DEPARTMENT OF ENERGY

10 CFR Part 431

[Docket No. 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: Final rule.

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 final rule, DOE establishes 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, today's rulemaking would maintain the current energy conservation standards for some electric motor types and amend the energy conservation standards for other electric motor types. DOE has determined that the new and amended energy conservation standards for this equipment would result in significant conservation of energy, and are technologically feasible and economically justified.

DATES: The effective date of this rule is July 28, 2014. Compliance with the standards established for commercial and industrial electric motors in today's final rule is required starting on June 1, 2016.

The incorporation by reference of a certain publication listed in this rule was approved by the **Federal Register** on May 4, 2012.

ADDRESSES: 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 rule 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.

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

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SUPPLEMENTARY INFORMATION:

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I. Summary of the Final Rule and Its Benefits

Title III of the Energy Policy and Conservation Act of 1975 (42 U.S.C. 6291, *et seq.;* ''EPCA''), Public Law 94–163, sets forth a variety of provisions designed to improve energy efficiency. Part C of title III, which for editorial reasons was re-designated as Part A–1 upon incorporation into the U.S. Code (42 U.S.C. 6311–6317), establishes the ''Energy Conservation Program for Certain Industrial Equipment,'' including certain electric motors.[1] (Within this preamble, DOE will use the terms ''electric motors'' and ''motors'' interchangeably as today's rulemaking only pertains to electric motors.) Pursuant to EPCA, any new or amended energy conservation standard must be designed to achieve the maximum improvement in energy efficiency that DOE determines is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A) and 6316(a)) Furthermore, the new or amended standards must result in significant conservation of energy. (42 U.S.C. 6295(o)(3)(B) and 6316(a))

In accordance with these and other statutory provisions discussed in this final rule, DOE is adopting new and amended energy conservation standards for electric motors by applying the standards currently in place to a wider scope of electric motors that DOE does not currently regulate. In setting these standards, DOE is addressing 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, today's rule, would require all currently regulated motors, with the exception of fire pump electric motors, to satisfy the efficiency levels (ELs) prescribed in Table 12–12 of National Electrical Manufacturers Association (NEMA) Standards Publication MG 1–2011, ''Motors and Generators;'' fire pump motors would continue to meet the current standards that apply. All other electric motors covered in today's rulemaking would also need to meet the efficiency levels found in MG 1–2011, Table 12–12. As a practical matter, most currently regulated motors would continue to be required to meet the same standards that they are already required to meet, but certain motors, such as those that satisfy the general purpose electric motors (subtype II) (*i.e.* ''subtype II'') or that are NEMA Design B (or equivalent IEC Design N) motors with a power rating of more than 200 horsepower, but not greater than 500 horsepower, would now be required to meet the more stringent levels prescribed by MG 1–2011, Tables 12–12. These adopted efficiency levels (depicted here as trial standard levels or ''TSLs'') and the motor types to which they apply are shown in Table I.1.

[1] All references to EPCA in this document refer to the statute as amended through the American Energy Manufacturing Technical Corrections Act (AEMTCA), Pub. L. 112–210 (December 18, 2012).

TABLE I.1—ENERGY CONSERVATION STANDARDS FOR ELECTRIC MOTORS

[Compliance starting June 1, 2016]

Equipment class group	Electric motor design type	Horsepower rating	Pole configuration	Enclosure	Adopted 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

*Indicates International Electrotechnical Commission (IEC) equivalent electric motors are included. Also, due to the elimination of an equipment class for brake motors, previously reported brake motor results are now reported in Equipment Class Group 1 (ECG 1).

**Tables I.2 through I.4 detail the various standard levels that compose TSL 2. Table I.2 applies to NEMA Design A & B, Table I.3 applies to NEMA Design C and Table I.4 applies to fire pump electric motors.

In determining where a particular motor with a certain horsepower (hp) or kilowatt (kW) rating would fall within the requirements, today's final rule establishes the same approach provided in current regulations to determine which rating would apply for compliance purposes. Namely:

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; and

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—ENERGY CONSERVATION STANDARDS FOR NEMA DESIGN A AND NEMA DESIGN B MOTORS (EXCLUDING FIRE PUMP ELECTRIC MOTORS)

[Compliance starting June 1, 2016]

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

TABLE I.3—ENERGY CONSERVATION STANDARDS FOR NEMA DESIGN C MOTORS

[Compliance starting June 1, 2016]

Motor horsepower/standard kilowatt equivalent	Nominal full-load efficiency (percent)					
	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—ENERGY CONSERVATION STANDARDS FOR FIRE PUMP ELECTRIC MOTORS

[Compliance starting June 1, 2016]

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

Note: Energy conservation standards for fire pump electric motors have not changed and remain at the current efficiency levels.

A. Benefits and Costs to Consumers

Table I.5 presents DOE's evaluation of the economic impacts of today's standards on consumers of electric motors, as measured by the weighted average life-cycle cost (LCC) savings and the median payback period. The average LCC savings are positive for all equipment classes for which consumers are impacted by the standards.

TABLE I.5—IMPACTS OF TODAY'S STANDARDS ON CONSUMERS OF ELECTRIC MOTORS

Equipment class group	Weighted average LCC savings* (2013$)	Weighted median payback period* (years)
1	160	2.9
2	53	4.5
3	N/A**	N/A**

* 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, 3, 9, and 10; ECG 2: Representative units 4 and 5; ECG 3: Representative units 6, 7, and 8. The weighted average lifetime in each equipment class is 15 years and ranges from 8 to 29 years, depending on the motor horsepower and application.

** For the ECG 3 motor, the 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 (2014 to 2045). Using a real discount rate of 9.1 percent, DOE estimates that the industry net present value (INPV) for manufacturers of electric motors is $3,478 million in 2013$. Under today's standards, DOE expects that manufacturers may lose up to 10.0 percent of their INPV, which is approximately $348 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 rule.

C. National Benefits and Costs [2]

DOE's analyses indicate that today's 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 (2016–2045) would amount to 7.0 quads (full-fuel-cycle energy).[3] The annualized energy savings (0.23 quad) is equivalent to one percent of total U.S. industrial primary energy consumption in 2013.[4]

The estimated cumulative net present value (NPV) of total consumer costs and savings attributed to today's standards for electric motors ranges from $11.3 billion (at a 7-percent discount rate) to $28.8 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 2016–2045.[5]

In addition, today's standards would have significant environmental benefits across the entire analysis period. Estimated energy savings would result in cumulative greenhouse gas emission reductions of approximately 395 million metric tons (Mt) [6] of carbon dioxide (CO_2), 1,883 thousand tons of methane, 673 thousand tons of sulfur dioxide (SO_2), 498 thousand tons of nitrogen oxides (NO_X) and 0.8 tons of mercury (Hg).[7] The cumulative reduction in CO_2 emissions through 2030 amounts to 96 Mt.

The value of the CO_2 reductions is calculated using a range of values per metric ton of CO_2 (otherwise known as the Social Cost of Carbon, or SCC) developed by a recent Federal interagency process.[8] The derivation of the SCC values is discussed in section IV.L. Using discount rates appropriate for each set of SCC values, DOE estimates that the present monetary value of the CO_2 emissions reductions is between $2.7 billion and $38.3 billion. DOE also estimates that the present monetary value of the NO_X emissions reductions is $0.3 billion at a 7-percent discount rate, and $0.7 billion at a 3-percent discount rate.[9]

Table I.6 summarizes the national economic costs and benefits expected to result from today's standards for electric motors.

TABLE I.6—SUMMARY OF NATIONAL ECONOMIC BENEFITS AND COSTS OF ELECTRIC MOTORS ENERGY CONSERVATION STANDARDS, PRESENT VALUE FOR MOTORS SHIPPED IN 2016–2045 IN BILLION 2013$ *

Category	Present value billion 2013$	Discount rate %
Benefits		
Consumer Operating Cost Savings	18.2	7
	41.4	3
CO_2 Reduction Monetized Value ($12.0/t case) **	2.7	5
CO_2 Reduction Monetized Value ($40.5/t case) **	12.4	3
CO_2 Reduction Monetized Value ($62.4/t case) **	19.7	2.5
CO_2 Reduction Monetized Value ($119/t case) **	38.3	3
NO_X Reduction Monetized Value (at $2,684/ton) **	0.3	7
	0.7	3
Total Benefits †	30.9	7
	54.4	3

[2] All monetary values in this section are expressed in 2013 dollars and are discounted to 2014.

[3] The agency also conducted the site energy analysis as well (see TSD chapter 10). One quad (quadrillion Btu) is the equivalent of 293 billion kilowatt hours (kWh) or 172.3 million barrels of oil.

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

[5] The analytic timeframe includes motors shipped each year from 2016 to 2045.

[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 Annual Energy Outlook (AEO) 2013 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.6—SUMMARY OF NATIONAL ECONOMIC BENEFITS AND COSTS OF ELECTRIC MOTORS ENERGY CONSERVATION STANDARDS, PRESENT VALUE FOR MOTORS SHIPPED IN 2016–2045 IN BILLION 2013$ *—Continued

Category	Present value billion 2013$	Discount rate %
Costs		
Consumer Incremental Installed Costs	6.9 12.5	7 3
Net Benefits		
Including CO_2 and NO_X Reduction Monetized Value	24.0 41.9	7 3

* This table presents the costs and benefits associated with electric motors shipped in 2016–2045. These results include benefits to customers which accrue after 2045 from the equipment purchased in 2016–2045. The results account for the incremental variable and fixed costs incurred by manufacturers due to the amended standard, some of which may be incurred in preparation for this final rule.

** The CO_2 values represent global monetized values of the SCC, in 2013$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series used by DOE incorporates 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% and 7% cases are derived using the series corresponding to SCC value of $40.5/t in 2015.

The benefits and costs of today's standards for electric motors, sold in 2016–2045, 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 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 value of operating savings and CO_2 emissions reductions provides a useful perspective, two issues should be considered. First, the national operating cost 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 2016–2045. 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 today's standards are shown in Table I.8. The results under the primary estimate are as follows. Using a 7-percent discount rate for benefits and costs other than CO_2 reduction (for which DOE used a 3-percent discount rate along with the average SCC series that uses a 3-percent discount rate) the cost of the standards in today's rule is $517 million per year in increased equipment costs (incremental installed costs), while the estimated benefits are $1,367 million per year in reduced equipment operating costs, $614 million in CO_2 emission reductions, and $23.3 million in reduced NO_X emissions. In this case, the net benefits would amount to $1,488 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 in today's rule is $621 million per year in increased equipment costs, while the estimated benefits are $2,048 million per year in reduced operating costs, $614 million in CO_2 emission reductions, and $32.9 million in reduced NO_X emissions. In this case, the net benefit would amount to approximately $2,074 million per year.

TABLE I.8—ANNUALIZED BENEFITS AND COSTS OF ENERGY CONSERVATION STANDARDS FOR ELECTRIC MOTORS

[Million 2013$/year]

	Discount rate	Primary estimate *	Low net benefits estimate *	High net benefits estimate *
Benefits				
Consumer Operating Cost Savings	7%	1,367	1,134	1,664
	3%	2,048	1,684	2,521
CO_2 Reduction Monetized Value ($12.0/t case) *	5%	166	143	192
CO_2 Reduction Monetized Value ($40.5/t case) *	3%	614	531	712
CO_2 Reduction Monetized Value ($62.4/t case) *	2.5%	920	795	1,066
CO_2 Reduction Monetized Value ($119/t case) *	3%	1,899	1,641	2,200
NO_X Reduction Monetized Value (at $2,684/ton) **	7%	23.3	20.1	26.8

[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 2014, 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 (2016 through 2045) 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 ENERGY CONSERVATION STANDARDS FOR ELECTRIC MOTORS—Continued

[Million 2013$/year]

	Discount rate	Primary estimate *	Low net benefits estimate *	High net benefits estimate *
	3%	32.9	28.4	38.0
Total Benefits †	7% plus CO_2 range	1,556 to 3,289	1,297 to 2,795	1,882 to 3,890
	7%	2,005	1,685	2,402
	3% plus CO_2 range	2,247 to 3,980	1,855 to 3,353	2,750 to 4,758
	3%	2,696	2,243	3,270
Costs				
Incremental Installed Costs	7%	517	582	503
	3%	621	697	616
Net Benefits				
Total †	7% plus CO_2 range	1,039 to 2,772	716 to 2,213	1,380 to 3,388
	7%	1,488	1,103	1,900
	3% plus CO_2 range	1,626 to 3,359	1,158 to 2,656	2,134 to 4,143
	3%	2,074	1,546	2,654

* This table presents the annualized costs and benefits associated with electric motors shipped in 2016–2045. These results include benefits to consumers which accrue after 2045 from the equipment purchased in years 2016–2045. 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 CO_2 values represent global monetized values of the SCC, in 2013$, in 2015 under several scenarios of the updated SCC values. The first three cases use the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The fourth case represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. The SCC time series used by DOE 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.

D. Conclusion

DOE has concluded that the standards in today's final rule represent the maximum improvement in energy efficiency that is technologically feasible and economically justified, and would result in significant conservation of energy. DOE further notes that equipment achieving these standard levels is already commercially available for most equipment classes covered by today's final rule. Based on the analyses described above, DOE has concluded that the benefits of the 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. However, DOE has concluded that the potential burdens of the more-stringent energy efficiency levels would outweigh the projected benefits.

II. Introduction

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

A. Authority

Title III of the Energy Policy and Conservation Act of 1975 (42 U.S.C. 6291, *et seq.;* "EPCA"), Public Law 94–163, sets forth a variety of provisions designed to improve energy efficiency. Part C of title III, which for editorial reasons was re-designated as Part A–1 upon incorporation into the U.S. Code (42 U.S.C. 6311–6317, as codified), establishes the "Energy Conservation Program for Certain Industrial Equipment," including certain 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 enacted 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))

Pursuant to EPCA, DOE's energy conservation program for covered equipment consists essentially of four parts: (1) Testing; (2) labeling; (3) the establishment of Federal energy conservation standards; and (4) certification and enforcement procedures. For those electric motors for which Congress established standards, or for which DOE amends or establishes standards, the required test procedure is found at 10 CFR part 431, subpart B. The test procedure is subject to review

[11] All references to EPCA in this document refer to the statute as amended through the American Energy Manufacturing Technical Corrections Act (AEMTCA), Public Law 112–210 (December 18, 2012).

and revision by the Secretary in accordance with certain criteria and conditions. (*See* 42 U.S.C. 6314(a))

As required by section 343(a)(5)(A) of EPCA, 42 U.S.C. 6314(a)(5)(A), DOE's electric motors test procedures are those procedures specified in two documents: National Electrical Manufacturers Association (NEMA) Standards Publication MG 1 and Institute of Electrical and Electronics Engineers (IEEE) Standard 112 (Test Method B) for motor efficiency.[12]

Manufacturers of covered equipment must use these methods, as described in appendix B to subpart B of 10 CFR part 431as 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 complies with standards adopted pursuant to EPCA.

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 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 significant conservation of energy. (42 U.S.C. 6295(o)(3) and 6316(a)) Moreover, DOE may not prescribe a standard: (1) For certain commercial and industrial equipment, including electric motors, if no test procedure has been established for the equipment, or (2) if DOE determines by rule that the new and amended standard is not technologically feasible or economically justified. (42 U.S.C. 6295(o)(3)(A)–(B) and 6316(a)) In deciding whether a new and amended 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 equipment subject to the standard;
2. The savings in operating costs throughout the estimated average life of the covered equipment in the type (or class) compared to any increase in the price, initial charges, or maintenance expenses for the covered equipment 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 equipment 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 standard that either increases the maximum allowable energy use or decreases the minimum required energy efficiency of a covered product or piece of equipment. (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- or equipment-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 equipment 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 equipment 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) Consumes a different kind of energy from that consumed by other covered equipment within such type (or class); or (B) has a capacity or other performance-related feature which other equipment within such type (or class) does not have and such feature justifies a higher or lower standard. (42 U.S.C. 6295(q)(1) and 6316(a)) In determining whether a performance-related feature justifies a different standard for a group of equipment, DOE must consider such factors as the utility to the consumer of such a feature and other factors DOE deems appropriate. *Id.* Any rule prescribing such a standard must include an explanation of the basis on which such higher or lower level was established. (42 U.S.C. 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

[12] DOE also added Canadian Standards Association (CSA) CAN/CSA C390–93, ''Energy Efficiency Test Methods for Three-Phase Induction Motors'' as an equivalent and acceptable test method, which aligns with industry practices.

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 on or 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) and 6313(b)) The current standards for these motors (available at 10 CFR 431.25(a)–(e)), which are reproduced in the regulatory text at the end of this rulemaking, 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 codify the EPACT 1992 electric motor requirements. See 64 FR 54114. After EISA 2007's enactment, DOE updated, among other things, the corresponding electric motor regulations at 10 CFR part 431 by incorporating the new definitions and energy conservation standards that the law established. *See* 74 FR 12058 (March 23, 2009). DOE subsequently updated its test procedures for electric motors and small electric motors, *see* 73 FR 78220 (December 22, 2008), and later finalized key provisions related to small electric motor testing. *See* 74 FR 32059 (July 7, 2009). Further updates to the test procedures for electric motors and small electric motors followed when DOE issued a rule that primarily focused on updating various definitions and incorporations by reference related to the current test procedure. *See* 77 FR 26608 (May 4, 2012). That rule defined the term ''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 also published a new test procedure on December 13, 2013, that further refined various electric motor definitions and added certain definitions and test procedure preparatory steps to address a wider variety of electric motor types than are currently regulated, including those electric motors that are largely considered to be special-or definite-purpose motors. 78 FR 75961.

DOE received numerous comments from interested parties who provided significant input to DOE in response to DOE's framework document and preliminary analysis for this rulemaking. *See* 75 FR 59657 (September 28, 2010) (framework document notice of availability) and 77 FR 43015 (July 23, 2012) (preliminary analysis notice of availability). All such comments were addressed in the December 6, 2013, notice of proposed rulemaking (standards NOPR). 78 FR 73589 During the framework document comment period, 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'' [13]) submitted the ''Joint Petition to Adopt Joint Stakeholder Proposal As it Relates to the Rulemaking on Energy Conservation Standards for Electric Motors'' (the ''Petition'') to DOE asking the agency to adopt a consensus stakeholder proposal that would amend the energy conservation standards for electric motors.[14] 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 adopts in today's notice (*i.e.,* efficiency levels in NEMA MG 1–2011 Tables 12–12).[15] (Motor Coalition, No. 35 at pp. 1–3) Several interested parties submitted comments supporting the Petition, including: U.S. Senators Lisa Murkowski and Jeff Bingaman, BBF and Associates, the Air Movement and Control Association International, Inc., the Hydraulic Institute, the Arkansas Economic Development and Commission—Energy Office, and the Power Transmission Distributors Association.

3. Process for Setting Energy Conservation Standards

Section 325(o) of EPCA (as applied to covered equipment via 42 U.S.C. 6316(a)), 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 seven factors listed at 42 U.S.C. 6295(o)(2)(B)(i)(I)–(VII) (as applied to commercial equipment via 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).

The Motor Coalition expressed concern that much of the relevant information regarding electric motors spans various rulemaking documents. It requested that DOE consolidate all documents related to electric motors at one place, which can serve as a quick and easy reference for any consumer or

[13] 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.

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

[15] DOE's final rule differs from the Motor Coalition's proposal in that DOE's rule covers all types of brake electric motors and does not set separate, lower standards for U-frame motors and does not cover open, special- and definite-purpose 56-frame motors.

manufacturer in the U.S or outside the U.S. (Motor Coalition, Pub. Mtg. Tr., No. 87 at p. 20–21) Baldor expressed similar concerns and suggested that DOE clearly state in the Code of Federal Regulations (CFR) whatever information manufacturers need to comply with standards. (Baldor, No. 100 at p. 2) NEMA commented that the notice needs to be clearer and unambiguous so that it is easier for anyone (such as offshore suppliers) to follow it. It added that the final rule should include all required information. (NEMA, Pub. Mtg. Tr., No. 87 at p. 46–47)

First, DOE notes that its regulatory requirements are incorporated into the CFR. The regulations laid out in the CFR comprise the official set of requirements that a regulated entity must follow. While any member of the public (including manufacturers) may seek guidance from DOE, the requirements laid out in the CFR provide the regulatory framework that manufacturers must follow and apply when determining which (if any) requirements a given motor must meet. DOE may issue related guidance documents, if needed, which are available on its Web site at *http://www1.eere.energy.gov/guidance/default.aspx?pid=2&spid=1*. Finally, it is worth noting that the division of regulations in 10 CFR 431.25(a)–(f) (for currently regulated electric motors) and 10 CFR 431.25(g)–(l) (for newly regulated electric motors) was developed as a mechanism to demonstrate the upcoming change in standards without creating confusion about existing standards. At some point in the future after the new standards being adopted in this final rule have been in effect for some time, DOE anticipates removing the standards currently at 10 CFR 431.25(a)–(f), as DOE has done in the past.

III. General Discussion

DOE developed today's 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.
Alliance to Save Energy	ASE	Energy Efficiency Advocates.
American Council for an Energy-Efficient Economy	ACEEE	Energy Efficiency Advocates.
American Forest & Paper Association	AF&PA	Trade Association.
American Fuel & Petrochemical Manufacturers	AFPM	Trade Association.
Appliance Standards Awareness Project	ASAP	Energy Efficiency Advocates.
Baldor Electric Co.	Baldor	Manufacturers.
BBF & Associates	BBF	Representative for Trade Association.
California Energy Commission	CEC	State Government Agency.
California Investor Owned Utilities	CA IOUs	Utilities.
Cato Institute	Cato	Public Interest Group.
China WTO/TBT National Notification & Enquiry Center	China WTO/TBT	Chinese Government Agency.
Copper Development Association	CDA	Trade Association.
Earthjustice	Earthjustice	Energy Efficiency Advocates.
Edison Electric Institute	EEI	Association of U.S. investor-owned electric companies.
Electric Apparatus Service Association	EASA	Trade Association.
European Committee of Manufacturers of Electrical Machines and Power Electronics.	CEMEP	Trade Association.
Flolo Corporation	Flolo	Electromechanical Repairer.
Greg Gerritsen	Gerritsen	Individual.
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.
Natural Resources Defense Council	NRDC	Energy Efficiency Advocates.
Nidec Corporation	Nidec	Manufacturer.
NORD Gear Corporation	NORD Gear	Manufacturer.
Northwest Energy Efficiency Alliance	NEEA	Energy Efficiency Advocates.
Northeast Energy Efficiency Partnerships	NEEP	Energy Efficiency Advocates.
Northwest Power & Conservation Council	NPCC	Utilities.
Oakland University	OU	Academic Institution.
PlasticMetal	PlasticMetal	Non-motor Manufacturer.
Regal Beloit	Regal Beloit	Manufacturer.
Scott Mohs	Scott	Individual.
SEW-Eurodrive, Inc.	SEWE	Manufacturer.
Siemens	Siemens	Manufacturer.
Southern California Edison	SCE	Utility.
UL LLC	UL	Testing Laboratory.
University of Michigan	UMI	Academic Institution.
WEG Electric Corporation	WEG	Manufacturer.

* 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).

A. Compliance Date

During the NOPR public meeting and in written comments, many interested parties, including the Motor Coalition, requested that DOE provide at least two years for compliance from the date of publication of the final rule. (Motor Coalition, Pub. Mtg. Tr., No. 87 at pp. 21–22; NEMA, Pub. Mtg. Tr., No. 87 at p. 29; CA IOUs, Pub. Mtg. Tr., No. 87 at p. 31; ASAP, Pub. Mtg. Tr., No. 87 at p. 32; CEMEP, No. 89 at p. 2; Joint Advocates,[16] No. 97 at p. 3; NEMA, No. 93 at p. 7; CA IOUs, No. 99 at p. 2; Nidec, No. 98 at pp. 2–3; SCE, No. 101 at p. 2)

DOE received other comments on the proposed compliance date for the newly covered equipment requesting that DOE provide more than two years after publication of the final rule for newly covered motors to comply with today's standards because such motors may require testing and/or modification of original equipment manufacturer (OEM) equipment within which these motors are used. (NEMA, No. 93 at p. 7; NEMA, Pub. Mtg. Tr., No. 87 at p. 30–31) Regal Beloit commented that manufacturers of these newly covered motors should be given 48 months for compliance, whereas EEI argued for a three-year lead time for such motors. (Regal Beloit, Pub. Mtg. Tr., No. 87 at pp. 34–35; EEI, Pub. Mtg. Tr., No. 87 at pp. 24–25, 33) EEI also noted that many manufacturers should be fine with a two-year compliance lead time for already-covered equipment since they anticipated the change in regulatory requirements coming after EISA 2007. (EEI, Pub. Mtg. Tr., No. 87 at pp. 24–25, 33) DOE notes that NEMA, as part of the Motor Coalition, had commented earlier in the Petition that a two-year compliance lead time would be sufficient for all motors covered by today's rule and this stance was reiterated by the Motor Coalition representative at the NOPR public meeting and NEMA in their NOPR comments. (Motor Coalition, Pub. Mtg. Tr., No. 87 at pp. 21–22; Motor Coalition, No. 35 at p. 9; NEMA, No. 93 at p. 7)

Regarding the compliance date that would apply to the requirements of today's rule, the energy conservation standards established under EISA 2007 went into effect after the three-year period beginning on the date of enactment of EISA 2007. Under 42 U.S.C. § 6313(b)(4)(B), EPCA directs the Secretary of Energy to publish a final rule amending such standards and to apply the rule to electric motors manufactured five years after the effective date EISA 2007. DOE is relying on the Congressionally established two-year spread between the effective date of the latest amendments to electric motor energy conservation standards and the date by which DOE must amend such standards to arrive at the two-year lead-time for manufacturers to comply with today's rule after its date of issuance. *See* 42 U.S.C. 6313(b).

B. 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 add some necessary steps to facilitate the testing of certain motor types that DOE does not currently require to meet standards. During the 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. *See* 78 FR 38456.

On December 13, 2013, DOE published a test procedure final rule (2013 test procedure) that incorporated comments from the test procedure NOPR and added and clarified both definitions and testing instructions for a variety of electric motors that DOE was considering for regulation under this standards rulemaking. 78 FR 75961. The test procedure changes published in the 2013 final test procedure allow DOE to require testing and compliance to meet the energy conservation standards established today.

Commenting on DOE's recent round of electric motor rulemakings, Baldor raised concerns that developing the standards rulemaking and test procedures rulemaking in parallel has caused inconsistencies that need to be resolved. For example, the 2013 test procedure used the term ''brake electric motor'' to refer jointly to what the standards NOPR published earlier had called ''integral'' and ''non-integral'' brake electric motors. Baldor suggested that definitions for NEMA Design A and B motors in the 2013 test procedure should refer to nine characteristics for covered equipment that are laid out in the NOPR. (Baldor, No. 100 at p. 7)

Inconsistencies, if any, are resolved in today's rule. DOE developed the nine criteria in 10 CFR 431.25(g) below to characterize all of the newly covered and currently covered motor types. Therefore, adding these characteristics to the definitions for motor types is unnecessary. Moreover, as described earlier, the regulatory structure proposed by DOE and adopted in this rule preserves the existing standards and structure for currently regulated motors while providing a new section for new standards for motors being regulated for the first time and amended standards for currently regulated motors.

CEC recommended that DOE should add definitions of continuous duty and duty type S1 (IEC) in 10 CFR 431.12. It also recommended that DOE revise the current definitions of NEMA Design A, B, and C motors to update the reference from NEMA MG 1–2009 to the revised document ANSI/NEMA MG 1–2011. (CEC, No. 96 at p. 3)

DOE understands that ''continuous'' and ''S1'' are terms well understood by the motor industry, and DOE has therefore not established definitions for these terms. DOE clarifies in this rule that these terms are used to designate a motor that can operate indefinitely in rated conditions and reaches thermal equilibrium. This stands in contrast to motors that may be rated for intermittent operation or with specific loading, braking, or starting restrictions.

