DEPARTMENT OF ENERGY

10 CFR Part 431

[Docket Number EERE–2010–BT–STD–0027]

RIN 1904–AC28

Energy Conservation Program: Energy Conservation Standards for Commercial and Industrial Electric Motors

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

ACTION: Notice of proposed rulemaking (NOPR) and public meeting.

SUMMARY: The Energy Policy and Conservation Act of 1975 (EPCA), as amended, prescribes energy conservation standards for various consumer products and certain commercial and industrial equipment, including commercial and industrial electric motors. EPCA also requires the U.S. Department of Energy (DOE) to determine whether more-stringent, amended standards would be technologically feasible and economically justified, and would save a significant amount of energy. In this notice, DOE proposes energy conservation standards for a number of different groups of electric motors that DOE has not previously regulated. For those groups of electric motors currently regulated, the proposed standards would maintain the current energy conservation standards for some electric motor types and amend the energy conservation standards for other electric motor types. The document also announces a public meeting to receive comment on these proposed standards and associated analyses and results.

DATES: DOE will hold a public meeting on Wednesday, December 11, 2013, from 9 a.m. to 4 p.m., in Washington, DC. The meeting will also be broadcast as a webinar. See section VII Public Participation for webinar registration information, participant instructions, and information about the capabilities available to webinar participants.

DOE will accept comments, data, and information regarding this NOPR before and after the public meeting, but no later than February 4, 2014. See section VII Public Participation for details.

ADDRESSES: The public meeting will be held at the U.S. Department of Energy, Forrestal Building, Room 8E–089, 1000 Independence Avenue SW., Washington, DC 20585. To attend, please notify Ms. Brenda Edwards at (202) 586–2945. Please note that foreign nationals visiting DOE Headquarters are subject to advance security screening procedures. Any foreign national wishing to participate in the meeting should advise DOE as soon as possible by contacting Ms. Edwards to initiate the necessary procedures. Please also note that those wishing to bring laptops into the Forrestal Building will be required to obtain a property pass. Visitors should avoid bringing laptops, or allow an extra 45 minutes. Persons can attend the public meeting via webinar. For more information, refer to the Public Participation section near the end of this notice.

Any comments submitted must identify the NOPR for Energy Conservation Standards for electric motors, and provide docket number EE–2010–BT–STD–2027 and/or regulatory information number (RIN) number 1904–AC28. Comments may be submitted using any of the following methods:

1. *Federal eRulemaking Portal: www.regulations.gov*. Follow the instructions for submitting comments.
2. *Email: ElecMotors-2010-STD-0027@ee.doe.gov*. Include the docket number and/or RIN in the subject line of the message.
3. *Mail:* Ms. Brenda Edwards, U.S. Department of Energy, Building Technologies Program, Mailstop EE–2J, 1000 Independence Avenue SW., Washington, DC 20585–0121. If possible, please submit all items on a CD. It is not necessary to include printed copies.
4. *Hand Delivery/Courier:* Ms. Brenda Edwards, U.S. Department of Energy, Building Technologies Program, 950 L'Enfant Plaza SW., Suite 600, Washington, DC 20024. Telephone: (202) 586–2945. If possible, please submit all items on a CD, in which case it is not necessary to include printed copies.

Written comments regarding the burden-hour estimates or other aspects of the collection-of-information requirements contained in this proposed rule may be submitted to Office of Energy Efficiency and Renewable Energy through the methods listed above and by email to *Chad_S_Whiteman@omb.eop.gov*.

For detailed instructions on submitting comments and additional information on the rulemaking process, see section VII of this document (Public Participation).

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

A link to the docket Web page can be found at *http://www.regulations.gov/#!docketDetail;D=EERE-2010-BT-STD-0027*. This Web page will contain a link to the docket for this notice on the regulations.gov site. The regulations.gov Web page will contain simple instructions on how to access all documents, including public comments, in the docket. See section VII for further information on how to submit comments through *www.regulations.gov*.

For further information on how to submit a comment, review other public comments and the docket, or participate in the public meeting, contact Ms. Brenda Edwards at (202) 586–2945 or by email: *Brenda.Edwards@ee.doe.gov*.

FOR FURTHER INFORMATION CONTACT:

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Ms. Ami Grace-Tardy, U.S. Department of Energy, Office of the General Counsel, GC–71, 1000 Independence Avenue SW., Washington, DC 20585–0121. Telephone: (202) 586–5709. Email: *Ami.Grace-Tardy@hq.doe.gov*.

SUPPLEMENTARY INFORMATION:

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I. Summary of the Proposed Rule

Title III, Part B of the Energy Policy and Conservation Act of 1975 (EPCA or the Act), Public Law 94–163 (42 U.S.C. 6291–6309, as codified), established the Energy Conservation Program for Consumer Products Other Than Automobiles. Part C of Title III of EPCA (42 U.S.C. 6311–6317) established a similar program for "Certain Industrial Equipment," including certain electric motors.[1] (Within this preamble, DOE will use the terms "electric motors" and "motors" interchangeably.) Pursuant to EPCA, any new or amended energy conservation standard that DOE may prescribe for certain equipment, such as electric motors, shall be designed to achieve the maximum improvement in energy efficiency that DOE determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A) and 6316(a)). Furthermore, any new or amended standard must result in a significant

[1] For editorial reasons, upon codification in the U.S. Code, Parts B and C were redesignated as Parts A and A–1, respectively.

conservation of energy. (42 U.S.C. 6295(o)(3)(B) and 6316(a)).

In accordance with these and other statutory provisions discussed in this notice, the U.S. Department of Energy (DOE) proposes amending the energy conservation standards for electric motors by applying the standards currently in place to a wider scope of electric motors for which DOE does not currently regulate. In setting these standards, DOE is proposing to address a number of different groups of electric motors that have, to date, not been required to satisfy the energy conservation standards currently set out in 10 CFR part 431. In addition, with the exception of fire pump electric motors, the proposal would require all currently regulated motors to satisfy the efficiency levels prescribed in Table 12–12 and Table 20–B [2] of MG1–2011, published by the National Electrical Manufacturers Association; fire pump motors would continue to meet the current standards that apply. All other electric motors that DOE is proposing to regulate would also need to meet these efficiency levels (i.e. Tables 12–12 and 20–B). As a practical matter, the many currently regulated motors would continue to be required to meet the standards that they already meet, but certain motors, such as those that satisfy the general purpose electric motors (subtype II) (''subtype II'') or that are NEMA Design B motors from 201 through 500 horsepower, would need to meet the more stringent levels prescribed by MG1–2011 Tables 12–12 and 20–B. These proposed efficiency levels are shown in Table I.1. If adopted, the proposed standards would apply to all covered motor types listed in Table I.1 that are manufactured in, or imported into, the United States starting on December 19, 2015. DOE may, however, depending on the nature of the comments it receives, revisit this proposed compliance date.

TABLE I.1—PROPOSED ENERGY CONSERVATION STANDARDS FOR ELECTRIC MOTORS

[Compliance starting December 19, 2015]

Equipment class group	Electric motor design type	Horsepower rating	Pole configuration	Enclosure	Proposed TSL
1	NEMA Design A & B *	1–500	2, 4, 6, 8	Open	2
				Enclosed	2
2	NEMA Design C *	1–200	4, 6, 8	Open	2
				Enclosed	2
3	Fire Pump *	1–500	2, 4, 6, 8	Open	2
				Enclosed	2
4	Brake Motors *	1–30	4, 6, 8	Open	2
				Enclosed	2

* Indicates IEC equivalent electric motors are included.

The following tables (Tables I.2 to I.5) detail the various proposed standard levels that comprise TSL 2 and that DOE would apply to each group of motors. In determining where a particular motor with a certain horsepower (hp) or kilowatt rating would fall within the requirements, as in DOE's current regulations, DOE would apply the following approach in determining which rating would apply for compliance purposes:

(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 the rules listed in (1) and (2).

TABLE I.2—PROPOSED ENERGY CONSERVATION STANDARDS FOR NEMA DESIGN A AND NEMA DESIGN B ELECTRIC MOTORS (EXCLUDING FIRE PUMP ELECTRIC MOTORS, INTEGRAL BRAKE ELECTRIC MOTORS, AND NON-INTEGRAL BRAKE ELECTRIC MOTORS)

[Compliance starting December 19, 2015]

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

[2] Table 20–B of MG1–2011 provides nominal full-load efficiencies for ratings without nominal full-load efficiencies in Table 12–12 of MG1–2011.

TABLE I.2—PROPOSED ENERGY CONSERVATION STANDARDS FOR NEMA DESIGN A AND NEMA DESIGN B ELECTRIC MOTORS (EXCLUDING FIRE PUMP ELECTRIC MOTORS, INTEGRAL BRAKE ELECTRIC MOTORS, AND NON-INTEGRAL BRAKE ELECTRIC MOTORS)—Continued

[Compliance starting December 19, 2015]

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
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	95.0	95.0
350/261	95.8	95.4	96.2	95.8	95.8	95.8	95.0	95.0
400/298	95.8	95.8	96.2	95.8	95.8	95.8	95.0	95.0
450/336	95.8	96.2	96.2	96.2	95.8	96.2	95.0	95.0
500/373	95.8	96.2	96.2	96.2	95.8	96.2	95.0	95.0

TABLE I.3—PROPOSED ENERGY CONSERVATION STANDARDS FOR NEMA DESIGN C ELECTRIC MOTORS (EXCLUDING NON-INTEGRAL BRAKE ELECTRIC MOTORS AND INTEGRAL BRAKE ELECTRIC MOTORS)

[Compliance starting December 19, 2015]

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
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 I.4—PROPOSED ENERGY CONSERVATION STANDARDS FOR FIRE PUMP ELECTRIC MOTORS

[Compliance starting December 19, 2015]

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	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

TABLE I.4—PROPOSED ENERGY CONSERVATION STANDARDS FOR FIRE PUMP ELECTRIC MOTORS—Continued

[Compliance starting December 19, 2015]

Motor horse-power/standard kilowatt equivalent	Nominal full load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
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	94.5	94.5
350/261	95.4	95.0	95.4	95.4	95.0	95.4	94.5	94.5
400/298	95.4	95.4	95.4	95.4	95.0	95.4	94.5	94.5
450/336	95.4	95.8	95.4	95.8	95.0	95.4	94.5	94.5
500/373	95.4	95.8	95.8	95.8	95.0	95.4	94.5	94.5

TABLE I.5—PROPOSED ENERGY CONSERVATION STANDARDS FOR INTEGRAL BRAKE ELECTRIC MOTORS AND NON-INTEGRAL BRAKE ELECTRIC MOTORS

[Compliance starting December 19, 2015]

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
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

A. Benefits and Costs to Consumers

Table I.6 presents DOE's evaluation of the economic impacts of the proposed standards on consumers of electric motors, as measured by the weighted average life-cycle cost (LCC) savings and the weighted average median payback period.

TABLE I.6—IMPACTS OF PROPOSED STANDARDS ON CONSUMERS OF ELECTRIC MOTORS

	Weighted average LCC savings * (2012$)	Weighted average median payback period * (years)
Equipment Class Group 1.	132	3.3
Equipment Class Group 2.	38	5.0
Equipment Class Group 3.	N/A **	N/A **
Equipment Class Group 4.	259	1.9

* The results for each equipment class group (ECG) are a shipment weighted average of results for the representative units in the group. ECG 1: Representative units 1, 2, and 3; ECG 2: Representative units 4 and 5; ECG 3: Representative units 6, 7, and 8; ECG 4: Representative units 9 and 10. The weighted average lifetime in each equipment classes is 15 years and ranges from 8 to 29 years depending on the motor horsepower and application.

** For equipment class group 3, the proposed standard level is the same as the baseline; thus, no customers are affected.

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 (2013 to 2044). Using a real discount rate of 9.1 percent, DOE estimates that the industry net present value (INPV) for manufacturers of electric motors is $3,371.2 million in 2012$. Under the proposed standards, DOE expects that manufacturers may lose up to 8.4 percent of their INPV, which corresponds to approximately $283.5 million. Additionally, based on DOE's interviews with the manufacturers of electric motors, DOE does not expect any plant closings or significant loss of employment based on the energy conservation standards chosen in today's Notice of Proposed Rulemaking (NOPR).

C. National Benefits and Costs [3]

DOE's analyses indicate that the proposed standards would save a significant amount of energy. Estimated lifetime savings for electric motors purchased over the 30-year period that begins in the year of compliance with new and amended standards (2015–2044) would amount to 7.0 quads (full-fuel-cycle energy).[4] The annualized energy savings (0.23 quads) are equivalent to one percent of total U.S. industrial primary energy consumption in 2011.[5]

The estimated cumulative net present value (NPV) of total consumer costs and savings attributed to the proposed standards for electric motors ranges from $8.7 billion (at a 7-percent discount rate) to $23.3 billion (at a 3-percent discount rate). This NPV expresses the estimated total value of future operating-cost savings minus the estimated increased equipment costs for equipment purchased in 2015–2044.

In addition, the proposed standards would have significant environmental benefits. Estimated energy savings would result in cumulative emission reductions of 396 million metric tons (Mt) [6] of carbon dioxide (CO_2), 674 thousand tons of sulfur dioxide (SO_2), 499 thousand tons of nitrogen oxides (NO_X) and 0.8 tons of mercury (Hg).[7] Through 2030, the estimated energy savings would result in cumulative emissions reductions of 96 Mt of CO_2.

The value of the CO_2 reductions is calculated using a range of values per metric ton of CO_2 (otherwise known as the Social Cost of Carbon (SCC) developed by an interagency process).[8] The derivation of the SCC values is discussed in section IV.M. DOE estimates the present monetary value of the CO_2 emissions reduction is between $2.5 and $36.6 billion. DOE also estimates the present monetary value of the NO_X emissions reduction is $0.3 billion at a 7-percent discount rate and $0.6 billion at a 3-percent discount rate.[9]

Table I.7 summarizes the national economic costs and benefits expected to result from the proposed standards for electric motors.

TABLE I.7—SUMMARY OF NATIONAL ECONOMIC BENEFITS AND COSTS OF ELECTRIC MOTORS ENERGY CONSERVATION STANDARDS, PRESENT VALUE FOR MOTORS SHIPPED IN 2015–2044 IN BILLION 2012$

Category	Present value billion 2012$	Discount rate (%)
Benefits:		
Consumer Operating Cost Savings	14.8	7
	34.9	3
CO_2 Reduction Monetized Value ($11.8/t case) *	2.5	5
CO_2 Reduction Monetized Value ($39.7/t case) *	11.8	3
CO_2 Reduction Monetized Value ($61.2/t case) *	18.9	2.5
CO_2 Reduction Monetized Value ($117.0/t case) *	36.6	3
NO_X Reduction Monetized Value (at $2,639/ton) **	0.3	7
	0.6	3
Total Benefits †	26.9	7
	47.4	3
Costs:		
Consumer Incremental Installed Costs	6.1	7
	11.7	3
Net Benefits:		

[3] All monetary values in this section are expressed in 2012 dollars and are discounted to 2013.

[4] One quad (quadrillion Btu) is the equivalent of 293.1 billion kilowatt hours (kWh) or 172.3 million barrels of oil.

[5] Based on U.S. Department of Energy, Energy Information Administration, Annual Energy Outlook (AEO) 2013 data.

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

[7] DOE calculates emissions reductions relative to the *AEO2013* reference case, which generally represents current legislation and environmental regulations for which implementing regulations were available as of December 31, 2012.

[8] *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.* Interagency Working Group on Social Cost of Carbon, United States Government. May 2013; revised November 2013. *http://www.whitehouse.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf.*

[9] DOE is currently investigating valuation of avoided Hg and SO_2 emissions.

TABLE I.7—SUMMARY OF NATIONAL ECONOMIC BENEFITS AND COSTS OF ELECTRIC MOTORS ENERGY CONSERVATION STANDARDS, PRESENT VALUE FOR MOTORS SHIPPED IN 2015–2044 IN BILLION 2012$—Continued

Category	Present value billion 2012$	Discount rate (%)
Including CO_2 and NO_X Reduction Monetized Value	20.8	7
	35.7	3

* The interagency group selected four sets of SCC values for use in regulatory analyses. Three sets of values are based on the average SCC from the three integrated assessment models, at discount rates of 2.5, 3, and 5 percent. The fourth set, which represents the 95th percentile SCC estimate across all three models at a 3-percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. The values in parentheses represent the SCC in 2015. The SCC time series incorporate an escalation factor.

** The value represents the average of the low and high NO_X values used in DOE's analysis.

† Total Benefits for both the 3% and 7% cases are derived using the series corresponding to SCC value of $39.7/t in 2015.

The benefits and costs of today's proposed standards for electric motors, sold in years 2015–2044, can also be expressed in terms of annualized values. The annualized monetary values are the sum of (1) the annualized national economic value of the benefits from operation of the commercial and industrial equipment that meet the proposed standards (consisting primarily of operating cost savings from using less energy, minus increases in equipment purchase and installation costs, which is another way of representing consumer NPV), and (2) the annualized monetary value of the benefits of emission reductions, including CO_2 emission reductions.[10]

Although combining the values of operating savings and CO_2 emission reductions provides a useful perspective, two issues should be considered. First, the national operating savings are domestic U.S. consumer monetary savings that occur as a result of market transactions while the value of CO_2 reductions is based on a global value. Second, the assessments of operating cost savings and CO_2 savings are performed with different methods that use different time frames for analysis. The national operating cost savings is measured over the lifetime of electric motors shipped in years 2015–2044. The SCC values, on the other hand, reflect the present value of some future climate-related impacts resulting from the emission of one ton of carbon dioxide in each year. These impacts continue well beyond 2100.

Estimates of annualized benefits and costs of the proposed standards for electric motors are shown in Table I.8. The results under the primary estimate are as follows. Using a 7-percent discount rate for benefits and costs other than CO_2 reduction, for which DOE used a 3-percent discount rate along with the average SCC series that uses a 3-percent discount rate, the cost of the standards proposed in today's rule is $462 million per year in increased equipment costs; while the estimated benefits are $1,114 million per year in reduced equipment operating costs, $586 million in CO_2 reductions, and $21.5 million in reduced NO_X emissions. In this case, the net benefit would amount to $957 million per year. Using a 3-percent discount rate for all benefits and costs and the average SCC series, the estimated cost of the standards proposed in today's rule is $577 million per year in increased equipment costs; while the estimated benefits are $1,730 million per year in reduced operating costs, $586 million in CO_2 reductions, and $31.5 million in reduced NO_X emissions. In this case, the net benefit would amount to approximately $1,354 million per year.

TABLE I.8—ANNUALIZED BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR ELECTRIC MOTORS, IN MILLION 2012$

	Discount rate	Primary estimate *	Low net benefits estimate *	High net benefits estimate *
		million 2012$/year		
Benefits:				
Consumer Operating Cost Savings	7%	1,114	924	1,358
	3%	1,730	1,421	2,134
CO_2 Reduction Monetized Value ($11.8/t case) *	5%	155	134	179
CO_2 Reduction Monetized Value ($39.7/t case) *	3%	586	506	679
CO_2 Reduction Monetized Value ($61.2/t case) *	2.5%	882	762	1022
CO_2 Reduction Monetized Value ($117.0/t case) *	3%	1,811	1,565	2,098
NO_X Reduction Monetized Value (at $2,639/ton) **	7%	21.46	18.55	24.68
	3%	31.48	27.20	36.39
Total Benefits †	7% plus CO_2 range	1,290 to 2,947	1,077 to 2,507	1,562 to 3,481
	7%	1,721	1,449	2,061
	3% plus CO_2 range	1,916 to 3,572	1,583 to 3,014	2,350 to 4,268
	3%	2,347	1,955	2,849
Costs:				

[10] DOE used a two-step calculation process to convert the time-series of costs and benefits into annualized values. First, DOE calculated a present value in 2013, the year used for discounting the NPV of total consumer costs and savings, for the time-series of costs and benefits using discount rates of three and seven percent for all costs and benefits except for the value of CO_2 reductions. For the latter, DOE used a range of discount rates, as shown in Table I.3. From the present value, DOE then calculated the fixed annual payment over a 30-year period (2015 through 2044) that yields the same present value. The fixed annual payment is the annualized value. Although DOE calculated annualized values, this does not imply that the time-series of cost and benefits from which the annualized values were determined is a steady stream of payments.

TABLE I.8—ANNUALIZED BENEFITS AND COSTS OF PROPOSED ENERGY CONSERVATION STANDARDS FOR ELECTRIC MOTORS, IN MILLION 2012$—Continued

	Discount rate	Primary estimate *	Low net benefits estimate *	High net benefits estimate *
Incremental Installed Costs	7%	462	492	447
	3%	577	601	569
Net Benefits:				
Total †	7% plus CO_2 range	585 to 2,016	1,115 to 3,033	1,353 to 3,438
	7%	957	1,614	1,887
	3% plus CO_2 range	982 to 2,413	1,781 to 3,700	1,957 to 4,043
	3%	1,354	2,280	2,492

* This table presents the annualized costs and benefits associated with electric motors shipped in 2015–2044. These results include benefits to consumers which accrue after 2044 from the equipment purchased in years 2015–2044. Costs incurred by manufacturers, some of which may be incurred in preparation for the rule, are not directly included, but are indirectly included as part of incremental equipment costs. The Primary, Low Benefits, and High Benefits Estimates are in view of projections of energy prices from the Annual Energy Outlook (AEO) 2013 Reference case, Low Estimate, and High Estimate, respectively. In addition, incremental equipment costs reflect a medium constant projected equipment price in the Primary Estimate, a declining rate for projected equipment price trends in the Low Benefits Estimate, and an increasing rate for projected equipment price trends in the High Benefits Estimate. The methods used to derive projected price trends are explained in section IV.F.1.

** The interagency group selected four sets of SCC values for use in regulatory analyses. Three sets of values are based on the average SCC from the three integrated assessment models, at discount rates of 2.5, 3, and 5 percent. The fourth set, which represents the 95th percentile SCC estimate across all three models at a 3-percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. The values in parentheses represent the SCC in 2015. The SCC time series incorporate an escalation factor. The value for NO_X is the average of the low and high values used in DOE's analysis.

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

DOE has tentatively concluded that the proposed standards represent the maximum improvement in energy efficiency that is technologically feasible and economically justified, and would result in the significant conservation of energy. DOE further notes that equipment achieving these standard levels are already commercially available for most equipment classes covered by today's proposal. Based on the analyses described above, DOE has tentatively concluded that the benefits of the proposed standards to the Nation (energy savings, positive NPV of consumer benefits, consumer LCC savings, and emission reductions) would outweigh the burdens (loss of INPV for manufacturers and LCC increases for some consumers).

DOE also considered more-stringent energy efficiency levels as trial standard levels, and is still considering them in this rulemaking. However, DOE has tentatively concluded that the potential burdens of the more-stringent energy efficiency levels would outweigh the projected benefits. Depending on the comments that DOE receives in response to this notice and related information collected and analyzed during the course of this rulemaking, DOE may adopt energy efficiency levels presented in this notice that are either higher or lower than the proposed standards, or some combination of level(s) that incorporate the proposed standards in part.

II. Introduction

The following section briefly discusses the statutory authority underlying today's proposed rule, as well as some relevant historical background related to the establishment of standards for electric motors.

A. Authority

Title III, Part B of the Energy Policy and Conservation Act of 1975 (EPCA or the Act), Public Law 94–163, as amended (42 U.S.C. 6291–6309) established the ''Energy Conservation Program for Consumer Products Other Than Automobiles.'' Part C of Title III of EPCA (42 U.S.C. 6311–6317) established a similar program for ''Certain Industrial Equipment,'' including electric motors.[11] The Energy Policy Act of 1992 (EPACT 1992) (Pub. L. 102–486) amended EPCA by establishing energy conservation standards and test procedures for certain commercial and industrial electric motors (in context, ''motors'') manufactured (alone or as a component of another piece of equipment) after October 24, 1997. In December 2007, Congress passed into law the Energy Independence and Security Act of 2007 (EISA 2007) (Pub. L. 110–140). 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)) EPCA directs the Secretary of Energy to publish a final rule no later than 24 months after the effective date of the previous final rule to determine whether to amend the standards already in effect. Any such amendment shall apply to electric motors manufactured after a date which is five years after either: (1) The effective date of the previous amendment or (2) if the previous final rule did not amend the standards, the earliest date by which a previous amendment could have been effective. (42 U.S.C. 6313(b)(4)(B))

DOE is issuing today's proposal pursuant to Part C of Title III, which establishes an energy conservation program for covered equipment that consists essentially of four parts: (1) Testing; (2) labeling; (3) the establishment of Federal energy conservation standards; and (4) certification and enforcement procedures. For those electric motors for which Congress established standards, or for which DOE amends or establishes standards, the DOE test procedure must be the prescribed procedures that currently appear at 10 CFR part 431 that apply to electric motors. The test procedure is subject to review and revision by the Secretary in accordance with certain criteria and conditions. (See 42 U.S.C. 6314(a))

Section 343(a)(5)(B)–(C) of EPCA, 42 U.S.C. 6314(a)(5)(B)–(C), provides in part that if the NEMA- and IEEE-developed test procedures are amended, DOE shall so amend the test procedures

[11] For editorial reasons, upon codification in the U.S. Code, Parts B and C were redesignated as Parts A and A–1, respectively.

under 10 CFR part 431, unless the Secretary determines, by rule, that the amended industry procedures would not meet the requirements for test procedures to produce results that reflect energy efficiency, energy use, and estimated operating costs of the tested motor, or, would be unduly burdensome to conduct. (42 U.S.C. 6314(a)(2)–(3), (a)(5)(B)) As newer versions of the NEMA and IEEE test procedures for electric motors were developed, DOE updated 10 CFR part 431 to reflect these changes. Manufacturers of covered equipment must use the prescribed DOE test procedure as the basis for certifying to DOE that their equipment complies with the applicable energy conservation standards adopted under EPCA and when making representations to the public regarding the energy use or efficiency of such equipment. (42 U.S.C. 6314(d)) Similarly, DOE must use these test procedures to determine whether the equipment comply with standards adopted pursuant to EPCA. *Id.*

DOE must follow specific statutory criteria for prescribing new and amended standards for covered equipment. In the case of electric motors, the criteria set out in relevant subsections of 42 U.S.C. 6295, which normally applies to standards related to consumer products, also apply to the setting of energy conservation standards for motors via 42 U.S.C. 6316(a). As indicated above, new and amended standards must be designed to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A) and 6316(a)) Furthermore, DOE may not adopt any standard that would not result in the significant conservation of energy. (42 U.S.C. 6295(o)(3) and 6316(a)) Moreover, DOE may not prescribe a standard: (1) For certain equipment, including electric motors, if no test procedure has been established for the product, or (2) if DOE determines by rule that the proposed standard is not technologically feasible or economically justified. (42 U.S.C. 6295(o)(3)(A)–6316(a)) In deciding whether a proposed standard is economically justified, DOE must determine whether the benefits of the standard exceed its burdens. (42 U.S.C. 6295(o)(2)(B)(i) and 6316(a)) DOE must make this determination after receiving comments on the proposed standard, and by considering, to the greatest extent practicable, the following seven 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 imposition of the standard;

3. The total projected amount of energy, or as applicable, water, savings likely to result directly from the imposition of the standard;

4. Any lessening of the utility or the performance of the covered products likely to result from the imposition of 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 imposition of 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. 6295(o)(2)(B)(i)(I)–(VII) and 6316(a))

EPCA, as codified, also contains what is known as an ''anti-backsliding'' provision, which prevents the Secretary from prescribing any new or amended standards that either increase the maximum allowable energy use or decrease the minimum required energy efficiency of a covered product. (42 U.S.C. 6295(o)(1) and 6316(a)) Also, the Secretary may not prescribe an amended or new standard if interested persons have established by a preponderance of the evidence that the standard is likely to result in the unavailability in the United States of any covered product type (or class) of performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as those generally available in the United States. (42 U.S.C. 6295(o)(4) and 6316(a))

Further, EPCA, as codified, establishes a rebuttable presumption that a standard is economically justified if the Secretary finds that the additional cost to the consumer of purchasing a product complying with an energy conservation standard level will be less than three times the value of the energy savings during the first year that the consumer will receive as a result of the standard, as calculated under the applicable test procedure. (42 U.S.C. 6295(o)(2)(B)(iii) and 6316(a))

Additionally, 42 U.S.C. 6295(q)(1), as applied to covered equipment via 42 U.S.C. 6316(a), specifies requirements when promulgating a standard for a type or class of covered product that has two or more subcategories. DOE must specify a different standard level than that which applies generally to such type or class of equipment for any group of covered equipment that have the same function or intended use if DOE determines that equipment within such group: (A) Consume a different kind of energy from that consumed by other covered equipment within such type (or class); or (B) have a capacity or other performance-related feature which other equipment within such type (or class) do not have and such feature justifies a higher or lower standard. (42 U.S.C. 6294(q)(1) and 6316(a)). In determining whether a performance-related feature justifies a different standard for a group of products, DOE must consider such factors as the utility to the consumer of the feature and other factors DOE deems appropriate. *Id.* Any rule prescribing such a standard must include an explanation of the basis on which such higher or lower level was established. (42 U.S.C. 6295(q)(2) and 6316(a))

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

B. Background

1. Current Standards

An electric motor is a device that converts electrical power into rotational mechanical power. The outside structure of the motor is called the frame, which houses a rotor (the spinning part of the motor) and the stator (the stationary part that creates a magnetic field to drive the rotor). Although many different technologies exist, DOE's rulemaking is concerned with squirrel-cage induction motors, which represent the majority of electric motor energy use. In squirrel-cage induction motors, the stator drives the rotor by inducing an electric current in the squirrel-cage, which then reacts with the rotating magnetic field to propel the rotor in the same way a person can repel one handheld magnet with another. The squirrel-cage used in the rotor of induction motors consists of longitudinal conductive bars (rotor bars) connected at both ends by rings (end rings) forming a cage-like shape. Among other design parameters, motors can vary in horsepower, number of ''poles'' (which determines how quickly the motor rotates), and torque characteristics. Most motors have ''open'' frames that allow cooling airflow through the motor body, though some have enclosed frames that offer added protection from foreign substances and bodies. DOE regulates various motor types from between 1 and 500 horsepower, with 2, 4, 6, and 8 poles, and with both open and enclosed frames.

EPACT 1992 amended EPCA by establishing energy conservation standards and test procedures for certain commercial and industrial electric motors manufactured either alone or as a component of another piece of equipment after October 24, 1997. Section 313 of EISA 2007 amended EPCA by: (1) Striking the definition of ''electric motor'' provided under EPACT 1992, (2) setting forth definitions for ''general purpose electric motor (subtype I)'' and ''general purpose electric motor (subtype II),'' and (3) prescribing energy conservation standards for ''general purpose electric motors (subtype I),'' ''general purpose electric motors (subtype II), ''fire pump electric motors,'' and ''NEMA Design B general purpose electric motors'' with a power rating of more than 200 horsepower but not greater than 500 horsepower. (42 U.S.C. 6311(13), 6313(b)). The current standards for these motors, which are reproduced in the proposed regulatory text at the end of this notice, are divided into four tables that prescribe specific efficiency levels for each of those groups of motors.

2. History of Standards Rulemaking for Electric Motors

On October 5, 1999, DOE published in the **Federal Register**, a final rule to implement the EPACT 1992 electric motor requirements. 64 FR 54114. In response to EISA 2007, on March 23, 2009, DOE updated, among other things, the corresponding electric motor regulations at 10 CFR part 431 with the new definitions and energy conservation standards. 74 FR 12058. On December 22, 2008, DOE proposed to update the test procedures under 10 CFR part 431 both for electric motors and small electric motors. 73 FR 78220. DOE finalized key provisions related to small electric motor testing in a 2009 final rule at 74 FR 32059 (July 7, 2009), and further updated the test procedures for electric motors and small electric motors at 77 FR 26608 (May 4, 2012). The May 2012 final rule primarily focused on updating various definitions and incorporations by reference related to the current test procedure. In that rule, DOE promulgated a regulatory definition of ''electric motor'' to account for EISA 2007's removal of the previous statutory definition of ''electric motor.'' DOE also clarified definitions related to those motors that EISA 2007 laid out as part of EPCA's statutory framework, including motor types that DOE had not previously regulated. See generally, id. at 26613–26619. DOE published a new proposed test procedure rulemaking on June 26, 2013, that proposes to further refine some existing electric motor definitions and add certain definitions and test procedure preparatory steps to address a wider variety of electric motor types than are currently regulated. 78 FR 38456.

Regarding the compliance date that would apply to the requirements of today's proposed rule, EPCA directs the Secretary of Energy to publish a final rule no later than 24 months after the effective date of the previous final rule to determine whether to amend the standards in effect for such equipment. Any such amendment shall apply to electric motors manufactured after a date which is five years after: (i) The effective date of the previous amendment; or (ii) if the previous final rule did not amend the standards, the earliest date by which a previous amendment could have been effective. (42 U.S.C. 6313(b)(4))

As described previously, EISA 2007 constitutes the most recent amendment to EPCA and energy conservation standards for electric motors. Because these amendments required compliance on December 19, 2010, DOE had indicated during the course of public meetings held in advance of today's proposal that motors manufactured after December 19, 2015, would need to comply with any applicable new standards that DOE may set as part of this rulemaking. Today's proposed standards would apply to motors manufactured starting on December 19, 2015. As noted in detail later in this notice, however, DOE is interested in receiving comments on the ability of manufacturers to meet this deadline.

DOE received numerous comments from interested parties who provided significant input to DOE in response to the framework document and preliminary analysis that the agency had issued. See 75 FR 59657 (Sept. 28, 2010) (framework document notice of availability) and 77 FR 43015 (July 23, 2012) (preliminary analysis notice of availability). During the framework document comment period for this rulemaking, several interested parties urged DOE to consider including additional motor types currently without energy conservation standards in DOE's analyses and establishing standards for such motor types. In the commenters' view, this approach would more effectively increase energy savings than setting more stringent standards for currently regulated electric motors. In response, DOE published a Request for Information (RFI) seeking public comments from interested parties regarding establishment of energy conservation standards for several types of definite and special purpose motors for which EISA 2007 did not provide energy conservation standards. 76 FR 17577 (March 30, 2011). DOE received comments responding to the RFI advocating that DOE regulate many of the electric motors discussed in the RFI, as well as many additional motor types.

Then, on August 15, 2012, a group of interested parties (the ''Motor Coalition'' [12]) submitted a Petition to DOE asking the agency to adopt a consensus stakeholder proposal that would amend the energy conservation standards for electric motors. The Motor Coalition's proposal advocated expanding the scope of coverage to a broader range of motors than what DOE currently regulates and it recommended that energy conservation standards for all covered electric motors be set at levels that are largely equivalent to what DOE proposes in today's NOPR (i.e., efficiency levels in NEMA MG1–2011 Tables 12–12 and 20–B).[13]

DOE received several comments from NEMA regarding the December 19, 2015, compliance date. First, NEMA pointed out that all publications and presentations prior to that preliminary analysis public meeting on August 21, 2012, indicated that DOE's statutory deadline for any final rule was December 19, 2012, but at the public meeting DOE showed a final rule completion date as the end of 2013. (NEMA, No. 54 at pp. 2, 6–7) NEMA questioned the authority by which DOE has decided to delay the Final Rule beyond the date of December 19, 2012, as stipulated in EPCA. (NEMA, No. 54 at p. 2)

Second, NEMA commented that shortening the time to comply with any new standards from three years to two years would place additional burdens on manufacturers considering all of the electric motors types that DOE is considering in the preliminary TSD, the burdensome candidate standard levels that DOE is considering, and the

[12] The members of the Motor Coalition include: National Electrical Manufacturers Association, American Council for an Energy-Efficient Economy, Appliance Standards Awareness Project, Alliance to Save Energy, Earthjustice, Natural Resources Defense Council, Northwest Energy Efficiency Alliance, Northeast Energy Efficiency Partnerships, and Northwest Power and Conservation Council.

[13] DOE's proposal differs from that of the Motor Coalition in that DOE's proposal covers brake motors and does not set separate standards for U-frame motors. It also seeks supplemental information regarding certain 56-frame motors. See section IV.A.2 for details.

possibility of expanding the scope of energy conservation standards. (NEMA, No. 54 at pp. 2, 7; NEMA, Public Meeting Transcript, No. 60 at p. 30)

Third, NEMA also noted that when EPACT 1992 first added electric motors as covered equipment, motor manufacturers were allowed five years to modify motor designs and certify compliance to the new standards. (NEMA, No. 54 at p. 7) It further noted that NEMA MG 1–1998 subsequently introduced NEMA Premium efficiency standards, and between 1998 and 2007 manufacturers voluntarily increased the number of NEMA Premium efficiency motor models available. (NEMA, No. 54 at p. 7) NEMA commented that this transition period eased the burden of satisfying the added stringency of the standards set by EISA 2007, which allowed three years to update energy conservation standards to mandatory NEMA Premium levels for certain motor ratings. (NEMA, No. 54 at p. 7) NEMA added that adhering to the statutory deadline for setting any new and amended standards would minimize any disruption in the electric motor market. (NEMA, No. 54 at p. 8) NEMA also commented that since the EISA 2007 standards were enacted, only a limited number of motor ratings above NEMA Premium have been offered because there is not sufficient space available in most frame ratings to increase the efficiency. (NEMA, No. 54 at p. 7) NEMA added that any standards above NEMA Premium would force manufacturers to redesign entire product lines and go through the process of certification and compliance, all of which would be expected to take longer than three years. (NEMA, No. 54 at pp. 7, 8)

Finally, NEMA also attempted to illustrate the difficulty of reaching NEMA Premium levels in IEC frame motors, noting that a comparison of certificates of compliance before and after EISA 2007 standards went into effect would demonstrate that some manufacturers were forced to abandon the U.S. electric motor market for some period of time before they could update their IEC frame motor product line. (NEMA, No. 54 at p. 8) NEMA added that increasing the efficiency of subtype II motors to NEMA Premium efficiency and expanding the scope of motors subject to energy conservation standards (many of which currently have efficiency levels below EPACT 1992 energy conservation levels) will also require extensive redesign, and manufacturers would be forced to comply in only three years. (NEMA, No. 54 at p. 8)

During the course of preparing for the electric motors energy conservation standards rulemaking, information was submitted to DOE by NEMA, ASAP, and CDA in response to DOE's RFI and then later in the Petition from the Motors Coalition [14] that caused DOE to reevaluate the scope of electric motors it was considering in this rulemaking. That Petition, and related supporting information, suggested that DOE apply the NEMA Premium efficiency levels (''NEMA Premium'') to a much broader swath of electric motors than are currently regulated by DOE, rather than increase the stringency of the standards that had only recently come into effect (i.e., EISA 2007 standards). As part of its routine practice, DOE reviewed the information and the merits of the Petition. With the potential prospect of expanding the types of motors that would be regulated by standards, DOE recognized the need to amend its test procedures to add the necessary testing preparatory steps (i.e. test set-up procedures) to DOE's regulations. The inclusion of these steps would help ensure that manufacturers of these new motor types would be performing the same steps as are performed when testing currently regulated motors.

The compliance date prescribed by statute would require manufacturers to begin manufacturing compliant motors by December 19, 2015. Accordingly, DOE is proposing a December 19, 2015, compliance date. DOE, however, recognizes that the statute also contemplated a three-year lead time for manufacturers in order to account for the potential logistical and production hurdles that manufacturers may face when transitioning to the new standards. Accordingly, while DOE is proposing a December 19, 2015 compliance deadline, it is also interested in comments that detail any hurdles with meeting this compliance deadline along with the merits of receiving the three-year lead-time also set out in the statute.

3. Process for Setting Energy Conservation Standards

Section 325(o) provides criteria for prescribing new or amended standards which are designed to achieve the maximum improvement in energy efficiency and for which the Secretary of Energy determines are technologically feasible and economically justified. Consequently, DOE must consider, to the greatest extent practicable, the following seven factors: (1) The economic impact of the standard on the manufacturers and consumers of the products subject to the standard; (2) the savings in operating costs throughout the estimated average life of the products compared to any increase in the prices, initial costs, or maintenance expenses for the products that are likely to result from the imposition of the standard; (3) the total projected amount of energy savings likely to result directly from the imposition of the standard; (4) any lessening of the utility or the performance of the covered products likely to result from the imposition of 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 imposition of the standard; (6) the need for national energy conservation; and (7) other factors the Secretary considers relevant. (42 U.S.C. 6295(o)(2)(B)(i) and 6316(a))

Other statutory requirements are set forth in 42 U.S.C. 6295(o)(1)–(2)(A), (2)(B)(ii)–(iii), and (3)–(4). These criteria apply to the setting of standards for electric motors through 42 U.S.C. 6316(a).

III. General Discussion

DOE developed today's proposed rule after considering input, including verbal and written comments, data, and information from interested parties that represent a variety of interests. All commenters, along with their corresponding abbreviations and affiliations, are listed in Table III.1 below. The issues raised by these commenters are addressed in the discussions that follow.

TABLE III.1—SUMMARY OF COMMENTERS

Company or organization	Abbreviation	Affiliation
Air Movement and Control Association International, Inc.	AMCAI	Trade Association.

[14] The Petition is available at: *http://www.regulations.gov/#!documentDetail;D=EERE-2010-BT-STD-0027-0035.*

TABLE III.1—SUMMARY OF COMMENTERS—Continued

Company or organization	Abbreviation	Affiliation
Alliance to Save Energy	ASE	Energy Efficiency Advocates.
American Council for an Energy-Efficient Economy.	ACEEE	Energy Efficiency Advocates.
Appliance Standards Awareness Project	ASAP	Energy Efficiency Advocates.
Baldor Electric Co.	Baldor	Manufacturers.
BBF & Associates	BBF	Representative for Trade Association.
California Investor Owned Utilities	CA IOUs	Utilities.
Copper Development Association	CDA	Trade Association.
Earthjustice	Earthjustice	Energy Efficiency Advocates.
Electric Apparatus Service Association	EASA	Trade Association.
Flolo Corporation	Flolo	Other.
Industrial Energy Consumers of America	IECA	Trade Association.
Motor Coalition *	MC	Energy Efficiency Advocates, Trade Associations, Manufacturers, Utilities.
National Electrical Manufacturers Association	NEMA	Trade Association.
Northwest Energy Efficiency Alliance	NEEA	Energy Efficiency Advocates.
Northwest Power & Conservation Council	NPCC	Utilities.
SEW-Eurodrive, Inc.	SEWE	Manufacturer.
UL LLC	UL	Testing Laboratory.

* The members of the Motor Coalition include: National Electrical Manufacturers Association (NEMA), American Council for an Energy-Efficient Economy (ACEEE), Appliance Standards Awareness Project (ASAP), Alliance to Save Energy (ASE), Earthjustice, Natural Resources Defense Council (NRDC), Northwest Energy Efficiency Alliance (NEEA), Northeast Energy Efficiency Partnerships (NEEP), and Northwest Power and Conservation Council (NPCC).

Subsequent to DOE's preliminary analysis public meeting, several other interested parties submitted comments supporting the Petition. Those supporters included: BBF and Associates, the Air Movement and Control Association International, Inc., U.S. Senators Lisa Murkowski and Jeff Bingaman, the Hydraulic Institute, the Arkansas Economic Development and Commission-Energy Office, and the Power Transmission Distributors Association.

A. Test Procedure

On June 26, 2013, DOE published a notice that proposed to incorporate definitions for certain motor types not currently subject to energy conservation standards (78 FR 38456). The notice also proposed to clarify several definitions for motor types currently regulated by energy conservation standards and adding some necessary steps to facilitate the testing of certain motor types that DOE does not currently require to meet standards. During its preliminary analysis stage, DOE received comments concerning definitions and test procedure set-up steps suggested for testing motors under an expanded scope approach. DOE addressed the comments as part of the test procedure NOPR. For additional details, see 78 FR 38456 (June 26, 2013).

B. Equipment Classes and Current Scope of Coverage

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 would justify a different standard. In making a determination whether a performance-related feature would justify a different standard, DOE must consider factors such as the utility to the consumer of the feature and other factors that DOE determines are appropriate. (42 U.S.C. 6295(q) and 6316(a))

Existing energy conservation standards cover electric motors that fall into four categories based on physical design features of the motor. These four categories are: General purpose electric motors (subtype I), general purpose electric motors (subtype II), fire pump electric motors, and NEMA Design B motors (with a horsepower rating from 201 through 500). Definitions for each of these terms can be found at 10 CFR 431.12.

C. Expanded Scope of Coverage

DOE has the authority to set energy conservation standards for a wider range of electric motors than those classified as general purpose electric motors (e.g., definite or special purpose motors). EPACT 1992 amended EPCA to include, among other things, a definition for the term ''electric motor''—which the statute defined as including certain ''general purpose'' motors. (42 U.S.C. 6311(13)(A) (1992)) The amendments also defined the terms ''definite purpose motors'' and ''special purpose motor.'' (42 U.S.C. 6311(13)(C) and (D)) (1992)) EPACT 1992 initially prescribed energy conservation standards for ''electric motors'' (i.e., subtype I general purpose electric motors) and explicitly stated that these standards did not apply to definite purpose or special purpose motors. (42 U.S.C. 6313(b)(1) (1992)) However, EISA 2007 struck the narrow EPACT 1992 definition of ''electric motor.'' With the removal of this definition, the term ''electric motor'' became broader in scope. As a result of these changes, both definite and special purpose motors fell under the broad heading of ''electric motors'' that previously only applied to ''general purpose'' motors. While EISA 2007 prescribed standards for general purpose motors, the Act did not apply those standards to definite or special purpose motors. (42 U.S.C. 6313(b) (2012))

Although DOE believes that EPCA, as amended through EISA 2007, provides sufficient statutory authority for the regulation of special purpose and definite purpose motors as ''electric motors,'' DOE notes it has additional authority under section 10 of the American Energy Manufacturing Technical Corrections Act, Public Law 112–210, which amended DOE's authority to regulate commercial and industrial equipment under section 340(2)(B) of EPCA to include ''other motors,'' in addition to ''electric motors''. (42 U.S.C. 6311(2)(B)(xiii)). Therefore, even if special and definite purpose motors were not ''electric motors,'' special and definite purpose motors would be considered as ''other motors'' that EPCA already treats as covered industrial equipment.[15]

Consistent with EISA 2007's reworking of the definition, the 2012 test procedure final rule broadly defined the term ''electric motor.'' at 10 CFR 431.12. (77 FR 26608 (May 4, 2012)). That definition covers ''general purpose,'' ''special purpose'' and ''definite purpose'' electric motors (as defined by EPCA). As noted above, EPCA did not require either ''special purpose'' or ''definite purpose'' motor types to meet energy conservation standards because they were not considered ''general purpose'' under the EPCA definition of ''general purpose motor''—a necessary element to meet the pre-EISA 2007 ''electric motor'' definition. See 77 FR 26612. Because of the restrictive nature of the prior electric motor definition, along with the restrictive definition of the term ''industrial equipment,'' DOE would have been unable to set standards for such motors without this change. (See 42 U.S.C. 6311(2)(B) (2006) (limiting the scope of equipment covered under EPCA)) In view of the changes introduced by EISA 2007 and the absence of energy conservation standards for special purpose and definite purpose motors, as noted in chapter 2 of DOE's July 2012 electric motors preliminary analysis technical support document (TSD),[16] it is DOE's view that both of these motors are categories of ''electric motors'' covered under EPCA, as currently amended. Accordingly, DOE is proposing standards for certain definite purpose and special purpose motors. To this end, DOE is considering setting energy conservation standards for those motors that exhibit all of the following nine characteristics:

- Is a single-speed, induction motor,
- Is rated for continuous duty (MG 1) operation or for duty type S1 (IEC),
- Contains a squirrel-cage (MG 1) or cage (IEC) rotor,
- Operates on polyphase alternating current 60-hertz sinusoidal line power,
- Is rated 600 volts or less,
- Has a 2-, 4-, 6-, or 8-pole configuration,
- Has a three-digit NEMA frame size (or IEC metric equivalent) or an enclosed 56 NEMA frame size (or IEC metric equivalent),
- Has no more than 500 horsepower, but greater than or equal to 1 horsepower (or kilowatt equivalent), and
- Meets all of the performance requirements of a NEMA Design A, B, or C electric motor or an IEC design N or H electric motor.

However, motor types that exhibit all of the characteristics listed above, but that DOE does not believe should be subject to energy conservation standards at this time because of the current absence of a reliable and repeatable method to test them for efficiency, would be listed as motors that would not at this time be subject to energy conservation standards. Once a test procedure becomes available, DOE may consider setting standards for these motors at that time. See generally, 78 FR 38456 (June 26, 2013). DOE requests comment on these nine characteristics and their appropriateness for outlining scope of coverage.

To facilitate the potential application of energy conservation standards to special and definite purpose motors, DOE proposed to define such motors and provide certain preparatory test procedure steps. 78 FR 38456 (June 26, 2013). The definitions under consideration would address motors currently subject to standards, specific motors DOE is considering requiring to meet standards, and some motors that will continue to not be required to meet particular energy conservation standards. Some of the clarifying definitions, such as the definitions for NEMA Design A and C electric motors, come from NEMA Standards Publication MG 1–2009, ''Motors and Generators.'' DOE understands that some of the motors addressed, such as partial motors and integral brake motors, do not have standard industry-accepted definitions. For such motor types, DOE worked with subject-matter experts (SMEs), manufacturers, and the Motor Coalition to create the working definitions that are proposed in the test procedure NOPR. (8 FR 38456 (June 26, 2013).

D. Technological Feasibility

1. General

EPCA requires that any new or amended energy conservation standard that DOE prescribes shall be designed to achieve the maximum improvement in energy efficiency that DOE determines is technologically feasible. (42 U.S.C. 6295(o)(2)(A) and 6316(a)). In each 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.

Where DOE determines that particular technology options are technologically feasible, it further evaluates each technology option in view of the following additional screening criteria: (1) Practicability to manufacture, install, or service; (2) adverse impacts on product utility or availability; and (3) adverse impacts on health or safety. Section IV.B of this notice addresses 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 trial standard levels (TSLs) in this rulemaking. For further details on the screening analysis for this rulemaking, see chapter 4 of the NOPR TSD.

[15] EPCA specifies the types of industrial equipment that can be classified as covered in addition to the equipment enumerated in 42 U.S.C. 6311(1). This equipment includes ''other motors'' (to be codified at 42 U.S.C. 6311(2)(B)). Industrial equipment must also, without regard to whether such equipment is in fact distributed in commerce for industrial or commercial use, be of a type that: (1) In operation consumes, or is designed to consume, energy in operation; (2) to any significant extent, is distributed in commerce for industrial or commercial use; and (3) is not a covered product as defined in 42 U.S.C. 6291(a)(2) of EPCA, other than a component of a covered product with respect to which there is in effect a determination under 42 U.S.C. 6312(c). (42 U.S.C. 6311 (2)(A)). Data from the 2002 United States Industrial Electric Motor Systems Market Opportunities Assessment estimated total energy use from industrial motor systems to be 747 billion kWh. Based on the expansion of industrial activity, it is likely that current annual electric motor energy use is higher than this figure. Electric motors are distributed in commerce for both the industrial and commercial sectors. According to data provided by the Motor Coalition, the number of electric motors manufactured in, or imported into, the United States is over five million electric motors annually, including special and definite purpose motors. Finally, special and definite purpose motors are not currently regulated under Title 10 of the Code of Federal Regulations, part 430 (10 CFR part 430).

To classify equipment as covered commercial or industrial equipment, the Secretary must also determine that classifying the equipment as covered equipment is necessary for the purposes of Part A–1 of EPCA. The purpose of Part A–1 is to improve the efficiency of electric motors, pumps and certain other industrial equipment to conserve the energy resources of the nation. (42 U.S.C. 6312(a)–(b)) In today's proposal, DOE has tentatively determined that the regulation of special and definite purpose motors is necessary to carry out the purposes of part A–1 of EPCA because regulating these motors will promote the conservation of energy supplies. Efficiency standards that may result from coverage would help to capture some portion of the potential for improving the efficiency of special and definite purpose motors.

[16] The preliminary TSD published in July 2012 is available at: *http://www.regulations.gov/#!documentDetail;D=EERE-2010-BT-STD-0027-0023.*

2. Maximum Technologically Feasible Levels

When DOE proposes to adopt a new or 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. 6295(p)(1)) This requirement also applies to DOE proposals to amend the standards for electric motors. See 42 U.S.C. 6316(a). Accordingly, in its 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 motors available on the market or in working prototypes. (See chapter 5 of the NOPR TSD.) The max-tech levels that DOE determined for this rulemaking are described in section IV.C.3 of this proposed rule.

