CHAPTER 8. LIFE-CYCLE COST AND PAYBACK PERIOD ANALYSIS

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CHAPTER 8. LIFE-CYCLE COST AND PAYBACK PERIOD ANALYSIS

8.1 INTRODUCTION

This chapter describes the Department of Energy (DOE)'s methodology for analyzing the economic impacts of possible energy efficiency standards on individual end users. The effect of standards on individual end users includes a change in operating expense (usually decreased) and a change in purchase price (usually increased). This chapter describes three metrics DOE used to determine the effect of standards on individual end users:

- **Life-cycle cost** (LCC) is the total consumer expense over the life of an appliance, including purchase expense and operating costs (including energy expenditures). DOE discounts future operating costs to the time of purchase, and sums them over the lifetime of the equipment.
- **Payback period** (PBP) is the change in purchase expense due to an increased efficiency standard divided by the change in annual operating expense that results from the standard. It represents the number of years it will take the user to recover the increased purchase expense through decreased operating expenses.
- **Rebuttable payback period** is a special case of the PBP. Where LCC and PBP are estimated over a range of inputs reflecting actual conditions, rebuttable payback period is based on laboratory conditions, specifically DOE test procedure inputs.

Inputs to the LCC and PBP are discussed in sections 8.2 and 8.3, respectively, of this chapter. Results for the LCC and PBP are presented in section 8.4. The rebuttable PBP is discussed in section 8.5. Key variables and calculations are presented for each metric. DOE performed the calculations discussed here using a Microsoft Excel spreadsheet which is accessible on the Internet (*http://www.eere.energy.gov/buildings/appliance_standards/*).

8.1.1 General Approach for Life-Cycle Cost and Payback Period Analysis

Recognizing that several inputs to the determination of consumer LCC and PBP are either variable or uncertain, DOE conducted the LCC and PBP analysis by modeling both the uncertainty and variability in the inputs using Monte Carlo simulation and probability distributions. DOE developed LCC and PBP spreadsheet models incorporating both Monte Carlo simulation and probability distributions by using a Microsoft Excel spreadsheet combined with Crystal Ball (a commercially available add-in program).

In addition to characterizing several of the inputs to the analysis with probability distributions, DOE also developed a sample of end-use applications for the equipment. These end-use applications determine the use profile of the motor and the economic characteristics of the motor owner. Table 8.1.1 shows the market shares of each application for each equipment class.

Table 8.1.1 Application Shares by Equipment Class

		Equipment Class		
No.	**Application**	**Polyphase**	**CSIR**	**CSCR**
1	Air and gas compressors	17.3%	14.9%	14.9%
2	Conveyors	13.3%	11.9%	11.9%
3	General industrial machinery	11.3%	12.5%	12.5%
4	Industrial and commercial fans and blowers	7.3%	6.9%	6.9%
5	Pumps and pumping equipment	50.7%	53.7%	53.7%
	TOTAL	100%	100%	100%

In each Monte Carlo iteration, for each equipment class, one of the applications is identified by sampling a distribution of applications for that equipment class. The selected application determines the number of operating hours per year as well as the motor loading. The operating hours and the motor loading for the application are used in the energy use calculation (see Chapter 6).

There is also a distribution of owner types (by sector) associated with each application (Table 8.1.2). The sector to which the application belongs determines the energy price and discount rate used in the LCC calculation in each simulation.

Table 8.1.2 Shares of Motor Owner Type by Application

		Motor Owner Type			
No.	**Application**	**Industrial**	**Commercial**	**Agricultural**	**Residential**
1	Air and gas compressors	40%	40%	10%	10%
2	Conveyors and packaging equipment	40%	50%	10%	0%
3	General industrial machinery	50%	40%	10%	0%
4	Industrial and commercial fans and blowers	50%	50%	0%	0%
5	Pumps and pumping equipment	40%	35%	20%	5%

DOE used Energy Information Administration (EIA) data on electricity prices in 2006 for different customer classes (which is accessible on the Internet at http://www.eia.doe.gov/cneaf/electricity/page/eia861.html) to establish the variability in energy pricing. DOE used data from the literature on motor loading and motor application characteristics to estimate the variability of annual energy use. Due to the large range of applications and motor use characteristics considered in the LCC and PBP analysis, the range of annual energy use and energy prices can be quite large. Thus, although the annual energy use and energy pricing are not uncertain for any particular application, their variability across all applications contributes to the range of LCCs and PBPs calculated for any particular standard level.

Results presented at the end of this chapter are based on 10,000 samples per Monte Carlo simulation run. DOE displays the LCC and PBP results as distributions of impacts compared to the base case without standards.

8.1.2 Overview of Life-Cycle Cost and Payback Period Inputs

DOE categorizes inputs to the LCC and PBP analysis as follows: (1) inputs for establishing the initial expense, otherwise known as the total installed cost, and (2) inputs for calculating the operating cost.

The primary inputs for establishing the total installed cost are:

- *Baseline manufacturer selling price*: The price at which the manufacturer sells the baseline equipment, which includes the costs incurred by the manufacturer to produce equipment meeting existing standards.

- *Manufacturer selling price increases*: The change in manufacturer selling price associated with producing equipment to meet a particular standard level.

- *Markups and sales tax*: The markups and sales tax associated with converting the manufacturer cost to a consumer equipment price. The markups and sale tax are described in detail in Chapter 7, Markups for Equipment Price Determination.

- *Installation cost*: The cost to the consumer of installing the equipment. The installation cost represents all costs required to install the equipment other than the marked-up consumer equipment price. The installation cost includes labor, overhead, and any miscellaneous materials and parts. Thus, the total installed cost equals the consumer equipment price plus the installation cost.

The primary inputs for calculating the operating cost are:

- *Equipment energy consumption and reactive power*: The equipment energy consumption is the site energy use associated with operating the equipment. Reactive power is power that is reflected back to the electrical system by a change in the phase of alternating current power. Chapter 6, Energy Use Characterization, details how DOE determined the equipment energy consumption based on various data sources.

- *Equipment efficiency*: The equipment efficiency dictates the energy consumption associated with standard-level equipment (i.e., equipment with efficiencies greater than baseline equipment). Chapter 6, Energy Use Characterization, details how energy and reactive power change with increasing equipment efficiency and how equipment efficiency relates to actual equipment energy use.

- *Energy prices*: Energy prices are the prices paid by end users for energy (i.e., electricity). DOE determined current energy prices based on data from the DOE-EIA.

- *Energy price trends*: DOE used the EIA *Annual Energy Outlook 2010* (*AEO2010*) to forecast energy prices into the future. For the results presented in this chapter, DOE used the Early Release case of *AEO2010* (DOE's reference case) to forecast future energy prices.

- *Repair and maintenance costs*: Repair costs are associated with repairing or replacing components that have failed. Maintenance costs are associated with maintaining the operation of the equipment.

- *Lifetime*: The age at which the equipment is retired from service.

- *Discount rate*: The rate at which DOE discounted future expenditures to establish their present value.

Figure 8.1.1 graphically depicts the relationships between the installed cost and operating cost inputs for the calculation of the LCC and PBP. In the figure below, the yellow boxes indicate the inputs, the green boxes indicate intermediate outputs, and the blue boxes indicate the final outputs (the LCC and PBP).

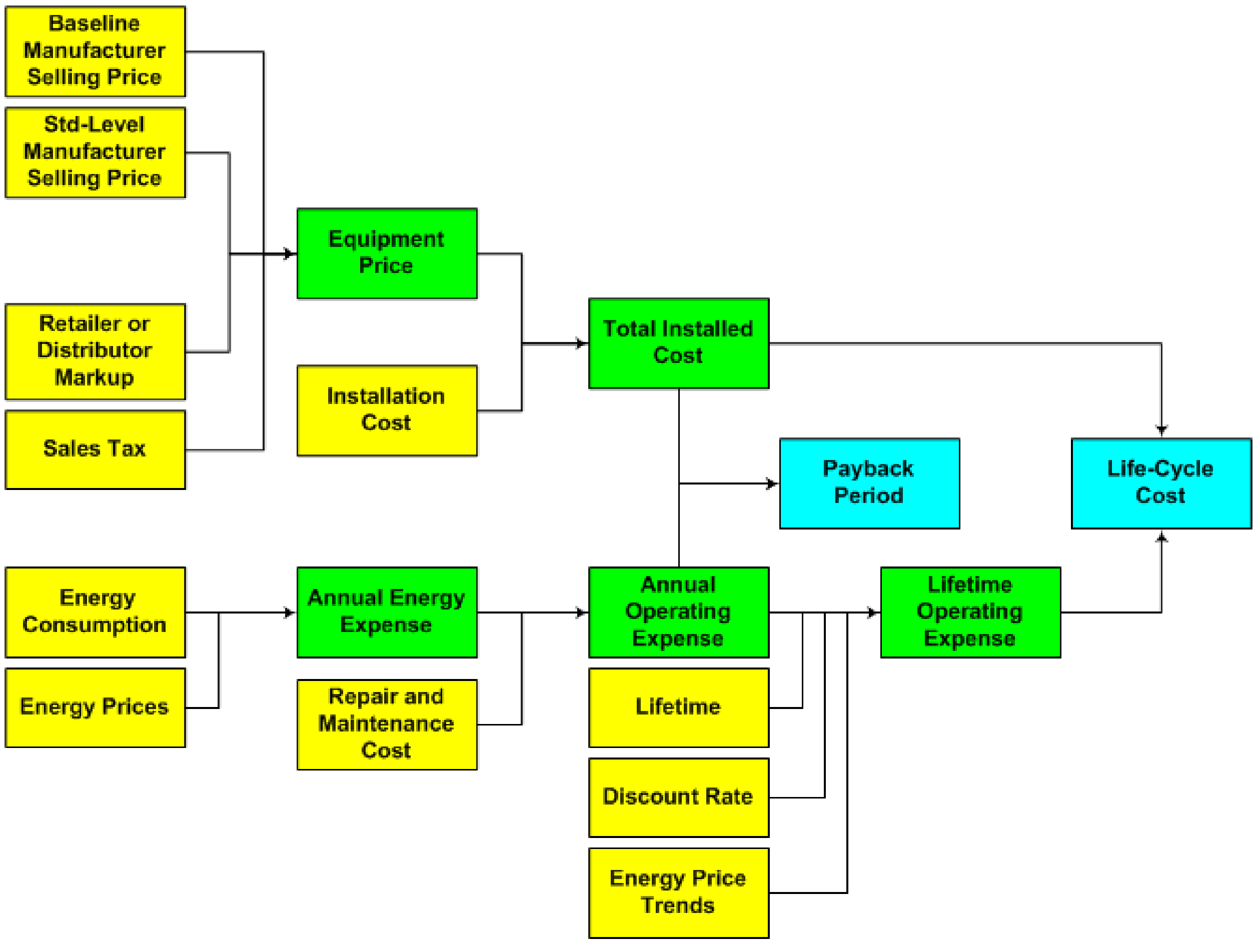

Figure 8.1.1 Flow Diagram of Inputs for the Determination of Life-Cycle Cost and Payback Period

8.2 LIFE-CYCLE COST INPUTS

Life-cycle cost is the total customer expense over the life of a piece of equipment, including purchase expense and operating costs (including energy expenditures). DOE discounts future operating costs to the time of purchase, and sums them over the lifetime of the equipment. DOE defines LCC by the following equation:

$$LCC = IC + \sum_{t=1}^{N} \frac{OC_t}{(1+r)^t}$$

Where:

LCC = life-cycle cost in dollars,

IC =	total installed cost in dollars,
$\sum$ =	sum over the lifetime, from year 1 to year N,
N =	lifetime of appliance in years,
OC =	operating cost in dollars,
r =	discount rate, and
t =	year for which operating cost is being determined.

DOE gathered most of its data for the LCC and PBP analysis in 2008, and updated its inputs to 2009$ using appropriate measures of inflation. Throughout this TSD, DOE expresses dollar values in 2009$.

Tables 8.1.1 through 8.1.3 summarize the input values that DOE used to calculate the LCC and PBP for the three equipment classes of small electric motors: polyphase, capacitor-start induction-run (CSIR), and capacitor-start capacitor-run (CSCR) respectively. Each table summarizes the total installed cost inputs and the operating cost inputs including the lifetime, discount rate, and energy price trends. DOE characterized all of the total cost inputs with single-point values, but characterized several of the operating cost inputs with probability distributions that capture the input's uncertainty and/or variability. For those inputs characterized with probability distributions, the values provided in the following tables are the average or typical values. Also listed in the following tables is the chapter of the technical support document (TSD) where more detailed information on the inputs can be found. The sections following the tables discuss total installed cost, operating cost, lifetime, and discount rate.

Table 8.2.1 Inputs for Life-Cycle Cost and Payback Period Analysis: Polyphase Motors

Input	Average or Typical Value	Characterization	TSD Chapter Reference
Total Installed Cost Inputs			
Baseline Manufacturer Selling Price	$98.54	Price for 1 HP, 4 pole motor. Single-Point Value. Scaled to other sizes and speeds.	5
Manufacturer Selling Price	EL 1 = $104.83 EL 2 = $108.17 EL 3 = $114.24 EL 4 = $118.54 EL 4b = $134.04 - $135.62 EL 5 = $153.92 - $230.92 EL 6 = $186.37 - $237.70 EL 7 = $326.18 - $1,766.06	Price for 1 HP, 4 pole motor. Price varies with efficiency level and whether or not application is space-constrained. DOE estimates 20% of applications may be space-constrained. Scaled to other sizes and speeds.	5
Distribution and OEM Markups	Baseline = 2.36 Incremental = 1.74 Shipping Cost = $0.50/pound	Point Value for each distribution chain with 20% variance added	7
Sales Tax	1.0684	Point Value	7
Installation Cost	$252.90	Point Value	8
Operating Cost Inputs			
Duty cycle	2562 hours/year	Full distribution ranging from 50 to 8760 hours per year and with distribution varying with application	6
Annual Energy Use	Baseline use* = 1882 kWh	Variability based on usage	6
Reactive Power	Baseline = 1.1 kilovolt-amperes reactive	Variability based on usage, load and power factor	6
Energy Prices (Marginal)	Electric Energy = 8.1 ¢/kWh	Variability based on application owner types	8
Repair and Maintenance Costs	No cost increase with efficiency	No cost increase with efficiency	8
Lifetime	9 years	Distribution based in part on annual hours of operation	8
Discount Rate	5.89%	Variability based on application owner types	8
Energy Price Trend	AEO 2010 Early Release	Two sensitivities: High & Low Energy Price Cases	8

* Annual use provided for market baseline product only. Annual use decreases with increased product efficiency.

