufacturing capacity (in this analysis these efficiency levels correspond to two or more NEMA bands of efficiency above NEMA Premium). Many electric motor manufacturers do not offer any electric motor models that would meet these higher efficiency levels. Based on the shipments analysis used in the NIA, DOE estimates that less than 1.5 percent of all electric motor shipments will meet any efficiency level above IE4, in the no-new-standards case in 2027, the compliance year of new and amended standards.

Additionally, most manufacturers stated they would not be able to provide a full portfolio of electric motors for any standards that would be met using copper rotors. Most manufacturers stated that they do not currently have the machinery, technology, or engineering resources to produce copper rotors in-house. Some manufacturers claim that the few manufacturers that do have the capability of producing copper rotors are not able to produce these motors in volumes sufficient to fulfill the entire electric motor market and would not be able to ramp up those production volumes over the four-year compliance period. For manufacturers to either completely redesign their motor production lines or significantly expand their very limited copper rotor production line would require a massive retooling and engineering effort, which could take more than a decade to complete. Most manufacturers stated they would have to outsource copper rotor production because they would not be able to modify their facilities and production processes to produce copper rotors in-house within a four-year time period. Most manufacturers agreed that outsourcing rotor die casting would constrain capacity by creating a bottleneck in rotor production, as there are very few companies that produce copper rotors.

Manufacturers also pointed out that there is substantial uncertainty surrounding the global availability and price of copper, which has the potential to constrain capacity. Several manufacturers expressed concern that the combination of all of these factors would make it impossible to support existing customers while redesigning product lines and retooling.

DOE estimates there is a strong likelihood of manufacturer capacity constraints in the near term for any standards that would likely require the use of copper rotors and for any standards set at efficiency levels higher than IE4.

d. Impacts on Subgroups of Manufacturers

Using average cost assumptions to develop an industry cash-flow estimate may not be adequate for assessing differential impacts among manufacturer subgroups. Small manufacturers, niche equipment manufacturers, and manufacturers exhibiting cost structures substantially different from the industry average could be affected disproportionately. DOE analyzed the impacts to small businesses in section VI.B and did not identify any other adversely impacted electric motor-related manufacturer subgroups for this rulemaking based on the results of the industry characterization.

e. Cumulative Regulatory Burden

One aspect of assessing manufacturer burden involves looking at the cumulative impact of multiple DOE standards and the product-specific regulatory actions of other Federal agencies 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. Assessing the impact of a single regulation may overlook this cumulative regulatory burden. In addition to energy conservation standards, other regulations can significantly affect manufacturers' financial operations. Multiple regulations affecting the same manufacturer can strain profits and lead companies to abandon product lines or markets with lower expected future returns than competing products. For these reasons, DOE conducts an analysis

[93] The TSL that require efficiency levels above IE4/NEMA Super-Premium is TSL 4.

of cumulative regulatory burden as part of its rulemakings pertaining to appliance efficiency. DOE requests information regarding the impact of cumulative regulatory burden on manufacturers of electric motors associated with multiple DOE standards or product-specific regulatory actions of other Federal agencies.

DOE evaluates product-specific regulations that will take effect approximately 3 years before or after the 2027 compliance date of any new and amended energy conservation standards for electric motors. This information is presented in Table V–30.

TABLE V–30—COMPLIANCE DATES AND EXPECTED CONVERSION EXPENSES OF FEDERAL ENERGY CONSERVATION STANDARDS AFFECTING ELECTRIC MOTOR MANUFACTURERS

Federal energy conservation standard	Number of manufacturers *	Number of manufacturers affected from this rule **	Approx. standards year	Industry conversion costs (millions)	Industry conversion costs/product revenue *** (%)
Dedicated-Purpose Pool Pump Motors 87 FR 37122 (Jun. 21, 2022) †.	5	5	2026	$46.2 (2020$)	2.8
Distribution Transformer 88 FR 1722 (Jan. 11, 2023) †.	27	6	2027	$343 (2021$)	2.7

* 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 electric motors that are also listed as manufacturers in the listed energy conservation standard contributing to cumulative regulatory burden.

*** This column presents industry conversion costs as a percentage of product revenue during the conversion period. Industry conversion costs are the upfront investments manufacturers must make to sell compliant products/equipment. The revenue used for this calculation is the revenue from just the covered product/equipment associated with each row. The conversion period is the time frame over which conversion costs are made and lasts from the publication year of the final rule to the compliance year of the energy conservation standard. The conversion period typically ranges from 3 to 5 years, depending on the rulemaking.

† Indicates a proposed rulemaking. Final values may change upon the publication of a final rule.

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 amended standards.

a. Significance of Energy Savings

To estimate the energy savings attributable to potential amended standards for electric motors, 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 amended standards (2027–2056). Table V–31 presents DOE's projections of the national energy savings for each TSL considered for electric motors. The savings were calculated using the approach described in section IV.H of this document.

TABLE V–31—CUMULATIVE NATIONAL ENERGY SAVINGS FOR ELECTRIC MOTORS; 30 YEARS OF SHIPMENTS
[2027–2056]

Equipment class group	Horsepower range	Trial standard level			
		1	2	3	4
			(quads)		
Primary Energy:					
MEM, 1–500 hp, NEMA Design A and B	1 ≤ hp ≤ 5	N/A	N/A	0.799	1.877
	5 < hp ≤ 20	N/A	N/A	2.303	4.461
	20 < hp ≤ 50	N/A	N/A	2.049	3.968
	50 < hp < 100	N/A	N/A	0.327	1.049
	100 ≤ hp ≤ 250	N/A	2.609	2.609	7.926
	250 < hp ≤ 500	N/A	N/A	1.411	2.497
MEM, 501–750 hp, NEMA Design A and B above 500 hp	500 < hp ≤ 750	0.003	0.003	0.029	0.073
AO–MEM (Standard Frame Size)	1 ≤ hp ≤ 20	0.045	0.045	0.104	0.184
	20 < hp ≤ 50	0.012	0.012	0.100	0.171
	50 < hp < 100*			0.018	0.047
	100 ≤hp ≤ 250	0.056	0.207	0.207	0.436
AO–Polyphase (Specialized Frame Size)	1 ≤ hp ≤ 20	0.021	0.021	0.036	0.049
Total		0.137	2.898	9.991	22.739
FFC:					
MEM, 1–500 hp, NEMA Design A and B	1 ≤ hp ≤ 5	N/A	N/A	0.830	1.950
	5 < hp ≤ 20	N/A	N/A	2.393	4.635
	20 < hp ≤ 50	N/A	N/A	2.128	4.123
	50 < hp < 100	N/A	N/A	0.339	1.090
	100 ≤ hp ≤ 250	N/A	2.710	2.710	8.234
	250 < hp ≤ 500	N/A	N/A	1.466	2.594
MEM, 501–750 hp, NEMA Design A and B above 500 hp	500 < hp ≤ 750	0.003	0.003	0.031	0.076

TABLE V–31—CUMULATIVE NATIONAL ENERGY SAVINGS FOR ELECTRIC MOTORS; 30 YEARS OF SHIPMENTS—Continued
[2027–2056]

Equipment class group	Horsepower range	Trial standard level			
		1	2	3	4
		(quads)			
AO–MEM (Standard Frame Size)	1 ≤ hp ≤ 20	0.047	0.047	0.108	0.192
	20 < hp ≤ 50	0.012	0.012	0.104	0.177
	50 ≤ hp ≤ 100 *	....	....	0.018	0.049
	100 ≤ hp ≤ 250 **	0.058	0.215	0.215	0.453
AO–Polyphase (Specialized Frame Size)	1 hp 20	0.022	0.022	0.037	0.051
Total	....	0.143	3.011	10.379	23.623

The entry ''N/A'' means not applicable because there is no change in the standard at certain TSLs.
* No impact at TSL1 and TSL2 because there are no shipments below the efficiency level corresponding to TSL1 and TSL2 in that equipment class group and horsepower range.

OMB Circular A–4 [94] 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 EPCA for the review of certain energy conservation standards and potential revision of and compliance with such revised standards.[95] The review timeframe established in EPCA is generally not synchronized with the product lifetime, product manufacturing cycles, or other factors specific to electric motors. 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–32. The impacts are counted over the lifetime of electric motors purchased in 2027–2035.

TABLE V–32—CUMULATIVE NATIONAL ENERGY SAVINGS FOR ELECTRIC MOTORS; 9 YEARS OF SHIPMENTS
[2027–2035]

Equipment class group	Horsepower range	Trial standard level			
		1	2	3	4
		(quads)			
Primary Energy:					
MEM, 1–500 hp, NEMA Design A and B	1 ≤ hp ≤ 5	N/A	N/A	0.182	0.427
	5 < hp ≤ 20	N/A	N/A	0.524	1.016
	20 < hp ≤ 50	N/A	N/A	0.466	0.903
	50 < hp < 100	N/A	N/A	0.074	0.239
	100 ≤ hp ≤ 250	N/A	0.592	0.592	1.799
	250 < hp ≤ 500	N/A	N/A	0.320	0.567
MEM, 501–750 hp, NEMA Design A and B above 500 hp	500 < hp ≤ 750	0.001	0.001	0.007	0.017
AO–MEM (Standard Frame Size)	1 ≤ hp ≤ 20	0.012	0.012	0.029	0.051
	20 < hp ≤ 50	0.003	0.003	0.027	0.047
	50 < hp < 100 *	....	....	0.005	0.013
	100 ≤ hp ≤ 250	0.015	0.057	0.057	0.119
AO–Polyphase (Specialized Frame Size)	1 ≤ hp ≤ 20	0.006	0.006	0.010	0.014
Total	....	0.038	0.671	2.294	5.211
FFC:					
MEM, 1—500 hp, NEMA Design A and B	1 ≤ hp ≤ 5	N/A	N/A	0.189	0.444
	5 < hp ≤ 20	N/A	N/A	0.545	1.056
	20 < hp ≤ 50	N/A	N/A	0.485	0.939
	50 < hp < 100	N/A	N/A	0.077	0.248
	100 ≤ hp ≤ 250	N/A	0.615	0.615	1.869
	250 < hp ≤ 500	N/A	N/A	0.333	0.589
MEM, 501–750 hp, NEMA Design A and B above 500 hp	500 < hp ≤ 750	0.001	0.001	0.007	0.017
AO–MEM (Standard Frame Size)	1 ≤ hp ≤ 20	0.013	0.013	0.030	0.053
	20 < hp ≤ 50	0.003	0.003	0.028	0.049
	50 < hp < 100 *	....	....	0.005	0.013
	100 ≤ hp ≤ 250 **	0.016	0.059	0.059	0.124

[94] U.S. Office of Management and Budget. *Circular A–4: Regulatory Analysis.* September 17, 2003. *obamawhitehouse.archives.gov/omb/circulars_a004_a-4* (last accessed September 30, 2022).