With respect to the MG 1 publication version, DOE notes that the terms mentioned by CEC are identical in both versions of MG 1. DOE, therefore, finds there is no reason to amend the reference.

1. Vertical Electric Motors

NEMA and Nidec both suggested several modifications in the test procedure for vertical electric motors and expressed concern that, without these changes, it will be difficult for manufacturers to test vertical electric motors correctly for compliance purposes. (NEMA, No. 93 at p. 29; Nidec, No. 98 at p. 9–10)

DOE recognizes the desire for clarification in the 2013 test procedure for vertical electric motors, but notes that the rule has now gone into effect and the changes suggested by commenters are beyond the scope of today's energy conservation standard. Based on stakeholder concerns, however, DOE will evaluate whether further clarification on the testing of vertical electric motors is necessary.

C. Current Equipment Classes and Scope of Coverage

When evaluating and establishing energy conservation standards, DOE divides covered equipment into equipment classes by the type of energy

[16] For the purposes of this document, ''Joint Advocates'' is a term used to describe NPCC, NEEA, ACEEE, ASAP, Earthjustice, ASE, NRDC, and NEEP, who commented jointly.

used or by capacity or other performance-related features that would justify a different standard. In making a determination whether a performance-related feature justifies a different standard, DOE must consider factors such as the utility to the consumer of the feature and other factors 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 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.

D. Updated Equipment Classes and 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 first provided DOE with the statutory authority to regulate ''electric motors,'' which were defined as including certain ''general purpose'' motors. (42 U.S.C. 6311(13)(A) (1992)) In addition to defining this term, Congress prescribed specific energy conservation standards for electric motors (*i.e.,* general purpose electric motors (subtype I). EPACT 1992 also defined the terms ''definite purpose motors'' and ''special purpose motor''. (42 U.S.C. 6311(13)(C) and (D) (1992)) EPACT 1992 explicitly excluded definite purpose and special purpose motors from the prescribed standards. (42 U.S.C. 6313(b)(1) (1992)) However, EISA 2007 struck the narrow EPACT 1992 definition of ''electric motor''. (42 U.S.C. 6311(13)) 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, it did not apply those standards to definite or special purpose motors. (42 U.S.C. 6313(b) (2012))

Consistent with EISA 2007's reworking of the ''electric motor'' definition, the 2012 test procedure broadly defined the term ''electric motor''. 77 FR 26608 (codified at 10 CFR 431.12). In view of the changes introduced by EISA 2007 and the absence of energy conservation standards for special purpose and definite purpose motors, it is DOE's view that both of these motors are categories of ''electric motors'' covered under EPCA, as currently amended. Accordingly, DOE added the term ''electric'' to the definitions of ''special purpose motor'' and ''definite purpose motor'' in the 2013 test procedure. *See* 78 FR 75994. Today's rule amends and establishes standards for a variety of electric motors, including certain definite purpose and special purpose motors. DOE is setting energy conservation standards for any electric motor exhibiting all of the following nine characteristics:

(1) Is a single-speed, induction motor,

(2) Is rated for continuous duty (MG 1) operation or for duty type S1 (IEC),

(3) Contains a squirrel-cage (MG 1) or cage (IEC) rotor,

(4) Operates on polyphase alternating current 60-hertz sinusoidal line power,

(5) Is rated 600 volts or less,

(6) Has a 2-, 4-, 6-, or 8-pole configuration,

(7) Is built in a three-digit or four-digit NEMA frame size (or IEC metric equivalent), including those designs between two consecutive NEMA frame sizes (or IEC metric equivalent), or an enclosed 56 NEMA frame size (or IEC metric equivalent),

(8) Produces at least 1 horsepower (0.746 kW) but not greater than 500 horsepower (373 kW), and

(9) Meets all of the performance requirements of a NEMA Design A, B, or C motor or of an IEC Design N or H motor.

However, the updated standards specifically do not apply to the following equipment:

- Air-over electric motors;
- Component sets of an electric motor;
- Liquid-cooled electric motors;
- Submersible electric motors; and
- Inverter-only electric motors.

To facilitate the potential application of energy conservation standards to special and definite purpose motors, DOE defined certain motors and provided certain preparatory test procedure steps in the 2013 test procedure. *See* 78 FR 75961. DOE chose not to establish standards for the component sets of an electric motor, liquid-cooled, submersible, and inverter-only electric motors listed above because of the current absence of a reliable and repeatable method to test them for efficiency. If a test procedure becomes available, DOE may consider setting standards for these motors at that time. For air-over electric motors, during the course of the test procedure rulemaking, DOE learned about a possible test procedure for such motors but DOE does not currently have enough information to support the establishment of a test method. 78 FR 75975.

Finally, as discussed in the NOPR, although DOE believes that EPCA, as amended through EISA 2007, provides sufficient statutory authority to regulate a wider variety of electric motors (including those commonly referred to as special purpose or definite purpose motors) than those already regulated as ''electric motors,'' DOE notes that section 10 of the American Energy Manufacturing Technical Corrections Act (''AEMTCA''), Public Law 112–210 (December 18, 2012), amended DOE's authority to regulate commercial and industrial equipment by including ''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.[17]

[17] 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 rule, DOE has 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.

In response to the NOPR, the Motor Coalition recognized that DOE's proposed broadening of the scope of motors that would be covered at TSL 2 efficiency levels is consistent with the Petition. (Motor Coalition, Pub. Mtg. Tr., No. 87 at pp. 18–19) NEMA agreed with DOE's proposed expansion of scope of coverage, noting that it is largely consistent with the Petition. (NEMA, No. 93 at p. 3) Nidec commented that DOE's proposal presents a sufficiently broad scope of coverage and that no further adjustment is needed. (Nidec, No. 98 at p. 5) The CA IOUs supported DOE in adopting TSL 2 for most equipment class groups. (CA IOUs, No. 99 at pp. 1–2) The Joint Advocates supported the proposed standards, noting that the standards will save 7 quads of energy over thirty years of equipment sales and will significantly contribute to the President's Climate Action Plan goal for new standards. It urged DOE to complete the final rule by May 2014 as previously committed to the Attorneys General of several states. (Joint Advocates, No. 97 at p. 2) The European Committee of Manufacturers of Electrical Machines and Power Electronics (CEMEP) expressed support for increasing certain motor efficiency standards to TSL 2, or NEMA Table 12–12. CEMEP noted that DOE is appropriately considering impacts on and perspectives of OEMs and end users, as well as global harmonization issues. (CEMEP, No. 89 at p. 2) Gerritsen supported the proposed standards, noting that is the standards are essential to curb carbon dioxide emissions. (Gerritsen, No. 81 at p. 1) Southern California Edison commented that they support DOE in adopting TSL 2, *i.e.*, NEMA Premium®[18] levels, noting that these will lead to ''the maximum improvement in energy efficiency that is technologically feasible and economically justified'' as well as significant energy savings. In view of significant energy savings and general stakeholder support, SCE requested that DOE publish final rule soon. (SCE, No. 101 at pp. 1–2)

The Copper Development Association (CDA) supported DOE's current rulemaking and the inclusion of additional motor categories and requiring motors that operate at 201 hp through 500 hp to meet premium standards. CDA suggested that DOE investigate covering motors over 500 hp and currently uncovered motors 1 hp through 500 hp for future rulemaking. CDA noted that motors over 500 hp consume 27 percent of all U.S. energy consumed by motors in operation. Noting that some manufacturers even currently offer motors significantly above premium efficiency levels, CDA suggested that DOE investigate the development of a new even higher energy efficiency category—''super premium'' above the current premium efficiencies. (CDA, No. 90 at pp. 1–2)

DOE may consider expanding the scope of its regulations to large motors, which carry different technologies and usage patterns, in future updates to the rule. At that time, DOE would consider any efficiency levels beyond premium efficiency in place and evaluate them for standards.

E. 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.

After DOE has determined 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 equipment utility or availability; and (3) adverse impacts on health or safety. Section IV.B of this rule discusses the results of the screening analysis for electric motors, particularly the designs DOE considered, those it screened out, and those that are the basis for the trial standard levels (TSLs) in this rulemaking. For further details on the screening analysis for this rulemaking, see chapter 4 of the final TSD.

2. Maximum Technologically Feasible Levels

When DOE adopts a new or amended standard for a type or class of covered equipment, it must determine the maximum improvement in energy efficiency or maximum reduction in energy use that is technologically feasible for such product. (42 U.S.C. 6295(p)(1)) This requirement also applies to DOE proposals to amend the standards for electric motors. (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 final TSD.) The max-tech levels that DOE determined for this rulemaking are described in section IV.C.3 of this final rule.

In response to the NOPR, CEC claimed that DOE has not provided the technological feasibility and economic justification as required by statute for updating the existing energy consumption standards for general purpose electric motors (subtype I or II) that are not NEMA Design A, B, or C, or IEC Design N or H, and for polyphase motors rated between 1 and 250 hp (2 poles) and motors between 1 and 350 hp (8 poles). It further stated that DOE did not provide market and technology analysis for motors greater than 500 hp, motors with more than 8 poles and shaded pole motors. (CEC, No. 96 at pp. 1, 3)

DOE acknowledges that the motors in the scope of today's rulemaking are not the only possible motors for which standards may produce economically justified energy savings. As detailed above, DOE's electric motor regulations came about due to statutory requirements that initially included a narrow scope of electric motors that DOE could regulate, but that has become increasingly broad with the changes brought about by EISA 2007 and AEMTCA. As that universe of electric motors that DOE is authorized to regulate expands, DOE considers other motor types that it may regulate under the statute and considers what types of electric motors use large amounts of energy, are produced in large volume, and have opportunities for efficiency gains. DOE may consider future regulation of some of the motor types which CEC mentions and welcomes data that illustrates savings potential of currently unregulated technologies.

The University of Michigan and Oakland University (UMI & OU)

[18] DOE notes that ''NEMA Premium'' is a registered trademark of NEMA. NEMA has removed the term ''NEMA'' from the title of MG 1–2011, Table 12–12. Unless indicated otherwise, in the remainder of this document, any reference to ''premium'' standards should be considered a reference to MG 1–2011, Table 12–12.

suggested that before finalizing the current rulemaking, DOE should conduct a study to update National Electrical Code Table 430.250, which is used to design circuits of motors covered by current regulation. UMI & OU suggested that before finalizing the current rulemaking, a study should be conducted to determine the optional method of establishing the nameplate ratings of combination HVAC equipment rated according to running load amperes. (UMI & OU, No. 92 at pp. 1–2)

DOE understands that NEC Table 430.250, mentioned by UMI & OU, helps engineers specify wiring in building by providing current as a function of motor power, voltage, and power factor. DOE understands that more efficient motors may cause application engineers to differently design building circuits which contain electric motors. If such changes brought by a technology have adverse impacts to safety or equipment utility, DOE may opt to remove that technology from consideration in its screening analysis. Presently, DOE has not learned of any such expected impacts resulting from the standard levels selected in today's rule. Moreover, the National Electrical Code is developed by the National Fire Protection Association (NFPA) and DOE has no authority to change this code.

F. 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 (2016–2045). The savings are measured over the entire lifetime of equipment purchased in the 30-year period.[19] 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 energy savings from new and amended standards for electric motors subject to this rulemaking. The NIA spreadsheet model (described in section IV.H of this rule) 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, which is referred to as primary energy. To convert electricity in kWh to primary energy units, on-site electricity consumption is multiplied by the site-to-power plant energy use factor (see TSD chapter 10). The site-to-power plant energy use factor is defined as the ratio of the marginal change in total primary energy consumption by the electric power sector (in quadrillion Btu's) divided by the change in total electricity generation due to a standard. DOE derives site-to-power plant energy use factors from the model used to prepare the Energy Information Administration's (EIA) *Annual Energy Outlook (AEO).*

DOE also estimates 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 (*i.e.,* coal, natural gas, petroleum 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.[20] The NAS report discusses that FFC was primarily intended for energy efficiency standards rulemakings where multiple fuels may be used by a particular product or piece of equipment. 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. Although, the addition of FFC energy savings in the rulemakings is consistent with the recommendations, 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 standards.

2. Significance of Savings

As noted above, 42 U.S.C. 6295(o)(3)(B) (as applied to equipment via 6316(a)) 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.

G. 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) (as applied to equipment via 6316(a))) The following sections discuss how DOE has addressed each of those seven factors in this rulemaking.

a. Economic Impact on Manufacturers and Consumers

In determining the impacts of a 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

[19] 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.

[20] ''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.*

regulation—and a long-term assessment over a 30-year period.[21] 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. These measures are discussed further in the following section. For consumers in the aggregate, DOE also calculates the national net present value of the economic impacts applicable to a particular rulemaking. DOE also evaluates the LCC impacts of potential standards on identifiable subgroups of consumers that may be affected disproportionately by a national standard.

b. Life-Cycle Costs

EPCA requires DOE to consider the savings in operating costs throughout the estimated average life of the covered equipment compared to any increase in the price of the covered equipment that are likely to result from the imposition of the standard. (42 U.S.C. 6295(o)(2)(B)(i)(II) and 6316(a)) DOE conducts this comparison in its LCC and PBP analysis.

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 the equipment. 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. For its analysis, DOE assumes that consumers will purchase the covered equipment in the first year of compliance with amended standards.

The LCC savings for the considered efficiency levels are calculated relative to a base case that reflects projected market trends in the absence of amended standards.

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.

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) and 6316(a)) As discussed in section IV.H, DOE uses the NIA spreadsheet to project national site energy savings.

d. Lessening of Utility or Performance of Products

In establishing classes of equipment, 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 equipment. (42 U.S.C. 6295(o)(2)(B)(i)(IV) and 6316(a)) As noted earlier, the substance of this provision applies to the equipment at issue in today's rule as well. DOE has determined that the standards in today's notice will not reduce the utility or performance of the equipment under consideration in this rulemaking. Currently, many motors are already commonly being sold at the selected levels (*i.e.,* ''premium efficiency'' designation). In addition, the selected standards closely track the recommendations of NEMA, a trade association that represents electric motor manufacturers. DOE assumes that NEMA would not recommend efficiency levels that would harm electric motor performance or utility.

e. Impact of Any Lessening of Competition

EPCA directs DOE to consider the impact of any lessening of competition that is likely to result from the imposition of a standard. (42 U.S.C. 6295(o)(2)(B)(i)(V) and 6316(a)) It also directs the Attorney General of the United States to determine the impact, if any, of any lessening of competition likely to result from a standard and to transmit such determination to the Secretary 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)(i)(V) and (B)(ii)) To assist the Attorney General in making a determination for electric motor standards, DOE provided the Department of Justice (DOJ) with copies of the NOPR and the TSD for review. DOE received no adverse comments from DOJ regarding the proposal.

f. Need for National Energy Conservation

The energy savings from today's 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.

Today's 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 rule. 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) and 6316(a)) In developing this final rule, DOE has also considered the submission of the Petition, which DOE believes sets forth a statement by interested persons that are representative of relevant points of view (including representatives of manufacturers of covered equipment, and efficiency advocates) and contains recommendations with respect to an energy conservation standard. DOE has encouraged the submission of consensus agreements as a way to bring diverse interested parties together, to develop an independent and probative analysis useful in DOE standard setting, and to expedite the rulemaking process. DOE also believes that standard levels recommended in the Petition may increase the likelihood for regulatory compliance, while decreasing the risk of litigation.

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

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

consumer of a product or piece of equipment that meets the standard is less than three times the value of the first year's energy savings resulting from the standard, as calculated under the applicable DOE test procedure. DOE's LCC and PBP analyses generate values used to calculate the effect potential amended energy conservation standards would have on the payback period for consumers. These analyses include, but are not limited to, the 3-year payback period contemplated under the rebuttable-presumption test. In addition, DOE routinely conducts an economic analysis that considers the full range of impacts to consumers, manufacturers, the nation, and the environment, as required under 42 U.S.C. 6295(o)(2)(B)(i). 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 final rule.

IV. Methodology and Discussion of Related Comments

DOE used four spreadsheet tools to estimate the impact of today's standards. The first spreadsheet calculates LCCs and PBPs of potential new energy conservation standards. The second provides shipments forecasts and the third calculate 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 standards analysis is called NEMS–BT [22] and is based on the *AEO* version with minor modifications.[23]

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 2012 test procedure added clarity to the definitions for each of these motor categories, which are now codified at 10 CFR 431.12. 77 FR 26608.

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 characteristics provided in the definitions of general purpose electric motor (subtype I or subtype II) at 10 CFR 431.12 determine whether an IEC motor should be considered subtype I or II. All of these elements flow directly from the statutory changes enacted by EISA 2007. Currently, electric motors are required to meet energy conservation standards as follows:

TABLE IV.1—CURRENT ELECTRIC MOTOR ENERGY CONSERVATION STANDARDS [24]

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.

In response to the NOPR, NEMA commented that the proposed standards do not resolve the confusion regarding IEC electric motors. NEMA explained that it is not clear whether an electric motor in an IEC frame size that meets the other criteria of a general purpose electric motor (subtype I) would be classified as equivalent to a T-frame, hence subtype I, or U-frame, hence subtype II. Therefore, NEMA suggested that IEC frame sizes be considered equivalent to NEMA T-frames. NEMA suggested that the pertinent portion of the definition of ''general purpose electric motor (subtype II)'' in 10 CFR 431.12 should be revised from ''(i) A U-Frame motor'' to read ''(i) Is built in accordance with NEMA U-frame dimensions as described in NEMA MG 1–1967 (incorporated by reference, see § 431.15), including a frame size that is between two consecutive NEMA frame sizes.'' (NEMA, No. 93 at pp. 3–5, 32)

Changes to the applicability of the electric motor standards currently in effect are outside the scope of this rulemaking. Additionally, DOE notes that NEMA's proposed changes to the definition of ''general purpose electric motor (subtype II)'' reflect that it may have been looking at an older version of the definition rather than the current

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

[23] 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) (February 1998), available at: *http://tonto.eia.doe.gov/FTPROOT/forecasting/058198.pdf.*

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

definition found at 10 CFR 431.12. DOE notes that the current definition of ''general purpose electric motor (subtype II)'' already includes the language being suggested by NEMA.

2. Expanded Scope of Electric Motor Energy Conservation Standards

a. Summary

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 rule. 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 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)

DOE is now requiring electric motor types beyond those currently covered 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 establishes energy conservation standards for electric motors that exhibit all of the characteristics listed in Table IV.2, with a limited number of exceptions, listed in Table IV.4.

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 built in a three-digit or four-digit NEMA frame size (or IEC metric equivalent), including those designs between two consecutive NEMA frame sizes (or IEC metric equivalent), or an enclosed 56 NEMA frame size (or IEC metric equivalent),
Produces at least 1 horsepower (0.746 kW) but not greater than 500 horsepower (373 kW) and
Meets all of the performance requirements of a NEMA Design A, B, or C motor or of an IEC Design N or H electric motor.

Table IV.3 lists the formerly unregulated electric motor types that will be covered by today's rule. Further details and definitions for the specific motor types can be found in DOE's 2013 test procedure. 78 FR 75961.

TABLE IV.3—CURRENTLY UNREGULATED MOTOR TYPES THAT ARE COVERED BY THIS RULE

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.
Brake electric motors	Electric motors with encapsulated windings.
Electric motors with separately powered blowers	

However, the new standards specifically do not apply to the following equipment:

TABLE IV.4—EQUIPMENT SPECIFICALLY EXCLUDED FROM COVERAGE

Electric Motor Type
Air-over electric motors.
Component sets of an electric motor.
Liquid-cooled electric motors.
Submersible electric motors.
Inverter-only electric motors.

Additionally, DOE is clarifying the design, construction, and performance characteristics of covered electric motors. Specifically, DOE is clarifying that only motors rated from 1 to 500 horsepower (inclusive), or their IEC equivalents, would be covered by the standards established in today's rulemaking. Finally, with regard to IEC-frame motors, DOE's standards would not regulate IEC motors on the singular basis of frame size, but would regulate such motors if they meet all the criteria of Table IV.2. In other words, an IEC-frame motor that meets these nine criteria and does not fit within one of the five exceptions would have to meet today's final standards.

In response to the NOPR, DOE received several comments on its scope criteria. CEMEP supported the nine characteristics to define electric motors, noting that using those criteria to define covered motors will lead to huge energy savings by covering millions of units. CEMEP believed that the nine characteristics definition can be applied by customs and other enforcement officers to improve overall enforcement activities. (CEMEP, No. 89 at p. 2).

Nidec commented that DOE should bring more clarity to characteristic #8 (*i.e.,* 1–500 hp as proposed as (g)(8)) by including kilowatt values corresponding to the given horsepower values (*e.g.,* 500 horsepower (343 kilowatts), 1 horsepower (0.75 kilowatt). (Nidec, No. 98 at pp. 2, 7–8) DOE believes this is a helpful suggestion that comports with the inclusion of IEC motors in today's rulemaking and is incorporating the suggestion into today's rule.

NEMA sought clarification regarding whether solid shaft medium and high thrust motors are included in the scope of coverage. (NEMA, No. 93 at p. 27) During the NOPR public meeting, CEC and EEI requested clarification on whether pool pump motors are covered under new standards or by the Small Electric Motors regulations. (CEC, Pub. Mtg. Tr., No. 87 at p. 55) The CA IOUs commented during the public meeting that most pump motors are single-phase and, sometimes, variable-speed, both of which would disqualify motors from coverage. (CA IOUs, Pub. Mtg. Tr., No. 87 at pp. 55–56). Nidec added its belief that the small motor rule does not cover variable speed motors. (Nidec, Pub. Mtg. Tr., No. 87 at p.56).

Any motor that meets the nine criteria as given in paragraph (g) and which is not explicitly exempted by criteria given in paragraph (m) is covered under the current rulemaking. Both single-phase and variable speed motors are not covered in today's rule, and so any motor with those qualities would not be subject to today's standards.

b. Definitions, Terminology, and Regulatory Language

In response to the NOPR, DOE received a number of comments requesting clarification on its choice of terminology.

''Motor'' and ''Electric Motor''

Baldor commented that the use of the terms ''motor'' and ''electric motor'' interchangeably in the NOPR is very confusing. DOE understands that the terms ''motor'' and ''electric motor'' may refer to a variety of machines outside of its regulatory context. In the NOPR, DOE used the terms to mean the same thing. 78 FR 73589. In addition, because there are no NEMA Design B motors, for example, that are not electrically driven, in DOE's view, the potential for ambiguity is minimal.

The Department chose to not include the term ''electric'' in the NEMA-designated motor types to be consistent with NEMA's definitions. In the regulatory context, however, DOE does not consider there to be any difference between the two terms and notes that all motors currently regulated under 10 CFR part 431, subpart B, are electric motors as stated in the title to 10 CFR part 431, subpart B and the purpose and scope section at 10 CFR 431.11. Moreover, NEMA itself uses the term ''motor'' in MG 1 to refer to electric motors.

Specificity of Definitions

Baldor stated that the definitions for ''NEMA Design A motor'' and ''NEMA Design B motor'' in 2013 test procedure does not make reference to nine characteristics listed in paragraph (g) and, thus, implies that it includes multi-speed motors, motors rated for voltages greater than 600 volts, motors rated for only 50 Hz, and motors constructed with more than 8 poles. According to Baldor, this conflicts with DOE's proposed scope of coverage in Table 4 and Table 5 of the NOPR. It noted that paragraph (i) and Table 6 for NEMA Design C motor are similarly confusing. (Baldor, No. 100 at pp. 2–4)

DOE agrees with Baldor that minimizing ambiguity in regulatory text is critical. In this case, however, DOE does not see the potential for confusion. DOE believes that today's regulatory text is of sufficient clarity that stakeholders will understand that the new standards apply only to those motors that meet the nine criteria in the new 10 CFR 431.25(g).

NEMA Design A, B or C motors are not defined to include these nine characteristics, which DOE is using to narrow the scope of covered electric motors. The definition of NEMA Design A may include multi-speed motors, motors rated for voltages greater than 600 volts, motors rated for only 50 Hz, and motors constructed with more than 8 poles. However, only NEMA Design A motors meeting all nine characteristics in § 431.25(g) are covered under today's rule. DOE's regulatory structure maintains the current standards at 10 CFR 431.25(a)–(f) while adding broader coverage in new paragraphs (g) through (l). The structure that DOE chose preserves the current regulatory text and allows DOE to use the same definitions for all motors covered under 10 CFR 431.25.

''NEMA Design A Motor'' Correction

NEMA commented that the definition for NEMA Design A motor needs to be corrected by replacing the phrase ''has a locked rotor current not to exceed'' the values shown in NEMA MG 1–2009, as proposed in the NOPR with ''has a locked rotor current higher than'' the values shown in NEMA MG 1–2009. (NEMA, No. 93 at p. 29) The Joint Advocates requested that DOE consider NEMA's comments on definitions to bring clarity to the covered motors. (Joint Advocates, No. 97 at p. 3)

DOE agrees with NEMA that the Department inadvertently used the incorrect phrase when discussing the locked rotor current in the definition of a ''NEMA Design A motor''. As evidenced in the preamble of the 2013 test procedure (78 FR 75968) and the preamble and regulatory text of the proposed test procedure (78 FR 38462, 38481), DOE intended to include locked rotor current that exceeds the maximum locked rotor current established for a NEMA Design B motor in the ''NEMA Design A motor'' definition. In today's rule, DOE is modifying the regulatory text accordingly.

''NEMA Design C Motor'' Correction

NEMA suggested DOE revise paragraph (i) and the title of Table 6 of the proposed 10 CFR 431.25 by replacing ''NEMA Design C electric motor'' with ''NEMA Design C motor'' for consistency with DOE's regulatory definitions.

As described above, DOE agrees, and has made the corresponding change in the regulatory text for consistency with the definitions adopted in the 2013 test procedure. DOE notes that it has further corrected the reference to ''NEMA Design A and B motors'' in the title of Table 5 to be consistent with the DOE regulatory definitions.

''Inverter-Only Electric Motor'' Definition

Baldor and NEMA raised concerns that DOE has defined ''inverter-only electric motor'' and not ''definite-purpose, inverter-fed electric motors'' which is the term that the NOPR referenced. Baldor noted that the term ''definite-purpose, inverter-fed electric motors'' is preferred and recognized by the motor industry as given in Part 31 of the NEMA MG 1 standard. (Baldor, No. 100 at p. 6; NEMA at pp. 2–3)

Although DOE has previously used the term ''definite-purpose, inverter-fed electric motor,'' DOE instead adopted the term ''inverter-only electric motor'' in its 2013 test procedure because ''definite-purpose''' is a term that has meaning in the context of many other motor types which DOE does not wish to be confused with those requiring inverters. DOE also wishes to define these motors in terms of their actual capabilities instead of design intent. *See* 78 FR 75989.

c. Horsepower Rating

DOE's proposed standards include only motors rated from 1–500 horsepower, inclusive. In its comments, NEMA agreed with DOE's decision not to cover fractional hp motors, noting that these motors do not fall within the scope of rating for which NEMA Design A, B and C performance standards are defined. (NEMA, No. 93 at p. 15) Consequently, DOE is continuing not to regulate fractional horsepower, enclosed, 56-frame motors in today's notice.

d. High-Horsepower Six- and Eight-Pole Motors

NEMA noted that Table 2 does not contain the higher horsepower ratings for large motors in 6 and 8 poles that are added in Table 7 and it suggested that DOE conform Table 7 to Table 2. (NEMA, No. 93 at pp. 23–26) Baldor made a similar comment. (Baldor, No. 100 at p. 4)

In keeping with the Motor Coalition's Petition and with MG 1–2009, DOE had proposed standards for motors with certain high horsepower and pole ratings (8-pole above 250 hp and 6-pole above 350 hp) that NEMA commented do not exist under MG 1's medium motors designations. For example, it is impossible to produce a NEMA Design A 6-pole motor of 400 hp because the criteria required to qualify a medium motor as Design A [25] do not extend to such a high horsepower motor. NEMA notes that the table in the 2011 version of MG 1 has corrected the mistake of MG 1–2009 and moved these higher horsepower motors to the large motor Table 20–20 of MG 1. In its written comments in response to the NOPR, NEMA asked DOE not to adopt standards for motors of this pole and horsepower configuration because NEMA Design A and B types are not defined for and are not applicable to large motors. (NEMA, No. 93 at pp. 23–26) Accordingly, DOE has removed several efficiency levels that were proposed in table 5. As the eliminated ratings are nonexistent—it is not possible to build motors meeting such specifications—motors shipments analyses used in today's rule are unaffected.

e. Frame Size

In response to the NOPR, DOE received a number of comments related to frame size.