Table 8.2.2 Inputs for Life-Cycle Cost and Payback Period Analysis: Capacitor-Start Induction-Run Motors

Input	Average or Typical Value	Characterization	TSD Chapter Reference
Total Installed Cost Inputs			
Baseline Manufacturer Selling Price	$91.24	Price for 1/2 HP, 4 pole motor. Single-Point Value. Scaled to other sizes and speeds.	5
Manufacturer Selling Price	EL 1 = $95.43 EL 2 = $98.45 EL 3 = $99.58 EL 4 = $104.99 - $114.31 EL 5 = $117..07 - $118.00 EL 6 = $132.22 - $182.09 EL 7 = $151.25 - $1,200.98	Price for 1/2 HP, 4 pole motor. Price varies with efficiency level and whether or not application is space-constrained. DOE estimates 20% of applications may be space-constrained. Scaled to other sizes and speeds.	5
Distribution and OEM Markups	Baseline = 2.36 Incremental = 1.74 Shipping Cost = $0.50/pound	Point Value for each distribution chain, with 20% variance added	7
Sales Tax	1.0684	Point Value	7
Installation Cost	$252.90	Point Value	8
Operating Cost Inputs			
Usage	2615 hours/year	Full distribution ranging from 50 to 8760 hours per year and with distribution varying with application	6
Annual Energy Use	Baseline use* = 1274 kWh	Variability based on usage	6
Reactive Power	Baseline = 0.93 kilovolt-amperes reactive	Variability based on usage, load and power factor	6
Energy Prices	Electric Energy = 8.1 ¢/kWh	Variability based on application owner types	8
Repair and Maintenance Costs	No cost increase with efficiency	No cost increase with efficiency	8
Lifetime	7 years	Distribution based in part on annual hours of operation	8
Discount Rate	5.87%	Variability based on application owner types	8
Energy Price Trend	AEO 2010 Early Release	Two sensitivities: High & Low Energy Price Cases	8

* Annual use provided for market baseline product only. Annual use decreases with increased product efficiency.

Table 8.2.3 Inputs for Life-Cycle Cost and Payback Period Analysis: Capacitor-Start Capacitor-Run Motors

Input	Average or Typical Value	Characterization	TSD Chapter Reference
Total Installed Cost Inputs			
Baseline Manufacturer Selling Price	\$111.72	Price for 3/4 HP, 4 pole motor. Single-Point Value.	5
Manufacturer Selling Price	EL 1 = \$117.13 EL 2 = \$129.88 - \$137.20 EL 3 = \$135.56 - \$142.63 EL 4 = \$142.76 - \$146.44 EL 5 = \$151.91 - \$154.55 EL 6 = \$158.25 - \$236.98 EL 7 = \$175.75 - \$244.03 EL 8 = \$327.69 - \$1,771.47	Price for 3/4 HP, 4 pole motor. Price varies with efficiency level and whether or not application is space-constrained. DOE estimates 20% of applications may be space-constrained. Scaled to other sizes and speeds.	5
Distribution and OEM Markups	Baseline = 2.36 Incremental = 1.74 Shipping Cost = \$0.50/pound	Point Value for each distribution chain, with 20% variance added	7
Sales Tax	1.0684	Single-Point Value	7
Installation Cost	\$252.90	Single-Point Value	8
Operating Cost Inputs			
Usage	2615 hours/year	Variability determined from distribution of applications. Usage ranges from 50 to 8760 hours/year	6
Annual Energy Use	Baseline use* = 2290 kWh	Variability based on usage	6
Reactive Power	Baseline = 1.28 kilovolt-amperes reactive	Variability based on usage, load and power factor	6
Energy Prices	Electric Energy = 8.1 ¢/kWh	Variability based on application owner types	8
Repair and Maintenance Costs	No cost increase with efficiency	No cost increase with efficiency	8
Lifetime	7 years	Distribution based in part on annual hours of operation	8
Discount Rate	5.87%	Variability based on application owner types	8
Energy Price Trend	AEO 2010 Early Release	Two sensitivities: High & Low Energy Price Cases	8

* Annual use provided for market baseline product only. Annual use decreases with increased product efficiency.

8.2.2 Total Installed Cost Inputs

DOE defines the total installed cost, IC, using the following equation:

$$IC = EQP + INST$$

Where:

EQP = equipment price (i.e., customer cost for the equipment only), expressed in dollars, and
$INST$ = installation cost or the customer price to install equipment (i.e., the cost for labor and materials), also in dollars.

The equipment price is based on how the customer (end user) purchases the equipment. As discussed in Chapter 7, Markups for Equipment Price Determination, DOE defined markups and sales taxes for converting manufacturing selling prices into customer equipment prices.

Table 8.2.4 summarizes the inputs for the determination of total installed cost.

Table 8.2.4 Inputs for Total Installed Cost

Baseline Manufacturer Selling Price
Manufacturer Selling Price Increase
Markups and Sales Tax
Installation Cost

The *baseline manufacturer selling price* is the price charged by the manufacturer to produce equipment for the current market. *Manufacturer selling price increase* is the change in manufacturer price associated with producing equipment at a standard level. *Markups and sales tax* convert the manufacturer selling price to a consumer equipment price. The *installation cost* is the cost to the consumer of installing the equipment and represents all costs required to install the equipment other than the marked-up consumer equipment price. The installation cost includes labor, overhead, and any miscellaneous materials and parts. Thus, the total installed cost equals the consumer equipment price plus the installation cost. DOE calculated the total installed cost for baseline products based on the following equation:

$$\begin{aligned} IC_{BASE} &= EQP_{BASE} + INST_{BASE} \\ &= MSP_{MFG} \times MU_{OVERALL\_BASE} + INST_{BASE} \end{aligned}$$

Where:

IC_{BASE} = baseline total installed cost,
EQP_{BASE} = consumer equipment price for baseline models,
$INST_{BASE}$ = baseline installation and shipping cost,
MSP_{MFG} = manufacturer selling price for baseline models, and
$MU_{OVERALL\_BASE}$ = baseline overall markup (product of manufacturer markup, baseline retailer or distributor markup, and sales tax).

DOE calculated the total installed cost for standard-level products based on the following equation:

$$
\begin{aligned}
IC_{STD} &= EQP_{STD} + INST_{STD} \\
&= \left(EQP_{BASE} + \Delta EQP_{STD}\right) + \left(INST_{BASE} + \Delta INST_{STD}\right) \\
&= \left(EQP_{BASE} + INST_{BASE}\right) + \left(\Delta EQP_{STD} + \Delta INST_{STD}\right) \\
&= IC_{BASE} + \left(\Delta MSP_{MFG} \times MU_{OVERALL\_INCR} + \Delta INST_{STD}\right)
\end{aligned}
$$

Where:

IC_{STD} =	standard-level total installed cost,
EQP_{STD} =	consumer equipment price for standard-level models,
$INST_{STD}$ =	standard-level installation cost,
EQP_{BASE} =	consumer equipment price for baseline models,
ΔEQP_{STD} =	change in equipment price for standard-level models,
$INST_{BASE}$ =	baseline installation and shipping cost,
$\Delta INST_{STD}$ =	change in installation and shipping cost for standard-level models,
IC_{BASE} =	baseline total installed cost,
ΔMSP_{MFG} =	change in manufacturer selling price for standard-level models, and
$MU_{OVERALL\_INCR}$ =	incremental overall markup (product of manufacturer markup, incremental retailer or distributor markup, and sales tax).

The remainder of this section provides information about each of the above input variables that DOE used to calculate the total installed cost for small electric motors.

8.2.2.1 Baseline Manufacturer Selling Price

The engineering analysis provides a baseline manufacturer selling price (MSP) that includes all manufacturer markups (see TSD chapter 5). Table 8.2.5 presents the baseline MSP and the associated energy efficiency for each equipment class for the baseline models analyzed in the engineering analysis.

Table 8.2.5 Engineering Baseline Manufacturer Selling Price

Product Class	Baseline Efficiency (%)	Baseline MSP (2009$)
Polyphase (1 hp)	77.15	$97.74
CSIR (0.5 hp)	57.70	$91.04
CSCR (0.75 hp)	71.00	$110.82

8.2.2.2 Manufacturer Selling Price Increases for Higher-Efficiency Products

DOE determined the MSP increases associated with increases in energy efficiency levels for small electric motors in the engineering analysis (see TSD chapter 5). Tables 8.2.6 through 8.2.8 present the MSP along with the associated energy efficiency for each equipment category.

Table 8.2.6 Polyphase Motors: Manufacturer Selling Price Increases, 1 Horsepower

Energy Efficiency Level	Efficiency (%)	Not Space-Constrained Standard-Level MSP (2009$)	Space-Constrained Standard-Level MSP (2009$)
Baseline	74.0	$98.54	$98.54
1	76.1	$104.83	$104.83
2	77.7	$108.17	$108.17
3	79.4	$114.24	$114.24
4	80.1	$118.54	$118.54
5 (4b)		$134.04	$135.62
6	82.6	$153.92	$230.92
7	84.4	$186.37	$237.70
8	85.4	$326.18	$1,766.06

Table 8.2.7 Capacitor-Start Induction-Run Motors: Manufacturer Selling Price Increases, 0.5 Horsepower

Energy Efficiency Level	Efficiency (%)	Not Space-Constrained Standard-Level MSP (2009$)	Space-Constrained Standard-Level MSP (2009$)
Baseline	59.0	$91.24	$91.24
1	62.2	$95.43	$95.43
2	64.5	$98.45	$98.45
3	66.7	$99.58	$99.58
4	71.5	$106.99	$114.31
5	72.7	$118.00	$117.07
6	74.0	$132.22	$182.09
7	78.4	$151.25	$1,200.98

Table 8.2.8 Capacitor-Start Capacitor-Run Motors: Manufacturer Selling Price Increases, 0.75 Horsepower

Energy Efficiency Level	Efficiency (%)	Not Space-Constrained Standard-Level MSP (2009$)	Space-Constrained Standard-Level MSP (2009$)
Baseline	72.0	$111.72	$111.72
1	75.7	$117.13	$117.13
2	80.0	$129.88	$137.20
3	82.2	$135.56	$142.63
4	83.2	$142.76	$146.44
5	84.5	$151.91	$154.55
6	85.2	$158.25	$236.98
7	87.1	$175.75	$244.03
8	88.4	$327.69	$1,771.47

Table 8.2.9 shows the baseline and incremental markups estimated for each point in the small motor supply chain. The overall baseline and incremental markups shown are weighted averages based on the share of shipments in each distribution channel. Refer to TSD chapter 7 for details.

Table 8.2.9 Markups for Small Electric Motors

Point in Supply Chain	Baseline	Incremental
Wholesale	1.10	1.04
OEM	1.37	1.27
Retail and Post-OEM	1.43	1.18
Contractor/Installer	1.10	1.10
Sales Tax	1.0684	
Overall*	2.52	1.86

* Weighted average of the three distribution channels.

DOE derived installation costs for small electric motors from data in the *RS Means Electrical Cost Data, 2008*.[1] The average cost estimated by DOE is $253. Since DOE found no information to indicate differences in installation costs among motor applications, it used the same installation cost for each equipment class. While DOE did find evidence of increasing installation costs with increasing motor size for medium motors in the *RS Means* data, DOE found no evidence that installation costs would be impacted with increased motor energy efficiency levels for small electric motors.

Total Installed Cost: The total installed cost is the sum of the end user equipment price and the installation cost. Refer back to section 8.2.1 to see the equations that DOE used to calculate the total installed cost for various energy efficiency levels. Tables 8.2.10 through 8.2.15 present the end user equipment price, installation costs, shipping and total installed costs for each small motor equipment class for both the space-constrained and the not space-constrained cases.

Table 8.2.10 Polyphase Motors (1 hp): Consumer Equipment Prices, Shipping Costs, Installation Costs, and Total Installed Costs for Motors that are Not Space-Constrained

Energy Efficiency Level	Efficiency (%)	Equipment Price (2009$)	Shipping Cost (2009$)	Installation Cost (2009$)	Total Installed Cost (2009$)
Baseline	74.0	$245.25	$15.31	$252.90	$516.89
1	76.1	$256.77	$16.51	$252.90	$529.77
2	77.7	$262.88	$17.61	$252.90	$537.07
3	79.4	$273.98	$18.28	$252.90	$549.01
4	80.1	$281.86	$18.99	$252.90	$557.72
5 (4b)	82.6	$310.21	$21.55	$252.90	$589.06
6	84.4	$346.59	$22.22	$252.90	$626.64
7	85.4	$405.97	$28.75	$252.90	$693.43
8	87.0	$661.78	$27.17	$252.90	$951.46

Table 8.2.11 Polyphase Motors (1 hp): Consumer Equipment Prices, Shipping Costs, Installation Costs, and Total Installed Costs for Motors that are Space-Constrained

Energy Efficiency Level	Efficiency (%)	Equipment Price (2009$)	Shipping Cost (2009$)	Installation Cost (2009$)	Total Installed Cost (2009$)
Baseline	74.0	$245.25	$15.31	$252.90	$513.47
1	76.1	$256.77	$16.51	$252.90	$526.17
2	77.7	$262.88	$17.61	$252.90	$533.39
3	79.4	$273.98	$18.28	$252.90	$545.16
4	80.1	$281.86	$18.99	$252.90	$553.75
5 (4b)	82.6	$313.11	$18.61	$252.90	$584.62
6	84.4	$487.48	$18.91	$252.90	$759.28
7	85.4	$499.89	$19.30	$252.90	$772.08
8	87.0	$3,296.37	$19.30	$252.90	$3,568.57

Table 8.2.12 Capacitor-Start Induction-Run Motors (0.5 hp): Consumer Equipment Prices, Shipping Costs, Installation Costs, and Total Installed Costs for Motors that are Not Space-Constrained

Energy Efficiency Level	Efficiency (%)	Equipment Price (2009$)	Shipping Cost (2009$)	Installation Cost (2009$)	Total Installed Cost (2009$)
Baseline	59.0	$227.09	$10.58	$252.90	$493.74
1	62.2	$234.76	$11.09	$252.90	$502.03
2	64.5	$240.29	$11.59	$252.90	$508.15
3	66.7	$242.35	$11.94	$252.90	$510.58
4	71.5	$255.92	$13.91	$252.90	$526.33
5	72.7	$276.05	$16.80	$252.90	$549.65
6	74.0	$302.08	$15.23	$252.90	$574.49
7	78.4	$336.89	$18.03	$252.90	$612.62

Table 8.2.13 Capacitor-Start Induction-Run Motors (0.5 hp): Consumer Equipment Prices, Shipping Costs, Installation Costs, and Total Installed Costs for Motors that are Space-Constrained