[95] 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–32—CUMULATIVE NATIONAL ENERGY SAVINGS FOR ELECTRIC MOTORS; 9 YEARS OF SHIPMENTS—Continued
[2027–2035]

Equipment class group	Horsepower range	Trial standard level 1	2	3	4
			(quads)		
AO–Polyphase (Specialized Frame Size)	1 ≤ hp ≤ 20	0.006	0.006	0.010	0.014
Total		0.039	0.698	2.384	5.416

The entry "N/A" means not applicable because there is no change in the standard at certain TSLs.
* No impact at TSL1 and TSL2 because there are no shipments below the efficiency level corresponding to TSL1 and TSL2 (EL1) in that equipment class group and horsepower range.

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 electric motors. In accordance with OMB's guidelines on regulatory analysis,[96] DOE calculated NPV using both a 7-percent and a 3-percent real discount rate. Table V–33 shows the consumer NPV results with impacts counted over the lifetime of products purchased in 2027–2056.

TABLE V–33—CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS FOR ELECTRIC MOTORS; 30 YEARS OF SHIPMENTS
[2027–2056]

Discount rate	Equipment class group	Horsepower range	Trial standard level 1	2	3	4
				(billion 2021$)		
3 percent	MEM, 1–500 hp, NEMA Design A and B	1 ≤ hp ≤ 5	N/A	N/A	−2.18	−8.54
		5 < hp ≤ 20	N/A	N/A	−7.17	−6.21
		20 < hp ≤ 50	N/A	N/A	−3.24	−0.93
		50 < hp < 100	N/A	N/A	−1.36	−1.50
		100 ≤ hp ≤ 250	N/A	6.73	6.73	5.13
		250 < hp ≤ 500	N/A	N/A	1.77	0.66
	MEM, 501–750 hp, NEMA Design A and B above 500 hp.	500 < hp ≤ 750	0.01	0.01	0.02	0.03
	AO–MEM (Standard Frame Size)	1 ≤ hp ≤ 20	0.12	0.12	0.05	−0.14
		20 < hp ≤ 50	0.04	0.04	0.04	0.17
		50 < hp < 100 *			−0.09	−0.16
		100 ≤ hp ≤ 250	0.11	0.52	0.52	0.18
	AO–Polyphase (Specialized Frame Size)	1 ≤ hp ≤ 20	0.05	0.05	0.05	0.01
	Total		0.33	7.47	−4.85	−11.30
7 percent	MEM, 1–500 hp, NEMA Design A and B	1 ≤ hp ≤ 5	N/A	N/A	−1.49	−5.30
		5 < hp ≤ 20	N/A	N/A	−4.77	−5.18
		20 < hp ≤ 50	N/A	N/A	−2.62	−2.25
		50 < hp < 100	N/A	N/A	−0.86	−1.26
		100 ≤ hp ≤ 250	N/A	2.00	2.00	−2.04
		250 < hp ≤ 500	N/A	N/A	0.09	−1.15
	MEM, 501–750 hp, NEMA Design A and B above 500 hp.	500 < hp ≤ 750	0.00	0.00	−0.01	−0.03
	AO–MEM (Standard Frame Size)	1 ≤ hp ≤ 20	0.04	0.04	−0.02	−0.16
		20 < hp ≤ 50	0.02	0.02	−0.02	0.01
		50 < hp < 100 *			−0.06	−0.11
		100 ≤ hp ≤ 250	0.02	0.16	0.16	−0.18
	AO–Polyphase (Specialized Frame Size)	1 ≤ hp ≤ 20	0.02	0.02	0.01	−0.02
	Total		0.11	2.23	−7.60	−17.67

The entry "N/A" means not applicable because there is no change in the standard at certain TSLs.
* No impact at TSL1 and TSL2 because there are no shipments below the efficiency level corresponding to TSL1 and TSL2 in that equipment class group and horsepower range.

The NPV results based on the aforementioned 9-year analytical period are presented in Table V–34. The impacts are counted over the lifetime of products purchased in 2027–2035. As mentioned previously, such results are presented for informational purposes only and are not indicative of any

[96] U.S. Office of Management and Budget. *Circular A–4: Regulatory Analysis.* September 17, 2003. *obamawhitehouse.archives.gov/omb/circulars_a004_a-4* (last accessed September 30, 2022).

change in DOE's analytical methodology or decision criteria.

TABLE V–34—CUMULATIVE NET PRESENT VALUE OF CONSUMER BENEFITS FOR ELECTRIC MOTORS; 9 YEARS OF SHIPMENTS

[2027–2035]

Discount rate	Equipment class group	Horsepower range	Trial standard level			
			1	2	3	4
			(billion 2021$)			
3 percent	MEM, 1–500 hp, NEMA Design A and B	1 ≤ hp ≤ 5	N/A	N/A	−0.66	−2.62
		5 < hp ≤ 20	N/A	N/A	−2.17	−1.79
		20 < hp ≤ 50	N/A	N/A	−0.95	−0.16
		50 < hp < 100	N/A	N/A	−0.41	−0.43
		100 ≤ hp ≤ 250	N/A	2.16	2.16	1.74
		250 < hp ≤ 500	N/A	N/A	0.58	0.25
	MEM, 501–750 hp, NEMA Design A and B above 500 hp.	500 < hp ≤ 750	0.00	0.00	0.01	0.01
	AO–MEM (Standard Frame Size)	1 ≤ hp ≤ 20	0.04	0.04	0.02	−0.04
		20 < hp ≤ 50	0.02	0.02	0.02	0.07
		50 < hp < 100*	....	....	−0.03	−0.06
		100 ≤ hp ≤ 250	0.04	0.20	0.20	0.08
	AO–Polyphase (Specialized Frame Size)	1 ≤ hp ≤ 20	0.02	0.02	0.02	0.01
	Total		0.12	2.44	−1.22	−2.95
7 percent	MEM, 1–500 hp, NEMA Design A and B	1 ≤ hp ≤ 5	N/A	N/A	−0.64	−2.30
		5 < hp ≤ 20	N/A	N/A	−2.06	−2.20
		20 < hp ≤ 50	N/A	N/A	−1.12	−0.93
		50 < hp < 100	N/A	N/A	−0.37	−0.54
		100 ≤ hp ≤ 250	N/A	0.90	0.90	−0.84
		250 < hp ≤ 500	N/A	N/A	0.05	−0.49
	MEM, 501—750 hp, NEMA Design A and B above 500 hp.	500 < hp ≤ 750	0.00	0.00	0.00	−0.01
	AO–MEM (Standard Frame Size)	1 ≤ hp ≤ 20	0.02	0.02	−0.01	−0.08
		20 < hp ≤ 50	0.01	0.01	−0.01	0.01
		50 < hp < 100	....	....	−0.03	−0.05
		100 ≤ hp ≤ 250	0.01	0.08	0.08	−0.08
	AO–Polyphase (Specialized Frame Size)	1 ≤ hp ≤ 20	0.01	0.01	0.01	−0.01
	Total		0.06	1.02	−3.21	−7.51

The entry "N/A" means not applicable because there is no change in the standard at certain TSLs.

* No impact at TSL1 and TSL2 because there are no shipments below the efficiency level corresponding to TSL1 and TSL2 in that equipment class group and horsepower range.

The previous results reflect the use of a default trend to estimate the change in price for electric motors over the analysis period (see section IV.F.1 of this document). In addition to the default trend (constant prices), DOE also conducted a sensitivity analysis that considered one scenario with a rate of price decline and one scenario with a rate of price increase. The results of these alternative cases are presented in appendix 10C of the direct final rule TSD. In the price-decline case, the NPV of consumer benefits is higher than in the default case. In the price-increase case, the NPV of consumer benefits is lower than in the default case.

c. Indirect Impacts on Employment

It is estimated that that amended energy conservation standards for electric motors would 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. 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 (2027–2031), where these uncertainties are reduced.

The results suggest that the standards would be likely to have a negligible impact on the net demand for labor in the economy. The net change in jobs is so small that it would be imperceptible in national labor statistics and might be offset by other, unanticipated effects on employment. Chapter 16 of the direct final rule TSD presents detailed results regarding anticipated indirect employment impacts.

4. Impact on Utility or Performance of Products

As discussed in section IV.C.1.b of this document, DOE concludes that the standards in this direct final rule would not lessen the utility or performance of the electric motors under consideration in this rulemaking. Manufacturers of these products currently offer units that meet or exceed the 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.F.1.e of this document, the Attorney General determines the impact, if any, of any lessening of competition likely to result from a standard, and transmits such determination in writing to the Secretary, together with an analysis of the nature and extent of such impact. To assist the Attorney General in making this determination, DOE has provided DOJ with copies of this direct final rule and the accompanying TSD for review. DOE will consider DOJ's comments on the rule in determining whether to proceed to a final rule. DOE will publish and respond to DOJ's comments in that document. DOE invites comment from the public regarding the competitive impacts that are likely to result from this rule. In addition, stakeholders may also provide comments separately to DOJ regarding these potential impacts. See the **ADDRESSES** section for information to send comments to DOJ.