E. Energy Savings

1. Determination of Savings

Section 325(o) of EPCA also provides that any new or amended energy conservation standard that DOE prescribes shall be designed to achieve the maximum improvement in energy efficiency that DOE determines is economically justified. (42 U.S.C. 6295(o)(2)(A)–(B) and 6316(a)). In addition, in determining whether such standard is technologically feasible and economically justified, DOE may not prescribe standards for certain types or classes of electric motors if such standards would not result in significant energy savings. (42 U.S.C. 6295(o)(3)(B) and 6316(a)). For each TSL, DOE projected energy savings from the motors that would be covered under this rulemaking and that would be purchased in the 30-year period that begins in the year of compliance with the new and amended standards (2015–2044). The savings are measured over the entire lifetime of equipment purchased in the 30-year period.[17] DOE quantified the energy savings attributable to each TSL as the difference in energy consumption between each standards case and the base case. The base case represents a projection of energy consumption in the absence of new or amended mandatory efficiency standards, and considers market forces and policies that affect demand for more efficient equipment.

DOE used its national impact analysis (NIA) spreadsheet model to estimate the energy savings from new and amended standards for the equipment that would be subject to this rulemaking. The NIA spreadsheet model (described in section IV.H of this notice) calculates energy savings in site energy, which is the energy directly consumed by motors at the locations where they are used. For electricity, DOE reports national energy savings in terms of the savings in the energy that is used to generate and transmit the site electricity. To calculate source energy, DOE derives annual conversion factors from the model used to prepare the Energy Information Administration's (EIA) *Annual Energy Outlook (AEO).*

DOE has begun to also estimate full-fuel-cycle energy savings. 76 FR 51282 (August 18, 2011), as amended at 77 FR 49701 (August 17, 2012). The full-fuel-cycle (FFC) metric includes the energy consumed in extracting, processing, and transporting primary fuels, and thus presents a more complete picture of the impacts of energy efficiency standards. DOE's evaluation of FFC savings is driven in part by the National Academy of Science's (NAS) report on FFC measurement approaches for DOE's Appliance Standards Program.[18] The NAS report discusses that FFC was primarily intended for energy efficiency standards rulemakings where multiple fuels may be used by a particular product. In the case of this rulemaking pertaining to electric motors, only a single fuel—electricity—is consumed by the equipment. DOE's approach is based on the calculation of an FFC multiplier for each of the energy types used by covered equipment. The methodology for estimating FFC does not project how fuel markets would respond to this particular standard rulemaking. The FFC methodology simply estimates how much additional energy, and in turn how many tons of emissions, may be displaced if the estimated fuel were not consumed by the equipment covered in this rulemaking. It is also important to note that inclusion of FFC savings does not affect DOE's choice of proposed standards.

2. Significance of Savings

As noted above, 42 U.S.C. 6295(o)(3)(B) prevents DOE from adopting a standard for a covered product unless such standard would result in ''significant'' energy savings. Although the term ''significant'' is not explicitly defined in EPCA, the U.S. Court of Appeals, in *Natural Resources Defense Council* v. *Herrington,* 768 F.2d 1355, 1373 (D.C. Cir. 1985), indicated that Congress intended ''significant'' energy savings in this context to be savings that were not ''genuinely trivial.'' DOE believes that the energy savings for all of the TSLs considered in this rulemaking (presented in section V.A) are nontrivial, and, therefore, DOE considers them ''significant'' within the meaning of section 325 of EPCA.

F. Economic Justification

1. Specific Criteria

EPCA provides seven factors to be evaluated in determining whether a potential energy conservation standard is economically justified. (42 U.S.C. 6295(o)(2)(B)(i)) The following sections detail how DOE addresses each of those factors in this rulemaking.

a. Economic Impact on Manufacturers and Consumers

In determining the impacts of a new or amended standard on manufacturers, 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.[19] The industry-wide impacts analyzed include industry net present value (INPV), which values the industry on the basis of expected future cash flows; cash flows by year; changes in revenue and income; and 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 life-cycle cost (LCC) and payback period (PBP) associated with new or amended standards. The LCC, addressed

[17] In the past DOE, presented energy savings results for only the 30-year period that begins in the year of compliance. In the calculation of economic impacts, however, DOE considered operating cost savings measured over the entire lifetime of equipment purchased in the 30-year period. DOE has chosen to modify its presentation of national energy savings to be consistent with the approach used for its national economic analysis.

[18] ''Review of Site (Point-of-Use) and Full-Fuel-Cycle Measurement Approaches to DOE/EERE Building Appliance Energy-Efficiency Standards,'' (Academy report) was completed in May 2009 and included five recommendations. A copy of the study can be downloaded at: *http://www.nap.edu/catalog.php?record_id=12670.*

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

as ''savings in operating costs'' at 42 U.S.C. 6295(o)(2)(B)(i)(II), is one of seven factors considered in determining the economic justification for a new or amended standard and is discussed in the following section. For consumers in the aggregate, DOE also calculates the national net present value of the economic impacts applicable to a particular rulemaking.

b. Life-Cycle Costs

The LCC is the sum of the purchase price of a piece of equipment (including its installation) and the operating expense (including energy, maintenance, and repair expenditures) discounted over the lifetime of that equipment. The LCC savings for the considered efficiency levels are calculated relative to a base case that reflects projected market trends in the absence of new or amended standards. The LCC analysis requires a variety of inputs, such as equipment prices, equipment energy consumption, energy prices, maintenance and repair costs, equipment lifetime, and consumer discount rates. For its analysis, DOE assumes that consumers, as users of electric motors, will purchase the considered equipment in the first year of compliance with new or amended standards.

To account for uncertainty and variability in specific inputs, such as equipment lifetime and discount rate, DOE uses a distribution of values with probabilities attached to each value. DOE identifies the percentage of consumers estimated to receive LCC savings or experience an LCC increase, in addition to the average LCC savings associated with a particular standard level. DOE also evaluates the LCC impacts of potential standards on identifiable subgroups of consumers that may be affected disproportionately by a national standard.

c. Energy Savings

Although significant conservation of energy is a separate statutory requirement for imposing an energy conservation standard, EPCA requires DOE, in determining the economic justification of a standard, to consider the total projected energy savings that are expected to result directly from the standard. (42 U.S.C. 6295(o)(2)(B)(i)(III)) As discussed in section IV.H, DOE uses the NIA spreadsheet to project national energy savings.

d. Lessening of Utility or Performance

In establishing classes of products, and in evaluating design options and the impact of potential standard levels, DOE evaluates standards that would not lessen the utility or performance of the considered products. (42 U.S.C. 6295(o)(2)(B)(i)(IV)) As noted earlier, the substance of this provision applies to the equipment at issue in today's proposal as well. DOE has determined that the standards proposed in today's notice will not reduce the utility or performance of the equipment under consideration in this rulemaking. One piece of evidence for this claim includes the fact that many motors are already commonly being sold at the proposed levels (NEMA's ''Premium'' designation). A second piece of evidence is that the proposed standards closely track the recommendations of NEMA, which represents manufacturers who understand deeply the design compromises entailed in reaching higher efficiencies and who would be acting against the interest of their customers in recommending standards that would harm performance or utility.

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 the imposition of a standard. (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 proposed standard and to transmit such determination to the Secretary of Energy within 60 days of the publication of a proposed rule, together with an analysis of the nature and extent of the impact. (42 U.S.C. 6295(o)(2)(B)(ii)) DOE will transmit a copy of today's proposed rule to the Attorney General with a request that the Department of Justice (DOJ) provide its determination on this issue. DOE will address the Attorney General's determination in the final rule.

f. Need for National Energy Conservation

The energy savings from the proposed 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.

The proposed standards also are likely to result in environmental benefits in the form of reduced emissions of air pollutants and greenhouse gases associated with energy production. DOE reports the emissions impacts from today's standards, and from each TSL it considered, in section V.B.4 of this notice. DOE also reports estimates of the economic value of emissions reductions resulting from the considered TSLs.

g. Other Factors

EPCA allows the Secretary of Energy, in determining whether a standard is economically justified, to consider any other factors that the Secretary deems to be relevant. (42 U.S.C. 6295(o)(2)(B)(i)(VII))

2. Rebuttable Presumption

As set forth in 42 U.S.C. 6295(o)(2)(B)(iii), EPCA creates a rebuttable presumption that an energy conservation standard is economically justified if the additional cost to the consumer of a product that meets the standard is less than three times the value of the first year's energy savings resulting from the standard, as calculated under the applicable DOE test procedure. DOE's LCC and PBP analyses generate values used to calculate the effects that proposed energy conservation standards would have on the payback period for consumers. These analyses include, but are not limited to, the three-year payback period contemplated under the rebuttable-presumption test. In addition, DOE routinely conducts an economic analysis that considers the full range of impacts to consumers, manufacturers, the Nation, and the environment, as required under 42 U.S.C. 6295(o)(2)(B)(i). 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.12 of this proposed rule.

IV. Methodology and Discussion of Related Comments

DOE used four spreadsheet tools to estimate the impact of today's proposed standards. The first spreadsheet calculates LCCs and PBPs of potential new energy conservation standards. The second provides shipments forecasts and the third calculates national energy savings and net present value impacts of potential new energy conservation standards. The fourth tool helps assess manufacturer impacts, largely through use of the Government Regulatory Impact Model (GRIM).

Additionally, DOE estimated the impacts of energy conservation standards for electric motors on utilities and the environment. DOE used a version of EIA's National Energy Modeling System (NEMS) for the utility and environmental analyses. The NEMS model simulates the energy sector of the U.S. economy. EIA uses NEMS to prepare its *Annual Energy Outlook (AEO),* a widely known energy forecast for the United States. The version of NEMS used for appliance standards analysis is called NEMS–BT [20] and is based on the *AEO* version with minor modifications.[21] The NEMS–BT model offers a sophisticated picture of the effect of standards because it accounts for the interactions between the various energy supply and demand sectors and the economy as a whole.

A. Market and Technology Assessment

For the market and technology assessment, DOE develops information that provides an overall picture of the market for the equipment concerned, including the purpose of the equipment, the industry structure, and market characteristics. 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 scope of coverage, equipment classes, types of equipment sold and offered for sale, and technology options that could improve the energy efficiency of the equipment under examination. Chapter 3 of the TSD contains additional discussion of the market and technology assessment.

1. Current Scope of Electric Motors Energy Conservation Standards

EISA 2007 amended EPCA to prescribe energy conservation standards for four categories of electric motors: General purpose electric motors (subtype I) (hereinafter, ''subtype I''), general purpose electric motors (subtype II) (hereinafter, ''subtype II''), fire pump electric motors, and NEMA Design B, general purpose electric motors that also meet the subtype I or subtype II definitions and are rated above 200 horsepower through 500 horsepower. DOE's most recent test procedure final rule added clarity to the definitions for each of these motor categories, which are now codified at 10 CFR 431.12. 77 FR 26608.

Although DOE is not proposing to modify these definitions, commenters sought additional clarifications. During the preliminary analysis public meeting, NEMA expressed confusion regarding whether IEC frame motors would fall under the subtype I or subtype II designation, as DOE defined them to be related to both definitions. NEMA added that because subtype I and subtype II electric motors are subject to different efficiency standards, manufacturers producing IEC frame motors are confused as to whether IEC frame motors are subject to NEMA MG 1 Table 12–11 or Table 12–12 efficiency standards.[22] (NEMA, Public Meeting Transcript, No. 60 at pp. 36, 37)

DOE understands that an IEC frame motor could be treated as either a subtype I or subtype II motor depending on its other characteristics. Having an IEC frame alone does not dictate whether a motor is a general purpose subtype I or subtype II motor; rather, other physical characteristics, such as equivalency to a NEMA Design A, B, or C electric motor, and whether it has mounting feet could determine the subtype designation and associated energy efficiency standard level. All of these elements flow directly from the statutory changes enacted by EISA 2007. (See EISA 2007, sec. 313(a)(3), codified at 42 U.S.C. 6311(13)) Currently, electric motors are required to meet energy conservation standards as follows:

TABLE IV.1—CURRENT ELECTRIC MOTOR ENERGY CONSERVATION STANDARDS [23]

Electric motor category	Horsepower range	Energy conservation standard level
General Purpose Electric Motors (Subtype I)	1 to 200 (inclusive)	MG 1–2011 Table 12–12.
General Purpose Electric Motors (Subtype II)	1 to 200 (inclusive)	MG 1–2011 Table 12–11.
NEMA Design B and IEC Design N Motors	201 to 500 (inclusive)	MG 1–2011 Table 12–11.
Fire Pump Electric Motors	1 to 500 (inclusive)	MG 1–2011 Table 12–11.

Additionally, NEMA requested clarification on the terminology DOE intends to use for NEMA Design B motors, namely whether the term is ''NEMA Design B motor'' or ''NEMA Design B electric motor'' and what, if any, differences there are between the two terms. (NEMA, No. 54 at p. 14) DOE understands that the terms ''motor'' and ''electric motor'' may refer to a variety of machines outside of its regulatory context. However, because there are no NEMA Design B motors that are not electrically-driven, in DOE's view, the potential for ambiguity is minimal. DOE clarifies that it is using the term ''NEMA Design B motor,'' as is currently codified in 10 CFR 431.12. Additionally, DOE does not consider there to be any meaningful difference between the two terms and notes that all motors currently regulated under 10 CFR part 431, subpart B, are electric motors.

DOE requests comment on whether the proposed standards help resolve the potential issue on which it had previously issued clarification of whether a [IEC] motor may be considered to be subject to two standards.

2. Expanded Scope of Electric Motor Energy Conservation Standards

As referenced above, on August 15, 2012, the Motor Coalition petitioned DOE to adopt the Coalition's consensus agreement, which, in part, formed the basis for today's proposal.[24] The Motor Coalition petitioned DOE to simplify coverage to address a broad array of electric motors with a few clearly identified exceptions. The Motor Coalition advocated this approach to

[20] BT stands for DOE's Building Technologies Program.

[21] The EIA allows the use of the name ''NEMS'' to describe only an AEO version of the model without any modification to code or data. Because the present analysis entails some minor code modifications and runs the model under various policy scenarios that deviate from AEO assumptions, the name ''NEMS–BT'' refers to the model as used here. For more information on NEMS, refer to The National Energy Modeling System: An Overview, DOE/EIA–0581 (98) (Feb. 1998), available at: *http://tonto.eia.doe.gov/FTPROOT/forecasting/058198.pdf.*

[22] The efficiency levels found in Table 12–12 are the more stringent of the two sets of efficiency tables.

[23] For the purposes of determining compliance, DOE assesses a motors horsepower rating according to the provisions of 10 CFR 431.25(e).

[24] The Petition is available at: *http://www.regulations.gov/#!documentDetail;D=EERE-2010-BT-STD-0027-0035.*

simplify manufacturer compliance and to help facilitate DOE's enforcement efforts. The Petition highlighted potential energy savings that would result from expanding the scope of covered electric motors. (Motor Coalition, No 35 at pp. 1–30) Subsequent to DOE's preliminary analysis public meeting, several other interested parties submitted comments supporting the Petition. Those supporters included: BBF and Associates, the Air Movement and Control Association International, Inc., U.S. Senators Lisa Murkowski and Jeff Bingaman, the Hydraulic Institute, the Arkansas Economic Development and Commission-Energy Office, and the Power Transmission Distributors Association.

The California Investor Owned Utilities (CA IOUs), represented by the Pacific Gas and Electric Company (PG&E), Southern California Gas Company (SCGC), San Diego Gas and Electric (SDG&E), and Southern California Edison (SCE) commented that they supported the Petition's intent to expand the scope of coverage to the vast majority of single speed, polyphase, and integral horsepower induction motors between 1 and 500 horsepower, as well as increasing energy conservation standards for some covered products. (CA IOUs, No. 57 at p. 2)

The Air Movement and Control Association International, Inc. (AMCA International) endorsed the Petition. AMCA International encouraged DOE to adopt the Petition to save energy as soon as possible. (AMCA International, No. 59 at p. 1)

The CDA and BBF supported DOE's preliminary analysis and the Petition, indicating that the Petition sets minimum efficiency levels that represent a challenge to the industry and can have a great impact on U.S. energy use. (BBF & Associates, No. 51 at pp. 1, 2; CDA, No. 55 at p. 1) BBF also urged DOE to investigate energy conservation standards for motors over 500 horsepower because preliminary indications suggest that as much as 27 percent of total motor power consumed in the U.S. is from motors over 500 horsepower, and higher efficiencies can provide substantial savings. (BBF, No. 51 at p. 4)

EASA supported the Motor Coalition's Petition, asserting that it is in the best interests of saving energy, U.S. jobs, and the economy overall to adopt that Petition's approach. EASA strongly encouraged the DOE to adopt the recommendations of the Motor Coalition, citing large and economically justified energy savings. (EASA, No. 47 at p. 1)

ACEEE commented on behalf of the Motor Coalition, stating that expanding the scope of energy conservation standards and only excluding a small group of motor types will enhance enforcement efforts by the government, by simplifying the standards to only include explicit exclusions. (ACEEE, Public Meeting Transcript, No. 60 at p. 19)

After reviewing the Petition, DOE is proposing to require electric motor types beyond those currently covered (and discussed in section IV.A.1) to meet energy conservation standards. DOE's proposed expansion is similar to the approach recommended by the Motor Coalition in its Petition (Motor Coalition, No. 35 at pp. 1–3). DOE's proposal would establish energy conservation standards for electric motors that exhibit all of the characteristics listed in Table IV.2, with a limited number of exceptions.

TABLE IV.2—CHARACTERISTICS OF MOTORS REGULATED UNDER EXPANDED SCOPE OF COVERAGE

Motor characteristic
Is a single-speed, induction motor,
Is rated for continuous duty (MG 1) operation or for duty type S1 (IEC),
Contains a squirrel-cage (MG 1) or cage (IEC) rotor,
Operates on polyphase alternating current 60-hertz sinusoidal power,
Is rated for 600 volts or less,
Is built with a 2-, 4-, 6-, or 8-pole configuration,
Is a NEMA Design A, B, or C motor (or IEC Design N or H)
Is built in a three-digit NEMA frame size or an enclosed 56-frame (or any IEC equivalent), and
Is rated from 1 to 500 horsepower (inclusive).

In response to its preliminary analysis, DOE received several comments about the characteristics that DOE should use to define the broad scope of electric motors potentially subject to energy conservation standards. First, NEMA suggested that DOE define motor types exhibiting the nine characteristics listed in Table IV.2. (NEMA, No. 54 at p. 32) NEMA also requested that DOE clarify the range of horsepower ratings included and the scope of 56- and IEC-frame motors covered. The Energy Advocates (NPCC, NEEA, ACEEE, ASAP, Earthjustice, ASE) also suggested that DOE include IEC-equivalents and NEMA 56-frame sizes in the scope of coverage. (NPCC, No. 56 at p. 2)

Additionally, DOE is proposing to clarify the design, construction, and performance characteristics of covered electric motors. Specifically, DOE is proposing to clarify that only motors rated from 1 to 500 horsepower (inclusive), or their IEC equivalents, would be covered by the standards being proposed in today's rulemaking. Finally, with regard to IEC-frame motors, DOE would not cover IEC motors on the singular basis of frame size, but would consider covering such motors when they meet the criteria of Table IV.2. In other words, an IEC-frame motor would need to satisfy these nine criteria for the proposed standards to apply.

In its submitted Petition, the Coalition requested that DOE cover all single-speed, polyphase, 56-frame induction motors rated at one horsepower or greater that do not meet the regulatory definition for ''small electric motor'' in 10 CFR part 431, subpart X. This definition applies to both single-phase and polyphase open-frame general purpose AC induction motors built in a two-digit frame size. The proposal put forth by the Coalition would expand energy conservation standards to polyphase, enclosed 56-frame motors rated at one or more horsepower along with polyphase, special and definite purpose open 56-frame motors of horsepower greater than or equal to one that are not covered by DOE's small electric motor regulations.

Regarding 56-frame motors at 1-hp or greater, DOE is proposing standards for polyphase, enclosed 56-frame motors that are rated at 1-hp or greater. DOE is also tentatively proposing TSL 2 for polyphase, open 56-frame special and definite purpose motors that are rated at 1-hp or greater as advocated by the Motor Coalition. With respect to these motors (i.e. 56-frame, open, special and definite purpose), DOE seeks additional data related to these motors, including, but not limited to the following categories: Motor efficiency distributions; shipment breakdowns between horsepower ratings, open and enclosed motors, and between general and special and definite purpose electric motors; and information regarding the typical applications that use these motors. If this proposal is adopted in the final rule, DOE will account for a substantial majority of 56-frame motors that are not already regulated by efficiency standards and ensure coverage for all general purpose motors along with a substantial number of special and definite purpose motors.

Based on currently available data, DOE estimates that approximately 270,000 polyphase, open 56-frame special and definite purpose motors (1-hp or greater) were shipped in 2011 and at least 70% of these motors have efficiency levels below NEMA Premium.[25] In addition, based on this data, DOE believes that establishing TSL 2 for this subset of 56-frame motors would result in national energy savings of 0.58 quads (full-fuel-cycle) and net present value savings of $1.11 billion (2012$), with a 7 percent discount rate.[26] DOE has not merged its data and analyses related to this subset of 56-frame motors with the other analyses in today's NOPR. As described above, DOE seeks additional information that can be incorporated into its final analysis.

DOE notes that enclosed 56-frame motors with horsepower ratings below 1 horsepower would not, however, be covered as part of today's proposal. DOE is not proposing to cover 56-frame size fractional motors because EPCA, as amended, establishes energy conservation standards for electric motors at 1-hp or greater and DOE requires the use of different test procedures for motors above and below 1-hp. In particular, DOE's regulations prescribe, consistent with industry practice, the use of the Institute of Electrical and Electronics Engineers (IEEE) Standard 112 (Test Method A) to test motors rated below 1-hp, and IEEE Standard 112 (Test Method B) to test motor rated at or above 1-hp. To ensure consistent testing results, DOE requires application of the same test procedure to all electric motors. Therefore, DOE is not proposing to regulate enclosed 56-frame size motors rated under 1-hp.[27] This tentative decision, however, does not foreclose the possibility that DOE may regulate the efficiency of these motors and may change depending on the nature of the feedback provided by commenters with respect to this issue. DOE requests comment on its tentative decision to not address fractional horsepower enclosed 56-frame motors as part of today's proposal, along with any relevant information and data.

In view of Table IV.2, Table IV.3 lists the various electric motor types that would be covered by DOE's proposed approach. Further details and definitions for the motor types can be found in DOE's electric motors test procedure NOPR, which was published on June 26, 2013 (78 FR 38456).

TABLE IV.3—CURRENTLY UNREGULATED MOTOR TYPES DOE PROPOSES TO COVER

Electric Motor Type	
NEMA Design A from 201 to 500 horsepower.	Electric motors with non-standard endshields or flanges.
Electric motors with moisture resistant windings.	Electric motors with non-standard bases.
Electric motors with sealed windings.	Electric motors with special shafts.
Partial electric motors.	Vertical hollow-shaft electric motors.
Totally enclosed non-ventilated (TENV) electric motors.	Electric motors with sleeve bearings.
Immersible electric motors.	Electric motors with thrust bearings.
Integral brake electric motors.	Non-integral brake electric motors.

In view of DOE's proposed approach described in Table IV.3, DOE is proposing to include certain motor types that some interested parties have suggested that DOE continue to exclude from any energy efficiency requirements. For example, the Motor Coalition would exclude integral brake motors from coverage, as DOE once did through policy guidance, *see* 62 FR 59978 (November 5, 1997), but which was subsequently removed. *See* 77 FR 26638 (May 4, 2012). (Motor Coalition, No. 35 at p. 3) SEW-Eurodrive also commented that there are two basic types of integral gearmotor: (1) One that meets the definition in DOE's preliminary analysis, and (2) another having a special shaft or mounting configuration. SEW-Eurodrive contended that the second type of integral gearmotor would require replacement of the entire rotor shaft and rotor cage to be tested. (SEWE, No. 53, p. 3)

In view of the foregoing, DOE continues to believe that consistent and repeatable test procedures can be prescribed for integral brake motors, integral gearmotors, integral partial motors, and partial ¾ motors. See 78 FR 38456 (June 26, 2013). In particular, DOE believes that an integral brake motor that meets the nine criteria in Table IV.2, could be readily tested and satisfy the proposed standards. In addition, DOE believes that the definition for ''partial electric motor'' and ''component set'' proposed in its June test procedure NOPR will clarify what types of items would meet these definitions, which should help manufacturers determine whether the equipment they manufacture fall under these terms. See 78 FR 38456 (June 26, 2013). Furthermore, DOE believes that the type of integral gearmotor addressed by SEW-Eurodrive (i.e., with a special shaft or mounting configuration) would likely satisfy DOE's proposed definition of component set, because it would require more than the addition of end shields and a bearing to create an operable motor. (Component sets would not be required to meet standards under today's proposal)

ACEEE supported the Motor Coalition's Petition in its approach to expand the scope of covered motors to comply with the energy efficiency levels found in Table 12–12 of NEMA Standards Publication MG 1–2011. According to ACEEE, such approach could be easily accomplished by manufacturers and, at the same time, allow them to refocus resources on designing and building the next generation of electric motor. (ACEEE, Public Meeting Transcript, No. 60 at pp. 18, 19) UL agreed with the ACEEE approach and suggested that DOE clarify the scope of coverage with a statement whereby all electric motors are subject to standards, except for those specifically mentioned as excluded. (UL, Public Meeting Transcript, No. 60 at pp. 60, 61) Finally, the California Independently Owned Utilities (CA IOUs) submitted similar comments, suggesting that DOE expand the scope of coverage and explicitly define those motor types excluded from standards. The CA IOUs stressed that this approach would provide clarity both to

[25] Shipments for these 56-open frame motors were estimated from data provided by the Motor Coalition. DOE assumed 56-frame open motors are distributed across 2-, 4-, and 6-pole configurations and 1 to 5 horsepower ratings. With this assumption, DOE used the shipments distributions from ECG 1 motors across these motor configurations and ratings to establish shipments data for open 56-frame motors by motor configuration and horsepower rating. Efficiency distributions were based on a limited survey of electric motor models from six major manufacturer catalogs.

[26] DOE used the same NIA model and inputs described in section IV.H to estimate these values of NES and NPV, but adjusted the shipments and efficiency distributions to match the data specific to these 56-frame open motors.

[27] DOE notes that general purpose, open 56-frame motors are already addressed by the standards for small electric motors.

compliance and enforcement efforts by government agencies and manufacturers. (CA IOUs, No. 57 at p. 1)

After considering these comments, and further analyzing available relevant information, DOE believes that a simplified approach to determining coverage would help ensure consistency to the extent possible when applying the proposed standards. Therefore, in today's notice, DOE is proposing that an electric motor that meets the nine characteristics in Table IV–3 would be covered and required to meet the applicable energy conservation standards, either in NEMA MG 1 Table 12–11 or 12–12. Additionally, DOE is proposing not to set standards at this time for the following motors: component sets, liquid-cooled motors, submersible motors, and definite-purpose inverter-fed motors. DOE is not proposing to set standards for these motors in light of the substantial difficulties and complexities that would be involved in testing these motors at this time. In addition, DOE is proposing not to set standards at this time for air-over motors, but intends to address these types of motors in a separate rulemaking. Definitions for the motor types and additional details about these issues are addressed at 78 FR 38456 (June 26, 2013).

3. Advanced Electric Motors

In its preliminary analysis, DOE addressed various ''advanced electric motor,'' which included those listed in Table IV.4. While DOE recognized that such motors could offer improved efficiency, regulating them would represent a significant shift for DOE, which has primarily focused on the efficiency of polyphase, single-speed induction motors. Seeking more information, DOE solicited public comments about these types of motors and how they would be tested for energy efficiency.

TABLE IV.4—ADVANCED ELECTRIC MOTORS

Motor description
Inverter drives.
Permanent magnet motors.
Electrically commutated motors.
Switched-reluctance motors.

DOE received comments about advanced motors from various interested parties. NEMA asserted that, in certain applications, inverter drives, permanent-magnet motors, electronically commutated motors, and switched-reluctance motors, could offer improved efficiency. However, NEMA also noted that these motors may include technologies where standard test procedures are still being developed, making it unable to comment. (NEMA, No. 54 at pp. 18–19) DOE understands that a test procedure would be necessary before it contemplates setting energy conservation standards for these types of motors. Additionally, during the preliminary analysis public meeting, ACEEE commented that advanced motor designs present the largest opportunity for future energy savings within the motor marketplace and NEMA member manufacturers are already exploring the standards-setting process for advanced motor designs in the NEMA MG 1 standards publication. (ACEEE, Public Meeting Transcript, No. 60 at p. 19)

Other interested parties submitted comments regarding the efficiency of ''advanced motor systems'' and, in general, motor-driven systems. Danfoss commented that system efficiency improvements would provide significant energy savings, and cited variable frequency drives (VFDs) as an example of a way to improve system efficiency. VFDs, or inverter drives, are external components used in motor-driven systems to control motor speed and torque by varying motor input frequency and voltage Danfoss elaborated that VFDs could save 20 to 30 percent of the energy that typical, non-VFD-motors consume and urged that DOE consider this approach, instead of seeking minimal energy conservation improvements in across-the-line start polyphase electric motors.[28] (Danfoss, Public Meeting Transcript, No. 60 at pp. 21–23, 174, 175) UL submitted similar comments during the preliminary analysis public meeting, indicating that DOE and the industry should focus on improving system-level efficiency. UL added that if a motor is not properly matched to its load then the system efficiency could be 20 or 30 percent less efficient than possible. (UL, Public Meeting Transcript, No. 60 at pp. 69, 70) BBF and the CDA commented that the overall evaluation of system efficiency is very important, and the evaluation of VFDs and the motor system represents many major opportunities for improved efficiency. (BBF, No. 51, p. 4; CDA, No. 55, p. 2)

DOE understands the concerns from interested parties regarding advanced motor efficiency and its connection with the possible regulation of advanced electric motors. At this time, however, DOE has chosen not to regulate advanced motors and knows of no established definitions or test procedures that could be applied to them. Because DOE agrees that significant energy savings may be possible for some advanced motors, DOE plans to keep abreast of changes to these technologies and their use within industry, and may consider regulating them in the future. DOE invites comment on the topic of advanced motors, including any related definitions or test procedures that it should consider applying as part of today's rulemaking.

4. Equipment Class Groups and Equipment Classes

When DOE prescribes or amends an energy conservation standard for a type (or class) of covered equipment, it considers (1) the type of energy used; (2) the capacity of the equipment; or (3) any other performance-related feature that justifies different standard levels, such as features affecting consumer utility. (42 U.S.C. 6295(q)) Due to the large number of characteristics involved in electric motor design, DOE has used two constructs to help develop its energy conservation standards proposals for electric motors: ''equipment class groups'' and ''equipment classes.'' An equipment class represents a unique combination of motor characteristics for which DOE is proposing a specific energy conservation standard. There are 580 potential equipment classes that consist of all permutations of electric motor design types (i.e., NEMA Design A & B, NEMA Design C, fire pump electric motor, or brake electric motor), 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 is a collection of equipment classes that share a common design type. For example, given a combination of motor design type, horsepower rating, pole-configuration, and enclosure type, the motor's design type dictates its equipment class group, while the combination of the remaining characteristics dictates its specific equipment class.[29]

[28] For this rulemaking, ''across-the-line start'' indicates the electric motor is run directly on polyphase, alternating current (AC) sinusoidal power, without any devices or controllers manipulating the power signal fed to the motor.

[29] At its core, the equipment class concept, which is being applied only as a structural tool for purposes of this rulemaking, is equivalent to a ''basic model.'' See 10 CFR 431.12. The fundamental difference between these concepts is that a ''basic model'' pertains to an individual manufacturer's equipment class. Each equipment class for a given manufacturer would comprise a basic model for that manufacturer.

In the preliminary analysis, DOE divided electric motors into three groups based on two main characteristics: NEMA (or IEC) design letter and whether the motor met the definition of a fire pump electric motor. For the NOPR, DOE is keeping these three groups and adding a fourth equipment class group for electric motors with brakes (integral and non-integral). DOE's four resulting equipment class groups are: NEMA Design A and B motors (ECG 1), NEMA Design C motors (ECG 2), fire pump electric motors (ECG 3), and electric motors with brakes (ECG 4). Within each of these groups, DOE would use combinations of other pertinent motor characteristics to enumerate individual equipment classes. To illustrate the differences between the two terms, consider the following example. A NEMA Design B, 50 horsepower, two-pole enclosed electric motor and a NEMA Design B, 100 horsepower, six-pole open electric motor would be in the same equipment class group (ECG 1), but each would represent a unique equipment class that will ultimately have its own efficiency standard. Table IV.5 outlines the relationships between equipment class groups and the characteristics used to define equipment classes.

TABLE IV.5—ELECTRIC MOTOR EQUIPMENT CLASS GROUPS FOR THE NOPR ANALYSIS

Equipment class group	Electric motor design	Horsepower	Poles	Enclosure
1	NEMA Design A & B *	1–500	2, 4, 6, 8	Open. Enclosed.
2	NEMA Design C *	1–200	4, 6, 8	Open. Enclosed.
3	Fire Pump *	1–500	2, 4, 6, 8	Open. Enclosed.
4	Brake Motors *	1–30	4, 6, 8	Open. Enclosed.

* Including IEC equivalents.

NEMA submitted multiple comments about DOE's equipment class groups and equipment classes. First, NEMA argued that such expansive groups could make it difficult to properly determine efficiency standards, particularly given the large expansion of scope being contemplated by DOE. (NEMA, No. 54 at p. 40) NEMA recommended that ''for 'electric motors' the term 'equipment class' be identified as those electric motors which are of the polyphase squirrel-cage induction type.'' It added that:

''An 'equipment class group' can be defined as a particular 'group' of such 'electric motor' having a particular set of common characteristics, such as NEMA Design A and B electric motors or NEMA Design C electric motors, or fire pump electric motors. Each 'equipment class group' can be organized according to 'rating' where 'rating' is as it is presently defined in § 431.12 [of 10 CFR Part 431]. When appropriate, an AEDM [alternative efficiency determination method] can then be substantiated for the complete 'equipment class' of polyphase squirrel-cage induction electric motors as is permitted and done today.''

Additionally, NEMA suggested that DOE separate U-frame motors from T-frame motors during the analysis because any proposed increase in efficiency standards for the low volume production of U-frame motors would likely result in a reduction in the availability of U-frame motors, which they assert, is not permitted under 42 U.S.C. 6295(o)(4). (NEMA, No. 54 at pp. 20, 26) Citing the high cost of redesigning these motors relative to the potential savings, the Motor Coalition predicted manufacturers would exit the U-frame market leaving only one or two manufacturers. (Motor Coalition, No. 35 at p. 13) NEMA also stated that the demand for this type of motor has been declining since the 1960's and U-frame motors have not been included in the NEMA MG 1 standard since U-frame motors were replaced by T-frame motors as the NEMA standard in the 1960s. (NEMA, No. 54 at pp. 19, 20) NEMA added that the challenge created by substituting a U-frame motor with a T-frame motor must be accounted for in the manufacturer and national impact analyses.

EISA 2007 prescribed energy conservation standards for electric motors built with a U-frame, whereas previously only electric motors built with a T-frame were covered.[30] (Compare 42 U.S.C. 6311(13)(A)(1992) with 42 U.S.C. 6311(13)(B)(2011)) In general, for the same combination of horsepower rating and pole configuration, an electric motor built in a U-frame is built with a larger ''D'' dimension than an electric motor built in a T-frame. The ''D'' dimension is a measurement of the distance from the centerline of the shaft to the bottom of the mounting feet. Consequently, U-frame motors should be able to reach efficiencies as high, or higher, than T-frame motors with similar ratings (i.e., horsepower, pole-configuration, and enclosure) because the larger frame size allows for more active materials, such as copper wiring and electrical steel, which help reduce I^2R (i.e., losses arising from the resistivity of the current-carrying material) and core losses (losses that result from magnetic field stability changes). Furthermore, U-frame motors do not have any unique utility relative to comparable T-frame motors. In general, a T-frame design could replace an equivalent U-frame design with minor modification of the mounting configuration for the driven equipment. By comparison, a U-frame design that is equivalent to a T-frame design could require substantial modification to the mounting configuration for the same piece of driven equipment because of its larger size. DOE's research indicated that manufacturers sell conversion brackets for installing T-frame motors into applications where a U-frame motor had previously been used.[31]

Regarding NEMA's contention that U-frame motors will become unavailable if DOE does not separate these motors from T-frame motors when developing efficiency standards, DOE understands NEMA's concerns regarding the diminishing market size of U-frame motors and the potential for them to disappear. However, DOE believes that such an occurrence would not be the

[30] The terms ''U-frame'' and ''T-frame'' refer to lines of frame size dimensions, with a T-frame motor having a smaller frame size for the same horsepower rating as a comparable U-frame motor. In general, ''T'' frame became the preferred motor design around 1964 because it provided more horsepower output in a smaller package.

[31] See, for example, *http://www.overlyhautz.com/adaptomounts1.html*.

result of an efficiency standard that is technologically infeasible for U-frame motors, but because U-frame motors offer no unique utility relative to T-frame motors. Furthermore, DOE believes that the proposed standards are unlikely to result in the unavailability of U-frame motors. Based on catalog data from several large electric motor manufacturers, DOE observed that 70 percent of currently available U-frame models meet the proposed standard (TSL 2). With much of the U-frame market already at the proposed standard, DOE sees no technical reason that U-frame manufacturers would not be able to comply with TSL 2.

DOE also notes that under 42 U.S.C. 6295(o)(4), EPCA proscribes the promulgation of standards that would 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 at the time of the Secretary's finding.'' The provision does not require the continued protection of particular classes or types of product—or in this case, electric motors—if the same utility continues to be available for the consumers who are purchasing the given product. Consequently, based on available information, DOE has not separated U-frame motors into a unique equipment class group. DOE welcomes any additional data relevant to this finding, including data that would suggest the need for an alternate approach. DOE also requests additional information from manufacturers on whether covering U-frame motors would cause them to be unavailable in the U.S. and whether U-frame motors have any particular performance characteristics, features, sizes, capacities, or volumes.

Finally, NEMA questioned DOE's use of the term ''equipment class'' to describe a combination of horsepower rating, pole configuration, and enclosure type instead of using the term ''rating,'' which is defined in 10 CFR 431.12, as part of the definition of a ''basic model.'' (NEMA, No. 54 at p. 25) NEMA believes that this could cause confusion because of proposals regarding certification, alternative efficiency determination methods (AEDMs), and enforcement in a separate rulemaking, which are all centered around ''equipment classes.'' (NEMA, No. 54 at p. 25) NEMA stated that DOE's definition in this rulemaking has the adverse impact of requiring substantiation of an AEDM separately for every rating for which it is to be used and would constitute a significant increase in compliance burden. (NEMA, No. 54 at p. 25) DOE understands NEMA's concerns regarding the potential of undue compliance burden. DOE notes that it has not proposed a regulatory definition for the term ''equipment class.'' It is merely a construct for use in the various analyses in today's rulemaking. The term ''equipment class'' as described in this rulemaking should not be misconstrued as having any regulatory meaning as it relates to the definition of ''basic model.'' In today's rulemaking, DOE is continuing to use the terminology as described in the preliminary analysis and above. DOE intends to address NEMA's concerns regarding the potential compliance burden in a separate rulemaking that will address compliance, certification and enforcement-related issues.

a. Electric Motor Design Letter

The first criterion that DOE considered when disaggregating equipment class groups was based on the NEMA (and IEC) design letter. The NEMA Standards Publication MG 1–2011, ''Motors and Generators,'' defines a series of standard electric motor designs that are differentiated by variations in performance requirements. These designs are designated by letter—Designs A, B, and C. (See NEMA MG 1–2011, paragraph 1.19.1). These designs are categorized by performance requirements for full-voltage starting and developing locked-rotor torque, breakdown torque, and locked-rotor current, all of which affect an electric motor's utility and efficiency. DOE is proposing to regulate the efficiency of each of these design types.

The primary difference between a NEMA Design A and NEMA Design B electric motor is that they have different locked-rotor current requirements. NEMA Design B motors must not exceed the applicable locked-rotor current level specified in NEMA MG 1–2011, paragraph 12.35.1. NEMA Design A motors, on the other hand, do not have a maximum locked-rotor current limit. In most applications, NEMA Design B motors are generally preferred because locked-rotor current is constrained to established industry standards, making it easier to select suitable motor-starting devices. However, certain applications have special load torque or inertia requirements, which result in a design with high locked-rotor current (NEMA Design A). When selecting starting devices for NEMA Design A motors, extra care must be taken in properly sizing electrical protective devices to avoid nuisance tripping during motor startup. The distinction between NEMA Design A and NEMA Design B motors is important to users who are sensitive to high locked-rotor current; however, both NEMA Design A and Design B motors have identical performance requirements in all other metrics, which indicates that they offer similar levels and types of utility. Given these similarities, DOE is proposing to group these motors together into a single equipment class grouping for the purposes of this rulemaking.

In contrast, DOE believes that the different torque requirements for NEMA Design C electric motors represent a change in utility that can affect efficiency performance. NEMA Design C motors are characterized by high starting torques. Applications that are hard to start, such as heavily loaded conveyors and rock crushers, require this higher starting torque. The difference in torque requirements will restrict which applications can use which NEMA Design types. As a result, NEMA Design C motors cannot always be replaced with NEMA Design A or B motors, or vice versa. Therefore, as in the preliminary analysis, DOE has analyzed NEMA Design C motors in an equipment class group separate from NEMA Design A and B motors.

In chapter two, ''Analytical Framework,'' of the preliminary technical support document, DOE noted numerous instances where manufacturers were marketing electric motors rated greater than 200 horsepower as NEMA Design C motors. DOE understands that NEMA MG 1–2011 specifies Design C performance requirements for motors rated 1–200 hp in four-, six-, and eight-pole configurations—a motor rated above 200 hp or using a two-pole configuration would not meet the Design C specifications. DOE requested public comment about whether motors that are name-plated as NEMA Design C, but that fall outside the ratings for which NEMA Design C is defined, can be considered to be NEMA Design C motors. In its comments, NEMA asserted it did not support marking a motor as NEMA Design C where no standard exists for two-pole designs, or four-, six- or eight-pole motors over 200 horsepower. NEMA recommended that any such improperly marked motor be examined for determination of its proper Design letter relative to the applicable standards in NEMA MG 1. Furthermore, NEMA recommended that DOE not include efficiency standards for motors of any design type for which NEMA or IEC standards do not exist. (NEMA, No. 54 at p. 19)

DOE understands that without established performance standards that form the basis for a two-pole NEMA

Design C motor or a NEMA Design C motor with a horsepower rating above 200, motors labeled as such would not meet the proposed regulatory definition for ''NEMA Design C motor.'' 78 FR 38456 (June 26, 2013). DOE considers motors at these ratings to be improperly labeled if they are name-plated as NEMA Design C. Mislabeled NEMA Design C motors, however, are still subject to energy conservation standards if they meet the definitions and performance standards for a regulated motor—e.g. NEMA Design A or B. And since these motors either need to meet the same efficiency levels or would be required by customers to meet specific performance criteria expected of a given design letter (i.e. Design A, B, or C), DOE does not foresee at this time any incentive that would encourage a manufacturer to identify a Design A or B motor as a Design C motor for standards compliance purposes. DOE understands, however, that NEMA Design C motors as a whole constitute an extremely small percentage of motor shipments—less than two percent of shipments—covered by this rulemaking, which would appear to create an unlikely risk that mislabeling motors as NEMA Design C will be used as an avenue to circumvent standards. Nevertheless, DOE will monitor the potential presence of such motors and may reconsider standards for them provided such practice becomes prevalent.

b. Fire Pump Electric Motors

In addition to considering the NEMA design type when establishing equipment class groups, DOE considered whether an electric motor is a fire pump electric motor. EISA 2007 prescribed energy conservation standards for fire pump electric motors (42 U.S.C. 6313(b)(2)(B)) and, subsequently, DOE adopted a definition for the term ''fire pump electric motor,'' which incorporated portions of National Fire Protection Association Standard (NFPA) 20, ''Standard for the Installation of Stationary Pumps for Fire Protection'' (2010). Pursuant to NFPA 20, a fire pump electric motor must comply with NEMA Design B performance standards and must continue to run in spite of any risk of damage stemming from overheating or continuous operation. The additional requirements for a fire pump electric motor constitutes a change in utility that DOE believes could also affect its performance and efficiency. Therefore, DOE established a separate equipment class group for such motors in the preliminary analysis to account for the special utility offered by these motors.

In its comments, NEMA agreed with DOE's decision to separate fire pump electrical motors as a separate equipment class group. (NEMA, No. 54 at p. 20) Consequently, DOE is proposing to continue using a separate equipment class group for fire pump electric motors.

c. Brake Motors

In its NOPR analyses, DOE considered whether the term ''electric motor'' should include an integral brake electric motor or a non-integral brake electric motor (collectively, ''brake motors''). In the test procedure NOPR, DOE proposed definitions both for integral and non-integral brake electric motors. 78 FR 38456 (June 26, 2013). Both of these electric motor types are contained in one equipment class group as separate from the equipment class groups established for NEMA Design A and B motors, NEMA Design C motors, and fire pump electric motors.

DOE understands that brake motors contain multiple features that can affect both utility and efficiency. In most applications, electric motors are not required to stop immediately. Instead, electric motors typically slow down and gradually stop after power is removed from the motor due to a buildup of friction and windage from the internal components of the motor. However, some applications require electric motors to stop quickly. Such motors may employ a brake component that, when engaged, abruptly slows or stops shaft rotation. The brake component attaches to one end of the motor and surrounds a section of the motor's shaft. During normal operation of the motor, the brake is disengaged from the motor's shaft—it neither touches nor interferes with the motor's operation. However, under normal operating conditions, the brake is drawing power from the electric motor's power source and may also be contributing to windage losses, because the brake is an additional rotating component on the motor's shaft. When power is removed from the electric motor (and therefore the brake component), the brake component de-energizes and engages the motor shaft, quickly slowing or stopping rotation of the rotor and shaft components. Because of these utility related features that affect efficiency, DOE has preliminarily established a separate equipment class group for electric motors with an integral or non-integral brake.

d. Horsepower Rating

In its preliminary analysis, DOE considered three criteria when differentiating equipment classes. The first criterion was horsepower, a critical performance attribute of an electric motor that is directly related to the capacity of an electric motor to perform useful work and that generally scales with efficiency. For example, a 50-horsepower electric motor would generally be considered more efficient than a 10-horsepower electric motor. In view of the direct correlation between horsepower and efficiency, DOE preliminarily used horsepower rating as a criterion for distinguishing equipment classes in the framework document and continued with that approach for the preliminary analysis.

NEMA agreed with DOE's view that horsepower is a performance attribute that must be considered when evaluating efficiency and urged that this long-established and workable concept not be abandoned. (NEMA, No. 54 at p. 40) In today's proposal, DOE continues to use horsepower as an equipment class-setting criterion.

e. Pole Configuration

The number of poles in an induction motor determines the synchronous speed (i.e., revolutions per minute) of that motor. There is an inverse relationship between the number of poles and a motor's speed. As the number of poles increases from two to four to six to eight, the synchronous speed drops from 3,600 to 1,800 to 1,200 to 900 revolutions per minute, respectively. In addition, manufacturer comments and independent analysis performed on behalf of DOE indicate that the number of poles has a direct impact on the electric motor's performance and achievable efficiency because some pole configurations utilize the space inside of an electric motor enclosure more efficiently than other pole configurations. DOE used the number of poles as a means of differentiating equipment classes in the preliminary analysis.

In response to the preliminary analysis, NEMA agreed that the number of poles of an electric motor has impacts a motor's achievable efficiency and supported DOE's decision to take this characteristic into consideration. (NEMA, No. 54 at p. 41) In today's proposal, DOE continues to use pole-configuration as an equipment class-setting criterion.

f. Enclosure Type

EISA 2007 prescribes separate energy conservation standards for open and enclosed electric motors. (42 U.S.C. 6313(b)(1)) Electric motors manufactured with open construction allow a free interchange of air between the electric motor's interior and exterior. Electric motors with enclosed construction have no direct air interchange between the motor's interior and exterior (but are not necessarily air-tight) and may be equipped with an internal fan for cooling (see NEMA MG 1–2011, paragraph 1.26). Whether an electric motor is open or enclosed affects its utility; open motors are generally not used in harsh operating environments, whereas totally enclosed electric motors often are. The enclosure type also affects an electric motor's ability to dissipate heat, which directly affects efficiency. For these reasons, DOE used an electric motor's enclosure type (open or enclosed) as an equipment class setting criterion in the preliminary analysis.

NEMA acknowledged in its comments that the enclosure type is an important characteristic that affects the achievable efficiency for any particular electric motor. NEMA added that it may become necessary to consider separate groups for various enclosures as DOE continues to expand the scope of electric motors subject to energy conservation standards, but did not make any specific suggestions regarding which enclosures could be considered separately. (NEMA, No. 54 at p. 42)

At this time, DOE is continuing to use separate equipment class groups for open and enclosed electric motors but is declining to further break out separate equipment classes for different types of open or enclosed enclosures because DOE does not have data supporting such separation.

g. Other Motor Characteristics

In the preliminary analysis, DOE addressed various other motor characteristics, but did not use them to disaggregate equipment classes. In the preliminary analysis TSD, DOE provided its rationale for not disaggregating equipment classes for vertical electric motors, electric motors with thrust or sleeve bearings, close-coupled pump motors, or by rated voltage or mounting feet. DOE believes that none of these electric motor characteristics provide any special utility that would impact efficiency and justify separate equipment classes.

In response to the preliminary analysis, DOE received comments about how it should treat other motor characteristics. NEMA agreed with DOE's decision that vertical motors, motors with thrust or sleeve bearings, and close-coupled pump motors do not merit separate equipment classes. (NEMA, No. 54 at p. 20) With no comments suggesting that DOE use any one of the alternative characteristics as a criterion for equipment class, DOE is using the approach it laid out in its preliminary analysis.

DOE also requests additional information from manufacturers on whether covering any of these technology options would reduce consumer utility or performance or cause any of the covered electric motors to be unavailable in the U.S. and whether U-frame motors have any particular performance characteristics, features, sizes, capacities, or volumes. In particular, DOE requests any information or data if these technology options would lead to increases in the size of the motors such that it would no longer work in a particular space constricted application, to decreases in power thereby affecting their usability of these motors, or to changes in any other characteristics that would affect the performance or utility of the motor.

5. Technology Assessment

The technology assessment provides information about existing technology options and designs used to construct more energy-efficient electric motors. Electric motors have four main types of losses that can be reduced to improve efficiency: Losses due to the resistance of conductive materials (stator and rotor I^2R losses), core losses, friction and windage losses, and stray load losses. These losses are interrelated such that measures taken to reduce one type of loss can result in an increase in another type of losses. In consultation with interested parties, DOE identified several technology options that could be used to reduce such losses and improve motor efficiency. These technology options are presented in Table IV.6. (See chapter 3 of the TSD for details).

TABLE IV.6—TECHNOLOGY OPTIONS TO INCREASE ELECTRIC MOTOR EFFICIENCY

Type of loss to reduce	Technology option
Stator I^2R Losses	Increase cross-sectional area of copper in stator slots.
	Decrease the length of coil extensions.
Rotor I^2R Losses	Use a die-cast copper rotor cage.
	Increase cross-sectional area of rotor conductor bars.
	Increase cross-sectional area of end rings.
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 preliminary analysis, DOE received multiple comments about these options.

At the preliminary analysis public meeting, NEMA requested clarification on what was meant by the technology option listed as ''improving rotor bar insulation.'' (NEMA, Public Meeting Transcript, No. 60 at p. 158) NEMA commented on the option of increasing the cross sectional area of the stator windings and clarified that this is one way to decrease stator resistance, but not necessarily a separate technology option. (NEMA, No. 54 at p. 44) NEMA also clarified that reducing rotor resistance through a change in volume is synonymous with an increase in rotor slot size, unless DOE intends to include variations in the volume of the end rings. (NEMA, No. 54 at p. 45)

NEMA also noted that chapter 3 of DOE's preliminary TSD did not discuss the option of increasing the flux density in the air gap, while chapter 4 did. (NEMA, No. 54 at p. 46) NEMA added that the air gap flux density is not a design option that can be independently adjusted and that for a given core length the only option available for changing the air gap flux density is to change the number of effective turns in the stator winding. (NEMA, No. 54 at pp. 62, 63) NEMA also commented on the limitations associated with reducing a motor's air gap by noting that manufacturers must ensure that the motor is still functional and that the air gap is not so small such that the rotor and stator may strike each other during operation. (NEMA, No. 54 at pp. 44–45)

Lastly, during the preliminary analysis public meeting, Danfoss commented that the term ''technology options'' is a bit misleading because of the design tradeoffs that must be made in order to maintain motor performance (other than efficiency). (Danfoss, Public Meeting Transcript, No. 60 at pp. 98, 99)

Regarding the requested clarifications, DOE notes the listed option of ''improved rotor insulation'' refers to increasing the resistance between the rotor squirrel-cage and the rotor laminations. Manufacturers use different methods to insulate rotor cages, such as applying an insulating coating on the rotor slot prior to die-casting or heating and quenching [32] the rotor to separate rotor bars from rotor laminations after die-casting. DOE has updated the discussion in the TSD chapter to clarify that there are multiple ways to implement this technology option.