Scope Characteristic #7

NEMA requested that DOE amend the nine characteristics of regulated motor to include four-digit frame sizes because 500 hp and 6- and 8-pole motors only come in frame sizes larger than three-digit frame sizes. (NEMA, Pub. Mtg. Tr., No. 87 at pp. 42–43; NEMA, No. 93 at p 26)

NEMA also noted that IEC does not put design specifications on the motor, especially for larger-sized motors. Therefore, it requested that DOE use language that will include all such motors (through 500 hp) equivalent to covered NEMA motors. (NEMA, Pub. Mtg. Tr., No. 87 at pp. 42–44; NEMA, No. 93 at p. 26)

Nidec added that the higher horsepower ratings as shown in table 4 of the NOPR are above current three-digit frame size. (Nidec, Pub. Mtg. Tr., No. 87 at p. 45) Secondly, Nidec commented that while the proposed standard helps clarify the IEC motor coverage, removing characteristic #7 from the nine characteristics in paragraph (g) of 10 CFR 431.25 would remove any confusion about motor size. It commented that DOE may add electric motors covered by the regulations for small electric motors to the list of exempted motors in paragraph (m) of the proposed 10 CFR 431.25.

DOE agrees with the above commenters that it was DOE's intent to ensure that four-digit frame size motors and IEC equivalents of covered motors are covered by these new standards and has adopted revised language in paragraph (g)(7) of § 431.25 to reflect that fact. The updated language covers three-digit frame sizes, four-digit frame sizes, IEC equivalents, and equivalents between NEMA frame sizes.

NEMA 56-Frame Motors Coverage

NEMA 56-frame motors at 1 hp or greater have been the subject of considerable discussion, due to the fact that they may be covered as a small electric motor under subpart X of 10 CFR part 431, or as an electric motor under subpart B of 10 CFR part 431 depending on whether they are general-purpose, definite or special purpose, or have an open or enclosed frame. Currently, 56-frame motors are covered as small electric motors if the motor is an open, general-purpose motor that meets the ''small electric motor'' definition at 10 CFR 431.442. The NOPR proposed to extend coverage to 56-frame enclosed motors rated at 1 hp or greater. 78 FR 73589. For 56-frame open, special and definite purpose motors, the NOPR stated that DOE was considering establishing standards for these motor types as well, but requested additional information on those motor types. 78 FR 73606, 73679. Today's rule covers enclosed 56-frame motors rated at 1 hp or greater but does not establish standards for 56-frame open, definite or special purpose motors. DOE notes that, because today's rule covers all enclosed 56-frame motors, both general purpose and special and definite purpose enclosed 56-frame motors are covered under today's rule.

In response to the NOPR, NEMA provided detailed comments about how DOE should rephrase characteristic #7 and add a sixth exemption to 10 CFR 431.25 if DOE chose to include 56-frame open, definite or special purpose motors. This would also eliminate any confusion regarding covering all IEC frame sizes and all frame sizes between two consecutive NEMA or IEC frame sizes. It also commented that it is ambiguous as to whether a 56-frame, open general purpose motor has different efficiency levels and nameplate markings as compared to the 56-frame open, special and definite purpose motors. (NEMA, No. 93 at pp. 14–15; NEMA, Pub. Mtg. Tr., No. 87 at p. 61) NEMA noted that the current rulemaking cannot be compared with the small motors rule in terms of efficiency requirements and ELs, because the small motor rule requirements are based on average efficiency while electric motor rule are based on nominal full-load efficiency. (NEMA, No. 93 at pp. 28–29)

DOE agrees that coverage of 56-frame, open, special- and definite-purpose motors would require coordination with DOE's small electric motor requirements. In the NOPR, DOE requested additional data on this subset of 56-frame motors to allow DOE to fully assess these motor types. No commenter provided DOE such data. As a result of these complications and the need for more data, DOE does not cover them in today's rule, but may consider covering such motors in a future rulemaking. As explained in the ''Scope Characteristic #7'' section of this section, IVA.2.e, DOE has modified Characteristic #7 accordingly. Table IV.5 provides a summary of respective coverage of 56-frame electric motors.

TABLE IV.5—56-FRAME REGULATION, 1 HORSEPOWER AND GREATER

	Open	Enclosed
General Purpose	Covered as a "small electric motor" up to 3 hp.[26]	Not currently covered; covered by this rule.
Special/Definite Purpose	Not currently covered; not covered by this rule	Not currently covered; covered by this rule.

f. IEC Motors

NEMA noted that: (1) There is no one-to-one correspondence between NEMA frame sizes and IEC metric equivalents; (2) the phrase ''NEMA frame'' refers to specific NEMA T-frame sizes; and (3) IEC 100 frames are currently exempt but should be covered. Based on the above, NEMA commented that DOE has

[25] As described in both MG 1–2009 and 10 CFR 431.12.

[26] *See* 10 CFR 431.442.

removed nearly all IEC motors from any requirement to meet efficiency standards. In order to effectively include standards for IEC motors, it suggested DOE to change the titles of table 5 and 6 and the contents of paragraphs (h) and (i) within 10 CFR 431.25 to reflect that they included the IEC equivalents. (NEMA, No. 93 at p 4) DOE agrees that it was the intent to cover these motors and has amended the regulatory language to make this clear.

In response to the NOPR, NEMA commented that it believed DOE may be of the opinion that because, in DOE's proposed rule, reference is no longer being made to T-frames and all covered frame sizes would have three digits, that DOE no longer needs the text ''including a frame size that is between two consecutive NEMA frame sizes or their IEC metric equivalents'' when describing coverage. NEMA noted, however, that manufacturers may mistakenly equate ''NEMA frame'' with ''T-frame,'' and mistakenly conclude that certain IEC motors (*e.g.,* IEC 100 frame) were uncovered. To remedy this ambiguity, NEMA suggested that DOE modify scope Characteristic #7. (NEMA, No. 93 at p. 26)

DOE appreciates the need to clarify coverage of NEMA versus IEC motors and their equivalents and, consistent with its stated intentions in the NOPR to cover IEC-equivalents of all covered motors, has modified characteristic #7 to make coverage of IEC equivalents more explicit. *See* 78 FR 73589.

g. Frequency

NEMA noted that characteristic #4 in paragraph (g) is described as ''operate on polyphase alternating current 60-hertz line power''. NEMA acknowledged that DOE has explained that this is intended to cover electric motors rated at 60 Hz and 50/60 Hz; however, as written, the provision could be read as requiring coverage of 50 Hz motors that are operated on 60 Hz. It is not clear from the proposed standards whether an efficiency standard would apply to a motor's operation at the frequency or frequencies marked on the nameplate of the electric motor or to operation just at 60 Hz. NEMA suggested that DOE add ''at 60 Hz'' to all efficiency table titles to make clear that the covered motors were required to meet the efficiency standard while operating at 60 Hz. (NEMA, No. 93 at p. 5)

DOE agrees that the suggestion brings clarity to the regulations and reflects DOE's intent in the NOPR. Therefore, corresponding changes were made in the regulatory text. Although the efficiency values apply at 60 Hz only, DOE points out that the ability to operate at other frequencies (*e.g.,* 50 Hz) in addition to 60 Hz does not, itself, exclude a motor from coverage.

h. Random Winding

Noting that DOE has established the efficiency levels based on NEMA MG 1 Table 12–12, Nidec raised concern that Table 12–12 is intended only for random wound motors and, therefore, DOE, should amend characteristic #5 to include only electric motors that contain a random wound stator winding. (Nidec, No. 98 at pp. 2, 7–8)

DOE is not aware of any particular winding technique that would make it significantly more difficult for a motor to meet standards and has received no comment suggesting as much. DOE's understanding is that random winding is mostly done automatically to reduce assembly cost, and that more strategic winding (*e.g.,* on a form) is generally done for increased insulation performance at higher voltages. Hand winding is considered in DOE's analysis and generally exhibits performance superior to random winding and would more easily reach higher efficiencies. As a result, DOE perceives no reason to further constrain scope and does not alter scope with respect to the winding method in today's rule.

i. Duty Cycle

DOE's proposed standards applied only to motors rated for continuous duty, which means that a motor may operate indefinitely without pausing for heat to dissipate.

CEC suggested that DOE revise the criterion in proposed section 431.25(g)(2) such that motors not rated for continuous duty are also subject to standards. It suggested that both motors rated or not rated for continuous duty can meet the nominal full-load efficiency standards. (CEC, No. 96 at p. 3)

Although DOE did not receive data on the relative usages of continuous vs. intermittent duty motors, it understands that continuous duty motors account for the majority of the energy consumption of motors investigated within this rulemaking. Due to their inherent limitations, intermittent duty motors are more likely to be used in applications with a lower fraction of the time spent switched on. As a result, these motors use less energy than continuous duty motors. Although DOE has thus far focused its efforts on continuous duty motors, it remains possible that other motor types may achieve cost-effective energy savings through standards, and DOE may consider exploring their future inclusion. DOE notes that the scope of the MG 1 sections to which the standards listed in Tables 12–10, 12–11, and 12–12 apply is continuous duty motors. DOE also notes that today's rule represents an evolution of existing standards for General Purpose Electric Motors (Subtypes I and II), which are defined in 10 CFR part 431, subpart B to have continuous ratings.

j. Gear Motors

Presently, DOE does not define ''gear motor'' or ''gearmotor,'' but understands that these are motors that have gears attached to the motor body, usually for the purpose of trading speed for torque. Depending on the exact configuration, the motor may meet the definition of ''partial electric motor'' as defined in 10 CFR 431.12. In the NOPR, DOE stated that it believed that certain gearmotors could be tested as partial electric motors by first removing the gearbox, so that manufacturers could certify the partial electric motor and be freed from certifying every conceivable motor/gearbox combination. 78 FR 73647. In the 2013 test procedure, DOE specifically addressed integral gear motors and how to test such motors if they meet DOE's definition of ''partial electric motor''. *See* 78 FR 75979, 75994.

Baldor raised concern that the scope of coverage of integral gear motors (or other integral motors under the groupings of ''partial electric motors'') is not clear. Moreover, DOE did not define or propose test procedures for ''integral gearmotors'' in the 2013 test procedure. (Baldor, No. 100 at p. 5–6) In response, DOE reiterates that it does not, at this time, treat gear motors as a distinct category of equipment. Gear motors would be subject to standards if they meet the definition of ''partial electric motor'' or of another type of equipment subject to standards. In those cases, gear motors would be required to certify using whichever test instructions were applicable to that type of motor. DOE notes that manufacturers may apply for a test procedure waiver if their equipment cannot be tested under the methods found in 10 CFR part 431, subpart B.

NORD Gear Corp. recommended that integral gear motors be excluded from the coverage as they do not meet the statutory definition of ''electric motor''. It commented that if gearmotors are subject to rulemaking, it would require the NORD gear motors to be heavier due to the increased copper, steel and aluminum content. It will also require an increase in frame size for some motors and, thus, will prevent the combination of some gearmotors that are currently in use, leading to a product gap in the market for significant amount of time and creating undue economic burden on gearmotor end users. Further, if gear motors are redesigned to meet the standard, millions of combinations of motors and gearboxes will have to be tested and this would place an undue economic burden on gearbox manufacturers. (NORD Gear, No. 91 at p. 2)

DOE understands that an investment of time and capital may be required by the imposition of any standard, and has attempted to discuss, quantify and consider those investments in its Manufacturer Impact Analysis in section IV.J. DOE believes that there should be sufficient time for manufacturers to make changes in designs (if needed) to comply with standards and make the integral gear motors available in the market. With respect to the question of statutory authority, DOE believes that EPCA, as amended through EISA 2007, provides sufficient statutory authority for the regulation of a wide variety of electric motors as described in detail in section II.A.

k. Partial Electric Motors

In response to the NOPR, NEMA raised concern that it is not clear whether the proposed standards in Tables 5 through 8 apply to partial electric motors. To clarify, NEMA recommended that DOE either revise paragraph (g) in 10 CFR 431.15 or add a tenth characteristic to include ‘‘partial electric motors’’. (NEMA, No. 93 at pp. 26–27) Baldor raised concerns that the content of Table IV of the NOPR implies that DOE intends to cover partial electric motors, however, these motors are neither mentioned in the NOPR nor are efficiency standard levels proposed for them. (NEMA, No. 93 at pp. 26–27)

Under the new regulatory scheme in today's final rule, DOE considers partial electric motors to be electric motors subject to the new requirements listed in 10 CFR 431.25(h)–(l) if they meet the nine criteria specified in paragraph (g) of the new § 431.25. DOE's 2013 test procedure provides instructions for testing these motor types to ensure their nominal full-load efficiency can be assessed. 78 FR 75961. To make the inclusion of these motor types abundantly clear, DOE has taken NEMA's suggestion of modifying the regulatory text in 10 CFR 431.25(g) to expressly state that partial electric motors are included.

Additionally, DOE now refers in the to ‘‘special-purpose’’ and ‘‘definite-purpose’’ ‘‘*electric* motors’’. The word ‘‘electric’’ was added in the 2013 test procedure. 78 FR 75961.

Finally, DOE notes that it has updated the definition of ‘‘partial electric motor’’ found in 10 CFR 431.12 to correct a typographical error: Repetition of the word ‘‘an’’ before ‘‘electric motor’’.

l. Certification Considerations Related to Expanded Scope

Baldor sought clarification on which manufacturer should be responsible to file compliance certification report with DOE. Baldor asked whether it should be the manufacturer of the partial electric motor or if instead the manufacturer of the electric motor or assembly of which the partial electric motor is a component must certify it. (Baldor, No. 100 at pp. 5–7)

DOE noted in the 2011 certification, compliance and enforcement rule that it intends to undertake a rulemaking to moving and harmonize, where possible, the certification, compliance, and enforcement provisions for electric motors into Part 429. 76 FR 12422, 12447. DOE will address the party responsible for certifying in that rulemaking.

m. Electric Motors With Separately Powered Blowers

In its comments, NEMA provides an ‘‘Appendix B’’ in which it outlines the ‘‘industry interpretation’’ of which motor types are covered by the rule. DOE notes that NEMA lists electric motors with separately powered blowers under the ‘‘not a covered product’’ category. (NEMA, No. 93 at p. 37)

In the 2013 test procedure, DOE established a method of testing for this type of motor and stated that at least some non-immersible motors that are furnished with separately-powered blowers would meet the same nine criteria that DOE was, at that time, considering applying with respect to its standards rulemaking. 78 FR 75986. Moreover, DOE did not propose to exempt these types of motors from standards in the standards NOPR. 78 FR 73681. DOE maintains its position that electric motors with separately powered blowers that meet the requirements in the new 10 CFR 431.25(g) are covered in today's rule.

3. Advanced Electric Motors

In its final rule analysis, DOE addressed various ‘‘advanced electric motor’’, which included those listed in Table IV.6. While DOE recognizes 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.

TABLE IV.6—ADVANCED ELECTRIC MOTORS

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

At this time, 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.

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) and 6316(a)) Due to the large number of characteristics involved in electric motor design, DOE has developed both ‘‘equipment class groups’’ and ‘‘equipment classes’’. An equipment class represents a unique combination of motor characteristics for which DOE is establishing a specific energy conservation standard. There are 482 potential equipment classes that consist of all permutations of electric motor design types (*i.e.,* NEMA Design A & B, NEMA Design C (and IEC equivalents), and fire pump 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 motor design type. The NEMA Standards Publication MG 1–2011, ‘‘Motors and Generators,’’ defines a series of standard electric motor designs (*i.e.,* Designs A, B and C) that are differentiated by variations in performance requirements. DOE chose to use these design types to establish equipment class groups because design types affect an electric motor's utility and efficiency.

In the NOPR, DOE had divided electric motors into four groups based on three main characteristics: NEMA (or IEC) design letter, whether the motor met the definition of ‘‘fire pump electric motor,'' and whether the motor had a brake. Within each of these groups, DOE utilized 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.[27]

At the NOPR stage, brake electric motors were separated out because DOE was concerned that the presence of a brake (which provides utility in the form of hastened stopping of the motor) might cause additional losses, thereby reducing the motors' ability to meet standards cost-effectively. In its 2013 test procedure, however, DOE established a method of testing brake motors that allowed exclusion of losses attributable to the brake, thereby allowing brake electric motors to be tested without regard to the brake. 78 FR 75995.

For today's final rule, then, 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. DOE's three resulting equipment class groups are: NEMA Design A and B and IEC Design N motors (ECG 1), NEMA Design C and IEC Design H motors (ECG 2), and fire pump electric motors (ECG 3). Table IV.7 outlines the relationships between equipment class groups and the characteristics used to define equipment classes.

TABLE IV.7—ELECTRIC MOTOR EQUIPMENT CLASS GROUPS FOR THE FINAL RULE 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.

* Including IEC equivalents.

a. U-Frame Motors

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.[28] (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 (*i.e.,* losses that result from magnetic field stability changes).[29] 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.[30] In the NOPR, DOE proposed standards for both T-frame and U-frame motors.

In response to the NOPR, NEMA and the Joint Advocates recommended that DOE keep the standards for U-frame motors at current EPACT 1992 (NEMA MG 1–2011,Table 12–11) levels. These commenters argued that U-frame motors are a legacy design used only in the automotive manufacturing industry and that their market share is small and declining; according to these commenters, re-designing of U-frame motors would entail huge costs. NEMA commented that new U-frame motors are not being designed currently, and the old designs primarily cater to the replacement market. According to NEMA, there are no suppliers of U-frame general purpose motors (subtype II) at premium efficiency levels, and its review showed that only one manufacturer of U-frame general purpose electric motors (subtype II) would be impacted by the proposed change in efficiency standards. NEMA also stated that the cost of U-frame motors is generally significantly higher than T-frame motors of the same rating, as indicative of the larger size of the U-frame motor and the costs associated with maintaining of production equipment for old designs. Therefore, it would be highly unlikely that

[27] 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.

[28] 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.

Under EPACT 1992, the only covered electric motors were T-frame electric motors. *See* 42 U.S.C. 6311(13)(A)(1992). These motors were redefined to be ''general purpose electric motor (subtype I)'' under EISA 2007, which, at the time, DOE defined as a motor that can be used in most general purpose applications and that meets standard operating characteristics and mechanical construction for use under usual or unusual service conditions in accordance with specific provisions of NEMA MG 1–1993. That version of MG 1 only included specifications for T-frame motors because the last version of MG 1 to contain U-frame dimensions was published in 1967. *See* 77 FR 266.8.

[29] Several manufacturers provide premium efficient U-frame motors. See, for example, *http://www.usmotors.com/Our-Products/~/media/USMotors/Documents/Literature/Datasheets/PDS/PDS_PREMIUM_EFFICIENT.ashx.*

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

consumers would increase purchases of U-frame motors of lower efficiency as substitutes for T-frame motors. NEMA claimed that DOE did not evaluate the cost burden on manufacturers from re-designing old U-frame motors, and if it did, the results would not support the increase in efficiency standards proposed in the NOPR. The Joint Advocates commented that leaving U-frame motor standards unchanged would enable manufacturers to direct scarce product design resources to product types with larger market shares. (NEMA, Pub. Mtg. Tr., No. 87 at pp. 69–70; NEMA, No. 93 at pp. 27–28; Joint Advocates, No. 97 at p. 2)

By contrast, Nidec supported DOE's proposal to raise efficiency standards of U-frame motors to EL2 (*i.e.,* Table 12–12) levels, noting that it is technologically feasible to increase the efficiency level of these motors. (Nidec, No. 98 at p. 5)

DOE understands NEMA's concerns regarding the diminishing market size of U-frame motors. However, DOE has determined that a complete phase-out of U-frame motors would not be the 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 has concluded that the updated standards are unlikely to result in the unavailability of U-frame motors. Based on catalog data from several large electric motor manufacturers, DOE has observed manufacturer offerings of premium efficiency U-frame motors on the market today.[31] DOE sees no technical reason why U-frame manufacturers would not be able to comply with standards corresponding to TSL 2. DOE notes that it requested, but did not receive, data suggesting that U-frame motors would be eliminated from the market under the standard levels adopted in today's final rule. *See* 78 FR 73610.

Under 42 U.S.C. 6295(o)(4), as applied to commercial and industrial equipment via 42 U.S.C. 6316(a), DOE cannot prescribe a standard that would result in the ''unavailability in the United States in any covered equipment 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''. However, DOE notes that this statutory provision does not require the continued protection of particular classes or types of equipment—in this case, electric motors—if the same utility continues to be available to consumers. Consequently, based on available information, DOE continues to believe that U-frame motors fail to merit a separate equipment class with lower standards and has not created one for them in this final rule.

b. 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 regulating the efficiency of motors of each of these design types.

The primary difference between a NEMA Design A and NEMA Design B 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 applications that 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 grouping these motors together into a single equipment class group for the purposes of this rulemaking.

In contrast, DOE believes that the different torque requirements for NEMA Design C 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 and NOPR, 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 technical support document, DOE noted numerous instances where manufacturers were marketing electric motors rated greater than 200 horsepower as NEMA Design C motors. (see Chapter 2 of TSD)[32] 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 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 regulatory definition for ''NEMA Design C motor'' as provided in the 2013 test procedure. 78 FR 75994. 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 circumvention purposes. DOE understands, however, that NEMA Design C motors as a whole constitute

[31] See, for example: *http://www.marathonelectric.com/motors/docs/manuals/SB547.pdf.*

[32] For instructions on how to access the TSD, visit the rulemaking page at: *http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/42.*

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. In addition, DOE received no comments suggesting this would be likely. Nevertheless, DOE will monitor the potential presence of such motors and may reconsider standards for them provided such practice becomes prevalent.

c. 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). (*See* 77 FR 26608 (codified at 10 CFR 431.12)) Pursuant to NFPA 20, a fire pump electric motor must comply with NEMA Design B performance standards and must continue to operate in spite of any risk of damage stemming from overheating or continuous operation. The additional requirements for a fire pump electric motor are intended to further the purpose of public safety and constitute 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 and maintained that practice through the NOPR and today's final rule.

Regarding the ''fire pump electric motor'' definition, as detailed in the 2012 test procedure (77 FR 26608), 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 26617–26618. As stated in the 2012 test procedure, DOE believes 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. *Id.* 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 MG 1 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. See the standards NOPR for a historical discussion of comments related to fire pump electric motors. 78 FR 73623.

NEMA suggested that DOE should change the title of Table 7 and the content of paragraph (j) to specifically refer to NEMA Design B fire pump electric motors. NEMA commented that although DOE has stated that the standards for fire pump electric motors are based on NEMA Design B types, that fact it is not clear in the definition of ''fire pump electric motor'' in 10 CFR 431.12. (NEMA, No. 93 at p. 5) Baldor also raised concern that the scope of coverage of fire pump electric motors is not clear from only referring to the definition proposed in 10 CFR 431.12., nothing that it had to go through several documents to determine that fire pump electric motors that meet nine criteria and are limited to NEMA Design B and IEC equivalents are covered. (Baldor, No. 100 at p. 4)

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. Therefore, DOE considers it unnecessary to add further restrictions in its regulatory text. DOE also wishes to avoid the implication that IEC equivalents would not be covered. Regarding having to review the nine criteria in the new 10 CFR 431.25(g) to know if a fire pump motor is covered, as DOE explained above, the regulatory scheme used in the new regulations was chosen to maintain the existing regulations for currently regulated electric motors while providing the criteria that all motors must meet if they are regulated motors under the new standards.

NEMA commented that it is aware of few entities that have listed IEC motors for application with fire pumps in the U.S. It also commented that there is confusion regarding the coverage of the efficiency standards for fire pump electric motors. (NEMA, No. 93 at p. 14) By contrast, Nidec provided a link to data on companies that have a UL certification for IEC motors for fire pump applications. (Nidec, No. 98 at p. 5)

Regarding IEC fire pump motors, DOE views Nidec's comment and the fact that IEC motors can be built to very similar specifications as Design B motors (even though they may not be labeled as such) as sufficient cause to maintain the requirement that IEC designs comply with fire pump motor standards as well.

Specifically regarding standards for fire pump electric motors, NEMA and Baldor both raised concerns that the proposed standards for fire pump electric motors in Table 7 were not consistent with the current standards for fire pump electric motors in Table 2, as suggested in the Petition and as DOE intended to propose (*see* 78 FR 73592). (NEMA, No. 93 at pp. 23, 26; Baldor, No. 100 at p. 4)

Finally, the NOPR had mistakenly listed a standard for 1 hp, 2 pole, open fire pump electric motors even though no standard for this configuration is currently in effect, as evidenced by the absence of a standard for this rating in DOE's regulations at 10 CFR 431.25(b). This standard has been removed from the final rule.

d. Brake Electric Motors

In its final rule analyses, DOE considered whether brake electric motors (both integral brake electric motors and non-integral brake electric motors). In the 2013 test procedure, DOE adopted a definition for brake electric motors. 78 FR 75993 In the NOPR, the two types of brake electric motor were 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 electric 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 [33] require electric motors to stop quickly. Motors used in such applications may employ a brake component that, when engaged, abruptly slows or stops shaft rotation.

[33] For example, some conveyor and other material-handling applications require motors to stop quickly.

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 had proposed to establish a separate equipment class group for electric motors with a brake.