Energy Efficiency Level	Efficiency (%)	Equipment Price (2009$)	Shipping Cost (2009$)	Installation Cost (2009$)	Total Installed Cost (2009$)
Baseline	59.0	$227.09	$10.58	$252.90	$490.57
1	62.2	$234.76	$11.09	$252.90	$498.74
2	64.5	$240.29	$11.59	$252.90	$504.78
3	66.7	$242.35	$11.94	$252.90	$507.19
4	71.5	$269.31	$12.26	$252.90	$534.47
5	72.7	$274.35	$12.25	$252.90	$539.51
6	74.0	$393.32	$12.52	$252.90	$658.75
7	78.4	$2,257.61	$12.49	$252.90	$2,523.00

Table 8.2.14 Capacitor-Start Capacitor-Run Motors (0.75 hp): Consumer Equipment Prices, Shipping Costs, Installation Costs, and Total Installed Costs for Motors that are Not Space-Constrained

Energy Efficiency Level	Efficiency (%)	Equipment Price (2009$)	Shipping Cost (2009$)	Installation Cost (2009$)	Total Installed Cost (2009$)
Baseline	72.0	$278.08	$12.71	$252.90	$547.58
1	75.7	$287.97	$13.40	$252.90	$558.31
2	80.0	$311.29	$16.28	$252.90	$584.85
3	82.2	$321.70	$17.64	$252.90	$596.77
4	83.2	$334.87	$17.96	$252.90	$610.46
5	84.5	$351.61	$19.72	$252.90	$629.20
6	85.2	$363.22	$21.14	$252.90	$642.40
7	87.1	$395.23	$18.96	$252.90	$672.71
8	88.4	$673.24	$22.61	$252.90	$958.50

Table 8.2.15 Capacitor-Start Capacitor-Run Motors (0.75 hp): Consumer Equipment Prices, Shipping Costs, Installation Costs, and Total Installed Costs for Motors that are Space-Constrained

Energy Efficiency Level	Efficiency (%)	Equipment Price (2009$)	Shipping Cost (2009$)	Installation Cost (2009$)	Total Installed Cost (2009$)
Baseline	72.0	$278.08	$12.71	$252.90	$543.69
1	75.7	$287.97	$13.40	$252.90	$554.28
2	80.0	$324.70	$13.80	$252.90	$591.40
3	82.2	$334.62	$14.50	$252.90	$602.02
4	83.2	$341.60	$14.96	$252.90	$609.46
5	84.5	$356.44	$15.72	$252.90	$625.06
6	85.2	$507.27	$14.83	$252.90	$775.00
7	87.1	$520.16	$15.18	$252.90	$788.24
8	88.4	$3,314.96	$15.09	$252.90	$3,582.95

8.2.3 Operating Cost Inputs

DOE defines the operating cost, OC, by the following equation:

$$OC = EC + RC + MC$$

Where:

EC = energy expenditure associated with operating the equipment,
RC = repair cost associated with component failure, and
MC = cost for maintaining equipment operation.

Table 8.2.16 shows the inputs for determining the operating costs. The inputs listed in Table 8.2.16 are also necessary for determining the present value of lifetime operating expenses, which include the energy price trends, product lifetime, discount rate, and effective date of the standard.

Table 8.2.16 Inputs for Operating Cost

Annual Energy Consumption
Energy Prices
Repair and Maintenance Costs
Energy Price Trends
Product Lifetime
Discount Rate
Effective Date of Standard

The *annual energy consumption* is the site energy use associated with operating the equipment. *Energy prices* are the prices paid by end users for energy supply including both energy and demand charges. Multiplying the annual energy and demand by the appropriate prices yields the annual energy cost. *Repair costs* are associated with repairing or replacing components that have failed, and *maintenance costs* are associated with maintaining the operation of the equipment. DOE used *energy price trends* to forecast energy supply prices into the future and, along with the product lifetime and discount rate, to establish the lifetime energy supply costs. The *product lifetime* is the age at which the equipment is retired from service. The *discount rate* is the rate at which DOE discounted future expenditures to establish their present value. DOE calculated the operating cost for baseline products based on the following equation:

$$
\begin{aligned}
OC_{BASE} &= EC_{BASE} + RC_{BASE} + MC_{BASE} \\
&= AEC_{BASE} \times PRICE_{ENERGY} + RC_{BASE} + MC_{BASE}
\end{aligned}
$$

Where:

OC_{BASE} = baseline operating cost,
EC_{BASE} = energy expenditure associated with operating the baseline equipment which may include reactive power costs,
RC_{BASE} = repair cost associated with component failure for the baseline equipment,
MC_{BASE} = cost for maintaining baseline equipment operation,
AEC_{BASE} = annual energy consumption for baseline equipment,

$PRICE_{ENERGY}$ = energy price.

DOE calculated the operating cost for standard-level products based on the following equation:

$$\begin{aligned} OC_{STD} &= EC_{STD} + RC_{STD} + MC_{STD} \\ &= AEC_{STD} \times PRICE_{ENERGY} + RC_{STD} + MC_{STD} \\ &= \left(AEC_{BASE} - \Delta AEC_{STD}\right) \times PRICE_{ENERGY} + \left(RC_{BASE} + \Delta RC_{STD}\right) + \left(MC_{BASE} + \Delta MC_{STD}\right) \end{aligned}$$

Where:

OC_{STD} = standard-level operating cost,
EC_{STD} = energy expenditure associated with operating standard-level equipment,
RC_{STD} = repair cost associated with component failure for standard-level equipment,
MC_{STD} = cost for maintaining standard-level equipment operation,
AEC_{STD} = annual energy consumption for standard-level equipment,
$PRICE_{ENERGY}$ = energy price,
ΔAEC_{STD} = decrease in annual energy consumption caused by standard-level equipment,
ΔRC_{STD} = change in repair cost caused by standard-level equipment, and
ΔMC_{STD} = change in maintenance cost caused by standard-level equipment.

The remainder of this section provides information about each of the above input variables that DOE used to calculate the operating costs for small electric motors.

8.2.3.1 Annual Energy Consumption

Chapter 6, Energy Use Characterization, details how DOE determined the annual energy consumption for baseline and standard-level products. Table 8.2.17 provides the average annual energy consumption by efficiency level for each small motor equipment class. DOE captured the variability in energy consumption by estimating energy consumption for a variety of motor-using applications.

Table 8.2.17 Average Annual Electricity Use by Efficiency Level for Small Electric Motors

Polyphase (1 hp)		CSIR (0.5 hp)		CSCR (0.75 hp)	
Efficiency (%)	**Energy Use (kWh/yr)**	**Efficiency (%)**	**Energy Use (kWh/yr)**	**Efficiency (%)**	**Energy Use (kWh/yr)**
74.0	1776	59.0	1250	72.0	1425
76.1	1729	62.2	1170	75.7	1360
77.7	1686	64.5	1116	80.0	1250
79.4	1630	66.7	1064	82.2	1205
80.1	1615	71.5	976	83.2	1214

82.6	1540	72.7	951	84.5	1201
84.4	1508	74.0	920	85.2	1179
85.4	1488	78.4	860	87.1	1146
87.0	1462	NA	NA	88.4	1115

8.2.3.2 Energy Prices

To estimate the energy prices faced by small motor end users throughout the U.S., DOE estimated electricity prices for end users in each sector using EIA Form 861 data.[2] These data are published annually and include annual electricity sales in kilowatt-hours (kWh), revenues from electricity sales, and number of consumers, for the residential, commercial, and industrial sectors, for every utility serving final consumers.

DOE sorted the volumes of electricity sold as reported by the year 2007 EIA Form 861 by price and customer class and calculated the distribution of electricity prices for each customer class. DOE used these electricity price distributions to represent the customer cost of electricity for the different classes of motor owners. DOE assigned the electricity price distribution for industrial customers to the class of agricultural motor owners. The resulting electricity price distributions are shown in Figure 8.2.1.

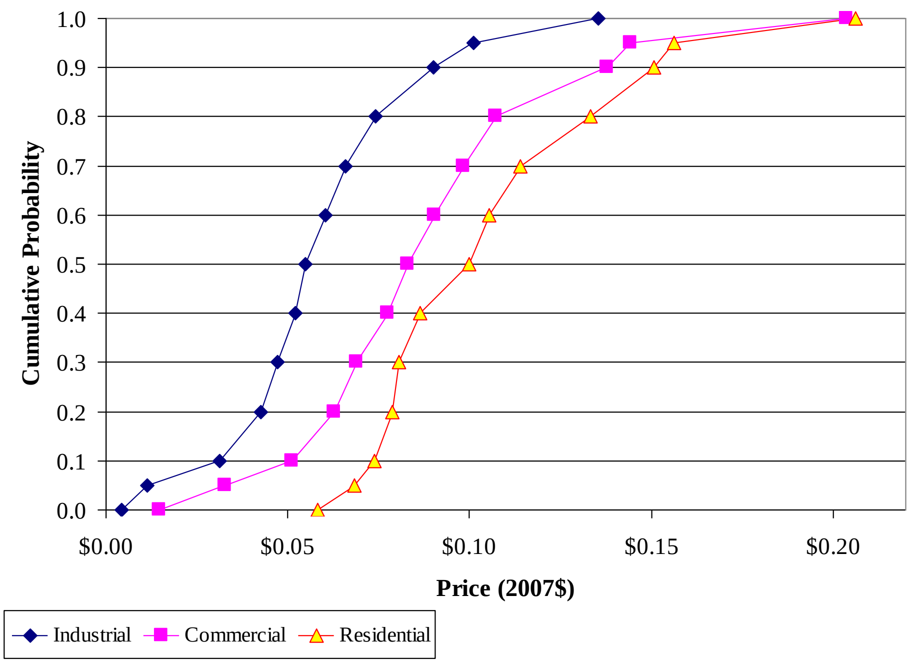

Figure 8.2.1 Electricity Price (2007$/kWh) Distributions

8.2.3.3 Energy Price Trends

DOE used price forecasts by the EIA to estimate the trends in electricity prices. To arrive at prices in future years, it multiplied the average prices described in the preceding section by the forecast of annual average price changes in EIA's *AEO 2009*. To estimate the trend after 2030, DOE followed past guidelines provided to the Federal Energy Management Program by EIA and used the average rate of change during 2020–2030 for electricity prices.

DOE calculated LCC and PBP using three separate projections from *AEO2009 and AEO2010*: the *AEO2010* Early Release, and the Low Energy Price and High Energy price cases of AEO 2009. DOE used the Low and High Energy Price scenarios from *AEO2009* to determine the ratio of energy prices in these scenarios to the *AEO2009* reference case. DOE then developed Low and High Price trends based on the EO 2010 Early Release by multiplying its prices by these ratios. These three cases reflect the uncertainty of energy prices in the forecast period. The high and low energy price cases show the projected effects of alternative growth assumptions on energy markets. Figure 8.2.2 shows the industrial electricity price trends based on the three projections. For the LCC results presented in section 8.4, DOE used only the energy price forecasts from the Department's reference case, the Early Release of *AEO2010*.

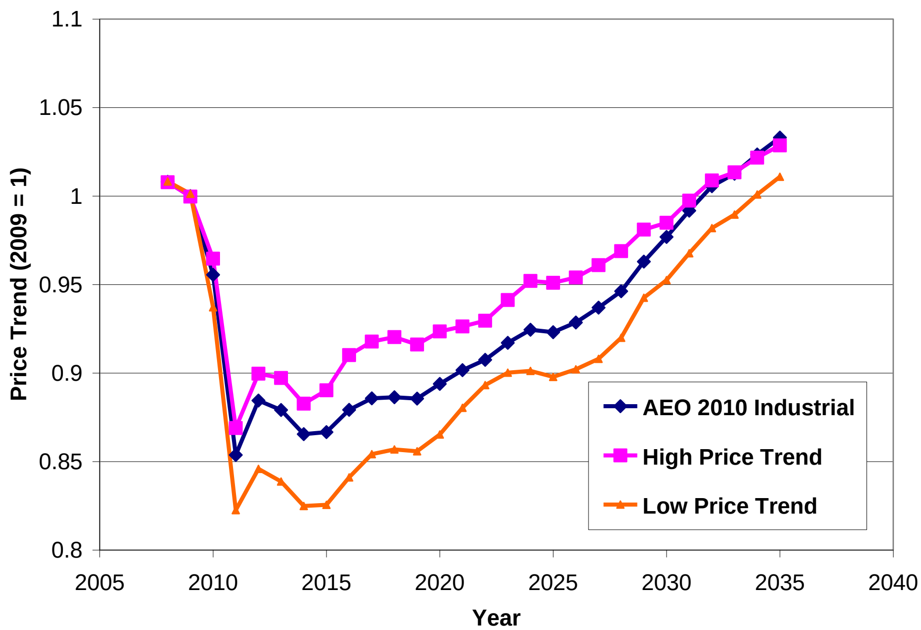

Figure 8.2.2 Industrial Electricity Price Trends

8.2.3.4 Repair and Maintenance Costs

DOE understands that small electric motors are usually not repaired. Most small motors are mass produced and are not constructed or designed to be repaired because the manufacturing process uses spot welding welds and rivets to fasten or secure the frame and assembled components, not nuts and bolts. DOE found no evidence that any repair or maintenance costs would increase with higher motor energy efficiency. Thus, it did not include any changes in repair and maintenance costs for motors more efficient than baseline products.

8.2.4 Motor Lifetime

DOE relied on several sources to inform its model of the lifetime of small electric motors. A study by Easton Consultants, prepared for the Department in 2001, surveyed experts in OEM industries, analyzed causes of motor failure, and developed estimates for typical motor lifetime of 7 years for capacitor-start motors and 9 years for small polyphase motors (two-digit frame series). The Department used Weibull distributions based on these values in its preliminary analysis. (The Weibull distribution is a standard distribution used to model failure processes.)

DOE has developed a more sophisticated model for motor lifetime for use in this stage of the analysis. This model combines annual hours of motor operation with OEM application lifetimes to estimate the distribution of motor lifetimes. This model results in a negative correlation between annual hours of operation and motor lifetime; motors operated many hours per year are likely to be retired sooner than motors which are used for only a few hundred hours per year.

The Department's motor lifetime model relies on four distributions: 1) the duty factor or annual hours of operation distribution derived for use in the energy use analysis (see chapter 6), 2) the distribution of motor shipments into five application areas, each with its own distribution of annual hours of operation, 3) a Weibull distribution of mechanical motor lifetimes, expressed in total hours of operation before failure, and 4) a Weibull distribution of application lifetimes, expressed in years. DOE combined expert interviews (conducted by Easton Consultants) regarding motor lifetime in hours with its estimates of typical motor lifetime to develop the parameters for the Weibull distributions for both polyphase and single-phase motors. DOE's Monte Carlo analysis of the motor life cycle cost selected an application, an appropriate number of hours of operation, motor mechanical lifetime, and application lifetime from these distributions in order to calculate the sampled motor's lifetime in years.