DOE agrees with NEMA that increasing the cross-sectional area of copper in the stator is synonymous with reducing the stator resistance, and has updated the discussion in TSD chapter 3 for clarity. Furthermore, DOE agrees with NEMA that increasing rotor slot size is a technique that reduces rotor resistivity. DOE also considered other techniques to reduce rotor resistivity such as increasing the volume of the rotor end rings and using die-cast copper rotors. For the sake of clarity, DOE has replaced the technology option ''reduce rotor resistance'' in the TSD discussion with the specific techniques that DOE considered in its analysis: Increasing the cross-sectional area of the rotor conductor bars, increasing the cross-sectional area of the end rings, and using a die-cast copper rotor cage.

With regard to increasing the flux density in the air gap, DOE consulted with its subject matter expert and acknowledges that this approach is not necessarily an independently adjustable design parameter used to increase motor efficiency and has removed it from its discussion in chapters 3 and 4 of the TSD. DOE notes that it understands that the technology options that it discusses do have limits, both practical limits in terms of manufacturing and design limits in terms of their effectiveness. DOE also understands that a manufacturer must balance any options to improve efficiency against the possible impacts on the performance attributes of its motor designs.

[32] Quenching is rapid cooling, generally by immersion in a fluid instead of allowing the rotor temperature to equalize to ambient

a. Decrease the Length of Coil Extensions

One method of reducing resistance losses in the stator is decreasing the length of the coil extensions at the end turns. Reducing the length of copper wire outside the stator slots not only reduces the resistive losses, but also reduces the material cost of the electric motor because less copper is being used.

NEMA submitted comments acknowledging decreased coil extension as an option to increase efficiency, but did not see the practicability. NEMA asserted that decreasing the length of a coil extension has been a common industry practice for over 50 years and it would be difficult to achieve any further reductions in motor losses under this option. NEMA added that any design changes that would decrease the length of a coil extension must be carefully considered to ensure that the coil heads meet all applicable creep and strike distance requirements.[33] (NEMA, No. 54 at p. 57)

DOE understands that there may be limited efficiency gains, if any, for most electric motors using this technology option. DOE also 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 maintains that this is a design parameter that affects efficiency and should be considered when designing an electric motor.

b. Increase Cross-Sectional Area of Rotor Conductor Bars

Increasing the cross-sectional area of the rotor bars, by changing the cross-sectional geometry of the rotor, can improve motor efficiency. Increasing the cross-sectional area of the rotor bars reduces the resistance and thus lowers the I^2R losses. However, changing the shape of the rotor bars may affect the size of the end rings and can also change the torque characteristics of the motor.

NEMA acknowledged that increasing the cross-sectional area of rotor bars is an option to increase efficiency, but doubted whether any additional reductions in motor losses were possible by using this method. After 50 years of increasing efficiency through this technique, NEMA questioned whether manufacturers could further increase the cross-sectional area of the rotor bars, adding that the increase in rotor current cannot exceed the square of the decrease in the rotor resistance in order for the rotor losses to decrease. NEMA added that any design changes using this option must be carefully considered to ensure that the motor will meet the applicable NEMA MG 1 performance requirements (i.e., stall time, temperature rise, overspeed) and, for certain applications, any other industry standards (i.e., IEEE 841 [34]) to maintain the same level of utility. (NEMA, No. 54 at pp. 57, 58)

DOE recognizes that increasing the cross-sectional area of a conductor rotor bar may yield limited efficiency gains for most electric motors. However, DOE maintains that this is a design parameter that affects efficiency and must be considered when designing an electric motor. Additionally, when creating its software models, DOE considered rotor slot design, including cross sectional areas, such that any software model produced was designed to meet the appropriate NEMA performance requirements for torque and locked rotor current.

[33] Creep distance is the shortest path between two conductive parts. An adequate creep distance protects against tracking, a process that can lead to insulation deterioration and eventual short circuit. Strike distance is the shortest distance through air from one conductor to another conductor or to ground. Adequate strike distance is required to prevent electrical discharge between two conductors or between conductors and ground.

c. Increase Cross-Sectional Area of End Rings

End rings are the components of a squirrel-cage rotor that create electrical connections between the rotor bars. Increasing the cross-sectional area of the end rings reduces the resistance and thus lowers the I^2R losses in the end rings. A reduction in I^2R losses will occur only when any proportional increase in current as a result of an increase in the size of the end ring is less than the square of the proportional reduction in the end ring resistance.

NEMA commented that increasing the end ring size increases the rotor weight, and consideration must be given to the effects a heavier end ring will have on the life of the rotor. NEMA added that any design changes using this option must be carefully considered to ensure that the applicable design requirements are met and intended utility retained. (NEMA, No. 54 at p. 58)

When developing its software models, DOE relied on the expertise of its subject matter expert. Generally,

[34] IEEE 841–2009, ''IEEE Standard for Petroleum and Chemical Industry—Premium-Efficiency, Severe-Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors—Up to and Including 370 kW (500 hp),'' identifies the recommended practice for petroleum and chemical industry severe duty squirrel-cage induction motors.

increases to end ring area were limited to 10–20% are unlikely to have significant impacts on the mechanical aspects of the rotor. Furthermore, DOE ensured that the appropriate NEMA performance requirements for torque and locked-rotor current were maintained with its software modeled motors.

d. Increase the Number of Stator Slots

Increasing the number of stator slots associated with a given motor design can, in some cases, improve motor efficiency. Similar to increasing the amount of copper wire in a particular slot, increasing the number of slots may in some cases permit the manufacturer to incorporate more copper into the stator slots. This option would decrease the losses in the windings, but can also affect motor performance. Torque, speed and current can vary depending on the combination of stator and rotor slots used.

NEMA indicated that increasing the number of slots to allow the motor design engineer to incorporate additional copper into the stator slots is contrary to any practical analysis. NEMA elaborated that the stator core holds the stator winding in the slots and carries the magnetic flux in the electrical steel. As stator slots increase, insulating material will increase, reducing the total amount of cross-sectional area for stator winding. Additionally, too large of an increase in the number of stator slots may make it impractical to wind the stator on automated equipment and the same may be true for a low number of stator slots. NEMA also commented that while it agrees with DOE that the number of stator slots can affect motor torque and efficiency, there is a relationship between the number of rotor slots and stator slots, and the combination of the two can have significant effects on starting torque, sound levels, and stray load losses. NEMA concluded that all of these effects must be considered to ensure the practicability of manufacturing the affected motors. Other factors NEMA noted included winding and potential sound levels—all of which could impact utility along with health and safety concerns. (NEMA, No. 54 at p. 61)

With respect to stator slot numbers, DOE understands that a motor manufacturer would not add stator slots without any appreciation of the impacts on the motor's performance. DOE also understands that there is an optimum combination of stator and rotor slots for any particular frame size and horsepower combination. DOE consulted with its subject matter expert and understands that optimum stator and rotor slot combinations have been determined by manufacturers and are in use on existing production lines.'' Consequently, DOE has removed this technology option from chapter 4 of the TSD.

e. Electrical Steel with Lower Losses

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 of these losses generate heat in the electrical steel.

In studying the techniques used to reduce steel losses, DOE considered two types of materials: Conventional silicon steels, and ''exotic'' steels, which contain a relatively high percentage of boron or cobalt. Conventional steels are commonly used in electric motors manufactured today. There are three types of steel that DOE considers ''conventional:'' cold-rolled magnetic laminations, fully processed non-oriented electrical steel, and semi-processed non-oriented electrical steel.

One way to reduce core losses is to incorporate a higher grade of core steel into the electric motor design (*e.g.,* switching from an M56 to an M19 grade). In general, higher grades of electrical steel exhibit lower core losses. Lower core losses can be achieved by adding silicon and other elements to the steel, thereby increasing its electrical resistivity. Lower core losses can also be achieved by subjecting the steel to special heat treatments during processing.

The exotic steels are not generally manufactured for use specifically in the electric motors covered in this rulemaking. These steels include vanadium permendur and other alloyed steels containing a high percentage of boron or cobalt. These steels offer a lower loss level than the best electrical steels, but are more expensive per pound. In addition, these steels can present manufacturing challenges because they come in nonstandard thicknesses that are difficult to manufacture.

NEMA and Baldor submitted multiple comments concerning DOE's discussion during the preliminary analysis regarding the use of Epstein testing to determine an electrical steel grade that would improve the efficiency of an electric motor. (NEMA, No. 54 at pp. 21–23, 62; NEMA, Public Meeting Transcript, No. 60 at pp. 100, 102, 103) The grading of electrical steel is made through a standardized test known worldwide as the Epstein Test.[35] This test provides a standardized method of measuring the core losses of different types of electrical steels. NEMA commented that relying solely on Epstein test results to select grades of steel could result in a motor designer inadvertently selecting a steel grade that performs poorly in a motor design. NEMA supplied data on two different samples of steel supplied by different manufacturers, but consisting of the same steel grade. The data illustrated how the lower loss steel (as determined by Epstein test results) resulted in a less efficient motor when used in a prototype. NEMA noted that this situation poses a problem for computer software modeling because a model that represents only the general class of electrical steel and not the steel source (manufacturer) would not be able to calculate the difference in the results between the supposedly equivalent grades of steels from separate manufacturers.

DOE clarifies that its computer software did not model general classes of electrical steel, but instead modeled vendor-specific electrical steel. DOE's software utilized core loss vs. flux density curves supplied by an electrical steel vendor as one component of the core loss calculated by the program. A second component was also added to account for high frequency losses. DOE agrees with NEMA's claim that relative performance derived from Epstein testing might not be indicative of relative performance in actual motor prototypes. DOE did not solely rely on relative steel grade when selecting electrical steels for its designs. To illustrate this point, DOE notes that almost all of its software modeled designs utilized M36 grade steel, even though it was not the highest grade of electrical steel considered in the analysis. When higher grade M15 steel was evaluated in DOE's software modeled designs, the resulting efficiencies were actually lower than the efficiencies when using M36 grade steel for several reasons including the reasons cited by NEMA. The Epstein test results for various grades of steel provided in chapter 3 of the preliminary analysis TSD were purely informational and intended to give an indication of the relative performance of a sample of

[35] ASTM Standard A343/A343M, 2003 (2008), ''Standard Test Method for Alternating-Current Magnetic Properties of Materials at Power Frequencies Using Wattmeter-Ammeter-Voltmeter Method and 25-cm Epstein Test Frame,'' ASTM International, West Conshohocken, PA 2008.

electrical steels considered. That information has been removed from chapter 3 of the TSD to avoid any further confusion.

f. Thinner Steel Laminations

As addressed earlier, there are two types of core losses that develop in the electrical steel of induction motors—hysteresis losses and losses due to eddy current. Electric motors can use thinner laminations of core steel to reduce eddy currents. The magnitude of the eddy currents induced by the magnetic field become smaller in thinner laminations, making the motor more energy efficient. In the preliminary analysis, DOE only considered conventional steels with standard gauges available in the market.

NEMA agreed with DOE's initial decision to consider only lamination thicknesses that are currently used in motor manufacturing, as there is a practical limit on how thick the laminations can be in electric motors before additional losses may become significant. (NEMA, No. 54 at p. 62) DOE continues to consider this as a viable technology option in the NOPR analysis.

g. Increase Stack Length

Adding electrical steel to the rotor and stator to lengthen the motor can also reduce the core losses in an electric motor. Lengthening the motor by increasing stack length reduces the magnetic flux density, which reduces core losses. However, increasing the stack length affects other performance attributes of the motor, such as starting torque. Issues can arise when installing a more efficient motor with additional stack length because the motor becomes longer and may not fit into applications with dimensional constraints.

NEMA requested clarification of the phrase ''add stack height,'' which DOE included in its summary of technology options for improving efficiency in chapter 3 of the preliminary TSD. NEMA was unsure if this meant increasing the length of the core or increasing the outer diameter of the stator core laminations. (NEMA, no. 54 at p. 45)

DOE clarifies that it was referring to increasing the length of the stator and rotor. However, increasing the outside diameter of the stator core is another way in which manufacturers could add active material to their electric motor designs and potentially increase efficiency.

NEMA agreed that changing the stack length of an electric motor can improve core losses (i.e. reduce them), but may also change other performance characteristics such as torque, speed and current. However, NEMA stressed that there are limits to this technology option because too much additional stack could cause the motor to increase in size (i.e., frame length), which might introduce utility problems in space-constrained applications (NEMA, No. 54 at p. 62) NEMA also commented that since the EISA 2007 standards were enacted, only a limited number of motor ratings above NEMA Premium have been offered because there is not sufficient space available in most frame ratings to increase the efficiency. (NEMA, No. 54 at p. 7) DOE understands that there are limits to increased stack length and, as discussed in IV.C, DOE established criterion to limit the length of the stack considered in the engineering analysis. DOE also understands that stack length affects consumer utility, which is a factor that DOE considers in its selection of a standard.

h. More Efficient Cooling System

Optimizing a motor's cooling system that circulates air through the motor is another technology option to improve the efficiency of electric motors. Improving the cooling system reduces air resistance and associated frictional losses and decreases the operating temperature (and associated electrical resistance) by cooling the motor during operation. This can be accomplished by changing the fan or adding baffles to the current fan to help redirect airflow through the motor.

NEMA agreed that changes in the cooling system may reduce the total losses of a motor, but did not agree that this is equivalent to a more efficient cooling system, as DOE described. NEMA elaborated that when the design of an electric motor is changed, losses associated with the cooling system may increase in order to provide a decrease in losses associated with some other part of the design. (NEMA, No. 54 at p. 63) DOE appreciates NEMA's comments and has clarified its phrasing of this technology option to reflect the fact that it is the motor that becomes more efficient, not necessarily the cooling system.

i. Reduce Skew on Conductor Cage

In the rotor, the conductor bars are not straight from one end to the other, but skewed or twisted slightly around the axis of the rotor. Decreasing the degree of skew can improve a motor's efficiency. The conductor bars are skewed to help eliminate harmonics that add cusps, losses, and noise to the motor's speed-torque characteristics. Reducing the degree of skew can help reduce the rotor resistance and reactance, which helps improve efficiency. However, overly reducing the skew also may have adverse effects on starting, noise, and the speed-torque characteristics.

NEMA inquired if this design option was considered for any of the designs used in the engineering analysis, as the preliminary TSD did not indicate if any rotors were skewed. (NEMA, No. 54 at p. 63) NEMA also inquired why the option to reduce skew on the conductor cage, was associated with I^2R losses in chapter 3 of the preliminary TSD, but in chapter 4 of the preliminary TSD this option was associated with reducing stray load losses. (NEMA, No. 54 at p. 46)

DOE notes that all software designs used in the analysis had skewed rotor designs and, in general, the skews used were approximately 100 percent of a stator or rotor slot pitch, whichever had the smaller number of slots. Additionally, DOE intended for the option of reducing the skew on the conductor cage to be an option associated with reducing stray load losses and has made the appropriate adjustments to its text and tables.

B. Screening Analysis

After DOE identified the technologies that might improve the energy efficiency of electric motors, DOE conducted a screening analysis. The purpose of the screening analysis is to determine which options to consider further and which to screen out. DOE consulted with industry, technical experts, and other interested parties in developing a list of design options. DOE then applied the following set of screening criteria, under sections 4(a)(4) and 5(b) of appendix A to subpart C of 10 CFR Part 430, ''Procedures, Interpretations and Policies for Consideration of New or Revised Energy Conservation Standards for Consumer Products,'' to determine which design options are unsuitable for further consideration in the rulemaking:

- *Technological Feasibility:* DOE will consider only those technologies incorporated in commercial equipment or in working prototypes to be technologically feasible.
- *Practicability to Manufacture, Install, and Service:* If mass production of a technology in commercial equipment and reliable installation and servicing of the technology could be achieved on the scale necessary to serve the relevant market at the time of the effective date of the standard, then DOE will consider that technology practicable to manufacture, install, and service.
- *Adverse Impacts on Equipment Utility or Equipment Availability:* DOE

will not further consider a technology if DOE determines it will have a significant adverse impact on the utility of the equipment to significant subgroups of customers. DOE will also not further consider a technology that will result in the unavailability of any covered equipment type with performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as equipment generally available in the United States at the time.

- *Adverse Impacts on Health or Safety:* DOE will not further consider a technology if DOE determines that the technology will have significant adverse impacts on health or safety.

Table IV.7 below presents a general summary of the methods that a manufacturer may use to reduce losses in electric motors. The approaches presented in this table refer either to specific technologies (*e.g.,* aluminum versus copper die-cast rotor cages, different grades of electrical steel) or physical changes to the motor geometries (*e.g.,* cross-sectional area of rotor conductor bars, additional stack height). For additional details on the screening analysis, please refer to chapter 4 of the preliminary TSD.

TABLE IV.7—SUMMARY LIST OF OPTIONS FROM TECHNOLOGY ASSESSMENT

Type of loss to reduce	Technology option
Stator I^2R Losses	Increase cross-sectional area of copper in stator slots. Decrease the length of coil extensions.
Rotor I^2R Losses	Use a die-cast copper rotor cage. Increase cross-sectional area of rotor conductor bars. Increase cross-sectional area of end rings.
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.

1. Technology Options Not Screened Out of the Analysis

The technology options in this section are options that passed the screening criteria of the analysis. DOE considers the technology options in this section to be viable means of improving the efficiency of electric motors. In NEMA's view, DOE's screening analysis lacked sufficient supporting information regarding whether a particular technology is included or screened out of the analysis. NEMA agreed that it is necessary to look at new technologies, but added that DOE did not provide adequate supporting information in its analysis and the group asserted that commenters were left without adequate material upon which to base comments in support of or in opposition to statements made in the preliminary TSD. NEMA suggested that a form clearly identifying the issues pertinent to the topic be provided for each option analyzed. NEMA stated that providing these forms for each technology option would supply adequate material on which commenters can develop public comments. (NEMA, No. 54 at p. 45) Additionally, when discussing the seven criteria that DOE must consider in its analysis, NEMA expressed that there are more criteria that should be considered. NEMA stated that DOE must consider 4(d)(7) of 10 CFR part 430, subpart C, appendix A which lists under sections 4.(d)(7)(viii) impacts of non-regulatory approaches and (ix) new information relating to the factors used for screening design options. (NEMA, No. 54 at p. 13)

Regarding NEMA's request for a form for each technology option considered, today's NOPR provides detailed information about each technology option considered and DOE is requesting comment on each option. DOE understands NEMA's concerns about the technology options not screened out of the DOE analysis. With the exception of copper rotor motors, DOE understands that each technology option that it has not screened out is a design option that a manufacturer would consider in each motor designed and built. DOE recognizes that manufacturers design their motors to balance a number of competing factors that all inter-relate with each other, including performance, reliability, and energy efficiency. Because the options DOE has identified can be modified to improve efficiency while maintaining performance, it is DOE's tentative view that at least some significant level of energy efficiency improvement is possible with each technology option not screened out by DOE.

Furthermore, DOE notes that it did not explicitly use each of the technology options that passed the screening criteria in the engineering analysis. As discussed in section IV.C, DOE's engineering analysis was a mixture of two approaches that DOE routinely uses in its engineering analysis methodology: The reverse-engineering approach (in which DOE has no control over the design parameters) and the efficiency-level approach (in which DOE tried to achieve a certain level of efficiency, rather than applying specific design options). This hybrid of methods did not allow for DOE to fully control which design parameters were ultimately used for each representative unit in the analysis. Without the ability to apply specific design options, DOE could not include every option that was not screened out of the analysis. Finally, DOE appreciates NEMA's comments regarding Appendix A to Subpart U of part 430. DOE has considered all comments related to the two factors identified by NEMA in its rule.

In addition, DOE notes that its analysis neither assumes nor requires manufacturers to use identical technology for all motor types, horsepower ratings, or equipment classes. In other words, DOE's standards are technology-neutral and permit manufacturers design flexibility.

a. Copper Die-Cast Rotors

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.

NEMA commented that performance is a relative term, and that the NEMA MG 1–2011 standard specifies performance characteristics and specifications for various types of motors. NEMA added that tradeoffs among various performance characteristics related to the conductivity of copper are required when designing a NEMA Design B electric motor that is in full conformance with the NEMA MG 1–2011 standards. NEMA commented that DOE did not address all aspects of motor performance specified in the NEMA MG 1–2011 standard, especially some of the performance requirements related to the choice of conductive material in the rotor. (NEMA, No. 54 at p. 46)

DOE acknowledges that using copper in rotors may require different design approaches and considerations. In its own modeling and testing of copper rotor motors, DOE ensured that performance parameters stayed within MG 1–2011 limits (i.e., met NEMA Design B criteria). DOE seeks comment on any particular aspects of copper rotor design, especially those on parameters widely viewed as challenging to meet, and requests explanation of why such parameters are especially challenging when using copper.

The Advocates (NEEA, NPCC, ACEEE, ASAP, Earthjustice, and ASE) disagreed with DOE's tentative decision during the preliminary analysis phase to include copper die-cast rotors. It urged DOE to exclude this option in order to avoid analyzing a technology that is not ready for use across all motor types, configurations, and horsepower ratings that DOE would cover as part of its rulemaking. (Advocates, No. 56 at pp. 3–4)

On a related note, NEMA commented that DOE has not publicly established what determines a ''mass quantity.'' NEMA elaborated that a ''mass quantity'' should mean the ability to be produced in significant volume for the entire industry. NEMA commented that DOE screened out certain electrical steels because they could not be produced in significant volume for the entire industry, and this same logic should apply to copper rotor technology. (NEMA, No. 54 at p. 24)

DOE did not screen out copper as a die-cast rotor conductor material because copper die-cast rotors passed the four screening criteria. Because copper is in commercial use today, DOE concluded that this material is technologically feasible and practicable to manufacture, install, and service. Additionally, manufacturers are already producing such equipment, which suggests that such equipment can be safely produced in mass quantities. For example, Siemens produces copper rotor motors for 1–20 hp and SEW-Eurodrive manufactures a full line of motors from 1–30 hp. In addition, DOE notes that its analysis neither assumes nor requires manufacturers to use identical technology for all motor types, horsepower ratings, or equipment classes.

DOE received considerable feedback concerning copper rotor technology. Consequently, DOE has organized those comments into sections below as they pertain to the four screening criteria.

Technological Feasibility

As part of its analysis, DOE intends to ensure that utility, which includes frame size considerations, is maintained. Increased shipping costs are also taken into account in the national impact analysis (NIA) and the life-cycle cost (LCC) analysis portions of DOE's analytical procedures.

NEMA commented that the use of a technology in a limited subclass of electric motors does not imply that the technology can be applied to every equipment class covered in this rulemaking. NEMA is not aware of any available complete product line of NEMA Design A, B, or C copper die-cast rotor electric motors manufactured in the United States, and stated that further investigation is required to prove this technology is valid for an entire range of designs. (NEMA, No. 54 at pp. 2, 48, 49) NEMA was able to find two manufacturers currently producing copper rotor motors in a total of only 33 out of over 600 equipment classes covered in this rulemaking.[36] NEMA and Baldor added that none of those motors are produced in the United States, and only about half of those ratings met NEMA Design B performance requirements. (NEMA, No. 54 at pp. 48, 49; Baldor, Public Meeting Transcript, No. 60 at pp. 109, 110)

NEMA commented that the die-casting process for copper rotors can increase core or stray load losses in the motor, and this is a problem with copper die-casting that has not been solved in all rotor sizes. (NEMA, No. 54 at p. 46)

NEMA cited recently conducted U.S. Army studies involving die-cast copper rotor motors. It explained that the first study evaluated the advantages of a die-cast copper rotor versus an aluminum rotor. The study also attempted to optimize the process and estimate manufacturing costs for die-cast copper rotors. NEMA commented that the results of the study showed that the die-cast copper rotor motor was unable to stay within the NEMA Design B locked-rotor current limits, and that efficiency increased by less than one full NEMA band over the comparable NEMA Design B aluminum cast-copper rotor motor. The study reported that continued investment in cast copper rotor motor technology development is needed to improve design optimization methods, improve the casting process, and to investigate utilization of cast copper in larger motor sizes. NEMA commented that the number of die-cast copper rotors manufactured in the study was insufficient to make any determination that die-casting could be performed on a high and consistent quality basis necessary for general production. (NEMA, No. 54 at p. 50, 51)

NEMA also described a different U.S. Army study where a 75-hp aluminum rotor motor driving a pump was to be replaced with a 75-hp copper rotor motor. NEMA explained that in the study the die-cast copper rotor motor's optimization study indicated the motor would have a one NEMA band increase in efficiency over the aluminum die-cast rotor motor it was replacing. However, once built, the 75-hp die-cast copper rotor motor had an actual efficiency of more than 1 NEMA band below the aluminum die-cast rotor motor, with core and stray load losses of the physical motor being higher than the computer model had predicted. NEMA concluded that neither study was successful in demonstrating that copper rotor die-casting technology is possible or feasible in its current state in the U.S., and that continued investment in die-cast copper rotor technology development is necessary to improve the copper die-casting process and reduce stray load losses. (NEMA, No. 54 at pp. 51–53)

BBF, a consulting company working on behalf of the Copper Development Association (CDA), commented that test data of multiple die-cast copper rotor motors resulted in an average tested efficiency above the motors' nameplate efficiency, whereas the test results from a similar model aluminum rotor motor tested below its nameplate efficiency. In its view, these results fall within the allowable variances prescribed by NEMA with respect to measuring electric motor energy efficiency and demonstrate the higher energy

[36] The equipment classes NEMA found included NEMA Design A motors from 1 to 30 hp, 4-pole configurations, and NEMA Design B motors from 1.5 to 20 hp in a 2-pole configuration, 1 to 20 hp in a 4-pole configuration, and 1 hp and 3–10 hp in a 6-pole configuration. All motor configurations NEMA mentioned were enclosed frame motors.

efficiency potential of die-cast copper rotor motors. (BBF, No. 51 at p. 3)

NEMA summarized that it is not aware of any prototypes or commercially available products that have demonstrated the technical feasibility of utilizing die-cast copper rotors sufficient to cover all equipment classes covered in this rulemaking. NEMA disagreed with DOE's conclusion that die-cast copper rotors successfully passed the screening criteria for technological feasibility relative to the class of all covered electric motors, including the 75-hp copper rotor motor which DOE used as a representative unit in the engineering analysis. NEMA added that DOE has not provided any evidence that die-casting copper can successfully be applied to all electric motors covered in this rulemaking by December 19, 2015. NEMA added that the recent studies conducted by the United States Army noted above showed that, in the U.S. at present or in any foreseeable future time, this technology is not currently feasible over the range of motor ratings regulated under this rulemaking. (NEMA, No. 54 at pp. 3, 53, 56; NEMA, Public Meeting Transcript, No. 60 at p. 111)

The CDA disagreed with NEMA, and stated that die-cast copper rotor motors are a feasible technology because manufacturers have already successfully entered the copper rotor motor market. The CDA added that a range of development issues have been overcome, again suggesting that it is technologically feasible, but copper die-cast rotors require redesign and optimization to take advantage of copper's different electrical properties compared to aluminum, and many motor manufacturers have undertaken this redesign and optimization to take advantage of the properties of copper. (BBF, No. 51 at p. 3) The CDA agreed, however, that current manufacturing capacity would be unable to produce motors on the scale of five million units yearly. (CDA, Public Meeting Transcript, No. 60 at p. 119)

DOE acknowledges that the industry is not equipped to produce all motors with copper rotors, but has estimated the costs of both capital and product development through interviews with manufacturers of motors and included these costs in its engineering analysis. DOE welcomes comment on the methodology, and on the resulting motor prices. As noted earlier, EPCA, as amended, does not require manufacturers to use identical technology for all motor types, horsepower ratings, or equipment classes.

DOE recognizes that assessing the technological feasibility of high-horsepower copper die-cast rotors 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;
3. They are possible to construct to required specifications, but would require manufacturing capital investment to do so and be so costly that few (if any) consumers would choose them.

Some exploratory research suggests that different organizations have developed and used copper rotors in high-horsepower traction (i.e., vehicle propulsion) motors. For example, Tesla Motors powers its Roadster [37] and Model S [38] vehicles with copper induction motors generating 300 [39] or more peak horsepower and Oshkosh die-cast copper rotor induction motors rated at 140 peak hp.[40] Remy International, Inc. (Remy) also builds high-horsepower copper motors that are claimed to exceed 300 horsepower at 600V.[41] DOE seeks comment on these, and on other high-horsepower motors that use copper rotors.

DOE recognizes that these motors are designed for a different purpose than most motors in the current scope of this rulemaking. Their existence suggests that copper has been successfully used at high power levels in an application where efficiency is critical and casts doubt on the idea that copper die-cast rotors can be screened out with certainty.

Another reason to be cautious about screening out copper die-cast rotors comes from an analogous product: Distribution transformers. DOE conducted a recent rulemaking on distribution transformers,[42] which (as with motors) have two sets of conductors that surround electrical steel to transfer power. Although distribution transformers do not rotate, many of the ways that they lose energy (e.g., conductor losses) are the same as electric motors. They also face constraints (as motors do) on performance aspects unrelated to efficiency; inrush current and overall volume are two examples. At current prices, copper is generally not viewed as economical for most efficiency levels but, if properly designed, copper windings almost always result in smaller, cooler, and more efficient transformers.

In general, copper may improve efficiency relative to aluminum because it carries an inherently higher level of electrical conductivity. Several organizations have conducted research and built prototype [43] motors that use materials even more conductive than copper, such as ''superconductive'' materials that have no conductive losses to achieve even greater electric motor efficiency. While DOE is not considering the use of these more conductive materials at this time, DOE notes their existence for purposes of demonstrating the potential advantages of using materials that lower conductive losses.

While recognizing that motors are not transformers, the parallels that can be drawn leave DOE hesitant to screen out copper die-cast rotors on the basis of technological feasibility. Relative to the above list of possible reasons for their absence from the high-horsepower market, DOE's analysis does not conclude copper die-cast rotors are either: (1) Physically impossible to construct or (2) possible to construct, but impossible to construct to required specifications.

Practicability To Manufacture, Install, and Service

Regarding DOE's projections that the annual sales of electric motors, as defined by EISA 2007 will have grown to 5,089,000 units by 2015, including over 24,000 possible motor configurations, NEMA commented that only a single manufacturer is currently producing die-cast copper rotor motors, and in a very limited range. In its view, without sufficient data and analysis to support DOE's conclusion that ''mass production'' of die-cast copper rotors is possible, NEMA asserts that this technology would not pass the screening criterion of practicability to manufacture, install, and service. It argues that, based on the limited advances of the technology from 1995 to present day in the United States, this technology is unlikely to be mature enough by the compliance date for this rulemaking to meet the required production of over 5 million motors in

[37] *http://www.teslamotors.com/roadster/technology/motor.*

[38] *http://www.teslamotors.com/models/specs.*

[39] *http://www.teslamotors.com/roadster/specs.*

[40] See *http://www.coppermotor.com/wp-content/uploads/2012/04/casestudy_army-truck.pdf.*

[41] *http://www.remyinc.com/docs/hybrid/REM–12_HVH410_DataSht.pdf.*

[42] Available at: *http://www.regulations.gov/#!documentDetail;D=EERE-2010-BT-STD-0048-0762.*

[43] See General Atomics marine propulsion motor at: *http://www.ga.com/electric-drive-motors.*

the U.S., even if all manufacturing were shifted overseas. (NEMA, No. 54 at pp. 3, 47, 53, 54, 56; NEMA, Public Meeting Transcript, No. 60 at p. 114) NEMA noted that mandating this technology may also have the indirect effect of establishing a monopoly market in the U.S. for those manufacturers who can produce copper rotor motors, or to push production jobs overseas and penalize motor manufacturers that do not have the capability to produce copper rotor motors. (NEMA, No. 54 at p. 24)

DOE recognizes the importance of maintaining a competitive market. However, because there are at least two domestic manufacturers of motors with copper rotors and because several more are manufacturing internationally, DOE believes the opportunity for price manipulation is limited. Furthermore, DOE has seen no evidence to suggest that a monopoly would be likely to occur. DOE requests comment and further information that would demonstrate the likelihood of a future monopoly.

BBF and the CDA commented that there are copper die-casting facilities in the U.S.—specifically in Colorado and Ohio—as well as in Mexico. They added that die-cast rotor motors have been produced for North American service since 2005, and some of these motors meet NEMA Design B requirements. The CDA and BBF added that multiple high-volume manufacturers in Europe and Asia have produced tens of thousands of die-cast copper rotor motors that satisfy the NEMA-specified performance requirements that meet or exceed the NEMA Premium levels. These motors have been sold to North American users. (BBF, No. 51 at pp. 2, 3) DOE was able to purchase and tear down a 5-hp copper rotor motor from an Asian manufacturer that performed at DOE's max-tech efficiency level, as well as the performance requirements for NEMA Design B.

SEW Eurodrive stated that it offers only three models of cast-copper rotor motors and cited the expenses and difficulty of casting copper rotors as the reason why it does not offer more die-cast copper rotor motor models. (SEWE, Public Meeting Transcript, No. 60 at p. 121) The company did not elaborate why it manufactures die-cast copper rotor motors in the configurations it offers for sale.

Based on these comments, DOE does not believe it has grounds to screen out copper die-cast rotors on the basis of practicability to manufacture, install, and service. The available facts indicate that manufacturers are already producing smaller motors with die-cast copper rotors, leaving the question of whether larger motors are being manufactured with die-cast copper rotors. DOE recognizes that as technology scales upward in size, it can require different equipment and processes. Nonetheless, Tesla's [44] and Remy's [45] 300+ horsepower motors with copper rotors cast doubt on the assertion that copper is impracticable in this size range.

DOE understands that full-scale deployment of copper would likely require considerable capital investment (see detailed discussion in SectionIV.J.2.a) and that such investment could increase the production cost of large copper rotor motors considerably. DOE believes that its current engineering analysis reflects this likelihood, and welcomes comment on this issue.

Adverse Impacts on Equipment Utility or Equipment Availability

NEMA commented that DOE failed to address the adverse impacts on equipment utility or availability caused by die-cast copper rotors. It asserted that the process for manufacturing die-cast copper rotors is underdeveloped, and energy conservation standards based on this technology, and implemented in 2015, would result in product unavailability of over 99 percent of the electric motors that would be impacted if DOE were to set a standard that would require the use of die-cast copper. NEMA reiterated that there is no justification as to how motors that are not available today, made from a technology that is not practiced in the U.S. today, will become available within three years, especially when taking into account the time needed for prototyping, testing, and AEDM certification. (NEMA, No. 54 at pp. 3, 47, 48, 54, 55, 56; NEMA, Public Meeting Transcript, No. 60 at pp. 114, 115)

NEMA also commented that it is difficult for die-cast copper rotor motors to stay under the maximum locked-rotor current limit for NEMA Design B motors. If this technology were adopted, in its view, many current NEMA Design B motors would become NEMA Design A motors. This would reduce the utility of a motor, because a NEMA Design A motor is not a direct drop-in place replacement for a NEMA Design B motor. (NEMA, No. 54 at p. 3)

DOE agrees that, in some cases, redesigning product lines to use copper would entail substantial cost. DOE's engineering analysis reflects its estimates of these costs and discusses them in detail in section IV.C. DOE was able to model copper rotor motors adhering to the specifications of NEMA Design B [46], including the reduced (relative to Design A) locked-rotor current.

Finally, based on DOE's own shipments analysis (see TSD Chapter 9) and estimates of worldwide annual copper production,[47] DOE estimates that .01-.02% of worldwide copper supply would be required to use copper rotors for every single motor within DOE's scope of coverage. At the present, DOE does not believe there is sufficient evidence to screen copper die-cast rotors from the analysis on the basis of adverse impacts to equipment utility or availability.

Adverse Impacts on Health or Safety

NEMA commented that the preliminary TSD does not sufficiently explain how DOE concluded that mandating performance levels that would require copper rotor die-casting would not have an adverse impact on health or safety, with the implication being on occupational health and safety. NEMA commented that the preliminary TSD mentioned potential impacts on the health or safety caused by the higher melting point of copper, but DOE did not elaborate on what these potential impacts were. NEMA disagreed with DOE's conclusion not to screen out die-cast copper rotor technology on the premise that handling molten copper is similar to handling molten aluminum. NEMA noted that copper has a pouring temperature of 2100 degrees Fahrenheit and a 150 percent higher casting pressure than aluminum, and that, combined, these two characteristics would increase the severity of any potential accidents. NEMA mentions an incident involving the two U.S. Army die-cast copper rotor studies previously mentioned, which resulted in injuries during the die-casting of aluminum [48] [*sic*] cage rotors and caused the only U.S. manufacturer of copper die-casting equipment to withdraw that equipment from the market. NEMA added that the equipment currently remains unavailable for purchase. (NEMA, No. 54 at pp. 10, 55, 56; NEMA, Public

[44] *http://www.teslamotors.com/roadster/technology/motor.*

[45] *http://www.remyinc.com/docs/hybrid/REM-12_HVH410_DataSht.pdf.*

[46] The parameters DOE believed to present the largest risk of rendering a motor noncompliant with NEMA MG 1–2011 standards were those related to NEMA design letter, which were adhered to in DOE's modeling efforts.

[47] *http://minerals.usgs.gov/minerals/pubs/commodity/copper/mcs-2012-coppe.pdf.*

[48] From the context of NEMA's comment, DOE believes the use of the word ''aluminum'' was a typographical error and that NEMA had intended this passage to use the word ''copper'' instead.

Meeting Transcript, No. 60 at p. 115) NEMA added that, especially regarding die-casting copper on larger motor sizes, DOE cannot justifiably claim that there are no adverse impacts on health or safety until they conduct a thorough investigation or feasibility study regarding this topic. (NEMA, No. 54 at p. 3)

However, BBF also commented that copper die-cast rotors can be safely manufactured, as one major manufacturer indicated that they have had no worker injuries in volume production over multiple years. (BBF, No. 51 at p. 3)

BBF commented that, with the extensive capabilities of copper die-cast rotors and commercial availability of copper die-cast rotors with efficiencies higher than NEMA MG 1–2011 Table 12–12 efficiencies, DOE should include in its evaluations copper die-cast rotor motors. BBF also added that they strongly disagree with the NEMA representatives' contrary verbal suggestions towards copper rotor motor technology presented during the public meeting. (BBF, No. 51 at p. 4)

DOE is aware of the higher melting point of copper (1084 degrees Celsius versus 660 degrees Celsius for aluminum) and the potential impacts this may have on the health or safety of plant workers. However, DOE does not believe at this time 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 observe strict protocols to operate safely. DOE understands that many plants already work with molten aluminum die casting processes and believes that similar processes could be adopted for copper. DOE has not received any supporting data about the increased risks associated with copper die casting, and could not locate any studies suggesting that the die-casting of copper inherently represented incrementally more risks to worker safety and health. DOE notes that several OSHA standards relate to the safety of ''Nonferrous Die-Castings, Except Aluminum,'' of which die-cast copper is part. DOE seeks comment on any adverse safety or health impacts and on these OSHA standards,[49] and on any other specific information document the safety of die-casting for both copper and aluminum.

b. Increase the Cross-Sectional Area of Copper in the Stator Slots

Increasing the slot fill by either adding windings or changing the gauge of wire used in the stator winding can also increase motor efficiency. Motor design engineers can achieve this by manipulating the wire gauges to allow for a greater total cross-sectional area of wire to be incorporated into the stator slots. This could mean either an increase or decrease in wire gauge, depending on the dimensions of the stator slots and insulation thicknesses. As with the benefits associated with larger cross-sectional area of rotor conductor bars, using more total cross-sectional area in the stator windings decreases the winding resistance and associated losses. However, this change could affect the slot fill factor of the stator. The stator slot openings must be able to fit the wires so that automated machinery or manual labor can pull (or push) the wire into the stator slots. In the preliminary analysis, DOE increased the cross-sectional area of copper in the stator slots of the representative units by employing a combination of additional windings, thinner gauges of copper wire, and larger slots.

In response to the preliminary analysis, NEMA commented that a majority of stator windings are manufactured on automated equipment. NEMA and Baldor noted that there is a practical limit of 82 percent slot fill for automated winding equipment for motors with four or more poles; motors with two poles have a limit of 78 percent. (NEMA, No. 54 at p. 58; Baldor, Public Meeting Transcript, No. 60 at p. 146) NEMA commented that the values for maximum slot fill for the automated winding models was approximately 82 percent and those based on hand winding were 85 percent. NEMA noted that this is not a practical change based on a change in conductor size alone because conductors are sized in a larger increment than this difference would suggest. Therefore, it would appear that the size of the stator slot in each case was selected to purposely result in the corresponding level of slot fill. (NEMA, No. 54 at p. 59) In other words, instead of only adjusting the conductor gauge to the slot size, the slot size could be adjusted to the conductor gauge.[50] (NEMA, No. 54 at p. 59) Baldor added that slot fills above 85 percent would be very difficult to do in current production volumes (5 million motors annually) and noted that this slot fill percentage was based on a DOE-presented software model and has not been proven in a prototype. (Baldor, Public Meeting Transcript, No. 60 at pp. 146, 147) NEMA requested that DOE clarify the method it used for calculating slot fill to avoid confusion among other interested parties who may have used a different calculation method. (NEMA, No. 54 at p. 58)

DOE calculated the slot fill by measuring the total area of the stator slot and then subtracting the cross sectional area for the slot insulation. This method gave DOE a net area of the slot available to house copper winding. DOE then identified the slot with the most windings and found the cross sectional area of the insulated copper wires to get the total copper cross sectional area per slot. DOE then divided the total copper cross sectional area by the total slot area to derive the slot fill. DOE's estimated slot fills for its teardowns and software models are all provided in chapter 5 of the TSD.

NEMA commented that several of DOE's designs presented maximum values of slot fill at 85 percent, whereas the closest automated winding slot fill was 82-percent. NEMA questioned the significant benefit DOE projected in designing the stator slot such that a hand winding would be required to gain a 3-percent change in slot fill. In NEMA's view, the change in core loss that might result from increasing the stator slot area by 3 percent would not be significant enough to warrant hand-winding the stator. (NEMA, No. 54 at p. 59) DOE notes that the software designs exhibiting these changes in slot fill were used when switching from aluminum to a copper rotor design. Therefore, changing slot geometries impacted the design's slot fill and the slot fill changes resulted from different motor designs. Consequently, a 3 percent increase in slot fill does not imply that this change was made to increase the efficiency of another design, but could have been made to change other performance criteria of the motor, such as locked-rotor current.

In the preliminary analysis, DOE indicated that motor design engineers can adjust slot fill by changing the gauge of wire used in fractions of half a gauge. NEMA commented that it did not understand DOE's statement, and indicated that manufacturers limit the number of gauges used at any particular manufacturing plant, and few of those gauges are ''fractions of a half a gauge.'' NEMA added that manufacturers may use multiple wire gauges in a particular winding, but DOE's examples in chapter 5 gave no indication that any sizes other

[49] For a list, see: *http://www.osha.gov/pls/imis/citedstandard.sic?p_esize=&p_state=FEFederal&p_sic=3364.*

[50] In practice, of course, a manufacturer may opt to do either or both.

than a single conductor size was used in each winding. (NEMA, No. 54 at pp. 58, 59) DOE clarifies that all the modeled motors utilized standard AWG wire sizes, either whole- or half-gauge sizes (i.e., 18 or 18½). DOE clarifies that the statement of ''fractions of a half gauge'' referred to sizes in between a whole gauge (i.e. 18½ of a gauge is a fraction of 18 gauge wire). DOE did not end up using fractions consisting of a half gauge of wire sizes to conduct its modeling, but did indicate that this was a design option used by the motor industry.

NEMA also commented that it is not uncommon for a manufacturer to use the same stator lamination design for all horsepower ratings built in the same NEMA MG 1–2011 Standard frame series. NEMA indicated that a high slot fill may require hand winding for one of the ratings and automated winding for the other rating, and that a good design practice for stator laminations will take into consideration more than just one motor rating to determine the best design for all ratings in that frame series. (NEMA, No. 54 at p. 59)

NEMA and Baldor questioned DOE's decision not to screen out hand-wound stators, and both parties commented that moving to hand-wound technology would be a reversal of the trend to automate manufacturing practices whenever possible. (NEMA, No. 54 at p. 59; Baldor, Public Meeting Transcript, No. 60 at pp. 122, 123) NEMA noted that none of the teardown motors in DOE's analysis appeared to use hand winding technology. (NEMA, No. 54 at p. 59)

While NEMA agrees that hand winding cannot be ruled out on the grounds of technological feasibility, it does believe that hand winding would not be practicable to use in mass production. A NEMA member survey indicated that hand winding can take up to 25 times longer than machine winding. NEMA added that the manpower required to replace automated winding would require an increase in manpower in excess of 20 times the number of automated machines. (NEMA, No. 54 at p. 60) NEMA and Baldor commented that moving to an energy conservation level based on hand-wound technology would not be achievable on the scale necessary to serve the relevant market at the time of the effective date of the standard. (NEMA, No. 54 at p. 60; Baldor, Public Meeting Transcript, No. 60 at p. 123) NEMA added that it would not be aware if such an expansion of the infrastructure would be required until after any amended or new standards are announced. (NEMA, No. 54 at p. 60) DOE is aware of the extra time involved with hand winding and has attempted to incorporate this time into efficiency levels (ELs) that it believes would require hand winding. DOE reiterates that should the increase in infrastructure, manpower, or motor cost increase beyond a reasonable means, then ELs utilizing this technology will be screened out during the downstream analysis.

NEMA also expressed concern that standards based on hand winding would shift U.S. manufacturing jobs to locations outside of the U.S. which have lower labor rates, and Nidec added that most U.S. manufacturers are currently globally positioned to move labor-intensive work into low-cost labor countries if energy conservation requirements force them to do so. (Nidec, Public Meeting Transcript, No. 60 at p. 124) DOE intends to fully capture this impact during the manufacturer impact analysis (MIA) portion of DOE's analysis. Please see section IV.J for a discussion of the manufacturer impact analysis.

NEMA also commented that hand-wound technology would have an adverse impact on product utility or product availability, saying that the infrastructure would not be in place in sufficient time to support the hand winding of all of the stators, and there will be an adverse impact on the availability of various ratings of electric motors at the time of effective standards. (NEMA, No. 54 at p. 60)

NEMA commented that hand winding would have adverse impacts on worker health or safety, as both hand winding and hand insertion of stator coils require operations performed by hand with repetitive motions, and such hand winding of stators also involves the moving and lifting of various stator and winding components, which may be of substantial size in larger horsepower rated electric motors. NEMA added that any increase in personnel performing the repetitive tasks required by hand winding can have an adverse effect on the overall health and safety record of any facility. (NEMA, No. 54 at p. 60; NEMA, Public Meeting Transcript, No. 60 at p. 123)

DOE disagrees with NEMA's assertion concerning the adverse impacts on health or safety, and notes that hand winding is currently practiced by industry. Furthermore, DOE is not aware of any data or studies suggesting hand-winding leads to negative health consequences. DOE acknowledges that, were hand-winding to become widespread, manufacturers would need to hire more workers to perform hand-winding to maintain person-winding-hour equivalence, and has accounted for the added costs of hand-winding in its engineering analysis. DOE requests comment on its cost estimates for hand-wound motors, as well as on the matter of hand-winding in general and on studies suggesting negative health impacts in particular.

NEMA summarized its concerns, saying that hand winding is not a viable technology option, especially for a slot fill increase of less than 5 percent. NEMA believes that the engineering analysis should not be based on stator slot fill levels which require hand winding, which are generally slot fills above 78 percent for 2-pole motor and 82 percent for 4-, 6-, and 8-pole motors. (NEMA, No. 54 at p. 60)

DOE acknowledges that the industry is moving towards increased automation. However, hand winding is currently practiced by manufacturers, making it a viable option for DOE to consider as part of its engineering analysis. Considering the four screening criteria for this technology option, DOE did not screen out the possibility of changing gauges of copper wire in the stator as a means of improving efficiency. Motor design engineers adjust this option by using different wire gauges when manufacturing an electric motor to achieve desired performance and efficiency targets. Because this design technique is in commercial use today, DOE considers this technology option both technologically feasible and practicable to manufacture, install, and service. DOE is not aware of any adverse impacts on consumer utility, reliability, health, or safety associated with changing the wire gauges in the stator to obtain increased efficiency. Should the technology option prove to not be economical on a scale necessary to supply the entire industry, then this technology option would be likely not be selected for in the analysis, either in the LCC or MIA.

DOE seeks comment generally on the process of increasing the cross-section of copper in the stator, and in particular on the costs and reliability of the hand winding process.

2. Technology Options Screened Out of the Analysis

DOE developed an initial list of design options from the technologies identified in the technology assessment. DOE reviewed the list to determine if the design options are practicable to manufacture, install, and service; would adversely affect equipment utility or equipment availability; or would have adverse impacts on health and safety. In the engineering analysis, DOE did not consider any of those options that failed to satisfy one or more of the screening criterion. The design options screened out are summarized in Table IV.8.

TABLE IV.8—DESIGN OPTIONS SCREENED OUT OF THE ANALYSIS

Design option excluded	Eliminating screening criterion
Plastic Bonded Iron Powder (PBIP).	Technological Feasibility.
Amorphous Steels	Technological Feasibility.

NEMA agreed with DOE in that plastic bonded iron powder has not been proven to be a technologically feasible method of construction of stator and rotor cores in induction motors. (NEMA, No. 54 at p. 64) NEMA also agreed that amorphous metal laminations are not a type of material that lends itself to use in electric motors in the foreseeable future. However, NEMA expressed concern that this technology was only screened out on the basis of technological feasibility because it had not been used in a prototype. (NEMA, No. 54 at p. 63)

Baldor and NPCC also agreed with DOE's decision to exclude PBIP and amorphous steels from the engineering analysis. (Baldor, Public Meeting Transcript, No. 60 at p. 108; Advocates, No. 56 at p. 3)

DOE is continuing to screen out both of these technology options from further consideration in the engineering analysis. Additionally, DOE understands the concerns expressed by NEMA regarding technological feasibility, but DOE maintains that if a working prototype exists, which implies that the motor has performance characteristics consistent with other motors using a different technology, then that technology would be deemed technologically feasible. However, that fact would not necessarily mean that a technology option would pass all three of the remaining screening criteria.

Chapter 4 of this preliminary TSD discusses each of these screened out design options in more detail, as well as the design options that DOE considered in the electric motor engineering analysis.

C. Engineering Analysis

The engineering analysis develops cost-efficiency relationships for the equipment that are the subject of a rulemaking by estimating manufacturer costs of achieving increased efficiency levels. DOE uses manufacturing costs to determine retail prices for use in the LCC analysis and MIA. In general, the engineering analysis estimates the efficiency improvement potential of individual design options or combinations of design options that pass the four criteria in the screening analysis. The engineering analysis also determines the maximum technologically feasible energy efficiency level.

When DOE proposes to adopt a new or 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. 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. (See chapter 5 of the NOPR TSD.) The max-tech levels that DOE determined for this rulemaking are described in IV.C.3 of this proposed rule.

In general, DOE can use three methodologies to generate the manufacturing costs needed for the engineering analysis. These methods are:

(1) The design-option approach—reporting the incremental costs of adding design options to a baseline model;

(2) the efficiency-level approach—reporting relative costs of achieving improvements in energy efficiency; and

(3) the reverse engineering or cost assessment approach—involving a ''bottoms up'' manufacturing cost assessment based on a detailed bill of materials derived from electric motor teardowns.

1. Engineering Analysis Methodology

DOE's analysis for the electric motor rulemaking is based on a combination of the efficiency-level approach and the reverse engineering approach. Primarily, DOE elected to derive its production costs by tearing down electric motors and recording detailed information regarding individual components and designs. DOE used the costs derived from the engineering teardowns and the corresponding nameplate nominal efficiency of the torn down motors to report the relative costs of achieving improvements in energy efficiency. DOE derived material prices from current, publicly available data as well as input from subject matter experts and manufacturers. For most representative units analyzed, DOE was not able to test and teardown a max-tech unit because such units are generally cost-prohibitive and are not readily available. Therefore, DOE supplemented the results of its test and teardown analysis with software modeling.

When developing its engineering analysis for electric motors, DOE divided covered equipment into equipment class groups. As discussed, there are four electric motor equipment class groups: NEMA Design A and B motors (ECG 1), NEMA Design C motors (ECG 2), fire pump electric motors (ECG 3), and brake motors (ECG 4). The motors within these ECGs are further divided into equipment classes based on pole-configuration, enclosure type, and horsepower rating. For DOE's rulemaking, there are 580 equipment classes.