During the NOPR public meeting, NEMA argued that DOE has captured most standard stock available and agreed with DOE's decision to limit standards for brake motors to 1–30 hp and 4-, 6- and 8-pole configurations. It commented that larger brake motors are generally design D or intermittent-duty motors for cranes and hoists, which are currently out of the scope of coverage. (NEMA, Pub. Mtg. Tr., No. 87 at pp. 70–71) In its written comments, NEMA noted that brakes can be treated as an accessory because in DOE's test procedure for brake motors, brake electrical losses are not included in the efficiency calculation. Therefore, it suggested that brake motors should not be put in separate equipment class but should be included in tables 5 and 6. (NEMA, No. 93 at pp. 7–8)

The Joint Advocates stated that they support inclusion of integral brake motors in the scope of coverage. However, they commented that establishing a separate class and table of standards for brake motors is unnecessary, because DOE has proposed setting standards for brake motors identical to other motors. Moreover, it requested that DOE include brake motors above 30 hp since there are some motors sold above 30 hp, and capping the brake motors coverage at 30 hp may create confusion about scope of coverage. (Joint Advocates, No. 97 at p. 2)

The Appliance Standards Awareness Project (ASAP) commented that if brake motors have the same standards as other motors, they would not require a separate equipment class group and would not only be regulated at the limited horsepower range proposed. (ASAP, Pub. Mtg. Tr., No. 87 at p. 74)

Regarding the brake motor standards proposed, Baldor raised concern that the title of table 8 does not fully identify the type of integral brake electric motors and non-integral brake electric motors to which the proposed standards apply. Baldor raised concern that DOE has not defined integral and non-integral brake motors in 10 CFR 431.12, even though it makes reference to these motors in the NOPR. Baldor raised concern that the term ''dedicated mechanism for speed reduction'' used in the definition of brake electric motors is ambiguous, stating that it is not clear what DOE intends to cover other than a ''brake''. (Baldor, No. 100 at p. 5)

WEG raised concern that even though a slight friction or windage adder needs to be considered due to brake, there is no need to create a separate equipment class group for brake motors because separate efficiency levels are not set for these motors. WEG commented that larger brake motors exist in the market, but most of them are special motors, which are out of scope of coverage. However, if any larger brake motor falls under the scope of coverage, the proposed standards (only up to 30 hp) may create a loophole. It commented that if it is a standard motor with a brake, the manufacturers would like to use same standard electrical design and not create special one to account for just a few losses. Therefore, it requested that DOE consider exclusion of the brake losses in the criteria. (WEG, Pub. Mtg. Tr., No. 87 at pp. 72–73, 75)

In response, DOE notes that as per the updated test procedures for brake motors, only power used to drive the motor is included in the efficiency calculation, and the power supplied to prevent the brake from engaging is not considered. Through that lens, the efficiency determination for brake motors is similar to that for any motor. Therefore, DOE has removed the separate equipment class group for brake motors in the final rule. DOE understands that most brake motors sold in the market would fall into ECG 1, but notes that a brake motor could be constructed such that it fell into other equipment classes, or none at all. For the purposes of analytical results, however, DOE is still reporting brake motors separately as equipment class subgroup 1b. Results of the former ECG 1 (NEMA Design A and Design B) are now reported as equipment class subgroup 1a. DOE notes that in the final rule, it is not segregating brake motors into ''integral brake motors'' and ''non-integral brake motors'' because it is not necessary for testing. Under this same logic, larger brake motors (*i.e.,* above 30 hp) are now also subject to coverage if rated from 1–500 hp, just as would any other motor type in ECG 1.

With respect to Baldor's concern on terminology, DOE's definition makes reference to a ''dedicated mechanism for speed reduction'' to clarify what is meant by a ''brake''. The definition aims to maintain the general sense of the term to avoid any loophole that may arise with an unnecessarily narrow definition.

The Chinese WTO/TBT National Notification & Enquiry Center acknowledged the energy conservation efforts of United States and requested more clarification about the efficiency values for brake motors given in Table I.5 of NOPR, particularly for 8-pole brake motors, 4-pole open brake motors and 6-pole closed brake motors. (China WTO/TBT NNEC, No. 104 at p. 3)

DOE notes that the confusion around Table I.5 in the NOPR is due to the formatting issues. For the final rule, DOE has deleted what was previously Table I.5 because brake motors are no longer in a separate equipment class group. Depending on the specific characteristics and configuration of a brake motor, it may fall under any ECG category and be subject to the corresponding efficiency standards.

e. 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. In today's rule, DOE continues to use horsepower as an equipment class-setting criterion.

f. 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. For example, eight pole motors have twice as many poles as four-pole motors and, correspondingly, less space for efficiency improvements. Two-pole motors have more internal space, but carry a greater magnetic field spacing which yields inherently less-efficient operation. DOE used the number of poles as a means of differentiating equipment classes in the preliminary analysis. In today's rule, DOE continues to use pole-configuration as an equipment class-setting criterion.

g. Enclosure Type

EISA 2007 prescribes separate energy conservation standards for open and enclosed electric motors. (42 U.S.C. 6313(b)(2)) 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. 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. DOE received no related comments during the NOPR. In today's rule, 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.

h. Other Motor Characteristics

In its analysis, DOE addressed various other motor characteristics, but did not use them to disaggregate equipment classes. In the final 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.

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.8. (See chapter 3 of the TSD for details.)

TABLE IV.8—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.

DOE made several changes to the technology options considered and how they are analyzed between the NOPR TSD and the final rule TSD. First, 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 [34] the rotor to separate rotor bars from rotor laminations after die-casting. DOE has updated the discussion in the TSD chapter 3 to clarify that there are multiple ways to implement this technology option.

Second, DOE notes 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.

Third, DOE notes 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.

Fourth, with regard to increasing the flux density in the air gap, DOE consulted with its subject matter expert (SME) [35] 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.

Other technology options considered are described in detail below.

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

A manufacturer may increase the total cross-section of copper in the stator slots by either increasing slot fill or by increasing the number of stator slots.

Increasing Slot Fill

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

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

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.

As described in the NOPR, 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. 78 FR 73620–73621. DOE's estimated slot fills for its teardowns and software models are all provided in chapter 5 of the TSD.[36]

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.

DOE notes that motor design engineers can adjust slot fill by changing the gauge of wire used in fractions of half a gauge. DOE clarified 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.

DOE is aware of the extra time involved with hand winding and has attempted to incorporate this time into efficiency levels that it believes would require hand winding. DOE added additional labor hours accounted for hand winding in its engineering analysis. 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.

DOE captured the impact of jobs shifting out of the country if hand winding became more widespread during the manufacturer impact analysis (MIA) portion of DOE's analysis. Please see section IV.J for a discussion of the manufacturer impact analysis.

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.

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 SME and understands that optimum stator and rotor slot combinations have been determined by manufacturers and are already currently in use on existing production lines. DOE does not anticipate further efficiency gains from optimizing the combination of stator and rotor slots at the efficiency levels being considered for this rulemaking. Consequently, DOE removed this technology option from chapter 4 of the TSD in the NOPR.

b. Decrease the Length of Coil Extensions

One method of reducing resistance losses in the stator is by 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.

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. DOE did not receive any additional comments regarding this technology option in response to the NOPR and continues to consider it for the final rule analysis.

c. Die-Cast Copper Rotor Cage

Copper offers lower resistivity than aluminum, as well as a potentially more compact design, both of which can contribute to higher efficiency. Manufacturers commonly use copper today to build high performance motors. Although a rotor of arbitrary size may be fabricated by hand, the economics of scale manufacturing demand die-casting of those wishing to produce at significant volumes. As a result, DOE considered die-cast copper only as a technology option. Die-cast copper rotors have been the subject of frequent comment and are more thoroughly discussed in the screening analysis section IV.B.1.a.

d. 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.

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. DOE did not receive any additional comments regarding this

[36] See TSD at: *http://www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/42.*

technology option in response to the NOPR and continues to consider it for the final rule analysis.

e. 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.

When developing its software models, DOE relied on the expertise of its SME. Generally, increases to end ring area were limited to 10–20 percent, which are unlikely to have significant negative 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. DOE did not receive any additional comments regarding this technology option in response to the NOPR and continues to consider it for the final rule analysis.

f. 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.

In the NOPR, DOE noted 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 noted 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 noted 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. The Epstein test results for various grades of steel provided in chapter 3 of the NOPR TSD were purely informational and intended to give an indication of the relative performance of a sample of electrical steels considered. That information was removed from chapter 3 of the NOPR TSD to avoid any further confusion. *See* 78 FR 73614.

DOE did not receive any additional comments regarding this technology option in response to the NOPR and continues to consider it for the final rule analysis.

g. 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 technology analysis, DOE only considered conventional steels with standard gauges available in the market. DOE did not receive any comments regarding this technology option in response to the NOPR and continues to consider it for the final rule analysis.

h. Increase Stack Length

Adding electrical steel to the rotor and stator to lengthen the motor (axially) 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. DOE did not receive any comments regarding this technology option in response to the NOPR and continues to consider it in the final rule analysis.

i. Optimize Bearing and Lubrication

DOE notes that bearings and lubrication can be optimized for cost, performance, maintenance, and other attributes depending on the design requirements. However, DOE is of the understanding that choice of bearing and lubricant is generally driven by considerations unrelated to efficiency for common motors, and so does not vary it as a design parameter in the engineering analysis. DOE received no comments regarding this technology in response to the NOPR and does not include performance gains due to advanced bearings or lubricants in the engineering analysis in today's final rule.

j. Improve 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.

DOE notes that an improved cooling system may be more or less efficient, itself, as long losses within the motor at-large decline. 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. DOE did not receive any comments regarding this technology option in response to the NOPR and continues to consider it for the final rule analysis.

k. 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.

DOE notes that all software designs used in the technology 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. (See TSD Chapter 4)

l. Improve Rotor Bar Insulation

In motors, rotor bars are usually insulated to contain current within the rotor. Because no insulation is ideal, some current will always leak and induce undesired stray losses in other parts of the motor. By improving rotor insulation, this effect may be reduced. Insulation, however, competes for space within the motor with conductor and electrical steel. Therefore, manufacturers look to balance insulation with preservation of volume. DOE received no comments in response to the NOPR and does not change insulation assumptions for the final rule.

m. Technology Options Not Considered

Variable-speed drives (VSDs) are solid-state electronic devices able to vary the voltage, current, and frequency of a motor's input signal in order to vary (often continuously) vary torque and speed. DOE acknowledges that the ability to modulate motor output may produce energy savings in certain applications, if properly controlled. DOE does not consider this technology in today's rule because the scope of coverage only pertains to single-speed motors. DOE notes that many motors within the scope of the rulemaking may be capable of operation with a VSD. Inverter-only motors, which are not able to operate on 60 Hz sinusoidal current, are not subject to today's standards as today's rule only applies to motors capable of operation at 60 Hz.

In response to the NOPR, PlasticMetal commented that DOE should consider the use of syncrospeed VFD technology in reducing the energy consumed by motors, especially for motors used in injection molding machines. PlasticMetal noted that VFD technology can also be used for agricultural pump and hydraulic pump motors. (PlasticMetal, No. 80 at p. 1)

Although DOE's proposed standards were limited to single-speed motors, DOE recognizes that VFDs may offer further energy savings in injection molding (among other applications). DOE may consider exploring this technology further in a future rulemaking, but at present retains coverage of only single-speed motors.

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.9 presents a general summary of potential 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 final rule TSD.

TABLE IV.9—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 the NOPR, DOE stated that the notice provides detailed information about each technology option considered. With the exception of die-cast copper rotors, which many manufacturers stated they would usually never consider when increasing efficiency for the reasons detailed below, DOE understands that each technology option that it has not screened out is a design option that a manufacturer would consider for each motor designed and built. DOE recognized that manufacturers design their motors to balance a number of competing and interrelated factors, including performance, reliability, and energy efficiency. Because the options DOE had identified can be modified to improve efficiency while maintaining performance, it was DOE's view that at least some significant level of energy efficiency improvement is possible with each technology option not screened out by DOE. *See* 78 FR 73616.

Furthermore, DOE noted 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 of the NOPR, 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. *See* 78 FR 73616.

In addition, in the NOPR, DOE noted 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. *See id.*

DOE did not receive any comments regarding the technology screening process in response to the NOPR and maintains this same approach in the final rule.

a. Die-Cast Copper 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 can offer better performance than aluminum because it has better electrical conductivity (*i.e.,* a lower electrical resistance). However, because copper also has a higher melting point than aluminum, the casting process becomes more difficult and is likely to increase both production time and cost.

DOE 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 did not screen out copper as a die-cast rotor conductor material in the NOPR because it believed that it passed the four screening criteria. Because several manufacturers currently die-cast copper rotors, DOE concluded that this material is both technologically feasible and practicable to manufacture, install, and service. Additionally, manufacturers are already producing such equipment, with no known increase in accidents or other health/safety problems. Finally, DOE's own engineering analysis supports what it sees in the market for copper rotors—that copper rotor motors may require some design tradeoffs but that, in general, it is possible to use copper and remain within NEMA Design A, B, or C specifications. 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. Moreover, DOE does not believe that the TSL chosen for today's standard would require most manufacturers to use copper rotor motors.

DOE received considerable feedback concerning copper rotor technology both in response to the preliminary analysis and the NOPR. DOE addressed comments made on this topic at the preliminary analysis stage in the NOPR (*see* 78 FR 73616–73620). Here DOE responds to comments made on this topic in response to the NOPR and organizes its responses by the four screening criteria. Although it is well-documented that die-cast copper rotors are available in the market to at least 30 hp, they are not widely marketed at the higher horsepower ratings. It is not clear precisely why copper rotor motors are not marketed at horsepowers greater than 30. It is possible that because it is impracticable to die-cast copper at those rotor sizes or there is simply a lack of demand at higher horsepowers to justify investment in production capacity.

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.

Technological Feasibility

In the NOPR, DOE cited a number of high horsepower designs with copper rotors as evidence of technological feasibility, as well as observing that distribution transformers, another large industrial product that uses conductors around electrical steel, commonly improve efficiency by replacing aluminum with copper. 78 FR 73618.

In response to the statements that DOE made in the NOPR (*see* 78 FR 73618), NEMA pointed out that transformers and induction motors are not comparable because the performance tradeoff between efficiency and inrush current is different in both cases. (NEMA, No. 93 at p. 10) Nidec commented that the examples of Tesla, REMY, and Oshkosh traction motors cited by DOE as evidence of the feasibility of copper die-cast rotors involved motors that operated at higher speeds and lower torques. Consequently, in its view, these comparisons were not an accurate representation of those motors that would be covered under DOE's proposal. (Nidec, No. 98 at pp. 3–4) NEMA agreed with Nidec, and made the point that it is physical rotor size, and not horsepower, that sets limits on copper die-casting. (NEMA, No. 93 at p. 9) NEMA also noted that, from a manufacturer perspective, the issue of importance is not the feasibility of designing a suitable copper rotor, but rather the issue of whether copper rotors can be die-cast and mass-produced. (NEMA, No. 93 at p. 9)

DOE recognizes that assessing the technological feasibility of high-horsepower copper die-cast rotors is made more complex by the fact that DOE believes that manufacturers do not offer them commercially. DOE acknowledges that the listed motor examples are of higher speed that those under consideration in this rule, and that horsepower must be discussed in the context of speed. DOE agrees with NEMA that the challenges with designing with copper rotor motors lie less in the feasibility of designing copper rotor motors, and more in the die-casting of large copper rotors. As a result, DOE views the debate as residing chiefly in the domain of manufacturability, considered in the next section. Commenters have not demonstrated that it would be technologically infeasible to develop and incorporate copper die-cast rotors in lower-speed motors. Therefore, DOE does not screen out die-cast copper on the basis of technological feasibility.

Practicability to Manufacture, Install, and Service

In the NOPR, DOE stated that it was not able to conclude copper rotors were impracticable to manufacture because DOE identified parties already manufacturing copper rotor motors. DOE was able to purchase and tear down a copper rotor motor, which performed at DOE's max-tech level at its horsepower (5 hp) and met NEMA Design B requirements. 78 FR 73617.

In response to the NOPR, NEMA maintained its position that copper die-cast rotors should be screened out of the analysis for the current rulemaking. NEMA and Nidec argued that designs modeled by DOE for ECG 1 at EL 4 and ECG 2 at EL 2 used copper rotor technology and, thus, implied that copper rotor technology is a requirement to meet max-tech efficiency levels. (NEMA, No. 93 at p. 8; Nidec, No. 98 at p. 3) Referring to the U.S. Department of the Army studies on die-cast copper rotor motors that NEMA discussed in its preliminary analysis comments, NEMA raised concern that it is difficult to successfully die cast a copper rotors of the required size in mass production. NEMA commented that it is not aware of manufacturing, in the United States or outside, capable of mass production of copper die-cast rotors ''on the scale necessary to serve the relevant market at the time of the effective date of the standard,'' as proposed in the NOPR. NEMA stated that the challenge to design a motor when the material of the rotor is changed is not limited to meeting only a required value of efficiency and the limits on torques and current that DOE specifies in the definitions in 10 CFR 431.12. Noting that particular TSL levels were developed based on the EL levels, NEMA commented that if the copper die-cast rotor technology were screened out, then EL 4 would not be included in the creation of any TSL level, and TSL 3 would represent the maximum technology designs. (NEMA, No. 93 at pp. 8–12)

Baldor commented that the Motor Coalition has submitted earlier that they do not have the capacity to produce copper rotors at a volume of 5 million units per year. It raised concerns that it is challenging to manufacture a better design in actual production. (Baldor, Pub. Mtg. Tr., No. 87 at pp. 118–119)

In contrast, CDA disagreed with the manufacturers' claims that die-cast copper rotor motors are not commercially available. CDA commented that die-cast copper rotor motors—60 Hz ''Ultra'' motors manufactured by Siemens—have been commercially available at certain horsepower ratings in North America since February 2006. Siemens has copper rotor die-casting capabilities in Denver, Ohio, and Mexico. Multiple countries in Europe and Asia also have copper rotor die casters. Siemens produces 50 Hz motors in Germany, and SEW-Eurodrive produces 50 Hz and 60 Hz motors for worldwide shipment. Therefore, CDA stated that die-cast copper rotors are commercially available, and DOE should continue to include them in their evaluations. (CDA, No. 90 at p. 2)

Following publication of the NOPR, DOE was able to speak with a manufacturer of die-casting equipment who confirmed their ability to die-cast copper rotors in excess of 500 lbs in a single ''shot''. DOE has not been able to obtain written verification of this capability. If true, however, the question is whether such rotor size is sufficient to reach the limits of the horsepower scope of today's rule.

Although DOE did not directly model a copper rotor that large, DOE did purchase and tear down a 30 hp motor of specification within the scope of this rulemaking with a die-cast copper rotor and found the weight to be 29 lbs, or roughly 1 lb/hp. DOE understands that the active mass of a motor grows sublinearly with power, and by extension, that a 500 hp motor of similar design could be built with a copper rotor of less than 500 lbs.

Although these figures are estimates, DOE believes there is evidence to suggest that copper die-cast rotor would be practicable to manufacture, install, or service and, consequently, this technology should not be screened out on that basis. DOE understands that full-scale deployment of copper would likely require considerable capital investment 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. DOE acknowledges that if it were adopting a max-tech standard, the chance that any manufacturer would use copper die-cast rotors would be much greater than the chance that any manufacturer would choose to use this technology under the efficiency level chosen in today's rule.

Adverse Impacts on Equipment Utility or Equipment Availability

For the NOPR, DOE acknowledged that the industry would need to make substantial investments in production capital to ensure the availability of motors at current production levels. DOE noted that, in some cases, redesigning equipment 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. Although using copper in place of aluminum can require design changes in order to keep parameters such as locked-rotor current within rated limits, DOE was able to model copper rotor motors adhering to the specifications of NEMA Design B,[37] including the reduced (relative to Design A) locked-rotor current.

In response, to the NOPR, NEMA reiterated many of its concerns about production capability worldwide and that utility may be impacted with respect to torque/speed characteristics if copper becomes a de facto standard. (NEMA, No. 93 at pp. 11–13)

Based on DOE's own shipments analysis (see final TSD, Chapter 9) and estimates of worldwide annual copper production,[38] DOE estimates that .01–.02 percent of worldwide copper supply would be required for electric motor manufacturers to use copper rotors for every single motor within DOE's scope of coverage. DOE acknowledges the need to vary design parameters in order to maintain equipment utility through a transition to copper rotors, but does not believe commenters have demonstrated that it is infeasible, particularly when DOE has been able to procure and test equipment meeting Design B specification. 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

In the NOPR, DOE did not screen out copper die-casting on the basis of adverse impacts to health or safety. 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

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

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

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 represents 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 did not receive comment on this topic specifically in response to the NOPR and maintains this approach for the final rule.

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

DOE describes its approach for ''Increase the Cross-Sectional Area of Copper in the Stator Slots'' in section IV.A.5.a. 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.

In response to the NOPR, NEMA commented that hand winding is not a viable technology to gain an increase in slot fill of less than 5% and thus suggested that hand winding should be screened out. NEMA stated that hand winding poses adverse impacts on manufacturing relative to mass production and may shift production of stators to cheaper labor locations outside of the United States. Hand winding also has adverse impacts on health and safety of personnel and on product utility and availability. Noting that none of the representative units are hand wound, it commented that the engineering analysis should not be based on stator slot fill levels which require hand winding (NEMA, No. 93 at pp. 12–13)

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. Furthermore, DOE is not aware of any data or studies suggesting hand-winding leads to negative health consequences and notes that hand winding is currently practiced by industry. In response to the NOPR, DOE did not receive any comment on its cost estimates for hand-wound motors nor on studies suggesting any health impacts. 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.

c. Power Factor

Although not considered as a technology option *per se,* several commenters commented on power factor in response to DOE's NOPR. Power factor is the ratio of real power to apparent power, or the fraction of power sent to a device divided by its actual power consumption. Power factor equals one for purely resistive loads, but falls for circuits with loads that are capacitive or (in the usual case of electric motors) inductive. Generally, low power factor is viewed as undesirable; it may force the use of larger conductors and hardware within a building. Furthermore, many industrial customers are charged more for electrical power by their utility as their net power factor falls. Because power factor has value to owners of electric motors, any standard that causes power factor to rise significantly could be said to negatively affected consumer utility. Several parties commented on power factor in response to DOE's NOPR.

The CA IOUs noted that energy saved in the motor can show up as energy lost in the building and utility distribution systems. (CA IOUs, Pub. Mtg. Tr., No. 87 at p. 115)

Baldor commented that it is challenging to get a higher efficiency motor along with good power factor and low inrush current. When a motor is redesigned for efficiency, power factor goes down when efficiency goes up and inrush current can rise and change motor design from Design B to Design A. (Baldor, Pub. Mtg. Tr., No. 87 at pp. 118–119)

EEI expressed concern that larger industrial facilities (having heavy motor populations) may incur higher economic costs if higher efficiency requirements lead to lower power factor. This is because larger customers are metered for kVA and they are penalized if the facility power factor goes below a certain level. (EEI, Pub. Mtg. Tr., No. 87 at pp. 120–121)

DOE acknowledges that power factor is one parameter of many that requires supervision in redesigning motors for greater efficiency. Electric motors, by their very nature, are highly inductive loads with correspondingly low power factors. Facilities with large numbers of motors often choose to add capacitance in parallel with their inductive loads in order to correct power factor, and often be charged lower rates for electricity. Several motor manufacturers advocate power factor correction and advertise equipment to do it.[39]

Furthermore, DOE notes that MG 1–2009 characterizes the relationship between motor efficiency and power factor in paragraph 14.44.1. This relationship is nonlinear, but it can be used to show that[40] even when going from 74% motor efficiency[41] to the corresponding premium efficiency requirement of 82.5%, power factor falls by only 11% Higher horsepower motors would be predicted (by paragraph 14.44.1) to experience smaller declines in power factor. Finally, Premium efficiency motors are in widespread use today, suggesting to DOE that the associated power factor considerations are not insurmountable. As a result, DOE does not view power factor as a significant obstacle in adopted of today's standards.

2. Technology Options Screened Out of the Analysis

DOE developed an initial list of design options from the technologies identified in the technology assessment.

[39] For example, *http://www.baldor.com/support/Literature/Load.ashx/FM1307?LitNumber=FM1307*.

[40] Taking the derivative suggests that power factor may scale inversely with efficiency raised to the −2 power.

[41] The current requirement for 1 horsepower, 8-pole, subtype II electric motors.

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.10.

TABLE IV.10—DESIGN OPTIONS SCREENED OUT OF THE ANALYSIS

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

At the preliminary analysis stage, NEMA, Baldor, and NPCC agreed with DOE 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, and that amorphous metal laminations are not a type of material that lends itself to use in electric motors in the foreseeable future. (NEMA, No. 54 at pp. 63–64; Baldor, Pub. Mtg. Tr., No. 60 at p. 108; Advocates, No. 56 at p. 3)

As DOE did in the NOPR, DOE is continuing to screen out both of these technology options from further consideration in the engineering analysis in the final rule. *See* 78 FR 73622. 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 the 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. DOE did not receive additional comments on the technology options screened out in response to the NOPR.

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 adopts a new or amended standard for a type or class of covered equipment, it must determine the maximum improvement in energy efficiency or maximum reduction in energy use that is technologically feasible for such equipment. (42 U.S.C. 6295(p)(1) and 6316(a)) Accordingly, in the engineering analysis, DOE determined the maximum technologically feasible (''max-tech'') improvements in energy efficiency for electric motors, using the design parameters for the most efficient equipment available on the market or in working prototypes. (See chapter 5 of the TSD) The max-tech levels that DOE determined for this rulemaking are described in IV.3 of this rule.

In general, DOE used 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 SMEs 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 above, there are three electric motor equipment class groups: ECG 1: NEMA Design A and B motors, ECG 2: NEMA Design C motors, and ECG 3: Fire pump electric motors. 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 482 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. Results are scaled to equipment classes not directly analyzed.[42] During the final rule 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. 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, DOE only selected NEMA Design B motors as representative units to analyze in the engineering analysis. DOE chose NEMA Design B motors because NEMA Design

[42] See Chapter 5 of the TSD for details.

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.

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. As noted above, 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 requirements.[43] 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.

Regarding DOE's ''fire pump electric motor'' definition, as detailed in the electric motors 2012 test procedure,[44] 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 2012 test procedure, DOE agrees 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 MG 1 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. See the standards NOPR for a historical discussion of comments related to fire pump electric motors. 78 FR 73623.

ECG 4 proposed in the NOPR consisted of brake electric motors and was 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. In today's final rule, brake motors no longer constitute a separate equipment class group and, therefore, brake motors fall into equipment classes based on their other characteristics (*e.g.,* pole count, design type).

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.

DOE 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 to establish efficiency levels for all equipment classes, it attempted to find a frame series and D-dimension[45] 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

[43] 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.

[44] 77 FR 26608.

[45] ''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.

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 part 13 [46] of NEMA MG 1–2011 does not standardize frame series for NEMA Design B motors at the highest horsepower levels covered in today's rule. 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 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 its preliminary analysis comments NEMA questioned DOE's selection of the 50-horsepower representative unit for the NEMA Design C equipment class group because the NEMA T-frame size for such a rating is three NEMA T-frame number series below the largest frame number series and the fact that the 2011 shipment data that DOE used to select its representative units was not broken down by NEMA design type. (NEMA, No. 54 at p. 66)

As stated in the NOPR and as DOE maintains in this final rule, 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. *See* 78 FR 73625. As for the shipments data used to select the 5-hp representative unit, DOE did not separate the data by design type within an ECG because the same standard applies to motors of any design type (*e.g.,* ''Design A'') within an ECG, and has revised the text for the final TSD to clarify that fact. *See id.* However, DOE still maintains that the prevalence of 5-hp units make it an appropriate selection as a representative unit. DOE did not receive further comments on representative units in response to the NOPR and has maintained its approach for the final rule.

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. Doing so allowed 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.

In the preliminary analysis, NEMA and Baldor commented that scaling across pole configurations will lead to inaccurate results. (NEMA, No. 54 at pp. 26, 66–67; Baldor, Pub. Mtg. Tr., No. 60 at pp. 130, 131)

As mentioned earlier, DOE assessed energy conservation standards for 482 equipment classes. As described in the NOPR [47] and as DOE retains in today's rule, 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.

Also as described in the NOPR [48] and as DOE retains in today's rule, 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.

At the preliminary analysis stage, NEMA and Baldor commented that DOE's analysis did not consider the significance of enclosure type as it relates to efficiency as there is generally a lower efficiency level designated for open-frame motors. (NEMA, No. 54 at p. 68; Baldor, Pub. Mtg. Tr., No. 60 at p. 131)

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. The Department used the same approach for the NOPR [49]

[46] This part provides standardized frame sizing by horsepower and speed for integral horsepower AC induction motors.

[47] *See* 78 FR 73625.

[48] *See* 78 FR 73625.

[49] *See* 78 FR 73625.

and today's final rule. DOE believed then and still believes that such an approach allows 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.

DOE did not receive additional comments on enclosure type as an equipment class setting criterion in response to the NOPR.