The Department determined the mechanical lifetime of each motor in years by dividing its mechanical lifetime in hours by its annual hours of operation. DOE then compared this mechanical lifetime (in years) with the sampled application lifetime (also in years), and assumed that the motor would be retired at the younger of these two ages. For example, a pump motor with a duty factor of 2500 hours per year may have a mechanical lifetime of 30,000 hours and an application lifetime of 10 years. The mechanical lifetime would be 12 years, which is greater than 10 years, so DOE would assume the motor would retire in 10 years, when its application reached its lifetime, even if the motor itself could run for several more years. If the pump motor were to run for 6000 hours per year, with the same mechanical and application lifetimes, DOE would assume it would retire after 5 years due to motor failure upon reaching its mechanical lifetime of 30,000 hours.

8.2.4.1 The Weibull Distribution

The Weibull distribution is a probability distribution commonly used to measure failure rates.[a] Its form is similar to an exponential distribution, which models a fixed failure rate, except that a Weibull distribution allows for a failure rate that changes over time in a particular fashion. The cumulative Weibull distribution takes the form:

$$P(x) = e^{-\left(\frac{x-\theta}{\alpha}\right)^{\beta}} \text{ for } x > \theta \text{ and}$$
$$P(x) = 1 \text{ for } x \le \theta$$

Where:

$P(x)$ = probability that the equipment is still in use at age x;
x = equipment age;
α = scale parameter, which would be the decay length in an exponential distribution;
β = shape parameter, which determines the way in which the failure rate changes through time; and
θ = delay parameter, or location, which allows for a delay before any failures occur.

When $\beta = 1$, the failure rate is constant over time, giving the distribution the form of a cumulative exponential distribution. In the case of mechanical equipment, β commonly is greater than 1, reflecting an increasing failure rate as equipment ages.

8.2.4.2 Capacitor-Start Mechanical and Application Lifetimes

DOE's derived Weibull parameters for capacitor-start motor mechanical lifetimes are:
α = 17,000 hours;
β = 2.5; and
θ = 15,000 hours.
These parameters produce a distribution in which no motors suffer mechanical failure until they have run at least 15,000 hours. The mean mechanical lifetime is 30,080 hours, and the median is 29,680 hours.

DOE's derived Weibull parameters for capacitor-start motor application lifetimes are:
α = 3.12 years;
β = 1.9; and
θ = 5 years.
These parameters produce a distribution in which no motors are retired due to their application's retirement until they are at least 5 years old. The mean application lifetime is 7.77 years, and the median is 7.57 years.

---

[a] For reference on the Weibull distribution, see sections 1.3.6.6.8 and 8.4.1.3 of the *NIST/SEMATECH e-Handbook of Statistical Methods*, <www.itl.nist.gov/div898/handbook/>.

In the course of the life-cycle analysis, DOE combines these two distributions with the appropriately weighted duty factor distribution to select a lifetime for each motor. The overall mean age at capacitor-start motor retirement is 6.95 years, with a median of 7 years. In this model, 95% of polyphase small electric motors have lifetimes between 2.8 and 10.8 years. The correlation coefficient between annual hours of operation and motor lifetime is -0.712, indicating an inverse relationship as expected.

8.2.5 Polyphase Mechanical and Application Lifetimes

Interviews with OEM-industry experts indicate that polyphase motors are expected to be used for more years before retirement. Mechanically and electrically, they are simpler than capacitor-start motors, due to the lack of a capacitor, and failure of the bearings is expected to be the dominant cause of motor failure. DOE therefore derived a polyphase mechanical motor lifetime distribution with somewhat higher number of hours until failure than for capacitor-start motors. DOE's derived Weibull parameters for polyphase motor mechanical lifetimes are:

α = 23,000 hours;
β = 2.5; and
θ = 20,000 hours.

These parameters produce a distribution in which no motors suffer mechanical failure until they have run at least 20,000 hours. The mean mechanical lifetime is 40,400 hours, and the median is 39,860 hours.

DOE's derived Weibull parameters for polyphase motor application lifetimes are:

α = 3.03 years;
β = 1.9; and
θ = 7 years.

These parameters produce a distribution in which no motors are retired due to their application's retirement until they are at least 7 years old. The mean application lifetime is 9.69 years, and the median is 9.50 years.

In the course of the life-cycle analysis, DOE combines these two distributions with the appropriately weighted duty factor distribution to select a lifetime for each motor. The overall mean age at capacitor-start motor retirement is 8.75 years, with a median of 9 years. In this model, 95% of polyphase small electric motors have lifetimes between 3.7 and 12.7 years. The correlation coefficient between annual hours of operation and motor lifetime is -0.746, indicating an inverse relationship as expected.

8.2.5.1 Discount Rates

DOE derived the discount rates for the LCC and PBP analysis from estimates of the finance cost of purchasing the considered products. Following financial theory, the finance cost of raising funds to purchase equipment can be interpreted as: (1) the financial cost of any debt incurred to purchase equipment, or (2) the opportunity cost of any equity used to purchase equipment.

Commercial, Industrial, and Agricultural Owners

For motors purchased and used in the industrial, agricultural, and commercial sectors, DOE calculated the discount rate for a distribution of representative product owners. This distribution of representative owners is the weighted sum of discount rate distributions for different ownership categories. DOE calculated a distribution of discount rates for owners within each ownership category. The discount rate for an individual owner is the weighted average cost of capital (WACC) where, given the mix of debt and equity for that individual owner, a weighted average of the discount rates for each loan and investment calculated in which the weights are equal to the size of the loan or investment.

DOE estimated the cost of equity using the capital asset pricing model (CAPM).[3] The CAPM assumes that the cost of equity (k_e) for a particular company is proportional to the systematic risk faced by that company, where high risk is associated with a high cost of equity and low risk is associated with a low cost of equity. The systematic risk facing a firm is determined by several variables: the risk coefficient of the firm (β), the expected return on risk-free assets (R_f), and the equity risk premium (*ERP*). The risk coefficient of the firm indicates the risk associated with that firm relative to the price variability in the stock market. The expected return on risk-free assets is defined by the yield on long-term government bonds. The *ERP* represents the difference between the expected stock market return and the risk-free rate. The cost of equity financing is estimated using the following equation, where the variables are defined as above:

$$\boldsymbol{k_e} = \boldsymbol{R_f} + (\beta \times \boldsymbol{ERP})$$

Where:

k_e = cost of equity,
R_f = expected return on risk-free assets,
β = risk coefficient of the firm, and
ERP = equity risk premium.

The cost of debt financing (k_d) is the interest rate paid on money borrowed by a company. The cost of debt is estimated by adding a risk adjustment factor (R_a) to the risk-free rate. This risk adjustment factor depends on the variability of stock returns represented by standard deviations in stock prices. So for firm *i*, the cost of debt financing is:

$$\boldsymbol{k_{di}} = \boldsymbol{R_f} + \boldsymbol{R_{ai}}$$

Where:

k_d = cost of debt financing for firm, *i*,
R_f = expected return on risk-free assets, and
R_{ai} = risk adjustment factor to risk-free rate for firm, *i*.

DOE estimates the WACC using the following equation:

$$WACC = k_e \times w_e + k_d \times w_d$$

Where:

$WACC$ =	weighted average cost of capital,
w_e =	proportion of equity financing, and
w_d =	proportion of debt financing.

Damodaran Online is a widely used source of information about company debt and equity financing for most types of firms.[4]

Several parameters of the cost of capital equations can vary substantially over time, and therefore the estimates can vary with the time period over which data is selected and the technical details of the data averaging method. For guidance on the time period for selecting and averaging data for key parameters and the averaging method, DOE used Federal Reserve methodologies for calculating these parameters. In its use of the CAPM, the Federal Reserve uses a forty-year period for calculating discount rate averages, utilizes the gross domestic product price deflator for estimating inflation, and considers the best method for determining the risk free rate as one where "the time horizon of the investor is matched with the term of the risk-free security."[5]

During the preliminary analysis, DOE adjusted the discount rate distributions from a previous rulemaking on distribution transformer standards with updated values of the equity risk premium, inflation, and the risk-free rate using the 10-year Treasury bond as the risk-free security. DOE did not receive comments in response to the preliminary analysis regarding this approach and has therefore retained the same estimates for the NOPR. By taking an updated forty-year (1967–2007) geometric average of Damodaran Online data, DOE found for this analysis a real (inflation-adjusted) risk free rate of 3.15 percent and an equity risk premium of 3.50 percent. The values for the previous analysis (for distribution transformer standards) were 3.20 percent and 5.50 percent respectively. Table 8.2.18 shows the conversion from the previous set of parameters to the new values and the new discount rate distributions assuming no change in the corresponding company weighted-average cost of capital betas. DOE used the CAPM equation to derive a relationship between beta and the discount rate that was used to convert discount rates to the values that correspond to the new values of risk-free rate and ERP. DOE obtained the following equation for beta by solving the CAPM equation:

$$\beta = (k_e - R_f) / ERP$$

Where:

k_e =	cost of equity,
R_f =	expected return on risk-free assets,
β =	risk coefficient of the firm, and
ERP =	equity risk premium.

Table 8.2.18 Adjusted Real Discount Rates for Updated Values of R_f and *ERP*.

Previous Discount Rate* (%)	CAPM Beta Value	Updated Discount Rate (%)	Industrial Discount Rate Distribution (%)	Commercial Discount Rate Distribution (%)
0.5	-0.491	1.43	0.0	0.0
1.5	-0.309	2.07	0.0	0.0
2.5	-0.127	2.70	0.5	3.1
3.5	0.055	3.34	1.3	1.2
4.5	0.236	3.98	4.2	2.1
5.5	0.418	4.61	14.6	9.8
6.5	0.600	5.25	24.7	22.4
7.5	0.782	5.89	24.9	23.9
8.5	0.964	6.52	6.6	23.2
9.5	1.145	7.16	6.5	6.6
10.5	1.327	7.80	8.6	4.0
11.5	1.509	8.43	6.8	2.3
12.5	1.691	9.07	0.9	0.5
13.5	1.873	9.70	0.2	0.1
14.5	2.055	10.34	0.1	0.7
15.5	2.236	10.98	0.0	0.0
16.5	2.418	11.61	0.0	0.0

From rulemaking on distribution transformer standards

Table 8.2.19 shows the average WACC values for the three non-residential ownership types in the small electric motors analysis. While WACC values for any sector may trend higher or lower over substantial periods of time, these values represent a private sector cost of capital that is averaged over major business cycles. For all sectors, the averages are slightly lower than 6 percent real.

Table 8.2.19 Weighted Average Cost of Capital for Sectors that Purchase Small Electric Motors

Sector	Weighted-Average Cost of Capital
Industrial	5.92%
Agricultural	5.92%
Commercial	5.86%

Residential Owners

Households use a variety of methods to finance equipment. In principle, one could estimate the interest rates on the actual financing vehicles used to purchase replacement equipment. The shares of different financing vehicles in total equipment purchases are unknown, however.

DOE's approach involves identifying all possible debt or asset classes that might be used to purchase equipment, including household assets that might be affected indirectly.[b] DOE did not include debt from primary mortgages and equity of assets considered non-liquid (such as retirement accounts), since these would likely not be affected by equipment purchases. DOE estimated the average shares of the various debt and equity classes in the average U.S. household equity and debt portfolios using Survey of Consumer Finances (SCF) data for 1989, 1992, 1995, 1998, 2001, and 2004. Table 8.2.20 shows the average shares of each considered class. DOE used the mean share of each class across the six years as a basis for estimating the effective financing of equipment.

Table 8.2.20 Average Shares of Considered Household Debt and Equity Types

Type	1989 SCF	1992 SCF	1995 SCF	1998 SCF	2001 SCF	2004 SCF	Mean (%)
Home equity loans	4.3	4.5	2.7	2.8	2.8	4.4	3.6
Credit cards	1.6	2.1	2.6	2.2	1.7	2.0	2.0
Other installment loans	2.8	1.7	1.4	1.7	1.1	1.3	1.7
Other residential loans	4.4	6.9	5.2	4.3	3.1	5.8	4.9
Other line of credit	1.1	0.6	0.4	0.2	0.3	0.5	0.5
Checking accounts	5.8	4.7	4.9	3.9	3.6	4.2	4.5
Savings & money market	19.2	18.8	14.0	12.8	14.2	15.1	15.7
Certificate of deposit (CD)	14.5	11.7	9.4	7.0	5.4	5.9	9.0
Savings bond	2.2	1.7	2.2	1.1	1.2	0.9	1.5
Bonds	13.8	12.3	10.5	7.0	7.9	8.4	10.0
Stocks	22.4	24.0	25.9	36.9	37.5	28.0	29.1
Mutual funds	8.0	11.1	20.9	20.1	21.3	23.4	17.5
Total	100	100	100	100	100	100	100

DOE estimated interest or return rates associated with each type of equity and debt. The data source for the interest rates for loans, credit cards, and lines of credit is the Federal Reserve Board's *SCF* in 1989, 1992, 1995, 1998, 2001, and 2004. Table 8.2.21 shows the average nominal rates in each year, and the inflation rates used to calculate real rates. For home equity loans, DOE calculated effective interest rates in a similar manner as for mortgage rates, since interest on such loans is tax deductible. Table 8.2.22 shows the average effective real rates in

[b] An indirect effect would arise if a household sold some assets in order to pay off a loan or credit card debt that might have been used to finance the actual appliance purchase.

each year and the mean rate across the years. Since the interest rates for each debt carried by households in these years were established over a range of time, DOE believes they are representative of rates that may be in effect in 2015.

Table 8.2.21 Average Nominal Interest Rates for Household Debt Classes (percent)

Type	1989 SCF	1992 SCF	1995 SCF	1998 SCF	2001 SCF	2004 SCF	Mean (%)
Home equity loans	11.5	9.6	9.6	9.8	8.7	5.7	9.2
Credit cards*	-	-	14.2	14.5	14.2	11.7	13.6
Other installment loans	9.0	7.8	9.3	7.8	8.7	7.4	8.3
Other residential loans	8.8	7.6	7.7	7.7	7.5	6.0	7.5
Other line of credit	14.8	12.7	12.4	11.9	14.7	8.8	12.5
Inflation rate	4.82	3.01	2.83	1.56	2.85	2.66	

* No interest rate data available for credit cards in 1989 or 1992.

Table 8.2.22 Average Real Effective Interest Rates for Household Debt Classes (percent)

Type	1989 SCF	1992 SCF	1995 SCF	1998 SCF	2001 SCF	2004 SCF	Mean (%)
Home equity loans	3.8	4.3	4.4	5.8	3.8	1.9	4.0
Credit cards*	-	-	11.0	12.7	11.1	9.1	11.0
Other installment loans	4.9	5.8	7.0	6.6	6.1	5.4	6.0
Other residential loans	4.0	4.7	4.8	6.0	4.6	3.3	4.6
Other line of credit	9.6	9.4	9.3	10.2	7.3	6.0	8.7

* No interest rate data available for credit cards in 1989 or 1992.