2. Representative Units

Due to the high number of equipment classes for electric motors, DOE selected and analyzed only a few representative units from each ECG and based its overall analysis for all equipment classes within that ECG on those representative units. During the NOPR analysis, DOE selected three units to represent ECG 1 and two units to represent ECG 2. DOE based the analysis of ECG 3 on the representative units for ECG 1 because of the low shipment volume and run time of fire pump electric motors. DOE also based the analysis of ECG 4 on the analysis of ECG 1 because the vast majority of brake motors are NEMA Design B motors. When selecting representative units for each ECG, DOE considered NEMA design type, horsepower rating, pole-configuration, and enclosure.

a. Electric Motor Design Type

For ECG 1, which includes all NEMA Design A and B motors that are not fire pump or brake motors, DOE only selected NEMA Design B motors as representative units to analyze in the preliminary analysis engineering analysis. DOE chose NEMA Design B motors because NEMA Design B motors have slightly more stringent performance requirements, namely their locked-rotor current has a maximum allowable level for a given rating. Consequently, NEMA Design B motors are slightly more restricted in terms of their maximum efficiency levels. Therefore, by analyzing a NEMA Design B motor, DOE could ensure technological feasibility for all designs covered in ECG 1. Additionally, NEMA Design B units have much higher shipment volumes than NEMA Design A motors because most motor driven equipment is designed (and UL listed) to run with NEMA Design B motors.

NEMA agreed with DOE's decision to base any amended or new standards for ECG 1 motors on NEMA Design B motor types because consumers generally prefer NEMA Design B motors due to the fact that locked-rotor current is constrained to established industry standards in these motors, making it easier to select suitable motor-starting devices. NEMA pointed out that, on the other hand, the use of a NEMA Design A motor may require the purchaser of the motor to expend a significant amount of time and expense in selecting suitable motor-starting devices to operate the motor in an appropriate and safe manner. NEMA elaborated that it is important to base the analysis on NEMA Design B motors in order to minimize any disruption to consumers based on their preference for NEMA Design B. (NEMA, No. 54 at p. 64) DOE appreciates NEMA's feedback. For its NOPR engineering analysis, DOE has continued to select NEMA Design B motors as its representative units in ECG 1.

As mentioned for ECG 2, DOE selected two representative units to analyze. Because NEMA Design C is the only NEMA design type covered by this ECG, DOE only selected NEMA Design C motors as its representative units.

For ECG 3, which consists of fire pump electric motors, DOE based its engineering analysis on the NEMA Design B units analyzed for ECG 1 in the preliminary analysis. As noted, in order to be in compliance with section 9.5 of National Fire Protection Association (NFPA) ''Standard for the Installation of Stationary Pumps for Fire Protection'' Standard 20–2010, which is a requirement for a motor to meet DOE's current definition of a fire pump electric motor, the motor must comply with NEMA Design B (or IEC Design N) requirements.[51] Although DOE understands that fire pump electric motors have additional performance requirements, DOE believed that analysis of the ECG 1 motors would serve as a sufficient approximation for the cost-efficiency relationship for fire pump electric motors. The design differences between a NEMA Design B motor (or IEC-equivalent) and fire pump electric motor are small and unlikely to greatly affect incremental cost behavior.

NEMA disagreed with DOE's assertion that fire pump electric motors are required to meet NEMA Design B standards, and commented that, as defined in 10 CFR 431.12, fire pump electric motors are not limited to NEMA Design B performance standards. NEMA requested that DOE clarify DOE's statement in the preliminary analysis that currently, efficiency standards have only been established for fire pump electric motors that are NEMA Design B. (NEMA, No. 54 at p. 25) NEMA also commented that the additional performance requirements for fire pump electric motors (e.g., the ability to withstand stall conditions for longer periods of time) mean they are usually designed with lower locked-rotor current limits. Therefore, NEMA stated that fire pump electric motors may have a maximum efficiency potential slightly lower than typical, general purpose NEMA Design B motors. (NEMA, No. 54 at pp. 24–25, 40, 64, 70; NEMA, Public Meeting Transcript, No. 60 at pp. 135, 136) NEMA added that they support DOE's decision to analyze fire pump motors in a separate equipment class group because of the short run time of fire pump electric motors. (NEMA, No. 54 at p. 71)

Regarding DOE's fire pump electric motor definition, as detailed in the final electric motors test procedure, DOE intends its fire pump electric motor definition to cover both NEMA Design B motors and IEC-equivalents that meet the requirements of section 9.5 of NFPA 20. *See* 77 FR 26617–18. As stated in the final electric motors test procedure, DOE agrees with stakeholders that IEC-equivalent motors should be included within the scope of the definition of ''fire pump electric motor,'' although NFPA 20 does not explicitly recognize the use of IEC motors with fire pumps. 77 FR 26617. DOE realizes that section 9.5 of NFPA 20 specifically requires that fire pump motors shall be marked as complying with NEMA Design B. The fire pump electric motor definition that DOE created focuses on ensuring that compliance with the energy efficiency requirements are applied in a consistent manner. DOE believes that there are IEC motors that can be used in fire pump applications that meet both NEMA Design B and IEC Design N criteria, as well as NEMA MG1 service factors. DOE's definition encompasses both NEMA Design B motors and IEC-equivalents. To the extent that there is any ambiguity as to how DOE would apply this definition, in DOE's view, any Design B or IEC-equivalent motor that otherwise satisfies the relevant NFPA requirements would meet the fire pump electric motor definition in 10 CFR 431.12. To the extent that there is confusion regarding this view, DOE invites comments on this issue, along with any data demonstrating whether any IEC-equivalent motors are listed for fire pump service either under the NFPA 20 or another relevant industry standard.

Regarding NEMA's other fire pump electric motor comment, DOE agrees that some fire pump electric motors may not be required to meet the NEMA Design B performance requirements (or IEC-equivalent comments). However, those motors that are not required to meet the NEMA Design B performance requirements are direct-current motors, motors with high voltages (i.e., greater than 600 V), motors with high horsepower ratings (i.e., greater than 500 horsepower), single-phase motors, universal-type motors, or wound-rotor motors. Any motor with such attributes would not meet the nine motor characteristics that define the scope of electric motors covered in this rulemaking. Additionally, any fire pump electric motor that is not rated for continuous duty is not, and would not be, covered by the scope of today's rulemaking. Therefore, DOE clarifies that any fire pump electric motor currently subject to, or potentially subject to, energy conservation standards as a result of this rulemaking, would have to meet the NEMA Design B (or IEC-equivalent) performance requirements. As indicated above, DOE seeks comment on whether its current regulatory definition requires further clarification.

Additionally, DOE understands NEMA's comments regarding the potential limitations of fire pump electric motors. However, DOE believes that its approximation, by using the NEMA Design B electric motors from ECG 1 is sufficient, at this time. In DOE's preliminary analysis, DOE found that all efficiency levels analyzed for fire pump electric motors resulted in negative life-cycle cost savings for consumers and a negative net present values for the Nation. This was the result of extremely low operating hours and therefore, limited energy cost savings potential. DOE notes that there are minimal shipments and no efficiency levels are likely to be deemed economically justifiable.

Additionally, DOE understands that fire pump motors are similar in both performance and architecture to NEMA Design B motors, the chief difference being the absence of thermal cutoff capability that would render a fire pump motor unable to perform its function in a hot environment. For compliance purposes, however, the distinction is less important. DOE welcomes comment on the similarity

[51] With the exception of having a thermal shutoff switch, which could prevent a fire pump motor from performing its duty in hot conditions, NFPA 20 also excludes several motor types not considered in this rulemaking from the NEMA Design B requirement. They are direct current, high-voltage (over 600 V), large-horsepower (over 500 hp), single-phase, universal-type, and wound-rotor motors.

between fire pump and NEMA Design B motors.

Equipment class group 4, consisting of brake motors, is also based on ECG 1 because DOE is only aware of brake motors being built to NEMA Design B specifications. Furthermore, DOE understands that there is no fundamental difference in design between brake and non-brake electric motors, other than the presence of the brake. Therefore, the same design options could be used on both sets of electric motors and both motor types are likely to exhibit similar cost versus efficiency relationships.

For the final rule, DOE may consider combining ECGs 1 and 4 again, as was done for the preliminary analysis, but such a decision depends, in part, on the outcome of its concurrent electric motors test procedure rulemaking. Currently, DOE believes that its proposed approach to testing brake motors will mitigate the impact of the brake component's contributions to motor losses such that the demonstrated efficiency would be the same as if the motor had been tested with the brake completely removed (essentially making it no different from the motors covered by ECG 1). (See 78 FR 38467) With this approach, a separate ECG would not be necessary.

b. Horsepower Rating

Horsepower rating is an important equipment class setting criterion. When DOE selected its preliminary analysis representative units, DOE chose those horsepower ratings that constitute a high volume of shipments in the market and provide a wide range upon which DOE could reasonably base a scaling methodology. For NEMA Design B motors, for example, DOE chose 5-, 30-, and 75-horsepower-rated electric motors to analyze as representative units. DOE selected the 5-horsepower rating because these motors have the highest shipment volume of all motors. DOE selected the 30-horsepower rating as an intermediary between the small and large frame number series electric motors. Finally, DOE selected a 75-horsepower unit because there is minimal variation in efficiency for motors with horsepower ratings above 75-horsepower. Based on this fact, DOE determined it was unnecessary to analyze a higher horsepower motor. Additionally, as horsepower levels increase, shipments typically decrease. Therefore, DOE believed there would be minimal gains to its analysis had it examined a higher horsepower representative unit.

During the public meeting, Baldor commented that the representative units should have been selected based on energy consumption and not shipment numbers. Baldor indicated that using this approach, the 10-horspower motor would have been designated as a representative unit rather than the 5-horsepower motors. (Baldor, Public Meeting Transcript, No. 58 at p. 132, 133) NEMA reiterated Baldor's stance in its submitted comments, saying that the 5-horsepower motor would not appear to be the only choice for the representative unit. (NEMA, No. 54 at p. 65) NEMA and Baldor also commented that there are motors built in frame series larger than the standard 75-horsepower frame series and DOE should select a motor built in the largest NEMA MG 1 frame series as a representative unit. (NEMA, No. 54 at p. 65; Baldor, Public Meeting Transcript, No. 60 at p. 133) NEMA added that efficiency ratings start to level off once horsepower ratings exceed 150-horsepower, not above 75-horsepower. Therefore, they argued that selecting a horsepower rating above 150-horsepower would have been a better indicator if the perceived increase in efficiency calculated for lower horsepower ratings would be achievable by larger horsepower ranges. (NEMA, No. 54 at pp. 27, 65) Baldor reiterated this comment in the preliminary analysis public meeting. (Baldor, Public Meeting Transcript, No. 60 at pp. 133–134)

While DOE agrees with NEMA that the 5-horsepower electric motor was not the only choice for the representative unit, it selected the 5-horsepower motor for multiple reasons. The 5-horsepower unit had the highest percentage of shipments for all covered electric motors, which ensured that there would be multiple efficiency levels from multiple manufacturers available for comparison during the teardown analysis. In addition, because DOE later employed scaling, it attempted to find a frame series and D-dimension [52] that could serve as a strong basis from which to scale to a relatively small set of unanalyzed frame series. The standard NEMA MG 1–2011 frame series for the 5-horsepower enclosed motor was a midpoint between the standard frame series for 1 horsepower and 10-horsepower motors, which was the group of ratings covered by the 5-horsepower representative unit. A larger representative unit would have meant a larger range of frame series on which to apply the scaling methodology.

As to DOE's selection of the 75-horsepower representative unit as a maximum, DOE understands that the 75-horsepower motor is not built in the largest NEMA MG 1–2011 frame series covered, but maintains that its selection is appropriate for this analysis. As stated previously, efficiency changes slowly when approaching the highest horsepower ratings, and choosing a higher horsepower rating would not have provided any appreciable improvement over the data DOE already developed for its analysis. DOE has found minimal variation in efficiency for motors above 75-horsepower. Because the change in efficiency diminishes with increasing horsepower, one may achieve a similar level of analytical accuracy with fewer data points at higher horsepower. Stated inversely, one needs more data points to accurately characterize a curve where it has a greater rate of change, such as lower horsepower. Finally, DOE notes that its scaling methodology mirrors the scaling methodology used in NEMA's MG 1–2011 tables of efficiencies, including the rate of change in efficiency with horsepower.

DOE also notes that section 13 of NEMA MG 1–2011 does not standardize frame series for NEMA Design B motors at the highest horsepower levels covered in today's proposal. Therefore, motors with the highest capacity have variability in their frame series. This added flexibility would give manufacturers more options to improve the efficiency of their largest motors covered by this rulemaking. Although altering the frame size of a motor may be costly, DOE believes that its selection of a 75-hp representative unit for higher horsepower motors is appropriate for scaling higher horsepower efficiency levels and the efficiency levels examined are technologically feasible for the largest capacity motors.

For NEMA Design C electric motors, DOE again selected the 5-horsepower rating because of its prevalence. In addition, DOE selected a 50-horsepower rating as an incrementally higher representative unit. DOE only selected two horsepower ratings for these electric motors because of their low shipment volumes. For more information on how DOE selected these horsepower ratings see chapter 5 of the TSD.

In submitted comments, NEMA expressed confusion over DOE's selection of the 50-horsepower representative unit for the NEMA Design C equipment class group. NEMA stated that the NEMA T-frame size for such a rating is 326T, which is three

[52] ''D'' dimension is the length from the centerline of the shaft to the mounting feet of the motor, and impacts how large the motor's laminations can be, impacting the achievable efficiency of the motor. ''D'' dimensions are designated in NEMA MG 1–2011 Section 4.2.1, Table 4–2.

NEMA T-frame number series below the largest frame number series of 440. NEMA requested that DOE clarify why it limited its NEMA Design C representative unit to such a low value in its engineering analysis. (NEMA, No. 54 at p. 66) Finally, NEMA commented that the 2011 shipment data that DOE used to select its representative units was not broken down by NEMA design type. NEMA believed that using such data to select representative units for ECGs 1 and 2 was not appropriate and requested clarification. (NEMA, No. 54 at p. 66)

As with ECG 1, DOE selected representative units that fell in the middle of the range of ratings covered in this rulemaking and not necessarily the largest frame size covered in the rulemaking. Furthermore, as discussed earlier, NEMA Design C motors are produced in a smaller range of horsepower ratings than NEMA Design B motors (1 to 200 rather than 1 to 500). With this smaller horsepower range, a correspondingly smaller range of representative units is needed. Therefore, DOE selected a slightly lower rating as its maximum for ECG 2. As for the shipments data used to select the 5-hp representative unit, DOE acknowledges that it did not separate the data by design type, and has revised the text for the NOPR's TSD to add clarity. However, DOE still maintains that the prevalence of 5-hp units make it an appropriate selection as a representative unit.

c. Pole-Configuration

Pole-configuration is another important equipment class setting criterion that DOE had to consider when selecting its representative units. For the preliminary analysis, DOE selected 4-pole motors for all of its representative units. DOE chose 4-pole motors because they represent the highest shipment volume of motors compared to other pole configurations. DOE chose not to alternate between pole configurations for its representative units because it wanted to keep as many design characteristics constant as possible. By doing so, it would allow DOE to more accurately identify how design changes affect efficiency across horsepower ratings. Additionally, DOE believed that the horsepower rating-versus-efficiency relationship is the most important (rather than pole-configuration and enclosure type-versus-efficiency) because there are significantly more horsepower ratings to consider.

NEMA noted that efficiency gains based on a 4-pole configuration do not confirm that those same gains are achievable in other pole configurations, and there is no foundation for scaling across different pole configurations. NEMA added that it is necessary to know how designs change with respect to pole-configuration, and analyzing samples of one pole configuration limits the ability to make decisions based on other pole-configurations. NEMA commented that designs significantly vary across pole-configurations, especially regarding torque characteristics. (NEMA, No. 54 at pp. 26, 66–67) NEMA also stated that the purpose of the engineering analysis is not necessarily to determine the ''reasons for efficiency improvements,'' but to determine if efficiency can be improved in accordance with meeting the requirements of being technologically feasible and economically justified per 42 U.S.C. 6295(o)(A) and (B). (NEMA, No. 54 at p. 26) Baldor also commented on scaling across pole configurations, saying that the rotor diameter grows as the pole number increases, which may cause higher losses in 2-pole motors compared to other pole configurations covered in this rulemaking. (Baldor, Public Meeting Transcript, No. 60 at pp. 130, 131)

As mentioned earlier, DOE is assessing energy conservation standards for 580 equipment classes. Analyzing each of the classes individually is not feasible, which requires DOE to select representative units on which to base its analysis. DOE understands that different pole-configurations have different design constraints. Originally, DOE selected only 4-pole motors to analyze because they were the most common, allowing DOE to most accurately characterize motor behavior at the pole configuration consuming the majority of motor energy. Additionally, by holding pole-configuration constant across its representative units, DOE would be able to develop a baseline from which to scale. By maintaining this baseline and holding all other variables constant, DOE is able to modify the horsepower of the various representative units and isolate which efficiency effects are due to size.

As discussed in section IV.C.8, DOE has used the simpler of two scaling approaches presented in the preliminary analysis because both methods had similar results. This simpler approach does not require DOE to develop a relationship for 4-pole motors from which to scale. Furthermore, DOE notes that the scaling approach it selected mirrors the scaling laid out in NEMA's MG 1–2011 tables, in which at least a subset of the motors industry has already presented a possible relationship between efficiency and pole count. DOE has continued to analyze 4-pole electric motors because they are the most common and DOE believes that all of the efficiency levels it has developed are technologically feasible.

d. Enclosure Type

The final equipment class setting criterion that DOE considered when selecting its representative units was enclosure type. For the preliminary analysis, DOE elected to analyze electric motors with enclosed designs rather than open designs for all of its representative units. DOE selected enclosed motors because, as with pole-configurations, these motors have higher shipments than open motors. Again, DOE did not alternate between the two design possibilities for its representative units because it sought to keep design characteristics as constant as possible in an attempt to more accurately identify the reasons for efficiency improvements.

NEMA commented that DOE's analysis did not consider the significance of enclosure type as it relates to efficiency, and that the NEMA MG 1 frame designations for open frame motors are often in a smaller frame series than an enclosed-frame motor of the same horsepower rating. NEMA and Baldor commented that there is generally a lower efficiency level designated for open-frame motors, and that there is no direct scaling relationship between the efficiency standards for open motors relative to enclosed frame motors in the scope of this rulemaking. (NEMA, No. 54 at p. 68; Baldor, Public Meeting Transcript, No. 60 at p. 131) Baldor recommended that DOE analyze motors of different enclosures in order to understand the difference between achievable efficiency levels in open and enclosed electric motors. (Baldor, Public Meeting Transcript, No. 60 at pp. 131–132) NEMA commented that the engineering analysis should be supported by the testing and analysis of both open and enclosed frame motors. (NEMA, No. 54 at p. 68) Finally, NEMA commented that by not selecting representative units with different enclosure types, DOE fails to meet the statutory requirement that any prescribed amended or new efficiency standards are in fact technically feasible, practical to manufacture, and have no adverse impacts on product utility or product availability. (NEMA, No. 54 at pp. 68–69)

DOE acknowledges the comments from interested parties regarding enclosure type and its selection of representative units. The final equipment class setting criterion that DOE had to consider when selecting its representative units was enclosure type. For the preliminary analysis, DOE analyzed only electric motors with totally enclosed, fan-cooled (TEFC) designs rather than open designs for all of its representative units. DOE selected TEFC motors because, as with pole configurations, DOE wanted as many design characteristics to remain constant as possible. DOE believed that such an approach would allow it to more accurately pinpoint the factors that affect efficiency. While DOE only analyzed one enclosure type, it notes that its scaling follows NEMA's efficiency tables (Table 12–11 and Table 12–12), which already map how efficiency changes with enclosure type. Finally, TEFC electric motors represented more than three times the shipment volume of open motors. DOE chose ELs that correspond to the tables of standards published in NEMA's MG 1–2011 and to efficiency bands derived from those tables, preserving the relationship between NEMA's standards for open and enclosed motors.

In the preliminary analysis, DOE stated that, given the same frame size, open motors are more efficient than enclosed motors. NEMA commented that DOE should not compare open and enclosed motors in the same frame size because NEMA MG 1 specifies larger frame sizes and a higher service factor for enclosed motors of a given rating than it does for open motors. NEMA added that TEFC motors have a fan which adds to the friction and windage losses, and even with this fan the TEFC motors can have higher efficiencies than open frame motors of the same horsepower and pole configuration. (NEMA, No. 54 at p. 41) DOE appreciates the clarification and has altered its discussion in chapter 3 of the TSD.

3. Efficiency Levels Analyzed

After selecting its representative units for each electric motor equipment class group, DOE examined the impacts on the cost of improving the efficiency of each of the representative units to evaluate the impact and assess the viability of potential energy conservation standards. As described in the technology assessment and screening analysis, there are numerous design options available for improving efficiency and each incremental improvement increases the electric motor efficiency along a continuum. The engineering analysis develops cost estimates for several efficiency levels (ELs) [53] along that continuum.

ELs are often based on: (1) Efficiencies available in the market; (2) voluntary specifications or mandatory standards that cause manufacturers to develop equipment at particular efficiency levels; and (3) the max-tech level.

Currently, there are two energy conservation standard levels that apply to various types of electric motors. In ECG 1, some motors currently must meet efficiency standards that correspond to NEMA MG 1–2011 Table 12–11 (i.e., EPACT 1992 levels [54]), others must meet efficiency standards that correspond to NEMA MG 1–2011 Table 12–12 (i.e., NEMA Premium levels), and some are not currently required to meet any energy conservation standard levels. Because DOE cannot establish energy conservation standards that are less efficient than current standards (i.e., the ''anti-backsliding'' provision at 42 U.S.C. 6295(o)(1) as applied via 42 U.S.C. 6316(a)) but ECG 1 includes both currently regulated and unregulated electric motors, DOE's analysis assumed the respective EPACT 1992 or NEMA Premium standard as the baseline for ELs 1 and 2. For ECG 1, DOE established an EL that corresponded to each of these levels, with EL 0 as the baseline (i.e., the lowest efficiency level available for unregulated motors and EPACT 1992 or NEMA Premium, as applicable, for currently regulated motors), EL 1 as equivalent to EPACT 1992 levels (or NEMA Premium, as applicable, for currently regulated motors), and EL 2 as equivalent to NEMA Premium levels. Additionally, DOE analyzed two ELs above EL 2. One of these levels was the max-tech level, denoted as EL 4 and one was an incremental level that approximated a best-in-market efficiency level (EL 3). For all equipment classes within ECG 1, EL 3 was a one ''band'' increase in NEMA nominal efficiency relative to NEMA Premium and EL 4 was a two ''band'' increase.[55] For ECG 3 and 4, DOE used the same ELs with one exception for ECG 3. Because fire pump electric motors are required to meet EPACT 1992 efficiency levels and those are the only motors in that equipment class group, EPACT 1992 levels were used as the baseline efficiency level, which means that fire pump electric motors have one fewer EL than ECGs 1 and 4 for purposes of DOE's analysis. Following the preliminary analysis, DOE adjusted one max-tech Design B representative unit level (5 hp) after receiving additional data. This allowed this unit to be based more on physical models for the NOPR analysis, thereby reducing exposure to modeling errors. Table IV.9 and Table IV.10 show the ELs for ECGs 1, 3, and 4.

TABLE IV.9—EFFICIENCY LEVELS FOR EQUIPMENT CLASS GROUPS 1 AND 4

Representative unit	EL 0 (baseline) (percent)	EL 1 (EPACT 1992) (percent)	EL 2 (NEMA premium) (percent)	EL 3 (best-in-market) * (percent)	EL 4 (max-tech) (percent)
5 hp (ECG 1 and 4)	82.5	87.5	89.5	90.2	91.0
30 hp (ECG 1 and 4)	89.5	92.4	93.6	94.1	94.5
75 hp (ECG 1 only **)	93.0	94.1	95.4	95.8	96.2

* Best-in-market represents the best or near best efficiency level at which current manufacturers are producing electric motors. Although these efficiencies represent the best-in-market values found for the representative units, but when efficiency was scaled to the remaining equipment classes, the scaled efficiency was sometimes above and sometimes below the best-in-market value for a particular rating.

** ECG 4 does not have a 75-horsepower representative unit because DOE was unable to find brake motors built with such a high horsepower rating. The maximum horsepower rating for ECG 4 is 30-horsepower.

[53] For the purposes of the NOPR analysis, the term ''efficiency level'' (EL) is equivalent to that of Candidate Standard Level (CSL) in the preliminary analysis.

[54] EPACT 1992 only established efficiency standards for motors up to and including 200 hp. Eventually, NEMA MG 1–2011 added a table, 20–A, which functioned as an extension of Table 12–11. So, although EPACT 1992 is a slight misnomer, DOE is using it to refer to those ELs that were based on Table 12–11.

[55] Because motor efficiency varies from unit to unit, even within a specific model, NEMA has established a list of standardized efficiency values that manufacturers use when labeling their motors. Each incremental step, or ''band,'' constitutes a 10 percent change in motor losses. NEMA MG 1–2011 Table 12–10 contains the list of NEMA nominal efficiencies.

TABLE IV.10—EFFICIENCY LEVELS FOR EQUIPMENT CLASS GROUP 3

Representative unit (percent)	EL 0 (EPACT 1992) (percent)	EL 1 (NEMA premium) (percent)	EL 2 (best-in-market) * (percent)	EL 3 (max-tech) (percent)
5 hp	87.5	89.5	90.2	91.0
30 hp	92.4	93.6	94.1	94.5
75 hp	94.1	95.4	95.8	96.2

For ECG 2, DOE took a similar approach in developing its ELs as it did for ECG 1, but with two primary differences. First, when DOE examined catalog data, it found that no NEMA Design C electric motors had efficiencies below EPACT 1992 levels, which is the current standard for all covered NEMA Design C electric motors. For DOE's representative units, it also found no catalog listings above the required EPACT 1992 levels. Additionally, when DOE's subject matter expert modeled NEMA Design C motors, the model would only generate designs at NEMA Premium levels and one incremental level above that while maintaining proper performance standards. Therefore, ECG 2 only contains three ELs: EPACT 1992 (EL 0), NEMA Premium (EL 1), and a max-tech level (EL 2).

These ELs differed slightly from the CSLs presented in the preliminary analysis for ECG2. In the preliminary analysis, a CSL for the 50 hp unit existed between two industry standard levels in order to provide greater resolution in selection of a standard (NEMA MG–1 Table 12–11 and Table 12–12). For the NOPR analysis, this level was removed so that the ELs analyzed would align with Tables 12–11 and 12–12. For the 5 hp rep unit, DOE also removed one preliminary analysis CSL, which was intended to represent the ''best in market'' level in the preliminary analysis. After further market research, DOE found that few Design C motors are offered above the baseline, and those that were mainly met the NEMA premium level, without going higher in efficiency. It determined that for the NOPR analysis, the previously designated ''max in market'' level was not applicable. The ELs analyzed for ECG2 in the NOPR are shown in Table IV.11.

TABLE IV.11—EFFICIENCY LEVELS FOR EQUIPMENT CLASS GROUP 2

Representative unit (percent)	EL 1 (EPACT 1992) (percent)	EL 2 (NEMA premium) (percent)	EL 3 (max-tech) (percent)
5 hp	87.5	89.5	91.0
50 hp	92.4	93.6	94.5

In response to its preliminary analysis, DOE received multiple comments regarding CSLs. NEMA and Baldor expressed confusion over the fact that the CSLs for ECG 2 do not align with the CSLs from ECG 1, and requested that DOE line up CSLs across different ECGs in an effort to avoid confusion when discussing the CSLs. (NEMA, No. 54 at p. 73; Baldor, Public Meeting Transcript, No. 60 at pp. 171, 172) DOE understands NEMA's concerns regarding the nomenclature of its ELs, however, it has maintained its approach for the NOPR analysis. DOE examines each ECG independently, and because different motor types have different baselines, the EL numbers do not always align.

NEMA also asked if the baseline CSL developed for ECG 1, which was developed based on an analysis of vertical, hollow-shaft motors, included losses related to testing those motors with thrust bearings. NEMA inquired because, at the time of its comment, DOE had not yet published the test procedure NOPR, indicating how these motor types might be tested. (NEMA, No. 54 at pp. 71–72, 77)

DOE clarifies that the vertical hollow-shaft motors purchased and used to determine the baseline efficiency level for ECG 1 contained bearings capable of horizontal operation. Therefore, DOE tested these motors in a horizontal configuration without any modifications to the bearings. Additionally, when tested, solid-shafts were welded inside the hollow-shaft to permit the motor to be attached to a dynamometer for testing. These modifications are in line with the proposals for vertical hollow shaft motors as described in DOE's electric motors test procedure NOPR. 78 FR 38456 (June 26, 2013).

During the preliminary analysis public meeting, NEMA noted that the CSL 5 software-modeled efficiency was 96.4 percent and should have been assigned a NEMA nominal efficiency level of 96.2 percent rather than 96.5. (NEMA, No. 54 at p. 80) NEMA and Baldor added that CSL 5 should not be included in any engineering analysis because of the infeasibility of cast-copper rotors, and that CSL 4 is the proper max-tech level when CSL 5 is eliminated from consideration. (NEMA, No. 54 at p. 73; Baldor, Public Meeting Transcript, No. 60 at p. 171) The Efficiency Advocates also expressed concern about some of the CSLs analyzed by DOE and questioned the viability of CSL 3. The Efficiency Advocates noted that some of the CSL 3 designs were at the very limits of critical motor performance parameters, such as locked-rotor torque and current. The Efficiency Advocates added that DOE has not tested motors that perform at the levels that would be required by CSL 3, 4, and 5. Without having done so, DOE cannot verify the predicted performance of its representative units. (NPCC, No. 56 at pp. 4, 5)

As discussed, DOE has removed EL 5 from consideration in the NOPR analysis, but it has not eliminated the use of copper-die cast rotor technology (see I.A.1). With regards to the comments from the Efficiency Advocates, DOE notes that EL 3 for ECG 1 is based on teardown data from commercially available motors, as it was for the preliminary analysis. Additionally, for the NOPR, DOE has tested a unit at EL 4 for one of its representative units. Furthermore, DOE has found many instances of electric motors being sold and marketed one or two NEMA bands of efficiency above NEMA Premium, which suggests that manufacturers have extended technological performance where they perceived market demand for higher efficiencies. In other words, DOE has seen no evidence suggesting that the absence of products on the market at any given EL implies that such products could not be developed, were there sufficient demand. DOE contends that all of the ELs analyzed in its engineering analysis are viable because equipment is currently commercially available at such levels [56] and, to the extent possible, has been included in DOE's analysis. DOE welcomes comment on the limits of technology, especially as it varies by equipment class.

Additionally, NEMA and Baldor commented on the design options analyzed for the various CSLs. NEMA and Baldor stressed that not using a common design option across all CSLs may result in a reduction of available product. (NEMA, No. 54 at pp. 3, 27, 73; Baldor, Public Meeting Transcript, No. 60 at pp. 169–171, 176–178) NEMA indicated that it is a standard practice of manufacturers to minimize the number of types of electrical steel used at a manufacturing facility and that typically a single type of electrical steel may be used for all electric motors manufactured at the facility. NEMA added that DOE should account for this situation when performing engineering analyses such that a common type of electrical steel is used for the different NEMA design types covered by a common CSL. (NEMA, No. 54 at p. 62) NEMA added that although NEMA Design C motors constitute less than 1 percent of total motor shipments, the electrical steel and die-cast rotor material used for manufacturing NEMA Design C electric motors is taken from the same inventory as used for NEMA Design B electric motors. Therefore, they contended that DOE should select the same material types for NEMA Design C motors as it does for NEMA Design B motors. (NEMA, No. 54 at p. 65, 74) Finally, NEMA stated that it did not understand why DOE used different steels and rotor conductors for CSLs 4 and 5 in some of the ECG 1 representative units but not in others. (NEMA, No. 54 at pp. 3, 72; Baldor, Public Meeting Transcript, No. 60 at p. 120)

As noted earlier, DOE has restructured its ELs for the NOPR analysis. One consequence of this restructuring is that DOE no longer mixes rotor casting technologies for a given EL. However, DOE does not limit the number of electrical steels used at a given EL to one. DOE understands that manufacturers try to limit the number of electrical steels at a given manufacturing facility, but most manufacturers have more than one manufacturing facility. Therefore, manufacturers could produce motors with multiple grades of electrical steel. Additionally, DOE believes that this approach is in line with current industry practice. For its analysis, DOE obtained multiple units for teardowns from the same manufacturer. After a steel analysis was conducted on its teardowns, DOE found that one manufacturer utilized multiple grades of steel, both across ELs within a representative unit and across representative units within an EL. Finally, DOE believes that the restructuring of the ELs should also address concerns over the technology differences between preliminary analysis ELs 4 and 5 because in the NOPR analysis there is no EL 5. DOE has updated chapter 5 of the TSD to include as pertinent design data.

During the preliminary analysis public meeting, ACEEE commented that new energy conservation levels would have to be raised by at least two NEMA bands because an increase of only one NEMA band is not statistically significant. (ACEEE, Public Meeting Transcript, No. 60 at p. 168) DOE disagrees with this assessment. Although the unit-to-unit efficiency of a specific electric motor design may vary by multiple NEMA bands of efficiency, an increase in the required efficiency level by one band would be significant. If efficiency standards are raised by one NEMA band, there is no evidence to suggest that manufacturing practices would change such that the distribution of unit-to-unit efficiencies for a given motor design would change. Therefore, if the required efficiency standard were changed by one band of efficiency, one would assume that the entire population of motors of a given design would shift by one band of efficiency as manufacturers begin to produce motors around a higher mean value.

Finally, NEMA commented that another important factor for defining CSLs is the ability for CSLs to provide efficiency values to be used in the scaling process and that it is important that the relative difference between the efficiency values for CSLs is selected such that the relativity is maintained across all of the representative units if it is to be applied by scaling to all electric motors included in an ECG. In other words, NEMA argues that CSLs must be chosen carefully to correspond with similar technologies and materials across the range of scaling (i.e., the entire equipment class) and that they should not be chosen to merely to align with NEMA's own tables and efficiency bands. (NEMA, No. 54 at p. 73) Responding to this concern, for each EL above the established NEMA Premium levels, DOE has incremented efficiency by one nominal band for all equipment classes. This equates to, roughly, a 10 percent decrease in motor losses for all equipment classes for each jump in EL.

4. Test and Teardowns

Whenever possible, DOE attempted to base its engineering analysis on actual electric motors being produced and sold in the market today. First, DOE identified electric motors in manufacturer catalogs that represented a range of efficiencies corresponding to the ELs discussed in the previous sections. Next, DOE had the electric motors shipped to a certified testing laboratory where each was tested in accordance with IEEE Standard 112 (Test Method B) to verify its nameplate-rated efficiency. After testing, DOE derived production and material costs by having a professional motor laboratory [57] disassemble and inventory the purchased electric motors. For ECG 1, DOE obtained tear-down results for all of the 5-horsepower ELs and all of the 30- and 75-horsepower ELs except the max-tech levels. For ECG 2, DOE obtained tear-down results only for the baseline EL, which corresponds to EPACT 1992 efficiency levels.

These tear-downs provided DOE with the necessary data to construct a bill of materials (BOM), which, along with a standardized cost model and markup structure, DOE could use to estimate a manufacturer selling price (MSP). DOE paired the MSP derived from the tear-down with the corresponding nameplate nominal efficiency to report the relative costs of achieving improvements in energy efficiency. DOE's estimates of material prices came from a combination of current, publicly available data, manufacturer feedback, and conversations with its subject matter experts. DOE supplemented the

[56] DOE understands that this is not true for every equipment classes covered by this rulemaking, but has not seen evidence to suggest that the absence of equipment in any particular classes is not due to lack of market demand instead of technological limitations.

[57] The Center for Electromechanics at the University of Texas at Austin, a 140,000 sq. ft. lab with 40 years of operating experience, performed the teardowns, which were overseen by Dr. Angelo Gattozzi, an electric motor expert with previous industry experience. DOE also used Advanced Energy Corporation of North Carolina to perform some of the teardowns.

findings from its tests and tear-downs through: (1) A review of data collected from manufacturers about prices, efficiencies, and other features of various models of electric motors, and (2) interviews with manufacturers about the techniques and associated costs used to improve efficiency.

As discussed earlier, DOE's engineering analysis documents the design changes and associated costs when improving electric motor efficiency from the baseline level up to a max-tech level. This includes considering improved electrical steel for the stator and rotor, interchanging aluminum and copper rotor bar material, increasing stack length, and any other applicable design options remaining after the screening analysis. As each of these design options are added, the manufacturer's cost increases and the electric motor's efficiency improves. DOE received multiple comments regarding its test and tear-down analysis.

NEMA commented that the cost for manufacturing an electric motor can increase as the efficiency level is increased even when the material and technology is not changed. It added that an increase in core length, without any change in the material used, will result in a higher cost not only due to the increase in the amount of steel, but also due to the increase in the amount of wire for the stator winding and aluminum for the rotor core. (NEMA, No. 54 at p. 74) Notwithstanding, DOE believes that it has accurately captured such changes. When each electric motor was torn down, components such as electrical steel and copper wiring were weighed. Therefore, any increase in stack length would result in increased costs associated with the increased amount of electrical steel and copper wiring.

NEMA also commented that the best known value of efficiency for a tested and torn down motor is the tested efficiency and the accuracy of this value improves as sample size increases. Because DOE only used a sample size of one, NEMA recommended that DOE should increase its sample size to something more statistically significant. (NEMA, No. 54 at p. 75) NEMA also referred to the small electric motors rulemaking and said that a sufficient sample size for testing was proven to be necessary. (NEMA, No. 54 at p. 27) NEMA also commented that Appendix A to Subpart U designates the appropriate sample size to support the conclusion that the name-plated efficiency of a motor is correctly stated. (NEMA, No. 54 at p. 79) NEMA and Baldor added that Appendix A to Subpart U requires the determination of a standard deviation from the sample, and it is not possible to determine a standard deviation when testing a sample of one motor, which was the sample size of DOE's motor testing. (NEMA, No. 54 at p. 79; Baldor, Public Meeting Transcript, No. 60 at p. 154)

DOE agrees that an increased sample size would improve the value of efficiency used in its analysis, but only if DOE were using an average full-load efficiency value, as it did for the small electric motors rulemaking engineering analysis, which did not have the benefit of NEMA-developed nominal efficiency values. For today's analysis, DOE did not use the tested efficiency value and believes that to do so would be erroneous precisely because it only tested and tore down one unit for a given representative unit and EL. Rather than using an average efficiency of a sample of multiple units that is likely to change with each additional motor tested, DOE elected to use the nameplate NEMA nominal efficiency given. DOE understands that this value, short of testing data, is the most accurate value to use to describe a statistically valid population of motors of a given design; that is, in part, why manufacturers use NEMA nominal efficiencies on their motors' nameplates.

Furthermore, when DOE conducts its tear-downs, the bill of materials generated is most representative of the tested value of efficiency, not necessarily the NEMA nominal value. However, DOE believes that the variance from unit-to-unit, in terms of materials, is likely to be insignificant because manufacturers have an incentive to produce equipment with consistent performance (i.e., characteristics other than efficiency) as possible. Changes in the tested efficiency are likely to occur because of variations in production that motor manufacturers have less control over (e.g., the quality of the electrical steel). DOE does not believe that the amount of material (in particular, electrical steel, copper wiring, and die-cast material) from unit-to-unit for a given design is likely to change significantly, if at all, because manufacturers have much greater control of those production variables. Therefore, additional tests and tear-downs are unlikely to change the MSP estimated for a given motor design and DOE believes that its sample size of one is appropriate.

In the preliminary engineering analysis, DOE replaced a tear-down result with a software model for CSL 2 of its 30-horsepower representative unit because it believed that it had inadvertently tested and torn down a motor with an efficiency equivalent to CSL 3. DOE noted that it removed the tear-down because there was conflicting efficiency information on the Web site, in the catalog, and on the physical nameplate. Subsequently, NEMA and Baldor commented that the 30-horsepower, CSL 2 motor should not have been replaced with a software-modeled motor, stating that the test result was statistically viable. (NEMA, No. 54 at pp. 76–79; Baldor, Public Meeting Transcript, No. 60 at pp. 150–155) NEMA and Baldor also asserted that DOE had placed emphasis on the use of purchased motors in its analysis only when the tested value of efficiency was less than or not significantly greater than the marked value of NEMA efficiency. (NEMA, No. 54 at p. 80; Baldor, Public Meeting Transcript, No. 60 at pp. 156, 157)

DOE understands that the test result may have been viable for either of the efficiency ratings that the manufacturer had assigned. Given the uncertainty, however, DOE elected to replace the motor. DOE did not discard the unit simply because it tested significantly above its nameplate efficiency. Rather, the motor was listed with different values of efficiency depending upon the source and when torn down, the resulting MSP was higher than the MSP for the next CSL. These facts suggested that the calculated results were erroneous because it is unlikely (based on available data) that it would be cheaper to build a more efficient motor than a less efficient one of comparable specifications. If DOE had included these data in its analysis, it would likely have resulted in a projection that even higher CSLs would be economically justified. The combination of these factors resulted in DOE eliminating that motor from the analysis. For its updated NOPR engineering analysis, DOE has tested and torn down a new 30-horsepower motor to describe CSL 2. As stated previously, DOE always prefers to base its analysis using motors purchased in the market when possible.

NEMA commented that the disproportionate variation in frame weights between the CSLs suggests that the CSLs of some representative units were not of similar construction. (NEMA, No. 54 at p. 78) When selecting motors for tear-down, DOE selected motors with increasing efficiencies. These motors may not have used the same frame material. For example, the CSL 0 for the 30-horsepower representative units was made out of cast aluminum, but CSL 1 unit used cast iron. This material change accounts for the large difference in frame weight.

During the preliminary analysis public meeting, Nidec requested clarification for the increase in stator copper weight for the 75-horsepower, ECG 1 representative unit between CSL 2 and CSL 3 since the reported slot fills were the same and the motors had similar stack lengths. (Nidec, Public Meeting Transcript, No. 60 at pp. 164, 165) After DOE's tear-down lab determined that the torn-down motors were machine-wound a precise measurement of the slot fill was not taken. Although the actual measurement of slot fill has no bearing on the estimates of the MSP, because the actual copper weights were measured and not calculated, DOE did ask its lab to provide actual measurements of slot fill on any subsequent tear-downs and has included the data in chapter 5 of the TSD.

5. Software Modeling

In the preliminary analysis, DOE worked with technical experts to develop certain CSLs, in particular, the max-tech efficiency levels for each representative unit analyzed. DOE retained an electric motors subject matter expert (SME) [58] with design experience and software, who prepared a set of designs with increasing efficiency. The SME also checked his designs against tear-down data and calibrated his software using the relevant test results. As new designs were created, DOE's SME ensured that the critical performance characteristics that define a NEMA design letter, such as locked-rotor torque, breakdown torque, pull-up torque and locked-rotor currents were maintained. For a given representative unit, DOE ensured that the modeled electric motors met the same set of torque and locked-rotor current requirements as the purchased electric motors. This was done to ensure that the utility of the baseline unit was maintained as efficiency improved. Additionally, DOE limited its modeled stack length increases based on teardown data and maximum ''C'' dimensions found in manufacturer's catalogs.[59]

In response to the preliminary analysis, Baldor and NEMA requested clarification on how DOE compared its software modeled results to the electric motors that it had tested and torn down. (NEMA, No. 54 at p. 74; Baldor, Public Meeting Transcript, No. 60 at p. 148) NEMA requested that more details regarding that comparison and the name of the software program used to be included in an updated technical support document. (NEMA, No. 54 at p. 12) Per the request of NEMA and Baldor, DOE has provided comparisons of software estimates and tested efficiencies in appendix 5C of the TSD. Additionally, the software program that DOE used for its analysis is a proprietary software program called VICA.[60]

NEMA expressed concern over efficiency standards based on the software platform DOE used and stated that DOE should build working prototypes of its software modeled motors to prove the designs work. (NEMA, No. 54 at pp. 24–25 and 74–75) Baldor reiterated this point in verbal comments and suggested that this was particularly important for CSLs with copper rotor designs given their concerns with copper rotor motors. (NEMA, No. 54 at pp. 76–77; Baldor Public Meeting Transcript, No. 60 at pp. 160, 161) During the preliminary analysis, DOE approached motor laboratories in an attempt to prototype its software models. DOE was unable to identify a laboratory that could prototype its software modeled motors in a manner that would exactly replicate the designs produced (i.e., they could not die-cast copper). Consequently, at this time, DOE has not built a prototype of its software models. However, DOE was able to procure a 5-horsepower NEMA Design B die-cast copper rotor motor with an efficiency two NEMA bands above the NEMA Premium level. Therefore, DOE elected to use this design to represent the max-tech EL for the 5-horsepower representative unit in equipment class group 1, rather than the software-modeled design used in the preliminary analysis. DOE's SME used information gained from testing and tearing down this motor to help corroborate the software modeling.

In the preliminary analysis, DOE indicated that its software modeling expert made changes to his software designs based on data collected during the motor teardowns. NEMA commented on this and asked why DOE's software modeling expert made changes to some of his designs based on teardown data. (NEMA, No. 54 at p. 75) DOE clarifies that the software program was updated using additional teardown data (e.g., more accurate dimensions and material types) to maintain as many consistencies in design as possible. For example, DOE's software modeling expert used lamination diameters measured during the teardowns as limits for the software models.

In submitted comments, NEMA noted that the NEMA nominal efficiency for the software-modeled motors was derived by selecting the value that was lower than the calculated efficiency. NEMA questioned this approach and added that assigning a value of NEMA nominal efficiency based on a calculated value of efficiency requires more knowledge than merely selecting the closest NEMA nominal value that is lower than the calculated value. (NEMA, No. 54 at p. 76) DOE notes that it selected the closest NEMA nominal efficiency that is less than or equal to the predicted efficiency of the software for multiple reasons. First, DOE wanted to maintain the use of nominal efficiency values to remain consistent with past electric motor efficiency standards. Second, DOE chose a value below its software estimate because this method would provide a more conservative approach. DOE believes its approach was appropriate given the various concerns raised with copper rotor motor technologies.

During the preliminary analysis public meeting, Regal-Beloit commented that calibration of the software-modeled motors is extremely important. Regal-Beloit added that the calibration of select models is very important due to the amount of interpolation that DOE is basing on these models. (Regal-Beloit, Public Meeting Transcript, No. 60 at pp. 159–160) Alluding to copper rotor motors, NEMA commented on DOE's software modeling, claiming that verifying the accuracy of a software program with respect to performance obtained from testing purchased motors does not verify the accuracy of the software program when it is used for a technology which has not been verified by tests. (NEMA, No. 54 at p. 76; Baldor, Public Meeting Transcript, No. 60 at pp. 160, 161) DOE appreciates these comments and, as stated, has conducted calibration of its software program using data obtained from motor teardowns. DOE has provided comparisons of software estimates and tested efficiencies for both aluminum and copper rotor motors in appendix 5C of the TSD.

NEMA commented that the preliminary TSD did not show that the software platform DOE used had been substantiated as being sufficiently accurate for motors incorporating existing and new technologies. (NEMA, No. 54 at p. 12) NEMA asserted that it is necessary to substantiate the software platform used for modeling as an

[58] Dr. Howard Jordan, Ph.D., an electric motor design expert with over 40 years of industry experience, served as DOE's subject matter expert.

[59] The ''C'' dimension of an electric motor is the length of the electric motor from the end of the shaft to the end of the opposite side's fan cover guard. Essentially, the ''C'' dimension is the overall length of an electric motor including its shaft extension.

[60] VICA stands for ''Veinott Interactive Computer Aid.''

alternate efficiency determination method (AEDM) such that the calculated efficiencies can be verified as accurate for the types of technologies included in a motor design. NEMA urged that DOE substantiate the software platform used by its SME as an AEDM. (NEMA, No. 54 at p. 76) Baldor added that DOE expects manufacturers to prototype five motors to certify a program, but DOE has not designed and built any of the motors designed in its own program. (Baldor, Public Meeting Transcript, No. 60 at p. 162) Nidec commented during the public meeting, asking if the software modeling suite DOE used has gone through the same scrutiny that manufacturers are subject to when they must submit their 25 samples to correlate their estimated computer data with actual testing data. (Nidec, Public Meeting Transcript, No. 60 at p. 147)

DOE understands the comments received regarding its software program, but maintains that substantiation of an AEDM is a concept intended for certifying compliance with energy efficiency standards. It is a tool that manufacturers use to help ensure that the equipment they manufacture comply with a Federal standard (which is the manufacturers' duty). It is not a tool for assessing whether a particular energy efficiency level under consideration by DOE satisfies the EPCA criteria. Accordingly, the use of the AEDM in the manner suggested by industry would not be relevant for the purposes of this engineering analysis, which is geared toward DOE's standards rulemaking.

NEMA also commented that to properly determine the impact of increased efficiency on motor utility, DOE must recognize the consequences of how motor performance, including parameters such as acceleration, safe stall time, overspeed, service factor, thermal performance, and in-rush current will be affected by more stringent energy conservation standards. NEMA also specifically referred to performance characteristics found in NEMA MG 1 sections 12.44, 12.45, 12.48, 12.49, 12.53, 12.54, and 12.56. (NEMA, No. 54 at pp. 5, 77) NEMA added that the narrow margin between the NEMA MG 1–2011 limits for locked-rotor current and the calculated locked-rotor current for some of the software-modeled designs in the preliminary analysis suggest that there will be problems with these motors meeting the NEMA MG 1 limits if they were prototyped. (NEMA, No. 54 at p. 77) Finally, NEMA indicated that two of the DOE software-modeled motors in the preliminary analysis, representing the 75-horsepower CSLs 4 and 5 for ECG 1, had torque ratings twice that of a U.S. Army 75-horsepower electric motor software model, and suggested that the software models used in DOE's analysis are not accurate in modeling copper rotor motor performance. (NEMA, No. 54 at p. 77)

DOE has carefully considered NEMA's comments in its updated NOPR analysis. As noted, DOE has eliminated designs from its preliminary analysis because of concerns regarding the feasibility of those efficiency levels. Regarding the additional performance parameters, DOE agrees that these characteristics must be maintained when improving an electric motor's efficiency. However, the performance parameters DOE believed to present the largest risk of rendering a motor noncompliant with NEMA MG 1–2011 standards were those related to NEMA design letter, which were adhered to in DOE's modeling efforts. Based on comparisons of motor teardowns and software estimates, DOE has no reason at this time to believe that its modeled designs would violate the additional performance parameters mentioned by NEMA.

DOE believes that its subject matter expert, who has been designing electric motors for several decades, is well qualified to understand the design tradeoffs that must be considered. Although the SME's primary task was to design a more efficient motor using various technologies, it was of critical importance that the designs be feasible. Even though DOE was unable to prototype its modeled designs, DOE has conducted comparisons of software estimates and tested efficiencies for both aluminum and copper rotor motors and believes this corroborates the modeled designs. Based on this work and its total analysis, which included input from its SME, DOE believes it developed a sufficiently robust set of technically feasible efficiency levels for its engineering analysis.

NEMA asked how DOE intended to take into consideration motor utility as motor size increases. (NEMA, No. 54 at pp. 23, 24) During the preliminary analysis public meeting, Baldor asked if the higher CSLs would fit into existing frame sizes, or if those motors would have to be redesigned to allow for the increased stack length. Baldor added that if the frame size increases, the motor may no longer fit current applications, which would cause additional burden for end-users or original equipment manufacturers. (Baldor, Public Meeting Transcript, No. 60 at pp. 164, 245) Baldor added that IEC frame motors are more constrained in terms of size and space than NEMA frame motors, and it is more difficult to increase the efficiency on IEC frame motors without changing frame size designations, which would lead to space constraint issues. (Baldor and ABB, Public Meeting Transcript, No. 60 at pp. 245, 246) Flolo Corporation also commented on motor length during the public meeting, insisting that it is important that DOE recognize the difference in ''C'' dimension that any new energy conservation standard would mandate, as increasing the ''C'' dimension will make it difficult for a motor to fit into its originally intended machine. (Flolo, Public Meeting Transcript, No. 60 at pp. 243, 244) The Efficiency Advocates also commented on motor length, indicating that DOE should be aware of absolute motor length limits when considering increased stack length, and that these changes could greatly increase the installed cost of many of the higher CSLs, impacting field and original equipment manufacturer (OEM) installation. (Advocates, No. 56 at p. 4)

In the preliminary TSD, DOE stipulated that any increase in stack length would fit into the existing frame designation for that particular motor rating. DOE noted that the frame designation does not limit frame length, but rather frame diameter. DOE also understands that manufacturers have fixed-length frames that they use when manufacturing motors. In addition to generating per unit costs associated with redesigning motors with new frames at all ELs above the NEMA Premium levels (see IV.C.6), DOE sought to maintain motor length by limiting how much it would modify stack dimensions to improve efficiency. First, the software models created by DOE used lamination diameters observed during teardowns, which ensured that the software-modeled designs would fit into existing frame designations. However, for some designs DOE increased the number of laminations (i.e., length of the stack of laminations, or stack length) beyond the stack lengths observed during the motor teardowns in order to achieve the desired efficiency gains.