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. Chapter 15 in the direct final rule TSD presents the estimated impacts on electricity generating capacity, relative to the no-new-standards case, for the TSLs that DOE considered in this rulemaking.

Energy conservation resulting from potential energy conservation standards for electric motors is expected to yield environmental benefits in the form of reduced emissions of certain air pollutants and greenhouse gases. Table V–35 provides DOE's estimate of cumulative emissions reductions expected to result from the TSLs considered in this rulemaking. The emissions were calculated using the multipliers discussed in section IV.K of this document. DOE reports annual emissions reductions for each TSL in chapter 13 of the direct final rule TSD.

TABLE V–35—CUMULATIVE EMISSIONS REDUCTION FOR ELECTRIC MOTORS SHIPPED IN 2027–2056

	Trial standard level			
	1	2	3	4
Power Sector Emissions				
CO_2 (*million metric tons*)	4.08	84.48	294.36	669.19
CH_4 (*thousand tons*)	0.28	5.73	20.15	45.77
N_2O (*thousand tons*)	0.04	0.79	2.78	6.31
NO_X (*thousand tons*)	1.93	39.32	138.52	314.54
SO_2 (*thousand tons*)	1.68	34.64	121.08	275.16
Hg (*tons*)	0.01	0.23	0.80	1.81
Upstream Emissions				
CO_2 (*million metric tons*)	0.34	7.20	24.88	56.62
CH_4 (*thousand tons*)	32.47	684.37	2,359.60	5,370.22
N_2O (*thousand tons*)	0.00	0.04	0.12	0.28
NO_X (*thousand tons*)	5.20	109.42	377.47	859.03
SO_2 (*thousand tons*)	0.02	0.47	1.67	3.79
Hg (*tons*)	0.00	0.00	0.00	0.01
Total FFC Emissions				
CO_2 (*million metric tons*)	4.42	91.69	319.24	725.80
CH_4 (*thousand tons*)	32.75	690.10	2,379.75	5,415.99
N_2O (*thousand tons*)	0.04	0.82	2.90	6.59
NO_X (*thousand tons*)	7.13	148.74	516.00	1,173.58
SO_2 (*thousand tons*)	1.71	35.12	122.75	278.95
Hg (*tons*)	0.01	0.23	0.80	1.82

As part of the analysis for this rulemaking, DOE estimated monetary benefits likely to result from the reduced emissions of CO_2 that DOE estimated for each of the considered TSLs for electric motors. Section IV.L of this document discusses the SC–CO_2 values that DOE used. Table V–36 presents the value of CO_2 emissions reduction at each TSL for each of the SC–CO_2 cases. The time-series of annual values is presented for the TSL in chapter 14 of the direct final rule TSD.

TABLE V–36—PRESENT VALUE OF CO_2 EMISSIONS REDUCTION FOR ELECTRIC MOTORS SHIPPED IN 2027–2056

TSL	SC–CO_2 case			
	Discount rate and statistics			
	5% Average	3% Average	2.5% Average	3% 95th percentile
	(Billion 2021$)			
1	35.69	155.25	243.87	470.82
2	553.79	2,504.21	3,979.48	7,570.82

TABLE V–36—PRESENT VALUE OF CO_2 EMISSIONS REDUCTION FOR ELECTRIC MOTORS SHIPPED IN 2027–2056—Continued

TSL	SC–CO_2 case			
	Discount rate and statistics			
	5% Average	3% Average	2.5% Average	3% 95th percentile
	(Billion 2021$)			
3	2,455.13	10,830.27	17,081.13	32,809.19
4	5,459.53	24,136.32	38,092.58	73,105.31

As discussed in section IV.L.2 of this document, DOE estimated the climate benefits likely to result from the reduced emissions of methane and N_2O that DOE estimated for each of the considered TSLs for electric motors. Table V–37 presents the value of the CH_4 emissions reduction at each TSL, and Table V–38 presents the value of the N_2O emissions reduction at each TSL. The time-series of annual values is presented for the TSL in chapter 14 of the direct final rule TSD.

TABLE V–37—PRESENT VALUE OF METHANE EMISSIONS REDUCTION FOR ELECTRIC MOTORS SHIPPED IN 2027–2056

TSL	SC–CH_4 case			
	Discount rate and statistics			
	5% Average	3% Average	2.5% Average	3% 95th percentile
	(Billion 2021$)			
1	12.16	37.03	51.92	97.98
2	194.82	623.71	884.30	1,651.65
3	845.85	2,621.71	3,690.13	6,932.36
4	1,884.39	5,857.68	8,250.30	15,490.67

TABLE V–38—PRESENT VALUE OF NITROUS OXIDE EMISSIONS REDUCTION FOR ELECTRIC MOTORS SHIPPED IN 2027–2056

TSL	SC–N_2O case			
	Discount rate and statistics			
	5% Average	3% Average	2.5% Average	3% 95th percentile
	(Billion 2021$)			
1	0.13	0.51	0.79	1.36
2	1.95	8.23	12.94	21.99
3	8.63	35.54	55.47	94.75
4	19.20	79.21	123.71	211.22

DOE is aware that scientific and economic knowledge about the contribution of CO_2 and other GHG emissions to changes in the future global climate and the potential resulting damages to the global and U.S. economy continues to evolve rapidly. DOE, together with other Federal agencies, will continue to review methodologies for estimating the monetary value of reductions in CO_2 and other GHG emissions. This ongoing review will consider the comments on this subject that are part of the public record for this and other rulemakings, as well as other methodological assumptions and issues. DOE notes that the standards would be economically justified even without inclusion of monetized benefits of reduced GHG emissions.

DOE also estimated the monetary value of the health benefits associated with NO_X and SO_2 emissions reductions anticipated to result from the considered TSLs for electric motors. The dollar-per-ton values that DOE used are discussed in section IV.L of this document. Table V–39 presents the present value for NO_X emissions reduction for each TSL calculated using 7-percent and 3-percent discount rates, and Table V–40 presents similar results for SO_2 emissions reductions. The results in these tables reflect application of EPA's low dollar-per-ton values, which DOE used to be conservative. The time-series of annual values is presented for the TSL in chapter 14 of the direct final rule TSD.

TABLE V–39—PRESENT VALUE OF NO_X EMISSIONS REDUCTION FOR ELECTRIC MOTORS SHIPPED IN 2027–2056

TSL	3% Discount rate	7% Discount rate
	(million 2021$)	
1	251.49	93.31
2	4,333.63	1,321.91
3	17,501.29	6,149.06
4	39,226.69	13,614.34

TABLE V–40—PRESENT VALUE OF SO_2 EMISSIONS REDUCTION FOR ELECTRIC MOTORS SHIPPED IN 2027–2056

TSL	3% Discount rate	7% Discount rate
	(million 2021$)	
1	82.00	31.35
2	1,388.59	434.33
3	5,658.54	2,042.58
4	12,671.52	4,517.89

Not all the public health and environmental benefits from the reduction of greenhouse gases, NO_x, and SO_2 are captured in the values above, and additional unquantified benefits from the reductions of those pollutants as well as from the reduction of direct PM and other co-pollutants may be significant. DOE has not included the monetary benefits of the reduction of Hg for this direct final rule because Hg emissions reductions are expected to be small.

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))

8. Summary of Economic Impacts

Table V–41 presents the NPV values that result from adding the estimates of the potential economic benefits resulting from reduced GHG and NO_X and SO_2 emissions to the NPV of consumer benefits calculated for each TSL considered in this rulemaking. The consumer benefits are domestic U.S. monetary savings that occur as a result of purchasing the covered electric motors, and are measured for the lifetime of products shipped in 2027–2056. The benefits associated with reduced GHG emissions resulting from the adopted standards are global benefits, and are also calculated based on the lifetime of electric motors shipped in 2027–2056.

TABLE V–41—CONSUMER NPV COMBINED WITH PRESENT VALUE OF BENEFITS FROM CLIMATE AND HEALTH BENEFITS

Category	TSL 1	TSL 2	TSL 3	TSL 4
3% Discount Rate for Consumer NPV and Health Benefits (billion 2021$)				
5% Average SC–GHG case	0.71	13.95	21.62	47.96
3% Average SC–GHG case	0.85	16.33	31.80	70.67
2.5% Average SC–GHG case	0.96	18.07	39.14	87.07
3% 95th percentile SC–GHG case	1.23	22.44	58.15	129.41
7% Discount Rate for Consumer NPV and Health Benefits (billion 2021$)				
5% Average SC–GHG case	0.28	4.74	3.90	7.83
3% Average SC–GHG case	0.43	7.13	14.08	30.54
2.5% Average SC–GHG case	0.53	8.87	21.42	46.93
3% 95th percentile SC–GHG case	0.80	13.24	40.43	89.27

C. Conclusion

When considering new or amended energy conservation standards, the standards that DOE adopts for any type (or class) of covered equipment 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. 6316(a); 42 U.S.C. 6295(o)(2)(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 in section III.F.1 of this document. (42 U.S.C. 6316(a); 42 U.S.C. 6295(o)(2)(B)(i)) The new or amended standard must also result in significant conservation of energy. (42 U.S.C. 6316(a); 42 U.S.C. 6295(o)(3)(B))

For this direct final rule, DOE considered the impacts of new and amended standards for electric motors 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 Electric Motors Standards

Tables V–42 and V–43 summarize the quantitative impacts estimated for each TSL for electric motors. The national impacts are measured over the lifetime of electric motors purchased in the 30-year period that begins in the anticipated year of compliance with amended standards (2027–2056). The energy savings, emissions reductions, and value of emissions reductions refer to full-fuel-cycle results. DOE is presenting monetized benefits of GHG emissions reductions in accordance with the applicable Executive Orders and DOE would reach the same conclusion presented in this notice in the absence of the social cost of greenhouse gases, including the Interim Estimates presented by the Interagency Working Group. The efficiency levels contained in each TSL are described in section V.A of this document.