To account for variation among new households, DOE sampled a rate for each household from a distribution of rates for each of the above debt classes. DOE developed a probability distribution of interest rates for each debt class based on the *SCF* data.

Similar rate data are not available from the *SCF* for the asset classes, so DOE derived data for these classes from national-level historical data. The interest rates associated with certificates of deposit (CDs), [6] savings bonds,[7] and bonds (AAA corporate bonds) [8] are from Federal Reserve Board time-series data covering 1977–2005. DOE assumed rates on checking accounts to be zero. Rates on savings and money market accounts are from Cost of Savings Index data covering 1984–2005. [9] The rates for stocks are the annual returns on the Standard and Poor's (S&P) 500 in the 1977–2005 period. [10] The mutual fund rates are a weighted average of the stock rates (two-thirds weight) and the bond rates (one-third weight) in each year of the 1977–2005 period. DOE adjusted the nominal rates to real rates using the annual inflation rate in each year. Average nominal and real interest rates for the classes of assets are shown in Table 8.2.23. Since the interest and return rates for each asset type cover a range of time, DOE believes they are representative of rates that may be in effect in 2015.

Table 8.2.23 Average Nominal and Real Interest Rates for Household Equity Types

Type	Average Nominal Rate (%)	Average Real Rate (%)
Checking accounts	-	0.0
Savings and money market	5.5	2.3
CDs	6.9	2.4
Savings bonds	8.0	3.5
Bonds	8.8	4.2
Stocks	13.3	8.8
Mutual funds	11.6	7.0

To account for variation among households, DOE sampled a rate for each household from a distribution of rates for each of the above asset types. DOE developed a normal probability distribution of interest rates for each asset type by using the mean value and standard deviation from the distribution.

Table 8.2.24 summarizes the mean real effective rates of each type of equity or debt. DOE determined the average share of each debt and asset using *SCF* data for 1989, 1992, 1995, 1998, 2001, and 2004. Each year of SCF data provides the debt and asset shares for U.S. households. DOE averaged the debt and asset shares over the six years of survey data to arrive at the shares shown below. The average rate across all types of household debt and equity, weighted by the shares of each class, is 5.6 percent.

Table 8.2.24 Shares and Interest or Return Rates Used for Household Debt and Equity Types

Type	Average Share of Household Debt plus Equity (%)*	Mean Effective Real Rate (%)**
Home equity loans	3.6	4.0
Credit cards	2.0	11.0
Other installment loans	1.7	6.0
Other residential loans	4.9	4.6
Other line of credit	0.5	8.7
Checking accounts	4.5	0.0
Savings and money market accounts	15.7	2.3
CDs	9.0	2.4
Savings bonds	1.5	3.5
Bonds	10.0	4.2
Stocks	29.1	8.8
Mutual funds	17.5	7.0
Total/Weighted-average discount rate	100	5.6

* Not including primary mortgage or retirement accounts.

** Adjusted for inflation and, for home equity loans, loan interest tax deduction.

8.2.5.2 Effective Date of Standard

The effective date of an energy conservation standard is the future date when a new standard becomes operative. Section 346(b)(3) of the Energy Policy and Conservation Act (EPCA) requires that any standard for small electric motors "shall apply to small electric motors manufactured 60 months after the date such rule is published." (42 USC 6317(b)(3)) In view of the Report to Congress on Appliance Energy Efficiency Rulemakings, dated February 2008, DOE is required to publish an energy conservation standard final rule by February 28, 2010. (See *http://www1.eere.energy.gov/buildings/appliance_standards/schedule_setting.html*.) Therefore, the effective date of any new energy conservation standards for small electric motors will be in February 2015. DOE calculated the LCC and PBP for all end users as if they each would purchase a new piece of equipment in the year the standard takes effect.

8.2.6 Product Energy Efficiency in the Base Case

For purposes of conducting the LCC analysis, DOE analyzed efficiency levels relative to a base case (i.e., the case without new energy efficiency standards). This requires an estimate of the distribution of product efficiencies in the base case (i.e., what consumers would have purchased in the year 2015 in the absence of new standards).

In other rulemakings, DOE often uses the distribution of product efficiencies currently in the marketplace to develop its estimate of such distribution in the base case. DOE did find some models offered in the manufacturer catalogues that were low first cost and then had matching higher-efficiency units. These so-called 'matched pairs' would seem to indicate that there is some voluntary purchasing of higher-efficiency motors. However, DOE did not have any data on the market shares of such motors. Therefore, DOE assumed that all motors purchased in the base case would be at the baseline efficiency levels, as shown in Table 8.2.25.

Table 8.2.25 Product Energy Efficiency in the Base Case

Product Class	Efficiency (%)
Polyphase, 1 hp	74
CSIR, 0.5 hp	59
CSCR, 0.75 hp	72

8.3 PAYBACK PERIOD INPUTS

The payback period is the amount of time it takes the consumer to recover the assumed higher purchase expense of more energy-efficient equipment as a result of lower operating costs. Numerically, the PBP is the ratio of the increase in purchase expense (i.e., from a less efficient design to a more efficient design) to the decrease in annual operating expenditures. This type of calculation is known as a “simple” payback period, because it does not take into account changes in operating expense over time or the time value of money; i.e., the calculation is done at an effective discount rate of zero percent.

The equation for PBP is:

$$PBP = \frac{\Delta IC}{\Delta OC}$$

Where:

ΔIC = increase in the total installed cost between the more efficient standard level and the baseline design, and
ΔOC = decrease in annual operating expenses.

Payback periods are expressed in years. Payback periods greater than the life of the product indicate that the increased total installed cost is not recovered in reduced operating expenses.

The data inputs to PBP are the total installed cost of the equipment to the consumer for each efficiency level and the annual (first year) operating expenditures for each standard level. The inputs to the total installed cost are the equipment price and the installation cost. The inputs to the operating costs are the annual energy cost, the annual repair cost, and the annual maintenance cost. The PBP uses the same inputs as the LCC analysis as described in section 8.2, except that lifetime, energy price trends and discount rates are not required. Since the PBP is a "simple" payback, the required energy price is only for the year in which a new standard is to take effect—in this case, the year 2015. The energy price DOE used in the PBP calculation was the price projected for that year.

8.4 LIFE-CYCLE COST AND PAYBACK PERIOD RESULTS FOR REPRESENTATIVE PRODUCT CLASSES

This section presents the LCC and PBP results for small motors. As discussed in section 8.1.1, DOE's approach for conducting the LCC analysis relied on developing samples of customers that use motors in each product class. DOE also characterized the uncertainty of many of the inputs to the analysis with probability distributions. DOE used a Monte Carlo simulation technique to perform the LCC calculations on the customers in the sample. For each set of sample customers using motors in each equipment class, DOE calculated the average LCC and LCC savings and the median and average PBP for each of the standard levels.

In the subsections below, DOE presents figures showing the distribution of LCCs in the base case for each equipment class. Also presented below for a specific standard level are figures showing the distribution of LCC impacts and the distribution of PBPs. The figures are presented as frequency charts that show the distribution of LCCs, LCC impacts, and PBPs with their corresponding probability of occurrence. DOE generated the figures for the distributions from a Monte Carlo simulation run based on 10,000 samples. The LCC and PBP calculations were performed 10,000 times by sampling from the probability distributions that DOE developed to characterize many of the inputs.

Based on the Monte Carlo simulations that DOE performed, for each efficiency level, DOE calculated the share of small motor users with a net LCC benefit, with a net LCC cost, and with no impact. To illustrate the range of LCC and PBP impacts among the small motor end users, the sections below present figures that provide such information for each equipment class.

8.4.1 Polyphase Motors

Figure 8.4.1 is an example of a frequency chart showing the distribution of LCC differences for the case of efficiency level 5 for polyphase motors. In the figure, a text box next to a vertical line at that value on the x-axis shows the mean change in LCC (a net cost of approximately $40 in this example Monte Carlo run).

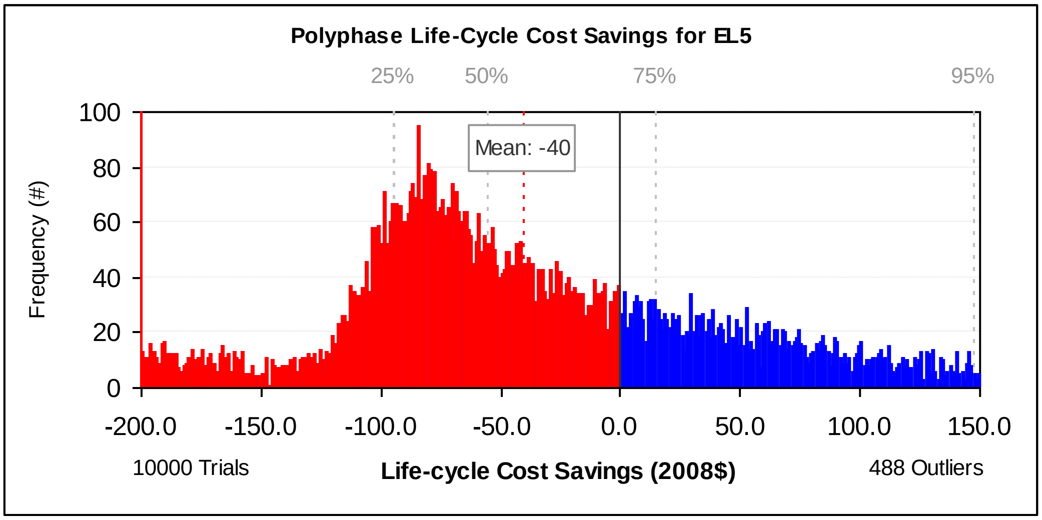

Figure 8.4.1 Polyphase Motors: Distribution of Life-Cycle Cost Savings for Efficiency Level 5

Figure 8.4.2 is an example of a frequency chart showing the distribution of payback periods of efficiency level 5 for polyphase motors. Because many motors operate for very few hours per year, this means that there is a significant number of motors that may have extremely long payback periods because the operating cost savings is very small compared to the increase in first cost. The distribution in the figure illustrates that most motors have a payback of less than 20 years, but the mean value of the distribution payback is large (49.5 years) because of the small, but significant number of motors with payback periods longer then 100 years.

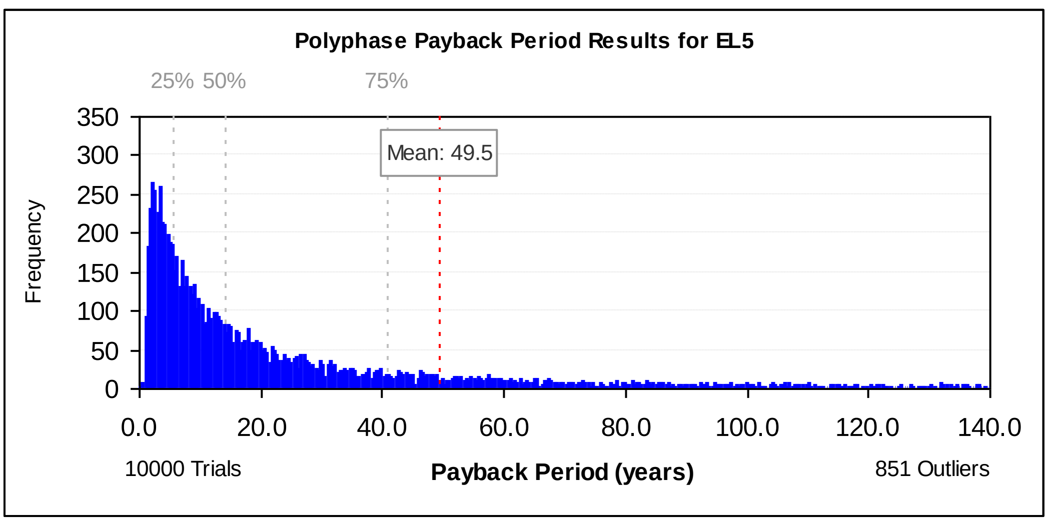

Figure 8.4.2 Polyphase Motors: Distribution of Payback Periods for Efficiency Level 5

Table 8.4.1 summarizes the LCC and PBP results for polyphase motors based on a run of 10,000 Monte Carlo samples. The highest energy efficiency level with positive average LCC savings is level 5, 82.6 percent. Approximately 49 percent of end users are estimated to have a net benefit (i.e., LCC decrease) at this level. The increase in average total installed cost at this level (relative to the base case) is $72, while operating costs decrease by approximately $17 per year.

Table 8.4.1 Polyphase Motors: Life-Cycle Cost and Payback Period Results (Representative Product Class)

Energy Efficiency Level	Efficiency *%*	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period *years*	
		Average Installed Price *$*	Average Energy Use *kWh/yr*	Average Annual Operating Cost *$*	Average Life-Cycle Cost *$*	Average Savings *$*	Customers with Net Cost *%*	Customers with Net Benefit *%*	Average	Median
Baseline	74.0	517	1,892	130	1,268					
1	76.1	530	1,729	127	1,261	8	46.8	53.2	21.8	7.1
2	77.7	537	1,686	123	1,249	19	41.3	58.7	17.8	5.8
3	79.4	549	1,630	119	1,237	31	40.6	59.4	17.7	5.6
4	80.1	558	1,615	118	1,240	29	45.1	54.9	20.4	6.5
5 (4b)	82.6	589	1,540	113	1,240	28	51.2	48.8	24.8	7.8
6	84.4	655	1,508	110	1,291	-23	65.8	34.3	41.5	12.4
7	85.3	711	1,488	109	1,339	-71	77.4	22.6	54.2	16.9
8	87.0	1,477	1,462	107	2,095	-827	96.8	3.2	243.0	51.1

8.4.2 Capacitor-Start Induction-Run Motors

Figure 8.4.3 is an example of a frequency chart showing the distribution of LCC impacts for the case of efficiency level 7 for CSIR motors. Efficiency level 7 is the maximum technologically feasible level for space-constrained CSIR motors. This can be seen by the significant population (approximately 20%) of motors that have large negative LCC impacts. For those motors that do not have space constraints, a substantial fraction (approximately half) experience a net LCC benefit from this level.