DOE limited the amount by which it would increase the stack length of its software-modeled electric motors in order to preserve the motor's utility. The maximum stack lengths used in the software-modeled ELs were determined by first analyzing the stack lengths and ''C'' dimensions of torn-down electric motors. Then, DOE analyzed the ''C'' dimensions of various electric motors in the marketplace conforming to the same design constraints as the representative units (same horsepower rating, NEMA frame size, enclosure type, and pole configuration). For each representative unit, DOE found the largest ''C'' dimension currently available on the marketplace and estimated a maximum stack length based on the stack length to ''C'' dimension ratios of motors it tore down. The resulting product was the value that DOE chose to use as the maximum stack length considered in its software modeled designs, although DOE notes that it did not always model a motor with that maximum stack length. In most instances, the SME was able to achieve the desired improvement in efficiency with a stack length shorter than DOE's estimated maximum. Table IV.12 shows the estimated maximum stack length, the maximum stack length found during tear-downs, and the maximum stack length modeled for a given representative unit. DOE welcomes additional comments on software modeling in general, and on specific data that could be used to calibrate its software designs.

TABLE IV.12—MAXIMUM STACK LENGTH DATA

Representative unit	Estimated maximum stack length	Maximum stack length of a torn down motor	Maximum stack length modeled
30 Horsepower Design B	8.87 in.	8.02 in. (EL 2)	7.00 in.
75 Horsepower Design B	13.06 in.	11.33 in. (EL 3)	12.00 in.
5 Horsepower Design C	5.80 in.	4.75 in. (EL 0)	5.32 in.
50 Horsepower Design C	9.55 in.	8.67 in. (EL 0)	9.55 in.

6. Cost Model

When developing manufacturer selling prices (MSPs) for the motor designs obtained from DOE's tear-downs and software models, DOE used a consistent approach to generate a more accurate approximation of the costs necessary to improve electric motor efficiency. DOE derived the manufacturer's selling price for each design in the engineering analysis by considering the full range of production and non-production costs. The full production cost is a combination of direct labor, direct materials, and overhead. The overhead contributing to full production cost includes indirect labor, indirect material, maintenance, depreciation, taxes, and insurance related to company assets. Non-production cost includes the cost of selling, general and administrative items (market research, advertising, sales representatives, logistics), research and development (R&D), interest payments, warranty and risk provisions, shipping, and profit factor. Because profit factor is included in the non-production cost, the sum of production and non-production costs is an estimate of the MSP. DOE utilized various markups to arrive at the total cost for each component of the electric motor and these markups are detailed in chapter 5 of the TSD.

a. Copper Pricing

DOE conducted the engineering analysis using material prices based on manufacturer feedback, industry experts, and publicly available data. In the preliminary analysis, most material prices were based on 2011 prices, with the exception of cast copper and copper wire pricing, which were based on a five-year (2007–2011) average price.

DOE received comments regarding its copper price development. NPCC supported DOE's decision to use a five-year price average for copper materials and suggested that this method should be used whenever a commodity price shows a pattern of irregular spikes or valleys. (Advocates, No. 56 at p. 4) Conversely, the Industrial Energy Consumers of America (IECA) stated that material costs for high efficiency motors are very volatile and cannot be reliably projected from a simple five-year average, as DOE did with copper prices during the preliminary analysis. IECA added that as a result of using a five-year average, the high efficiency motor material costs may be highly underestimated in DOE's engineering analysis, and IECA suggested that a range of material costs rather than averages could better inform a range of life-cycle costs and payback periods for each CSL. (IECA, No. 52 at p. 3)

Based on these comments, DOE has slightly modified its approach. First, DOE added updated data for 2012 pricing. Second, rather than a five-year average, DOE changed to a three-year average price for copper materials. DOE made this modification based on feedback received during manufacturer interviews. By reducing to a three-year average, DOE eliminated data from 2008 and 2009, which manufacturers believed were unrepresentative data points due to the recession. Data from those two years had the effect of depressing the five-year average calculated.

b. Labor Rate and Non-Production Markup

In the preliminary analysis, DOE looked at the percentage of electric motors imported into the U.S. and the percentage of electric motors built domestically and based the balance of foreign and domestic labor rates on these percentages. During the preliminary analysis public meeting, Nidec commented that the labor rate DOE used in its analysis seems high if that number is weighted towards offshore labor. Nidec also agreed with DOE's smaller markup on the lower-horsepower motors, but commented that the overall markups DOE used seem to be high. (Nidec, Public Meeting Transcript, No. 60 at p. 184) WEG added to these comments, indicating that they believed DOE was adequately addressing the cost structure variations among the different motor manufacturers. Additionally, WEG believed that basing a labor rate on both foreign and domestic labor rates increases accuracy of the analysis, but warned that DOE should be careful not encourage production moving outside the United States. (WEG, Public Meeting Transcript, No. 60 at pp. 184–186)

At this time, DOE has elected to keep the same labor rates and markups as were used in the preliminary analysis. DOE is basing this decision on additional feedback received during interviews with manufacturers and the absence of any alternative labor rate or markups to apply.

Finally, DOE is aware of potential cost increases caused by increased slot fill, including the transition to hand-wound stators in motors requiring higher slot fills. In the preliminary analysis, DOE assigned a higher labor hour to any tear-down motor which it determined to be hand-wound. NEMA commented that DOE did not assign a hand-wound labor-hour assumption to any of the tear-down motors, and requested clarification about whether there were instances of hand winding in these motors. (NEMA, No. 54 at p. 23) DOE found that none of the tear-down motors were hand-wound, and therefore no hand-winding labor-hour amounts were assigned. This has been clarified in the NOPR analysis. Additionally, DOE has assumed that all of its max-tech software models require hand-winding, which is reflected in its increased labor time assumptions for those motors. For additional details please see chapter 5 of the TSD.

In response to DOE's request for comment on the possibility of higher labor costs for lower-volume electric motors, NEMA indicated that plants with few manufacturing setup changes, because they may focus on standard motor designs with no special motors, have the ability to produce more motors per employee, and that this is the case with many offshore companies that build designs for import to the U.S. (NEMA, No. 54 at pp. 27, 28). For other companies that cater to OEMs that require special designs and small lot production, setup changes eat into the capacity of these plants, particularly in the 56/140T through 250T frame series where there is high volume. A plant where the lot (i.e., batch) size per order is smaller has less impact from setup.

DOE acknowledges that lower-volume products will often realize higher per unit costs, and believes this reality is common to most or all manufacturing processes in general. Because DOE's analysis focuses on the differential impacts on cost due to standards, and because DOE has no evidence to suggest a significant market shift to lower production volume in a post-standards scenario, DOE expects that the relative mix of high- and low-volume production would be preserved. Indeed, because DOE is proposing to expand scope of coverage and bring many previously-excluded motor types to NEMA Premium levels, DOE sees the possibility that standardization may increase and average production volume may, in fact, rise.[61] DOE welcomes additional comment on how standards may cause average production run volume to rise or fall, and how labor costs may vary as a result.

c. Catalog Prices

NEMA also requested that DOE publish the purchase price for its torn down motors, so that they could be compared to the MSPs DOE derived from its motor tear-downs. (NEMA, No. 54 at p. 27; Baldor, Public Meeting Transcript, No. 60 at pp. 181, 182) At this time, DOE is electing not to include the purchase price for its torn down motors. DOE believes that such information is not relevant and could lead to erroneous conclusions. Some of the purchased motors were more expensive to purchase based on certain features that do not affect efficiency, which could skew the price curves incorrectly and indicate incorrect trends. For these reasons, in the engineering analysis, DOE develops its own cost model so that a consistent cost structure can be applied to similar equipment. The details of this model are available in appendix 5A. Because DOE purchased electric motors that were built by different manufacturers and sold by different distributors, who all have different costs structures, DOE does not believe that such a comparison is a meaningful evaluation.

d. Product Development Cost

In response to the preliminary analysis, NEMA commented that DOE presumes that the incremental cost between motors of different designs and different technologies is based solely on the difference in material costs and markups. NEMA also commented that there is a higher cost of manufacturing a die-cast copper rotor compared to an aluminum die-cast rotor motor that is not captured in material costs. (NEMA, No. 54 at p. 12, 74) During the preliminary analysis public meeting, ACEEE commented that the Motor Coalition has concerns about CSL 3 for ECG 1, stating that DOE's analysis may not have captured the full cost of an industry-transition to that efficiency level. (ACEEE, Public Meeting Transcript, No. 60 at p. 20)

DOE has made some additions to its cost model for the NOPR analysis based on NEMA's comments. However, DOE clarifies that its cost model for the preliminary analysis did include an incremental markup used to account for higher production costs associated with manufacturing copper die-cast rotors. Although DOE used this incremental markup in the preliminary analysis, after conducting manufacturer interviews for the NOPR analysis, it believed that additional costs were warranted for the examined ELs that exceeded the NEMA Premium level. NEMA commented that the manufacturer production costs (MPCs) and subsequent LCCs must take into account the large additional conversion costs, since manufacturers would likely attempt to recover the costs of meeting a higher efficiency standard. (NEMA, No. 54 at p. 4) Therefore, DOE developed a per-unit adder[62] for the MPCs intended to capture one-time increased product development and capital conversion costs that would likely result if an efficiency level above NEMA Premium were established.

DOE's per-unit adder reflects the additional cost passed along to the consumer by manufacturers attempting to recover the costs incurred from having to redevelop their equipment lines as a result of higher energy conservation standards. The conversion costs incurred by manufacturers include capital investment (e.g., new tooling and machinery), equipment development (e.g., reengineering each motor design offered), plus testing and compliance certification costs.

The conversion cost adder was only applied to ELs above NEMA Premium based on manufacturer feedback. Most manufacturers now offer NEMA Premium motors for a significant portion of their equipment lines as a result of EISA 2007, which required manufacturers to meet this level. Many manufacturers also offer certain ratings with efficiency levels higher than NEMA Premium. However, DOE is not aware of any manufacturer with a complete line of motors above NEMA Premium. Consequently, DOE believes that energy conservation standards above NEMA Premium would result in manufacturers incurring significant conversion costs to bring offerings of electric motors up to the higher standard.

DOE developed the various conversion costs from data collected during manufacturer interviews that were conducted for the Manufacturer Impact Analysis (MIA). For more information on the MIA, see TSD chapter 12. DOE used the manufacturer-supplied data to estimate industry-wide capital conversion costs and product conversion costs for each EL above NEMA Premium. DOE then assumed that manufacturers would mark up their motors to recover the total conversion costs over a seven year period. By dividing industry-wide conversion costs by seven years of expected industry-

[61] Labor costs may rise starkly at max-tech levels, where hand-winding is employed in order to maximize slot fill. DOE's engineering analysis reflects this fact.

[62] The ''per-unit adder'' discussed in this section refers to a fixed adder for each motor that varies based on horsepower and NEMA design letter. Each representative unit has their own unique ''per-unit adder'' that is fixed for the analysis.

wide revenue, DOE obtained a percentage estimate of how much each motor would be marked up by manufacturers. The conversion costs as a percentage of 7-year revenue that DOE derived for each NEMA band above NEMA premium are shown below. Details on these calculations are shown in Chapter 5 of the TSD.

TABLE IV.13—PRODUCT CONVERSION COSTS AS A PERCENTAGE OF 7-YEAR REVENUE

NEMA bands above NEMA premium	Conversion costs as a percentage of 7-year revenue (percent)
1	4.1
2	6.5

The percentage markup was then applied to the full production cost (direct material + direct labor + overhead) at the NEMA Premium levels to derive the per unit adder for levels above NEMA Premium (see Table IV.14).

TABLE IV.14—PRODUCT CONVERSION COSTS FOR EFFICIENCY LEVELS ABOVE NEMA PREMIUM

Representative unit	Per unit adder for 1 band above NEMA premium	Per unit adder for 2 bands above NEMA premium
5 HP, Design B	$11.06	$17.36
30 HP, Design B	32.89	1.61
75 HP, Design B	66.18	103.86
5 HP, Design C	10.68	16.75
50 HP, Design C	60.59	95.08

7. Engineering Analysis Results

The results of the engineering analysis are reported as cost versus efficiency data in the form of MSP (in dollars) versus nominal full-load efficiency (in percentage). These data form the basis for subsequent analyses in today's NOPR. Table IV.15 through Table IV.19 show the results of DOE's updated NOPR engineering analysis.

Results for Equipment Class Group 1 (NEMA Design A and B Electric Motors)

TABLE IV.15—MANUFACTURER SELLING PRICE AND EFFICIENCY FOR 5-HORSEPOWER REPRESENTATIVE UNIT

Efficiency level	Efficiency (%)	Manufacturer selling price ($)
EL 0 (Baseline)	82.5	330
EL 1 (EPACT 1992)	87.5	341
EL 2 (NEMA Premium)	89.5	367
EL 3 (Best-in-Market)	90.2	402
EL 4 (Max-Tech)	91.0	670

TABLE IV.16—MANUFACTURER SELLING PRICE AND EFFICIENCY FOR 30-HORSEPOWER REPRESENTATIVE UNIT

Efficiency level	Efficiency (%)	Manufacturer selling price ($)
EL 0 (Baseline)	89.5	848
EL 1 (EPACT 1992)	92.4	1,085
EL 2 (NEMA Premium)	93.6	1,156
EL 3 (Best-in-Market)	94.1	1,295
EL 4 (Max-Tech)	94.5	2,056

TABLE IV.17—MANUFACTURER SELLING PRICE AND EFFICIENCY FOR 75-HORSEPOWER REPRESENTATIVE UNIT

Efficiency level	Efficiency (%)	Manufacturer selling price ($)
EL 0 (Baseline)	93.0	1,891
EL 1 (EPACT 1992)	94.1	2,048
EL 2 (NEMA Premium)	95.4	2,327
EL 3 (Best-in-Market)	95.8	2,776
EL 4 (Max-Tech)	96.2	3,620

Results for Equipment Class Group 2 (NEMA Design C Electric Motors)

TABLE IV.18—MANUFACTURER SELLING PRICE AND EFFICIENCY FOR 5-HORSEPOWER REPRESENTATIVE UNIT

Efficiency level	Efficiency (%)	Manufacturer selling price ($)
EL 0 (Baseline/EPACT 1992)	87.5	331
EL 1 (NEMA Premium)	89.5	355
EL 2 (Max-Tech)	91.0	621

TABLE IV.19—MANUFACTURER SELLING PRICE AND EFFICIENCY FOR 50-HORSEPOWER REPRESENTATIVE UNIT

Efficiency level	Efficiency (%)	Manufacturer selling price ($)
EL 0 (Baseline/EPACT 1992)	93.0	1,537
EL 1 (NEMA Premium)	94.5	2,130
EL 2 (Max-Tech)	95.0	2,586

Results for Equipment Class Group 3 (Fire Pump Electric Motors)

TABLE IV.20—MANUFACTURER SELLING PRICE AND EFFICIENCY FOR 5-HORSEPOWER REPRESENTATIVE UNIT

Efficiency level	Efficiency (%)	Manufacturing selling price ($)
EL 0 (Baseline/EPACT 1992)	87.5	341
EL 1 (NEMA Premium)	89.5	367
EL 2 (Best-in-Market)	90.2	402
EL 3 (Max-Tech)	91.0	670

TABLE IV.21—MANUFACTURER SELLING PRICE AND EFFICIENCY FOR 30-HORSEPOWER REPRESENTATIVE UNIT

Efficiency level	Efficiency (%)	Manufacturer selling price ($)
EL 0 (Baseline/EPACT 1992)	92.4	1,085
EL 1 (NEMA Premium)	93.6	1,156
EL 2 (Best-in-Market)	94.1	1,295
EL 3 (Max-Tech)	94.5	2,056

TABLE IV.22—MANUFACTURER SELLING PRICE AND EFFICIENCY FOR 75-HORSEPOWER REPRESENTATIVE UNIT

Efficiency level	Efficiency (%)	Manufacturer selling price ($)
EL 0 (Baseline/EPACT 1992)	94.1	2,048
EL 1 (NEMA Premium)	95.4	2,327
EL 2 (Best-in-Market)	95.8	2,776
EL 3 (Max-Tech)	96.2	3,620

Results for Equipment Class Group 4 (Brake Electric Motors)

TABLE IV.23—MANUFACTURER SELLING PRICE AND EFFICIENCY FOR 5-HORSEPOWER REPRESENTATIVE UNIT

Efficiency level	Efficiency (%)	Manufacturer selling price ($)
EL 0 (Baseline)	82.5	330
EL 1 (EPACT 1992)	87.5	341
EL 2 (NEMA Premium)	89.5	367
EL 3 (Best-in-Market)	90.2	402
EL 4 (Max-Tech)	91.0	670

TABLE IV.24—MANUFACTURER SELLING PRICE AND EFFICIENCY FOR 30-HORSEPOWER REPRESENTATIVE UNIT

Efficiency level	Efficiency (%)	Manufacturer selling price ($)
EL 0 (Baseline)	89.5	848
EL 1 (EPACT 1992)	92.4	1,085
EL 2 (NEMA Premium)	93.6	1,156
EL 3 (Best-in-Market)	94.1	1,295
EL 4 (Max-Tech)	94.5	2,056

8. Scaling Methodology

Once DOE has identified cost-efficiency relationships for its representative units, it must appropriately scale the efficiencies analyzed for its representative units to those equipment classes not directly analyzed. 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, between DOE's four ECGs, there are 580 combinations of horsepower rating, pole configuration, and enclosure. Within these combinations there are a large number of standardized frame number series. Given the sizable number of frame number series and equipment classes, DOE cannot feasibly analyze all of these variants, hence, the need for scaling. Scaling across horsepower ratings, pole configurations, enclosures, and frame number series is a necessity. For the preliminary analysis, DOE considered two methods to scaling, one that develops a set of power law equations based on the relationships found in the EPACT 1992 and NEMA Premium tables of efficiency in NEMA Standard Publication MG 1, and one based on the incremental improvement of motor losses. As discussed in the preliminary analysis, DOE did not find a large discrepancy between the results of the two approaches and, therefore, used the simpler, incremental improvement of motor losses approach in its NOPR analysis.

As discussed in IV.C.3, some of the ELs analyzed by DOE were based on existing efficiency standards (i.e., EPACT 1992 and NEMA Premium). Additionally, the baseline EL is based on the lowest efficiency levels found for each horsepower rating, pole configuration, and enclosure type observed in motor catalog data. Therefore, DOE only required the use of scaling when developing the two ELs above NEMA Premium (only one EL above NEMA Premium for ECG 2).

For the higher ELs in ECG 1, DOE's scaling approach relies on NEMA MG 1–2011 Table 12–10 of nominal efficiencies and the relative improvement in motor losses of the representative units. As has been discussed, each incremental improvement in NEMA nominal efficiency (or NEMA band) corresponds to roughly a 10 percent reduction in motor losses. After ELs 3 and 4 were developed for each representative unit, DOE applied the same reduction in motor losses (or the same number of NEMA band improvements) to various segments of the market based on its representative units. DOE assigned a segment of the electric motors market, based on horsepower ratings, to each representative unit analyzed. DOE's assignments of these segments of the markets were in part based on the standardized NEMA frame number series that NEMA MG 1–2011 assigns to horsepower and pole combinations. In the end, EL 3 corresponded to a one band improvement relative to NEMA Premium and EL 4 corresponded to a two-band improvement relative to NEMA Premium. In response to the preliminary analysis, DOE received multiple comments regarding scaling.

NEMA commented that DOE states that scaling is necessary for the national impacts analysis, but NEMA contends that the foremost reason for the scaling is that the scaling is used to establish the values of any amended or new efficiency standards. (NEMA, No. 54 at p. 68) NEMA also expressed its belief that the scaling method used in the preliminary analysis does not adequately take into consideration numbers of poles, stack length, and frame enclosures and that scaling based on changes in efficiency for lower horsepower motor models, as interpreted by software, does not accurately reflect what is achievable for higher horsepower ratings. (NEMA, No. 54 at p. 5)

During the preliminary analysis public meeting, Baldor commented that because some energy conservation levels could not be reached without using a different technology option, at least 30 percent of the ratings in an equipment classes could not achieve energy conservation levels above CSL 2. Because of this, a scaling method based on any particular set of technology is not scalable across all equipment classes. Baldor suggested that DOE could use software modeling to check some of the motor configurations not directly analyzed. (Baldor, Public Meeting Transcript, No. 60 at pp. 196, 197, 200)

Nidec commented during the public meeting that scaling has too many variables, and that manufacturers do not use scaling because it is not possible. (Nidec, Public Meeting Transcript, No. 60 at pp. 198–199) ACEEE added that there is no underlying fundamental physical theory associated with the efficiencies listed in NEMA MG 1–2011 Table 12–11 or Table 12–12. (ACEEE, Public Meeting Transcript, No. 60 at pp. 198–199)

DOE appreciates the comments received regarding scaling; however, it maintains that scaling is a tool necessary to analyze the potential effects of energy conservation standards above NEMA Premium levels. As stated earlier, DOE is evaluating energy conservation standards for 580 equipment classes. DOE acknowledges that analyzing every one of these classes individually is not feasible, which requires DOE to choose representative units on which to base its analysis. DOE agrees with Baldor that the primary reason for scaling is to establish efficiency levels for any potential new or amended standards for electric motors.

However, DOE notes that its analysis neither assumes nor requires manufacturers to use identical technology for all motor types and horsepower ratings. In other words, although DOE may choose a certain set of technologies to estimate cost behavior across efficiency, DOE's standards are technology-neutral and permit manufacturers design flexibility. DOE clarifies that the national impacts analysis is one of the primary ways in which DOE analyses those potential efficiency levels and determines if they would be economically justified. As DOE has stated, it is also important that the levels be technically feasible. In order to maintain technical feasibility, DOE has maintained the scaling approach that it developed for the preliminary analysis. DOE believes that this approach, which is as conservative as possible while maintaining the use of NEMA nominal efficiencies, accomplishes that. For each incremental EL above the NEMA Premium level, DOE has incremented possible efficiency levels by just one band of efficiency. Through the use of this conservative approach to scaling, DOE believes that it has helped conserve the technological feasibility of each of its ELs to the greatest extent practicable.

D. Markups Analysis

The markups analysis develops appropriate markups in the distribution chain to convert the estimates of manufacturer selling price derived in the engineering analysis to customer prices. (''Customer'' refers to purchasers of the equipment being regulated). In the preliminary analysis, DOE determined the distribution channels for electric motors, their shares of the market, and the markups associated with the main parties in the distribution chain, distributors and contractors. For the NOPR, DOE retained these distribution channels.

DOE developed average distributor and contractor markups by examining the contractor cost estimates provided by RS Means Electrical Cost Data 2013.[63] DOE calculates baseline and overall incremental markups based on the equipment markups at each step in the distribution chain. The incremental markup relates the change in the manufacturer sales price of higher efficiency models (the incremental cost increase) to the change in the customer price. Chapter 6 of the NOPR TSD addresses estimating markups.

E. Energy Use Analysis

The energy use analysis provides estimates of the annual energy consumption of commercial and industrial electric motors at the considered efficiency levels. DOE uses these values in the LCC and PBP analyses and in the NIA. DOE developed energy consumption estimates for all equipment analyzed in the engineering analysis.

The annual energy consumption of an electric motor that has a given nominal full-load efficiency depends on the electric motor's sector (industry, agriculture, or commercial) and application (compressor, fans, pumps, material handling, fire pumps, and others), which in turn determine the electric motor's annual operating hours and load.

To calculate the annual kilowatt-hours (kWh) consumed at each efficiency level in each equipment class, DOE used the nominal efficiencies at various loads from the engineering analysis, along with estimates of operating hours and electric motor load for electric motors in various sectors and applications.

In the preliminary analysis, DOE used statistical information on annual electric motor operating hours and load derived from a database of more than 15,000 individual motor field assessments obtained through the Washington State University and the New York State Energy Research and Development Authority to determine the variation in field energy use in the industrial sector. For the agricultural and the commercial sector, DOE relied on data found in the literature.

As part of its NOPR analysis, for the industrial sector, DOE re-examined its initial usage profiles and recalculated motor distribution across applications, operating hours, and load information based on additional motor field data compiled by the Industrial Assessment Center at the University of Oregon, which includes over 20,000 individual motor records. For the agricultural sector, DOE revised its average annual operating hours assumptions based on additional data found in the literature. No changes were made to the commercial sector average annual operating hours.

Chapter 7 of the NOPR TSD describes the energy use analysis.

1. Comments on Operating Hours

Several interested parties commented on the annual operating hours assumptions. NEMA and UL commented that fire pumps typically operate when being tested on a monthly basis and that the annual operating-hour assumption for fire pump electric motors in the industrial sector seemed high but did not provide data to support their comment. NEMA agreed with the fire pump electric motor annual operating-hour assumptions in the commercial and agricultural sectors. (NEMA, No. 54 at p. 83) (UL, No. 46 at p. 1)

For the NOPR, DOE reviewed the field data for fire pump electric motors used in the preliminary analysis and noticed some values were associated with motors driving jockey pumps, which are pressure maintenance pumps used to maintain pressure in fire sprinkler systems. After filtering out the motors driving jockey pumps, DOE derived an average value of annual operating hours similar to the fire pump electric motor annual operating hours for the commercial and agricultural sectors. Therefore, DOE revised its fire pumps operating hour assumption accordingly.

NEMA submitted data regarding annual operating hour assumptions in the industrial sector based on its expert knowledge. These assumptions were lower than those used in the preliminary analysis. (NEMA, No. 54 at p. 10)

As previously mentioned, DOE revised the average operating hours associated with applications in the industrial sector (compressor, fans, pump, material handling, and others) based on additional individual motor nameplate and field data compiled by the Industrial Assessment Center at the University of Oregon.[64] The revised average operating hour values are generally lower than the estimates from the preliminary analysis and differ from what NEMA provided. DOE could not verify the estimates provided by NEMA and it is not clear that these estimates represent an accurate picture of the entire industrial sector. In contrast, the average operating hours by motor application that DOE used in the NOPR were based on an analysis of annual operating hours for over 35,000 individual motors. DOE notes that it analyzed a sensitivity case that reflects the NEMA estimates.

IECA commented that the database of plant assessments is based on surveys conducted between 2005 and 2011 and there is no explanation of the effects of the recession on these surveys. (IECA, No. 52 at p. 2) DOE could not estimate the impact of the recession on the average operating hour values derived from the database of field assessment from the Washington State University and the New York State Energy Research and Development Authority, as the year of the assessment was not specified for all of the entries. The additional data from the Industrial Assessment Center cover a longer time period (1987–2007). Thus, DOE believes that its estimates of operating hours are not unduly affected by lower industrial activity during the recession.

[63] RS Means (2013), Electrical Cost Data, 36th Annual Edition, Kingston, MA.

[64] Strategic Energy Group (January, 2008), Northwest Industrial Motor Database Summary from Regional Technical Forum. *http://rtf.nwcouncil.org/subcommittees/osumotor/Default.htm.* This database provides information on motors collected by the Industrial Assessment Center (IAC) at Oregon State University (OSU). The database includes more than 22,000 records, each with detailed motor application and field usage data.

2. Comments on Other Issues

In response to DOE's energy use discussion from the preliminary analysis, NEMA commented that NEMA Design C motors are not typically found in pump applications. (NEMA, No. 54 at p. 83) For NEMA Design C motors, DOE re-examined its distribution by application and agrees with NEMA that NEMA Design C motors are not typically found in pump applications. These motors are characterized by high torque and generally found in compressors and other applications such as conveyors. Consistent with this review, DOE adjusted its analyses.

NEMA commented that the curve fit for the polynomial equations modeling the load versus losses relationships for NEMA Design B motors did not seem to represent the test data accurately. (NEMA, No. 54 at p. 81)

For each representative unit, DOE based its energy use calculation on nominal values of efficiency. DOE obtained data on part load losses from test data developed in the engineering analysis and fitted these data to derive load versus losses relationships in the form of a third degree polynomial equation. The representative units showed tested efficiencies which were not equal to the nominal efficiencies and DOE adjusted the coefficients of the polynomial equations to match the full load losses expected at nominal efficiency. The adjusted equation, therefore, calculates losses for a motor with full load efficiency equal to the full load nominal efficiency. For the NOPR, DOE followed the same approach and revised the polynomial equations to reflect the NOPR engineering outputs.

NEMA commented that the installation of a more efficient motor in variable torque applications could lead to less energy savings than anticipated. Because a more efficient motor usually has less slip [65] than a less efficient one does, this attribute can result in a higher operating speed and a potential overloading of the motor. NEMA recommended that DOE include the consequence of a more efficient motor operating at an increased speed in any determination of energy savings. (NEMA, No. 54 at p. 28)

DOE acknowledges that the arithmetic cubic relation between speed and power requirement in many variable torque applications can affect the benefits gained by using efficient electric motors, which have a lower slip. DOE agrees that it is possible to quantify this impact for one individual motor. However, DOE was not able to extend this analysis to the national level. DOE does not have robust data related to the overall share of motors that would be negatively impacted by higher speeds in order to incorporate this effect in the main analysis. Further, in the engineering analysis, DOE could not extend the synchronous speed information from the representative units to the full range of electric motor configurations. Instead, DOE developed assumptions [66] and estimated the effects of higher operating speeds as a sensitivity analysis in the LCC spreadsheet. For the representative units analyzed in the LCC analysis, the LCC spreadsheet allows one to consider this effect as a sensitivity analysis according to a scenario described in appendix 7–A of the NOPR TSD.

IECA commented that estimates of regional shares of motors should be based on current inventories of motors rather than sector-specific indicators and that the data from the 2006 Manufacturer Energy Consumption Survey (MECS) is outdated. (IECA, No. 52 at p. 2) DOE did not find any information regarding motor inventory and instead used indirect indicators to derive motor distribution. For the NOPR, DOE updated its regional shares of motors based on industrial electricity consumption by region from *AEO 2013*.

F. Life-Cycle Cost and Payback Period Analysis

For each representative unit analyzed in the engineering analysis, DOE conducts LCC and PBP analyses to evaluate the economic impacts on individual customers of potential energy conservation standards for electric motors. The LCC is the total customer expense over the life of the motor, consisting of equipment and installation costs plus operating costs over the lifetime of the equipment (expenses for energy use, maintenance and repair). DOE discounts future operating costs to the time of purchase using customer discount rates. The PBP is the estimated amount of time (in years) it takes customers to recover the increased total installed cost (including equipment and installation costs) of a more efficient type of equipment through lower operating costs. DOE calculates the PBP by dividing the change in total installed cost (normally higher) due to a standard by the change in annual operating cost (normally lower) which results from the standard.

For any given efficiency level, DOE measures the PBP and the change in LCC relative to an estimate of the base-case efficiency levels. The base-case estimate reflects the market in the absence of new or amended energy conservation standards, including the market for equipment that exceeds the current energy conservation standards.

For each representative unit, DOE calculated the LCC and PBP for a distribution of individual electric motors across a range of operating conditions. DOE used Monte Carlo simulations to model the distributions of inputs. The Monte Carlo process statistically captures input variability and distribution without testing all possible input combinations. Therefore, while some atypical situations may not be captured in the analysis, DOE believes the analysis captures an adequate range of situations in which electric motors operate.

The following sections contain brief discussions of comments on the inputs and key assumptions of DOE's LCC and PBP analysis and explain how DOE took these comments into consideration.

1. Equipment Costs

In the LCC and PBP analysis, the equipment costs faced by electric motor purchasers are derived from the MSPs estimated in the engineering analysis and the overall markups estimated in the markups analysis.

To forecast a price trend for the preliminary analysis, DOE derived an inflation-adjusted index of the producer price index (PPI) for integral horsepower motors and generators manufacturing from 1969 to 2011. These data show a long-term decline from 1985 to 2003, and then a steep increase since then. DOE also examined a forecast based on the ''chained price index—industrial equipment'' that was forecasted for *AEO2012* out to 2040. This index is the most disaggregated category that includes electric motors. These data show a short-term increase from 2011 to 2015, and then a steep decrease since then. DOE believes that there is considerable uncertainty as to whether the recent trend has peaked, and would be followed by a return to the previous long-term declining trend, or whether the recent trend represents the beginning of a long-term rising trend due to global demand for electric motors and rising commodity costs for key motor components. Given the uncertainty, DOE chose to use constant

[65] The slip is the difference between the synchronous speed of the magnetic field (as defined by the number of poles), and the actual rotating speed of the motor shaft.

[66] DOE assumed that 60 percent of pumps, fans and compressor applications are variable torque applications. Of these 60 percent, DOE assumed that all fans and a majority (70 percent) of compressors and pumps would be negatively impacted by higher operating speeds; and that 30 percent of compressors and pumps would not be negatively impacted from higher operating speeds as their time of use would decrease as the flow increases with the speed (e.g. a pump filling a reservoir).

prices (2010 levels) for both its LCC and PBP analysis and the NIA. For the NIA, DOE also analyzed the sensitivity of results to alternative electric motor price forecasts.

DOE did not receive comments on the trend it used for electric motor prices, and it retained the approach used in the preliminary analysis for the NOPR.

2. Installation Costs

In the preliminary analysis, the engineering analysis showed that for some representative units, increased efficiency led to increased stack length. However, the electric motor frame remained in the same NEMA frame size requirements as the baseline electric motor, and the motor's ''C'' dimension remained fairly constant across efficiency levels. In addition, electric motor installation cost data from RS Means Electrical Cost Data 2013 showed a variation in installation costs by horsepower (for three-phase electric motors), but not by efficiency. Therefore, in the preliminary analysis, DOE assumed there is no variation in installation costs between a baseline efficiency electric motor and a higher efficiency electric motor.

Two interested parties commented that DOE might have to consider increased installation costs related to larger diameter motors in comparison to baseline motors. (CA IOUs, No. 57 at p. 2; NEMA, No. 54 at p. 83) NEMA added that the size of a motor may need to be increased to provide the necessary material to obtain higher levels of energy efficiency, such as CSL 3 examined for Design B electric motors. (NEMA, No. 54 at p. 83)

DOE's engineering data show that the motor's ''C'' dimension remained fairly constant across efficiency levels. For equipment class Group 1, the stack length of higher efficiency motors (EL 3 and above) did not show significant increases in size in comparison to NEMA Premium level motors (EL 2). In addition, the frame size remained the same and the ''C'' dimension data did not significantly vary. Therefore, for the NOPR, DOE retained the same approach as in the preliminary analysis and did not incorporate changes in installation costs for electric motors that are more efficient than baseline equipment.

NEMA stated that when a user replaces a baseline NEMA Design B motor with a higher efficiency NEMA Design A motor, the user might experience additional installation costs compared to replacing the motor with a baseline NEMA Design B motor due to, for example, potential needs for new motor controller or motor protection devices. (NEMA, No. 54 at p. 29) In the engineering analysis, for equipment class Group 1, all representative units selected were NEMA Design B motors and the NEMA Design B requirements are maintained across all efficiency levels. Therefore, DOE did not account for additional installation costs related to the replacement of NEMA Design B motors with NEMA Design A motors.

3. Maintenance Costs

In the preliminary analysis, DOE did not find data indicating a variation in maintenance costs between a baseline efficiency and higher efficiency electric motor. According to data from Vaughen's Price Publishing Company,[67] which publishes an industry reference guide on motor repair pricing, the price of replacing bearings, which is the most common maintenance practice, is the same at all efficiency levels. Therefore, DOE did not consider maintenance costs for electric motors. DOE did not receive comments on this issue and retained the approach used for the preliminary analysis for the NOPR.

4. Repair Costs

In the preliminary analysis, DOE accounted for the differences in repair costs of a higher efficiency motor compared to a baseline efficiency motor and defined a repair as including a rewind and reconditioning. Based on data from Vaughen's, DOE derived a model to estimate repair costs by horsepower, enclosure and pole, for each EL.

The Electrical Apparatus Service Association (EASA), which represents the electric motor repair service sector, noted that DOE should clarify the definition of repair as including rewinding and reconditioning. (EASA, No. 47 at p. 1) DOE agrees with this suggestion and has modified its terminology in chapter 7 of the NOPR TSD.

One interested party, Flolo Corporation, noted that since the 1990's, increased windings protection has led to longer repair cycles and the repair frequency values used in the preliminary analysis were too low. (Pub. Mtg. Tr., No. 58 at p. 234)

For the preliminary analysis, DOE estimated that NEMA Design A, B and C electric motors were repaired on average after 32,000 hours of operation based on data for the industrial sector. This estimate reflected a situation where electric motors from 1 to 20-horsepower, with an average lifetime of 5 years, are not repaired; motors from 25- to 75-horsepower, with an average lifetime of 10 years, are repaired at half their lifetime; and motors from 100- to 500-horsepower, with an average lifetime of 15 years, are repaired at a third of their lifetime. In the NOPR analysis, DOE retained a similar approach for the industrial and commercial sectors. For the agricultural sector, DOE did not find sufficient data to distinguish by horsepower range and assumed that motors are repaired on average at half of their lifetime. With the revised NOPR mechanical lifetime and operating hour estimates, the repair frequency in hours increased to 48,600 hours in the industrial sector compared to DOE's earlier estimate of 32,000 hours.

5. Unit Energy Consumption

The NOPR analysis uses the same approach for determining unit energy consumptions (UECs) as the preliminary analysis. The UEC was determined for each application and sector based on estimated load points and annual operating hours. For the NOPR, DOE refined the average annual operating hours, average load, and shares of motors by application and sector.

In the preliminary analysis, DOE assumed that one-third of repairs are done following industry recommended practice as defined by EASA. (EASA Standard AR100–2010, Recommended Practice for the Repair of Rotating Electrical Apparatus) and do not impact the efficiency of the electric motor (i.e., no degradation of efficiency after repair). DOE assumed that two-thirds of repairs do not follow good practice and that a slight decrease in efficiency occurs when the electric motor is repaired. DOE assumed the efficiency decreases by 1 percent in the case of electric motors of less than 40 horsepower, and by 0.5 percent in the case of larger electric motors.

NEMA and EASA asked DOE to clarify its assumption regarding the share of repairs performed following industry recommended practices. (NEMA, No. 54 at p. 29) (EASA, No. 47 at p. 1) For the NOPR, DOE reviewed data from the U.S. Economic Census[68] and EASA[69] and estimated that the majority of motor repair shops are EASA members and follow industry recommended practices. DOE revised its assumption for the NOPR analysis and estimated that 90 percent of repairs are done following industry recommended practice and would not impact the

[67] Vaughen's (2011, 2013), Vaughen's Motor & Pump Repair Price Guide, 2011, 2013 Edition. *http://www.vaughens.com/.*

[68] U.S. Economic Census 1997 and 2007 data on the number of motor repair establishments (based on NAICS 811, 811310, and SIC 7694).

[69] Members of EASA available at: *http://www.easa.com/.*

efficiency of the motor (i.e. no degradation of efficiency after repair).

NEMA also requested clarification on whether the LCC is based on site energy or full fuel cycle energy. (NEMA, No. 54 at p. 31) In the LCC, DOE considers site energy use only.

6. Electricity Prices and Electricity Price Trends

In the preliminary analysis, DOE derived sector-specific weighted average electricity prices for four different U.S. Bureau of the Census (Census) regions (Northeast, Midwest, South, and West) using data from the Energy Information Administration (EIA Form 861). For each utility in a region, DOE used the average industrial or commercial price, and then weighted the price by the number of customers in each sector for each utility.

For each representative motor, DOE assigned electricity prices using a Monte Carlo approach that incorporated weightings based on the estimated share of electric motors in each region. The regional shares were derived based on indicators specific to each sector (e.g., commercial floor space from the Commercial Building Energy Consumption Survey for the commercial sector[70]) and assumed to remain constant over time. To estimate future trends in energy prices, DOE used projections from the EIA's Annual Energy Outlook 2011 (*AEO 2011*). The NOPR retains the same approach for determining electricity prices, and used *AEO 2013* to project electricity price trends.

IECA commented that the sector specific average electricity prices do not account for differences across census regions where industrial activity is concentrated. (IECA, No. 52 at p. 2) As noted above, the industrial electricity price for each region is a weighted average based on the number of industrial customers of each utility. Thus, the prices reasonably account for concentration of industrial activity.

7. Lifetime

In the preliminary analysis, DOE estimated the mechanical lifetime of electric motors in hours (i.e., the total number of hours an electric motor operates throughout its lifetime), depending on its horsepower size. DOE then developed Weibull distributions of mechanical lifetimes. The lifetime in years for a sampled electric motor was then 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 hundred hours per year. DOE considered that electric motors of less than 75-hp 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 ages. For the NOPR analysis, DOE retained the same approach and revised some of the lifetime assumptions based on additional information collected.

NEMA and WEG commented that the mechanical lifetime of agricultural motors should be lower than in the commercial or industrial sectors due to lower levels of maintenance performed in the field and the lighter duty steel frame constructions of these motors. (Pub. Mtg. Tr., No. 58 at p. 253) The NOPR analysis estimates that the average motor lifetime (across all sizes) for the agricultural sector to be 20 years.[71] This revised estimate translates into average mechanical lifetimes between 24,000 and 30,000 hours depending on the horsepower range, which is lower than in the industrial sector.

For the NOPR, DOE collected sector-specific mechanical motor lifetime information where available and revised the lifetime assumptions where appropriate. For the industrial sector, DOE estimated average mechanical lifetimes of 5, 15, and 20 years, depending on the horsepower range (the values correspond to 43,800, 87,600, and 131,400 hours respectively). These values are higher than those used in the preliminary analysis.

8. Discount Rate

The discount rate is the rate at which future expenditures are discounted to estimate their present value. The cost of capital commonly is used to estimate the present value of cash flows to be derived from a typical company project or investment. Most companies use both debt and equity capital to fund investments, so the cost of capital is the weighted-average cost to the firm of equity and debt financing. DOE uses the capital asset pricing model (CAPM) to calculate the equity capital component, and financial data sources to calculate the cost of debt financing.

For the NOPR, DOE estimated a statistical distribution of industrial and commercial customer discount rates by calculating the average cost of capital for the different types of electric motor owners (e.g., chemical industry, food processing, and paper industry). For the agricultural sector, DOE assumed similar discount rates as in industry. More details regarding DOE's estimates of motor customer discount rates are provided in chapter 8 of the NOPR TSD.

9. Base Case Market Efficiency Distributions

For the LCC analysis, DOE analyzed the considered motor efficiency levels relative to a base case (i.e., the case without new or amended energy efficiency standards). This requires an estimate of the distribution of product efficiencies in the base case (i.e., what consumers would have purchased in the compliance year in the absence of new standards). DOE refers to this distribution of product energy efficiencies as the base case efficiency distribution.

Data on motor sales by efficiency are not available. In the preliminary analysis, DOE used the number of models meeting the requirements of each efficiency level from six major manufacturers and one distributor's catalog data to develop the base-case efficiency distributions. The distribution is estimated separately for each equipment class group and horsepower range and was assumed constant and equal to 2012 throughout the analysis period (2015–2044).

For the NOPR, DOE retained the same approach to estimate the base case efficiency distribution in 2012, but it updated the base case efficiency distributions to account for the NOPR engineering analysis (revised ELs) and for the update in the scope of electric motors considered in the analysis. Beyond 2012, DOE assumed the efficiency distributions for equipment class group 1 and 4 vary over time based on historical data[72] for the market penetration of NEMA Premium motors within the market for integral alternating current induction motors. The assumed trend is shown in chapter 10 of the NOPR TSD. For equipment class group 2 and 3, which represent a very minor share of the market (less

[70] U.S. Department of Energy Information Administration (2003), Commercial Buildings Energy Consumption Survey, *http://www.eia.gov/consumption/commercial/data/2003/pdf/a4.pdf.*

[71] Gallaher, M., Delhotal, K., & Petrusa, J. (2009). Estimating the potential CO_2 mitigation from agricultural energy efficiency in the United States. Energy Efficiency, 2 (2):207–220.

[72] Robert Boteler, USA Motor Update 2009, Energy Efficient Motor Driven Systems Conference (EEMODS) 2009.

than 0.2 percent), DOE believes the overall trend in efficiency improvement for the total integral AC induction motors may not be representative, so DOE kept the base case efficiency distributions in the compliance year equal to 2012 levels.

Two interested parties commented on the base case efficiency distributions. Regal-Beloit stated that the share of 1- to 5-horsepower motors in equipment class 1 at CSL 0 in the base case distribution was too low by at least one percentage point. (Pub. Mtg. Tr., No. 58 at p. 263) NEMA requested clarifications on how DOE derived its base case efficiency distributions and commented that it would expect CSL 0 to represent 60 percent of total units shipped when considering the expanded scope as proposed by NEMA. (NEMA, No. 54 at p. 84) Neither stakeholder, however, provided supporting data.

As mentioned previously, DOE developed the 2012 base case efficiency distributions based on catalog information on the number of models meeting the requirements of each efficiency level. For the NOPR, DOE retained the same methodology and revised the catalog information to account for the addition of brake motors and NEMA 56-frame size enclosed electric motors in the analysis. DOE has no data to assess the stakeholders' input on the base case efficiency distributions.

10. Compliance Date

Any amended standard for electric motors shall apply to electric motors manufactured on or after a date which is five years after the effective date of the previous amendment. (42 U.S.C. 6313(b)(4)) In this case, the effective date of the previous amendment (established by EISA in 2007) is December 19, 2010, and the compliance date of any amended energy conservation standards for electric motors would be December 19, 2015. In light of the proposal's attempt to establish amended or new standards for currently regulated and unregulated electric motor types, DOE has chosen to retain the same compliance date for both the amended and new energy conservation standards to simplify the requirements and to avoid any potential confusion from manufacturers. The final rule for this rulemaking is scheduled to be published in early 2014. DOE calculated the LCC and PBP for all end-users as if each would purchase a new piece of equipment in the year that compliance is required. As DOE notes elsewhere, DOE is interested in comments regarding the feasibility of achieving compliance with this proposed date.

11. Payback Period Inputs

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

The inputs to the PBP calculation are the total installed cost of the product to the customer for each efficiency level and the average annual operating expenditures for each efficiency level. The PBP calculation uses the same inputs as the LCC analysis, except that discount rates are not needed.

12. Rebuttable-Presumption Payback Period

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 energy (and, as applicable, water) savings during the first year that the consumer will receive as a result of the standard, as calculated under the test procedure in place for that standard. (42 U.S.C. 6295(o)(2)(B)(iii)) For each considered efficiency level, DOE determines the value of the first year's energy savings by calculating the quantity of those savings in accordance with the applicable DOE test procedure, and multiplying that amount by the average energy price forecast for the year in which compliance with the new or amended standards would be required.

G. Shipments Analysis

DOE uses projections of product shipments to calculate the national impacts of standards on energy use, NPV, and future manufacturer cash flows. DOE develops shipment projections based on historical data and an analysis of key market drivers for each product.

To populate the model with current data, DOE used data from a market research report,[73] confidential inputs from manufacturers, trade associations, and other interested parties' responses to the Request for Information (RFI) published in the **Federal Register**. 76 FR 17577 (March 30, 2011). DOE then used estimates of market distributions to redistribute the shipments across pole configurations, horsepower, and enclosures within each electric motor equipment class and also by sector.

DOE's shipments projection assumes that electric motor sales are driven by machinery production growth for equipment including motors. DOE estimated that growth rates for total motor shipments correlate to growth rates in fixed investment in equipment and structures including motors, which is provided by the U.S. Bureau of Economic Analysis (BEA).[74] Projections of real gross domestic product (GDP) from *AEO 2013* for 2015–2040 were used to project fixed investments in the equipment and structures including motors. The current market distributions are maintained over the forecast period.

For the NOPR, with the expanded scope by horsepower, DOE estimates total shipments in scope were 5.43 million units in 2011. This estimate represents an increase compared to the shipments estimated in the preliminary analysis because of the inclusion of integral brake motors and of NEMA integral enclosed 56-frame motors.

For the preliminary analysis, DOE collected data on historical series of shipment quantities and value for the 1990–2003 period, but concluded that the data were not sufficient to estimate motor price elasticity.[75] Consequently, DOE assumed zero price elasticity for all efficiency standards cases and did not estimate any impact of potential standards levels on shipments. DOE requested stakeholder recommendations on data sources to help better estimate the impacts of increased efficiency levels on shipments.

The Motor Coalition commented that higher equipment costs required to achieve efficiency levels above CSL 2 (NEMA Premium) would encourage the refurbishment of existing motors rather than their replacement by new, more efficient motors, leading to reduced cost effective energy savings at CSL 3. (Motor Coalition, No. 35 at p. 7)

DOE acknowledges that increased electric motor prices could affect the

[73] IMS Research (February 2012), The World Market for Low Voltage Motors, 2012 Edition, Austin.

[74] Bureau of Economic Analysis (March 01, 2012), Private Fixed Investment in Equipment and Software by Type and Private Fixed Investment in Structures by Type. *http://www.bea.gov/iTable/iTable.cfm?ReqID=12&step=1.*

[75] Business Trend Analysts, The Motor and Generator Industry, 2002; U.S. Census Bureau (November 2004), Motors and Generators—2003.MA335H(03)–1. *http://www.census.gov/manufacturing/cir/historical_data/discontinued/ma335h/index.html*; and U.S. Census Bureau (August 2003), Motors and Generators—2002.MA335H(02)–1. *http://www.census.gov/manufacturing/cir/historical_data/discontinued/ma335h/ma335h02.xls.*

''repair versus replace'' decision, leading to the increased longevity of existing electric motors and a decrease in shipments of newly-manufactured energy-efficient electric motors. Considering the minimal cost increase between EL 2 and EL 3 in the preliminary analysis (approximately 3 percent for representative unit 1), DOE does not believe it is reasonable to consider non-zero price elasticity when calculating the standards-case shipments for levels above EL 2 and zero price elasticity when calculating shipments for the standards case at EL 2 of the preliminary analysis. For the above reasons, DOE retained its shipments projections, which do not incorporate price elasticities, for the NOPR. However, DOE also performed a sensitivity analysis that demonstrates the impact of possible price elasticities on projected shipments and the NIA results. See TSD appendix 10–C for more details and results.

NEMA commented that shipments of imported motors might decrease if higher efficiency levels are mandated. (NEMA, No. 54 at p. 29) NEMA, however, provided no data in support of its view. DOE has reviewed shipments information from market reports, the U.S. Census, as well as market information provided by the Motor Coalition and has been unable to obtain any data to assess the potential reduction in quantity of imported motors due to standards and whether this would impact the total number of motors shipped in the U.S.[76] DOE's shipments projection assumes that electric motor sales are driven by machinery production growth for equipment including motors without distinction between imported and domestic motors.

H. National Impact Analysis

The NIA assesses the national energy savings (NES) and the national NPV of total customer costs and savings that would be expected to result from new and amended standards at specific efficiency levels.

To make the analysis more accessible and transparent to all interested parties, DOE used an MS Excel spreadsheet model to calculate the energy savings and the national customer costs and savings from each TSL.[77] DOE used the NIA spreadsheet to calculate the NES and NPV, based on the annual energy consumption and total installed cost data from the energy use analysis and the LCC analysis. DOE forecasted the lifetime energy savings, energy cost savings, equipment costs, and NPV of customer benefits for each product class for equipment sold from 2015 through 2044. In addition, DOE analyzed scenarios that used inputs from the *AEO 2013* Low Economic Growth and High Economic Growth cases. These cases have higher and lower energy price trends compared to the reference case.

DOE evaluated the impacts of potential new and amended standards for electric motors by comparing base-case projections with standards-case projections. The base-case projections characterize energy use and customer costs for each equipment class in the absence of new and amended energy conservation standards. DOE compared these projections with projections characterizing the market for each equipment class if DOE were to adopt new or amended standards at specific energy efficiency levels (i.e., the standards cases) for that class.

Table IV.25 summarizes all the major preliminary analysis inputs to the NIA and whether those inputs were revised for the NOPR.

TABLE IV.25—INPUTS FOR THE NATIONAL IMPACT ANALYSIS

Input	Preliminary analysis description	Changes for NOPR
Shipments	Annual shipments from shipments model	No change.
Compliance date of standard	Modeled used January 1, 2015	December 19, 2015 (modeled as January 1, 2016).
Equipment Classes	Three separate equipment class groups for NEMA Design A and B motors, NEMA Design C motors, and Fire Electric Pump Motors.	Added one equipment class group for brake motors.
Base case efficiencies	Constant efficiency from 2015 through 2044	No change for Equipment Class 2 and 3. Added a trend for the efficiency distribution of equipment class groups 1 and 4.
Standards case efficiencies	Constant efficiency at the specified standard level from 2015 to 2044	No change.
Annual energy consumption per unit.	Average unit energy use data are calculated for each horsepower rating and equipment class based on inputs from the Energy use analysis.	No change.
Total installed cost per unit	Based on the MSP and weight data from the engineering, and then scaled for different hp and enclosure categories.	No change.
Electricity expense per unit	Annual energy use for each equipment class is multiplied by the corresponding average energy price.	No change.
Escalation of electricity prices	*AEO 2011* forecasts (to 2035) and extrapolation for 2044 and beyond	Updated to AEO 2013.
Electricity site-to-source conversion	A time series conversion factor; includes electric generation, transmission, and distribution losses.	No change.
Discount rates	3% and 7% real	No change.
Present year	2012	2013.