TABLE V–42—SUMMARY OF ANALYTICAL RESULTS FOR ELECTRIC MOTORS TSLS: NATIONAL IMPACTS

Category	TSL 1	TSL 2	TSL 3	TSL 4
Cumulative FFC National Energy Savings				
Quads	0.1	3.0	10.4	23.6
Cumulative FFC Emissions Reduction				
CO_2 (*million metric tons*)	4.42	91.69	319.24	725.80
CH_4 (*thousand tons*)	32.75	690.10	2,379.75	5,415.99
N_2O (*thousand tons*)	0.04	0.82	2.90	6.59
NO_X (*thousand tons*)	7.13	148.74	516.00	1,173.58
SO_2 (*thousand tons*)	1.71	35.12	122.75	278.95
Hg (*tons*)	0.01	0.23	0.80	1.82
Present Value of Benefits and Costs (3% discount rate, billion 2021$)				
Consumer Operating Cost Savings	0.51	8.82	34.86	73.26
Climate Benefits *	0.19	3.14	13.49	30.07
Health Benefits **	0.33	5.72	23.16	51.90
Total Benefits †	1.04	17.68	71.50	155.23
Consumer Incremental Product Costs ‡	0.18	1.35	39.70	84.56
Consumer Net Benefits	0.33	7.47	−4.85	−11.30
Total Net Benefits	0.85	16.33	31.80	70.67
Present Value of Benefits and Costs (7% discount rate, billion 2021$)				
Consumer Operating Cost Savings	0.21	2.95	13.44	27.14
Climate Benefits *	0.19	3.14	13.49	30.07
Health Benefits **	0.12	1.76	8.19	18.13
Total Benefits †	0.53	7.85	35.11	75.34
Consumer Incremental Product Costs ‡	0.10	0.72	21.03	44.80
Consumer Net Benefits	0.11	2.23	−7.60	−17.67
Total Net Benefits	0.43	7.13	14.08	30.54

Note: This table presents the costs and benefits associated with electric motors shipped in 2027–2056. These results include benefits to consumers which accrue after 2056 from the products shipped in 2027–2056.

* Climate benefits are calculated using four different estimates of the SC–CO_2, SC–CH_4 and SC–N_2O. Together, these represent the global SC–GHG. For presentational purposes of this table, the climate benefits associated with the average SC–GHG at a 3 percent discount rate are shown, but the Department does not have a single central SC–GHG point estimate. To monetize the benefits of reducing GHG emissions this analysis uses the interim estimates presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990* published in February 2021 by the Interagency Working Group on the Social Cost of Greenhouse Gases (IWG).

** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing (for NO_X and SO_2) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. The health benefits are presented at real discount rates of 3 and 7 percent. See section IV.L of this document for more details.

† Total and net benefits include consumer, climate, and health benefits. For presentation purposes, total and net benefits for both the 3-percent and 7-percent cases are presented using the average SC–GHG with 3-percent discount rate, but the Department does not have a single central SC–GHG point estimate. DOE emphasizes the importance and value of considering the benefits calculated using all four SC–GHG estimates.

‡ Costs include incremental equipment costs as well as installation costs.

TABLE V–43—SUMMARY OF ANALYTICAL RESULTS FOR ELECTRIC MOTORS TSLS: MANUFACTURER AND CONSUMER IMPACTS

Category	TSL 1	TSL 2	TSL 3	TSL 4
Manufacturer Impacts				
Industry NPV (*million 2021$*) (No-new-standards case INPV = 5,023)	4,896–4,899	4,690–4,720	3,659–4,681	(6,066)–(3,840)

TABLE V–43—SUMMARY OF ANALYTICAL RESULTS FOR ELECTRIC MOTORS TSLS: MANUFACTURER AND CONSUMER IMPACTS—Continued

Category	TSL 1	TSL 2	TSL 3	TSL 4
Industry NPV (*% change*)	(2.5)	(6.6)–(6.0)	(27.2)–(6.8)	(220.8)–(176.4)
Consumer Average LCC Savings (2021$)				
RU1	N/A	N/A	−101.8	−276.4
RU2	N/A	N/A	−336.9	−309.4
RU3	N/A	N/A	−916.7	−1,439.6
RU4	N/A	567.1	567.1	−2,541.1
RU5	N/A	N/A	−945.5	−5,257.2
RU6	2,550.1	2,550.1	−2,287.8	−6,710.3
RU7	57.6	57.6	−39.2	−156.5
RU8	472.4	472.4	−160.8	−105.5
RU9 *			−930.5	−1,795.0
RU10	608.8	930.7	930.7	−1,846.6
RU11	49.9	49.9	2.5	−153.2
Shipment-Weighted Average **	159.8	337.4	−196.2	−404.2
Consumer Simple PBP (years)				
RU1	N/A	N/A	16.7	20.3
RU2	N/A	N/A	15.4	11.9
RU3	N/A	N/A	30.2	20.6
RU4	N/A	4.1	4.1	18.1
RU5	N/A	N/A	11.8	17.7
RU6	3.7	3.7	9.6	12.6
RU7	4.0	4.0	6.5	9.0
RU8	1.6	1.6	5.9	6.1
RU9 *			9.0	10.6
RU10	6.1	4.9	4.9	10.1
RU11	4.1	4.1	5.6	7.9
Shipment-Weighted Average **	3.8	3.9	15.6	16.3
Percent of Consumers that Experience a Net Cost				
RU1	N/A	N/A	64.1%	95.9%
RU2	N/A	N/A	82.2%	75.0%
RU3	N/A	N/A	88.4%	90.5%
RU4	N/A	20.2%	20.2%	89.1%
RU5	N/A	N/A	66.9%	89.0%
RU6	2.1%	2.1%	58.3%	83.2%
RU7	10.3%	10.3%	62.9%	80.7%
RU8	0.9%	0.9%	73.9%	64.5%
RU9 *			99.9%	96.4%
RU10	6.3%	11.7%	11.7%	79.0%
RU11	32.1%	32.1%	53.4%	74.5%
Shipment-Weighted Average **	10.9%	14.9%	70.6%	86.3%

The entry "N/A" means not applicable because there is no change in the standard at certain TSLs.
* No impact because there are no shipments below the efficiency level corresponding to TSL1 and TSL2 for RU9.
** Weighted by shares of each equipment class in total projected shipments in 2027 for impacted consumers.

DOE first considered TSL 4, which represents the max-tech efficiency levels. At this level, DOE expects that all equipment classes would require 35H210 silicon steel and die-cast copper rotors. DOE estimates that approximately 0.34 percent of annual shipments across all electric motor equipment classes currently meet the max-tech efficiencies required. TSL 4 would save an estimated 23.6 quads of energy, an amount DOE considers significant. Under TSL 4, the NPV of consumer benefit would be −$17.67 billion using a discount rate of 7 percent, and −$11.30 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 4 are 725.80 Mt of CO_2, 278.95 thousand tons of SO_2, 1,173.58 thousand tons of NO_X, 1.82 tons of Hg, 5,415.99 thousand tons of CH_4, and 6.59 thousand tons of N_2O. The estimated monetary value of the climate benefits from reduced GHG emissions (associated with the average SC–GHG at a 3-percent discount rate) at TSL 4 is $30.07 billion. The estimated monetary value of the health benefits from reduced SO_2 and NO_X emissions at TSL 4 is $18.13 billion using a 7-percent discount rate and $51.90 billion using a 3-percent discount rate.

Using a 7-percent discount rate for consumer benefits and costs, health benefits from reduced SO_2 and NO_X emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated total NPV at TSL 4 is $30.54 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 4 is $70.67 billion.

At TSL 4, for the largest equipment class group and horsepower ranges, which are represented by RU1 and RU2, which together represent approximately 90 percent of annual shipments, there is a life cycle cost savings of −$276.4 and −$309.4 and a payback period of 20.3

years and 11.9 years, respectively. For these equipment classes, the fraction of customers experiencing a net LCC cost is 95.9 percent and 75.0 percent due to increases in total installed cost of $434.7 and $1,003.0, respectively. Overall, for the remaining equipment class groups and horsepower ranges, a majority of electric motor consumers (84.5 percent) would experience a net cost and the average LCC savings would be negative for all remaining equipment class groups and horsepower ranges.

At TSL 4, the projected change in INPV ranges from a decrease of $11,090 million to a decrease of $8,863 million, which corresponds to decreases of 220.8 percent and 176.4 percent, respectively. DOE estimates that industry must invest $13,516 million to comply with standards set at TSL 4. The significant increase in product and capital conversion costs is because DOE assumes that electric motor manufacturers will need to use die-cast copper rotors for most, if not all, electric motors manufactured to meet this TSL. This technology requires a significant level of investment because almost all existing electric motor production machinery would need to be replaced or significantly modified. Based on the shipments analysis used in the NIA, DOE estimates that approximately 0.3 percent of all electric motor shipments will meet the efficiency levels required at TSL 4, in the no-new-standards case in 2027, the compliance year of new and amended standards.