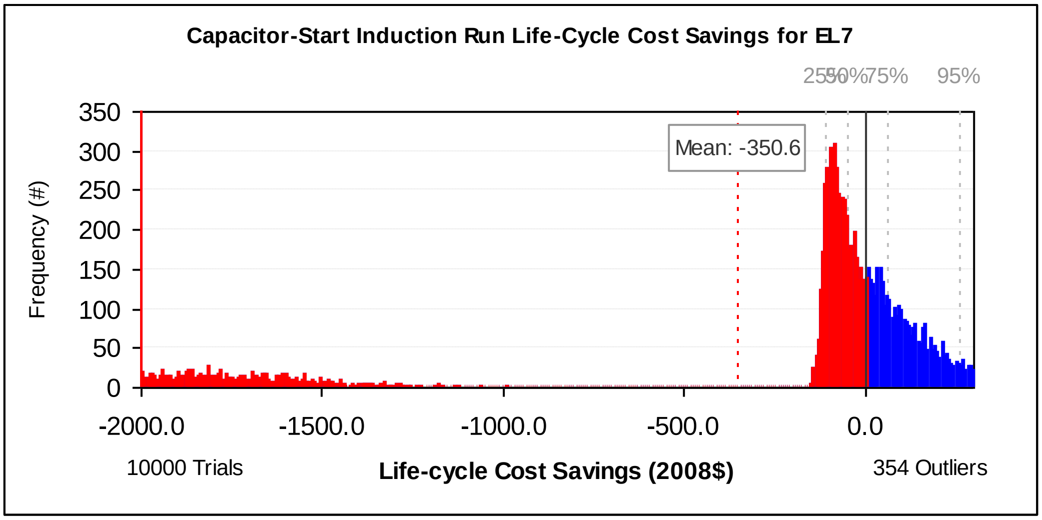

Figure 8.4.3 Capacitor-Start Induction-Run Motors: Distribution of Life-Cycle Cost Savings for Efficiency Level 7

Figure 8.4.4 is an example of a frequency chart showing the distribution of payback periods of efficiency level 7 for CSIR motors. While a majority of motors have a payback time less than 12 years, because of a significant fraction of motors with extremely high payback periods, the average of the distribution is nearly 100 years.

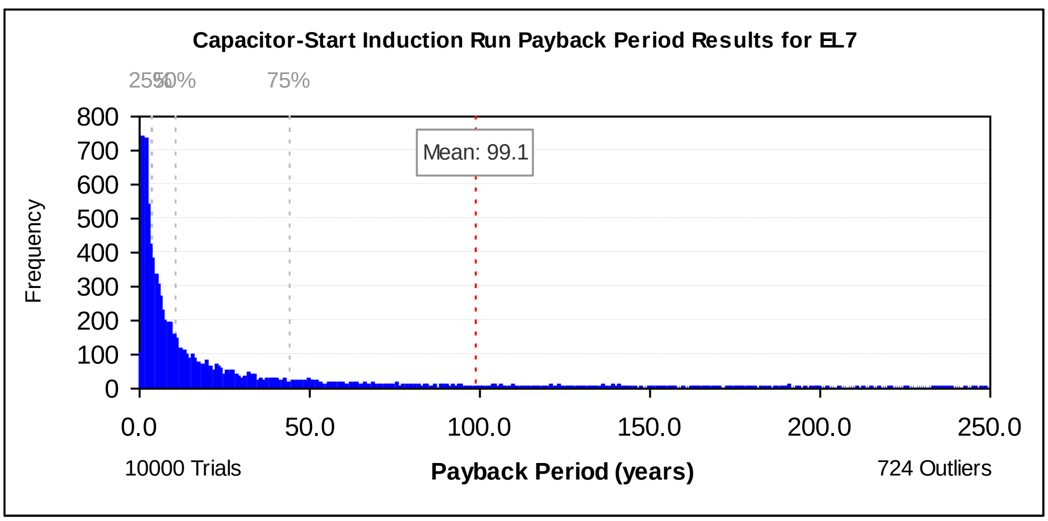

Figure 8.4.4 Capacitor-Start Induction-Run Motors: Distribution of Payback Periods for Efficiency Level 7

Table 8.4.2 summarizes the LCC and PBP results for CSIR motors based on a run of 10,000 Monte Carlo samples. The highest energy efficiency level with positive average LCC savings is level 6. However, approximately 55 percent of end users are estimated to have a net cost (i.e., LCC increase) at this level. The increase in average total installed cost at this level (relative to the base case) is $99, while annual operating costs decrease by $24.

Table 8.4.2 Capacitor-Start Induction-Run Motors: Life-Cycle Cost and Payback Period Results (Representative Product Class)

Energy Efficiency Level	Efficiency *%*	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period *years*	
		Average Installed Price *$*	Average Energy Use *kWh/yr*	Average Annual Operating Cost *$*	Average Life-Cycle Cost *$*	Average Savings *$*	Customers with			
							Net Cost *%*	Net Benefit *%*	Average	Median
Baseline	59.0	494	1,250	91	915					
1	62.2	502	1,170	85	896	19	27	73	8.6	2.7
2	64.5	508	1,116	81	884	31	28	72	8.8	2.8
3	66.7	511	1,064	77	869	46	24	76	7.5	2.3
4	71.5	529	976	71	857	58	32	68	10.5	3.2
5	72.7	549	951	69	868	47	42	58	15.1	4.7
6	74.0	593	920	67	902	13	55	45	24.9	7.2
7	78.4	996	860	63	1,285	-369	66	34	108.2	12.4

8.4.3 Capacitor-Start Capacitor-Run Motors

Figure 8.4.5 is an example of a frequency chart showing the distribution of LCC savings for the case of efficiency level 3 for CSCR motors. DOE can generate a frequency chart like the one shown in Figure 8.4.5 for every efficiency level.

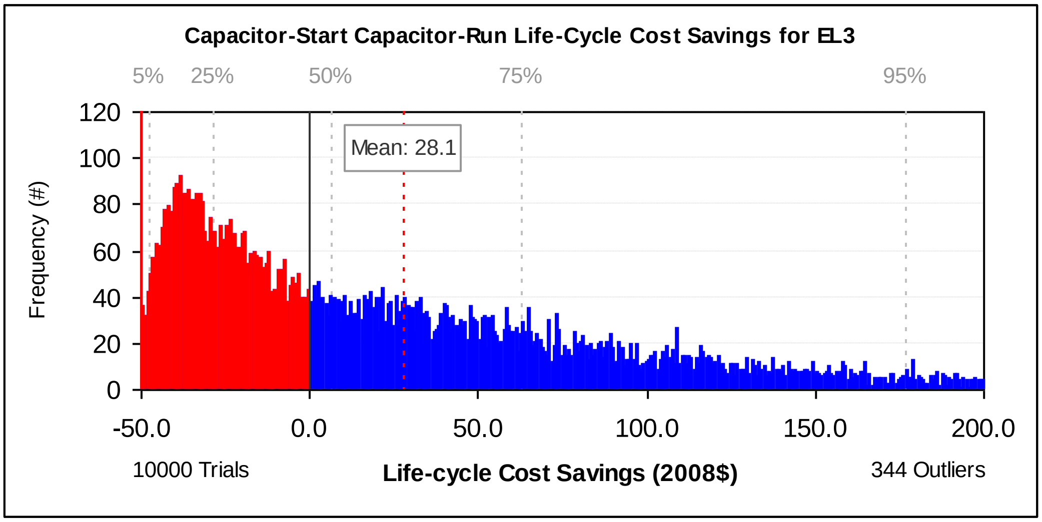

Figure 8.4.5 Capacitor-Start Capacitor-Run Motors: Distribution of Life-Cycle Cost Savings for Efficiency Level 3

Figure 8.4.6 is an example of a frequency chart showing the distribution of payback periods of efficiency level 3 for CSCR motors. DOE can generate a frequency chart like the one shown in Figure 8.4.6 for every efficiency level.

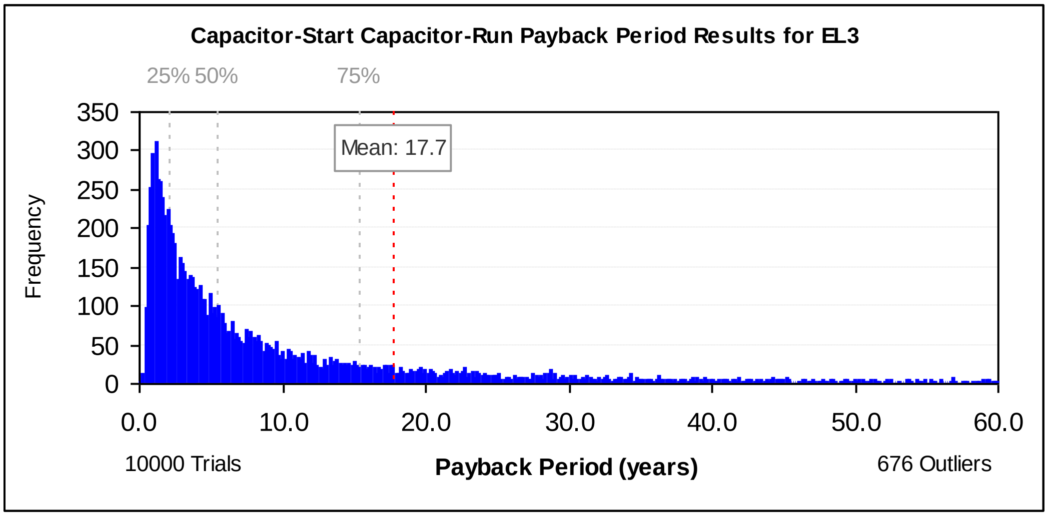

Figure 8.4.6 Capacitor-Start Capacitor-Run Motors: Distribution of Payback Periods for Efficiency Level 3

Table 8.4.3 summarizes the LCC and PBP results for CSCR motors based on a run of 10,000 Monte Carlo samples. The highest energy efficiency level with positive average LCC savings is level 4, 83.2 percent. Approximately 45 percent of end users are estimated to have a net benefit at this level. The increase in average total installed cost at this level (relative to the base case) is $64, while average annual operating costs decrease by $16.

Table 8.4.3 Capacitor-Start Capacitor-Run Motors: Life-Cycle Cost and Payback Period Results (Representative Product Class)

Energy Efficiency Level	Efficiency %	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period *years*	
		Average Installed Price *$*	Average Energy Use *kWh/yr*	Average Annual Operating Cost *$*	Average Life-Cycle Cost *$*	Average Savings *$*	Customers with			
							Net Cost *%*	Net Benefit *%*	Average	Median
Baseline	72.0	548	1,425	104	1,026					
1	75.7	559	1,360	99	1,014	12	36	64	13.4	4.3
2	80.0	587	1,250	91	1,005	21	46	54	18.5	5.8
3	82.2	599	1,205	88	1,002	24	48	52	19.1	5.9
4	83.2	612	1,214	88	1,015	11	55	45	24.4	7.8
5	84.5	630	1,201	88	1,029	-3	62	38	29.5	9.4
6	85.2	670	1,179	86	1,062	-36	70	30	40.3	11.8
7	87.1	697	1,146	84	1,078	-52	75	25	43.5	13.1
8	88.4	1,485	1,115	81	1,856	-830	99	1	250.0	49.0

8.5 LIFE CYCLE COSTS FOR ALL PRODUCT CLASSES

The Department's engineering analysis (chapter 5) along with the markups analysis (chapter 6) allowed the Department to develop a distribution of consumer purchase costs for each of the three representative product classes analyzed in detail in the engineering analysis. However, in order to present national impacts (chapter 10), examine the LCC results for other product classes (section 8.6), and to model the current market interplay between CSIR and CSCR motors, the Department developed a power-law-based scaling relation to estimate the costs of motors in other product classes. This scaling relation applies to the purchase cost of the motor, and not to installation costs (which DOE assumed were fixed and equal for all product classes).

The Department first used manufacturer catalog data to develop average list prices for each product class available for sale. DOE then fit the price of each combination of motor category and number of poles to a power law function of motor horsepower. That is, DOE developed a best-fit power law function for the prices of 4 pole CSIR motors, 6 pole polyphase motors, etc. The power law equations for each motor category take the following form:

$$\$(p, hp) = C(p) \times \$(4, hp_{ref}) \times \left(\frac{hp}{hp_{ref}} \right)^{\gamma(p,Cat)}$$

Where:

$\$(p, hp)$ = the purchase cost of an hp horsepower motor with p poles,
hp_{ref} = the horsepower of the motor analyzed by DOE in the engineering analysis for the equipment category (1 hp for polyphase, ¾ hp for CSCR, and ½ hp for CSIR),
$C(p)$ = the ratio of the purchase cost of an hp_{ref} horsepower motor with p poles to one with 4 poles, and
$\gamma(p, Cat)$ = the best-fit power law exponent to average list price data collected from manufacturer catalogs, for motors in category Cat with p poles.

The best-fit values for C and γ are given in Table 9.4.7. DOE did not calculate power law fit parameters (γ) for 2 pole CSCR or 6 pole CSCR motors because it determined that there were not enough published prices to derive an accurate scaling relation. Instead, DOE assigned the power law of the 4 pole CSCR motors to all CSCR classes, and used only C to match the average prices of ¾ hp CSCR motors with each number of poles. These scaling relations allow the Department to estimate the list prices of motors, such as small CSCR motors with 2 or 6 poles, not currently available from any manufacturer.

Table 8.5.1 Parameters for Motor Purchase Cost Model

	Polyphase	**CSIR**	**CSCR**
Six Poles			
$C(6, Cat)$ γ	1.2957 0.2492	1.5780 0.6746	1.3033 0.3646
Four Poles			
$C(4, Cat)$ γ	1.0000 0.3387	1.0000 0.5007	1.0000 0.3646
Two Poles			
$C(2, Cat)$ γ	0.9167 0.3442	0.8396 0.4494	0.7923 0.3646

Tables 9.4.8, 9.4.9, and 9.4.10 show the consumer purchase cost scaling relation derived from this model, where the value of 1.0 in each motor category is assigned to the motor examined in detail in the engineering analysis. Product classes in which there are no shipments under any of the Department's scenarios are marked with a dash in the tables.