[76] IMS Research (February 2012), The World Market for Low Voltage Motors, 2012 Edition, Austin; Business Trend Analysts, The Motor and Generator Industry, 2002; U.S. Census Bureau (November 2004), Motors and Generators—2003.MA335H(03)–1. *http://www.census.gov/manufacturing/cir/historical_data/discontinued/ma335h/index.html*; and U.S. Census Bureau (August 2003), Motors and Generators—2002.MA335H(02)–1. *http://www.census.gov/manufacturing/cir/historical_data/discontinued/ma335h/ma335h02.xls.*

[77] DOE understands that MS Excel is the most widely used spreadsheet calculation tool in the United States and there is general familiarity with its basic features. Thus, DOE's use of MS Excel as the basis for the spreadsheet models provides interested parties with access to the models within a familiar context. In addition, the TSD and other documentation that DOE provides during the rulemaking help explain the models and how to use them, and interested parties can review DOE's analyses by changing various input quantities within the spreadsheet.

1. Efficiency Trends

In the preliminary analysis, DOE did not include any change in base case efficiency in its shipments and national energy savings models. As explained in section IV.F, for equipment class groups 1 and 4, for the NOPR, DOE presumed that the efficiency distributions in the base case change over time. The projected share of 1 to 5 horsepower NEMA Premium motors (EL 2) for equipment class group 1 grows from 36.6 percent to 45.5 percent over the analysis period, and for equipment class group 4, it grows from 30.0 percent to 38.9 percent. For equipment class group 2 and 3, DOE assumed that the efficiency remains constant from 2015 to 2044.

In the standards cases, equipment with efficiency below the standard levels ''roll up'' to the standard level in the compliance year. Thereafter, for equipment class groups 1 and 4, DOE assumed that the level immediately above the standard would show a similar increase in market penetration as the NEMA Premium motors in the base case.

The presumed efficiency trends in the base case and standards cases are described in chapter 10 of the NOPR TSD.

2. National Energy Savings

For each year in the forecast period, DOE calculates the lifetime national energy savings for each standard level by multiplying the shipments of electric motors affected by the energy conservation standards by the per-unit lifetime annual energy savings. Cumulative energy savings are the sum of the NES for all motors shipped during the analysis period, 2015–2044.

DOE estimated energy consumption and savings based on site energy and converted the electricity consumption and savings to primary energy using annual conversion factors derived from the *AEO 2013* version of the NEMS. Cumulative energy savings are the sum of the NES for each year over the timeframe of the analysis.

DOE has historically presented NES in terms of primary energy savings. 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 Science, DOE announced its intention to use full-fuel-cycle (FFC) measures of energy use and greenhouse gas and other emissions in the national impact analyses and emissions analyses included in future energy conservation standards rulemakings. 76 FR 51281 (August 18, 2011). While DOE stated in that notice that it intended to use the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model to conduct the analysis, it also said it would review alternative methods, including the use of EIA's National Energy Modeling System (NEMS). After evaluating both models and the approaches discussed in the August 18, 2011 notice, DOE published a statement of amended policy in the **Federal Register** in which DOE explained its determination that NEMS is a more appropriate tool for this specific use. 77 FR 49701 (August 17, 2012). Therefore, DOE is using NEMS to conduct FFC analyses. The approach used for today's NOPR, and the FFC multipliers that were applied, are described in appendix 10–C of the TSD.

3. Equipment Price Forecast

As noted in section IV.F.2, DOE assumed no change in electric motor prices over the 2015–2044 period. In addition, DOE conducted a sensitivity analysis using alternative price trends. DOE developed one forecast in which prices decline after 2011, and one in which prices rise. These price trends, and the NPV results from the associated sensitivity cases, are described in appendix 10–B of the NOPR TSD.

4. Net Present Value of Customer Benefit

The inputs for determining the NPV of the total costs and benefits experienced by consumers of considered equipment are: (1) Total annual installed cost; (2) total annual savings in operating costs; and (3) a discount factor. DOE calculates the lifetime net savings for motors shipped each year as the difference between the base case and each standards case in total lifetime savings in lifetime operating costs and total lifetime increases in installed costs. DOE calculates lifetime operating cost savings over the life of each motor shipped during the forecast period.

In calculating the NPV, DOE multiplies the net savings in future years by a discount factor to determine their present value. DOE estimates the NPV using both a 3-percent and a 7-percent real discount rate, in accordance with guidance provided by the Office of Management and Budget (OMB) to Federal agencies on the development of regulatory analysis.[78] 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.

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

I. Consumer Subgroup Analysis

In analyzing the potential impacts of new or amended standards, DOE evaluates impacts on identifiable groups (i.e., subgroups) of customers that may be disproportionately affected by a national standard. For the NOPR, DOE evaluated impacts on various subgroups using the LCC spreadsheet model.

The customer subgroup analysis is discussed in detail in chapter 11 of the TSD.

J. Manufacturer Impact Analysis

1. Overview

DOE conducted an MIA for electric motors to estimate the financial impact of proposed new and amended energy conservation standards on manufacturers of covered electric motors. The MIA has both quantitative and qualitative aspects. The quantitative part of the MIA primarily relies on the GRIM, an industry cash flow model customized for electric motors covered in this rulemaking. The key GRIM inputs are data on the industry cost structure, equipment costs, shipments, and assumptions about markups and conversion expenditures. The key MIA output is INPV. DOE used the GRIM to calculate cash flows using standard accounting principles and to compare changes in INPV between a base case and various TSLs (the standards case). The difference in INPV between the base and standards cases represents the financial impact of new and amended standards on manufacturers of covered electric motors. Different sets of assumptions (scenarios) produce different INPV results. The qualitative part of the MIA addresses factors such as manufacturing capacity; characteristics of, and impacts on, any particular sub-group of manufacturers; and impacts on competition.

DOE conducted the MIA for this rulemaking in three phases. In the first phase DOE prepared an industry characterization based on the market and technology assessment, preliminary manufacturer interviews, and publicly available information. In the second phase, DOE estimated industry cash flows in the GRIM using industry financial parameters derived in the first phase and the shipment scenario used in the NIA. In the third phase, DOE conducted structured, detailed interviews with a variety of manufacturers that represent more than 75-percent of domestic electric motors sales covered by this rulemaking. During these interviews, DOE discussed engineering, manufacturing, procurement, and financial topics specific to each company, and obtained each manufacturer's view of the electric motor industry as a whole. The interviews provided valuable information that DOE used to evaluate the impacts of new and amended standards on manufacturers' cash flows, manufacturing capacities, and employment levels. See section IV.J.4 of this NOPR for a description of the key issues manufacturers raised during the interviews.

During the third phase, DOE also used the results of the industry characterization analysis in the first phase and feedback from manufacturer interviews to group manufacturers that exhibit similar production and cost structure characteristics. DOE identified one sub-group for a separate impact analysis—small business manufacturers—using the small business employee threshold published by the Small Business Administration (SBA). This threshold includes all employees in a business' parent company and any other subsidiaries. Based on this classification, DOE identified 13 electric motor manufacturers that qualify as small businesses.

The complete MIA is presented in chapter 12 of the NOPR TSD.

2. GRIM Analysis and Key Inputs

DOE uses the GRIM to quantify the changes in cash flow over time due to a standard. These changes in cash flow result in either a higher or lower INPV for the standards case compared to the base case, the case where a standard is not set. The GRIM analysis uses a standard annual cash flow analysis that incorporates manufacturer costs, markups, shipments, and industry financial information as inputs. It then models changes in costs, investments, and manufacturer margins that result from new and amended energy conservation standards. The GRIM spreadsheet uses the inputs to calculate a series of annual cash flows beginning with the base year of the analysis, 2013, and continuing to 2044. DOE computes INPVs by summing the stream of annual discounted cash flows during this analysis period. DOE used a real discount rate of 9.1 percent for electric motor manufacturers. The discount rate estimates were derived from industry corporate annual reports to the Securities and Exchange Commission (SEC 10–Ks) and then modified according to feedback during manufacturer interviews. Many inputs into the GRIM come from the engineering analysis, the NIA, manufacturer interviews, and other research conducted during the MIA. The major GRIM inputs are described in detail in the sections below.

a. Product and Capital Conversion Costs

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

DOE calculated the product and capital conversion costs using both a top-down approach and a bottom-up approach based on feedback from manufacturers during manufacturer interviews and manufacturer submitted comments. DOE then adjusted these conversion costs if there were any discrepancies in the final costs using the two methods to arrive at a final product and capital conversion cost estimate for each representative unit at each EL.

During manufacturer interviews, DOE asked manufacturers for their estimated total product and capital conversion costs needed to produce electric motors at specific ELs. To arrive at top-down industry wide product and capital conversion cost estimates for each representative unit at each EL, DOE calculated a market share weighted average value for product and capital conversion costs based on the data submitted during interviews and the market share of the interviewed manufacturers.

DOE also calculated bottom-up conversion costs based on manufacturer input on the types of costs and the dollar amounts necessary to convert a single electric motor 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 and certification 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. The bottom-up conversion costs estimates DOE created were consistent with the manufacturer top down estimates provided, so DOE used the bottom-up conversion cost estimates as the final values for each representative unit in the MIA.

In written comments and during manufacturer interviews, electric motor manufacturers stated there would be very large product and capital conversion costs associated with ELs above NEMA Premium, especially for any ELs that require manufacturers to switch to die-cast copper rotors. Manufacturers addressed the difficulties associated with using copper die-cast rotors and the uncertainty of a standard that requires manufacturers to produce electric motors on a commercial level for all horsepower ranges using this technology. NEMA stated that switching to die-cast copper rotors would cost each manufacturer approximately $80 million in retooling costs and approximately $68 million to redesign, test and certify electric motors at these ELs. (NEMA, No. 54 at p. 11) NEMA stated that significant conversion costs associated with any EL above NEMA Premium exist even if die-cast copper rotors are not used. Several manufacturers during interviews and in comments stated they would need to devote significant engineering time to redesign their entire production line to comply with ELs that are just one NEMA band higher than NEMA Premium. NEMA also stated that testing and certifying electric motors to ELs above NEMA Premium would be a significant cost to each manufacturer, since each manufacturer could have thousands or hundreds of thousands of unique electric motor specifications they would need to certify. (NEMA, No. 54 at p. 4) DOE took these submitted comments into account when developing the industry product and capital conversion costs. The final product and capital conversion cost estimates were in the range of estimates submitted by NEMA.

See chapter 12 of the TSD for a complete description of DOE's assumptions for the product and capital conversion costs.

b. Manufacturer Production Costs

Manufacturing a more efficient electric motor is typically more expensive than manufacturing a baseline product due to the use of more costly materials and components. The higher MPCs for these more efficient equipment can affect the revenue, gross margin, and cash flows of electric motor manufacturers.

DOE developed the MPCs for the representative units at each EL analyzed in one of two ways: (1) DOE purchased, tested and then tore down a motor to create a bill of materials (BOM) for the motor; and (2) DOE created a BOM based on a computer software model for a specific motor that complies with the associated efficiency level. This second approach was used when DOE was unable to find and purchase a motor that matched the efficiency criteria for a specific representative unit. Once DOE created a BOM for a specific motor, either by tear downs or software modeling, DOE then estimated the labor hours and the associated scrap and overhead costs necessary to produce a motor with that BOM. DOE was then able to create an aggregated MPC based on the material costs from the BOM and the associated scrap costs, the labor costs based on an average labor rate and the labor hours necessary to manufacture the motor, and the overhead costs, including depreciation, based on a markup applied to the material, labor, and scrap costs based on the materials used.

DOE created a BOM from tear downs for 15 of the 21 analyzed representative unit ELs and applied these BOM data to create ELs for certain representative units. The representative unit ELs based on tear downs include: All five ELs for the Design B, 5-horsepower representative unit; the baseline and ELs 1, 2, and 3 for the Design B, 30-horsepower and 75-horsepower representative units; and the baseline for the Design C, 5-horsepower and 50-horsepower representative units. DOE created a BOM based on a computer software model for the remaining six analyzed representative unit ELs: EL 4 for the Design B, 30-horsepower and 75-horsepower representative units; and ELs 1 and 2 for the Design C, 5-horsepower and 50-horsepower representative units.

Due to the very large product and capital conversion costs manufacturers would face if standards forced manufacturers to produce motors above NEMA Premium ELs, DOE decided to include the product and capital conversion costs as a portion of the MPCs for all ELs above NEMA Premium. DOE applied a per unit adder, which was a flat percentage of the MPC at NEMA Premium, for all MPCs above NEMA Premium. For a complete description of MPCs and the inclusion of manufacturer conversion costs into the MPC see the engineering analysis discussion in section IV.C of this NOPR.

c. Shipment Forecast

INPV, the key GRIM output, depends on industry revenue, which in turn, depends on the quantity and prices of electric motors shipped in each year of the analysis period. Industry revenue calculations require forecasts of: (1) Total annual shipment volume; (2) the distribution of shipments across analyzed representative units (because prices vary by representative unit); and, (3) the distribution of shipments across efficiencies (because prices vary with efficiency).

In the NIA, DOE estimated the total number of electric motor shipments by year for the analysis period. The NIA projects electric motor shipments to generally increase over time. This is consistent with the estimates manufacturers revealed to DOE during manufacturer interviews. The NIA then estimated the percentage of shipments assigned to each ECG. DOE further estimated the percentage of shipments by horsepower rating, pole configuration, and enclosure type within each ECG. For the NIA, the shipment distribution across ECG and the shipment distribution across horsepower rating, pole configuration, and enclosure type do not change on a percentage basis over time. Nor does the shipment distribution across ECGs or across horsepower rating, pole configuration, and enclosure type change on a percentage basis due to an energy conservation standard (e.g. the number of shipments of Design C, 1 horsepower, 4 pole, open motor are the same in the base case as in the standards case). Finally, the NIA estimated a distribution of shipments across ELs (an efficiency distribution), for each horsepower range within each ECG. As described in further detail below, the efficiency distributions for ECG 1 and ECG 4 motors become more energy efficient over time in the base case, while the efficiency distributions for ECG 2 and ECG 3 do not change on a percentage basis over time (i.e., for ECG 2 and ECG 3 motors, the efficiency distributions at the beginning of the analysis period are the same as the efficiency distributions at the end of the analysis period). DOE also assumed the total volume of shipments does not decrease due to energy conservation standards, so total shipments are the same in the base case as in the standards case.

For the NIA, DOE modeled a ''shift'' shipment scenario for ECG 1 and ECG 4 motors and a ''roll-up'' shipment scenario for ECG 2 and ECG 3 motors. In the standards case of the ''shift'' shipment scenario, shipments continue to become more efficient after a standard is set—in this case, immediately after the standards go into effect, all shipments below the selected TSL are brought up to meet that TSL. However, motors at or above the selected TSL migrate to even higher efficiency levels and continue to do so over time. In contrast, in the standards case of the ''roll-up'' shipment scenario, when a TSL is selected to become the new energy conservation standard, all shipments that fall below that selected TSL roll-up to the selected TSL. Therefore, the shipments that are at or above the selected TSL remain unchanged in the standards case of the ''roll-up'' shipment scenario compared to the base case. For the ''roll-up'' shipment scenario, the only difference in the efficiency distribution between the standards case and the base case is that in the standards case all shipments falling below the selected TSL in the base case are now at the selected TSL in the standards case.

While the shipments from the NIA are broken out into a total number of motor shipments for each ECG, horsepower rating, pole configuration, and enclosure type, the MIA consolidates the number of motor shipments into the representative units for each ECG. For example, the Design B, 5-horsepower, 4-pole, enclosed motor was the representative unit for all Design A and B motors between 1 and 10-horsepower regardless of the number of poles or enclosure type. So in the MIA DOE treated all ECG 1 (Design A and B) motor shipments between 1 and 10-horsepower as shipments of the Design B, 5-horsepower representative unit; all ECG 1 motor shipments between 15-

and 50-horsepower as shipments of the Design B, 30-horsepower representative unit; and all ECG 1 motor shipments between 60- and 500-horsepower as shipments of the Design B, 75-horsepower representative unit. For ECG 2 (Design C) motors, ECG 3 (fire pump) motors, and ECG 4 (brake) motors the MIA consolidated shipments in a similar manner, treating all shipments in the representative units' horsepower range as shipments of that representative unit.

See the shipment analysis, chapter 9, of this NOPR TSD for additional details.

d. Markup Scenarios

As discussed in the MPC section above, the MPCs for the representative units are the factory costs of electric motor manufacturers; these costs include material, direct labor, overhead, depreciation, and any extraordinary conversion cost recovery. The MSP is the price received by electric motor manufacturers from their direct customer, typically either an OEM or a distributor. The MSP is not the cost the end-user pays for the electric motor since there are typically multiple sales along the distribution chain and various markups applied to each sale. The MSP equals the MPC multiplied by the manufacturer markup. The manufacturer markup covers all the electric motor manufacturer's non-production costs (i.e., selling, general and administrative expenses (SG&A), normal R&D, and interest, etc.) and profit. Total industry revenue for electric motor manufacturers equals the MSPs at each EL for each representative unit multiplied by the number of shipments at that EL.

Modifying these manufacturer markups in the standards case yields a different set of impacts on manufacturers than in the base case. For the MIA, DOE modeled three standards case markup scenarios to represent the uncertainty regarding the potential impacts on prices and profitability for manufacturers following the implementation of new and amended energy conservation standards: (1) A flat markup scenario, (2) a preservation of operating profit scenario, and (3) a two-tiered markup scenario. These scenarios lead to different markup values, which, when applied to the inputted MPCs, result in varying revenue and cash flow impacts on manufacturers.

The flat markup scenario assumed that the cost of goods sold for each product is marked up by a flat percentage to cover SG&A expenses, R&D expenses, interest expenses, and profit. There were two values used for the flat markup, a 1.37 markup for high volume representative units and a 1.45 markup for low volume representative units. The 1.37 markup was used for the Design B, 5-horsepower representative unit; the Design C, 5-horsepower representative unit; the fire pump, 5-horsepower representative unit; and the brake, 5-horsepower representative unit. The 1.45 markup is used for the Design B, 30-horsepower and 75-horsepower representative units; the Design C, 50 horsepower representative unit; the fire pump, 30-horsepower and 75-horsepower representative units; and the brake, 30-horsepower and 75-horsepower representative units. This scenario represents the upper bound of industry profitability in the standards case because manufacturers are able to fully pass through additional costs due to standards to their customers. To derive the flat markup percentages, DOE examined the SEC 10-Ks of publicly traded electric motor manufacturers to estimate the industry average gross margin percentage. DOE then used that estimate along with the flat manufacturer markups used in the small electric motors rulemaking at 75 FR 10874 (March 9, 2010), since several of the small electric motor manufacturers are also manufacturers of electric motors covered in this rulemaking, to create a final estimate of the flat markups used for electric motors covered in this rulemaking.

DOE included an alternative markup scenario, the preservation of operating profit markup, because manufacturers stated that they do not expect to be able to markup the full cost of production given the highly competitive market, in the standards case. The preservation of operating profit markup scenario assumes that manufacturers are able to maintain only the base case total operating profit in absolute dollars in the standards case, despite higher product costs and investment. The base case total operating profit is derived from marking up the cost of goods sold for each product by the flat markup described above. In the standards case for the preservation of operating profit markup scenario, DOE adjusted the manufacturer markups in the GRIM at each TSL to yield approximately the same earnings before interest and taxes in the standards case in the year after the compliance date of the new and amended standards as in the base case. Under this scenario, while manufacturers are not able to yield additional operating profit from higher production costs and the investments that are required to comply with new and amended energy conservation standards, they are able to maintain the same operating profit in the standards case that was earned in the base case.

DOE modeled a third profitability scenario, a two-tiered markup scenario. During interviews, several manufacturers stated they offer two tiers of motor lines that are differentiated, in part, by efficiency level. For example, several manufacturers offer Design B motors that meet, and in some cases exceed, NEMA Premium levels. Motors that exceed these levels typically command higher prices over NEMA Premium level motors at identical horsepower levels. These manufacturers suggested that the premium currently earned by the higher efficiency tiers would erode as new and amended standards are set at higher efficiency levels, which would harm profitability. To model this effect, DOE used information from manufacturers to estimate the higher and lower markups for electric motors under a two-tier pricing strategy in the base case. In the standards case, DOE modeled the situation in which product efficiencies offered by a manufacturer are altered due to standards. This change reduces the markup of higher efficiency equipment as they become the new baseline caused by the energy conservation standard. The change in markup is based on manufacturer statements made during interviews and on DOE's understanding of industry pricing.

The preservation of operating profit and two-tiered markup scenarios represent the lower bound of industry profitability in the standards case because manufacturers are not able to fully pass through the additional costs due to standards, as manufacturers are able to do in the flat markup scenario. Therefore, manufacturers earn less revenue in the preservation of operating profit and two-tiered markup scenarios than they do in the flat markup scenario.

3. Discussion of Comments

During the August 2012 preliminary analysis public meeting, interested parties commented on the assumptions and results of the preliminary analysis TSD. Oral and written comments addressed several topics, including the scope of coverage, conversion costs, enforcement of standards, and the potential increase in the motor refurbishment market. DOE addresses these comments below.

a. Scope of Coverage

SEW-Eurodrive expressed concern about establishing energy conservation standards for integral gearmotors. SEW-Eurodrive stated that manufacturers would have to review and ensure the compatibility between the motor and the gearbox for all new integral gearmotor designs. Setting standards for these motors, in its view, may cause manufacturers to review potentially millions of motor-gear box combinations. SEW-Eurodrive also stated that since integral gearmotors comprise a system whose overall efficiency is limited by the low efficiency of the mating gearing, an increase in the efficiency of the motor alone would have a very small effect on the overall system efficiency. (SEW-Eurodrive, No. 53 at p. 3) DOE believes that these integral gearmotors can be tested by removing the gearbox and simply testing the partial motor in accordance with the partial motor test procedure proposed at 78 FR 38455 (June 26, 2013). This approach would allow integral gearmotor motor manufacturers to test and certify the electric motors and not every combination of electric motor and gearbox.

b. Conversion Costs

NEMA made a few comments regarding the potential difficulties and costs associated with increasing energy conservation standards to efficiency levels above NEMA Premium. First, NEMA stated that DOE should consider the current difficulties that manufacturers from IEC countries are having when meeting the efficiency levels under NEMA MG 1 Table 12–12. NEMA stated these manufacturers already face difficulties due to the limits of an electric motor frame size and stack length, as these limits pose physical constraints to higher efficiency levels. Moreover, such limits to IEC frame size and stack length are comparable to what manufacturers of NEMA frame motors would face if required efficiency levels were increased above current NEMA Premium efficiency levels. (NEMA, No. 54 at p. 84) NEMA did not provide any cost data, in engineering time or dollars, that these manufacturers were faced with regarding their compliance with NEMA MG 1 Table 12–12 efficiency levels.

NEMA went on to give estimates for the conversion costs associated with manufacturers producing motors above NEMA Premium efficiency levels. NEMA stated that it would cost each manufacturer approximately $80 million in retooling and $68 million in reengineering, testing and prototyping to switch from currently used materials to die-cast copper rotor production. NEMA also stated there are other costs not directly related to the die-casting process manufacturers would incur, if standards required copper rotor technology. For example, NEMA noted that there are additional costs associated with redesigning the rotor and stator to maintain compliance with NEMA MG 1 performance requirements. NEMA also provided DOE with a few of the major costs placed on the manufacturers if energy conservation standards exceeded NEMA Premium efficiency levels. NEMA said manufacturers would incur significant costs due to retooling slot insulators, automatic winding machines, and progressive lamination stamping dies—the last of which can cost between $500,000 and $750,000 per set. Manufacturers would also need to reengineer potentially 100,000 to 200,000 specifications per manufacturer to comply with standards above NEMA Premium levels. (NEMA, No. 54 at p. 11)

DOE took these difficulties and costs that could be placed on manufacturers into consideration when creating the conversion costs of standards above NEMA Premium efficiency levels. DOE also recognizes the magnitude of the conversion costs on the industry at efficiency levels above NEMA Premium and this was one of the main reasons DOE included a portion of the conversion costs in the MPC for efficiency levels above NEMA Premium. DOE believes it is likely that motor manufacturers would attempt to recover these large one-time extraordinary conversion costs at standards above NEMA Premium through a variable cost increase in the MPCs of electric motors sold by manufacturers.

c. Enforcement of Standards

NEMA stated that large domestic manufacturers could be adversely impacted by higher energy conservation standards if DOE does not strictly enforce those new and amended standards, especially on imported machinery with embedded motors. NEMA commented that domestic manufacturers are currently competing with imported goods containing electric motors that are below current motor standards. This practice puts compliant motor manufacturers at a disadvantage because the machinery containing a non-compliant motor is often sold at a lower cost than machinery with a compliant motor. (NEMA, No. 54 at p. 11) DOE recognizes the need to enforce any energy conservation standard established for motors manufactured alone or as a component of another piece of equipment to ensure that all manufacturers are operating on a level playing field and to realize the actual reduction in energy consumption from these standards.

d. Motor Refurbishment

NEMA commented that if electric motors had to be redesigned to achieve higher energy conservation standards potential new motor customers may be forced to rewind older, less efficient motors because the longer or larger frame sizes that could be required to satisfy more stringent efficiency standards might not fit as drop-in replacements for existing equipment. (NEMA, No. 54 at p. 10) DOE agrees that adopting higher energy conservation standards for electric motors may force motor manufacturers to increase the length and/or the diameter of the frame. Such increase in motor frame size may cause some machinery using electric motors to be incompatible with previous electric motor designs. DOE requested comment on the quantitative impacts this could have on the electric motor and OEM markets but did not receive any quantitative responses regarding this issue. DOE is aware this could be a possible issue at the ELs above NEMA Premium, but does not consider this to be an issue at ELs that meet or are below NEMA Premium, since the majority of the electric motors used in existing equipment should already be at NEMA Premium efficiency levels. Therefore, based on data available at this time, DOE does not believe that motor refurbishment is likely to act as a barrier to the efficiency levels proposed in today's NOPR.

4. Manufacturer Interviews

DOE conducted additional interviews with manufacturers following the preliminary analysis in preparation for the NOPR analysis. In these interviews, DOE asked manufacturers to describe their major concerns with this rulemaking. The following section describes the key issues identified by manufacturers during these interviews.

a. Efficiency Levels above NEMA Premium

During these interviews, several manufacturers were concerned with the difficulties associated with increasing motor efficiency levels above NEMA Premium. Manufacturers stated that even increasing the efficiency of motors to one band above NEMA Premium 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 motor configuration offered, which could take several years of engineering time.

According to manufacturers, another potential problem with setting standards above NEMA Premium is that this would misalign U.S. electric motor standards with global motor standards (e.g., IEC motor standards). They noted that over the past few decades, there has been an effort to harmonize global motor standards that setting new U.S. electric motor standards at a level exceeding the NEMA Premium level would cause U.S. electric motor markets to be out of synchronization with the rest of the world's efficiency standards.

Several manufacturers also commented they believe any standard requiring die-casting copper rotors is infeasible. One main concern manufacturers have regarding copper is that not only has the price of copper significantly increased over the past several years, there has been tremendous volatility in the price as well. Manufacturers worry that if standards required manufacturers to use copper rotors, they would be subject to this volatile copper market. Manufacturers also noted that motor efficiency standards requiring copper rotors for all electric motors would likely increase the price of copper due to the increase in demand from the motors industry.

Another key concern that manufacturers have regarding standards that require using copper rotors is that copper has a much higher melting temperature than aluminum, and the pressure required to die-cast copper is much higher than aluminum. They contend that there is a much greater chance that a significant accident or injury to their employees could occur if manufacturers were required to produce copper rotors rather than aluminum rotors.

Lastly, several manufacturers stated they would not be able to produce copper die-cast rotors in-house and would have to outsource this production. Manufacturers stated that if the entire motor industry had to outsource their rotor production as a result of standards that required the use of die-cast copper rotors, there would be significant supply chain problems in the motor manufacturing process. Manufacturers emphasized during interviews that the capacity to produce copper rotors on a large commercial scale does not exist and would be very difficult to implement in even a three-year time period.

Overall, manufacturers are very concerned if any electric motor standard required motor efficiency levels beyond NEMA Premium, especially if those efficiency levels required the use of copper rotor technology. According to manufacturers, efficiency levels beyond NEMA Premium would require a significant level of investment from all electric motor manufacturers and would cause the U.S. to be out of sync with the electric motor standards around the world. If standards required the use of copper rotors, manufacturers would experience further difficulties due to the potential increase in copper prices and the volatility of the copper market, as well as the potential safety concerns regarding the higher melting temperature of copper than aluminum.

b. Increase in Equipment Repairs

Manufacturers have stated that as energy conservation standards increase customers are more likely to rewind old, less efficient motors, as opposed to purchasing newer more efficient and compliant motors. Therefore, if motor standards significantly increase the price of motors, manufacturers believe rewinding older motors might become a more attractive option for some customers. These customers would in turn be using more energy than if they simply purchased a currently compliant motor, since rewound motors typically do not operate at their original efficiency level after being rewound. Manufacturers believe that DOE must take the potential consumer rewinding decision into account when deciding on an electric motors standard.

c. Enforcement

Manufacturers have stated that one of their biggest concerns with additional energy conservation standards is the lack of enforcement of current electric motor standards. In general, domestic manufacturers have stated they comply with the current electric motor regulations and will continue to comply with any future standards. However, these manufacturers believe that there are several foreign motor manufacturers that do not comply with the current electric motor regulations and will not comply with any future standards if the efficiency standards are increased. This would cause compliant manufacturers to be placed at a competitive disadvantage, since complying with any increased efficiency standards will be very costly. Some domestic manufacturers believe the most cost effective way to reduce energy consumption of electric motors is to more strictly enforce the existing electric motor standards rather than increase the efficiency standards of electric motors.

K. Emissions Analysis

In the emissions analysis, DOE estimated the reduction in power sector emissions of carbon dioxide (CO_2), nitrogen oxides (NO_X), sulfur dioxide (SO_2), and mercury (Hg) from potential energy conservation standards for electric motors. In addition, DOE estimates emissions impacts in production activities (extracting, processing, and transporting fuels) that provide the energy inputs to power plants. These are referred to as ''upstream'' emissions. Together, these emissions account for the full-fuel-cycle (FFC). In accordance with DOE's FFC Statement of Policy (76 FR 51282 (August 18, 2011) as amended at 77 FR 49701 (August 17, 2012)), the FFC analysis includes impacts on emissions of methane (CH_4) and nitrous oxide (N_2O, both of which are recognized as greenhouse gases.

DOE conducted the emissions analysis using emissions factors that were derived from data in the Energy Information Agency's (EIA's) *Annual Energy Outlook 2013* (*AEO 2013*), supplemented by data from other sources. DOE developed separate emissions factors for power sector emissions and upstream emissions. The method that DOE used to derive emissions factors is described in chapter 13 of the NOPR TSD.

EIA prepares the *Annual Energy Outlook* using the National Energy Modeling System (NEMS). Each annual version of NEMS incorporates the projected impacts of existing air quality regulations on emissions. *AEO 2013* generally represents current legislation and environmental regulations, including recent government actions, for which implementing regulations were available as of December 31, 2012.

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). SO_2 emissions from 28 eastern states and DC were also limited under the Clean Air Interstate Rule (CAIR; 70 FR 25162 (May 12, 2005)), which created an allowance-based trading program that operates along with the Title IV program. CAIR was remanded to the U.S. Environmental Protection Agency (EPA) by the U.S. Court of Appeals for the District of Columbia Circuit but it remained in effect. See *North Carolina* v. *EPA,* 550 F.3d 1176 (D.C. Cir. 2008); *North Carolina* v. *EPA,* 531 F.3d 896 (D.C. Cir. 2008). On July 6, 2011 EPA issued a replacement for CAIR, the Cross-State Air Pollution Rule (CSAPR). 76 FR 48208 (August 8, 2011). On August 21, 2012, the DC Circuit issued a decision to vacate CSAPR. See *EME Homer City Generation, LP* v. *EPA,* No. 11–1302, 2012 WL 3570721 at *24 (D.C. Cir. Aug.

21, 2012). The court ordered EPA to continue administering CAIR. The *AEO 2013* emissions factors used for today's NOPR assumes that CAIR remains a binding regulation through 2040.

The attainment of emissions caps is typically flexible among EGUs and is enforced through the use of emissions allowances and tradable permits. Under existing EPA regulations, any excess SO_2 emissions allowances resulting from the lower electricity demand caused by the adoption of an efficiency standard could be used to permit offsetting increases in SO_2 emissions by any regulated EGU. In past rulemakings, DOE recognized that there was uncertainty about the effects of efficiency standards on SO_2 emissions covered by the existing cap-and-trade system, but it concluded that negligible reductions in power sector SO_2 emissions would occur as a result of standards.

Beginning in 2015, however, SO_2 emissions will fall as a result of the Mercury and Air Toxics Standards (MATS) for power plants. 77 FR 9304 (Feb. 16, 2012). In the final MATS rule, EPA established a standard for hydrogen chloride as a surrogate for acid gas hazardous air pollutants (HAP), and also established a standard for SO_2 (a non-HAP acid gas) as an alternative equivalent surrogate standard for acid gas HAP. The same controls are used to reduce HAP and non-HAP acid gas; thus, SO_2 emissions will be reduced as a result of the control technologies installed on coal-fired power plants to comply with the MATS requirements for acid gas. *AEO 2013* assumes that, in order to continue operating, coal plants must have either flue gas desulfurization or dry sorbent injection systems installed by 2015. Both technologies, which are used to reduce acid gas emissions, also reduce SO_2 emissions. Under the MATS, NEMS shows a reduction in SO_2 emissions when electricity demand decreases (e.g., as a result of energy efficiency standards). Emissions will be far below the cap established by CAIR, so it is unlikely that excess SO_2 emissions allowances resulting from the lower electricity demand would be needed or used to permit offsetting increases in SO_2 emissions by any regulated EGU. Therefore, DOE believes that efficiency standards will reduce SO_2 emissions in 2015 and beyond.

CAIR established a cap on NO_X emissions in 28 eastern States and the District of Columbia. Energy conservation standards are expected to have little effect on NO_X emissions in those States covered by CAIR because excess NO_X emissions allowances resulting from the lower electricity demand could be used to permit offsetting increases in NO_X emissions. However, standards would be expected to reduce NO_X emissions in the States not affected by the caps, so DOE estimated NO_X emissions reductions from the standards considered in today's NOPR for these States.

The MATS limit mercury emissions from power plants, but they do not include emissions caps and, as such, DOE's energy conservation standards would likely reduce Hg emissions. DOE estimated mercury emissions reduction using emissions factors based on *AEO 2013,* which incorporates the MATS.

NEMA commented that DOE should consider emissions related to all aspects involved in the production of higher efficiency motors. (NEMA, No. 54 at p. 31) In response, DOE notes that EPCA directs DOE to consider the total projected amount of energy, or as applicable, water, savings likely to result directly from the imposition of the standard when determining whether a standard is economically justified. (42 U.S.C. 6295(o)(2)(B)(i)(III) and 6316(a)) DOE interprets this to include energy used in the generation, transmission, and distribution of fuels used by appliances or equipment. In addition, DOE is using the full-fuel-cycle measure, which includes the energy consumed in extracting, processing, and transporting primary fuels. DOE's current accounting of primary energy savings and the full-fuel-cycle measure are directly linked to the energy used by appliances or equipment. DOE believes that energy used in manufacturing of appliances or equipment falls outside the boundaries of ''directly'' as intended by EPCA. Thus, DOE did not consider such energy use and air emissions in the NIA or in the emissions analysis.

L. Monetizing Carbon Dioxide and Other Emissions Impacts

As part of the development of this proposed rule, DOE considered the estimated monetary benefits from the reduced emissions of CO_2 and NO_X that are expected to result from each of the TSLs considered. In order to make this calculation similar to the calculation of the NPV of consumer benefit, DOE considered the reduced emissions expected to result over the lifetime of equipment shipped in the forecast period for each TSL. This section summarizes the basis for the monetary values used for each of these emissions and presents the values considered in this rulemaking.

For today's NOPR, DOE is relying on a set of values for the social cost of carbon (SCC) that was developed by an interagency process. A summary of the basis for these values is provided below, and a more detailed description of the methodologies used is provided as an appendix to chapter 14 of the NOPR TSD.

1. Social Cost of Carbon

The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services. Estimates of the SCC are provided in dollars per metric ton of carbon dioxide. A domestic SCC value is meant to reflect the value of damages in the United States resulting from a unit change in carbon dioxide emissions, while a global SCC value is meant to reflect the value of damages worldwide.

Under section 1(b)(6) of Executive Order 12866, ''Regulatory Planning and Review,'' 58 FR 51735 (Oct. 4, 1993), agencies must, to the extent permitted by law, assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. The purpose of the SCC estimates presented here is to allow agencies to incorporate the monetized social benefits of reducing CO_2 emissions into cost-benefit analyses of regulatory actions that have small, or ''marginal,'' impacts on cumulative global emissions. The estimates are presented with an acknowledgement of the many uncertainties involved and with a clear understanding that they should be updated over time to reflect increasing knowledge of the science and economics of climate impacts.

As part of the interagency process that developed the SCC estimates, technical experts from numerous agencies met on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss key model inputs and assumptions. The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions grounded in the existing scientific and economic literatures. In this way, key uncertainties and model differences transparently and consistently inform the range of SCC estimates used in the rulemaking process.

a. Monetizing Carbon Dioxide Emissions

When attempting to assess the incremental economic impacts of carbon dioxide emissions, the analyst faces a number of serious challenges. A recent report from the National Research Council points out that any assessment will suffer from uncertainty, speculation, and lack of information about: (1) Future emissions of greenhouse gases; (2) the effects of past and future emissions on the climate system; (3) the impact of changes in climate on the physical and biological environment; and (4) the translation of these environmental impacts into economic damages. As a result, any effort to quantify and monetize the harms associated with climate change will raise serious questions of science, economics, and ethics and should be viewed as provisional.

Despite the serious limits of both quantification and monetization, SCC estimates can be useful in estimating the social benefits of reducing carbon dioxide emissions. Most Federal regulatory actions can be expected to have marginal impacts on global emissions. For such policies, the agency can estimate the benefits from reduced emissions in any future year by multiplying the change in emissions in that year by the SCC value appropriate for that year. The net present value of the benefits can then be calculated by multiplying the future benefits by an appropriate discount factor and summing across all affected years. This approach assumes that the marginal damages from increased emissions are constant for small departures from the baseline emissions path, an approximation that is reasonable for policies that have effects on emissions that are small relative to cumulative global carbon dioxide emissions. For policies that have a large (non-marginal) impact on global cumulative emissions, there is a separate question of whether the SCC is an appropriate tool for calculating the benefits of reduced emissions. This concern is not applicable to this rulemaking, however.

It is important to emphasize that the interagency process is committed to updating these estimates as the science and economic understanding of climate change and its impacts on society improves over time. In the meantime, the interagency group will continue to explore the issues raised by this analysis and consider public comments as part of the ongoing interagency process.

b. Social Cost of Carbon Values Used in Past Regulatory Analyses

Economic analyses for Federal regulations have used a wide range of values to estimate the benefits associated with reducing carbon dioxide emissions. In the final model year 2011 CAFE rule, the U.S. Department of Transportation (DOT) used both a ''domestic'' SCC value of $2 per metric ton of CO_2 and a ''global'' SCC value of $33 per metric ton of CO_2 for 2007 emission reductions (in 2007$), increasing both values at 2.4 percent per year. DOT also included a sensitivity analysis at $80 per metric ton of CO_2.[79] A 2008 regulation proposed by DOT assumed a domestic SCC value of $7 per metric ton of CO_2 (in 2006$) for 2011 emission reductions (with a range of $0–$14 for sensitivity analysis), also increasing at 2.4 percent per year.[80] A regulation for packaged terminal air conditioners and packaged terminal heat pumps finalized by DOE in October of 2008 used a domestic SCC range of $0 to $20 per metric ton CO_2 for 2007 emission reductions (in 2007$). 73 FR 58772, 58814 (Oct. 7, 2008). In addition, EPA's 2008 Advance Notice of Proposed Rulemaking on Regulating Greenhouse Gas Emissions Under the Clean Air Act identified what it described as ''very preliminary'' SCC estimates subject to revision. 73 FR 44354 (July 30, 2008). EPA's global mean values were $68 and $40 per metric ton CO_2 for discount rates of approximately 2 percent and 3 percent, respectively (in 2006$ for 2007 emissions).

In 2009, an interagency process was initiated to offer a preliminary assessment of how best to quantify the benefits from reducing carbon dioxide emissions. To ensure consistency in how benefits are evaluated across agencies, the Administration sought to develop a transparent and defensible method, specifically designed for the rulemaking process, to quantify avoided climate change damages from reduced CO_2 emissions. The interagency group did not undertake any original analysis. Instead, it combined SCC estimates from the existing literature to use as interim values until a more comprehensive analysis could be conducted. The outcome of the preliminary assessment by the interagency group was a set of five interim values: Global SCC estimates for 2007 (in 2006$) of $55, $33, $19, $10, and $5 per metric ton of CO_2. These interim values represented the first sustained interagency effort within the U.S. government to develop an SCC for use in regulatory analysis. The results of this preliminary effort were presented in several proposed and final rules.

c. Current Approach and Key Assumptions

Since the release of the interim values, the interagency group reconvened on a regular basis to generate improved SCC estimates. Specifically, the group considered public comments and further explored the technical literature in relevant fields. The interagency group relied on three integrated assessment models commonly used to estimate the SCC: The FUND, DICE, and PAGE models. These models are frequently cited in the peer-reviewed literature and were used in the last assessment of the Intergovernmental Panel on Climate Change. Each model was given equal weight in the SCC values that were developed.

Each model takes a slightly different approach to model how changes in emissions result in changes in economic damages. A key objective of the interagency process was to enable a consistent exploration of the three models while respecting the different approaches to quantifying damages taken by the key modelers in the field. An extensive review of the literature was conducted to select three sets of input parameters for these models: climate sensitivity, socio-economic and emissions trajectories, and discount rates. A probability distribution for climate sensitivity was specified as an input into all three models. In addition, the interagency group used a range of scenarios for the socio-economic parameters and a range of values for the discount rate. All other model features were left unchanged, relying on the model developers' best estimates and judgments.

In 2010, the interagency group selected four sets of SCC values for use in regulatory analyses.[81] Three sets of

[79] See *Average Fuel Economy Standards Passenger Cars and Light Trucks Model Year 2011,* 74 FR 14196 (March 30, 2009) (Final Rule); Final Environmental Impact Statement Corporate Average Fuel Economy Standards, Passenger Cars and Light Trucks, Model Years 2011–2015 at 3–90 (Oct. 2008) (Available at: *http://www.nhtsa.gov/fuel-economy*) (Last accessed December 2012).

[80] See *Average Fuel Economy Standards, Passenger Cars and Light Trucks, Model Years 2011–2015,* 73 FR 24352 (May 2, 2008) (Proposed Rule); Draft Environmental Impact Statement Corporate Average Fuel Economy Standards, Passenger Cars and Light Trucks, Model Years 2011–2015 at 3–58 (June 2008) (Available at: *http://www.nhtsa.gov/fuel-economy*) (Last accessed December 2012).

[81] *Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.* Interagency Working Group on Social Cost of Carbon, United States Government, February 2010. *http://*

values are based on the average SCC from three integrated assessment models, at discount rates of 2.5 percent, 3 percent, and 5 percent. The fourth set, which represents the 95th-percentile SCC estimate across all three models at a 3-percent discount rate, is included to represent higher-than-expected impacts from climate change further out in the tails of the SCC distribution. The values grow in real terms over time. Additionally, the interagency group determined that a range of values from 7 percent to 23 percent should be used to adjust the global SCC to calculate domestic effects, although preference is given to consideration of the global benefits of reducing CO_2 emissions. Table IV.26 presents the values in the 2010 interagency group report, which is reproduced in appendix 14–A of the NOPR TSD.

TABLE IV.26—ANNUAL SCC VALUES FROM 2010 INTERAGENCY REPORT, 2010–2050

[In 2007 dollars per metric ton CO_2]

Year	Discount rate %			
	5	3	2.5	3
	Average	Average	Average	95th Percentile
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3
2045	14.2	42.1	61.7	127.8
2050	15.7	44.9	65.0	136.2

The SCC values used for today's notice were generated using the most recent versions of the three integrated assessment models that have been published in the peer-reviewed literature.[82] Table IV.27shows the updated sets of SCC estimates from the 2013 interagency update in five-year increments from 2010 to 2050. Appendix 14A of the NOPR TSD provides the full set of values. The central value that emerges is the average SCC across models at 3-percent discount rate. However, for purposes of capturing the uncertainties involved in regulatory impact analysis, the interagency group emphasizes the importance of including all four sets of SCC values.

TABLE IV.27—ANNUAL SCC VALUES FROM 2013 INTERAGENCY UPDATE, 2010–2050

[In 2007 dollars per metric ton CO_2]

Year	Discount rate %			
	5	3	2.5	3
	Average	Average	Average	95th Percentile
2010	11	32	51	89
2015	11	37	57	109
2020	12	43	64	128
2025	14	47	69	143
2030	16	52	75	159
2035	19	56	80	175
2040	21	61	86	191
2045	24	66	92	206
2050	26	71	97	220

It is important to recognize that a number of key uncertainties remain, and that current SCC estimates should be treated as provisional and revisable since they will evolve with improved scientific and economic understanding. The interagency group also recognizes that the existing models are imperfect and incomplete. The National Research Council report mentioned above points out that there is tension between the goal of producing quantified estimates of the economic damages from an incremental ton of carbon and the limits of existing efforts to model these effects. There are a number of concerns and problems that should be addressed by the research community, including research programs housed in many of the Federal agencies participating in the interagency process to estimate the SCC. The interagency group intends to periodically review and reconsider those estimates to reflect increasing knowledge of the science and economics of climate impacts, as well as improvements in modeling.

In summary, in considering the potential global benefits resulting from reduced CO_2 emissions resulting from today's rule, DOE used the values from the 2013 interagency report, adjusted to 2012$ using the Gross Domestic Product

www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf.

[82] *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.* Interagency Working Group on Social Cost of Carbon, United States Government. May 2013; revised November 2013.*http://www.whitehouse.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf.*

price deflator. For each of the four cases specified, the values used for emissions in 2015 were $11.8, $39.7, $61.2, and $117 per metric ton avoided (values expressed in 2012$). DOE derived values after 2050 using the relevant growth rate for the 2040–2050 period in the interagency update.

DOE multiplied the CO_2 emissions reduction estimated for each year by the SCC value for that year in each of the four cases. To calculate a present value of the stream of monetary values, DOE discounted the values in each of the four cases using the specific discount rate that had been used to obtain the SCC values in each case.

2. Valuation of Other Emissions Reductions

DOE investigated the potential monetary benefit of reduced NO_X emissions from the TSLs it considered. As noted above, DOE has taken into account how new or amended energy conservation standards would reduce NO_X emissions in those 22 states not affected by the CAIR. DOE estimated the monetized value of NO_X emissions reductions resulting from each of the TSLs considered for today's NOPR based on estimates found in the relevant scientific literature. Available estimates suggest a very wide range of monetary values per ton of NO_X from stationary sources, ranging from $468 to $4,809 per ton in 2012$).[83] In accordance with OMB guidance,[84] DOE calculated a range of monetary benefits using each of the economic values for NO_X and real discount rates of 3-percent and 7-percent.

DOE is evaluating appropriate monetization of avoided SO_2 and Hg emissions in energy conservation standards rulemakings. It has not included monetization in the current analysis.

M. Utility Impact Analysis

The utility impact analysis estimates several effects on the power generation industry that would result from the adoption of new or amended energy conservation standards. In the utility impact analysis, DOE analyzes the changes in installed electricity capacity and generation that would result for each trial standard level. The utility impact analysis uses a variant of NEMS,[85] which is a public domain, multi-sectored, partial equilibrium model of the U.S. energy sector. DOE uses a variant of this model, referred to as NEMS–BT,[86] to account for selected utility impacts of new or amended energy conservation standards. DOE's analysis consists of a comparison between model results for the most recent *AEO* Reference Case and for cases in which energy use is decremented to reflect the impact of potential standards. The energy savings inputs associated with each TSL come from the NIA. Chapter 15 of the NOPR TSD describes the utility impact analysis in further detail.

N. Employment Impact Analysis

Employment impacts from new or amended energy conservation standards include direct and indirect impacts. Direct employment impacts are any changes in the number of employees of manufacturers of the equipment subject to standards; 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 equipment. Indirect employment impacts from standards consist of the jobs created or eliminated in the national economy, other than in the manufacturing sector being regulated, due to: (1) Reduced spending by end users on energy; (2) reduced spending on new energy supply by the utility industry; (3) increased consumer spending on the purchase of new equipment; and (4) the effects of those three factors throughout the economy.

One method for assessing the possible effects on the demand for labor of such shifts in economic activity is to compare sector employment statistics developed by the Labor Department's Bureau of Labor Statistics (BLS). BLS regularly publishes its estimates of the number of jobs per million dollars of economic activity in different sectors of the economy, as well as the jobs created elsewhere in the economy by this same economic activity. Data from BLS indicate that expenditures in the utility sector generally create fewer jobs (both directly and indirectly) than expenditures in other sectors of the economy. 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, based on the BLS data alone, DOE believes net national employment may increase because of shifts in economic activity resulting from new and amended standards.

For the standard levels considered in the NOPR, DOE estimated indirect national employment impacts using an input/output model of the U.S. economy called Impact of Sector Energy Technologies, Version 3.1.1 (ImSET). 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 the 187 sectors. ImSET's national economic I–O structure is based on a 2002 U.S. benchmark table, specially aggregated to the 187 sectors most relevant to industrial, commercial, and residential building energy use. DOE notes that ImSET is not a general equilibrium forecasting model, and understands the uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Because ImSET does not incorporate price changes, the employment effects predicted by ImSET may over-estimate actual job impacts over the long run. For the NOPR, DOE used ImSET only to estimate short-term employment impacts.

For more details on the employment impact analysis, see chapter 16 of the NOPR TSD.

O. Other Comments Received

IECA commented that motor end-users have not participated in DOE's electric motor standards process, and they urge DOE to provide an outreach effort to include those who buy motors. (IECA, No. 52 at p. 3) Throughout the rulemaking process, DOE makes a

[83] For additional information, refer to U.S. Office of Management and Budget, Office of Information and Regulatory Affairs, *2006 Report to Congress on the Costs and Benefits of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities,* Washington, DC.

[84] OMB, Circular A–4: Regulatory Analysis (Sept. 17, 2003).

[85] For more information on NEMS, refer to the U.S. Department of Energy, Energy Information Administration documentation. A useful summary is *National Energy Modeling System: An Overview 2003,* DOE/EIA–0581(2003) (March, 2003).

[86] DOE/EIA approves use of the name NEMS to describe only an official version of the model without any modification to code or data. Because this analysis entails some minor code modifications and the model is run under various policy scenarios that are variations on DOE/EIA assumptions, DOE refers to it by the name ''NEMS–BT'' (''BT'' is DOE's Building Technologies Program, under whose aegis this work has been performed).

considerable effort to understand rulemaking impacts to consumers, most specifically in the life-cycle cost analysis. It encourages various interested parties, including end-users of electric motors, to attend public meetings and submit comments. DOE recognizes the central importance of the consumer perspective, and welcomes comment from IECA and any other organizations serving consumer interest, as well as from individual consumers, themselves.

V. Analytical Results

A. Trial Standard Levels

DOE ordinarily considers several Trial Standard Levels (TSLs) in its analytical process. TSLs are formed by grouping different Efficiency Levels (ELs), which are standard levels for each Equipment Class Grouping (ECG) of motors. DOE analyzed the benefits and burdens of the TSLs developed for today's proposed rule. DOE examined four TSLs for electric motors. Table V.1 presents the TSLs analyzed and the corresponding efficiency level for each equipment class group.

The efficiency levels in each TSL can be characterized as follows: TSL 1 represents each equipment class group moving up one efficiency level from the current baseline, with the exception of fire-pump motors, which remain at their baseline level; TSL 2 represents NEMA Premium levels for all equipment class groups with the exception of fire-pump motors, which remain at the baseline; TSL 3 represents 1 NEMA band above NEMA Premium for all groups except fire-pump motors, which move up to NEMA Premium; and TSL 4 represents the maximum technologically feasible level (max tech) for all equipment class groups. Because today's proposal includes equipment class groups containing both currently regulated motors and those proposed to be regulated, at certain TSLs, an equipment class group may encompass different standard levels, some of which may be above one EL above the baseline. For example, at TSL1, EL1 is being proposed for equipment class group 1. However, a large number of motors in equipment class group 1 already have to meet EL2. If TSL1 was selected, these motors would continue to be required to meet the standards at TSL2, while currently un-regulated motors would be regulated to TSL1.