Under 42 U.S.C. 6295(o)(2)(B)(i), DOE determines whether a standard is economically justified after considering seven factors. Based on these factors, the Secretary concludes that at TSL 4 for electric motors, 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, economic burden on many consumers, and the impacts on manufacturers, including the extremely large conversion costs, profit margin impacts that will result in a negative INPV, and the lack of manufacturers currently offering products meeting the efficiency levels required at this TSL. A majority of electric motor consumers (86.3 percent) would experience a net cost and the average LCC savings for each representative unit DOE examined is negative. In both manufacturer markup scenarios, INPV is negative at TSL 4, which implies that manufacturers would never recover the conversion costs they must make to produce electric motors at TSL 4. Consequently, the Secretary concludes that TSL 4 is not economically justified.

DOE then considered TSL 3, which represents a level corresponding to the IE4 level, except for AO–polyphase specialized frame size electric motors, where it corresponds to a lower level of efficiency (*i.e.,* NEMA Premium level). TSL 3 would save an estimated 10.4 quads of energy, an amount DOE considers significant. Under TSL 3, the NPV of consumer benefit would be −$7.60 billion using a discount rate of 7 percent, and −$4.85 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 3 are 319.24 Mt of CO_2, 122.75 thousand tons of SO_2, 516.00 thousand tons of NO_X, 0.80 tons of Hg, 2,379.75 thousand tons of CH_4, and 2.90 thousand tons of N_2O. The estimated monetary value of the climate benefits from reduced GHG emissions (associated with the average SC–GHG at a 3-percent discount rate) at TSL 3 is $13.49 billion. The estimated monetary value of the health benefits from reduced SO_2 and NO_X emissions at TSL 3 is 8.19 billion using a 7-percent discount rate and $23.16 billion using a 3-percent discount rate.

Using a 7-percent discount rate for consumer benefits and costs, health benefits from reduced SO_2 and NO_X emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated total NPV at TSL 3 is $14.08 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 3 is $31.80 billion.

At TSL 3, for the largest equipment class group and horsepower ranges, which are represented by RU1 and RU2, there is a life cycle cost savings of −$101.8 and −$336.9 and a payback period of 16.7 and 15.4, respectively. For these equipment classes, the fraction of customers experiencing a net LCC cost is 64.1 percent and 82.2 percent due to increases in total installed cost of $171.3 and $690.5, respectively. Overall, for the remaining equipment class groups and horsepower ranges, a majority of electric motor consumers (55.5 percent) would experience a net cost and the shipments-weighted average LCC savings would be negative for all remaining equipment class groups and horsepower ranges.

At TSL 3, the projected change in INPV ranges from a decrease of $1,364 million to a decrease of $342 million, which correspond to decreases of 27.2 percent and 6.8 percent, respectively. DOE estimates that industry must invest $1,618 million to comply with standards set at TSL 3. Based on the shipments analysis used in the NIA, DOE estimates that approximately 13.3 percent of all electric motor shipments will meet or exceed the efficiency levels required at TSL 3, in the no-new-standards case in 2027, the compliance year of new and amended standards.

Under 42 U.S.C. 6295(o)(2)(B)(i), DOE determines whether a standard is economically justified after considering seven factors. Based on these factors, the Secretary concludes that at TSL 3 for electric motors, 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, economic burden on many consumers, and the impacts on manufacturers, including the large conversion costs, profit margin impacts that could result in a large reduction in INPV, and the lack of manufacturers currently offering products meeting the efficiency levels required at this TSL. A majority of electric motor consumers (70.6 percent) would experience a net cost and the average LCC savings would be negative. The potential reduction in INPV could be as high as 27.2 percent. Consequently, the Secretary concludes that TSL 3 is not economically justified.

DOE then considered TSL 2, the standard levels recommended in the November 2022 Joint Recommendation by the Electric Motors Working Group. TSL 2 would also align with the EU Ecodesign Directive 2019/1781, which requires IE4 levels for 75–200 kW motors.[97] TSL 2 would save an estimated 3.0 quads of energy, an amount DOE considers significant. Under TSL 2, the NPV of consumer benefit would be $2.23 billion using a discount rate of 7 percent, and $7.47 billion using a discount rate of 3 percent.

The cumulative emissions reductions at TSL 2 are 91.69 Mt of CO_2, 35.12 thousand tons of SO_2, 148.74 thousand tons of NO_X, 0.23 tons of Hg, 690.10 thousand tons of CH_4, and 0.82 thousand tons of N_2O. The estimated monetary value of the climate benefits from reduced GHG emissions (associated with the average SC–GHG at a 3-percent discount rate) at TSL 2 is $3.14 billion. The estimated monetary value of the health benefits from reduced SO_2 and NO_X emissions at TSL 2 is $1.76 billion using a 7-percent discount rate and $5.72 billion using a 3-percent discount rate.

Using a 7-percent discount rate for consumer benefits and costs, health benefits from reduced SO_2 and NO_X

[97] In terms of standardized horsepowers, this would correspond to 100–250 hp when applying the provisions from 10 CFR 431.25(k) (and new section 10 CFR 431.25(q)).

emissions, and the 3-percent discount rate case for climate benefits from reduced GHG emissions, the estimated total NPV at TSL 2 is $7.13 billion. Using a 3-percent discount rate for all benefits and costs, the estimated total NPV at TSL 2 is $16.33 billion.

At TSL 2, for the largest equipment class group and horsepower ranges, which are represented by RU1 and RU2, there would be no changes in the standards. Overall, for the remaining equipment class groups and horsepower ranges, 14.9 percent of electric motor consumers would experience a net cost and the shipments-weighted average LCC savings would be positive for all remaining equipment class groups and horsepower ranges.

At TSL 2, the projected change in INPV ranges from a decrease of $333 million to a decrease of $303 million, which correspond to decreases of 6.6 percent and 6.0 percent, respectively. DOE estimates that industry must invest $468 million to comply with standards set at TSL 2. Based on the shipments analysis used in the NIA, DOE estimates that approximately 96.2 percent of all electric motor shipments will meet or exceed the efficiency levels required at TSL 2, in the no-new-standards case in 2027, the compliance year of new and amended standards.

Under 42 U.S.C. 6295(o)(2)(B)(i), DOE determines whether a standard is economically justified after considering seven factors. Based on these factors, the Secretary concludes that a standard set at TSL 2 for electric motors would be economically justified. At this TSL, the average LCC savings is positive. Only an estimated 14.9 percent of electric motor consumers experience a net cost. The FFC national energy savings are significant and the NPV of consumer benefits is positive using both a 3-percent and 7-percent discount rate. Notably, the benefits to consumers vastly outweigh the cost to manufacturers. Notably, at TSL 2, the NPV of consumer benefits, even measured at the more conservative discount rate of 7 percent, is over 6 times higher than the maximum estimated manufacturers' loss in INPV. The standard levels at TSL 2 are economically justified even without weighing the estimated monetary value of emissions reductions. When those emissions reductions are included—representing $3.14 billion in climate benefits (associated with the average SC–GHG at a 3-percent discount rate), and $5.72 billion (using a 3-percent discount rate) or $1.76 billion (using a 7-percent discount rate) in health benefits—the rationale becomes stronger still.

As stated, DOE conducts the walk-down analysis to determine the TSL that represents the maximum improvement in energy efficiency that is technologically feasible and economically justified as required under EPCA. The walk-down is not a comparative analysis, as a comparative analysis would result in the maximization of net benefits instead of energy savings that are technologically feasible and economically justified, which would be contrary to the statute. 86 FR 70892, 70908. Although DOE has not conducted a comparative analysis to select the energy conservation standards, DOE notes that as compared to TSL 3 and TSL 4, TSL 2 has higher average LCC savings for consumers, significantly smaller percentages of electric motor consumers experiencing a net cost, a lower maximum decrease in INPV, and lower manufacturer conversion costs.

Although DOE considered amended standard levels for electric motors by grouping the efficiency levels for each equipment class groups and horsepower ranges into TSLs, DOE evaluates all analyzed efficiency levels in its analysis. For all equipment class groups and horsepower ranges, TSL 2 represents the maximum energy savings that does not result in the majority of consumers experiencing a net LCC cost. The ELs at the adopted TSL result in average positive LCC savings for all equipment class groups and horsepower ranges, significantly reduce the number of consumers experiencing a net cost, and reduce the decrease in INPV and conversion costs to the point where DOE has concluded they are economically justified, as discussed for TSL 2 in the preceding paragraphs.

Therefore, based on the previous considerations, DOE adopts the energy conservation standards for electric motors at TSL 2. The new and amended energy conservation standards for electric motors, which are expressed as full-load nominal efficiency values are shown in Table V–44, Table V–45 and Table V–46.

TABLE V–44—NOMINAL FULL-LOAD EFFICIENCIES OF NEMA DESIGN A, NEMA DESIGN B AND IEC DESIGN N, NE, NEY OR NY MOTORS (EXCLUDING FIRE PUMP ELECTRIC MOTORS AND AIR-OVER ELECTRIC MOTORS) AT 60 Hz

Motor horsepower/standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/.75	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5/1.1	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0
2/1.5	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5
3/2.2	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5/3.7	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5/5.5	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10/7.5	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15/11	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20/15	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0
25/18.5	91.7	91.7	93.6	93.6	93.0	93.0	90.2	91.0
30/22	91.7	91.7	93.6	94.1	93.0	93.6	91.7	91.7
40/30	92.4	92.4	94.1	94.1	94.1	94.1	91.7	91.7
50/37	93.0	93.0	94.5	94.5	94.1	94.1	92.4	92.4
60/45	93.6	93.6	95.0	95.0	94.5	94.5	92.4	93.0
75/55	93.6	93.6	95.4	95.0	94.5	94.5	93.6	94.1
100/75	95.0	94.5	96.2	96.2	95.8	95.8	94.5	95.0
125/90	95.4	94.5	96.2	96.2	95.8	95.8	95.0	95.0
150/110	95.4	94.5	96.2	96.2	96.2	95.8	95.0	95.0
200/150	95.8	95.4	96.5	96.2	96.2	95.8	95.4	95.0
250/186	96.2	95.4	96.5	96.2	96.2	96.2	95.4	95.4

TABLE V–44—NOMINAL FULL-LOAD EFFICIENCIES OF NEMA DESIGN A, NEMA DESIGN B AND IEC DESIGN N, NE, NEY OR NY MOTORS (EXCLUDING FIRE PUMP ELECTRIC MOTORS AND AIR-OVER ELECTRIC MOTORS) AT 60 Hz—Continued

Motor horsepower/standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
300/224	95.8	95.4	96.2	95.8	95.8	95.8	....	....
350/261	95.8	95.4	96.2	95.8	95.8	95.8	....	....
400/298	95.8	95.8	96.2	95.8	....	....	....	....
450/336	95.8	96.2	96.2	96.2	....	....	....	....
500/373	95.8	96.2	96.2	96.2	....	....	....	....
550/410	95.8	96.2	96.2	96.2	....	....	....	....
600/447	95.8	96.2	96.2	96.2	....	....	....	....
650/485	95.8	96.2	96.2	96.2	....	....	....	....
700/522	95.8	96.2	96.2	96.2	....	....	....	....
750/559	95.8	96.2	96.2	96.2	....	....	....	....