Table 8.5.2 Polyphase Motor Consumer Cost Scaling Factors

Motor Power	**Six Poles**	**Four Poles**	**Two Poles**
1/4 hp	0.917	0.625	0.569
1/3 hp	0.985	0.689	0.628
1/2 hp	1.090	0.791	0.722
3/4 hp	1.206	0.907	0.830
1 hp	1.296	1.000	0.917
1 1/2 hp	1.433	1.147	1.054
2 hp	--	1.265	1.164
3 hp	--	1.451	1.338

Table 8.5.3 CSIR Motor Consumer Cost Scaling Factors

Motor Power	Six Poles	Four Poles	Two Poles
1/4 hp	0.989	0.707	0.615
1/3 hp	1.200	0.816	0.699
1/2 hp	1.578	1.000	0.840
3/4 hp	2.074	1.225	1.007
1 hp	2.519	1.415	1.146
1 1/2 hp	--	1.733	1.376
2 hp	--	2.002	1.565
3 hp	--	--	1.878

Table 8.5.4 CSCR Motor Consumer Cost Scaling Factors

Motor Power	Six Poles	Four Poles	Two Poles
1/4 hp	0.873	0.670	0.531
1/3 hp	0.969	0.744	0.589
1/2 hp	1.124	0.863	0.683
3/4 hp	1.303	1.000	0.792
1 hp	1.447	1.111	0.880
1 1/2 hp	--	1.288	1.020
2 hp	--	1.430	1.133
3 hp	--	--	1.313

The cost scaling relations described in Tables 8.5.2, 8.5.3, and 8.5.4, when combined with the loss scaling relations derived in Chapter 5, Engineering Analysis, allow the Department to analyze the life-cycle cost impacts due to potential standards on customers using motors in each product class. Appendix 8D provides these LCC results for every product class. These calculations also allow the Department to develop national shipment-weighted average LCC results for polyphase, CSIR, and CSCR motors. These results are presented in Tables 8.5.5, 8.5.6, and 8.5.7.

Table 8.5.5 Polyphase Motors: Life-Cycle Cost and Payback Period Results (National Shipment-Weighted Distribution)

Energy Efficiency Level	Efficiency %	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period *years*	
		Average Installed Price $	Average Energy Use *kWh/yr*	Average Annual Operating Cost $	Average Life-Cycle Cost $	Average Savings $	Customers with			
							Net Cost %	Net Benefit %	Average	Median
Baseline	78.8	515	1934	139.52	1,323					
1	80.6	528	1883	135.85	1,314	9	44.7	55.3	21.1	6.6
2	82.0	535	1836	132.45	1,302	22	39.2	60.8	17.2	5.3
3	83.4	547	1775	128.07	1,287	36	38.7	61.3	17.1	5.2
4	84.0	556	1759	126.91	1,289	34	42.7	57.3	19.6	6.0
4b	86.1	587	1678	121.06	1,288	36	49.2	50.8	23.9	7.3
5	87.6	651	1643	118.52	1,337	-13	63.2	36.8	39.1	11.5
6	88.4	707	1622	116.99	1,383	-60	74.8	25.2	51.8	15.7
7	89.7	1,465	1594	114.96	2,131	-808	96.2	3.8	220.4	47.8

Table 8.5.6 Capacitor-Start Induction-Run Motors: Life-Cycle Cost and Payback Period Results (National Shipment-Weighted Distribution)

Energy Efficiency Level	Efficiency %	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period *years*	
		Average Installed Price $	Average Energy Use *kWh/yr*	Average Annual Operating Cost $	Average Life-Cycle Cost $	Average Savings $	Customers with			
							Net Cost %	Net Benefit %	Average	Median
Baseline	49.9	496	1265	92.12	920					
1	53.2	504	1182	86.03	900	20	26.9	73.1	8.5	2.5
2	55.7	510	1125	81.89	888	33	27.7	72.3	8.7	2.6
3	58.1	513	1071	77.96	871	49	24.0	76.0	7.4	2.2
4	63.5	531	979	71.28	859	62	30.7	69.3	10.4	3.1
5	64.8	551	953	69.40	870	51	40.2	59.8	14.9	4.5
6	66.3	595	920	67.00	903	17	54.1	45.9	24.5	7.0
7	71.5	1,000	858	62.48	1,287	-367	65.1	34.9	104.4	11.7

Table 8.5.7 Capacitor-Start Capacitor-Run Motors: Life-Cycle Cost and Payback Period Results (National Shipment-Weighted Distribution)

Energy Efficiency Level	Efficiency %	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period *years*	
		Average Installed Price *$*	Average Energy Use *kWh/yr*	Average Annual Operating Cost *$*	Average Life-Cycle Cost *$*	Average Savings *$*	Customers with			
							Net Cost *%*	Net Benefit *%*	Average	Median
Baseline	73.2	582	2310	167.38	1,349					
1	76.7	594	2208	160.02	1,325	24	29.3	70.7	10.9	3.3
2	80.9	626	2036	147.55	1,299	50	38.4	61.6	14.9	4.4
3	83.0	639	1965	142.43	1,289	60	39.7	60.3	15.4	4.6
4	84.0	653	1979	143.43	1,304	45	46.1	53.9	19.8	5.9
5	85.2	673	1959	141.96	1,318	32	52.6	47.4	23.9	7.2
6	85.9	719	1923	139.37	1,351	-1	60.2	39.9	32.5	8.9
7	87.8	749	1873	135.72	1,364	-15	65.1	35.0	35.1	10.1
8	89.0	1,629	1824	132.17	2,228	-879	94.7	5.3	200.0	36.4

8.6 LIFE-CYCLE COST SENSITIVITY CALCULATIONS

DOE developed a number of sensitivity analyses in order to analyze the particular impacts of many inputs to its life-cycle cost analysis. These sensitivity analyses include lower and higher markups, lower and higher hours of motor operation, lower and higher motor loading, two models for including the cost of greenhouse gas emissions, variation in the starting year for the analysis, and three options for including the costs of reactive power. These sensitivities may also be combined with analysis of the LCC for each product class, or for a national shipment-weighted distribution, using the price scaling described in section 8.5 and the loss scaling described in chapter 5. Doe also developed the ability to report the distribution of customers with net costs and net benefits, including division into three categories for costs above a threshold fraction of life-cycle cost, benefits greater than a threshold fraction of life-cycle cost, and customers whose impact, whether positive or negative, falls below the user-selected threshold.

Tables 8.6.1 thorugh 8.6.3 shows an example of these sensitivity analyses. The data in the table corresponds to the case of low energy prices. This scenario uses energy prices which are loer than the AEO 2010 Early Release forecast values by the same ratio that the low energy price case of the AEO2009 March Release displays with the reference case energy prices. All three tables are calculated using the shipment-weighted product class distribution.

Table 8.6.1 Polyphase Motors: Low Energy Price Trend Scenario

Energy Efficiency Level	Efficiency	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period (years)	
		Average Installed Price	Average Annual Energy Use (KWh)	Average Annual Operating Cost	Average Life-Cycle Cost	Average Life-Cycle Cost Savings	Consumers with Net Cost (%)	Consumers with Net Benefit (%)	Average	Median
Base case	78.8%	$517	1940	$131.18	$1,278					
1	80.6%	$530	1889	$127.75	$1,270	$8	47.4%	52.6%	22.9	7.3
2	82.0%	$538	1842	$124.58	$1,259	$19	42.3%	57.7%	18.7	6.0
3	83.4%	$550	1782	$120.49	$1,246	$31	41.6%	58.4%	18.5	5.9
4	84.0%	$558	1766	$119.40	$1,249	$29	45.8%	54.2%	21.3	6.8
4B	86.1%	$590	1684	$113.93	$1,250	$28	52.3%	47.7%	25.9	8.2
5	87.6%	$655	1649	$111.56	$1,301	-$23	66.6%	33.4%	43.8	12.8
6	88.4%	$711	1628	$110.13	$1,348	-$71	77.6%	22.4%	57.0	17.8
7	89.7%	$1,487	1600	$108.24	$2,114	-$836	97.1%	3.0%	261.4	53.2

Table 8.6.2 Capacitor-Start Induction Run Motors: Low Energy Price Trend Scenario

Energy Efficiency Level	Efficiency	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period (years)	
		Average Installed Price	Average Annual Energy Use (KWh)	Average Annual Operating Cost	Average Life-Cycle Cost	Average Life-Cycle Cost Savings	Consumers with Net Cost (%)	Consumers with Net Benefit (%)	Average	Median
CSCR Base case	51.7%	$499	1139	$76.23	$850					
CSIR Base case	49.9%	$498	1283	$85.84	$895	$0	0.0%	0.0%	0.0	0.0
1	53.2%	$507	1198	$80.18	$878	$18	28.3%	71.7%	9.1	2.8
2	55.7%	$513	1141	$76.33	$866	$29	29.4%	70.6%	9.4	2.9
3	58.1%	$515	1086	$72.68	$851	$44	25.0%	75.1%	7.9	2.4
4	63.5%	$534	993	$66.47	$841	$55	33.0%	67.0%	11.1	3.4
5	64.8%	$554	967	$64.72	$852	$43	42.7%	57.3%	16.0	4.9
6	66.3%	$599	933	$62.50	$887	$8	57.4%	42.6%	26.0	7.7
7	71.5%	$1,013	870	$58.29	$1,282	-$387	68.1%	31.9%	107.1	13.4

Table 8.6.3 Capacitor-Start Capacitor Run Motors: Low Energy Price Trend Scenario

Energy Efficiency Level	Efficiency	Life-Cycle Cost				Life-Cycle Cost Savings		Payback Period (years)
		Average	Average	Average	Average	Average	Consumers	

		Installed Price	Annual Energy Use (KWh)	Annual Operating Cost	Life-Cycle Cost	Life-Cycle Cost Savings	with			
							Net Cost (%)	Net Benefit (%)	Average	Median
CSIR Base case	65.5%	$618	2732	$182.48	$1,467					
CSCR Base case	73.2%	$586	2349	$156.99	$1,313	$0	0.0%	0.0%	0.0	0.0
1	76.7%	$598	2246	$150.10	$1,291	$22	30.8%	69.2%	11.6	3.6
2	80.9%	$630	2071	$138.43	$1,269	$44	41.0%	59.0%	15.8	4.9
3	83.0%	$643	1999	$133.65	$1,260	$53	42.4%	57.6%	16.3	5.0
4	84.0%	$657	2014	$134.59	$1,275	$38	48.9%	51.2%	21.0	6.5
5	85.2%	$678	1993	$133.22	$1,289	$24	56.1%	43.9%	25.4	7.9
6	85.9%	$724	1957	$130.79	$1,324	-$11	64.3%	35.7%	34.1	9.9
7	87.8%	$755	1906	$127.37	$1,339	-$26	69.0%	31.0%	36.9	11.2
8	89.0%	$1,656	1856	$124.05	$2,224	-$911	95.5%	4.5%	204.9	41.5

As described in more details in chapters 9 and 10, DOE analyzed the market dynamics between CSIR and CSCR motors. In this context, it is illustrative to examine the LCC impacts of standards for customers who may switch for CSIR to CSCR motors of the same speed and horsepower, or vice versa. Table 8.6.4 shows the shipment-weighted average LCC results for the case baseline CSIR motor customers moving from a CSIR motor to a CSCR motor of each efficiency level.

Table 8.6.4 Capacitor-Start Small Electric Motors: Life-Cycle Cost and Payback Period Sensitivity Results for a Space-Constrained 0.5 hp, 4-pole CSCR Motor Customer with a CSIR Motor Baseline

Energy Efficiency Level	Efficiency %	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period *years*	
		Average Installed Price *$*	Average Energy Use *kWh/yr*	Average Annual Operating Cost *$*	Average Life-Cycle Cost *$*	Average Savings *$*	Customers with			
							Net Cost *%*	Net Benefit *%*	Average	Median
CSIR Base case	65.5	614	2688	196.05	1,520					
CSCR Base case	73.2	582	2311	168.63	1,358	162	4.1	95.9	9.1	2.6
1	76.7	594	2209	161.23	1,334	186	6.0	94.0	5.5	1.4
2	80.9	626	2037	148.67	1,307	213	11.8	88.2	5.1	1.0
3	83.0	640	1966	143.52	1,297	223	14.7	85.3	5.5	1.2
4	84.0	653	1981	144.54	1,312	208	18.9	81.1	7.1	1.8
5	85.2	674	1960	143.07	1,326	194	23.9	76.1	9.3	2.5
6	85.9	719	1925	140.45	1,359	161	33.3	66.8	13.4	3.3
7	87.8	749	1874	136.78	1,372	148	39.0	61.1	15.6	4.2
8	89.0	1,632	1825	133.21	2,238	-718	81.3	18.7	104.6	20.0

DOE used the results shown in Table 8.6.4, combined with the market share shifts forecast to occur under the Department's segmented market scenario (see section 9.4 for details on CSIR/CSCR market share shifts), to calculate the shipment-weighted average LCC results for 0.5 hp, 4-pole CSIR customers under each trial standard level. Table 8.6.5 shows these results.

Table 8.6.5 Capacitor-Start Induction-Run Motors: Shipment-Weighted Life-Cycle Cost and Payback Period Results for a 4-Pole One-Half Horsepower Motor with Switching to CSCR

Trial Standard Level	Life-Cycle Cost				Life-Cycle Cost Savings		
	Average Installed Price $	Average Energy Use kWh/yr	Average Annual Operating Cost	Average Life-Cycle Cost	Average Savings	Customers with Net Cost %	Customers with Net Benefit %
Baseline							
1	528	969	70.8	854	58	32.5	67.5
2	528	969	70.8	854	58	32.5	67.5
3	547	945	69.0	865	47	41.7	58.3
4	590	913	66.7	897	15	55.0	45.0
5	589	913	66.7	897	15	55.0	45.0
6	994	854	62.4	1,282	-370	66.0	34.0
7	601	863	63.1	891	23	53.7	46.3
8	633	847	61.9	917	-3	60.6	39.4

DOE has collected the results of each sensitivity analysis, applied individually, in Appendix 8C. The Department's life-cycle analysis and payback period spreadsheet tool is available for download via the Internet, and allows the user to examine the results for the sensitivity scenario of their choice.

8.6.2 Application Data Submitted by NEMA

In comments submitted following the NOPR stage of this rulemaking, the National Electrical Manufacturers Association (NEMA) submitted alternate versions of the data shown in Tables 9.2.1 and 9.2.2, based on a survey of Original Equipment Manufacturers (OEMs). These alternate tables are reproduced below, as Tables 8.6.1 and 8.6.2. This data submittal added a sixth motor application, Service Industry, and proposed that DOE should consider the cases in with 62% and 95% of applications ar space constrained. (According to NEMA, 62% of OEMs reported they would be negatively impacted if the motors they use change size at all; 95% reported that they face some sort of space constraint.) DOE used these data to develop alternate scenarios for the life-cycle cost analyses, and the results of these sensitivity scenarios (for shipment-weighted product class distributions) are presented in Tables 8.6.3 through 8.6.11.