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 [50] 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 [51]), others must meet efficiency standards that correspond to NEMA MG 1–2011 Table 12–12 (*i.e.,* premium efficiency levels), and some are not currently required to meet any energy conservation standard levels. 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)). ECG 1 includes both currently regulated and unregulated electric motors. For the baseline, DOE selected the lowest efficiency level available for unregulated motors for all motors in this group rather than applying the current standard requirements to an ECG that includes unregulated motors. However, in estimating the base case efficiency distribution, DOE accounted for the fact that the regulated motors are already at least at the current standard requirements. 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), EL 1 as equivalent to EPACT 1992 levels, and EL 2 as equivalent to premium efficiency levels for ECG 1 motors. 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 premium efficiency and EL 4 was a two ''band'' increase.[52] 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 ECG 1 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 in order to base that level on a physical unit in place of modeling. Table IV.11 and Table IV.12 show the ELs for ECGs 1 and 3.

TABLE IV.11—EFFICIENCY LEVELS FOR EQUIPMENT CLASS GROUP 1**

Representative unit	EL 0 (baseline) (percent)	EL 1 (EPACT 1992) (percent)	EL 2 (premium efficiency) (percent)	EL 3 (best-in-market*) (percent)	EL 4 (max-tech) (percent)
5 hp (ECG 1)	82.5	87.5	89.5	90.2	91.0
30 hp (ECG 1)	89.5	92.4	93.6	94.1	94.5
75 hp (ECG 1)	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 1 includes both currently regulated and unregulated electric motors. For the baseline, DOE selected the lowest efficiency level available for unregulated motors for all motors in this group rather than applying the current standard requirements to an ECG that includes unregulated motors. However, in estimating the base case efficiency distribution, DOE accounted for the fact that the regulated motors are already at least at the current standard requirements.

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

[51] 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.

[52] 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.12—EFFICIENCY LEVELS FOR EQUIPMENT CLASS GROUP 3

Representative unit	EL 0 (EPACT 1992) (percent)	EL 1 (premium efficiency) (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 motors had efficiencies below EPACT 1992 levels, which is the current standard for all covered NEMA Design C motors. For DOE's representative units, it also found no catalog listings above the required EPACT 1992 levels. Additionally, when DOE's SME modeled NEMA Design C motors, the model would only generate designs at premium efficiency levels and one incremental level above that while maintaining proper performance standards. Therefore, ECG 2 only contains three ELs: EPACT 1992 (EL 0), premium efficiency (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 final rule analysis, this level was removed so that the ELs analyzed would align with Tables 12–11 and 12–12. For the 5 hp representative 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 premium efficiency level, without going higher in efficiency. It determined that for the final rule analysis, the previously designated ''max in market'' level was not applicable. The ELs analyzed for ECG2 are shown in Table IV.13.

TABLE IV.13—EFFICIENCY LEVELS FOR EQUIPMENT CLASS GROUP 2

Representative unit	EL 0 (EPACT 1992) (percent)	EL 1 (premium efficiency) (percent)	EL 2 (max-tech) (percent)
5 hp	87.5	89.5	91.0
50 hp	93.0	94.5	95.0

DOE has found many instances of electric motors being sold and marketed one or two NEMA bands of efficiency above premium efficiency, 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 equipment on the market at any given EL implies that such equipment 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 [53] and, to the extent possible, has been included in DOE's analysis.

In response to the NOPR, NEMA and Baldor both raised concern that it is not clear what horsepower rated motors in 6 and 8 poles are covered because NEMA Design A and B are not defined under MG 1 for large motors. This is because motors of higher horsepower rating in 6 and 8 poles are covered by the standards for large motors in Part 20 of NEMA MG 1. However, DOE defined NEMA Design A and Design B types in 10 CFR 431.12 with respect to the standards in Part 12 of NEMA MG 1 and not with respect to Part 20. NEMA noted that DOE took Table 5 values for large motors from an incorrect table (*i.e.,* Table 12–12) that was submitted to DOE previously in the Petition. NEMA commented that in order to align Table 12–12 with the scope of Part 12, it has removed the ratings for large motors from Table 12–12 and has included them in premium efficiency standards in Part 20 for large motors. NEMA and Baldor suggested that DOE either remove standards for higher horsepower rating 6 and 8 poles motors from Table 5 of the proposed rule to properly represent only ratings for which Design A and B standards apply. NEMA also suggested that DOE could modify 10 CFR 431.12 to define large motors covered by the standards and 10 CFR 431.25 to include efficiency standards for these new covered large motors. (NEMA, No. 93 at p. 22; NEMA, Pub. Mtg. Tr., No. 87 at pp. 48–50, Baldor, No. 100 at p. 4)

DOE agrees with NEMA and Baldor that large motors given in NEMA MG 1 Part 20 (*i.e.* 6-pole motors with horsepower ratings greater than 400 hp and 8-pole motors with horsepower ratings greater than 300 hp) are not defined for NEMA Design A and B. Therefore, DOE has modified the efficiency tables as suggested. See Section IV.A.2.c for further detail. DOE notes that the standards adopted today, as well as those proposed in the NOPR, as well as those suggested by the Motor Coalition, still contain efficiency values for 300 and 350 hp 6 pole motors which are the same as their corresponding 250 hp values and which are not found on MG 1–2011's Table 12–12.

In response to the NOPR, CEC sought clarification on the efficiency levels selected by DOE for Design C motors. CEC commented that it expected DOE to choose a baseline above the current market minimum. Second, CEC asked for clarification regarding the selected ECG 2 representative unit picked to

[53] 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.

represent the efficiency levels and noted that the baseline level was below the EPACT 1992 level for the 50 horsepower motor. Third, CEC asked clarification regarding the EL numbering for ECG 2 in Table IV.11 of the NOPR. (CEC, No. 96 at p. 3)

Both ECG 1 and ECG 2 contain currently regulated and unregulated electric motors. For the baseline, DOE selected the lowest efficiency level available for unregulated motors for all motors in this group rather than applying the current standard requirements to an ECG that includes unregulated motors. However, in estimating the base case efficiency distribution, DOE accounted for the fact that the regulated motors are already at least at the current standard requirements. See Chapter 10 of the TSD for details.

With respect to the EL numbering in Table IV.10 of the NOPR, DOE notes that the table's values should have begun at EL 0 (instead of EL 1) and reached EL 2 (instead of EL 3). DOE always labels its baseline ''EL 0'' in this rulemaking, and the error was limited to mislabeling of the table in question rather than a more fundamental mistake in the analysis. In other words, there are no representative units for which the analysis should be at EL 1, as had been indicated in the NOPR's Table V.10. This mislabeling was confined to the table in question and has been fixed for the final rule.

4. Testing 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 [54] 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 SME. DOE supplemented the 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.

At the preliminary analysis stage, DOE received multiple comments regarding its test and tear-down analysis. (NEMA, No. 54 at p. 27, 74–75) In its NOPR response, DOE stated that it accurately captured such changes because electric motor was torn down, components such as electrical steel and copper wiring were weighed. 78 FR 73629.

DOE noted in the NOPR and re-assert today 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. *See* 78 FR 73629. For the analysis in the NOPR and the final rule, 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.

Also, DOE believes that the bill of materials generated is more is likely to be representative of the motor's nominal efficiency value rather efficiency than as-tested. 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). 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, Pub. Mtg. Tr., 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, Pub. Mtg. Tr., No. 60 at pp. 156, 157)

[54] 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.

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. 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.

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

DOE worked with technical experts to develop certain ELs, in particular, the max-tech efficiency levels for each representative unit analyzed. To this end, DOE retained an electric motors (SME [55] with significant experience in terms of both design and related software, who prepared a set of electric motor designs with increasing efficiency. The software program used for this analysis is a proprietary software program called VICA.[56] The SME also checked his designs against tear-down data and calibrated the 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 (*e.g.,* 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, and that the unit in question did not meet the criteria of a different equipment class. Additionally, DOE limited its modeled stack length increases based on teardown data and maximum ''C'' dimensions found in manufacturer's catalogs, also to ensure the utility of the baseline units was maintained [57] DOE has provided comparisons of software estimates and tested efficiencies in Appendix 5C of the TSD.

During the preliminary analysis, DOE approached motor laboratories in an attempt to build physical prototypes of 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, DOE did not build 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 premium efficiency 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.

Since that time, DOE has conducted further calibration of its software program using data obtained from motor teardowns, has provided comparisons of software estimates, and tested efficiencies for both aluminum and copper rotor motors in Appendix 5C of the TSD. DOE eliminated designs from its preliminary analysis because of concerns regarding the feasibility of certain efficiency levels. Regarding performance parameters beyond efficiency,[58] DOE understands 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, and these 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.

DOE's SME, 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 has concluded that these actions corroborate the modeled designs. Based on this work and its total analysis, which included input from its SME, DOE has concluded that it has developed a sufficiently robust set of technically feasible efficiency levels for its engineering analysis.

In the final rule TSD, DOE also shows 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 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 premium efficiency levels (see section 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 equipment served as the basis for the maximum stack length value that DOE used 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

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

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

[57] 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.

[58] For example, locked-rotor current or locked-rotor torque.

able to achieve the desired improvement in efficiency with a stack length shorter than DOE's estimated maximum. Table IV.14 presents the estimated maximum stack length,[59] the maximum stack length found during tear-downs, and the maximum stack length modeled for a given representative unit. DOE notes that the 5-horsepower Design B representative unit is not shown because modeling was not performed, as described earlier.

TABLE IV.14—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.

During the NOPR public meeting, several parties commented with respect to modeling. Noting that all the components of loss are first calculated and summed together to obtain efficiency, Nidec sought clarification as to how friction and windage component losses (mechanical loss), I^2R losses and stray losses were obtained. Nidec also sought clarification on how the area of conductors was calculated to obtain slot fill. (Nidec, Pub. Mtg. Tr., No. 87 at pp. 103–108) Regal Beloit commented that the VICA program used by DOE's SME to model efficiency may be over ten years old. (Regal Beloit, Pub. Mtg. Tr., No. 87 at p. 110)

DOE responded that the friction and windage losses were input items into the VICA program and were obtained as average values from data on various frame sizes. I^2R losses and stray losses were also input items into VICA. Stray losses were obtained as a percentage of the full-load value. DOE performed correlations of the estimated value and the values obtained from the testing of motors. DOE found that the estimated value was very close to the average of tested values. DOE also noted that the square method was used to calculate the area of the conductor. The number of conductors in the slot was multiplied by the square of the conductor diameter.

6. Cost Model

When developing manufacturer selling prices (MSPs) for the motor designs obtained from DOE's tear-downs and software models, DOE used modeling 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, which are detailed in chapter 5 of the final rule TSD. The following subsections discuss specific features of the DOE's cost model.

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.

Noting the comments of interested parties during the preliminary analysis phase, DOE slightly modified its approach in the NOPR. 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.

In response to the NOPR, NEMA raised concern about the potential for copper price volatility. (NEMA, No. 93 at p. 12)

DOE acknowledges that price volatility can affect the economic results of a standards rulemaking, either in the positive or negative direction depending on the relative movement of raw materials and energy. To diminish the effect of volatility on the engineering analysis results, DOE used a 3-year average for copper, from 2010–2012. DOE's understanding is that manufacturers may choose to use financial instruments in cases where raw material volatility is exceptionally high in order to guarantee margins. Although DOE has not published a formal materials price sensitivity in this rulemaking, it observes that for the highest ELs examined across all representative units, copper cost amount to roughly 3 percent of the installed price. At these levels, copper would have to more than quadruple in price in order to increase installed price by 10 percent. At the levels being adopted in today's rule, however, DOE's engineering analysis does not suggest significantly increased demand for copper and, therefore, does not suggest significantly increased exposure to volatility in copper price. DOE discusses material pricing in greater detail in Appendix 5A of the final rule TSD.

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 calculated the ratio 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

[59] Based on manufacturer product offerings. See Chapter 5 of the TSD for details.

that number is weighted towards offshore labor. Nidec agreed with DOE's smaller markup on the lower-horsepower motors, but commented that the overall markups seem to be high. (Nidec, Pub. Mtg. Tr., No. 60 at p. 184) WEG commented that DOE was adequately addressing the cost structure variations among the different motor manufacturers. Additionally, WEG stated that basing a labor rate on both foreign and domestic labor rates increases accuracy of the analysis, but that it could encourage production moving outside the United States. (WEG, Pub. Mtg. Tr., No. 60 at pp. 184–186)

In the NOPR, and again in today's final rule, DOE 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 (which suggested that DOE's labor rates and markups are appropriate) and the absence of any alternative labor rate or markups to apply. DOE does not expect that use of the most accurate labor rates possible in its analyses will contribute to outsourcing of jobs in the electric motors industry.

Finally, DOE is aware of potential cost increases caused by increased slot fill,[60] 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. 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 final rule 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 final rule TSD.

DOE understands that lower-volume equipment will often realize higher per-unit costs, and has concluded that 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 energy conservation standards, and because DOE has no evidence to suggest a significant market shift to lower production volume equipment in a post-standards scenario, DOE expects that the relative mix of high-volume and low-volume production would be preserved. Indeed, because DOE is expanding the scope of coverage and bringing many previously excluded motor types to premium efficiency levels, DOE sees the possibility that standardization may increase and that average production volume may, in fact, rise.[61]

c. Catalog Prices

At the preliminary analysis stage, NEMA 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, Pub. Mtg. Tr., No. 60 at pp. 181, 182) As stated in the NOPR[62] and reaffirmed today, DOE elects 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 of the final rule TSD. 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 as NEMA suggests would provide a meaningful evaluation.

d. Product Development Cost

DOE's preliminary analysis cost model included 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, it determined that additional cost adders were warranted for the examined ELs that exceeded the premium efficiency level. For the NOPR and final rule, DOE developed a per-unit adder[63] for the manufacturer production costs (MPCs) intended to capture one-time increased equipment development and capital conversion costs that would likely result if an energy conservation standard with an efficiency level above premium efficiency levels 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 premium efficiency based on manufacturer feedback. Most manufacturers now offer premium efficiency 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 premium efficiency. However, DOE is not aware of any manufacturer with a complete line of motors above premium efficiency. Consequently, DOE believes that energy conservation standards above premium efficiency 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 chapter 12 of the final rule TSD. DOE used the manufacturer-supplied data to estimate industry-wide capital conversion costs and equipment conversion costs for each EL above premium efficiency. 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-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 seven-year revenue that DOE derived for each NEMA band above premium efficiency are shown below. Details on these calculations are shown in Chapter 5 of the final rule TSD.

[60] A measure of how efficiently conductor is packed into the stator slots, which affects efficiency.

[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] *See* 78 FR 73633.

[63] 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.

TABLE IV.15—PRODUCT CONVERSION COSTS AS A PERCENTAGE OF 7-YEAR REVENUE

NEMA Bands above premium efficiency	Conversion costs as a percentage of 7-year revenue
1	4.1%
2	6.5%

The percentage markup was then applied to the full production cost (direct material + direct labor + overhead) at the premium efficiency levels to derive the per-unit adder for levels above premium efficiency (see Table IV.16). DOE received no comments in response to the NOPR and maintained its approach for the final rule.

TABLE IV.16—PRODUCT CONVERSION COSTS FOR EFFICIENCY LEVELS ABOVE PREMIUM EFFICIENCY

Representative unit	Per-unit adder for 1 band above premium efficiency (2013$)	Per-unit adder for 2 bands above premium efficiency (2013$)
5 hp, Design B	$11.06	$17.36
30 hp, Design B	32.89	51.61
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 notice. Table IV.17 through Table IV.21 show the results of DOE's updated engineering analysis.

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

TABLE IV.17—MANUFACTURER SELLING PRICE AND EFFICIENCY FOR 5-HORSEPOWER REPRESENTATIVE UNIT

Efficiency level	Efficiency (%)	Manufacturer selling price (2013$)
EL 0 (Baseline)	82.5	333
EL 1 (EPACT 1992)	87.5	344
EL 2 (Premium Efficiency)	89.5	371
EL 3 (Best-in-Market)	90.2	406
EL 4 (Max-Tech)	91.0	677

TABLE IV.18—MANUFACTURER SELLING PRICE AND EFFICIENCY FOR 30-HORSEPOWER REPRESENTATIVE UNIT

Efficiency level	Efficiency (%)	Manufacturer selling price (2013$)
EL 0 (Baseline)	89.5	856
EL 1 (EPACT 1992)	92.4	1,096
EL 2 (Premium Efficiency)	93.6	1,168
EL 3 (Best-in-Market)	94.1	1,308
EL 4 (Max-Tech)	94.5	2,077

TABLE IV.19—MANUFACTURER SELLING PRICE AND EFFICIENCY FOR 75-HORSEPOWER REPRESENTATIVE UNIT

Efficiency level	Efficiency (%)	Manufacturer selling price (2013$)
EL 0 (Baseline)	93.0	1,910
EL 1 (EPACT 1992)	94.1	2,068
EL 2 (Premium Efficiency)	95.4	2,351
EL 3 (Best-in-Market)	95.8	2,804
EL 4 (Max-Tech)	96.2	3,656

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

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

Efficiency level	Efficiency (%)	Manufacturer selling price (2013$)
EL 0 (Baseline/EPACT 1992)	87.5	334
EL 1 (Premium Efficiency)	89.5	358
EL 2 (Max-Tech)	91.0	627

TABLE IV.21—MANUFACTURER SELLING PRICE AND EFFICIENCY FOR 50-HORSEPOWER REPRESENTATIVE UNIT

Efficiency level	Efficiency (%)	Manufacturer selling price (2013$)
EL 0 (Baseline/EPACT 1992)	93.0	1,552
EL 1 (Premium Efficiency)	94.5	2,152
EL 2 (Max-Tech)	95.0	2,612

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

TABLE IV.22—MANUFACTURER SELLING PRICE AND EFFICIENCY FOR 5-HORSEPOWER REPRESENTATIVE UNIT

Efficiency level	Efficiency (%)	Manufacturer selling price (2013$)
EL 0 (Baseline/EPACT 1992)	87.5	344
EL 1 (Premium Efficiency)	89.5	371
EL 2 (Best-in-Market)	90.2	406
EL 3 (Max-Tech)	91.0	677

TABLE IV.23—MANUFACTURER SELLING PRICE AND EFFICIENCY FOR 30-HORSEPOWER REPRESENTATIVE UNIT

Efficiency level	Efficiency (%)	Manufacturer selling price (2013$)
EL 0 (Baseline/EPACT 1992)	92.4	1,096
EL 1 (Premium Efficiency)	93.6	1,168
EL 2 (Best-in-Market)	94.1	1,308
EL 3 (Max-Tech)	94.5	2,077

TABLE IV.24—MANUFACTURER SELLING PRICE AND EFFICIENCY FOR 75-HORSEPOWER REPRESENTATIVE UNIT

Efficiency level	Efficiency (%)	Manufacturer selling price (2013$)
EL 0 (Baseline/EPACT 1992)	94.1	2,068
EL 1 (Premium Efficiency)	95.4	2,351
EL 2 (Best-in-Market)	95.8	2,804
EL 3 (Max-Tech)	96.2	3,656

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 three ECGs, there are 482 equipment classes, reflecting the various 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 directly, hence, the need for scaling. Thus, 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 Premium tables of efficiency in MG 1, and one based on the incremental improvement in 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 in motor losses approach in its final rule analysis.

As discussed in section IV.C.3, some of the ELs analyzed by DOE were based on existing efficiency standards (*i.e.,* EPACT 1992 and premium efficiency). 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 premium efficiency (only one EL above premium efficiency 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 premium efficiency level, and EL 4 corresponded to a two-band improvement relative to premium efficiency level.

DOE maintains that scaling is a tool necessary to analyze the potential effects of energy conservation standards above premium efficiency levels. As stated earlier, DOE is evaluating energy conservation standards for 482 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. Consequently, DOE has concluded that scaling is necessary and suitable for establishing appropriate efficiency levels for new or amended energy conservation standards for electric motors.

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 at varying efficiencies, 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, which accomplishes that objective while maintaining the use of NEMA nominal efficiencies. For each incremental EL above the premium efficiency 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 ensure the technological feasibility of each of its ELs to the greatest extent practicable. DOE received no comments in response to the NOPR on this issue and has maintained its approach for the final rule.

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 (the term ''customer'' refers to purchasers of the equipment being regulated). For the NOPR, DOE determined the distribution channels for electric motors, the percentage of shipments sold through either of these channels, and the markups associated with the main parties in the distribution chain (distributors and contractors).

Several stakeholders, including NEMA and NEEA, commented that the OEM distribution channel (manufacturer to OEM to end-user), which represents the distribution channel for 50 percent of shipments, is further divided into shipments going directly to the user (25 percent) and shipments going through a distributor and then to the customer (25 percent). (WEG, NEMA, NEEA, Pub. Mtg. Tr., No. 87 at p. 131) For the final rule, DOE modified its distribution channels in accordance with the channels and shares described by the commenters.

DOE developed average distributor and contractor markups by examining the contractor cost estimates provided by RS Means Electrical Cost Data 2013.[64] 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 final rule 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[65] to determine the variation in field energy use in the industrial sector. For the agricultural and the commercial sectors, 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

[64] RS Means (2013), Electrical Cost Data, 36th Annual Edition (Available at: *http://www.rsmeans.com*).

[65] Database of motor nameplate and field measurement data compiled by the Washington State University Extension Energy Program (WSU) and Applied Proactive Technologies (APT) under contract with the New York State Energy Research and Development Authority (NYSERDA). 2011.

compiled by the Industrial Assessment Center at the University of Oregon,[66] 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.

In response to the NOPR, DOE did not receive any comments regarding the energy use analysis and retained the same approach for the final rule. Chapter 7 of the final rule TSD describes the energy use analysis in further detail.

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 NOPR 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 in the PPI from 1985 to 2003, and a steep increase in the PPI since then. DOE also examined a forecast based on the ''chained price index—industrial equipment'' that was forecasted for *AEO2013* out to 2040. This index is the most disaggregated category that includes electric motors. These data show a short-term increase in the PPI from 2011 to 2015, and then a steep decrease. DOE believes that there is considerable uncertainty as to whether the recent increasing 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 prices 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 NOPR analysis for the final rule.

2. Installation Costs

In the NOPR 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 NOPR analysis, DOE assumed there is no variation in installation costs between a baseline efficiency electric motor and a higher efficiency electric motor.

DOE did not receive comments on the installation costs it used for electric motors, and it retained the approach used in the NOPR analysis for the final rule.

3. Maintenance Costs

In the NOPR 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 NOPR analysis for the final rule.

4. Repair Costs

In the NOPR 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. 86 at p. 1) DOE agrees with this suggestion and defines a motor repair as repair including rewinding and reconditioning.

5. Unit Energy Consumption

The analysis used in the final rule uses the same approach for determining unit energy consumptions (UECs) as the NOPR analysis. The UEC was determined for each application and sector based on estimated load points and annual operating hours.

6. Electricity Prices and Electricity Price Trends

In the NOPR analysis, DOE derived sector-specific weighted average electricity prices for four different U.S.

[66] Strategic Energy Group (January, 2008), Northwest Industrial Motor Database Summary. From Regional Technical Forum. Retrieved March 5, 2013 from *http://rtf.nwcouncil.org/subcommittees/osumotor/Default.htm.*

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

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 [68]) and assumed to remain constant over time. To estimate future trends in energy prices, DOE used projections from the EIA's Annual Energy Outlook 2013 (*AEO 2013*). DOE did not receive any comments regarding the electricity prices and today's rulemaking retains the same approach for determining electricity prices.

7. Lifetime

In the NOPR 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 and sector of application. 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. DOE did not receive any comments regarding lifetimes and retained the same approach and lifetime assumptions for the final rule.

8. Discount Rate

DOE did not receive any comments regarding discount rates and retained the same approach as used in the NOPR for the final rule. 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 today's rulemaking, 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 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 equipment 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 equipment 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.

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 [69] for the market penetration of Premium motors within the market for integral alternating current induction motors. For equipment class groups 2 and 3, which represent a very minor share of the market (less 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. DOE did not receive additional comments and retained the same approach for the final rule.

10. Compliance Date

DOE calculated customer impacts as if each new electric motor purchase occurs in the year that manufacturers must comply with the standard. As discussed in section III.A, any amended standard for electric motors shall apply to electric motors manufactured on or after June 1, 2016. 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 for manufacturers.

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 equipment mean that the increased total installed cost is not recovered in reduced operating expenses. DOE did not receive any comments regarding the PBP calculation.

The inputs to the PBP calculation are the total installed cost of the equipment 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 as it only takes into account the totaled installed costs and the first year of operating expenses.

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 equipment 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) and 6316(a)) 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

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

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

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.

13. Comments on Other Issues

In response to DOE's request for comments regarding whether there are features or attributes of the more efficient electric motors that could impact how customers use their equipment. NEMA commented that higher efficiency motors could have increased inrush currents, reduced starting torque, longer frames, and higher speeds. (NEMA, No. 93 at p. 15).

DOE acknowledges that some manufacturers may choose to produce higher efficiency motors in a way that could impact the inrush current, starting torque, frame size, and speed. However, in the engineering analysis, for all efficiency levels, DOE analyzed motors that remain within the NEMA Design B design requirements for inrush currents and torque characteristics and kept the frame size constant. Therefore, DOE maintained installation costs constant across all efficiency levels (see section IV.F.2)

With respect to the potential for higher efficiency motors having higher speed, DOE acknowledges that this could occur and affect the benefits gained by using efficient electric motors. Although it is possible to quantify this impact for an individual motor, DOE was not able to extend this analysis to the national level because DOE does not have robust data related to the overall share of motors that would be negatively impacted by higher speeds. Instead, DOE developed assumptions [70] and estimated the effects of higher operating speeds as a sensitivity analysis in the LCC spreadsheet (see appendix 7–A of the final TSD).

G. Shipments Analysis

DOE uses projections of equipment 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 type of equipment.

To populate the model with current data, DOE used data from a market research report,[71] confidential inputs from manufacturers, trade associations, and other interested parties' responses to the 2011 RFI. 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).[72] Projections of real gross domestic product (GDP) from *AEO 2013* for 2015–2040 were used to project fixed investments in equipment and structures including motors. The current market distributions are maintained over the forecast period.

For the preliminary analysis, DOE collected data on historical series of shipment quantities and values for the 1990–2003 period, but concluded that the data were not sufficient to estimate motor price elasticity.[73] 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. DOE did not receive further comments on this issue and retained the same approach for the final rule.

Including the NOPR's proposed expansion of motor coverage, DOE estimates total in-scope shipments were 5.43 million units in 2011. DOE did not receive any NOPR comments on shipments and maintained the same estimate for the final rule. For further information on DOE's shipments analysis, see chapter 9 of the final rule TSD.

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 a spreadsheet model to calculate the energy savings and the national customer costs and savings from each TSL.[74] The NES and NPV are 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 equipment class for equipment sold from 2016 through 2045. 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 NOPR analysis inputs to the NIA and whether those inputs were revised for the final rule.

[70] 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).

[71] IMS Research (February 2012), The World Market for Low Voltage Motors, 2012 Edition (Available at: *http://www.imsresearch.com/report/Motor_Drives_Low_Voltage_World_2012*).

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

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

[74] DOE's use of 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.

TABLE IV.25—INPUTS FOR THE NATIONAL IMPACT ANALYSIS

Input	NOPR Analysis description	Changes for final rule
Shipments	Annual shipments from shipments model.	No change.
Compliance date of standard	2016	No change.
Equipment Classes	Four separate equipment class groups for NEMA Design A and B motors, NEMA Design C motors, Fire Electric Pump Motors, and brake motors.	Three separate equipment class groups. Brake motors were added to ECG 1 (NEMA Design A and B motors).
Base case efficiencies	Constant efficiency from 2015 through 2044 for ECG 2 and 3.Trend for the efficiency distribution of ECG 1 and 4.	No change in methodology. Constant efficiency from 2016 through 2045 for ECG 2 and 3.Trend for the efficiency distribution of ECG 1.
Standards case efficiencies	Constant efficiency from 2015 through 2044 for ECG 2 and 3.Trend for the efficiency distribution of ECG 1 and 4.	No change in methodology. Constant efficiency from 2016 through 2045 for ECG 2 and 3.Trend for the efficiency distribution of ECG 1.
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 2013* forecasts (to 2035) and extrapolation for 2044 and beyond.	No change.
Electricity site-to-primary 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	2013.	2014.