TABLE V–45—NOMINAL FULL-LOAD EFFICIENCIES OF NEMA DESIGN A, NEMA DESIGN B AND IEC DESIGN N, NE, NEY OR NY STANDARD FRAME SIZE AIR-OVER ELECTRIC MOTORS (EXCLUDING FIRE PUMP ELECTRIC MOTORS) AT 60 Hz

Motor horsepower/standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/.75	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5/1.1	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0
2/1.5	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5
3/2.2	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5/3.7	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5/5.5	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10/7.5	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15/11	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20/15	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0
25/18.5	91.7	91.7	93.6	93.6	93.0	93.0	90.2	91.0
30/22	91.7	91.7	93.6	94.1	93.0	93.6	91.7	91.7
40/30	92.4	92.4	94.1	94.1	94.1	94.1	91.7	91.7
50/37	93.0	93.0	94.5	94.5	94.1	94.1	92.4	92.4
60/45	93.6	93.6	95.0	95.0	94.5	94.5	92.4	93.0
75/55	93.6	93.6	95.4	95.0	94.5	94.5	93.6	94.1
100/75	95.0	94.5	96.2	96.2	95.8	95.8	94.5	95.0
125/90	95.4	94.5	96.2	96.2	95.8	95.8	95.0	95.0
150/110	95.4	94.5	96.2	96.2	96.2	95.8	95.0	95.0
200/150	95.8	95.4	96.5	96.2	96.2	95.8	95.4	95.0
250/186	96.2	95.4	96.5	96.2	96.2	96.2	95.4	95.4

TABLE V–46—NOMINAL FULL-LOAD EFFICIENCIES OF NEMA DESIGN A, NEMA DESIGN B AND IEC DESIGN N, NE, NEY OR NY SPECIALIZED FRAME SIZE AIR-OVER ELECTRIC MOTORS (EXCLUDING FIRE PUMP ELECTRIC MOTORS) AT 60 Hz

Motor horsepower/standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/.75	74.0	....	82.5	82.5	80.0	80.0	74.0	74.0
1.5/1.1	82.5	82.5	84.0	84.0	85.5	84.0	77.0	75.5
2/1.5	84.0	84.0	84.0	84.0	86.5	85.5	82.5	85.5
3/2.2	85.5	84.0	87.5	86.5	87.5	86.5	84.0	86.5
5/3.7	87.5	85.5	87.5	87.5	87.5	87.5	85.5	87.5
7.5/5.5	88.5	87.5	89.5	88.5	89.5	88.5	85.5	88.5
10/7.5	89.5	88.5	89.5	89.5	89.5	90.2	....	....
15/11	90.2	89.5	91.0	91.0	....	....	....	....
20/15	90.2	90.2	91.0	91.0	....	....	....	....

2. Annualized Benefits and Costs of the 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 2021$) of the benefits from operating equipment that meet the adopted standards (consisting primarily of operating cost savings from using less energy, minus increases in equipment purchase costs, and (2) the annualized monetary value of the climate and health benefits from emission reductions.

Table V–47 shows the annualized values for electric motors under TSL 2, expressed in 2021$. The results under the primary estimate are as follows.

Using a 7-percent discount rate for consumer benefits and costs and NO_X and SO_2 reduction benefits, and a 3-percent discount rate case for GHG social costs, the estimated cost of the standards for electric motors is $62.1 million per year in increased equipment costs, while the estimated annual benefits are $254.8 million in reduced equipment operating costs, $164.8 million in climate benefits, and $151.4 million in health benefits. In this case, the net benefit amounts to $508.9 million per year.

Using a 3-percent discount rate for all benefits and costs, the estimated cost of the standards for electric motors is $71.0 million per year in increased equipment costs, while the estimated annual benefits are $463.6 million in reduced operating costs, $164.8 million in climate benefits, and $300.7 million in health benefits. In this case, the net benefit amounts to $858.2 million per year.

TABLE V–47—ANNUALIZED BENEFITS AND COSTS OF AMENDED ENERGY CONSERVATION STANDARDS FOR ELECTRIC MOTORS

[TSL 2]

	Million 2021$/year		
	Primary estimate	Low-net-benefits estimate	High-net-benefits estimate
3% discount rate			
Consumer Operating Cost Savings	463.6	405.1	542.9
Climate Benefits *	164.8	148.0	186.5
Health Benefits **	300.7	269.5	341.0
Total Benefits †	929.1	822.5	1070.4
Consumer Incremental Equipment Costs ‡	71.0	73.7	73.0
Net Benefits	858.2	748.8	997.4
7% discount rate			
Consumer Operating Cost Savings	254.8	225.3	293.6
Climate Benefits * (3% discount rate)	164.8	148.0	186.5
Health Benefits **	151.4	137.1	169.5
Total Benefits †	571.0	510.4	649.6
Consumer Incremental Product Costs	62.1	63.8	63.9
Net Benefits	508.9	446.6	585.6

Note: This table presents the costs and benefits associated with electric motors shipped in 2027–2056. These results include benefits to consumers which accrue after 2056 from the products shipped in 2027–2056. The Primary, Low Net Benefits, and High Net Benefits Estimates utilize projections of energy prices from the *AEO2022* Reference case, Low Economic Growth case, and High Economic Growth case, respectively. In addition, incremental equipment costs reflect a constant rate in the Primary Estimate, an increasing rate in the Low Net Benefits Estimate, and a declining rate in the High Net Benefits Estimate. The methods used to derive projected price trends are explained in section IV.H.3 of this document. Note that the Benefits and Costs may not sum to the Net Benefits due to rounding.

* Climate benefits are calculated using four different estimates of the global SC–GHG (see section IV.L of this notice). For presentational purposes of this table, the climate benefits associated with the average SC–GHG at a 3 percent discount rate are shown, but the Department does not have a single central SC–GHG point estimate, and it emphasizes the importance and value of considering the benefits calculated using all four SC–GHG estimates. To monetize the benefits of reducing GHG emissions this analysis uses the interim estimates presented in the *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates Under Executive Order 13990* published in February 2021 by the Interagency Working Group on the Social Cost of Greenhouse Gases (IWG).

** Health benefits are calculated using benefit-per-ton values for NO_X and SO_2. DOE is currently only monetizing (for SO_2 and NO_X) $PM_{2.5}$ precursor health benefits and (for NO_X) ozone precursor health benefits, but will continue to assess the ability to monetize other effects such as health benefits from reductions in direct $PM_{2.5}$ emissions. The health benefits are presented at real discount rates of 3 and 7 percent. See section IV.L of this document for more details.

† Total benefits for both the 3-percent and 7-percent cases are presented using the average SC–GHG with 3-percent discount rate, but the Department does not have a single central SC–GHG point estimate.

‡ Costs include incremental equipment costs as well as installation costs.

D. Reporting, Certification, and Sampling Plan

Manufacturers, including importers, must use product-specific certification templates to certify compliance to DOE. For electric motors, the certification template reflects the general certification requirements specified at 10 CFR 429.64 and the product-specific requirements specified at 10 CFR 429.64. DOE is not amending the product-specific certification requirements for this equipment in this direct final rule.

VI. Procedural Issues and Regulatory Review

A. Review Under Executive Orders 12866, 13563, and 14094

Executive Order (''E.O.'') 12866, ''Regulatory Planning and Review,'' 58 FR 51735 (Oct. 4, 1993), as supplemented and reaffirmed by E.O. 13563, ''Improving Regulation and

Regulatory Review,'' 76 FR 3821 (Jan. 21, 2011) and amended by E.O. 14094, ''Modernizing Regulatory Review,'' 88 FR 21879 (April 11, 2023), requires agencies, to the extent permitted by law, 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 E.O. 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, the Office of Information and Regulatory Affairs (''OIRA'') in the Office of Management and Budget (''OMB'') 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, this final regulatory action is consistent with these principles.

Section 6(a) of E.O. 12866 also requires agencies to submit ''significant regulatory actions'' to OIRA for review. OIRA has determined that this final regulatory action constitutes a significant regulatory action within the scope of section 3(f)(1) of E.O. 12866. Accordingly, pursuant to section 6(a)(3)(C) of E.O. 12866, DOE has provided to OIRA an assessment, including the underlying analysis, of benefits and costs anticipated from the final regulatory action, together with, to the extent feasible, a quantification of those costs; and an assessment, including the underlying analysis, of costs and benefits of potentially effective and reasonably feasible alternatives to the planned regulation, and an explanation why the planned regulatory action is preferable to the identified potential alternatives. These assessments are summarized in this preamble and further detail can be found in the technical support document for this rulemaking.