Table 8.6.1 Application Shares by Equipment Type (NEMA)

		Equipment Category		
No.	**Application**	**Polyphase**	**CSIR**	**CSCR**
1	Air and gas compressors	45%	22%	45%
2	Conveyors	5%	2%	2%
3	General industrial machinery	7%	1%	1%
4	Industrial and commercial fans and blowers	23%	51%	29%
5	Pumps and pumping equipment	15%	13%	12%
6	Service Industry	5%	11%	11%
	TOTAL	100%	100%	100%

Table 8.6.2 Shares of Motor Owner Type by Application (NEMA)

		Motor Owner Type			
No.	**Application**	**Industrial**	**Commercial**	**Agricultural**	**Residential**
1	Air and gas compressors	0%	15%	15%	70%
2	Conveyors	65%	35%	0%	0%
3	General industrial machinery	80%	20%	0%	0%
4	Industrial and commercial fans and blowers	20%	80%	0%	0%
5	Pumps and pumping equipment	10%	40%	20%	30%
6	Service Industry	10%	80%	0%	10%

Table 8.6.3 Polyphase Motors: NEMA with 20% Space-Constrained

Energy Efficiency Level	Efficiency	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period (years)	
		Average Installed Price	Average Annual Energy Use (KWh)	Average Annual Operating Cost	Average Life-Cycle Cost	Average Life-Cycle Cost Savings	Consumers with			
							Net Cost	Net Benefit	Average	Median
Base case	78.8%	$515	1535	$127.89	$1,255					
1	80.6%	$527	1495	$124.51	$1,248	$7	58.8%	41.3%	35.1	13.3
2	82.0%	$535	1459	$121.56	$1,238	$17	55.4%	44.6%	29.6	11.3
3	83.4%	$546	1415	$117.94	$1,228	$27	55.4%	44.6%	30.3	11.6
4	84.0%	$555	1402	$116.87	$1,230	$25	58.4%	41.6%	34.7	13.3
4B	86.1%	$586	1344	$112.04	$1,235	$21	63.0%	37.0%	43.1	16.3
5	87.6%	$651	1316	$109.72	$1,285	-$30	71.6%	28.4%	70.7	25.3
6	88.4%	$707	1299	$108.28	$1,332	-$77	78.0%	22.0%	92.5	34.8

7	89.7%	$1,474	1276	$106.41	$2,090	-$835	94.8%	5.2%	405.8	102.6

Table 8.6.4 Polyphase Motors: NEMA with 62% Space-Constrained

Energy Efficiency Level	Efficiency	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period (years)	
		Average Installed Price	Average Annual Energy Use (KWh)	Average Annual Operating Cost	Average Life-Cycle Cost	Average Life-Cycle Cost Savings	Consumers with			
							Net Cost	Net Benefit	Average	Median
Base case	78.8%	$513	1550	$129.33	$1,260					
1	80.6%	$526	1509	$125.93	$1,252	$8	58.9%	41.1%	34.7	13.8
2	82.0%	$533	1474	$122.98	$1,242	$18	56.2%	43.8%	29.4	11.6
3	83.4%	$544	1430	$119.35	$1,232	$28	56.0%	44.0%	30.2	11.9
4	84.0%	$553	1417	$118.28	$1,235	$25	58.7%	41.3%	34.5	13.6
4B	86.1%	$584	1358	$113.38	$1,238	$22	62.5%	37.5%	42.8	16.8
5	87.6%	$706	1328	$110.89	$1,345	-$85	77.9%	22.1%	99.2	36.4
6	88.4%	$739	1312	$109.52	$1,369	-$110	80.9%	19.2%	108.4	42.1
7	89.7%	$2,557	1283	$107.10	$3,175	-$1,915	97.5%	2.5%	855.8	215.5

Table 8.6.5 Capacitor-Start Induction Run Motors: NEMA with 20% Space-Constrained

Energy Efficiency Level	Efficiency	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period (years)	
		Average Installed Price	Average Annual Energy Use (KWh)	Average Annual Operating Cost	Average Life-Cycle Cost	Average Life-Cycle Cost Savings	Consumers with			
							Net Cost	Net Benefit	Average	Median
CSCR Base case	51.7%	$498	1413	$118.04	$1,020					
CSIR Base case	49.9%	$498	1553	$129.71	$1,073	$0	0.0%	0.0%	0.0	0.0
1	53.2%	$506	1459	$121.90	$1,047	$26	28.9%	71.1%	10.1	1.9
2	55.7%	$512	1394	$116.51	$1,029	$44	29.6%	70.4%	10.4	2.0
3	58.1%	$515	1335	$111.52	$1,009	$64	26.5%	73.5%	8.8	1.7
4	63.5%	$533	1229	$102.68	$988	$86	31.9%	68.2%	12.3	2.4
5	64.8%	$553	1201	$100.34	$997	$76	38.2%	61.8%	17.7	3.4
6	66.3%	$598	1164	$97.28	$1,029	$45	48.4%	51.7%	29.0	5.3
7	71.5%	$1,010	1092	$91.31	$1,414	-$341	58.7%	41.3%	122.8	10.9

Table 8.6.6 Capacitor-Start Induction Run Motors: NEMA with 62% Space-Constrained

Energy Efficiency Level	Efficiency	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period (years)	
		Average Installed Price	Average Annual Energy Use (KWh)	Average Annual Operating Cost	Average Life-Cycle Cost	Average Life-Cycle Cost Savings	Consumers with		Average	Median
							Net Cost	Net Benefit		
CSCR Base case	51.7%	$495	1411	$118.75	$1,018					
CSIR Base case	49.9%	$495	1546	$130.21	$1,070	$0	0.0%	0.0%	0.0	0.0
1	53.2%	$503	1453	$122.35	$1,043	$27	29.7%	70.3%	10.1	2.0
2	55.7%	$510	1389	$116.93	$1,025	$44	30.4%	69.6%	10.4	2.1
3	58.1%	$512	1329	$111.91	$1,005	$65	27.2%	72.9%	8.8	1.7
4	63.5%	$535	1219	$102.64	$987	$82	35.0%	65.0%	13.8	2.7
5	64.8%	$547	1193	$100.43	$990	$80	38.6%	61.4%	16.7	3.3
6	66.3%	$632	1160	$97.62	$1,062	$8	56.7%	43.3%	40.0	7.6
7	71.5%	$1,820	1081	$90.98	$2,220	-$1,150	81.0%	19.0%	315.8	41.0

Table 8.6.7 Capacitor-Start Induction Run Motors: NEMA with 95% Space-Constrained

Energy Efficiency Level	Efficiency	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period (years)	
		Average Installed Price	Average Annual Energy Use (KWh)	Average Annual Operating Cost	Average Life-Cycle Cost	Average Life-Cycle Cost Savings	Consumers with		Average	Median
							Net Cost	Net Benefit		
CSCR Base case	51.7%	$495	1414	$119.01	$1,019					
CSIR Base case	49.9%	$495	1551	$130.47	$1,071	$0	0.0%	0.0%	0.0	0.0
1	53.2%	$504	1457	$122.61	$1,045	$27	30.4%	69.6%	10.2	1.9
2	55.7%	$510	1393	$117.18	$1,027	$44	31.1%	69.0%	10.5	2.0
3	58.1%	$512	1333	$112.17	$1,007	$65	28.1%	71.9%	8.9	1.7
4	63.5%	$539	1219	$102.58	$992	$80	37.0%	63.0%	15.3	2.9
5	64.8%	$545	1195	$100.49	$988	$83	37.8%	62.2%	16.2	3.1
6	66.3%	$662	1164	$97.88	$1,093	-$22	62.9%	37.1%	49.3	9.4
7	71.5%	$2,466	1079	$90.74	$2,865	-$1,794	97.5%	2.5%	473.9	85.7

Table 8.6.8 Polyphase Motors: NEMA with 95% Space-Constrained

Energy Efficiency Level	Efficiency	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period (years)	
		Average Installed Price	Average Annual Energy Use (KWh)	Average Annual Operating Cost	Average Life-Cycle Cost	Average Life-Cycle Cost Savings	Consumers with Net Cost	Consumers with Net Benefit	Average	Median
Base case	78.8%	$512	1524	$124.15	$1,237					
1	80.6%	$525	1483	$120.87	$1,230	$7	59.2%	40.8%	34.2	14.0
2	82.0%	$532	1448	$118.01	$1,220	$17	56.4%	43.6%	28.9	11.7
3	83.4%	$544	1405	$114.49	$1,211	$26	56.2%	43.9%	29.7	11.9
4	84.0%	$552	1392	$113.46	$1,213	$24	59.3%	40.7%	33.9	13.7
4B	86.1%	$583	1333	$108.67	$1,217	$21	63.1%	36.9%	42.0	16.7
5	87.6%	$750	1302	$106.14	$1,369	-$132	84.3%	15.7%	120.6	47.3
6	88.4%	$765	1287	$104.87	$1,376	-$139	84.2%	15.8%	119.8	47.5
7	89.7%	$3,418	1253	$102.13	$4,014	-$2,777	99.6%	0.4%	1,205.3	457.9

Table 8.6.9 Capacitor-Start Capacitor Run Motors: NEMA with 20% Space-Constrained

Energy Efficiency Level	Efficiency	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period (years)	
		Average Installed Price	Average Annual Energy Use (KWh)	Average Annual Operating Cost	Average Life-Cycle Cost	Average Life-Cycle Cost Savings	Consumers with Net Cost	Consumers with Net Benefit	Average	Median
CSIR Base case	65.5%	$617	2205	$186.66	$1,480					
CSCR Base case	73.2%	$584	1931	$163.54	$1,336	$0	0.0%	0.0%	0.0	0.0
1	76.7%	$596	1845	$156.22	$1,312	$24	44.2%	55.8%	17.7	6.4
2	80.9%	$628	1718	$145.54	$1,294	$42	54.0%	46.0%	26.5	9.4
3	83.0%	$641	1664	$140.99	$1,286	$50	55.5%	44.5%	27.5	9.7
4	84.0%	$655	1665	$141.02	$1,297	$39	58.4%	41.6%	33.9	12.2
5	85.2%	$676	1647	$139.51	$1,311	$25	62.5%	37.5%	40.9	14.8
6	85.9%	$722	1623	$137.47	$1,347	-$11	68.0%	32.0%	56.2	18.7
7	87.8%	$752	1583	$134.08	$1,362	-$26	70.6%	29.4%	60.8	20.8
8	89.0%	$1,647	1550	$131.29	$2,243	-$907	93.6%	6.4%	347.7	79.1

Table 8.6.10 Capacitor-Start Capacitor Run Motors: NEMA with 62% Space-Constrained

Energy Efficiency Level	Efficiency	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period (years)	
		Average Installed Price	Average Annual Energy Use (KWh)	Average Annual Operating Cost	Average Life-Cycle Cost	Average Life-Cycle Cost Savings	Consumers with Net Cost	Consumers with Net Benefit	Average	Median
CSIR Base case	65.5%	$610	2196	$186.01	$1,455					
CSCR Base case	73.2%	$579	1919	$162.59	$1,314	$0	0.0%	0.0%	0.0	0.0
1	76.7%	$590	1833	$155.29	$1,290	$23	44.2%	55.8%	17.2	6.6
2	80.9%	$627	1711	$144.94	$1,280	$34	57.3%	42.7%	29.6	11.2
3	83.0%	$640	1662	$140.80	$1,273	$41	57.8%	42.3%	30.1	11.4
4	84.0%	$651	1656	$140.33	$1,279	$35	59.2%	40.8%	34.4	13.1
5	85.2%	$669	1642	$139.11	$1,292	$21	63.0%	37.1%	41.1	15.6
6	85.9%	$778	1608	$136.24	$1,388	-$74	76.1%	23.9%	79.7	27.6
7	87.8%	$800	1568	$132.90	$1,395	-$81	76.6%	23.4%	78.9	28.3
8	89.0%	$2,851	1535	$130.09	$3,433	-$2,120	96.9%	3.1%	731.0	177.0

Table 8.6.11 Capacitor-Start Capacitor Run Motors: NEMA with 95% Space-Constrained

Energy Efficiency Level	Efficiency	Life-Cycle Cost				Life-Cycle Cost Savings			Payback Period (years)	
		Average Installed Price	Average Annual Energy Use (KWh)	Average Annual Operating Cost	Average Life-Cycle Cost	Average Life-Cycle Cost Savings	Consumers with Net Cost	Consumers with Net Benefit	Average	Median
CSIR Base case	65.5%	$612	2138	$179.93	$1,449					
CSCR Base case	73.2%	$579	1866	$157.17	$1,307	$0	0.0%	0.0%	0.0	0.0
1	76.7%	$591	1782	$150.14	$1,284	$23	44.4%	55.6%	17.6	6.7
2	80.9%	$632	1666	$140.32	$1,280	$27	59.9%	40.1%	33.1	12.4
3	83.0%	$644	1622	$136.63	$1,273	$33	59.6%	40.4%	33.2	12.5
4	84.0%	$653	1612	$135.80	$1,275	$31	59.7%	40.3%	36.0	13.7
5	85.2%	$671	1601	$134.86	$1,289	$18	63.8%	36.2%	42.7	16.2
6	85.9%	$831	1559	$131.38	$1,433	-$127	83.0%	17.0%	102.6	38.1
7	87.8%	$847	1521	$128.17	$1,434	-$127	81.8%	18.3%	97.1	36.1
8	89.0%	$3,841	1489	$125.42	$4,417	-$3,110	99.6%	0.4%	1,085.2	388.6

8.7 REBUTTABLE PAYBACK PERIOD

A more energy efficient motor will usually cost more to buy than a motor of standard energy efficiency. However, the more efficient motor will usually cost less to operate due to reductions in operating costs (i.e., lower energy bills). The PBP is the time (usually expressed in years) it takes to recover the additional installed cost of the more efficient motor through energy cost savings. EPCA provides a rebuttable presumption that, in essence, an energy conservation standard is economically justified if the increased purchase cost for a product that meets the standard is less than three times the value of the first-year energy savings resulting from the standard. However, DOE routinely conducts a full economic analysis that considers the full range of impacts, including those to the customer, manufacturer, Nation, and environment, as required under 42 U.S.C. 6295(o)(2)(B)(i) and 42 U.S.C. 6316(e)(1). The results of this analysis serve as the basis for DOE to evaluate definitively the economic justification for a potential standard level (thereby supporting or rebutting the results of any preliminary determination of economic justification).

The results of DOE's rebuttable payback period calculations are shown in Tables 8.5.1 and 8.5.2 below.

Table 8.7.1 Rebuttable Presumption Payback for Polyphase Motors

TSL	Payback Period *years*
1	3.3
2	3.0
3	3.3
4	3.8
4b	4.9
5	7.9
6	10.2
7	45.7

Table 8.7.2 Rebuttable Presumption Payback for Capacitor-Start Motors

TSL	Induction-Run (1/2 hp, 4 poles)		Capacitor-Run (3/4 hp 4 poles)	
	CSIR Efficiency Level	Payback Period *years*	CSCR Efficiency Level	Payback Period *years*
1	4	1.7	2	1.5
2	4	1.7	3	2.7
3	5	2.5	3	2.7
4	6	4.1	4	3.3
5	6	4.1	3	2.7
6	7	17.7	8	35.5
7	7	17.7	3	2.7
8	7	17.7	7	6.0

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