1. Efficiency Trends

As explained in section IV.F, for the NOPR, DOE assumed that the efficiency distributions in the base case for ECGs 1 changes over time. The projected share of 1 to 5 horsepower Premium motors (EL 2) for equipment class subgroup 1.a. grows from 36.6 percent to 45.5 percent over the analysis period, and for equipment class subgroup 1.b., it grows from 30.0 percent to 38.9 percent. For ECG 2 and 3, DOE assumed that the efficiency remains constant from 2016 to 2045.

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

The Joint Advocates commented that DOE's ''rollup'' scenario will lead to conservative energy saving estimates and given that some manufacturers already offer motors with efficiency levels above Premium, one would expect that the adoption of standards at or above Premium would accelerate the interest in more efficient motor designs. (Joint Advocates, No. 97 at p. 3)

The ''rollup'' scenario was used to establish the efficiency distributions in the compliance year. Thereafter, for ECGs 1, DOE used a shift scenario and assumed that the level immediately above the standard would show a similar increase in market penetration as the Premium motors in the base case. This approach aligns with the Joint Advocates' suggestion. DOE did not receive any other comments on efficiency trends and, consequently, retained the same approach for the final rule. The assumed efficiency trends in the base case and standards cases are described in chapter 10 of the TSD.

2. National Energy Savings

For each year in the forecast period, DOE calculates the 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, 2016–2045.

DOE estimated energy consumption and savings based on site energy and converted the electricity consumption and savings to primary energy (power plant energy use) using annual conversion factors derived from the *AEO 2013* version of the NEMS.

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). After evaluating 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 the most appropriate tool for its FFC analysis and its intention to use NEMS for that purpose. 77 FR 49701 (August 17, 2012). The approach used for today's final rule, and the FFC multipliers that were applied, are described in appendix 10–C of the final TSD.

3. Electric Motor Weights

NEMA commented that motors vary greatly when it comes to frame length, thickness, material and weights for comparable ratings. It disagreed a with the motor weight estimates as performed by DOE. NEMA stated that there are too many variables to accurately determine weights relative to motor performance attributes. NEMA listed variables such as the construction material for the frame (iron, steel, and aluminum), the casting variations (robust, thin), the inclusion of packaging weight in the total weight, and other variations in construction practices. NEMA did not provide an alternative method or additional information that could be used to refine the approach DOE used for estimating weights. (NEMA, No. 93 at pp. 6–7)

Weight data are used to estimate shipping costs, which are a component of the total installed cost used to calculate the life cycle cost. The LCC results show that the average shipping costs represent a small fraction of the total installed costs (about 15 percent) and less than one percent of the total life cycle cost. While manufacturer catalogs contain weight data, these data showed some variations in weights.[75] To account for these variations, DOE performed a sensitivity analysis to evaluate the impacts of lower and higher weight assumptions. Since the shipping costs are such a small fraction of the LCC, the variations in weights did not significantly impact the results. Therefore, DOE retained the same approach for establishing weights for motors configurations not directly analyzed in the engineering analysis.

4. Equipment Price Forecast

As noted in section IV.F.2, DOE assumed no change in electric motor prices over the 2016–2045 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 TSD.

5. 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.[76] The 7-percent real value is an estimate of the average before-tax rate of return to private capital in the U.S. economy. The 3-percent real value represents the ''social rate of time preference,'' which is the rate at which society discounts future consumption flows to their present value.

I. Consumer Subgroup Analysis

In analyzing the potential 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 final rule, DOE evaluated impacts on various subgroups (e.g., customer from the agricultural, commercial, and industrial sector; customers with lower electricity prices) using the LCC spreadsheet model. DOE did not receive any comments on its consumer subgroup analysis in response to the NOPR. The customer subgroup analysis is discussed in detail in chapter 11 of the final rule TSD.

J. Manufacturer Impact Analysis

DOE conducted an MIA to estimate the financial impact of new and amended energy conservation standards on manufacturers of covered electric motors. The MIA also estimates the impact standards could have on direct employment, manufacturing capacity, manufacturer subgroups, and the cumulative regulatory burden. The MIA has both quantitative and qualitative aspects. The quantitative aspect 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, MPCs, shipments, and assumptions about manufacturer markups and conversion costs. 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 standards on manufacturers of covered electric motors. DOE employed different assumptions about manufacturer markups to produce ranges of results that represent the uncertainty about how electric motor manufacturers will respond to standards. The qualitative part of the MIA addresses factors such as manufacturing capacity; characteristics of, and impacts on, any particular subgroup of manufacturers; impacts on competition; and the cumulative regulatory burden of electric motor manufacturers.

DOE outlined its complete methodology for the MIA in the previously published NOPR. Also the complete MIA is presented in chapter 12 of this final TSD.

1. Manufacturer Production Costs

Manufacturing more efficient equipment is typically more expensive than manufacturing baseline equipment due to the need for more costly components and more extensive R&D to reduced motor losses. The resulting changes in the MPCs of the analyzed equipment can affect the revenues, gross margins, and cash flows of manufacturers. DOE strives to accurately model the potential changes in these equipment costs, as they are a key input for the GRIM and DOE's overall analysis. For the final rule, DOE only updated the dollar year of the MPCs from 2012$, the dollar year used in the NOPR, to 2013$. For a complete description of the how the MPCs were created see section IV.C of this final rule.

2. Shipment Projections

Changes in sales volumes and efficiency distribution of equipment over time can significantly affect manufacturer finances. The GRIM estimates manufacturer revenues based on total unit shipment projections and the distribution of shipments by efficiency level. For the final rule, DOE slightly altered the distribution of shipments across pole configuration at the highest horsepower ratings based on stakeholder comments. This had a negligible effect on the MIA results. For the MIA, the GRIM used the NIA's annual shipment projections from 2014, the base year, to 2045, the end of the analysis period. For a complete description of the shipment analysis see section IV.G of this final rule.

3. Markup Scenarios

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, or preservation of gross margin, markup scenario; (2) a

[75] For example, in the case of a 50 horsepower motor, a standard deviation equal to 18 percent of the average weight was observed.

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

preservation of operating profit markup scenario; and (3) a two-tiered markup scenario. These scenarios lead to different manufacturer markup values, which when applied to the inputted MPCs, result in varying revenue and cash-flow impacts.

The Joint Advocates commented that the lower bound markup scenarios overstated the negative impacts to electric motor manufacturers. They also stated that manufacturer support for the standards proposed in the NOPR suggests that the lower bound markup scenario is unrealistic. (Joint Advocates, No. 97 at p. 4) DOE presents an upper bound to manufacturer impacts, which are positive for all TSLs, and a lower bound to manufacturer impacts, which are negative for all TSLs. This range of possible manufacturer impacts represents the uncertainty of manufacturers' profitability following standards. The lower bound to manufacturer impacts represents a worst-case scenario for manufacturers and does not imply that this will be the markup scenario manufacturers will face following standards. Just as the upper bound markup scenario represents a best-case scenario for manufacturers and again does not imply that this will be the markup scenario manufacturers will face following standards. Therefore, DOE believes that the lower bound markup scenario presented in this final rule is an appropriate worst-case scenario for manufacturers and is not intended to represent the true outcome for all electric motor manufacturers following standards, simply the lower bound of a range of possible outcomes.

NEEA commented that since there is an enormous range of electric motor types covered in this rulemaking (*e.g.,* horsepower, pole configuration) and since there are several distribution channels these motors could be sold through, different markup scenarios might apply to different motor sizes, different markets, and different distribution channels. (NEEA, Pub. Mtg. Tr., No. 87 at p. 172) DOE agrees with this assessment of the market as various manufacturers could markup various motors differently following new and amended energy conservation standards. The upper and lower bound markup scenarios represent this range of various markup options that manufacturers will pursue following standards given the unique circumstances each manufacture faces.

For the final rule, DOE did not alter the markup scenarios or the methodology used to calculate the markup values from those used in the NOPR analysis.

4. Product and Capital Conversion Costs

New and amended energy conservation standards will cause manufacturers to incur one-time conversion costs to bring their production facilities and equipment designs into compliance. 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 R&D, testing, compliance, marketing, and other non-capitalized costs necessary to make equipment designs comply with standards. Capital conversion costs are one-time investments in property, plant, and equipment necessary to adapt or change existing production facilities such that new equipment designs can be fabricated and assembled. For the preliminary analysis NEMA commented that electric motors at ELs above premium efficiency levels, and especially at ELs requiring die-cast copper rotors, would require manufacturers to make significant capital investments and significant time to redesign, test, and certify their entire production lines. (NEMA, No. 54 at p. 4 & 11) For the NOPR analysis, DOE incorporated NEMA's comment when creating the conversion costs for electric motors at ELs requiring die-cast copper rotors. For the final rule, DOE only updated the dollar year of the conversion costs from 2012$, the dollar year used in the NOPR, to 2013$.

5. Other Comments From Interested Parties

During the NOPR public meeting and comment period, interested parties commented on the assumptions, methodology, and results of the NOPR MIA. DOE received comments about the manufacturer markups used in the MIA versus the NIA and potential trade barriers. These comments are addressed in the following sections.

a. Manufacturer Markups Used in the MIA Versus the NIA

The Joint Advocates commented that while the MIA presents a range of potential changes to manufacturers' INPV by altering the manufacturer markups, the NIA only uses one manufacturer markup when analyzing the impacts to customers. Further, they state that the manufacturer markup that is used in the NIA typically yields a higher customer purchase price for more efficient equipment analyzed in the rulemaking. (Joint Advocates, No. 97 at p. 4) Based on manufacturer interviews and DOE's understanding of the electric motor market, DOE believes that manufacturers might not be able to maintain their gross margin on all motors sold if the MPCs for those motors increased significantly due to standards. Therefore, the MIA conducted a sensitivity analysis around the manufacturer markup by modeling a lower bound manufacturer markup where manufacturers must compress their manufacturer markup to maintain market competition. This lower bound represents a worse-case scenario for manufacturer profitability. The NIA, which looks at the impacts of standards on customers, only models the scenario where manufacturers are able to maintain their manufacturer markup (the upper bound manufacturer markup scenario in the MIA). This manufacturer markup used in the NIA is the most conservative estimate for the purchase price that customers would pay for the equipment. Since there is uncertainty regarding how manufacturers would markup specific equipment following standards, DOE uses the most conservative estimates for the impacts to customers and manufacturers in the NIA and MIA respectively.

b. Potential Trade Barriers

Baldor commented that if electric motor energy conservation standards are set above the rest of the world's standards, it could be a potential trade barrier for foreign motor manufacturer trying to sell electric motors in the United States. Baldor states that there are a lot of small foreign motor manufacturers, so they might not have the resources to manufacture separate motor production lines specifically to comply with U.S. electric motor standards. (Baldor, Pub. Mtg. Tr., No. 87 at p. 176–177) DOE acknowledge that manufacturers selling motors in the United States and other countries with standards below the United States could be required to operate motor production lines specifically for the U.S. market. However, DOE does not believe that setting electric motor standards above other countries' standards would constitute a potential trade barrier because all motor sold in the United States must comply with U.S. standards regardless if the motor is manufactured domestically or abroad. Also, DOE is not adopting standards above premium efficiency levels, which are the standards other countries have recently adopted for electric motors (*e.g.,* the European Union).

6. Manufacturer Interviews

DOE interviewed manufacturers representing more than 75 percent of covered electric motor sales in the

United States. The NOPR interviews were in addition to the preliminary interviews DOE conducted as part of the preliminary analysis. DOE outlined the key issues for the rulemaking for electric motor manufacturers in the NOPR. DOE considered the information received during these interviews in the development of the NOPR and this final rule. Comments on the NOPR regarding the impact of standards on manufacturers were discussed in the preceding sections. DOE did not conduct interviews with manufacturers between the publication of the NOPR and this final rule. Also, DOE did not receive any comments on the key issues identified in the NOPR.

K. Emissions Analysis

In the emissions analysis, DOE estimates 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 primarily conducted the emissions analysis using emissions factors for CO_2 and other gases derived from data in *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 TSD.

For CH_4 and N_2O, DOE calculated emissions reduction in tons and also in terms of units of carbon dioxide equivalent (CO_2eq). Gases are converted to CO_2eq by multiplying the physical units by the gas' global warming potential (GWP) over a 100 year time horizon. Based on the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,[77] DOE used GWP values of 25 for CH_4 and 298 for N_2O.

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 (42 U.S.C. 7651 *et seq.*) 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. 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.[78] *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). In 2011, EPA issued a replacement for CAIR, the Cross-State Air Pollution Rule (CSAPR). 76 FR 48208 (August 8, 2011). On August 21, 2012, the DC Circuit issued a decision to vacate CSAPR.[79] The court ordered EPA to continue administering CAIR. The *AEO 2013* emissions factors used for today's final rule 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 tradable emissions allowances. Under existing EPA regulations, any excess SO_2 emissions allowances resulting from the lower electricity demand caused by the adoption of a new or amended efficiency standard could be used to allow 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 (February 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 that would be 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 allow 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 allow 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 final rule for these States.

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

[77] Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn,G. Raga, M. Schulz and R. Van Dorland. 2007: Changes in Atmospheric Constituents and in Radiative Forcing. In *Climate Change 2007: The Physical Science Basis.* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller, Editors. 2007. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. p. 212.

[78] 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).

[79] See *EME Homer City Generation, LP* v. *EPA,* 696 F.3d 7, 38 (D.C. Cir. 2012), cert. granted, 81 U.S.L.W. 3567, 81 U.S.L.W. 3696, 81 U.S.L.W. 3702 (U.S. June 24, 2013) (No. 12–1182).

L. Monetizing Carbon Dioxide and Other Emissions Impacts

As part of the development of today's 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 analogous 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 final rule.

For today's final rule, DOE is relying on a set of values for the SCC that was developed by a Federal interagency process. The basis for these values is summarized below, and a more detailed description of the methodologies used is provided as an appendix to chapter 14 of the final rule 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) of Executive Order 12866, 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. The estimates are presented with an acknowledgement of the many uncertainties involved and with a clear understanding that they should be updated over time to reflect increasing knowledge of the science and economics of climate impacts.

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

a. Monetizing Carbon Dioxide Emissions

When attempting to assess the incremental economic impacts of carbon dioxide emissions, the analyst faces a number of challenges. A report from the National Research Council [80] points out that any assessment will suffer from uncertainty, speculation, and lack of information about (1) future emissions of GHGs, (2) the effects of past and future emissions on the climate system, (3) the impact of changes in climate on the physical and biological environment, and (4) the translation of these environmental impacts into economic damages. As a result, any effort to quantify and monetize the harms associated with climate change will raise questions of science, economics, and ethics and should be viewed as provisional.

Despite the limits of both quantification and monetization, SCC estimates can be useful in estimating the social benefits of reducing CO_2 emissions. The agency can estimate the benefits from reduced (or costs from increased) emissions in any future year by multiplying the change in emissions in that year by the SCC values appropriate for that year. The net present value of the benefits can then be calculated by multiplying each of these future benefits by an appropriate discount factor and summing across all affected years.

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

[80] National Research Council. *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use.* 2009. National Academies Press: Washington, DC.

b. Development of Social Cost of Carbon Values

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

c. Current Approach and Key Assumptions

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

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

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 IAMs, at discount rates of 2.5, 3, and 5 percent. The fourth set, which represents the 95th percentile SCC estimate across all three models at a 3-percent discount rate, was included to represent higher than expected impacts from temperature 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,[81] 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,[82] which is reproduced in appendix 14–A of the 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.[83] Table IV.27 shows the updated sets of SCC estimates in 5-year increments from 2010 to 2050. The full set of annual SCC estimates between 2010 and 2050 is reported in appendix 14B of the DOE final rule TSD. The central value that emerges is the average SCC across models at the 3 percent discount rate. However, for purposes of capturing the uncertainties involved in regulatory impact analysis, the interagency group emphasizes the importance of including all four sets of SCC values.

TABLE IV.27—ANNUAL SCC VALUES FROM 2013 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	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 2009 National Research Council report mentioned above points out that there is tension between the goal of producing

[81] It is recognized that this calculation for domestic values is approximate, provisional, and highly speculative. There is no *a priori* reason why domestic benefits should be a constant fraction of net global damages over time.

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

[83] *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*

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 analytic challenges that are being addressed by the research community, including research programs housed in many of the Federal agencies participating in the interagency process to estimate the SCC. The interagency group intends to periodically review and reconsider those estimates to reflect increasing knowledge of the science and economics of climate impacts, as well as improvements in modeling.

In summary, in considering the potential global benefits resulting from reduced CO_2 emissions, DOE used the values from the 2013 interagency report adjusted to 2012$ using the GDP price deflator. For each of the four sets of SCC values, the values 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 rates for the 2040–2050 period in the interagency update.

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

NEMA provided a lengthy critique of the integrated assessment models (IAMs) that were utilized by the Interagency Working Group to projecting future damages from CO_2 emissions, pointing out that there is enormous uncertainty in the models. (NEMA, No. 93 at p. 16) The Cato Institute stated that the determination of the SCC is discordant with the best scientific literature on the equilibrium climate sensitivity and the fertilization effect of carbon dioxide—two critically important parameters for establishing the net externality of carbon dioxide emissions, at odds with existing OMB guidelines for preparing regulatory analyses, and founded upon the output of IAMs that encapsulate such large uncertainties as to provide no reliable guidance as to the sign, much less the magnitude of the social cost of carbon. (Cato Institute, No. 94 at p. 1)

NEMA stated that the monetized benefits of carbon emission reductions are informative at some level, but should not be considered as determinative in the Secretary's decision-making under EPCA. NEMA believes that DOE should base its net benefit determination for justifying a particular energy conservation standard on the traditional criteria relied upon by DOE—impacts on manufacturers, consumers, employment, energy savings, and competition. (NEMA, No. 93 at p. 16) The American Forest & Paper Association (AF&PA) and the American Fuel & Petrochemical Manufacturers (AFPM) stated that the SCC calculation should not be used in any rulemaking and/or policymaking until it undergoes a more rigorous notice, review and comment process.[84] (AF&PA and AFPM, No. 95 at p. 1) Similarly, the Cato Institute stated that the SCC should not be used in this or other rulemakings. (Cato Institute, No. 94 at p. 1) In contrast, the Joint Advocates and CA IOUs expressed support for the use of the updated SCC values that are based on the interagency working group's most recent review of peer-reviewed models on the subject. (Joint Advocates, No. 97 at p. 4; CA IOUs, No. 99 at p. 2)

In response to the comments on the SCC values, DOE acknowledges the limitations in the SCC estimates, which are discussed in detail in the 2010 interagency group report. Specifically, uncertainties in the assumptions regarding climate sensitivity, as well as other model inputs such as economic growth and emissions trajectories, are discussed and the reasons for the specific input assumptions chosen are explained. However, the three integrated assessment models used to estimate the SCC are frequently cited in the peer-reviewed literature and were used in the last assessment of the IPCC. In addition, new versions of the models that were used in 2013 to estimate revised SCC values were published in the peer-reviewed literature (see appendix 14B of the final rule TSD for discussion). Although uncertainties remain, the revised estimates that were issued in November, 2013 are based on the best available scientific information on the impacts of climate change. The current estimates of the SCC have been developed over many years, using the best science available, and with input from the public. In November 2013, OMB announced a new opportunity for public comment on the interagency technical support document underlying the revised SCC estimates. See 78 FR 70586. The comment period for the OMB announcement closed on February 26, 2014. OMB is currently reviewing comments and considering whether further revisions to the 2013 SCC estimates are warranted. DOE stands ready to work with OMB and the other members of the interagency working group on further review and revision of the SCC estimates as appropriate.

[84] AF&PA and AFPM pointed to more detailed comments that were filed by AFPM and several other trade associations on DOE's Energy Conservation Standards for Commercial Refrigeration Equipment. *http://www.regulations.gov/#!documentDetail;D=EERE-2010-BT-STD-0003-0079.*

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 rule based on estimates found in the relevant scientific literature. Estimates of monetary value for reducing NO_X from stationary sources range from $476 to $4,893 per ton (2013$).[85] DOE calculated monetary benefits using a medium value for NO_X emissions of $2,684 per short ton (in 2014$), 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 NEMS–BT 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 final rule TSD describes the utility impact analysis in further detail.

[85] 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.

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 [86]). 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, 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 final rule, DOE did not receive any comments and retained the same approach using ImSET only to estimate short-term employment impacts.

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

O. Other Comments Received

In response to the NOPR, interested parties submitted additional comments on a variety of general issues. CEC and NEMA both pointed out a table formatting error that appeared in Table 4 on p. 73679 the **Federal Register** version of the NOPR.[87] (CEC, No. 96 at p. 3, NEMA, No. 93 at p. 30) DOE notes that this error was corrected in the CFR and future versions of the table. The Office of the **Federal Register** published a correction to the table on February 14, 2014. *See* 79 FR 8309.

In response to the NOPR, Scott Mohs raised concern about loss of wildlife habitat due to corn acreage. (Scott Mohs, No. 102 at p. 1) This issue is beyond the scope of the electric motors rulemaking, and, accordingly, DOE does not discuss corn acreage in today's final rule.

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. Within each equipment class grouping, DOE established equipment classes based on pole configuration, horsepower rating, and enclosure, leading to a total of 482 equipment classes (see section IV.A.4). DOE analyzed the benefits and burdens of the TSLs developed for today's final 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 Premium levels for all equipment class groups with the exception of fire-pump motors, which remain at the baseline; TSL 3 represents one NEMA band above Premium for all groups except fire-pump motors, which move up to Premium; and TSL 4 represents the maximum technologically feasible level (max-tech) for all equipment class groups.[1] Because today's final rule includes equipment class groups containing both currently regulated motors and newly regulated motors, 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 selected 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 (see TSD chapter 10).

TABLE V.1—SUMMARY OF TSLS

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

[86] See Labor Department's Bureau of Labor Statistics, Current Employment Statistics (Available at: *http://www.bls.gov/ces/.*)

[87] 78 FR 73679.

TABLE V.1—SUMMARY OF TSLS—Continued

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

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)(I)–(VII) as applied to equipment via 6316(a)) 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 typically affect customers in two ways: (1) Annual operating expense would decrease, and (2) purchase price would increase. Section IV.F of this rule 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 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	7.8	34.8	83.3
Customers with Net LCC Benefit (%) **	10.9	34.3	44.7	9.4
Customers with No Change in LCC (%) **	88.8	57.9	20.4	7.3
Mean LCC Savings ($)	$55	$160	$98	−$409
Median PBP (Years)	1.0	2.9	6.0	26.5

* The results for equipment class group 1 are the shipment weighted averages of the results for representative units 1, 2, 3, 9 and 10.
** 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 (%) **	18.6	18.6	92.8	92.8
Customers with Net LCC Benefit (%) **	71.5	71.5	7.2	7.2
Customers with No Change in LCC (%) **	9.8	9.8	0.0	0.0
Mean LCC Savings ($)	$53	$53	−$280	−$280
Median PBP (Years)	4.5	4.5	20.7	20.7

* 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 ***	−$64.6	−$807
Median PBP (Years)	N/A ***	N/A ***	3016	11632

* 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, TSLs 1 and 2 are the same as the baseline; thus, no customers are affected.

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.5 and Table V.6 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.5—SUMMARY LIFE-CYCLE COST RESULTS FOR SUBGROUPS FOR EQUIPMENT CLASS GROUP 1: AVERAGE LCC SAVINGS

EL	TSL	Average LCC savings (2013$) *					
		Reference scenario	Low energy price	Small business	Industrial sector only	Commercial sector only	Agricultural sector only
1	1	55	55	49	65	52	20
2	2	160	160	141	195	148	11
3	3	98	97	76	136	85	−100
4	4	−409	−410	−439	−355	−428	−701

* The results for equipment class group 1 are the shipment weighted averages of the results for representative units 1, 2, 3, 9 and 10.

TABLE V.6—SUMMARY LIFE-CYCLE COST RESULTS FOR SUBGROUPS FOR EQUIPMENT CLASS GROUP 1: MEDIAN PAYBACK PERIOD

EL	TSL	Median payback period (years)*					
		Reference scenario	Low energy price	Small business	Industrial sector only	Commercial sector only	Agricultural sector only
1	1	1.0	1	1	1	1	3
2	2	2.9	3	3	2	3	7
3	3	6.0	6	6	4	7	23
4	4	26.5	26	27	18	30	126

* The results for equipment class group 1 are the shipment weighted averages of the results for representative units 1, 2, 3, 9 and 10.

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.7 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 final rule.

TABLE V.7—REBUTTABLE-PRESUMPTION PAYBACK PERIODS (YEARS)

Equipment class group*	Trial standard level			
	1	2	3	4
1	0.5	0.8	1.2	4.0
2	1.6	1.6	7.3	7.3
3	N/A**	N/A**	817	4,991

*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, 3, 9 and 10; ECG 2: Representative units 4 and 5; ECG 3: Representative units 6, 7, and 8.
**For equipment class group 3, TSLs 1 and 2 are the same as the baseline; thus, no customers are affected.

2. Economic Impacts on Manufacturers

DOE performed an MIA to estimate the impact of new and amended energy conservation standards on manufacturers of covered electric motors. The following section describes the expected impacts on manufacturers at each TSL. Chapter 12 of this final rule TSD explains the analysis in further detail.

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, or gross margin, 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. 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 MPC 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.8, Table V.9, and Table V.10 present the results for all electric motors under the flat, two-tiered, and preservation of operating profit markup scenarios. DOE examined all three ECGs (Design A and B motors, Design C motors, fire pump motors) together.

TABLE V.8—MANUFACTURER IMPACT ANALYSIS FOR ELECTRIC MOTORS—FLAT MARKUP SCENARIO

	Units	Base case	Trial standard level			
			1	2	3	4
INPV	(2013$ millions)	$3,478.0	$3,486.4	$3,870.6	$4,541.9	$5,382.1
Change in INPV	(2013$ millions)		$8.4	$392.6	$1,063.9	$1,904.1
	(%)		0.2%	11.3%	30.6%	54.7%
Product Conversion Costs	(2013$ millions)		$6.2	$58.0	$618.1	$627.4
Capital Conversion Costs	(2013$ millions)		$0.0	$26.6	$222.8	$707.2
Total Conversion Costs	(2013$ millions)		$6.2	$84.6	$841.0	$1,334.6

TABLE V.9—MANUFACTURER IMPACT ANALYSIS FOR ELECTRIC MOTORS—TWO-TIERED MARKUP SCENARIO

	Units	Base case	Trial standard level			
			1	2	3	4
INPV	(2013$ millions)	$3,478.0	$3,481.6	$3,130.4	$2,928.3	$3,282.0
Change in INPV	(2013$ millions)		$3.6	$−347.7	$−549.7	$−196.0
	(%)		0.1%	−10.0%	−15.8%	−5.6%
Product Conversion Costs	(2013$ millions)		$6.2	$58.0	$618.1	$627.4
Capital Conversion Costs	(2013$ millions)		$0.0	$26.6	$222.8	$707.2
Total Conversion Costs	(2013$ millions)		$6.2	$84.6	$841.0	$1,334.6

TABLE V.10—MANUFACTURER IMPACT ANALYSIS FOR ELECTRIC MOTORS—PRESERVATION OF OPERATING PROFIT MARKUP SCENARIO

	Units	Base case	Trial standard level			
			1	2	3	4
INPV	(2013$ millions)	$3,478.0	$3,461.3	$3,643.0	$3,362.0	$2,048.3
Change in INPV	(2013$ millions)		$−16.7	$165.0	$−116.0	$−1,429.8
	(%)		−0.5%	4.7%	−3.3%	−41.1%
Product Conversion Costs	(2013$ millions)		$6.2	$58.0	$618.1	$627.4
Capital Conversion Costs	(2013$ millions)		$0.0	$26.6	$222.8	$707.2
Total Conversion Costs	(2013$ millions)		$6.2	$84.6	$841.0	$1,334.6

TSL 1 represents EL 1 for ECG 1 and ECG 2 motors and baseline for ECG 3 motors. At TSL 1, DOE estimates impacts on INPV to range from $8.4 million to −$16.7 million, or a change in INPV of 0.2 percent to −0.5 percent. At this TSL, industry free cash flow is estimated to decrease by approximately 1 percent to $164.3 million, compared to the base case value of $166.1 million in 2015.