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 E.O. 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 (*www.energy.gov/gc/office-general-counsel*).

DOE is not obligated to prepare a regulatory flexibility analysis for this rulemaking because there is not a requirement to publish a general notice of proposed rulemaking under the Administrative Procedure Act. See 5 U.S.C. 601(2), 603(a). As discussed previously, DOE has determined that the November 2022 Joint Recommendation meets the necessary requirements under EPCA to issue this direct final rule for energy conservation standards for electric motors under the procedures in 42 U.S.C. 6295(p)(4). DOE notes that the NOPR for energy conservation standards for electric motors published elsewhere in this **Federal Register** contains an IRFA.

C. Review Under the Paperwork Reduction Act

Under the procedures established by the Paperwork Reduction Act of 1995 (''PRA''), a person is not required to respond to a collection of information by a Federal agency unless that collection of information displays a currently valid OMB Control Number.

OMB Control Number 1910–1400, Compliance Statement Energy/Water Conservation Standards for Appliances, is currently valid and assigned to the certification reporting requirements applicable to covered equipment, including electric motors.

DOE's certification and compliance activities ensure accurate and comprehensive information about the energy and water use characteristics of covered products and covered equipment sold in the United States. Manufacturers of all covered products and covered equipment must submit a certification report before a basic model is distributed in commerce, annually thereafter, and if the basic model is redesigned in such a manner to increase the consumption or decrease the efficiency of the basic model such that the certified rating is no longer supported by the test data. Additionally, manufacturers must report when production of a basic model has ceased and is no longer offered for sale as part of the next annual certification report following such cessation. DOE requires the manufacturer of any covered product or covered equipment to establish, maintain, and retain the records of certification reports, of the underlying test data for all certification testing, and of any other testing conducted to satisfy the requirements of part 429, part 430, and/or part 431. Certification reports provide DOE and consumers with comprehensive, up-to date efficiency information and support effective enforcement.

New certification data would be required for electric motors were this direct final rule to be finalized as proposed; however, DOE is not proposing new or amended certification or reporting requirements for electric motors in this direct final rule. Instead, DOE may consider proposals to establish certification requirements and reporting for electric motors under a separate rulemaking regarding appliance and equipment certification. DOE will address changes to OMB Control Number 1910–1400 at that time, as necessary.

Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB Control Number.

D. Review Under the National Environmental Policy Act of 1969

Pursuant to the National Environmental Policy Act of 1969 (''NEPA''), DOE has analyzed this rule in accordance with NEPA and DOE's NEPA implementing regulations (10 CFR part 1021). DOE has determined that this rule qualifies for categorical exclusion under 10 CFR part 1021, subpart D, appendix B5.1 because it is a rulemaking that establishes energy conservation standards for consumer products or industrial equipment, none of the exceptions identified in B5.1(b) apply, no extraordinary circumstances exist that require further environmental analysis, and it meets the requirements for application of a categorical exclusion. See 10 CFR 1021.410. Therefore, DOE has determined that promulgation of this rule is not a major Federal action significantly affecting the quality of the human environment within the meaning of NEPA, and does not require an environmental assessment or an environmental impact statement.

E. Review Under Executive Order 13132

E.O. 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 equipment 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. 6316(a) and (b); 42 U.S.C. 6297) Therefore, no further action is required by Executive Order 13132.

F. Review Under Executive Order 12988

With respect to the review of existing regulations and the promulgation of new regulations, section 3(a) of E.O. 12988, ''Civil Justice Reform,'' imposes on Federal agencies the general duty to adhere to the following requirements: (1) eliminate drafting errors and ambiguity, (2) write regulations to minimize litigation, (3) provide a clear legal standard for affected conduct rather than a general standard, and (4) promote simplification and burden reduction. 61 FR 4729 (Feb. 7, 1996). Regarding the review required by section 3(a), section 3(b) of E.O. 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 E.O. 12988 requires Executive agencies to review regulations in light of applicable standards in section 3(a) and section 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, this direct final rule meets the relevant standards of E.O. 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. Public Law 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 *www.energy.gov/sites/prod/files/gcprod/documents/umra_97.pdf.*

DOE has concluded that this direct final rule may require expenditures of $100 million or more in any one year by the private sector. Such expenditures may include (1) investment in research and development and in capital expenditures by electric motor manufacturers in the years between the direct final rule and the compliance date for the new standards and (2) incremental additional expenditures by consumers to purchase higher-efficiency electric motors, starting at the compliance date for the applicable standard.

Section 202 of UMRA authorizes a Federal agency to respond to the content requirements of UMRA in any other statement or analysis that accompanies the direct final rule. (2 U.S.C. 1532(c)) The content requirements of section 202(b) of UMRA relevant to a private sector mandate substantially overlap with the economic analysis requirements that apply under section 325(o) of EPCA and Executive Order 12866. The **SUPPLEMENTARY INFORMATION** section of this document and the TSD for this direct final rule respond to those requirements.

Under section 205 of UMRA, the Department is obligated to identify and consider a reasonable number of regulatory alternatives before promulgating a rule for which a written statement under section 202 is required. (2 U.S.C. 1535(a)) DOE is required to select from those alternatives the most cost-effective and least burdensome alternative that achieves the objectives of the rule unless DOE publishes an explanation for doing otherwise, or the selection of such an alternative is inconsistent with law. As required by 42 U.S.C. 6295(m) and 42 U.S.C. 6316(a), this rule establishes new and amended energy conservation standards for electric motors that are designed to achieve the maximum improvement in energy efficiency that DOE has determined to be both technologically feasible and economically justified, as required by 42 U.S.C. 6316(a); 42 U.S.C. 6295(o)(2)(A) and 42 U.S.C. 6295(o)(3)(B). A full discussion of the alternatives considered by DOE is presented in chapter 17 of the TSD for this rule.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105–277) requires Federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This rule will 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 E.O. 12630, ''Governmental Actions and Interference with Constitutionally Protected Property Rights,'' 53 FR 8859 (Mar. 15, 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). Pursuant to OMB Memorandum M–19–15, Improving Implementation of the Information Quality Act (April 24, 2019), DOE published updated guidelines which are available at *www.energy.gov/sites/prod/files/2019/12/f70/DOE%20Final%20Updated%20IQA%20Guidelines%20Dec%202019.pdf.* DOE has reviewed this direct final rule under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

K. Review Under Executive Order 13211

E.O. 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 concludes that this regulatory action, which sets forth new and amended energy conservation standards for electric motors, is not a significant energy action because standards are not likely to have a significant adverse effect on the supply, distribution, or use of energy, nor has it been designated as such by the Administrator at OIRA. Accordingly, DOE has not prepared a Statement of Energy Effects on this direct final rule.

L. Information Quality

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.'' 70 FR 2664, 2667.

In response to OMB's Bulletin, DOE conducted formal peer reviews of the energy conservation standards development process and the analyses that are typically used and has prepared a report describing that peer review.[98] 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. Because available data, models, and technological understanding have changed since 2007, DOE has engaged with the National Academy of Sciences to review DOE's analytical methodologies to ascertain whether modifications are needed to improve the Department's analyses. DOE is in the process of evaluating the resulting report.[99]

NEMA MG 1–2016 was previously approved for incorporation by reference in the section where it appears in this proposed rule and no change is made.

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).

VII. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this direct final rule.

List of Subjects in 10 CFR Part 431

Administrative practice and procedure, Confidential business information, Energy conservation test procedures, Incorporation by reference, Reporting and recordkeeping requirements.

Signing Authority

This document of the Department of Energy was signed on May 1, 2023, Francisco Alejandro Moreno, Acting Assistant Secretary for Energy Efficiency and Renewable Energy. That document with the original signature and date is maintained by DOE. For administrative purposes only, and in compliance with requirements of the Office of the Federal Register, the undersigned DOE **Federal Register** Liaison Officer has been authorized to sign and submit the document in electronic format for publication, as an official document of the Department of Energy. This administrative process in no way alters the legal effect of this document upon publication in the **Federal Register**.

Signed in Washington, DC, on May 5, 2023.

Treena V. Garrett,

Federal Register Liaison Officer, U.S. Department of Energy.

For the reasons stated in the preamble, DOE amends part 431 of chapter II of title 10 of the Code of Federal Regulations, as set forth below:

[98] The 2007 ''Energy Conservation Standards Rulemaking Peer Review Report'' is available at the following website: *energy.gov/eere/buildings/downloads/energy-conservation-standards-rulemaking-peer-review-report-0* (last accessed December 12, 2022).

[99] The report is available at *www.nationalacademies.org/our-work/review-of-methods-for-setting-building-and-equipment-performance-standards.*

PART 431—ENERGY EFFICIENCY PROGRAM FOR CERTAIN COMMERCIAL AND INDUSTRIAL EQUIPMENT

■ 1. The authority citation for part 431 continues to read as follows:

Authority: 42 U.S.C. 6291–6317; 28 U.S.C. 2461 note.

■ 2. Amend § 431.12 by adding, in alphabetical order, definitions for ''Specialized frame size'' and ''Standard frame size,'' to read as follows:

§ 431.12 Definitions.

* * * * *

Specialized frame size means an electric motor frame size for which the rated output power of the motor exceeds the motor frame size limits specified for standard frame size. Specialized frame sizes have maximum diameters corresponding to the following NEMA Frame Sizes:

Motor horsepower/standard kilowatt equivalent	Maximum NEMA frame diameters							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/.75	48	....	48	48	48	48	140	140
1.5/1.1	48	48	48	48	140	140	140	140
2/1.5	48	48	48	48	140	140	180	180
3/2.2	140	48	140	140	180	180	180	180
5/3.7	140	140	140	140	180	180	210	210
7.5/5.5	180	140	180	180	210	210	210	210
10/7.5	180	180	180	180	210	210	....	....
15/11	210	180	210	210	....	....	....	....
20/15	210	210	210	210	....	....	....	....