TABLE V.1—SUMMARY OF PROPOSED TSLS

Equipment class group	TSL 1	TSL 2	TSL 3	TSL 4
1	EL 1	EL 2	EL 3	EL 4
2	EL 1	EL 1	EL 2	EL 2
3	EL 0	EL 0	EL 1	EL 3
4	EL 1	EL 2	EL 3	EL 4

B. Economic Justification and Energy Savings

As discussed in section II.A, EPCA provides seven factors to be evaluated in determining whether a potential energy conservation standard is economically justified. (42 U.S.C. 6295(o)(2)(B)(i)) The following sections generally discuss how DOE is addressing each of those seven factors in this rulemaking.

1. Economic Impacts on Individual Customers

DOE analyzed the economic impacts on electric motor customers by looking at the effects standards would have on the LCC and PBP. DOE also examined the rebuttable presumption payback periods for each equipment class, and the impacts of potential standards on customer subgroups. These analyses are discussed below.

a. Life-Cycle Cost and Payback Period

To evaluate the net economic impact of standards on electric motor customers, DOE conducted LCC and PBP analyses for each TSL. In general, higher-efficiency equipment would affect customers in two ways: (1) Annual operating expense would decrease, and (2) purchase price would increase. Section IV.F of this notice discusses the inputs DOE used for calculating the LCC and PBP. The LCC and PBP results are calculated from electric motor cost and efficiency data that are modeled in the engineering analysis (section IV.C).

For each representative unit, the key outputs of the LCC analysis are a mean LCC savings and a median PBP relative to the base case, as well as the fraction of customers for which the LCC will decrease (net benefit), increase (net cost), or exhibit no change (no impact) relative to the base-case product forecast. No impacts occur when the base-case efficiency equals or exceeds the efficiency at a given TSL. Table V.2 through Table V.5 show the key shipment weighted average of results for the representative units in each equipment class group.

TABLE V.2—SUMMARY LIFE-CYCLE COST AND PAYBACK PERIOD RESULTS FOR EQUIPMENT CLASS GROUP 1

Trial standard level *	1	2	3	4
Efficiency level	1	2	3	4
Customers with Net LCC Cost (%) **	0.3	8.4	38.0	84.6
Customers with Net LCC Benefit (%) **	9.7	32.0	40.4	7.6
Customers with No Change in LCC (%) **	90.0	59.6	21.5	7.7
Mean LCC Savings ($)	43	132	68	−417
Median PBP (Years)	1.1	3.3	6.7	29.9

* The results for equipment class group 1 are the shipment weighted averages of the results for representative units 1, 2, and 3.
** Rounding may cause some items to not total 100 percent.

TABLE V.3—SUMMARY LIFE-CYCLE COST AND PAYBACK PERIOD RESULTS FOR EQUIPMENT CLASS GROUP 2

Trial Standard level *	1	2	3	4
Efficiency level	1	1	2	2
Customers with Net LCC Cost (%) **	21.5	21.5	94.7	94.7
Customers with Net LCC Benefit (%) **	68.6	68.6	5.3	5.3
Customers with No Change in LCC (%) **	9.9	9.9	0.0	0.0
Mean LCC Savings ($)	38	38	−285	−285
Median PBP (Years)	5.0	5.0	22.8	22.8

* The results for equipment class group 2 are the shipment weighted averages of the results for representative units 4 and 5.
** Rounding may cause some items to not total 100 percent.

TABLE V.4—SUMMARY LIFE-CYCLE COST AND PAYBACK PERIOD RESULTS FOR EQUIPMENT CLASS GROUP 3

Trial standard level *	1	2	3	4
Efficiency level	0	0	1	3
Customers with Net LCC Cost (%) **	0.0	0.0	81.7	100.0
Customers with Net LCC Benefit (%) **	0.0	0.0	0.0	0.0
Customers with No Change in LCC (%) **	0.0	0.0	18.3	0.0
Mean LCC Savings ($)	N/A ***	N/A ***	−61	−763
Median PBP (Years)	N/A ***	N/A ***	3,299	11,957

* The results for equipment class group 3 are the shipment weighted averages of the results for representative units 6, 7, and 8.
** Rounding may cause some items to not total 100 percent.
*** For equipment class group 3, TSL 1 and 2 are the same as the baseline; thus, no customers are affected.

TABLE V.5—SUMMARY LIFE-CYCLE COST AND PAYBACK PERIOD RESULTS FOR EQUIPMENT CLASS GROUP 4

Trial standard level *	1	2	3	4
Efficiency level	1	2	3	4
Customers with Net LCC Cost (%) **	1.0	10.8	33.1	79.6
Customers with Net LCC Benefit (%) **	31.8	60.8	65.8	19.9
Customers with No Change in LCC (%) **	67.3	28.4	1.1	0.3
Mean LCC Savings ($)	137	259	210	−291
Median PBP (Years)	1.2	1.9	3.7	16.0

* The results for equipment class group 4 are the shipment weighted averages of the results for representative units 9 and 10.
** Rounding may cause some items to not total 100 percent.

b. Consumer Subgroup Analysis

In the customer subgroup analysis, DOE estimated the LCC impacts of the electric motor TSLs on various groups of customers. Table V.6 and Table V.7 compare the weighted average mean LCC savings and median payback periods for ECG 1 at each TSL for different customer subgroups.

Chapter 11 of the TSD presents the detailed results of the customer subgroup analysis and results for the other equipment class groups.

TABLE V.6—SUMMARY LIFE-CYCLE COST RESULTS FOR SUBGROUPS FOR EQUIPMENT CLASS GROUP 1: AVERAGE LCC SAVINGS

EL	TSL	Average LCC savings (2012$) *					
		Default	Low energy price	Small business	Industrial sector only	Commercial sector only	Agricultural sector only
1	1	43	38	37	53	40	16
2	2	132	115	111	169	118	5
3	3	68	46	45	111	53	−103
4	4	−417	−447	−448	−356	−440	−675

* The results for equipment class group 1 are the shipment weighted averages of the results for representative units 1, 2, and 3.

TABLE V.7—SUMMARY LIFE-CYCLE COST RESULTS FOR SUBGROUPS FOR EQUIPMENT CLASS GROUP 1: MEDIAN PAYBACK PERIOD

EL	TSL	Median payback period (Years) *					
		Default	Low energy price	Small business	Industrial sector only	Commercial sector only	Agricultural sector only
1	1	1.1	1.3	1.1	0.8	1.3	3.5
2	2	3.3	3.7	3.3	2.1	3.9	7.0
3	3	6.7	7.6	6.7	4.2	7.9	22.7
4	4	29.9	33.7	29.9	18.8	34.7	123.5

* The results for equipment class group 1 are the shipment weighted averages of the results for representative units 1, 2, and 3.

c. Rebuttable Presumption Payback

As discussed in section IV.F.12, EPCA establishes a rebuttable presumption that an energy conservation standard is economically justified if the increased purchase cost for equipment that meets the standard is less than three times the value of the first-year energy savings resulting from the standard. (42 U.S.C. 6295(o)(2)(B)(iii) and 6316(a)) DOE calculated a rebuttable-presumption PBP for each TSL to determine whether DOE could presume that a standard at that level is economically justified. DOE based the calculations on average usage profiles. As a result, DOE calculated a single rebuttable-presumption payback value, and not a distribution of PBPs, for each TSL. Table V.8 shows the rebuttable-presumption PBPs for the considered TSLs. The rebuttable presumption is fulfilled in those cases where the PBP is three years or less. However, DOE routinely conducts an economic analysis that considers the full range of impacts to the customer, manufacturer, Nation, and environment, as required under 42 U.S.C. 6295(o)(2)(B)(i) as applied to equipment via 42 U.S.C. 6316(a). 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 three-year PBP analysis). Section V.C addresses how DOE considered the range of impacts to select today's NOPR.

TABLE V.8—REBUTTABLE-PRESUMPTION PAYBACK PERIODS (YEARS)

	Trial standard level			
	1	2	3	4
Equipment Class Group 1*	0.6	0.8	1.2	4.3
Equipment Class Group 2*	1.8	1.8	8.0	8.0
Equipment Class Group 3*	0.0	0.0	900	5,464
Equipment Class Group 4*	0.6	0.9	1.3	4.5

* The results for each equipment class group (ECG) are a shipment weighted average of results for the representative units in the group. ECG 1: Representative units 1, 2, and 3; ECG 2: Representative units 4 and 5; ECG 3: Representative units 6, 7, and 8; ECG 4: Representative units 9 and10.

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 section below describes the expected impacts on manufacturers at each TSL. Chapter 12 of the TSD explains the analysis in further detail.

The tables below depict the financial impacts (represented by changes in INPV) of new and amended energy conservation standards on manufacturers as well as the conversion costs that DOE estimates manufacturers would incur at each TSL. DOE displays the INPV impacts by TSL for each ECG in accordance with the grouping described in detail in section V.A. To evaluate the range of cash flow impacts on the electric motor industry, DOE modeled three markup scenarios that correspond to the range of anticipated market responses to new and amended standards. Each markup scenario results in a unique set of cash flows and corresponding industry value at each TSL. All three markup scenarios are presented below. In the following discussion, the INPV results refer to the difference in industry value between the base case and the standards case that result from the sum of discounted cash flows from the base year (2013) through the end of the analysis period. The results also discuss the difference in cash flow between the base case and the standards case in the year before the compliance date for new and amended energy conservation standards. This figure represents how large the required conversion costs are relative to the cash flow generated by the industry in the absence of new and amended energy conservation standards. In the engineering analysis, DOE enumerates common technology options that achieve the efficiencies for each of the representative units within an ECG. For descriptions of these technology options and the required efficiencies at each TSL, see section IV.C of today's notice.

a. Industry Cash-Flow Analysis Results

The results below show three INPV tables representing the three markup scenarios used for the analysis. The first table reflects the flat markup scenario, which is the upper (less severe) bound of impacts. To assess the lower end of the range of potential impacts, DOE modeled two potential markup scenarios, a two-tiered markup scenario and a preservation of operating profit markup scenario. As discussed in section IV.J.2.d, the two-tiered markup scenario assumes manufacturers offer two different tiers of markups—one for lower efficiency levels and one for higher efficiency levels. Meanwhile the preservation of operating profit markup scenario assumes that in the standards case, manufacturers would be able to earn the same operating margin in absolute dollars in the standards case as in the base case. In general, the larger the product price increases, the less likely manufacturers are able to fully pass through additional costs due to standards calculated in the flat markup scenario.

Table V.9, Table V.10, and Table V.11 present the projected results for all electric motors under the flat, two-tiered and preservation of operating profit markup scenarios. DOE examined all four ECGs (Design A and B motors, Design C motors, fire pump motors, and brake motors) together. The INPV results follow in the tables below.

TABLE V.9—MANUFACTURER IMPACT ANALYSIS FOR ELECTRIC MOTORS—FLAT MARKUP SCENARIO

	Units	Base case	Trial standard level			
			1	2	3	4
INPV	(2012$ millions)	$3,371.2	$3,378.7	$3,759.2	$4,443.7	$5,241.3
Change in INPV	(2012$ millions)		$7.5	$388.0	$1,072.5	$1,870.1
	(%)		0.2%	11.5%	31.8%	55.5%
Product Conversion Costs	(2012$ millions)		$6.1	$57.4	$611.7	$620.6
Capital Conversion Costs	(2012$ millions)		$0.0	$26.4	$220.5	$699.8
Total Conversion Costs	(2012$ millions)		$6.2	$83.7	$832.3	$1,320.4

TABLE V.10—MANUFACTURER IMPACT ANALYSIS FOR ELECTRIC MOTORS—TWO-TIERED MARKUP SCENARIO

	Units	Base case	Trial standard level			
			1	2	3	4
INPV	(2012$ millions)	$3,371.2	$3,374.3	$3,087.6	$2,979.6	$3,335.7
Change in INPV	(2012$ millions)		$3.2	$(283.5)	$(391.6)	$(35.5)
	(%)		0.1%	−8.4%	−11.6%	−1.1%
Product Conversion Costs	(2012$ millions)		$6.1	$57.4	$611.7	$620.6
Capital Conversion Costs	(2012$ millions)		$0.0	$26.4	$220.5	$699.8
Total Conversion Costs	(2012$ millions)		$6.2	$83.7	$832.3	$1,320.4

TABLE V.11—MANUFACTURER IMPACT ANALYSIS FOR ELECTRIC MOTORS—PRESERVATION OF OPERATING PROFIT MARKUP SCENARIO

	Units	Base case	Trial standard level			
			1	2	3	4
INPV	(2012$ millions)	$3,371.2	$3,019.5	$3,089.7	$2,356.8	$1,383.1
Change in INPV	(2012$ millions)		$(351.7)	$(281.5)	$(1,014.4)	$(1,988.1)
	(%)		−10.4%	−8.4%	−30.1%	−59.0%
Product Conversion Costs	(2012$ millions)		$6.1	$57.4	$611.7	$620.6
Capital Conversion Costs	(2012$ millions)		$0.0	$26.4	$220.5	$699.8
Total Conversion Costs	(2012$ millions)		$6.2	$83.7	$832.3	$1,320.4

TSL 1 represents EL 1 for ECG 1, ECG 2 and ECG 4 motors and baseline for ECG 2 motors. At TSL 1, DOE estimates impacts on INPV to range from $7.5 million to −$351.7 million, or a change in INPV of 0.2 percent to −10.4 percent. At this proposed level, industry free cash flow is estimated to decrease by approximately 1.1 percent to $164.9 million, compared to the base case value of $166.7 million in the year leading up to the proposed energy conservation standards.

The INPV impacts at TSL 1 range from slightly positive to moderately negative, however DOE does not anticipate that manufacturers would lose a significant portion of their INPV at this TSL. This is because the vast majority of shipments already meets or exceeds the efficiency levels prescribed at TSL 1. DOE estimates that in the year of compliance, 90 percent of all electric motor shipments (90 percent of ECG 1, eight percent of ECG 2, 100 percent of ECG 3, and 67 percent of ECG 4 shipments) would meet the efficiency levels at TSL 1 or higher in the base case. Since ECG 1 shipments account for over 97 percent of all electric motor shipments the effects on those motors are the primary driver for the impacts at this TSL. Only a few ECG 1 shipments not currently covered by the existing electric motors rule and a small amount of ECG 2 and ECG 4 shipments would need to be converted at TSL 1 to meet this efficiency standard.

DOE expects conversion costs to be small compared to the industry value because most of the electric motor shipments, on a volume basis, already meet the efficiency levels analyzed at this TSL. DOE estimates product conversion costs of $6.1 million due to the proposed expanded scope of this rulemaking which includes motors previously not covered by the current electric motor energy conservation standards. DOE believes that at this TSL, there will be some engineering costs as well as testing and certification costs associated with this proposed scope expansion. DOE estimates the capital conversion costs to be minimal at TSL 1. This is mainly because almost all manufacturers currently produce some motors that are compliant at TSL 1 efficiency levels and it would not be much of a capital investment to bring all motor production to this efficiency level.

TSL 2 represents EL 2 for ECG 1 and ECG 4 motors; EL 1 for ECG 2 motors; and baseline for ECG 3 motors. At TSL 2, DOE estimates impacts on INPV to range from $388 million to −$283.5 million, or a change in INPV of 11.5 percent to −8.4 percent. At this proposed level, industry free cash flow is estimated to decrease by approximately 17.2 percent to $138 million, compared to the base case value of $166.7 million in the year leading up to the proposed energy conservation standards.

The INPV impacts at TSL 2 range from moderately positive to moderately negative. DOE estimates that in the year of compliance, 59 percent of all electric motor shipments (60 percent of ECG 1, eight percent of ECG 2, 100 percent of ECG 3, and 30 percent of ECG 4 shipments) would meet the efficiency levels at TSL 2 or higher in the base case. The majority of shipments are currently covered by an electric motors standard that requires general purpose Design A and B motors to meet this TSL. Therefore, only previously non-covered Design A and B motors and a few ECG 2 and ECG 4 motors would have to be converted at TSL 2 to meet this efficiency standard.

DOE expects conversion costs to increase significantly from TSL 1, however, these conversion costs do not represent a large portion of the base case INPV, since again the majority of electric motor shipments already meet the efficiency levels analyzed at this TSL. DOE estimates product conversion costs of $57.4 million due to the proposed expanded scope of this rulemaking, which includes motors previously not covered by the current electric motor energy conservation standards and the inclusion of ECG 2 and ECG 4 motors. DOE believes there will be sizable engineering costs as well as testing and certification costs at this TSL associated with this proposed scope expansion. DOE estimates the capital conversion costs to be approximately $26.4 million at TSL 2. While most manufacturers already produce at least some motors that are compliant at TSL 2, these manufacturers would likely have to invest in expensive machinery to bring all motor production to these efficiency levels.

TSL 3 represents EL 3 for ECG 1 and ECG 4 motors, EL 2 for ECG 2 motors and EL 1 for ECG 3 motors. At TSL 3, DOE estimates impacts on INPV to range from $1,072.5 million to −$1,014.4 million, or a change in INPV of 31.8 percent to −30.1 percent. At this proposed level, industry free cash flow is estimated to decrease by approximately 167.5 percent to −$112.5 million, compared to the base case value of $166.7 million in the year leading up to the proposed energy conservation standards.

The INPV impacts at TSL 3 range from significantly positive to significantly negative. DOE estimates that in the year of compliance, 23 percent of all electric motor shipments (24 percent of ECG 1, less than one percent of ECG 2, 19 percent of ECG 3, and four percent of ECG 4 shipments) would meet the efficiency levels at TSL 3 or higher in the base case. The majority of shipments would need to be converted to meet energy conservation standards at this TSL.

DOE expects conversion costs to increase significantly at TSL 3 and become a substantial investment for manufacturers. DOE estimates product conversion costs of $611.7 million at TSL 3, since most electric motors in the base case do not exceed the current motor standards set at NEMA Premium for Design A and B motors, which represent EL 2 for ECG 1. DOE believes there would be a massive reengineering effort that manufacturers would have to undergo to have all motors meet this TSL. Additionally, motor manufacturers would have to increase the efficiency levels for ECG 2, ECG 3, and ECG 4 motors. DOE estimates the capital conversion costs to be approximately $220.5 million at TSL 3. Most manufacturers would have to make significant investments to their production facilities in order to convert all their motors to be compliant at TSL 3.

TSL 4 represents EL 4 for ECG 1 and ECG 4 motors, EL 3 for ECG 3 motors and EL 2 for ECG 2 motors. At TSL 4, DOE estimates impacts on INPV to range from $1,870.1 million to −$1,988.1 million, or a change in INPV of 55.5 percent to −59.0 percent. At this proposed level, industry free cash flow is estimated to decrease by approximately 298.4 percent to −$330.8 million, compared to the base case value of $166.7 million in the year leading up to the proposed energy conservation standards.

The INPV impacts at TSL 4 range from significantly positive to significantly negative. DOE estimates that in the year of compliance only eight percent of all electric motor shipments (nine percent of ECG 1, less than one percent of ECG 2, zero percent of ECG 3, and less than one percent of ECG 4 shipments) would meet the efficiency levels at TSL 2 or higher in the base case. Almost all shipments would need to be converted to meet energy conservation standards at this TSL.

DOE expects conversion costs again to increase significantly from TSL 3 to TSL 4. Conversion costs at this TSL now represent a massive investment for electric motor manufacturers. DOE estimates product conversion costs of $620.6 million at TSL 4, which are the same conversion costs at TSL 3. DOE believes that manufacturers would need to completely reengineer almost all electric motors sold as well as test and certify those motors. DOE estimates capital conversion costs of $699.8 million at TSL 4. This is a significant increase in capital conversion costs from TSL 3 since manufacturers would need to adopt copper die-casting at this TSL. This technology requires a significant level of investment because the majority of the machinery would need to be replaced or significantly modified.

b. Impacts on Employment

DOE quantitatively assessed the impact of potential new and amended energy conservation standards on direct employment. DOE used the GRIM to estimate the domestic labor expenditures and number of domestic production workers in the base case and at each TSL from the announcement of any potential new and amended energy conservation standards in 2013 to the end of the analysis period in 2044. DOE used statistical data from the U.S. Census Bureau's 2011 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 product and the manufacturing production costs 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 the tables below 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 all existing production were moved outside of the U.S. While the results present a range of employment impacts following 2015, the sections below 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 NOPR TSD.

Based on 2011 ASM data and interviews with manufacturers, DOE estimates approximately 60 percent of electric motors 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 7,237 domestic production workers involved in manufacturing all electric motors covered by this rulemaking in 2015. The table below shows the range of potential impacts of new and amended energy conservation standards for all ECGs on U.S. production workers in the electric motor industry. However, because ECG 1 motors comprise more than 97 percent of the electric motors covered by this rulemaking, DOE believes that potential changes in domestic employment will be driven primarily by the standards that are selected for ECG 1, Design A and B electric motors.

TABLE V.12—POTENTIAL CHANGES IN THE TOTAL NUMBER OF ALL DOMESTIC ELECTRIC MOTOR PRODUCTION WORKERS IN 2015

Base case		Trial standard level			
		1	2	3	4
Total Number of Domestic Production Workers in 2015 (without changes in production locations)	7,237	7,270	7,420	8,287	15,883
Potential Changes in Domestic Production Workers in 2015 *		33 – 0	183 – (362)	1,050 – (3,619)	8,646 – (7,237)

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

Most manufacturers agree that any standards that involve expanding the scope of equipment required to meet NEMA Premium would not significantly change domestic employment levels. At this efficiency level (TSL 2), manufacturers would not be required to make major modifications to their production lines nor would they have to undertake new manufacturing processes. A few small business manufacturers who primarily make electric motors currently out of the scope of coverage, but whose equipment would be covered by new electric motor standards, could be impacted by efficiency standards at TSL 2. These impacts, including employment impacts, are discussed in section VI.B of today's NOPR. Overall, DOE believes there would not be a significant decrease in domestic employment levels at TSL 2. DOE created a lower bound of the potential loss of domestic employment at 362 employees for TSL 2. DOE estimated only five percent of the electric motors market is comprised of manufacturers that do not currently produce any motors at NEMA Premium efficiency levels. DOE estimated that at most five percent of domestic electric motor manufacturing could potentially move abroad or exit the market entirely. DOE similarly estimated that all electric motor manufacturers produce some electric motors at or above TSL 1 efficiency levels. Therefore, DOE does not believe that any potential loss of domestic employment would occur at TSL 1.

Manufacturers, however, cautioned that any standard set above NEMA Premium would require major changes to production lines, large investments in capital and labor, and would result in extensive stranded assets. This is largely because manufacturers would have to design and build motors with larger frame sizes and could potentially have to use copper, rather than aluminum rotors. Several manufacturers pointed out that this would require extensive retooling, vast engineering resources, and would ultimately result in a more labor-intensive production process. Manufacturers generally agreed that a shift toward copper rotors would have uncertain impacts on energy efficiency and would cause companies to incur higher labor costs. These factors could cause manufacturers to consider moving production offshore to reduce labor costs or they may choose to exit the market entirely. Therefore, DOE believes it is more likely that efficiency standards set above NEMA Premium could result in a decrease of labor. Accordingly, DOE set the lower bound on the potential loss of domestic employment at 50 percent of the existing domestic labor market for TSL 3 and 100 percent of the domestic labor market for TSL 4. However, these values represent the worst case scenario DOE modeled. Manufacturers also stated that larger motor manufacturing (that is for motors above 200 horsepower) would be very unlikely to move abroad since the shipping costs associated with those motors are very large. Consequently, DOE does not currently believe standards set at TSL 3 and TSL 4 would likely result in a large loss of domestic employment.

c. Impacts on Manufacturing Capacity

Most manufacturers agreed that any standard expanding the scope of equipment required to meet NEMA Premium would not have a significant impact on manufacturing capacity. Manufacturers pointed out, however, that a standard that required them to use copper rotors would severely disrupt manufacturing capacity. Most manufacturers emphasized 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 meet the demands of their customers. For manufacturers to either completely redesign their motor production lines or significantly expand their fairly limited copper rotor production line would require a massive retooling and engineering effort, which could take several years 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 three 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 difficult to support existing business while redesigning product lines and retooling. The need to support existing business would also cause the redesign effort to take several years.

In summary, for those TSLs that require copper rotors, DOE believes there is a likelihood of capacity constraints in the near term due to fluctuations in the copper market and limited copper die casting machinery and expertise. However, for the levels proposed in this rule, DOE does not foresee any capacity constraints.

d. Impacts on Sub-Group 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 subgroups for this rulemaking based on the results of the industry characterization.

e. Cumulative Regulatory Burden

While any one regulation may not impose a significant burden on manufacturers, the combined effects of recent or impending regulations may have serious consequences for some manufacturers, groups of manufacturers, or an entire industry. Assessing the impact of a single regulation may overlook this cumulative regulatory burden. In addition to energy conservation standards, other regulations can significantly affect manufacturers' financial operations. Multiple regulations affecting the same manufacturer can strain profits and lead companies to abandon product lines or markets with lower expected future returns than competing equipment. For these reasons, DOE conducts an analysis of cumulative regulatory burden as part of its rulemakings pertaining to appliance efficiency.

During previous stages of this rulemaking, DOE identified a number of requirements, in addition to new and amended energy conservation standards for electric motors, that manufacturers will face for equipment they manufacture approximately three years prior to and three years after the compliance date of the new and amended standards. The following section briefly addresses comments DOE received with respect to cumulative regulatory burden and summarizes other key related concerns that manufacturers raised during interviews.

Several manufacturers expressed concern about the compliance date of this rulemaking to the proximity of the 2015 compliance date for the small electric motors rulemaking at 75 FR 10874 (March 9, 2010). Most manufacturers of electric motors covered by this rulemaking also produce electric motors that are covered by the small electric motors rulemaking. Manufacturers stated that adopting these two regulations in a potentially short timeframe could strain R&D and capital expenditure budgets for motor manufacturers. Some manufacturers also raised concerns about other existing regulations separate from DOE's energy conservation standards that electric motors must meet: the National Fire Protection Association (NFPA) 70, National Electric Code; the NFPA 20, Standard for the Installation of Stationary Pumps for Fire Protection; and Occupational Safety and Health Administration (OSHA) regulations. DOE discusses these and other requirements in chapter 12 of the NOPR TSD. DOE takes into account the cost of compliance with other published Federal energy conservation standards in weighing the benefits and burdens of today's proposed rulemaking. In the 2010 small motors final rule, DOE estimated that manufacturers may lose up to 11.3 percent of their INPV, which was approximately $39.5 million, in 2009$. To see the range of impacts DOE estimated for the small motors rule, see chapter 12 of the NOPR TSD. DOE does not describe the quantitative impacts of standards that have not yet been finalized because any impacts would be highly speculative. DOE also notes that certain standards are optional for manufacturers and takes that into account when creating the cumulative regulatory burden analysis.

3. National Impact Analysis

a. Significance of Energy Savings

For each TSL, DOE projected energy savings for electric motors purchased in the 30-year period that begins in the year of compliance with new and amended standards (2015–2044). The savings are measured over the entire lifetime of equipment purchased in the 30-year period. DOE quantified the energy savings attributable to each TSL as the difference in energy consumption between each standards case and the base case. Table V.13 presents the estimated primary energy savings for each considered TSL, and Table V.14 presents the estimated FFC energy savings for each considered TSL. The approach for estimating national energy savings is further described in section IV.H.

TABLE V.13—CUMULATIVE PRIMARY ENERGY SAVINGS FOR ELECTRIC MOTORS TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2015–2044

Equipment class	Trial standard level			
	1	2	3	4
	quads			
Group 1 (NEMA Design A and B)	0.82	6.27	9.86	12.64

TABLE V.13—CUMULATIVE PRIMARY ENERGY SAVINGS FOR ELECTRIC MOTORS TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2015–2044—Continued

Equipment class	Trial standard level			
	1	2	3	4
Group 2 (NEMA Design C)	0.02	0.02	0.03	0.03
Group 3 (Fire Pump Electric Motors)	0.00	0.00	0.00	0.00
Group 4 (Brake Motors)	0.26	0.58	0.71	0.81
Total All Classes	1.10	6.87	10.60	13.49

TABLE V.14—CUMULATIVE FULL-FUEL-CYCLE ENERGY SAVINGS FOR ELECTRIC MOTORS TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2015–2044

Equipment class	Trial standard level			
	1	2	3	4
	quads			
Group 1 (NEMA Design A and B)	0.83	6.38	10.02	12.85
Group 2 (NEMA Design C)	0.02	0.02	0.03	0.03
Group 3 (Fire Pump Electric Motors)	0.00	0.00	0.00	0.00
Group 4 (Brake Motors)	0.26	0.59	0.73	0.83
Total All Classes	1.11	6.98	10.78	13.71

Circular A–4 requires agencies to present analytical results, including separate schedules of the monetized benefits and costs that show the type and timing of benefits and costs. Circular A–4 also directs agencies to consider the variability of key elements underlying the estimates of benefits and costs. For this rulemaking, DOE undertook a sensitivity analysis using nine rather than 30 years of equipment shipments. The choice of a nine-year period is a proxy for the timeline in EPCA for the review of certain energy conservation standards and potential revision of and compliance with such revised standards.[87] We would note that the review timeframe established in EPCA generally does not overlap with the equipment lifetime, equipment manufacturing cycles or other factors specific to electric motors. Thus, this information is presented for informational purposes only and is not indicative of any change in DOE's analytical methodology. The NES results based on a 9-year analytical period are presented in Table V.15. The impacts are counted over the lifetime of electric motors purchased in 2015–2023.

TABLE V.15—CUMULATIVE NATIONAL ENERGY SAVINGS FOR ELECTRIC MOTORS TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2015–2023

Equipment class	Trial standard level			
	1	2	3	4
	quads			
Group 1 (NEMA Design A and B)	0.355	1.440	2.168	2.833
Group 2 (NEMA Design C)	0.004	0.004	0.006	0.006
Group 3 (Fire Pump Electric Motors)	0.000	0.000	0.000	0.000
Group 4 (Brake Motors)	0.060	0.125	0.152	0.176
Total All Classes	0.420	1,569	2.326	3.015

b. Net Present Value of Customer Costs and Benefits

DOE estimated the cumulative NPV of the total costs and savings for customers that would result from the TSLs considered for electric motors. In accordance with OMB's guidelines on regulatory analysis,[88] DOE calculated the NPV using both a 7-percent and a 3-percent real discount rate. The 7-percent rate is an estimate of the average before-tax rate of return on private capital in the U.S. economy, and reflects the returns on real estate and small business capital as well as corporate capital. This discount rate approximates the opportunity cost of capital in the private sector (OMB analysis has found the average rate of return on capital to be near this rate). The 3-percent rate reflects the potential effects of standards on private consumption (*e.g.,* through higher prices for equipment and reduced purchases of energy). This rate represents the rate at which society discounts future consumption flows to

[87] 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 consumer products, the compliance period is 5 years rather than 3 years.

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

their present value. It can be approximated by the real rate of return on long-term government debt (*i.e.,* yield on United States Treasury notes), which has averaged about 3 percent for the past 30 years.

Table V.16 shows the customer NPV results for each TSL considered for electric motors. In each case, the impacts cover the lifetime of equipment purchased in 2015–2044.

TABLE V.16—NET PRESENT VALUE OF CUSTOMER BENEFITS FOR ELECTRIC MOTORS TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2015–2044

[Billion 2012$]

Equipment class	Discount rate %	Trial standard level			
		1	2	3	4
Group 1 (NEMA Design A and B)	3	4.5	20.7	1.5	−41.2
Group 2 (NEMA Design C)		0.0	0.0	0.0	0.0
Group 3 (Fire Pump Electric Motors)		0.0	0.0	0.0	0.0
Group 4 (Brake Motors)		1.3	2.5	1.5	−1.2
Total All Classes		5.8	23.3	3.0	−42.4
Group 1 (NEMA Design A and B)	7	2.2	7.7	−3.7	−29.1
Group 2 (NEMA Design C)		0.0	0.0	0.0	0.0
Group 3 (Fire Pump Electric Motors)		0.0	0.0	0.0	0.0
Group 4 (Brake Motors)		0.5	1.0	0.3	−1.2
Total All Classes		2.7	8.7	−3.4	−30.3

The NPV results based on the aforementioned 9-year analytical period are presented in Table V.17. The impacts are counted over the lifetime of equipment purchased in 2015–2023. As mentioned previously, this information is presented for informational purposes only and is not indicative of any change in DOE's analytical methodology or decision criteria.

TABLE V.17—NET PRESENT VALUE OF CUSTOMER BENEFITS FOR ELECTRIC MOTORS TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2015–2023

[Billion 2012$]

Equipment class	Discount rate %	Trial standard level			
		1	2	3	4
Group 1 (NEMA Design A and B)	3	2.253	6.473	2.541	−12.055
Group 2 (NEMA Design C)		0.011	0.011	−0.012	−0.012
Group 3 (Fire Pump Electric Motors)		0.000	0.000	−0.001	−0.009
Group 4 (Brake Motors)		0.389	0.706	0.495	−0.372
Total All Classes		2.654	7.190	3.023	−12.448
Group 1 (NEMA Design A and B)	7	1.344	3.492	−0.102	−12.017
Group 2 (NEMA Design C)		0.005	0.005	−0.016	−0.016
Group 3 (Fire Pump Electric Motors)		0.000	0.000	−0.001	−0.007
Group 4 (Brake Motors)		0.225	0.391	0.201	−0.498
Total All Classes		1.574	3.887	0.083	−12.537

c. Indirect Impacts on Employment

DOE expects energy conservation standards for electric motors to reduce energy costs for equipment owners, and the resulting net savings to be redirected to other forms of economic activity. Those shifts in spending and economic activity could affect the demand for labor. As described in section IV.N, DOE used an input/output model of the U.S. economy to estimate indirect employment impacts of the TSLs that DOE considered in this rulemaking. DOE understands that there are uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Therefore, DOE generated results for near-term time frames (2015–2019), where these uncertainties are reduced.

The results suggest that today's standards are likely to have 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 NOPR TSD presents detailed results.

4. Impact on Utility or Performance

DOE believes that the standards it is proposing today will not lessen the utility or performance of electric motors.

5. Impact of Any Lessening of Competition

DOE has also considered any lessening of competition that is likely to result from new and amended standards. The Attorney General determines the impact, if any, of any lessening of competition likely to result from a proposed standard, and transmits such determination to the Secretary, together with an analysis of the nature and extent of such impact. (42 U.S.C. 6295(o)(2)(B)(i)(V) and (B)(ii))

To assist the Attorney General in making such determination, DOE will provide DOJ with copies of this NOPR and the TSD for review. DOE will consider DOJ's comments on the proposed rule in preparing the final rule, and DOE will publish and respond to DOJ's comments in that document.

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 or costs of energy production. Reduced electricity demand due to energy conservation standards is also likely to reduce the cost of maintaining the reliability of the electricity system, particularly during peak-load periods. As a measure of this reduced demand, chapter 15 in the NOPR TSD presents the estimated reduction in generating capacity in 2044 for the TSLs that DOE considered in this rulemaking.

Energy savings from standards for electric motors could also produce environmental benefits in the form of reduced emissions of air pollutants and greenhouse gases associated with electricity production. Table V.18 provides DOE's estimate of cumulative emissions reductions projected to result from the TSLs considered in this rulemaking. DOE reports annual emissions reductions for each TSL in chapter 13 of the NOPR TSD.

TABLE V.18—CUMULATIVE EMISSIONS REDUCTION ESTIMATED FOR ELECTRIC MOTORS TRIAL STANDARD LEVELS

	Trial standard level			
	1	2	3	4
Primary Energy Emissions				
CO_2 (million metric tons)	62.4	374.1	576.0	733.3
NO_X (thousand tons)	105.3	669.7	1,034.7	1,315.5
SO_2 (thousand tons)	33.5	196.3	301.9	384.5
Hg (tons)	0.1	0.8	1.3	1.6
N_2O (thousand tons)	1.2	8.3	12.9	16.4
CH_4 (thousand tons)	7.3	46.3	71.6	91.0
Upstream Emissions				
CO_2 (million metric tons)	3.5	22.0	34.0	43.2
NO_X (thousand tons)	0.8	4.7	7.3	9.3
SO_2 (thousand tons)	48.6	303.1	467.8	595.0
Hg (tons)	0.0	0.0	0.0	0.0
N_2O (thousand tons)	0.0	0.2	0.3	0.4
CH_4 (thousand tons)	294.8	1,841.4	2,841.9	3,614.6
Total Emissions				
CO_2 (million metric tons)	65.9	396.1	610.0	776.5
NO_X (thousand tons)	106.0	674.4	1,042.0	1,324.8
SO_2 (thousand tons)	82.1	499.4	769.6	979.5
Hg (tons)	0.1	0.8	1.3	1.6
N_2O (thousand tons)	1.3	8.5	13.2	16.8
CH_4 (thousand tons)	302.2	1,887.7	2,913.5	3,705.5

As part of the analysis for this rule, DOE estimated monetary benefits likely to result from the reduced emissions of CO_2 and NO_X that DOE estimated for each of the TSLs considered. As discussed in section IV.L, DOE used values for the SCC developed by an interagency process. The four sets of SCC values resulting from that process (expressed in 2012$) are represented by $12.9/metric ton (the average value from a distribution that uses a 5-percent discount rate), $40.8/metric ton (the average value from a distribution that uses a 3-percent discount rate), $62.2/metric ton (the average value from a distribution that uses a 2.5-percent discount rate), and $117.0/metric ton (the 95th-percentile value from a distribution that uses a 3-percent discount rate). These values correspond to the value of emission reductions in 2015; the values for later years are higher due to increasing damages as the projected magnitude of climate change increases.

Table V.19 presents the global value of CO_2 emissions reductions at each TSL. For each of the four cases, DOE calculated a present value of the stream of annual values using the same discount rate as was used in the studies upon which the dollar-per-ton values are based. DOE calculated domestic values as a range from 7 percent to 23 percent of the global values, and these results are presented in chapter 14 of the NOPR TSD.

TABLE V.19—ESTIMATES OF GLOBAL PRESENT VALUE OF CO_2 EMISSIONS REDUCTION UNDER ELECTRIC MOTORS TRIAL STANDARD LEVELS

[Million 2012$]

TSL	SCC Case *			
	5% discount rate, average *	3% discount rate, average *	2.5% discount rate, average *	3% discount rate, 95th percentile *
Primary Energy Emissions				
1	433	1,961	3,113	6,040
2	2,366	11,179	17,876	34,552
3	3,622	17,159	27,452	53,047
4	4,622	21,871	34,985	67,609
Upstream Emissions				
1	24	110	174	338
2	136	650	1,042	2,012
3	209	1,001	1,604	3,097
4	266	1,274	2,042	3,943
Total Emissions				
1	457	2,071	3,287	6,378
2	2,502	11,829	18,918	36,564
3	3,831	18,159	29,056	56,143
4	4,888	23,145	37,027	71,552

* For each of the four cases, the corresponding SCC value for emissions in 2015 is $11.8, $39.7, $61.2, and $117.0 per metric ton (2012$).

DOE is well aware that scientific and economic knowledge about the contribution of CO_2 and other greenhouse gas (GHG) emissions to changes in the future global climate and the potential resulting damages to the world economy continues to evolve rapidly. Thus, any value placed on reducing CO_2 emissions in this rulemaking is subject to change. DOE, together with other Federal agencies, will continue to review various methodologies for estimating the monetary value of reductions in CO_2 and other GHG emissions. This ongoing review will consider the comments on this subject that are part of the public record for this and other rulemakings, as well as other methodological assumptions and issues. However, consistent with DOE's legal obligations, and taking into account the uncertainty involved with this particular issue, DOE has included in this proposed rule the most recent values and analyses resulting from the ongoing interagency review process.

DOE also estimated a range for the cumulative monetary value of the economic benefits associated with NO_X emissions reductions anticipated to result from new and amended standards for electric motors. The low and high dollar-per-ton values that DOE used are discussed in section IV.L present the cumulative present values for each TSL calculated using seven-percent and three-percent discount rates.

TABLE V.20—ESTIMATES OF PRESENT VALUE OF NO_X EMISSIONS REDUCTION UNDER ELECTRIC MOTORS TRIAL STANDARD LEVELS

[Million 2012$]

TSL	3% discount rate	7% discount rate
Power Sector Emissions		
1	49.5	26.4
2	257.1	120.2
3	392.2	181.6
4	501.3	233.2
Upstream Emissions		
1	68.0	33.8
2	378.4	164.8
3	579.9	250.3
4	739.7	320.6
Total Emissions		
1	117.5	60.2
2	635.4	285.0
3	972.2	432.0
4	1,241.0	553.8

7. Summary of National Economic Impacts

The NPV of the monetized benefits associated with emissions reductions can be viewed as a complement to the NPV of the customer savings calculated for each TSL considered in this rulemaking. Table V.21 presents the NPV values that result from adding the estimates of the potential economic benefits resulting from reduced CO_2 and NO_X emissions in each of four valuation scenarios to the NPV of customer savings calculated for each TSL considered in this rulemaking, at both a seven-percent and three-percent discount rate. The CO_2 values used in the columns of each table correspond to the four sets of SCC values discussed above.

TABLE V.21—NET PRESENT VALUE OF CUSTOMER SAVINGS COMBINED WITH NET PRESENT VALUE OF MONETIZED BENEFITS FROM CO_2 AND NO_X EMISSIONS REDUCTIONS

[Billion 2012$]

TSL	SCC Case $11.8/metric ton CO_2* and low value for NO_X**	SCC Case $39.7/metric ton CO_2* and medium value for NO_X**	SCC Case $61.2/metric ton CO_2* and medium value for NO_X**	SCC Case $117.0/metric ton CO_2* and high value for NO_X**
	Customer NPV at 3% discount rate added with:			
1	6.3	8.0	9.2	12.4
2	25.9	35.7	42.8	61.0
3	7.0	22.1	33.0	60.9
4	−37.3	−18.0	−4.1	31.4
	Customer NPV at 7% discount rate added with:			
1	3.2	4.8	6.1	9.2
2	11.2	20.8	27.9	45.7
3	0.5	15.2	26.1	53.5
4	−25.3	−6.6	7.3	42.3

* These label values represent the global SCC in 2015, in 2012$.
** Low Value corresponds to $468 per ton of NO_X emissions. Medium Value corresponds to $2,639 per ton, and High Value corresponds to $4,809 per ton.

Although adding the value of customer savings to the values of emission reductions provides a valuable perspective, two issues should be considered. First, the national operating cost savings are domestic U.S. customer monetary savings that occur as a result of market transactions, while the value of CO_2 reductions is based on a global value. Second, the assessments of operating cost savings and the SCC are performed with different methods that use quite different time frames for analysis. The national operating cost savings is measured for the lifetime of equipment shipped in 2015–2044. The SCC values, on the other hand, reflect the present value of future climate-related impacts resulting from the emission of one metric ton of CO_2 in each year. These impacts continue well beyond 2100.

8. 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)(VI)) No other factors were considered in this analysis.

C. Proposed Standards

When considering proposed standards, the new or amended energy conservation standard that DOE adopts for any type (or class) of covered equipment shall 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. 6295(o)(2)(A) and 6316(a)) In determining whether a standard is economically justified, the Secretary must determine whether the benefits of the standard exceed its burdens to the greatest extent practicable, considering the seven statutory factors discussed previously. (42 U.S.C. 6295(o)(2)(B)(i) and 6316(a)) The new or amended standard must also ''result in significant conservation of energy.'' (42 U.S.C. 6295(o)(3)(B) and 6316(a))

For today's NOPR, DOE considered the impacts of standards at each TSL, beginning with the max-tech 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 technologically feasible, economically justified and saves a significant amount of energy. Throughout this process DOE also considered the recommendations made by the Motors Coalition and other stakeholders in their submitted comments. For more details on the Motors Coalition see Section II.B.2.

To aid the reader in understanding the benefits and/or burdens of each TSL, tables in this section summarize the quantitative analytical results for each TSL, based on the assumptions and methodology discussed herein. The efficiency levels contained in each TSL are described in section V.A. 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 customers who may be disproportionately affected by a national standard, and impacts on employment. Section V.B.1.b presents the estimated impacts of each TSL for the considered subgroup. DOE discusses the impacts on employment in electric motor manufacturing in section V.B.2.b, and discusses the indirect employment impacts in section V.B.3.c.

1. Benefits and Burdens of Trial Standard Levels Considered for Electric Motors

Table V.22 and Table V.23 summarize the quantitative impacts estimated for each TSL for electric motors.

TABLE V.22—SUMMARY OF ANALYTICAL RESULTS FOR ELECTRIC MOTORS: NATIONAL IMPACTS

Category	TSL 1	TSL 2	TSL 3	TSL 4
National Full-Fuel-Cycle Energy Savings *quads:*	1.1	7.0	10.8	13.7
NPV of Consumer Benefits *2012$ billion:*				

TABLE V.22—SUMMARY OF ANALYTICAL RESULTS FOR ELECTRIC MOTORS: NATIONAL IMPACTS—Continued

Category	TSL 1	TSL 2	TSL 3	TSL 4
3% discount rate	5.8	23.3	3.0	−42.4
7% discount rate	2.7	8.7	−3.4	−30.3
Cumulative Emissions Reduction (Total FFC Emissions):				
CO_2 *million metric tons*	65.9	396.1	610.0	776.5
SO_2 *thousand tons*	106.0	674.4	1,042.0	1,324.8
NO_X *thousand tons*	82.1	499.4	769.6	979.5
Hg *tons*	0.1	0.8	1.3	1.6
N_2O *thousand tons*	1.3	8.5	13.2	16.8
CH_4 *thousand tons*	302.2	1,887.7	2,913.5	3,705.5
Value of Emissions Reduction (Total FFC Emissions):				
CO_2 2012$ *million**	457 to 6,378	2,502 to 36,564	3,831 to 56,143	4,888 to 71,552
NO_X—3% discount rate *2012$ million*	117.5	635.4	972.2	1,241.0
NO_X—7% discount rate *2012$ million*	60.2	285.0	432.0	553.8

* Range of the economic value of CO_2 reductions is based on estimates of the global benefit of reduced CO_2 emissions.

TABLE V.23—SUMMARY OF ANALYTICAL RESULTS FOR ELECTRIC MOTORS: MANUFACTURER AND CONSUMER IMPACTS

Category	TSL 1	TSL 2	TSL 3	TSL 4
Manufacturer Impacts:				
Industry NPV 2012$ million	3,378.7–3,019.5	3,759.2–3,087.6	4,443.7–2,356.8	5,241.3–1,383.1
Industry NPV % change	0.2–(10.4)	11.5–(8.4)	31.8–(30.1)	55.5–(59.0)
Consumer Mean LCC Savings * *2012$:*				
Equipment Class Group 1	43	132	68	−417
Equipment Class Group 2	38	38	−285	−285
Equipment Class Group 3	N/A **	N/A **	−61	−763
Equipment Class Group 4	137	259	210	−291
Consumer Median PBP * *years:*				
Equipment Class Group 1	1.1	3.3	6.7	29.9
Equipment Class Group 2	5.0	5.0	22.8	22.8
Equipment Class Group 3	N/A **	N/A **	3,299	11,957
Equipment Class Group 4	1.2	1.9	3.7	16.0
Equipment Class Group 1:				
Net Cost %	0.3	8.4	38.0	84.6
Net Benefit %	9.7	32.0	40.4	7.6
No Impact %	90.0	59.6	21.5	7.7
Equipment Class Group 2:				
Net Cost %	21.5	21.5	94.7	94.7
Net Benefit %	68.6	68.6	5.3	5.3
No Impact %	9.9	9.9	0.0	0.0
Equipment Class Group 3:				
Net Cost (%)	0.0	0.0	81.7	100.0
Net Benefit (%)	0.0	0.0	0.0	0.0
No Impact (%)	0.0	0.0	18.3	0.0
Equipment Class Group 4:				
Net Cost (%)	1.0	10.8	33.1	79.6
Net Benefit (%)	31.8	60.8	65.8	19.9
No Impact (%)	67.3	28.4	1.1	0.3

** The results for each equipment class group (ECG) are a shipment weighted average of results for the representative units in the group. ECG 1: Representative units 1, 2, and 3; ECG 2: Representative units 4 and 5; ECG 3: Representative units 6, 7, and 8; ECG 4: Representative units 9 and 10.

** For equipment class group 3, TSL 1 and 2 are the same as the baseline; thus, no customers are affected.

First, DOE considered TSL 4, the most efficient level (max tech), which would save an estimated total of 13.7 quads of energy, an amount DOE considers significant. TSL 4 has an estimated NPV of customer benefit of −30.3 billion using a 7 percent discount rate, and −42.4 billion using a 3 percent discount rate.

The cumulative emissions reductions at TSL 4 are 776.5 million metric tons of CO_2, 979.5 thousand tons of NO_X, 1,324.8 thousand tons of SO_2, and 1.6 tons of Hg. The estimated monetary value of the CO_2 emissions reductions at TSL 4 ranges from $4,888 million to $71,552 million.

At TSL 4, the weighted average LCC impact ranges from $−763 for ECG 3 to $−285 for ECG 2. The weighted average median PBP ranges from 16 years for ECG 4 to 11,957 years for ECG 3. The weighted average share of customers experiencing a net LCC benefit ranges from 0 percent for ECG 3 to 19.9 percent for ECG 4.

At TSL 4, the projected change in INPV ranges from a decrease of $1,988.1 million to an increase of $1,870.1 million. If the decrease of $1,988.1 million were to occur, TSL 4 could result in a net loss of 59 percent in INPV to manufacturers of covered electric motors.

In view of the foregoing, DOE concludes that, at TSL 4 for electric motors, the benefits of energy savings, emission reductions, and the estimated monetary value of the emissions reductions would be outweighed by the potential multi-billion dollar negative net economic cost; the economic burden on customers as indicated by the increase in customer LCC (negative savings), large PBPs, the large percentage of customers who would experience LCC increases; the increase in the cumulative regulatory burden on manufacturers; and the capital and engineering costs that could result in a large reduction in INPV for manufacturers at TSL 4. Additionally, DOE believes that efficiency standards at this level, could result in significant impacts on OEMs due to larger and faster motors. Although DOE has not quantified these potential impacts, DOE believes that it is possible that these impacts could be significant and further reduce any potential benefits of standards established at this TSL. Consequently, DOE has concluded that TSL 4 is not economically justified.

Next, DOE considered TSL 3, which would save an estimated total of 10.6 quads of energy, an amount DOE considers significant. TSL 3 has an estimated NPV of customer benefit of $−3.4 billion using a 7 percent discount rate, and $3.0 billion using a 3 percent discount rate.

The cumulative emissions reductions at TSL 3 are 610.0 million metric tons of CO_2, 769.6 thousand tons of NO_X, 1,042.0 thousand tons of SO_2, and 1.3 tons of Hg. The estimated monetary value of the CO_2 emissions reductions at TSL 4 ranges from $3,831 million to $ 56,143 million.

At TSL 3, the weighted average LCC impact ranges from $−285 for ECG 2 to $210 for ECG 4. The weighted average median PBP ranges from 3.7 years for ECG 4 to 3,299 years for ECG 3. The share of customers experiencing a net LCC benefit ranges from 0 percent for ECG 3 to 65.8 percent for ECG 4.

At TSL 3, the projected change in INPV ranges from a decrease of $1,014,4 million to an increase of $1,072.5 million. If the decrease of $1,014.4 million were to occur, TSL 3 could result in a net loss of 30.1 percent in INPV to manufacturers of covered electric motors.

In view of the foregoing, DOE concludes that, at TSL 3 for electric motors, the benefits of energy savings, positive weighted average customer LCC savings for some ECGs, generating capacity reductions, emission reductions, and the estimated monetary value of the emissions reductions would be outweighed by the potential negative net economic cost; the economic burden on customers as indicated by the increase in weighted average LCC for some ECGs (negative savings), large PBPs, the large percentage of customers who would experience LCC increases; the increase in the cumulative regulatory burden on manufacturers; and the capital and engineering costs that could result in a large reduction in INPV for manufacturers at TSL 3. Additionally, DOE believes that efficiency standards at this level could result in significant impacts on OEMs due to larger and faster motors. Although DOE has not quantified these potential impacts, DOE believes that it is possible that these impacts could be significant and further reduce any potential benefits of standards established at this TSL. Consequently, DOE has concluded that TSL 3 is not economically justified.

Next, DOE considered TSL 2, which would save an estimated total of 7.0 quads of energy, an amount DOE considers significant. TSL 2 has an estimated NPV of customer benefit of $8.7 billion using a 7 percent discount rate, and $23.3 billion using a 3 percent discount rate.