The INPV impacts at TSL 1 range from slightly positive to slightly negative. Consequently, 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 (2016), 90 percent of all electric motor shipments (91 percent of ECG 1a, 68 percent of ECG 1b, 8 percent of ECG 2, and 100 percent of ECG 3 shipments) would already meet the efficiency levels at TSL 1 or higher in the base case. Since ECG 1a 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 1a shipments not currently covered by the existing electric motor standard and a small amount of ECG 1b and ECG 2 shipments would need to be converted to comply with efficiency standards prescribed at TSL 1.

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 $6.2 million due to the expanded scope of motors covered by this rulemaking, which includes motors previously not covered by the existing 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 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 1a and ECG 1b motors, EL 1 for ECG 2 motors, and baseline for ECG 3 motors. At TSL 2, DOE estimates impacts on INPV to range from $392.6 million to −$347.7 million, or a change in INPV of 11.3 percent to −10.0 percent. At this TSL, industry free cash flow is estimated to decrease by approximately 17 percent to $137.1 million, compared to the base case value of $166.1 million in 2015.

The INPV impacts at TSL 2 range from moderately positive to slightly negative. DOE estimates that in the year of compliance (2016), 60 percent of all electric motor shipments (60 percent of ECG 1a, 31 percent of ECG 1b, 8 percent of ECG 2, and 100 percent of ECG 3 shipments) would already 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 the efficiency levels at this TSL. Therefore, only previously non-covered Design A and B motors and most ECG 1b and ECG 2 motors would need to be converted to comply with efficiency standards prescribed at TSL 2.

At TSL 2, 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 the majority of electric motor shipments already meet the efficiency levels required at this TSL. DOE estimates product conversion costs of $58.0 million due to the expanded scope of this rulemaking, which includes motors not previously covered by the existing electric motor energy conservation standards and the inclusion of ECG 1b and ECG 2 motors. DOE believes there will be moderate engineering costs, as well as testing and certification costs at this TSL associated with this scope expansion. DOE estimates the capital conversion costs to be approximately $26.6 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 machinery to bring all motor production to these efficiency levels.

TSL 3 represents EL 3 for ECG 1a and ECG 1b motors, EL 2 for ECG 2 motors, and EL 1 for ECG 3 motors. At TSL 3, DOE estimates the impacts on INPV to range from $1,063.9 million to −$549.7 million, or a change in INPV of 30.6 percent to −15.8 percent. At this TSL, industry free cash flow is estimated to decrease by approximately 170 percent to −$116.0 million, compared to the base case value of $166.1 million in 2015.

The INPV impacts at TSL 3 range from significantly positive to moderately negative. DOE estimates that in the year of compliance (2016), 23 percent of all electric motor shipments (24 percent of ECG 1a, 4 percent of ECG 1b, less than 1 percent of ECG 2, and 19 percent of ECG 3 shipments) would already meet the efficiency levels at TSL 3 or higher in the base case. The majority of shipments would need to be converted to comply with efficiency standards prescribed at TSL 3.

DOE expects conversion costs to increase significantly at TSL 3 and become a substantial investment for manufacturers. DOE estimates product conversion costs of $618.1 million at TSL 3, since most electric motors in the base case do not exceed the current motor standards set at premium efficiency levels for Design A and B motors, which represents EL 2 for ECG 1a. DOE believes there would need to 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 1b, ECG 2, and ECG 3 motors. DOE estimates the capital conversion costs to be approximately $222.8 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 1a and ECG 1b motors, EL 2 for ECG 2 motors, and EL 3 for ECG 3 motors. At TSL 4, DOE estimates impacts on INPV to range from $1,904.1 million to −$1,429.8 million, or a change in INPV of 54.7 percent to −41.1 percent. At this TSL, industry free cash flow is estimated to decrease by approximately 303 percent to −$336.6 million, compared to the base case value of $166.1 million in 2015.

The INPV impacts at TSL 4 range from significantly positive to significantly negative. DOE estimates that in the year of compliance (2016) only 8 percent of all electric motor shipments (9 percent of ECG 1a, less than 1 percent of ECG 1b, less than 1 percent of ECG 2, and no ECG 3 shipments) would meet the efficiency levels at TSL 2 or higher in the base case. Almost all shipments would need to be converted to comply with efficiency standards prescribed at TSL 4.

DOE expects conversion costs again to increase significantly from TSL 3 to TSL 4. Conversion costs at TSL 4 now represent a massive investment for electric motor manufacturers. DOE estimates product conversion costs of $627.4 million at TSL 4, which are only slightly more than 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 $707.2 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 TSL 4. This technology requires a significant level of investment because the majority of manufacturers' machinery would need to be replaced or significantly modified.

b. Impacts on Employment

DOE quantitatively assessed the impact of new and amended energy conservation standards on direct employment in the electric motors industry. DOE used the GRIM to estimate the domestic labor expenditures and number of domestic production workers in the base case and at each TSL from the announcement of standards in 2014 (*i.e.,* the publication of this final rule) to the end of the analysis period in 2045. DOE used statistical data from the U.S. Census Bureau's 2011 Annual Survey of Manufacturers [88] (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 equipment, the MPC of the equipment, the sales volume, and an assumption that wages remain fixed in real terms over time.

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

The production worker estimates in this employment section cover only workers up to the line-supervisor level who are directly involved in fabricating and assembling an electric motor within a motor facility. Workers performing services that are closely associated with production operations, such as material

[88] See *http://www.census.gov/manufacturing/asm/index.html.*

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 production 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 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 standards, the lower bound of the employment results includes the estimated total number of U.S. production workers in the industry who could lose their jobs if some or all existing production were moved outside of the U.S. While the results present a range of employment impacts following 2016, the following sections 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 this final rule 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 7,313 domestic production workers involved in manufacturing all electric motors covered by this rulemaking in 2016. Table V.11 shows the range of potential impacts of standards on U.S. production workers in the electric motor industry. However, because ECG 1a 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 1a (*i.e.,* Design A and B motors).

TABLE V.11—POTENTIAL CHANGES IN THE TOTAL NUMBER OF ALL DOMESTIC ELECTRIC MOTOR PRODUCTION WORKERS IN 2016

	Base case	Trial standard level			
		1	2	3	4
Total Number of Domestic Production Workers in 2016 (upper bound: without changes in production locations)	7,313	7,346	7,498	8,374	16,049
Total Number of Domestic Production Workers in 2016 (lower bound: with changes to off-shore production locations)	7,313	7,313	6,947	3,657	0
Potential Changes in Domestic Production Workers in 2016*		33 to 0	185 to −366	1,061 to −3,656	8,736 to −7,313

* DOE presents a range of potential employment impacts.

Most manufacturers agree that any standard that involves expanding the scope of equipment required to meet premium efficiency levels for ECG 1a motors would not significantly change domestic employment levels. For standards that required ECG 1a motors to be at premium efficiency levels (the efficiency levels required for ECG 1a motors at TSL 2), most large manufacturers would not need to make major modifications to their production lines nor would they have to undertake new manufacturing processes. A few small manufacturers who primarily make electric motors outside the scope of coverage for the existing electric motor standards, but whose equipment would be covered by these electric motor standards, could be impacted by efficiency standards at TSL 2. These impacts to small manufacturers, including employment impacts, are discussed in more detail in section VI.B of today's final rule.

Overall, DOE believes there would not be a significant decrease in domestic employment levels at TSL 2, the selected TSL in today's final rule. DOE created a lower bound of the potential loss of domestic employment at 366 employees for TSL 2. DOE based this lower bound estimate on the fact that approximately 5 percent of the electric motor market is comprised of manufacturers that do not currently produce any motors at Premium efficiency levels. Therefore, DOE estimated that at most 5 percent of domestic electric motor employment in the base case in 2016 could potentially move abroad or exit the market entirely. However, 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 energy conservation standard set above premium efficiency levels 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 cause companies to incur higher labor costs. These factors could cause manufacturers to consider moving production offshore in an attempt 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 premium efficiency levels 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 domestic labor market in the base case in 2016 for TSL 3 and 100 percent for TSL 4. However, these values represent the worst-case scenario DOE modeled. Manufacturers also stated that larger motor manufacturing (*i.e.,* the manufacturing of motors above 200 horsepower) would be very unlikely to move abroad, because the shipping costs associated with those motors are very large. Consequently, DOE believes that standards set at TSL 3 and TSL 4 would not necessarily result in the large losses of domestic employment suggested by the lower bound of DOE's direct employment analysis.

c. Impacts on Manufacturing Capacity

Most manufacturers agree that any standard expanding the scope of equipment required to meet premium efficiency levels would not have a significant impact on manufacturing capacity. Manufacturers pointed out, however, that standards that required them to use copper rotors would severely disrupt manufacturing capacity. Baldor commented that motor manufacturers do not have the capacity to produce 5 million copper rotors per year. They stated it is challenging to manufacture better motor designs in actual production, compared to what can be obtained on paper. (Baldor, Pub. Mtg. Tr., No. 87 at p. 118–119) 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 the entire market. 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 two year time period. Most manufacturers agree that outsourcing copper rotor die-casting would constrain capacity by creating a bottleneck in copper 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. NEMA commented they are concerned about the potential price volatility with any standards requiring copper rotors. (NEMA, No. 93 at p. 12) DOE acknowledges that it is likely that there could be copper capacity concerns at any TSL requiring copper rotor motors. Currently, there is only a limited amount of copper die-casting machinery and companies with experience die-casting copper today. In addition, there could be significant fluctuations in the price of copper in the near term, which could lead to supply chain problems. Because the TSL selected in today's final rule (TSL 2) does not require the use of copper rotors for any motors, DOE does not anticipate that today's electric motor standards will cause any manufacturing capacity constraints.

d. Impacts on Sub-Group of Manufacturers

Using average cost assumptions to develop industry cash-flow estimates may not adequately assess 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 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 production 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 equipment 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 standards selected in today's final rule, such as the small electric motors standard (75 FR 10874) and the distribution transformers standard (78 FR 23336). The following section briefly addresses comments DOE received with respect to cumulative regulatory burden.

Baldor commented that DOE should try to harmonize electric motor standards with the rest of the world. Baldor stated that the European Union's (EU's) electric motor standards will be set at premium efficiency levels in the next few years, so having U.S. electric motor standards at premium efficiency levels would harmonize U.S. electric motor standards with the EU's standards. Baldor also stated that no other country is setting electric motor standards above premium efficiency levels, so any U.S. standards set above premium efficiency levels would cause the U.S. motor market to be out of synchronization with the rest of the world's standards. Also, there is an ongoing effort to develop global markings for electric motors so that manufacturers do not have to conduct separate compliance testing and approvals for each country. Therefore, standards that are harmonized with the rest of the world's standards would benefit manufacturers. (Baldor, Pub. Mtg. Tr., No. 87 at p. 176–180) The standards adopted in today's final rule do not require motor manufacturers to exceed premium efficiency levels for any motors. Therefore, the U.S. standards prescribed in today's final rule would keep U.S. standards in harmony with the rest of the world and would not significantly add to the motor manufacturers' cumulative regulatory burden from a global standards perspective.

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 (2016–2045). 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.12 presents the estimated primary energy savings for each considered TSL, and Table V.13 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.12—CUMULATIVE PRIMARY ENERGY SAVINGS FOR ELECTRIC MOTORS TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2016–2045

Equipment class	Trial standard level			
	1	2	3	4
	quads			
1	1.08	6.83	10.54	13.42
2	0.02	0.02	0.03	0.03
3	0.00	0.00	0.00	0.00
Total all classes	1.10	6.85	10.57	13.45

TABLE V.13—CUMULATIVE FULL-FUEL-CYCLE ENERGY SAVINGS FOR ELECTRIC MOTORS TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2016–2045

Equipment class	Trial standard level			
	1	2	3	4
	quads			
1	1.10	6.95	10.72	13.64
2	0.02	0.02	0.03	0.03
3	0.00	0.00	0.00	0.00
Total all classes	1.12	6.97	10.75	13.67

OMB 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.[89] DOE notes 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.14. The impacts are counted over the lifetime of electric motors purchased in 2016–2024.

TABLE V.14—CUMULATIVE NATIONAL ENERGY SAVINGS FOR ELECTRIC MOTORS TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2016–2024

Equipment class	Trial standard level			
	1	2	3	4
	quads			
1	0.42	1.59	2.35	3.05
2	0.00	0.00	0.01	0.01
3	0.00	0.00	0.00	0.00
Total all classes	0.43	1.59	2.36	3.06

[89] 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.

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,[90] 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 it 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 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.15—NET PRESENT VALUE OF CUSTOMER BENEFITS FOR ELECTRIC MOTORS TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2016–2045

[Billion 2013$]

Equipment class	Discount rate %	Trial standard level			
		1	2	3	4
1	3	6.91	28.75	8.61	−39.27
2		0.06	0.06	−0.02	−0.02
3		0.00	0.00	0.00	−0.03
Total All Classes		6.97	28.81	8.59	−39.32
1	7	3.34	11.27	−1.50	−31.29
2		0.02	0.02	−0.03	−0.03
3		0.00	0.00	0.00	−0.02
Total All Classes		3.36	11.29	−1.54	−31.34

The NPV results based on the aforementioned 9-year analytical period are presented in Table V.16. The impacts are counted over the lifetime of equipment purchased in 2016–2024. The review timeframe established in EPCA is generally not synchronized with the product lifetime, product manufacturing cycles, or other factors specific to electric motors. 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.16—NET PRESENT VALUE OF CUSTOMER BENEFITS FOR ELECTRIC MOTORS TRIAL STANDARD LEVELS FOR UNITS SOLD IN 2016–2024

[Billion 2013$]

Equipment class	Discount rate %	Trial standard level			
		1	2	3	4
1	3	3.15	8.81	4.79	−11.60
2		0.01	0.01	−0.01	−0.01
3		0.00	0.00	0.00	−0.01
Total All Classes		3.17	8.83	4.78	−11.61
1	7	1.95	5.02	1.04	−12.94
2		0.01	0.01	−0.02	−0.02
3		0.00	0.00	0.00	−0.01
Total All Classes		1.95	5.02	1.03	−12.97

c. Indirect Impacts on Employment

DOE expects energy conservation standards for electric motors to reduce energy costs for equipment owners, with the resulting net savings being redirected to other forms of economic activity. Those shifts in spending and economic activity could affect the overall domestic 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 (2016–2021), 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 TSD presents detailed results.

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

4. Impact on Utility or Performance

DOE believes that today's standards 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 energy conservation 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 in writing 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 (ii); 42 U.S.C. 6316(a))

To assist the Attorney General in making such determination, DOE transmitted a copy of its proposed rule and NOPR TSD to the Attorney General with a request that the Department of Justice (DOJ) provide its determination on this issue. DOJ's response, that the proposed energy conservation standards are unlikely to have a significant adverse impact on competition, is reprinted at the end of this rule.

6. Need of the Nation To Conserve Energy

Enhanced energy efficiency, where economically justified, improves the Nation's energy security, strengthens the economy, and reduces the environmental impacts or costs of energy production. Reduced electricity demand due to energy conservation standards is also likely to reduce the cost of maintaining and increase the reliability of the electricity system, particularly during peak-load periods. As a measure of this reduced demand, chapter 15 in the TSD presents the estimated reduction in the growth of generating capacity in 2044 for the TSLs that DOE considered in this rulemaking.

Energy savings from energy conservation 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.17 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 TSD.

TABLE V.17—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)	62.7	373	574	731
NO_X (thousand tons)	106	668	1,032	1,312
SO_2 (thousand tons)	33.6	196	301	383
Hg (tons)	0.132	0.819	1.26	1.61
N_2O (thousand tons)	1.24	8.30	12.9	16.3
CH_4 (thousand tons)	7.38	46.2	71.4	90.7
Upstream Emissions				
CO_2 (million metric tons)	3.55	22.0	33.9	43.1
NO_X (thousand tons)	0.761	4.71	7.26	9.23
SO_2 (thousand tons)	48.8	302	466	593
Hg (tons)	0.002	0.012	0.018	0.023
N_2O (thousand tons)	0.036	0.221	0.341	0.433
CH_4 (thousand tons)	296	1,837	2,834	3,604
Full-Fuel-Cycle Emissions				
CO_2 (million metric tons)	66.2	395	608	774
NO_X (thousand tons)	107	673	1,039	1,321
SO_2 (thousand tons)	82.5	498	767	977
Hg (tons)	0.134	0.831	1.28	1.63
N_2O (thousand tons)	1.27	8.52	13.2	16.8
CH_4 (thousand tons)	304	1,883	2,905	3,695

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 [91] (expressed in 2013$) are represented in today's rule as the value of emission reductions in 2015 by $12.0/metric ton (the average value from a distribution that uses a 5-percent discount rate), $40.5/metric ton (the average value from a distribution that uses a 3-percent discount rate), $62.4/metric ton (the average value from a distribution that uses a 2.5-percent discount rate), and $119 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.18 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

[91] These values reflect the latest SCC values developed by interagency process (November 2013) (see IV.L.1).

values as a range from 7 percent to 23 percent of the global values, and these results are presented in chapter 14 of the final rule TSD.

TABLE V.18—ESTIMATES OF GLOBAL PRESENT VALUE OF CO_2 EMISSIONS REDUCTION UNDER ELECTRIC MOTORS TRIAL STANDARD LEVELS

[Million 2013$]

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	465	2,070	3,269	6,373
2	2,529	11,720	18,651	36,225
3	3,870	17,985	28,633	55,600
4	4,939	22,923	36,488	70,858
Upstream Emissions				
1	25.7	116	183	357
2	146	682	1,087	2,110
3	223	1,049	1,673	3,246
4	285	1,335	2,129	4,132
Full-Fuel-Cycle Emissions				
1	491	2,185	3,452	6,730
2	2,675	12,402	19,738	38,335
3	4,094	19,033	30,306	58,845
4	5,223	24,258	38,618	74,991

* For each of the four cases, the corresponding SCC value for emissions in 2015 is $12.0, $40.5, $62.4, and $119 per metric ton (2013$).

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.

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. Table V.19 presents the estimated cumulative present values of NO_X emissions reductions for each TSL calculated using seven-percent and three-percent discount rates.

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

[Million 2013$]

TSL	3% discount rate	7% discount rate
Power Sector Emissions		
1	52.1	28.8
2	269	131
3	410	197
4	524	253
Upstream Emissions		
1	71.5	36.9
2	396	179
3	606	272
4	773	348
Full-Fuel-Cycle Emissions		
1	124	65.8
2	664	310
3	1,016	469
4	1,297	601

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.20 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.20—NET PRESENT VALUE OF CUSTOMER SAVINGS COMBINED WITH NET PRESENT VALUE OF MONETIZED BENEFITS FROM CO_2 AND NO_X EMISSIONS REDUCTIONS

[Billion 2013$]

TSL	SCC Case $12.0/metric ton CO_2* and Low Value for NO_X**	SCC Case $40.5/metric ton CO_2* and Medium Value for NO_X**	SCC Case $62.4/metric ton CO_2* and Medium Value for NO_X**	SCC Case $119/metric ton CO_2* and High Value for NO_X**
	Customer NPV at 3% Discount Rate added with:			
1	7.5	9.3	10.6	13.9
2	31.6	41.9	49.2	68.4
3	12.9	28.6	39.9	69.3
4	−33.9	−13.8	0.6	38.0
	Customer NPV at 7% Discount Rate added with:			
1	3.9	5.6	6.9	10.2
2	14.0	24.0	31.3	50.2
3	2.6	18.0	29.2	58.2
4	−26.0	−6.5	7.9	44.7

* These label values represent the global SCC in 2015, in 2013$.

** Low Value corresponds to $476 per ton of NO_X emissions. Medium Value corresponds to $2,684 per ton, and High Value corresponds to $4,893 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 2016–2045. 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)) DOE has considered the submission of the Petition under this factor. As described previously, DOE believes the Petition sets forth a statement by interested persons that are fairly representative of relevant points of view (including representatives of manufacturers of covered equipment, efficiency advocates, and others) and contains recommendations with respect to an energy conservation standard that are technologically feasible, economically justified, and likely to save significant energy. DOE encourages the submission of such consensus agreements as a way to bring diverse interested parties together, to develop an independent and probative analysis useful in DOE standard setting, and to expedite the rulemaking process. DOE also believes that standard levels recommended in the Petition may increase the likelihood for regulatory compliance, while decreasing the risk of litigation.

C. Conclusions

When considering 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 final rule, 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 consensus recommendations made by the Motors Coalition and the views of other stakeholders in their submitted comments.

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 the electric motor manufacturing sector 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.21 and Table V.22 summarize the quantitative impacts estimated for each TSL for electric motors.

TABLE V.21—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	10.7	13.7
NPV of Consumer Benefits 2013$ billion				
3% discount rate	7.0	28.8	8.6	−39.3
7% discount rate	3.4	11.3	−1.5	−31.3
Cumulative Emissions Reduction (Total FFC Emissions)				
CO_2 million metric tons	66.2	395	608	774
SO_2 thousand tons	107	673	1,039	1,321
NO_X thousand tons	82.5	498	767	977
Hg *tons*	0.134	0.831	1.28	1.63
N_2O thousand tons	1.27	8.52	13.2	16.8
CH_4 thousand tons	304	1,883	2,905	3,695
Value of Emissions Reduction (Total FFC Emissions)				
CO_2 2013$ *million**	491 to 6,730	2,675 to 38,335	4,094 to 58,845	5,233 to 74,991
NO_X—3% discount rate *2013$ million*	124	664	1,016	1,297
NO_X—7% discount rate *2013$ million*	66	310	469	601

* Range of the economic value of CO_2 reductions is based on estimates of the global benefit of reduced CO_2 emissions.

TABLE V.22—SUMMARY OF ANALYTICAL RESULTS FOR ELECTRIC MOTORS: MANUFACTURER AND CONSUMER IMPACTS

Category	TSL 1	TSL 2	TSL 3	TSL 4
Manufacturer Impacts				
INPV (2013$ million) (Base Case INPV of $3,478.0)	3,486.4 to 3,461.3	3,870.6 to 3,130.4	4,541.9 to 2,928.3	5,382.2 to 2,048.3
INPV (change in 2013$)	8.4 to −16.7	392.6 to −347.7	1,063.9 to −549.7	1,904.1 to −1,429.8
INPV (% change)	0.2 to −0.5	11.3 to −10.0	30.6 to −15.8	54.7 to −41.1
Consumer Mean LCC Savings * 2013$				
Equipment Class Group 1	55	160	98	−409
Equipment Class Group 2	53	53	−280	−280
Equipment Class Group 3	N/A **	N/A **	−65	−807
Consumer Median PBP * years				
Equipment Class Group 1	1.0	2.9	6.0	26.5
Equipment Class Group 2	4.5	4.5	20.7	20.7
Equipment Class Group 3	N/A **	N/A **	3,016	11,632
Equipment Class Group 1				
Net Cost %	0.3	7.8	34.8	83.3
Net Benefit %	10.9	34.3	44.7	9.4
No Impact %	88.8	57.9	20.4	7.3
Equipment Class Group 2				
Net Cost %	18.6	18.6	92.8	92.8
Net Benefit %	71.5	71.5	7.2	7.2
No Impact %	9.8	9.8	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

* 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, 3, 9, and 10; ECG 2: Representative units 4 and 5; ECG 3: Representative units 6, 7, and 8.

** 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 −31.3 billion using a 7-percent discount rate, and −39.3 billion using a 3-percent discount rate.

The cumulative emissions reductions at TSL 4 are 774 million metric tons of CO_2, 977 thousand tons of NO_X, 1,321 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 $5,233 million to $74,991 million.

At TSL 4, the weighted average LCC impact ranges from $−807 for ECG 3 to $−280 for ECG 2. The weighted average median PBP ranges from 20.7 years for ECG 2 to 11,632 years for ECG 3. The weighted average share of customers experiencing a net LCC benefit ranges from 0-percent for ECG 3 to 9.4-percent for ECG 1.

At TSL 4, the projected change in INPV ranges from a decrease of $1,429.8 million to an increase of $1,904.1 million. If the decrease of $1,429.8 million were to occur, TSL 4 could result in a net loss of 41.1 percent in INPV to manufacturers of covered electric motors.

Based on the foregoing, DOE concludes that, at TSL 4 for electric motors, the benefits of energy savings, generating capacity reductions, 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 OEM 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 10.7 quads of energy, an amount DOE considers significant. TSL 3 has an estimated NPV of customer benefit of $−1.5 billion using a 7-percent discount rate, and $8.6 billion using a 3-percent discount rate.

The cumulative emissions reductions at TSL 3 are 608 million metric tons of CO_2, 767 thousand tons of NO_X, 1,039 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 $4,094 million to $58,845 million.

At TSL 3, the weighted average LCC impact ranges from $−280 for ECG 2 to $98 for ECG 1. The weighted average median PBP ranges from 6 years for ECG 1 to 3,016 years for ECG 3. The share of customers experiencing a net LCC benefit ranges from 0-percent for ECG 3 to 44.7-percent for ECG 1.

At TSL 3, the projected change in INPV ranges from a decrease of $549.7 million to an increase of $1,063.9 million. If the decrease of $549.7 million were to occur, TSL 3 could result in a net loss of 15.8 percent in INPV to manufacturers of covered electric motors.

Based on 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 OEM 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 $11.3 billion using a 7-percent discount rate, and $28.8 billion using a 3-percent discount rate.

The cumulative emissions reductions at TSL 2 are 395 million metric tons of CO_2, 498 thousand tons of NO_X, 673 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 $2,675 million to $38,335 million.

At TSL 2, the weighted average LCC impact ranges from no impacts for ECG 3 to $160 for ECG 1. The weighted average median PBP ranges from 0 years for ECG 3 to 4.5 years for ECG 2. The share of customers experiencing a net LCC benefit ranges from 0-percent for ECG 3 to 71.5-percent for ECG 2.The share of motors already at TSL2 efficiency levels varies by equipment class group and by horsepower range (from 0- to 57.9-percent). For ECG 1, which represents the most significant share of the market, about 30-percent of motors already meet the TSL levels.

At TSL 2, the projected change in INPV ranges from a decrease of $347.7 million to an increase of $392.6 million. If the decrease of $347.7 million were to occur, TSL 2 could result in a net loss of 10.0 percent in INPV to manufacturers of covered electric motors.

After considering the analysis and weighing the benefits and the burdens, DOE has 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, 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 adopts the energy conservation standards for electric motors at TSL 2. Table V.23 through Table V.25 present the energy conservation standards for electric motors.