Standard frame size means a motor frame size that aligns with the specifications in NEMA MG 1–2016, section 13.2 for open motors, and NEMA MG 1–2016, section 13.3 for enclosed motors (incorporated by reference, see § 431.15).

* * * * *

■ 3. Amend § 431.25 by:

■ a. Revising paragraph (h) introductory text; and

■ b. Adding paragraphs (m) through (r).

The revision and additions read as follows:

§ 431.25 Energy conservation standards and effective dates.

* * * * *

(h) Each NEMA Design A motor, NEMA Design B motor, and IEC Design N (including NE, NEY, or NY variants) motor that is an electric motor meeting the criteria in paragraph (g) of this section and with a power rating from 1 horsepower through 500 horsepower, but excluding fire pump electric motors, manufactured (alone or as a component of another piece of equipment) on or after June 1, 2016, but before June 1, 2027, shall have a nominal full-load efficiency of not less than the following:

* * * * *

(m) The standards in tables 8 through 10 of this section apply only to electric motors, including partial electric motors, that satisfy the following criteria:

(1) Are single-speed, induction motors;

(2) Are rated for continuous duty (MG 1) operation or for duty type S1 (IEC);

(3) Contain a squirrel-cage (MG 1) or cage (IEC) rotor;

(4) Operate on polyphase alternating current 60-hertz sinusoidal line power;

(5) Are rated 600 volts or less;

(6) Have a 2-, 4-, 6-, or 8-pole configuration,

(7) Are built in a three-digit or four-digit NEMA frame size (or IEC metric equivalent), including those designs between two consecutive NEMA frame sizes (or IEC metric equivalent), or an enclosed 56 NEMA frame size (or IEC metric equivalent),

(8) Produce at least one horsepower (0.746 kW) but not greater than 750 horsepower (559 kW), and

(9) Meet all of the performance requirements of one of the following motor types: A NEMA Design A, B, or C motor or an IEC Design N, NE, NEY, NY or H, HE, HEY, HY motor.

(n) Starting on June 1, 2027, each NEMA Design A motor, NEMA Design B motor, and IEC Design N (including NE, NEY, or NY variants) motor that is an electric motor meeting the criteria in paragraph (m) of this section and with a power rating from 1 horsepower through 750 horsepower, but excluding fire pump electric motors and air-over electric motors, manufactured (alone or as a component of another piece of equipment) shall have a nominal full-load efficiency of not less than the following:

TABLE 8 TO PARAGRAPH (n)—NOMINAL FULL-LOAD EFFICIENCIES OF NEMA DESIGN A, NEMA DESIGN B AND IEC DESIGN N, NE, NEY OR NY MOTORS (EXCLUDING FIRE PUMP ELECTRIC MOTORS AND AIR-OVER ELECTRIC MOTORS) AT 60 Hz

Motor horsepower/standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/.75	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5/1.1	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0
2/1.5	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5
3/2.2	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5/3.7	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5/5.5	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10/7.5	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2

TABLE 8 TO PARAGRAPH (n)—NOMINAL FULL-LOAD EFFICIENCIES OF NEMA DESIGN A, NEMA DESIGN B AND IEC DESIGN N, NE, NEY OR NY MOTORS (EXCLUDING FIRE PUMP ELECTRIC MOTORS AND AIR-OVER ELECTRIC MOTORS) AT 60 Hz—Continued

Motor horsepower/standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
15/11	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20/15	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0
25/18.5	91.7	91.7	93.6	93.6	93.0	93.0	90.2	91.0
30/22	91.7	91.7	93.6	94.1	93.0	93.6	91.7	91.7
40/30	92.4	92.4	94.1	94.1	94.1	94.1	91.7	91.7
50/37	93.0	93.0	94.5	94.5	94.1	94.1	92.4	92.4
60/45	93.6	93.6	95.0	95.0	94.5	94.5	92.4	93.0
75/55	93.6	93.6	95.4	95.0	94.5	94.5	93.6	94.1
100/75	95.0	94.5	96.2	96.2	95.8	95.8	94.5	95.0
125/90	95.4	94.5	96.2	96.2	95.8	95.8	95.0	95.0
150/110	95.4	94.5	96.2	96.2	96.2	95.8	95.0	95.0
200/150	95.8	95.4	96.5	96.2	96.2	95.8	95.4	95.0
250/186	96.2	95.4	96.5	96.2	96.2	96.2	95.4	95.4
300/224	95.8	95.4	96.2	95.8	95.8	95.8		
350/261	95.8	95.4	96.2	95.8	95.8	95.8		
400/298	95.8	95.8	96.2	95.8				
450/336	95.8	96.2	96.2	96.2				
500/373	95.8	96.2	96.2	96.2				
550/410	95.8	96.2	96.2	96.2				
600/447	95.8	96.2	96.2	96.2				
650/485	95.8	96.2	96.2	96.2				
700/522	95.8	96.2	96.2	96.2				
750/559	95.8	96.2	96.2	96.2				

(o) Starting on June 1, 2027, each NEMA Design A motor, NEMA Design B motor, and IEC Design N (including NE, NEY, or NY variants) motor that is an air-over electric motor meeting the criteria in paragraph (m) of this section and with a power rating from 1 horsepower through 250 horsepower, built in a standard frame size, but excluding fire pump electric motors, manufactured (alone or as a component of another piece of equipment) shall have a nominal full-load efficiency of not less than the following:

TABLE 9 TO PARAGRAPH (o)—NOMINAL FULL-LOAD EFFICIENCIES OF NEMA DESIGN A, NEMA DESIGN B AND IEC DESIGN N, NE, NEY OR NY STANDARD FRAME SIZE AIR-OVER ELECTRIC MOTORS (EXCLUDING FIRE PUMP ELECTRIC MOTORS) AT 60 Hz

Motor horsepower/standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/.75	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5/1.1	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0
2/1.5	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5
3/2.2	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5/3.7	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5/5.5	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10/7.5	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15/11	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20/15	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0
25/18.5	91.7	91.7	93.6	93.6	93.0	93.0	90.2	91.0
30/22	91.7	91.7	93.6	94.1	93.0	93.6	91.7	91.7
40/30	92.4	92.4	94.1	94.1	94.1	94.1	91.7	91.7
50/37	93.0	93.0	94.5	94.5	94.1	94.1	92.4	92.4
60/45	93.6	93.6	95.0	95.0	94.5	94.5	92.4	93.0
75/55	93.6	93.6	95.4	95.0	94.5	94.5	93.6	94.1
100/75	95.0	94.5	96.2	96.2	95.8	95.8	94.5	95.0
125/90	95.4	94.5	96.2	96.2	95.8	95.8	95.0	95.0
150/110	95.4	94.5	96.2	96.2	96.2	95.8	95.0	95.0
200/150	95.8	95.4	96.5	96.2	96.2	95.8	95.4	95.0
250/186	96.2	95.4	96.5	96.2	96.2	96.2	95.4	95.4

(p) Starting on June 1, 2027, each NEMA Design A motor, NEMA Design B motor, and IEC Design N (including NE, NEY, or NY variants) motor that is an air-over electric motor meeting the criteria in paragraph (m) of this section and with a power rating from 1 horsepower through 20 horsepower, built in a specialized frame size, but excluding fire pump electric motors, manufactured (alone or as a component of another piece of equipment) shall have a nominal full-load efficiency of not less than the following:

TABLE 10 TO PARAGRAPH (p)—NOMINAL FULL-LOAD EFFICIENCIES OF NEMA DESIGN A, NEMA DESIGN B AND IEC DESIGN N, NE, NEY OR NY SPECIALIZED FRAME SIZE AIR-OVER ELECTRIC MOTORS (EXCLUDING FIRE PUMP ELECTRIC MOTORS) AT 60 Hz

Motor horsepower/standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/.75	74.0	....	82.5	82.5	80.0	80.0	74.0	74.0
1.5/1.1	82.5	82.5	84.0	84.0	85.5	84.0	77.0	75.5
2/1.5	84.0	84.0	84.0	84.0	86.5	85.5	82.5	85.5
3/2.2	85.5	84.0	87.5	86.5	87.5	86.5	84.0	86.5
5/3.7	87.5	85.5	87.5	87.5	87.5	87.5	85.5	87.5
7.5/5.5	88.5	87.5	89.5	88.5	89.5	88.5	85.5	88.5
10/7.5	89.5	88.5	89.5	89.5	89.5	90.2	....	....
15/11	90.2	89.5	91.0	91.0	....	....	....	....
20/15	90.2	90.2	91.0	91.0	....	....	....	....

(q) For purposes of determining the required minimum nominal full-load efficiency of an electric motor that has a horsepower or kilowatt rating between two horsepower or two kilowatt ratings listed in any table of energy conservation standards in paragraphs (n) through (p) through of this section, each such motor shall be deemed to have a listed horsepower or kilowatt rating, determined as follows:

(1) A horsepower at or above the midpoint between the two consecutive horsepowers shall be rounded up to the higher of the two horsepowers;

(2) A horsepower below the midpoint between the two consecutive horsepowers shall be rounded down to the lower of the two horsepowers; or

(3) A kilowatt rating shall be directly converted from kilowatts to horsepower using the formula 1 kilowatt = ($1/0.746$) horsepower. The conversion should be calculated to three significant decimal places, and the resulting horsepower shall be rounded in accordance with paragraphs (q)(1) or (2) of this section, whichever applies.

(r) The standards in tables 8 through 10 of this section do not apply to the following electric motors exempted by the Secretary, or any additional electric motors that the Secretary may exempt:

(1) Component sets of an electric motor;

(2) Liquid-cooled electric motors;

(3) Submersible electric motors; and

(4) Inverter-only electric motors.

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