The cumulative emissions reductions at TSL 2 are 396.1 million metric tons of CO_2, 674.4 thousand tons of NO_X, 499.4 thousand tons of SO_2, and 0.8 tons of Hg. The estimated monetary value of the CO_2 emissions reductions at TSL 4 ranges from $2,502 million to $36,564 million.

At TSL 2, the weighted average LCC impact ranges from no impacts for ECG 3 to $259 for ECG 4. The weighted average median PBP ranges from 0 years for ECG 3 to 5 years for ECG 2. The share of customers experiencing a net LCC benefit ranges from 0 percent for ECG 3 to 68.6 percent for ECG 2. The share of motors already at TSL 2 efficiency levels varies by equipment class group and by horsepower range (from 0 to 62 percent). For ECG 1, which represents the most significant share of the market, about 30 percent of motors meet the TSL 2 levels.

At TSL 2, the projected change in INPV ranges from a decrease of $283.5 million to an increase of $388 million. If the decrease of $283.5 million were to occur, TSL 2 could result in a net loss of 8.4 percent in INPV to manufacturers of covered electric motors.

After considering the analysis and weighing the benefits and the burdens, DOE has tentatively concluded that at TSL 2 for electric motors, the benefits of energy savings, positive NPV of customer benefit, positive impacts on consumers (as indicated by positive weighted average LCC savings for all ECGs impacted at TSL 2, favorable PBPs, and the large percentage of customers who would experience LCC benefits, emission reductions, and the estimated monetary value of the emissions reductions would outweigh the slight increase in the cumulative regulatory burden on manufacturers and the risk of small negative impacts if manufacturers are unable to recoup investments made to meet the standard. In particular, the Secretary of Energy has concluded that TSL 2 would save a significant amount of energy and is technologically feasible and economically justified.

In addition, DOE notes that TSL 2 most closely corresponds to the standards that were proposed by the Motor Coalition, as described in section II.B.2. Based on the above considerations, DOE today proposes to adopt the energy conservation standards for electric motors at TSL 2. Table V.24 through Table V.27 present the proposed energy conservation standards for electric motors.

TABLE V.24—PROPOSED ENERGY CONSERVATION STANDARDS FOR NEMA DESIGN A AND NEMA DESIGN B ELECTRIC MOTORS

[Compliance starting December 19, 2015]

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

TABLE V.24—PROPOSED ENERGY CONSERVATION STANDARDS FOR NEMA DESIGN A AND NEMA DESIGN B ELECTRIC MOTORS—Continued

[Compliance starting December 19, 2015]

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
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	95.0	95.0
350/261	95.8	95.4	96.2	95.8	95.8	95.8	95.0	95.0
400/298	95.8	95.8	96.2	95.8	95.8	95.8	95.0	95.0
450/336	95.8	96.2	96.2	96.2	95.8	96.2	95.0	95.0
500/373	95.8	96.2	96.2	96.2	95.8	96.2	95.0	95.0

TABLE V.25—PROPOSED ENERGY CONSERVATION STANDARDS FOR NEMA DESIGN C ELECTRIC MOTORS

[Compliance starting December 19, 2015]

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
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 V.26—PROPOSED ENERGY CONSERVATION STANDARDS FOR FIRE PUMP ELECTRIC MOTORS

[Compliance starting December 19, 2015]

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	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

TABLE V.26—PROPOSED ENERGY CONSERVATION STANDARDS FOR FIRE PUMP ELECTRIC MOTORS—Continued

[Compliance starting December 19, 2015]

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
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	94.5	94.5
350/261	95.4	95.0	95.4	95.4	95.0	95.4	94.5	94.5
400/298	95.4	95.4	95.4	95.4	95.0	95.4	94.5	94.5
450/336	95.4	95.8	95.4	95.8	95.0	95.4	94.5	94.5
500/373	95.4	95.8	95.8	95.8	95.0	95.4	94.5	94.5

TABLE V.27—PROPOSED ENERGY CONSERVATION STANDARDS FOR BRAKE MOTORS

[Compliance starting December 19, 2015]

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
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

2. Summary of Benefits and Costs (Annualized) of the Proposed Standards

The benefits and costs of today's proposed standards, for equipment sold in 2015–2044, can also be expressed in terms of annualized values. The annualized monetary values are the sum of: (1) The annualized national economic value of the benefits from consumer operation of equipment that meet the proposed standards (consisting primarily of operating cost savings from using less energy, minus increases in equipment purchase and installation costs, which is another way of representing consumer NPV), and (2) the annualized monetary value of the benefits of emission reductions, including CO_2 emission reductions.[89]

[89] DOE used a two-step calculation process to convert the time-series of costs and benefits into annualized values. First, DOE calculated a present value in 2013, the year used for discounting the NPV of total consumer costs and savings, for the time-series of costs and benefits using discount rates of three and seven percent for all costs and benefits except for the value of CO_2 reductions. For the latter, DOE used a range of discount rates, as shown in Table I.3. From the present value, DOE then calculated the fixed annual payment over a 30-year period (2015 through 2044) that yields the same present value. The fixed annual payment is the annualized value. Although DOE calculated annualized values, this does not imply that the time-series of cost and benefits from which the annualized values were determined is a steady stream of payments.

Although combining the values of operating savings and CO_2 emission reductions provides a useful perspective, two issues should be considered. First, the national operating savings are domestic U.S. consumer monetary savings that occur as a result of market transactions while the value of CO_2 reductions is based on a global value. Second, the assessments of operating cost savings and CO_2 savings are performed with different methods that use different time frames for analysis. The national operating cost savings is measured for the lifetime of electric motors shipped in 2015 –2044. The SCC values, on the other hand, reflect the present value of some future climate-related impacts resulting from the emission of one ton of carbon dioxide in each year. These impacts continue well beyond 2100.

Estimates of annualized benefits and costs of the proposed standards for electric motors are shown in Table V.28. The results under the primary estimate are as follows. Using a 7-percent discount rate for benefits and costs other than CO_2 reduction, for which DOE used a 3-percent discount rate along with the average SCC series that uses a 3-percent discount rate, the cost of the standards proposed in today's rule is $462 million per year in increased equipment costs; while the estimated benefits are $1,114 million per year in reduced equipment operating costs, $586 million in CO_2 reductions, and $21.5 million in reduced NO_X emissions. In this case, the net benefit would amount to $957 million per year. Using a 3-percent discount rate for all benefits and costs and the average SCC series, the estimated cost of the standards proposed in today's rule is $577 million per year in increased equipment costs; while the estimated benefits are $1,730 million per year in reduced operating costs, $586 million in CO_2 reductions, and $31.5 million in reduced NO_X emissions. In this case, the net benefit would amount to approximately $1,354 million per year.

TABLE V.28—ANNUALIZED BENEFITS AND COSTS OF PROPOSED STANDARDS FOR ELECTRIC MOTORS

[million 2012$/year]

	Discount rate	Primary estimate*	Low Net benefits estimate*	High Net benefits estimate*
Benefits:				
Consumer Operating Cost Savings	7%	1,114	924	1,358.
	3%	1,730	1,421	2,134.
CO_2 Reduction Monetized Value ($11.8/t case)*.	5%	155	134	179.
CO_2 Reduction Monetized Value ($39.7/t case)*.	3%	586	506	679.
CO_2 Reduction Monetized Value ($61.2/t case)*.	2.5%	882	762	1022.
CO_2 Reduction Monetized Value $117.0/t case)*.	3%	1,811	1,565	2,098.
NO_X Reduction Monetized Value (at $2,639/ton)**.	7%	21.46	18.55	24.68.
	3%	31.48	27.20	36.39.
Total Benefits†	7% plus CO_2 range	1,290 to 2,947	1,077 to 2,507	1,562 to 3,481.
	7%	1,721	1,449	2,061.
	3% plus CO_2 range	1,916 to 3,572	1,583 to 3,014	2,350 to 4,268.
	3%	2,347	1,955	2,849.
Costs:				
Consumer Incremental Equipment Costs	7%	462	492	447.
	3%	577	601	569.
Net Benefits:				
Total†	7% plus CO_2 range	585 to 2,016	1,115 to 3,033	1,353 to 3,438.
	7%	957	1,614	1,887.
	3% plus CO_2 range	982 to 2,413	1,781 to 3,700	1,957 to 4,043.
	3%	1,354	2,280	2,492.

* This table presents the annualized costs and benefits associated with electric motors shipped in 2015–2044. These results include benefits to consumers which accrue after 2044 from the equipment purchased in years 2015–2044. Costs incurred by manufacturers, some of which may be incurred in preparation for the rule, are not directly included, but are indirectly included as part of incremental equipment costs. The Primary, Low Benefits, and High Benefits Estimates are in view of projections of energy prices from the Annual Energy Outlook (AEO) 2013 Reference case, Low Estimate, and High Estimate, respectively. In addition, incremental equipment costs reflect a medium constant projected equipment price in the Primary Estimate, a decline rate for projected equipment price trends in the Low Benefits Estimate, and an increasing rate for projected equipment price trends in the High Benefits Estimate. The methods used to derive projected price trends are explained in section IV.F.1.

** The interagency group selected four sets of SCC values for use in regulatory analyses. Three sets of values are based on the average SCC from the three integrated assessment models, at discount rates of 2.5, 3, and 5 percent. The fourth set, which represents the 95th percentile SCC estimate across all three models at a 3-percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. The values in parentheses represent the SCC in 2015. The SCC time series incorporate an escalation factor. The value for NO_X is the average of the low and high values used in DOE's analysis.

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

VI. Procedural Issues and Regulatory Review

A. Review Under Executive Orders 12866 and 13563

Section 1(b)(1) of Executive Order 12866, ''Regulatory Planning and Review,'' 58 FR 51735 (Oct. 4, 1993), requires each agency to identify the problem that it intends to address, including, where applicable, the failures of private markets or public institutions that warrant new agency action, as well as to assess the significance of that problem. The problems that today's standards address are as follows:

(1) There are external benefits resulting from improved energy efficiency of covered electric motors which are not captured by the users of such equipment. These benefits include externalities related to environmental protection and energy security that are not reflected in energy prices, such as emissions of greenhouse gases. DOE attempts to quantify some of the external benefits through use of Social Cost of Carbon values.

In addition, DOE has determined that today's regulatory action is an ''economically significant regulatory action'' under section 3(f)(1) of Executive Order 12866. Accordingly, section 6(a)(3) of the Executive Order requires that DOE prepare a regulatory impact analysis (RIA) on today's rule and that the Office of Information and Regulatory Affairs (OIRA) in the Office of Management and Budget (OMB) review this rule. DOE presented to OIRA for review the draft rule and other documents prepared for this rulemaking, including the RIA, and has included these documents in the rulemaking record. The assessments prepared pursuant to Executive Order 12866 can be found in the technical support document for this rulemaking.

DOE has also reviewed this regulation pursuant to Executive Order 13563, issued on January 18, 2011 (76 FR 3281, Jan. 21, 2011). EO 13563 is supplemental to and explicitly reaffirms the principles, structures, and definitions governing regulatory review established in Executive Order 12866. To the extent permitted by law, agencies are required by Executive Order 13563 to: (1) Propose or adopt a regulation only upon a reasoned determination that its benefits justify its costs (recognizing that some benefits and costs are difficult to quantify); (2) tailor regulations to impose the least burden on society, consistent with obtaining regulatory objectives, taking into account, among other things, and to the extent practicable, the costs of cumulative regulations; (3) select, in choosing among alternative regulatory approaches, those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity); (4) to the extent feasible, specify performance objectives, rather than specifying the behavior or manner of compliance that regulated entities must adopt; and (5) identify and assess available alternatives to direct regulation, including providing economic incentives to encourage the desired behavior, such as user fees or marketable permits, or providing information upon which choices can be made by the public.

DOE emphasizes as well that Executive Order 13563 requires agencies to use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible. In its guidance, the Office of Information and Regulatory Affairs has emphasized that such techniques may include identifying changing future compliance costs that might result from technological innovation or anticipated behavioral changes. For the reasons stated in the preamble, DOE believes that today's NOPR is consistent with these principles, including the requirement that, to the extent permitted by law, benefits justify costs and that net benefits are maximized.

B. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*) requires preparation of an initial regulatory flexibility analysis (IRFA) for any rule that by law must be proposed for public comment, unless the agency certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities. As required by Executive Order 13272, ''Proper Consideration of Small Entities in Agency Rulemaking,'' 67 FR 53461 (August 16, 2002), DOE published procedures and policies on February 19, 2003, to ensure that the potential impacts of its rules on small entities are properly considered during the rulemaking process. 68 FR 7990 DOE has made its procedures and policies available on the Office of the General Counsel's Web site (*http://energy.gov/gc/office-general-counsel*).

DOE has prepared an IRFA for this rulemaking, a copy of which DOE will transmit to the Chief Counsel for Advocacy of the SBA for review under 5 U.S.C. 605(b). As presented and discussed below, the IFRA describes potential impacts on electric motors manufacturers associated with capital and product conversion costs and discusses alternatives that could minimize these impacts.

A statement of the objectives of, and reasons and legal basis for, the proposed rule are set forth elsewhere in the preamble and not repeated here.

1. Description and Estimated Number of Small Entities Regulated

a. Methodology for Estimating the Number of Small Entities

For manufacturers of electric motors, the Small Business Administration (SBA) has set a size threshold, which defines those entities classified as ''small businesses'' for the purposes of the statute. DOE used the SBA's small business size standards to determine whether any small entities would be subject to the requirements of the rule. The size standards are listed by North American Industry Classification System (NAICS) code and industry description available at: *http://www.sba.gov/content/table-small-business-size-standards*. Electric motor manufacturing is classified under NAICS 335312, ''Motor and Generator Manufacturing.'' The SBA sets a threshold of 1,000 employees or less for an entity to be considered as a small business for this category.

To estimate the number of companies that could be small business manufacturers of equipment covered by this rulemaking, DOE conducted a market survey using publicly available information. DOE's research involved industry trade association membership directories (including NEMA), information from previous rulemakings, UL qualification directories, individual company Web sites, and market research tools (e.g., Hoover's reports). DOE also asked stakeholders and industry representatives if they were aware of any other small manufacturers during manufacturer interviews and DOE public meetings. DOE used information from these sources to create a list of companies that potentially manufacture electric motors covered by this rulemaking. As necessary, DOE contacted companies to determine whether they met the SBA's definition of a small business manufacturer. DOE screened out companies that do not offer equipment covered by this rulemaking, do not meet the definition of a ''small business,'' or are foreign owned and operated.

DOE initially identified 60 potential manufacturers of electric motors sold in the U.S. After reviewing publicly available information DOE contacted 27 of the companies that DOE suspected were small business manufacturers to determine whether they met the SBA definition of a small business and whether they manufactured the equipment that would be affected by today's proposal. Based on these efforts, DOE estimates that there are 13 small business manufacturers of electric motors.

b. Manufacturer Participation

DOE contacted the 13 identified small businesses to invite them to take part in a small business manufacturer impact analysis interview. Of the electric motor manufacturers DOE contacted, 10 responded and three did not. Eight of the 10 responding manufacturers declined to be interviewed. Therefore, DOE was able to reach and discuss potential standards with two of the 13 small business manufacturers. DOE also obtained information about small business manufacturers and potential impacts while interviewing large manufacturers.

c. Electric Motor Industry Structure and Nature of Competition

Eight major manufacturers supply approximately 90 percent of the market for electric motors. None of the major manufacturers of electric motors covered in this rulemaking is a small business. DOE estimates that approximately 50 percent of the market is served by imports. Many of the small businesses that compete in the electric motor market produce specialized motors, many of which have not been regulated under previous standards. Most of these low-volume manufacturers do not compete directly with large manufacturers and tend to occupy niche markets for their equipment. There are a few small business manufacturers that produce general purpose motors; however, these motors currently meet NEMA Premium efficiency levels, the efficiency levels being proposed in today's notice.

d. Comparison Between Large and Small Entities

For electric motors, small manufacturers differ from large manufacturers in several ways that affect the extent to which a manufacturer would be impacted by proposed standards. Characteristics of small manufacturers include: lower production volumes, fewer engineering resources, less technical expertise, and less access to capital.

Lower production volumes lie at the heart of most small business disadvantages, particularly for a small manufacturer that is vertically integrated. A lower-volume manufacturer's conversion costs would need to be spread over fewer units than a larger competitor. Thus, unless the small business can differentiate its product in some way that earns a price premium, the small business is a 'price taker' and experiences a reduction in profit per unit relative to the large manufacturer. Therefore, because much of the same equipment would need to be purchased by both large and small manufacturers in order to produce electric motors at higher TSLs, undifferentiated small manufacturers would face a greater variable cost penalty because they must depreciate the one-time conversion expenditures over fewer units.

Smaller companies are also more likely to have more limited engineering resources and they often operate with lower levels of design and manufacturing sophistication. Smaller companies typically also have less experience and expertise in working with more advanced technologies. Standards that required these technologies could strain the engineering resources of these small manufacturers if they chose to maintain a vertically integrated business model. Small business electric motor manufacturers can also be at a disadvantage due to their lack of purchasing power for high performance materials. For example, more expensive low-loss steels are needed to meet higher efficiency standards and steel cost grows as a percentage of the overall product cost. Small manufacturers who pay higher per pound prices would be disproportionately impacted by these prices.

Lastly, small manufacturers typically have less access to capital, which may be needed by some to cover the conversion costs associated with new technologies.

2. Description and Estimate of Compliance Requirements

In its market survey, DOE identified three categories of small business electric motor manufacturers that may be impacted differently by today's proposed rule. The first group, which includes approximately five of the 13 small businesses, consists of manufacturers that produce specialty motors that were not required to meet previous Federal standards, but would need to do so under the expanded scope of today's proposed rule. DOE believes that this group would likely be the most impacted by expanding the scope of equipment required to meet NEMA Premium efficiency levels. The second group, which includes approximately five different small businesses, consists of manufacturers that produce a small amount of covered equipment and primarily focus on other types of motors not covered in this rulemaking, such as single-phase or direct-current motors. Because generally less than 10 percent of these manufacturers' revenue comes from covered equipment, DOE does not believe new standards will substantially impact their business. The third group, which includes approximately three small businesses, consists of manufacturers that already offer NEMA Premium general purpose and specialty motors. DOE expects these manufacturers to face similar conversion costs as large manufacturers, in that they will not experience high capital conversion costs as they already have the design and production experience necessary to bring their motors up to NEMA Premium efficiency levels. It is likely, however, that some of the specialty equipment these manufacturers produce will be included in the expanded scope of this proposed rule and is likely to result in these small businesses incurring additional certification and testing costs. These manufacturers could also face product development costs if they have to redesign any motors that are not currently meeting the NEMA Premium level.

At TSL 2, the level proposed in today's notice, DOE estimates capital conversion costs of $1.88 million and product conversion costs of $3.75 million for a typical small manufacturer in the first group (manufacturers that produce specialized motors previously not covered by Federal standards). Meanwhile, DOE estimates a typical large manufacturer would incur capital and product conversion costs of $3.29 million and $7.25 million, respectively, at the same TSL. Small manufacturers that predominately produce specialty motors would face higher relative capital conversion costs at TSL 2 than large manufacturers because large manufacturers have been independently pursuing higher efficiency motors as a result of the efficiency standards prescribed by EISA 2007 (10 CFR part 431.25) and consequently have built up more design and production experience. Large manufacturers have also been innovating as a result of the small electric motors rulemaking at 75 FR 10874 (March 9, 2010), which exempted many of the specialized equipment that these small business manufacturers produce. Many large manufacturers of general purpose motors offer equipment that was covered by the 2010 small electric motors rule, as well as equipment that falls under this proposed rule. Small manufactures pointed out that this would give large manufacturers an advantage in that they already have experience with the technology necessary to redesign their equipment and are familiar with the steps they will have to take to upgrade their manufacturing equipment and processes. Small manufactures, whose specialized motors were not required to meet the standards prescribed by the small electric motors rule and EISA 2007 have not undergone these processes and, therefore, would have to put more time and resources into redesign efforts.

The small businesses whose product lines consist of a high percentage of equipment that are not currently required to meet efficiency standards would need to make significant capital investments relative to large manufacturers to upgrade their production lines with equipment necessary to produce NEMA Premium motors. As Table VI.1 illustrates, these manufacturers would have to drastically increase their capital expenditures to purchase new lamination die sets, and new winding and stacking equipment.

TABLE VI.1—ESTIMATED CAPITAL AND PRODUCT CONVERSION COSTS AS A PERCENTAGE OF ANNUAL CAPITAL EXPENDITURES AND R&D EXPENSE

	Capital conversion cost as a percentage of annual capital expenditures (%)	Product conversion cost as a percentage of annual R&D expense (%)	Total conversion cost as a percentage of annual revenue (%)
Typical Large Manufacturer	14	31	2
Typical Small Manufacturer	188	490	75

Table VI.1 also illustrates that small manufacturers whose product lines contain many motors that are not currently required to meet Federal standards face high relative product conversion costs compared to large manufacturers, despite the lower dollar value. In interviews, these small manufacturers expressed concern that they would face a large learning curve relative to large manufacturers, due to the fact that many of the equipment they produce has not had to meet Federal standards. In its market survey, DOE learned that for some manufacturers, the expanded scope of specialized motors that would have to meet NEMA Premium could affect nearly half the equipment they offer. They would need to hire additional engineers and would have to spend considerable time and resources redesigning their equipment and production processes. DOE does not expect the small businesses that already manufacture NEMA Premium equipment or those that offer very few alternating-current motors to incur these high costs.

Manufacturers also expressed concern about testing and certification costs associated with new standards. They pointed out that these costs are particularly burdensome on small businesses that produce a wide variety of specialized equipment. As a result of the wide variety of equipment they produce and their relatively low output, small manufacturers are forced to certify multiple small batches of motors, the costs of which need to be spread out over far fewer units than large manufacturers.

Small manufacturers that produce equipment not currently required to meet efficiency standards also pointed out that they would face significant challenges supporting current business while making changes to their production lines. While large manufacturers could shift production of certain equipment to different plants or product lines while they made updates, small businesses would have limited options. Most of these small businesses have only one plant and would have to find a way to continue to fulfill customer needs while redesigning production lines and installing new equipment. In interviews with DOE, small manufacturers said that it would be difficult to quantify the impacts that downtime and the possible need for external support could have on their businesses.

3. Duplication, Overlap, and Conflict With Other Rules and Regulations

DOE is not aware of any rules or regulations that duplicate, overlap, or conflict with the rule being considered today.

4. Significant Alternatives to the Proposed Rule

The discussion above analyzes impacts on small businesses that would result from the TSL DOE is proposing in today's notice. Though TSLs lower than the proposed TSL are expected to reduce the impacts on small entities, DOE is required by EPCA to establish standards that achieve the maximum improvement in energy efficiency that are technically feasible and economically justified, and result in a significant conservation of energy. Therefore, DOE rejected the lower TSLs.

In addition to the other TSLs being considered, the NOPR TSD includes a regulatory impact analysis in chapter 17. For electric motors, this report discusses the following policy alternatives: (1) Consumer rebates, (2) consumer tax credits, and (3) manufacturer tax credits. DOE does not intend to consider these alternatives further because they either are not feasible to implement or are not expected to result in energy savings as large as those that would be achieved by the standard levels under consideration.

DOE continues to seek input from businesses that would be affected by this rulemaking and will consider comments received in the development of any final rule.

5. Significant Issues Raised by Public Comments

DOE's MIA suggests that, while TSL 2 presents greater difficulties for small businesses than lower efficiency levels, the business impacts at higher TSLs would be greater. DOE expects that most small businesses will generally be able to maintain profitability at the TSL proposed in today's rulemaking. It is possible, however, that the small manufacturers whose product lines consist of a high percentage of previously exempted motors could incur significant costs as a result of this proposed rule, and those high costs could endanger their business. DOE's MIA is based on its interviews of both small and large manufacturers, and consideration of small business impacts explicitly enters into DOE's choice of the TSLs proposed in this NOPR.

DOE did not receive any public comments suggesting that small businesses would not be able to achieve the efficiency levels at TSL 2.

C. Review Under the Paperwork Reduction Act

Manufacturers of electric motors that are currently subject to energy conservation standards must certify to DOE that their equipment comply with any applicable energy conservation standards. In certifying compliance, manufacturers must test their equipment according to the DOE test procedures for electric motors, including any amendments adopted for those test procedures. The collection-of-information requirement for the certification and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act (PRA). This requirement has been approved by OMB under OMB control number 1910–1400. Public reporting burden for the certification is estimated to average 20 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. DOE intends to address revised certification requirements for electric motors in a separate rulemaking.

Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB Control Number.

D. Review Under the National Environmental Policy Act of 1969

Pursuant to the National Environmental Policy Act (NEPA) of 1969, DOE has determined that the proposed rule fits within the category of actions included in Categorical Exclusion (CX) B5.1 and otherwise meets the requirements for application of a CX. See 10 CFR Part 1021, App. B, B5.1(b); 1021.410(b) and Appendix B, B(1)–(5). The proposed rule fits within the category of actions because it is a rulemaking that establishes energy conservation standards for consumer products or industrial equipment, and for which none of the exceptions identified in CX B5.1(b) apply. Therefore, DOE has made a CX determination for this rulemaking, and DOE does not need to prepare an Environmental Assessment or Environmental Impact Statement for this proposed rule. DOE's CX determination for this proposed rule is available at *http://cxnepa.energy.gov/.*

E. Review Under Executive Order 13132

Executive Order 13132, ''Federalism.'' 64 FR 43255 (Aug. 10, 1999) imposes certain requirements on Federal agencies formulating and implementing policies or regulations that preempt State law or that have Federalism implications. The Executive Order requires agencies to examine the constitutional and statutory authority supporting any action that would limit the policymaking discretion of the States and to carefully assess the necessity for such actions. The Executive Order also requires agencies to have an accountable process to ensure meaningful and timely input by State and local officials in the development of regulatory policies that have Federalism implications. On March 14, 2000, DOE published a statement of policy describing the intergovernmental consultation process it will follow in the development of such regulations. 65 FR 13735. EPCA governs and prescribes Federal preemption of State regulations as to energy conservation for the equipment that are the subject of today's proposed rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297) No further action is required by Executive Order 13132.

F. Review Under Executive Order 12988

With respect to the review of existing regulations and the promulgation of new regulations, section 3(a) of Executive Order 12988, ''Civil Justice Reform,'' imposes on Federal agencies the general duty to adhere to the following requirements: (1) Eliminate drafting errors and ambiguity; (2) write regulations to minimize litigation; and (3) provide a clear legal standard for affected conduct rather than a general standard and promote simplification and burden reduction. 61 FR 4729 (Feb. 7, 1996). Section 3(b) of Executive Order 12988 specifically requires that Executive agencies make every reasonable effort to ensure that the regulation: (1) Clearly specifies the preemptive effect, if any; (2) clearly specifies any effect on existing Federal law or regulation; (3) provides a clear legal standard for affected conduct while promoting simplification and burden reduction; (4) specifies the retroactive effect, if any; (5) adequately defines key terms; and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. Section 3(c) of Executive Order 12988 requires Executive agencies to review regulations in light of applicable standards in section 3(a) and section 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, this proposed rule meets the relevant standards of Executive Order 12988.

G. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA) requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and Tribal governments and the private sector. Public Law 104–4, sec. 201 (codified at 2 U.S.C. 1531). For a proposed 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 proposed ''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 small governments. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820. DOE's policy statement is also available at *http://energy.gov/gc/downloads/unfunded-mandates-reform-act-intergovernmental-consultation.*

Although today's proposed rule does not contain a Federal intergovernmental mandate, it may require expenditures of $100 million or more on the private sector. Specifically, the proposed rule will likely result in a final rule that could require expenditures of $100 million or more. Such expenditures may include: (1) Investment in research and development and in capital expenditures by electric motor manufacturers in the years between the 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 proposed rule. 2 U.S.C. 1532(c). The content requirements of section 202(b) of UMRA relevant to a private sector mandate substantially overlap the economic analysis requirements that apply under section 325(o) of EPCA and Executive Order 12866. The **SUPPLEMENTARY INFORMATION** section of the NOPR and the ''Regulatory Impact Analysis'' section of the TSD for this proposed 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 proposed 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(d), (f), and (o) and 6316(a), today's proposed rule would establish 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. A full discussion of the alternatives considered by DOE is presented in the ''Regulatory Impact Analysis'' section of the TSD for today's proposed 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 proposed rule would not have any impact on the autonomy or integrity of the family as an institution. Accordingly, DOE has concluded that it is not necessary to prepare a Family Policymaking Assessment.

I. Review Under Executive Order 12630

DOE has determined, under Executive Order 12630, ''Governmental Actions and Interference with Constitutionally Protected Property Rights'' 53 FR 8859 (Mar. 18, 1988), that this proposed regulation 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 guidelines established by each agency pursuant to general guidelines issued by OMB. OMB's guidelines were published at 67 FR 8452 (Feb. 22, 2002), and DOE's guidelines were published at 67 FR 62446 (Oct. 7, 2002). DOE has reviewed today's NOPR under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

K. Review Under Executive Order 13211

Executive Order 13211, ''Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use'' 66 FR 28355 (May 22, 2001), requires Federal agencies to prepare and submit to OIRA at OMB, a Statement of Energy Effects for any proposed 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 proposed significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

DOE has tentatively concluded that today's proposed regulatory action, which sets forth potential energy conservation standards for commercial and industrial electric motors, is not a significant energy action because the proposed 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 the proposed rule.

L. Review Under the Information Quality Bulletin for Peer Review

On December 16, 2004, OMB, in consultation with the Office of Science and Technology Policy (OSTP), issued its Final Information Quality Bulletin for Peer Review (the Bulletin). 70 FR 2664 (Jan. 14, 2005). The Bulletin establishes that certain scientific information shall be peer reviewed by qualified specialists before it is disseminated by the Federal Government, including influential scientific information related to agency regulatory actions. The purpose of the bulletin is to enhance the quality and credibility of the Government's scientific information. Under the Bulletin, the energy conservation standards rulemaking analyses are ''influential scientific information,'' which the Bulletin defines as scientific information the agency reasonably can determine will have, or does have, a clear and substantial impact on important public policies or private sector decisions. 70 FR 2667.

In response to OMB's Bulletin, DOE conducted formal in-progress peer reviews of the energy conservation standards development process and analyses and has prepared a Peer Review Report pertaining to the energy conservation standards rulemaking analyses. Generation of this report involved a rigorous, formal, and documented evaluation using objective criteria and qualified and independent reviewers to make a judgment as to the technical/scientific/business merit, the actual or anticipated results, and the productivity and management effectiveness of programs and/or projects. The ''Energy Conservation Standards Rulemaking Peer Review Report'' dated February 2007 has been disseminated and is available at the following Web site: *www1.eere.energy.gov/buildings/appliance_standards/peer_review.html*.

VII. Public Participation

A. Attendance at the Public Meeting

The time, date, and location of the public meeting are listed in the **DATES** and **ADDRESSES** sections at the beginning of this notice. If you plan to attend the public meeting, please notify Ms. Brenda Edwards at (202) 586–2945 or *Brenda.Edwards@ee.doe.gov*. As explained in the **ADDRESSES** section, foreign nationals visiting DOE Headquarters are subject to advance security screening procedures.

In addition, you can attend the public meeting via webinar. Webinar registration information, participant instructions, and information about the capabilities available to webinar participants will be published on DOE's Web site at: *https://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/42*. Participants are responsible for ensuring their systems are compatible with the webinar software.

B. Procedure for Submitting Prepared General Statements For Distribution

Any person who has plans to present a prepared general statement may request that copies of his or her statement be made available at the public meeting. Such persons may submit requests, along with an advance electronic copy of their statement in PDF (preferred), Microsoft Word or Excel, WordPerfect, or text (ASCII) file format, to the appropriate address shown in the **ADDRESSES** section at the beginning of this notice. The request and advance copy of statements must be received at least one week before the public meeting and may be emailed, hand-delivered, or sent by mail. DOE prefers to receive requests and advance copies via email. Please include a telephone number to enable DOE staff to make follow-up contact, if needed.

C. Conduct of the Public Meeting

DOE will designate a DOE official to preside at the public meeting and may also use a professional facilitator to aid discussion. The meeting will not be a judicial or evidentiary-type public hearing, but DOE will conduct it in accordance with section 336 of EPCA (42 U.S.C. 6306). A court reporter will be present to record the proceedings and prepare a transcript. DOE reserves the right to schedule the order of presentations and to establish the procedures governing the conduct of the public meeting. After the public meeting, interested parties may submit further comments on the proceedings as well as on any aspect of the rulemaking until the end of the comment period.

The public meeting will be conducted in an informal, conference style. DOE will present summaries of comments received before the public meeting, allow time for prepared general statements by participants, and encourage all interested parties to share their views on issues affecting this rulemaking. Each participant will be allowed to make a general statement (within time limits determined by DOE), before the discussion of specific topics. DOE will allow, as time permits, other participants to comment briefly on any general statements.

At the end of all prepared statements on a topic, DOE will permit participants to clarify their statements briefly and comment on statements made by others. Participants should be prepared to answer questions by DOE and by other participants concerning these issues. DOE representatives may also ask questions of participants concerning other matters relevant to this rulemaking. The official conducting the public meeting will accept additional comments or questions from those attending, as time permits. The presiding official will announce any further procedural rules or modification of the above procedures that may be needed for the proper conduct of the public meeting.

A transcript of the public meeting will be included in the docket, which can be viewed as described in the *Docket* section at the beginning of this notice. In addition, any person may buy a copy of the transcript from the transcribing reporter.

D. Submission of Comments

DOE will accept comments, data, and information regarding this proposed rule before or after the public meeting, but no later than the date provided in the **DATES** section at the beginning of this proposed rule. Interested parties may submit comments, data, and other information using any of the methods described in the **ADDRESSES** section at the beginning of this notice.

Submitting comments via regulations.gov. The regulations.gov Web page will require you to provide your name and contact information. Your contact information will be viewable to DOE Building Technologies staff only. Your contact information will not be publicly viewable except for your first and last names, organization name (if any), and submitter representative name (if any). If your comment is not processed properly because of technical difficulties, DOE will use this information to contact you. If DOE cannot read your comment due to technical difficulties and cannot contact you for clarification, DOE may not be able to consider your comment.

However, your contact information will be publicly viewable if you include it in the comment itself or in any documents attached to your comment. Any information that you do not want to be publicly viewable should not be included in your comment, nor in any document attached to your comment. Otherwise, persons viewing comments will see only first and last names, organization names, correspondence containing comments, and any documents submitted with the comments.

Do not submit to regulations.gov information for which disclosure is restricted by statute, such as trade secrets and commercial or financial information (hereinafter referred to as Confidential Business Information (CBI)). Comments submitted through regulations.gov cannot be claimed as CBI. Comments received through the Web site will waive any CBI claims for the information submitted. For information on submitting CBI, see the Confidential Business Information section below.

DOE processes submissions made through regulations.gov before posting. Normally, comments will be posted within a few days of being submitted. However, if large volumes of comments are being processed simultaneously, your comment may not be viewable for up to several weeks. Please keep the comment tracking number that regulations.gov provides after you have successfully uploaded your comment.

Submitting comments via email, hand delivery/courier, or mail. Comments and documents submitted via email, hand delivery, or mail also will be posted to regulations.gov. If you do not want your personal contact information to be publicly viewable, do not include it in your comment or any accompanying documents. Instead, provide your contact information in a cover letter. Include your first and last names, email address, telephone number, and optional mailing address. The cover letter will not be publicly viewable as long as it does not include any comments.

Include contact information each time you submit comments, data, documents, and other information to DOE. If you submit via mail or hand delivery/courier, please provide all items on a CD, if feasible. It is not necessary to submit printed copies. No facsimiles (faxes) will be accepted.

Comments, data, and other information submitted to DOE electronically should be provided in PDF (preferred), Microsoft Word or Excel, WordPerfect, or text (ASCII) file format. Provide documents that are not secured, that are written in English, and that are free of any defects or viruses. Documents should not contain special characters or any form of encryption and, if possible, they should carry the electronic signature of the author.

Campaign form letters. Please submit campaign form letters by the originating organization in batches of between 50 to 500 form letters per PDF or as one form letter with a list of supporters' names compiled into one or more PDFs. This reduces comment processing and posting time.

Confidential Business Information. According to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit via email, postal mail, or hand delivery/courier two well-marked copies: One copy of the document marked confidential including all the information believed to be confidential, and one copy of the document marked non-confidential with the information believed to be confidential deleted. Submit these documents via email or on a CD, if feasible. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

Factors of interest to DOE when evaluating requests to treat submitted information as confidential include: (1) A description of the items; (2) whether and why such items are customarily treated as confidential within the industry; (3) whether the information is generally known by or available from other sources; (4) whether the information has previously been made available to others without obligation concerning its confidentiality; (5) an explanation of the competitive injury to the submitting person which would result from public disclosure; (6) when such information might lose its confidential character due to the passage of time; and (7) why disclosure of the information would be contrary to the public interest.

It is DOE's policy that all comments may be included in the public docket, without change and as received, including any personal information provided in the comments (except information deemed to be exempt from public disclosure).

E. Issues on Which DOE Seeks Comment

Although DOE welcomes comments on any aspect of this proposal, DOE is particularly interested in receiving comments and views of interested parties concerning the following issues:

1. DOE requests comment on the potential impacts of new and amended standards on small electric motor manufacturers, especially regarding DOE's proposed expansion of scope of covered electric motors.

2. DOE requests comment on whether the proposed standards help resolve the potential issue on which it had previously issued clarification of whether a [IEC] motor may be considered to be subject to two standards.

3. DOE seeks comment on any additional sources of data that could be used to establish the distribution of electric motors across equipment class groups.

4. DOE seeks comment on any additional sources of data that could be used to establish the distribution of electric motors across sectors by horsepower range and within each equipment class group.

5. DOE seeks comment on any additional sources for determining the frequency of motor repair depending on equipment class group and sector.

6. DOE seeks comment on any additional sources of data on motor lifetime that could be used to validate DOE's estimates of motor mechanical lifetime and its method of estimating lifetimes. DOE defines equipment lifetime as the lesser of the age at which electric motors are retired from service or the equipment in which they are embedded is retired. For the NIA, DOE uses motor average lifetime in years derived from motor mechanical lifetime in hours (see Chapter 8, Section 8.2.3) and from annual operating hours (see Section 10.2.2.2). DOE based expected equipment lifetime on discussions with industry experts and developed a distribution of typical lifetimes for several categories of electric motors. DOE welcomes further input on the average equipment lifetimes for the LCC and NIA analyses.

7. DOE seeks comment on the estimated base case distribution of product efficiencies and on any additional sources of data.

8. DOE seeks comments on its decision to use efficiency trends for equipment class groups 1 and 4 and constant efficiencies for equipment class groups 2 and 3 over the analysis period. Specifically, DOE would like comments on additional sources of data on trends in efficiency improvement.

9. DOE seeks comment on any sources of data that could be used to establish the elasticity of electric motor shipments with respect to changes in purchase price.

10. DOE seeks comment on its scaled values for MSPs. In particular, DOE seeks comments on its methodology for scaling MSP data from the representative equipment classes to the remaining equipment classes.

11. DOE seeks comment on the scaled values for motor weights. In particular, DOE seeks comments on its methodology for scaling weight data from the representative equipment classes to the remaining equipment classes.

12. DOE seeks comment on the trial standard levels (TSLs) developed for the NOPR.

13. DOE seeks comment on its proposed compliance date of December 19, 2015.

14. DOE seeks comment on its decision to analyze brake motors in a separate equipment class group.

15. DOE seeks comment on its decision to limit standards for brake motors to 1–30 hp, and 4, 6, and 8 pole configurations. DOE selected these ratings after reviewing manufacturer catalogs and only finding brake motors in these configurations.

16. DOE seeks comment on its decision to not screen out copper die-cast copper rotor motors.

17. DOE seeks comment on the availability of copper in the market to manufacture die-cast copper rotor motors on a ''mass quantity'' scale.

18. DOE seeks comment on its decision to not screen out hand winding in its analysis.

19. DOE seeks comment on its estimation for labor hours for each representative unit.

20. DOE seeks comments on the cost to manufacturers to change their product lines to meet EL3.

21. DOE seeks comments on the cost to manufacturers to change their product lines to meet EL4.

22. DOE is aware that motors used in fire pump applications may carry various definitions, including, but not limited to, NEMA, IEC, and NFPA designations. DOE requests comment on its current definition of fire pump motors, the suitability of that definition for the United States market, and on its advantages or disadvantages relative to other potential definitions.

23. In DOE's view any Design B or IEC-equivalent motor that otherwise satisfies the relevant NFPA requirements would meet the fire pump electric motor definition in 10 CFR 431.12. To the extent that there is confusion regarding this view, DOE invites comments on this issue, along with any data demonstrating whether any IEC-equivalent motors are listed for fire pump service either under the NFPA 20 or another relevant industry standard.

24. DOE seeks data on any other subsets of 56-frame motors, particularly those motors that are: (1) Enclosed general purpose electric motors that have a rating of under 1 horsepower and (2) open, special or definite purpose (inclusive) electric motors. The types of data that DOE seeks include, but are not limited to, the following categories: Efficiency distribution; shipment breakdown between horsepower ratings, open and enclosed motors, and between general and special and definite purpose electric motors; and typical applications that use these motors.

25. Currently, DOE's reference case projects that prices for future shipments of motors will remain constant. DOE is seeking input on the appropriateness of this assumption.

26. DOE requests comment on whether there are features or attributes of the more energy-efficient electric motors that manufacturers would produce to meet the standards in this proposed rule that might affect how they would be used by consumers. DOE requests comment specifically on how any such effects should be weighed in the choice of standards for the electric motors for the final rule.

27. For this rulemaking, DOE analyzed the effects of this proposal assuming that the electric motors would be available to purchase for 30 years and undertook a sensitivity analysis using 9 years rather than 30 years of product shipments. The choice of a 30-year period of shipments is consistent with the DOE analysis for other products and commercial equipment. 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. We are seeking input, information and data on whether there are ways to further refine the analytic timeline.

28. DOE solicits comment on the application of the new SCC values used to determine the social benefits of CO_2 emissions reductions over the rulemaking analysis period. (The rulemaking analysis period covers from 2015 to 2044 plus the appropriated number of years to account for the lifetime of the equipment purchased between 2015 and 2044.) In particular, the agency solicits comment on the

agency's derivation of SCC values after 2050 where the agency applied the average annual growth rate of the SCC estimates in 2040–2050 associated with each of the four sets of values.

29. DOE solicits comment on whether its proposal presents a sufficiently broad scope of regulatory coverage to help ensure that significant energy savings would be met or whether further adjustments to the proposed scope—whether to exclude certain categories or to include others—are necessary.

30. DOE requests comment on the nine characteristics listed in section III.C and their appropriateness for outlining scope of coverage.

VIII. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of today's proposed rule.

List of Subjects in 10 CFR Part 431

Administrative practice and procedure, Confidential business information, Energy conservation, Commercial and industrial equipment, Imports, Intergovernmental relations, Reporting and recordkeeping requirements, and Small businesses.

Issued in Washington, DC, on November 25, 2013.

David T. Danielson,

Assistant Secretary, Energy Efficiency and Renewable Energy.

For the reasons set forth in the preamble, DOE proposes to amend part 431 of chapter II of title 10 of the Code of Federal Regulations, as set forth below:

PART 431—ENERGY CONSERVATION PROGRAM FOR CERTAIN COMMERCIAL AND INDUSTRIAL EQUIPMENT

■ 1. The authority citation for part 431 continues to read as follows:

Authority: 42 U.S.C. 6291–6317

■ 2. Revise § 431.25 to read as follows:

§ 431.25 Energy conservation standards and effective dates.

(a) Except as provided for fire pump electric motors in paragraph (b) of this section, each general purpose electric motor (subtype I) with a power rating of 1 horsepower or greater, but not greater than 200 horsepower, including a NEMA Design B or an equivalent IEC Design N motor that is a general purpose electric motor (subtype I), manufactured (alone or as a component of another piece of equipment) on or after December 19, 2010, but before December 19, 2015, shall have a nominal full-load efficiency that is not less than the following:

TABLE 1—NOMINAL FULL-LOAD EFFICIENCIES OF GENERAL PURPOSE ELECTRIC MOTORS (SUBTYPE I), EXCEPT FIRE PUMP ELECTRIC MOTORS

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

(b) Each fire pump electric motor that is a general purpose electric motor (subtype I) or general purpose electric motor (subtype II) manufactured (alone or as a component of another piece of equipment) on or after December 19, 2010, but before December 19, 2015, shall have a nominal full-load efficiency that is not less than the following:

TABLE 2—NOMINAL FULL-LOAD EFFICIENCIES OF FIRE PUMP ELECTRIC MOTORS

Motor horsepower/standard kilowatt equivalent	Nominal full-load efficiency							
	Open motors (number of poles)				Enclosed motors (number of poles)			
	8	6	4	2	8	6	4	2
1/.75	74.0	80.0	82.5	—	74.0	80.0	82.5	75.5
1.5/1.1	75.5	84.0	84.0	82.5	77.0	85.5	84.0	82.5

TABLE 2—NOMINAL FULL-LOAD EFFICIENCIES OF FIRE PUMP ELECTRIC MOTORS—Continued

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

(c) Except as provided for fire pump electric motors in paragraph (b) of this section, each general purpose electric motor (subtype II) with a power rating of 1 horsepower or greater, but not greater than 200 horsepower, including a NEMA Design B or an equivalent IEC Design N motor that is a general purpose electric motor (subtype II), manufactured (alone or as a component of another piece of equipment) on or after December 19, 2010, but before December 19, 2015, shall have a nominal full-load efficiency that is not less than the following:

TABLE 3—NOMINAL FULL-LOAD EFFICIENCIES OF GENERAL PURPOSE ELECTRIC MOTORS (SUBTYPE II), EXCEPT FIRE PUMP ELECTRIC MOTORS

Motor horsepower/ standard kilowatt equivalent	Nominal full-load efficiency							
	Open motors (number of poles)				Enclosed motors (number of poles)			
	8	6	4	2	8	6	4	2
1/.75	74.0	80.0	82.5	—	74.0	80.0	82.5	75.5
1.5/1.1	75.5	84.0	84.0	82.5	77.0	85.5	84.0	82.5
2/1.5	85.5	85.5	84.0	84.0	82.5	86.5	84.0	84.0
3/2.2	86.5	86.5	86.5	84.0	84.0	87.5	87.5	85.5
5/3.7	87.5	87.5	87.5	85.5	85.5	87.5	87.5	87.5
7.5/5.5	88.5	88.5	88.5	87.5	85.5	89.5	89.5	88.5
10/7.5	89.5	90.2	89.5	88.5	88.5	89.5	89.5	89.5
15/11	89.5	90.2	91.0	89.5	88.5	90.2	91.0	90.2
20/15	90.2	91.0	91.0	90.2	89.5	90.2	91.0	90.2
25/18.5	90.2	91.7	91.7	91.0	89.5	91.7	92.4	91.0
30/22	91.0	92.4	92.4	91.0	91.0	91.7	92.4	91.0
40/30	91.0	93.0	93.0	91.7	91.0	93.0	93.0	91.7
50/37	91.7	93.0	93.0	92.4	91.7	93.0	93.0	92.4
60/45	92.4	93.6	93.6	93.0	91.7	93.6	93.6	93.0
75/55	93.6	93.6	94.1	93.0	93.0	93.6	94.1	93.0
100/75	93.6	94.1	94.1	93.0	93.0	94.1	94.5	93.6
125/90	93.6	94.1	94.5	93.6	93.6	94.1	94.5	94.5
150/110	93.6	94.5	95.0	93.6	93.6	95.0	95.0	94.5
200/150	93.6	94.5	95.0	94.5	94.1	95.0	95.0	95.0

(d) Each NEMA Design B or an equivalent IEC Design N motor that is a general purpose electric motor (subtype I) or general purpose electric motor (subtype II), excluding fire pump electric motors, with a power rating of more than 200 horsepower, but not greater than 500 horsepower, manufactured (alone or as a component of another piece of equipment) on or after December 19, 2010, but before December 19, 2015 shall have a nominal full-load efficiency that is not less than the following:

TABLE 4—NOMINAL FULL-LOAD EFFICIENCIES OF NEMA DESIGN B GENERAL PURPOSE ELECTRIC MOTORS (SUBTYPE I AND II), EXCEPT FIRE PUMP ELECTRIC MOTORS

Motor horsepower/ standard kilowatt equivalent	Nominal full-load efficiency							
	Open motors (number of poles)	Enclosed motors (number of poles)						
		8	6	4	2	8	6	4
250/186	94.5	95.4	95.4	94.5	94.5	95.0	95.0	95.4
300/224	—	95.4	95.4	95.0	—	95.0	95.4	95.4
350/261	—	95.4	95.4	95.0	—	95.0	95.4	95.4
400/298	—	—	95.4	95.4	—	—	95.4	95.4
450/336	—	—	95.8	95.8	—	—	95.4	95.4
500/373	—	—	95.8	95.8	—	—	95.8	95.4

(e) 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 (a) through (d) 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 paragraph (e)(1) or (2) of this section, whichever applies.

(f) The standards in Table 1 through Table 4 of this section do not apply to definite purpose motors, special purpose motors, or those motors exempted by the Secretary.

(g) The standards in Table 5 through Table 8 of this section apply to 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) Have a three-digit NEMA frame size (or IEC metric equivalent) or an enclosed 56 NEMA frame size (or IEC metric equivalent),

(8) Are rated no more than 500 horsepower, but greater than or equal to 1 horsepower (or kilowatt equivalent), 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 or H motor.

(h) Starting on December 19, 2015, each NEMA Design A and NEMA Design B 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, integral-brake electric motors, and non-integral brake 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 5—NOMINAL FULL LOAD EFFICIENCIES OF NEMA DESIGN A AND NEMA DESIGN B ELECTRIC MOTORS

[Excluding fire pump electric motors, integral-brake electric motors, and non-integral brake electric motors]

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

TABLE 5—NOMINAL FULL LOAD EFFICIENCIES OF NEMA DESIGN A AND NEMA DESIGN B ELECTRIC MOTORS—Continued

[Excluding fire pump electric motors, integral-brake electric motors, and non-integral brake electric motors]

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
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	95.0	95.0
350/261	95.8	95.4	96.2	95.8	95.8	95.8	95.0	95.0
400/298	95.8	95.8	96.2	95.8	95.8	95.8	95.0	95.0
450/336	95.8	96.2	96.2	96.2	95.8	96.2	95.0	95.0
500/373	95.8	96.2	96.2	96.2	95.8	96.2	95.0	95.0

(i) Starting on December 19, 2015, each NEMA Design C electric motor that is an electric motor meeting the criteria in paragraph (g) of this section and with a power rating from 1 horsepower through 200 horsepower, but excluding non-integral brake electric motors and integral brake electric motors, manufactured (alone or as a component of another piece of equipment) shall have a nominal full-load efficiency that is not less than the following:

TABLE 6—NOMINAL FULL LOAD EFFICIENCIES OF NEMA DESIGN C ELECTRIC MOTORS

[excluding non-integral brake electric motors and integral brake electric motors]

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
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

(j) Starting on December 19, 2015, each fire pump electric motor meeting the criteria in paragraph (g) of this section and with a power rating of 1 horsepower through 500 horsepower, manufactured (alone or as a component of another piece of equipment) shall have a nominal full-load efficiency that is not less than the following:

TABLE 7—NOMINAL FULL LOAD EFFICIENCIES OF FIRE PUMP ELECTRIC MOTORS

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	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

TABLE 7—NOMINAL FULL LOAD EFFICIENCIES OF FIRE PUMP ELECTRIC MOTORS—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
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	94.5	94.5
350/261	95.4	95.0	95.4	95.4	95.0	95.4	94.5	94.5
400/298	95.4	95.4	95.4	95.4	95.0	95.4	94.5	94.5
450/336	95.4	95.8	95.4	95.8	95.0	95.4	94.5	94.5
500/373	95.4	95.8	95.8	95.8	95.0	95.4	94.5	94.5

(k) Starting on December 19, 2015, each integral brake electric motor and non-integral brake electric motor meeting the criteria in paragraph (g) of this section, and with a power rating of 1 horsepower through 30 horsepower, manufactured (alone or as a component of another piece of equipment) shall have a nominal full-load efficiency that is not less than the following:

TABLE 8—NOMINAL FULL LOAD EFFICIENCIES OF INTEGRAL BRAKE ELECTRIC MOTORS AND NON-INTEGRAL BRAKE ELECTRIC MOTORS

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
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

(l) 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 (h) through (k) 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 paragraph (l)(1) or (2) of this section, whichever applies.

(m) The standards in Table 5 through Table 8 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) Air-over electric motors;

(2) Component sets of an electric motor;

(3) Liquid-cooled electric motors;

(4) Submersible electric motors; and

(5) Definite-purpose, inverter-fed electric motors.

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