TABLE V.23—ENERGY CONSERVATION STANDARDS FOR NEMA DESIGN A AND NEMA DESIGN B MOTORS

[Compliance starting June 1, 2016]

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

TABLE V.23—ENERGY CONSERVATION STANDARDS FOR NEMA DESIGN A AND NEMA DESIGN B MOTORS—Continued

[Compliance starting June 1, 2016]

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	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15/11	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20/15	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0
25/18.5	91.7	91.7	93.6	93.6	93.0	93.0	90.2	91.0
30/22	91.7	91.7	93.6	94.1	93.0	93.6	91.7	91.7
40/30	92.4	92.4	94.1	94.1	94.1	94.1	91.7	91.7
50/37	93.0	93.0	94.5	94.5	94.1	94.1	92.4	92.4
60/45	93.6	93.6	95.0	95.0	94.5	94.5	92.4	93.0
75/55	93.6	93.6	95.4	95.0	94.5	94.5	93.6	94.1
100/75	94.1	93.6	95.4	95.4	95.0	95.0	93.6	94.1
125/90	95.0	94.1	95.4	95.4	95.0	95.0	94.1	94.1
150/110	95.0	94.1	95.8	95.8	95.8	95.4	94.1	94.1
200/150	95.4	95.0	96.2	95.8	95.8	95.4	94.5	94.1
250/186	95.8	95.0	96.2	95.8	95.8	95.8	95.0	95.0
300/224	95.8	95.4	96.2	95.8	95.8	95.8		
350/261	95.8	95.4	96.2	95.8	95.8	95.8		
400/298	95.8	95.8	96.2	95.8				
450/336	95.8	96.2	96.2	96.2				
500/373	95.8	96.2	96.2	96.2				

TABLE V.24—ENERGY CONSERVATION STANDARDS FOR NEMA DESIGN C MOTORS

[Compliance starting June 1, 2016]

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.25—ENERGY CONSERVATION STANDARDS FOR FIRE PUMP ELECTRIC MOTORS

[Compliance starting June 1, 2016]

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

TABLE V.25—ENERGY CONSERVATION STANDARDS FOR FIRE PUMP ELECTRIC MOTORS—Continued

[Compliance starting June 1, 2016]

Motor horsepower/ standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2-Pole		4-Pole		6-Pole		8-Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
15/11	90.2	89.5	91.0	91.0	90.2	90.2	88.5	89.5
20/15	90.2	90.2	91.0	91.0	90.2	91.0	89.5	90.2
25/18.5	91.0	91.0	92.4	91.7	91.7	91.7	89.5	90.2
30/22	91.0	91.0	92.4	92.4	91.7	92.4	91.0	91.0
40/30	91.7	91.7	93.0	93.0	93.0	93.0	91.0	91.0
50/37	92.4	92.4	93.0	93.0	93.0	93.0	91.7	91.7
60/45	93.0	93.0	93.6	93.6	93.6	93.6	91.7	92.4
75/55	93.0	93.0	94.1	94.1	93.6	93.6	93.0	93.6
100/75	93.6	93.0	94.5	94.1	94.1	94.1	93.0	93.6
125/90	94.5	93.6	94.5	94.5	94.1	94.1	93.6	93.6
150/110	94.5	93.6	95.0	95.0	95.0	94.5	93.6	93.6
200/150	95.0	94.5	95.0	95.0	95.0	94.5	94.1	93.6
250/186	95.4	94.5	95.0	95.4	95.0	95.4	94.5	94.5
300/224	95.4	95.0	95.4	95.4	95.0	95.4		
350/261	95.4	95.0	95.4	95.4	95.0	95.4		
400/298	95.4	95.4	95.4	95.4				
450/336	95.4	95.8	95.4	95.8				
500/373	95.4	95.8	95.8	95.8				

2. Summary of Benefits and Costs (Annualized) of Today's Standards

The benefits and costs of today's standards, for equipment sold in 2016–2045, 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 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.[92]

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 2016–2045. 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 today's standards for electric motors are shown in Table V.26. 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 today's standards is $517 million per year in increased equipment costs; while the estimated benefits are $1,367 million per year in reduced equipment operating costs, $614 million per year in CO_2 reductions, and $23.3 million per year in reduced NO_X emissions. In this case, the net benefit would amount to $1,488 million per year. Using a 3-percent discount rate for all benefits and costs and the average SCC series, the estimated cost of today's standards is $621 million per year in increased equipment costs; while the estimated benefits are $2,048 million per year in reduced operating costs, $614 million per year in CO_2 reductions, and $32.9 million per year in reduced NO_X emissions. In this case, the net benefit would amount to approximately $2,074 million per year.

TABLE V.26—ANNUALIZED BENEFITS AND COSTS OF STANDARDS FOR ELECTRIC MOTORS

[Million 2013$/year]

	Discount rate	Primary estimate *	Low net benefits estimate *	High net benefits estimate *
Benefits				
Consumer Operating Cost Savings	7%	1,367	1,134	1,664
	3%	2,048	1,684	2,521
CO_2 Reduction Monetized Value ($12.0/t case) *	5%	166	143	192
CO_2 Reduction Monetized Value ($40.5/t case) *	3%	614	531	712

[92] 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 2014, 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 (2016 through 2045) 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 V.26—ANNUALIZED BENEFITS AND COSTS OF STANDARDS FOR ELECTRIC MOTORS—Continued

[Million 2013$/year]

	Discount rate	Primary estimate *	Low net benefits estimate *	High net benefits estimate *
CO_2 Reduction Monetized Value ($62.4/t case) *	2.5%	920	795	1,066
CO_2 Reduction Monetized Value $119/t case) *	3%	1,899	1,641	2,200
NO_X Reduction Monetized Value (at $2,684/ton) **	7%	23.3	20.1	26.8
	3%	32.9	28.4	38.0
Total Benefits †	7% plus CO_2 range	1,556 to 3,289	1,297 to 2,795	1,882 to 3,890
	7%	2,005	1,685	2,402
	3% plus CO_2 range	2,247 to 3,980	1,855 to 3,353	2,750 to 4,758
	3%	2,696	2,243	3,270
Costs				
Consumer Incremental Equipment Costs	7%	517	582	503
	3%	621	697	616
Net Benefits				
Total †	7% plus CO_2 range	1,039 to 2,772	716 to 2,213	1,380 to 3,388
	7%	1,488	1,103	1,900
	3% plus CO_2 range	1,626 to 3,359	1,158 to 2,656	2,134 to 4,143
	3%	2,074	1,546	2,654

* This table presents the annualized costs and benefits associated with electric motors shipped in 2016–2045. These results include benefits to consumers which accrue after 2044 from the equipment purchased in years 2016–2045. 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 (October. 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: 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 a ''significant regulatory action'' under section 3(f)(1) Executive Order 12866. DOE presented to the Office of Information and Regulatory Affairs (OIRA) in the OMB 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 (January 21, 2011). EO 13563 is supplemental to and explicitly reaffirms the principles, structures, and definitions governing regulatory review established in Executive Order 12866. To the extent permitted by law, agencies are required by Executive Order 13563 to: (1) Propose or adopt a regulation only upon a reasoned determination that its benefits justify its costs (recognizing that some benefits and costs are difficult to quantify); (2) tailor regulations to impose the least burden on society, consistent with obtaining regulatory objectives, taking into account, among other things, and to the extent practicable, the costs of cumulative regulations; (3) select, in choosing among alternative regulatory approaches, those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity); (4) to the extent feasible, specify performance objectives, rather than specifying the behavior or manner of compliance that regulated entities must adopt; and (5) identify and assess available alternatives to direct regulation, including providing economic incentives to encourage the desired behavior, such as user fees or marketable permits, or providing information upon which choices can be made by the public.

DOE emphasizes as well that Executive Order 13563 requires agencies to use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible. In its guidance, OIRA has emphasized that such techniques may include identifying changing future compliance costs that might result from technological innovation or anticipated behavioral changes. For the reasons stated in the preamble, DOE believes that today's final rule is consistent with these principles, including the requirement that, to the extent permitted by law, benefits justify costs and that net benefits are maximized.

B. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601, *et seq.*) requires preparation of an initial regulatory flexibility analysis (IRFA) for any rule that by law must be proposed for public comment, and a final regulatory flexibility analysis (FRFA) for any such rule that an agency adopts as a final rule, 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 reviewed the December 2013 NOPR (78 FR 73590) and today's final rule under the provisions of the Regulatory Flexibility Act and the procedures and policies published on February 19, 2003.

As a result of this review, DOE has prepared a FRFA for electric motors. As presented and discussed in the following section, the FRFA describes impacts on electric motor manufacturers and discusses alternatives that could minimize these impacts. A statement of the reasons for establishing the standards in today's final rule, and the objectives of, and legal basis for these standards, are set forth elsewhere in the preamble and not repeated here. Chapter 12 of the TSD contains more information about the impact of this rulemaking on manufacturers.

1. Description and Estimated Number of Small Entities Regulated

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. 65 FR 30836, 30850 (May 15, 2000), as amended at 65 FR 53533, 53545 (September 5, 2000) and codified at 13 CFR part 121. The size standards are listed by North American Industry Classification System (NAICS) code and industry description and are available at *http://www.sba.gov/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 [93]), information from previous rulemakings, UL qualification directories, individual company Web sites, and market research tools (*e.g.,* Hoover's reports [94]). 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 could 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 completely foreign-owned and -operated.

DOE initially identified 60 potential manufacturers of electric motors sold in the United States. After reviewing publicly available information on these potential electric motor manufacturers, DOE determined that 33 were either large manufacturers or manufacturers that did not sell electric motors covered by this rulemaking. DOE then contacted the remaining 27 companies 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 standards. Based on these efforts, DOE estimates that there are 13 small business manufacturers of electric motors covered by this rulemaking in the United States.

a. Manufacturer Participation

As stated in the December 2013 NOPR (78 FR at 73670), DOE attempted to contact 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.

b. 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, which are currently not required to comply with existing electric motor standards but would be required to comply with the standards in this final rule. There are a few small business manufacturers that produce general purpose motors; however, these motors already meet premium efficiency levels, which correspond to the efficiency levels being selected for the majority of electric motors covered in today's final rule.

c. 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 selected standards. Characteristics of small manufacturers include: lower production volumes, fewer engineering resources, less technical expertise, and less access to capital.

A lower-volume manufacturer's conversion costs would need to be spread over fewer units than a larger competitor. 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.

[93] *http://www.nema.org/Products/Pages/Motor-and-Generator.aspx.*

[94] *http://www.hoovers.com.*

Small manufacturers of electric motor 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 equipment 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 manufacturers of electric motors that may be impacted differently by today's final 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 final rule. DOE believes that this group would likely be the most impacted by expanding the scope of equipment required to meet 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 premium efficiency general purpose and specialty motors. DOE expects these manufacturers to face conversion costs similar to 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 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 rule and is likely to result in these small businesses incurring additional certification and testing costs. These manufacturers could also face equipment development costs if they have to redesign any motors that are not currently meeting the premium level.

At TSL 2, the level adopted in today's notice, DOE estimates capital conversion costs of $1.88 million and equipment 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 equipment 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 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). This rule did not apply to non-general purpose small electric motors that many of 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 rule. Small manufacturers pointed out that this fact 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 manufacturers, 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 equipment 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 motors that can satisfy the levels being adopted today. 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.

For small manufacturers in the second group (manufacturers whose revenue from covered equipment in this rulemaking is less than 10 percent of total company revenue), DOE believes that these small manufacturers would lose no more than 10 percent of their company revenue. This lower bound is because these manufacturers could always choose not to make the investments necessary to convert the newly covered electric motors subject to standards in today's final rule. This lower bound is similar to the lower bound estimate of the entire electric motor industry at TSL 2, the TSL adopted in this final rule.

For small manufacturers in the third group (manufacturer that produces general purpose motors currently covered by Federal standards), DOE predicts that these small manufacturers would not have any conversion costs or decrease in revenue since they already manufacture electric motors that are compliant with the standards being adopted for this final rule.

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 (percent)	Product conversion cost as a percentage of annual R&D expense (percent)	Total conversion cost as a percentage of annual revenue (percent)
Typical large manufacturer	14	31	2
Typical small manufacturer that produces specialty motors previously not covered by Federal standards	188	490	75

TABLE VI.1—ESTIMATED CAPITAL AND PRODUCT CONVERSION COSTS AS A PERCENTAGE OF ANNUAL CAPITAL EXPENDITURES AND R&D EXPENSE—Continued

	Capital conversion cost as a percentage of annual capital expenditures (percent)	Product conversion cost as a percentage of annual R&D expense (percent)	Total conversion cost as a percentage of annual revenue (percent)
Typical small manufacturer who revenue from covered equipment is less than 10% of total company revenue	NA	NA	* ≤ 10
Typical small manufacturer that produces general purpose motors currently covered by Federal standards	0	0	0

* The most these manufacturers would lose is 10% of their annual revenue if they choose not to invest in upgrading the equipment they currently manufacture, which is not covered by Federal energy conservation standards, but that would now be covered by the standards prescribed in this final rule.

Table VI.1 also illustrates that small manufacturers whose equipment lines contain many motors that are not currently required to meet Federal standards face high relative equipment 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 types have 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 the levels adopted by today's rule 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 motors meeting the levels adopted by today's rule or those small businesses 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 are 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 equipment 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 Rule

Section VI.B.2 analyzes impacts on small businesses that would result from DOE's adopted final rule. Though TSLs lower than the one serving as the basis for today's final rule would be likely 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 it had been considering.

In addition to the other TSLs that DOE considered, the final rule TSD includes a regulatory impact analysis (RIA). For electric motors, the RIA discusses the following policy alternatives: (1) Consumer rebates, (2) consumer tax credits, (3) manufacturer tax credits, (4) voluntary energy efficiency targets, (5) early replacement, and (6) bulk government purchases. While these alternatives may mitigate to some varying extent the economic impacts on small entities compared to the standards, DOE determined that the energy savings of these alternatives are significantly smaller than those that would be expected to result from the adopted standard levels. Accordingly, DOE is declining to adopt any of these alternatives and is adopting the standards set forth in this rulemaking. (See chapter 17 of this final TSD for further detail on the policy alternatives DOE considered.)

DOE only received one public comment regarding the impact of the rule on small manufacturers. Baldor asked why DOE does not consider impacts on the many small manufacturers outside of the U.S. (Baldor, Pub. Mtg. Tr., No. 87 at pp. 176–177). Under the Regulatory Flexibility Act, the term ''small business concern'' is defined by reference to SBA's regulations. SBA's regulations state that a small business concern is ''a business entity organized for profit, with a place of business located in the United States, and which operates primarily within the United States or which makes a significant contribution to the U.S. economy through payment of taxes or use of American products, materials or labor''. 13 CFR 121.105(a)(1). As a result, under the Regulatory Flexibility Act, DOE must assess impacts on domestic small businesses. DOE did not receive any comments suggesting that small business manufacturers would not be able to achieve the efficiency levels required at TSL 2, the selected standards in today's final rule.

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 complies 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 rule fits within the category of actions included in Categorical Exclusion (CX) B5.1 and otherwise meets the requirements for application of a CX.(10 CFR part 1021, App. B, B5.1(b); 1021.410(b) and Appendix B, B(1)–(5)). The rule fits within the category of actions because it is a rulemaking that establishes energy conservation standards for consumer products or industrial equipment, and for which none of the exceptions identified in CX B5.1(b) apply. Therefore, DOE has made a CX determination for this rulemaking, and DOE does not need to prepare an Environmental Assessment or Environmental Impact Statement for this rule. DOE's CX determination for this rule is available at *http://cxnepa.energy.gov/*.

E. Review Under Executive Order 13132

Executive Order 13132, ''Federalism'' 64 FR 43255 (August10, 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 is the subject of today's final rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297) 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 (February 7, 1996). Section 3(b) of Executive Order 12988 specifically requires that Executive agencies make every reasonable effort to ensure that the regulation: (1) Clearly specifies the preemptive effect, if any; (2) clearly specifies any effect on existing Federal law or regulation; (3) provides a clear legal standard for affected conduct while promoting simplification and burden reduction; (4) specifies the retroactive effect, if any; (5) adequately defines key terms; and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. Section 3(c) of Executive Order 12988 requires Executive agencies to review regulations in light of applicable standards in section 3(a) and section 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, this final rule meets the relevant standards of Executive Order 12988.

G. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA) requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and Tribal governments and the private sector. Public Law 104–4, sec. 201 (codified at 2 U.S.C. 1531). For the new and amended regulatory action likely to result in a rule that may cause the expenditure by State, local, and Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of State, local, and Tribal governments on a ''significant intergovernmental mandate,'' and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect 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*.

DOE has concluded that this final rule would likely 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 final rule. 2 U.S.C. 1532(c). The content requirements of section 202(b) of UMRA relevant to a private sector mandate substantially overlap the economic analysis requirements that apply under section 325(o) of EPCA and Executive Order 12866. The **SUPPLEMENTARY INFORMATION** section of today's final rule and the ''Regulatory Impact Analysis'' section of the TSD accompanying the final rule respond to those requirements.

Under section 205 of UMRA, the Department is obligated to identify and consider a reasonable number of regulatory alternatives before promulgating a rule for which a written statement under section 202 is required.

2 U.S.C. 1535(a). DOE is required to select from those alternatives the most cost-effective and least burdensome alternative that achieves the objectives of the rule unless DOE publishes an explanation for doing otherwise, or the selection of such an alternative is inconsistent with law. As required by 42 U.S.C. 6295(d), (f), and (o) and 6316(a), today's final 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 final rule.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105–277) requires Federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This 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 (March 18, 1988), that this 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 (February 22, 2002), and DOE's guidelines were published at 67 FR 62446 (October 7, 2002). DOE has reviewed today's final rule under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

K. Review Under Executive Order 13211

Executive Order 13211, ''Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use'' 66 FR 28355 (May 22, 2001), requires Federal agencies to prepare and submit to OIRA at OMB, a Statement of Energy Effects for any significant energy action. A ''significant energy action'' is defined as any action by an agency that promulgates or is expected to lead to promulgation of a final rule, and that: (1) Is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy, or (3) is designated by the Administrator of OIRA as a significant energy action. For any significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

DOE has concluded that today's regulatory action, which sets forth energy conservation standards for electric motors, is not a significant energy action because the new and amended 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 final rule.

L. Review Under the Information Quality Bulletin for Peer Review

On December 16, 2004, OMB, in consultation with the Office of Science and Technology Policy (OSTP), issued its Final Information Quality Bulletin for Peer Review (the Bulletin). 70 FR 2664 (January14, 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*.

M. Congressional Notification

As required by 5 U.S.C. 801, DOE will report to Congress on the promulgation of this rule prior to its effective date. The report will state that it has been determined that the rule is a ''major rule'' as defined by 5 U.S.C. 804(2).

VII. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of today's final rule.

List of Subjects in 10 CFR Part 431

Administrative practice and procedure, Confidential business information, Energy conservation, Commercial and industrial Equipment, Imports, Incorporation by reference, Intergovernmental relations, Reporting and recordkeeping requirements, and Small businesses.

Issued in Washington, DC, on May 8, 2014.

David T. Danielson,

Assistant Secretary, Energy Efficiency and Renewable Energy.

For the reasons set forth in the preamble, DOE amends part 431 of chapter II 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. Amend § 431.12 by revising the definitions of ''NEMA Design A motor'' and ''partial electric motor'' to read as follows:

§ 431.12 Definitions.

* * * * *

NEMA Design A motor means a squirrel-cage motor that:

(1) Is designed to withstand full-voltage starting and developing locked-rotor torque as shown in NEMA MG 1–2009, paragraph 12.38.1 (incorporated by reference, see § 431.15);

(2) Has pull-up torque not less than the values shown in NEMA MG 1–2009, paragraph 12.40.1;

(3) Has breakdown torque not less than the values shown in NEMA MG 1–2009, paragraph 12.39.1;

(4) Has a locked-rotor current higher than the values shown in NEMA MG 1–2009, paragraph 12.35.1 for 60 hertz and NEMA MG 1–2009, paragraph 12.35.2 for 50 hertz; and

(5) Has a slip at rated load of less than 5 percent for motors with fewer than 10 poles.

* * * * *

Partial electric motor means an assembly of motor components necessitating the addition of no more than two endshields, including bearings, to create an electric motor capable of operation in accordance with the applicable nameplate ratings.

* * * * *

■ 3. 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 June 1, 2016, 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 June 1, 2016, 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
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

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
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 June 1, 2016, 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 June 1, 2016 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	2
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 (e)(2) of this section, whichever applies.

(f) The standards in Table 1 through Table 4 of this section do not apply to definite purpose electric motors, special purpose electric motors, or those motors exempted by the Secretary.

(g) The standards in Table 5 through Table 7 of this section apply only to electric motors, including partial electric motors, that satisfy the following criteria:

(1) Are single-speed, induction motors;

(2) Are rated for continuous duty (MG 1) operation or for duty type S1 (IEC);

(3) Contain a squirrel-cage (MG 1) or cage (IEC) rotor;

(4) Operate on polyphase alternating current 60-hertz sinusoidal line power;

(5) Are rated 600 volts or less;

(6) Have a 2-, 4-, 6-, or 8-pole configuration,

(7) Are built in a three-digit or four-digit NEMA frame size (or IEC metric equivalent), including those designs between two consecutive NEMA frame sizes (or IEC metric equivalent), or an enclosed 56 NEMA frame size (or IEC metric equivalent),

(8) Produce at least one horsepower (0.746 kW) but not greater than 500 horsepower (373 kW), and

(9) Meet all of the performance requirements of one of the following motor types: A NEMA Design A, B, or C motor or an IEC Design N or H motor.

(h) Starting on June 1, 2016, each NEMA Design A motor, NEMA Design B motor, and IEC Design N motor that is an electric motor meeting the criteria in paragraph (g) of this section and with a power rating from 1 horsepower through 500 horsepower, but excluding fire pump electric motors, manufactured (alone or as a component of another piece of equipment) shall have a nominal full-load efficiency of not less than the following:

TABLE 5—NOMINAL FULL-LOAD EFFICIENCIES OF NEMA DESIGN A, NEMA DESIGN B AND IEC DESIGN N MOTORS (EXCLUDING FIRE PUMP ELECTRIC MOTORS) AT 60 HZ

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

TABLE 5—NOMINAL FULL-LOAD EFFICIENCIES OF NEMA DESIGN A, NEMA DESIGN B AND IEC DESIGN N MOTORS (EXCLUDING FIRE PUMP ELECTRIC MOTORS) AT 60 HZ—Continued

Motor horsepower/ standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
300/224	95.8	95.4	96.2	95.8	95.8	95.8		
350/261	95.8	95.4	96.2	95.8	95.8	95.8		
400/298	95.8	95.8	96.2	95.8				
450/336	95.8	96.2	96.2	96.2				
500/373	95.8	96.2	96.2	96.2				

(i) Starting on June 1, 2016, each NEMA Design C motor and IEC Design H 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 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 AND IEC DESIGN H MOTORS AT 60 HZ

Motor horsepower/standard kilowatt equivalent	Nominal full-load efficiency (%)					
	4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/.75	85.5	85.5	82.5	82.5	75.5	75.5
1.5/1.1	86.5	86.5	87.5	86.5	78.5	77.0
2/1.5	86.5	86.5	88.5	87.5	84.0	86.5
3/2.2	89.5	89.5	89.5	88.5	85.5	87.5
5/3.7	89.5	89.5	89.5	89.5	86.5	88.5
7.5/5.5	91.7	91.0	91.0	90.2	86.5	89.5
10/7.5	91.7	91.7	91.0	91.7	89.5	90.2
15/11	92.4	93.0	91.7	91.7	89.5	90.2
20/15	93.0	93.0	91.7	92.4	90.2	91.0
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 June 1, 2016, 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 AT 60 HZ

Motor horsepower/ standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/.75	75.5		82.5	82.5	80.0	80.0	74.0	74.0
1.5/1.1	82.5	82.5	84.0	84.0	85.5	84.0	77.0	75.5
2/1.5	84.0	84.0	84.0	84.0	86.5	85.5	82.5	85.5
3/2.2	85.5	84.0	87.5	86.5	87.5	86.5	84.0	86.5
5/3.7	87.5	85.5	87.5	87.5	87.5	87.5	85.5	87.5
7.5/5.5	88.5	87.5	89.5	88.5	89.5	88.5	85.5	88.5
10/7.5	89.5	88.5	89.5	89.5	89.5	90.2	88.5	89.5
15/11	90.2	89.5	91.0	91.0	90.2	90.2	88.5	89.5
20/15	90.2	90.2	91.0	91.0	90.2	91.0	89.5	90.2
25/18.5	91.0	91.0	92.4	91.7	91.7	91.7	89.5	90.2
30/22	91.0	91.0	92.4	92.4	91.7	92.4	91.0	91.0
40/30	91.7	91.7	93.0	93.0	93.0	93.0	91.0	91.0

TABLE 7—NOMINAL FULL-LOAD EFFICIENCIES OF FIRE PUMP ELECTRIC MOTORS AT 60 HZ—Continued

Motor horsepower/ standard kilowatt equivalent	Nominal full-load efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
50/37	92.4	92.4	93.0	93.0	93.0	93.0	91.7	91.7
60/45	93.0	93.0	93.6	93.6	93.6	93.6	91.7	92.4
75/55	93.0	93.0	94.1	94.1	93.6	93.6	93.0	93.6
100/75	93.6	93.0	94.5	94.1	94.1	94.1	93.0	93.6
125/90	94.5	93.6	94.5	94.5	94.1	94.1	93.6	93.6
150/110	94.5	93.6	95.0	95.0	95.0	94.5	93.6	93.6
200/150	95.0	94.5	95.0	95.0	95.0	94.5	94.1	93.6
250/186	95.4	94.5	95.0	95.4	95.0	95.4	94.5	94.5
300/224	95.4	95.0	95.4	95.4	95.0	95.4		
350/261	95.4	95.0	95.4	95.4	95.0	95.4		
400/298	95.4	95.4	95.4	95.4				
450/336	95.4	95.8	95.4	95.8				
500/373	95.4	95.8	95.8	95.8				

(k) 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 (l) 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 (k)(1) or (k)(2) of this section, whichever applies.

(l) The standards in Table 5 through Table 7 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) Inverter-only electric motors.

[**Note:** The following letter from the Department of Justice will not appear in the Code of Federal Regulations.]

APPENDIX TO FINAL RULE

U.S. Department of Justice
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February 3, 2014

Eric J. Fygi
Deputy General Counsel
Department of Energy
Washington, DC 20585

Dear Deputy General Counsel Fygi:

I am responding to your December 11, 2013 letter seeking the views of the Attorney General about the potential impact on competition of proposed energy conservation standards for certain types of commercial and industrial electric motors. Your request was submitted under Section 325(o)(2)(B)(i)(V) of the Energy Policy and Conservation Act, as amended (ECPA), 42 U.S.C. 6295(o)(2)(B)(i)(V), which requires the Attorney General to make a determination of the impact of any lessening of competition that is likely to result from the imposition of proposed energy conservation standards. The Attorney General's responsibility for responding to requests from other departments about the effect of a program on competition has been delegated to the Assistant Attorney General for the Antitrust Division in 28 CFR § 0.40(g).

In conducting its analysis the Antitrust Division examines whether a proposed standard may lessen competition, for example, by substantially limiting consumer choice, by placing certain manufacturers at an unjustified competitive disadvantage, or by inducing avoidable inefficiencies in production or distribution of particular products. A lessening of competition could result in higher prices to manufacturers and consumers, and perhaps thwart the intent of the revised standards by inducing substitution to less efficient products.

We have reviewed the proposed standards contained in the Notice of Proposed Rulemaking (78 Fed. Reg. 235, December 6, 2013). We have also reviewed supplementary information submitted to the Attorney General by the Department of Energy, including a transcript of the public meeting held on the proposed standards on December 11, 2013. Based on this review, our conclusion is that the proposed energy conservation standards for certain commercial and industrial electric motors can advance the Department of Energy's goal of energy conservation without causing a significant adverse impact on competition.

Sincerely,
William J. Baer.

[FR Doc. 2014–11201 Filed 5–28–14; 8:45 am]

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