CHAPTER 11. LIFE-CYCLE COST SUBGROUP ANALYSIS

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CHAPTER 11. LIFE-CYCLE COST SUBGROUP ANALYSIS

11.1 INTRODUCTION

Chapter 8 describes the life-cycle cost (LCC) and payback period (PBP) analysis that examines impacts of energy conservation standards on purchasers of the affected products. In analyzing the potential impact of new or amended standards on residential, industrial, and commercial customers, DOE further evaluates the impact on identifiable groups of customers (i.e., subgroups) that may be disproportionately affected by a national standard level. The LCC subgroup analysis evaluates impacts by analyzing the LCC and PBPs for subgroups of customers. For its analysis of small electric motors, DOE identified three customer subgroups: small businesses and customers with and without space constraints restricting their choice of motor.

Because DOE did not conduct its LCC and PBP analysis with a sample of small motor users, it did not develop specific subgroup samples for the subgroup analysis. Instead, it varied certain inputs to the LCC and PBP calculations in order to approximate the impacts of potential standards on the considered subgroups. This chapter describes the subgroup analysis in further detail and gives the results of the LCC and PBP analyses for the considered subgroups.

11.2 SMALL ELECTRIC MOTOR CUSTOMER SUBGROUPS

DOE considered three subgroups for the LCC and PBP analyses for small electric motors: (1) customers facing space constraints in their motor installation, (2) customers without space constraints in their motor installation, and (3) small businesses.

For customers with space constraints, DOE analyzed the potential impacts of standards by conducting the analysis with motor designs constrained to a stack length increase of 20% or less. For customers without space constraints, DOE analyzed the potential impacts of standards by conducting the analysis with motor designs constrained to a stack length increase of 100% or less. For small businesses, DOE analyzed the potential impacts of standards by conducting the analysis with different discount rates, as small businesses do not have the same access to capital as larger businesses.

11.2.1 Inputs to the Subgroup Analysis for Customers with and without Space Constraints

One of the more cost-effective ways to increase motor efficiency is by increasing the motor stack length. However, many motor users face space constraints, which restrict their ability to replace existing motors with much longer, more efficient, designs. The Department's engineering analysis produced motor designs that meet space constraints by restricting stack length increases to 20% or less. The Department also analyzed designs in which the stack length was free to increase up to 100% (effectively an unconstrained stack length increase).

DOE assumed that 20% of customers face space constraints in order to develop national average LCC results in chapter 8. For its space-constrained customer subgroup analysis, DOE used its LCC spreadsheet tool, but selected only customers who face space constraints. For its non-space-constrained customer subgroup analysis, DOE selected only customers who do not face space constraints. These customers use the same motor designs at low energy efficiency levels (where all designs the Department considered have stack length increases of less than 20%), but constrained designs become distinct at efficiency level (EL) 4b for polyphase, EL 6 for CSIR, and EL 2 for CSCR. Generally, these space-constrained designs cost more than less constrained designs to achieve the same efficiency.

11.2.2 Inputs to the Subgroup Analysis for Small Businesses

The Small Business Administration (SBA) defines a small business by its annual receipts or its number of employees. Small motors are used throughout the U.S. economy, so DOE did not assign a different distribution of motor applications or sectors of the economy to this subgroup.

To calculate discount rates for small companies that purchase small electric motors, DOE used the same methodology as for the general population of small electric motor customers as presented in chapter 8.[a] Although the methodology is appropriate, the capital asset pricing model (CAPM)[b] described in chapter 8 for the general population underestimates the cost of capital for small companies. In CAPM, the risk premium β is used to account for the higher returns associated with greater risk. However, for small companies, particularly very small companies, historic returns have been significantly higher than the CAPM equation predicts. This additional return can be accounted for by adding a size premium to the cost of equity for small firms:

$$k_e = R_f + (\beta \times ERP) + S$$

k_e = Cost of equity,
R_f = Expected return on risk-free assets,
β = Risk coefficient of the firm,
ERP = Equity risk premium, and
S = Size Premium.

DOE obtained size premium data from Ibbotson Associates' *Stocks, Bonds, Bills, and Inflation 2007 Yearbook*.[1] For the period of 1926–2006, the average size premium for the smallest companies in all industries is 6.27 percent, implying that on average, historic

[a] DOE assumed that small businesses as a whole are a reasonable approximation for small businesses which use small electric motors.
[b] See 8.2.4.3 for more extensive description of CAPM and its parameters.

performance of small companies has been 6.27 percent higher than the CAPM estimate of the small company cost of equity.[c]

DOE calculated the real weighted average cost of capital (as described in chapter 8) using the cost of equity including a size premium for small companies instead of the CAPM cost of equity. DOE estimates that in industries that purchase small electric motors, small companies have an average discount rate 4.2 percent higher than the industry average. This conclusion is supported by the similar difference (3.8 percent) between small and average company discount rates for the entire market based on data from Damodaran[d, 2] (see Table 11.2.1).

Table 11.2.1 Discount Rate Difference Between Small Company and Market Average

	Discount Rate		
Sector	**Average**	**Std Dev**	**Difference**
Entire Market	6.3%	2.3%	--
Small Company	10.2%	3.3%	3.8%

In chapter 8, DOE estimated the average discount rate for both industrial and commercial customers to be 5.9 percent. Applying the additional small capitalization (small cap) discount rate premium of 4.2 percent presented above to these discount rates for businesses that purchase small electric motors, the average discount rate for small industrial and commercial companies is approximately 10.1 percent.

11.3 RESULTS FOR SMALL ELECTRIC MOTOR SUBGROUPS

Tables 11.3.1 through 11.3.3 summarize the polyphase small electric motor results for customers with and without space-constrained applications and those that are small businesses. Tables 11.3.4 through 11.3.6 summarize the capacitor-start induction-run small electric motor results for the same subgroup types, while Tables 11.3.7 - 11.3.9 summarize the capacitor-start capacitor-run small electric motor results. For the eight energy efficiency levels for polyphase motors, seven energy efficiency levels for CSIR motors, and the eight energy efficiency levels for CSCR motors, the tables provide the average or mean LCC, the LCC savings or costs relative to the base case, and the percentage of customers that are burdened with net costs or realize net savings. The mean and median payback periods are also provided. The LCC results presented here are national averages based on the current distribution of shipments among motors of different sizes, for each motor type.

LCC results for space-constrained and non-space-constrained customers are different in the following tables even at efficiency levels below the level at which the motor designs differ, due to randomness resulting from the Monte Carlo sampling method.

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[c] In this calculation, small companies are defined as companies with market capitalization of less than or equal to $84.5 million, the Ibbotson Associates' definition of Decile 10 companies.

[d] The Damodaran database for the entire market used for this analysis includes 6559 companies, 2605 of which are small companies.

In general, the benefits of moving to a higher efficiency are less in the case of the small business subgroups than in the overall sample. Space-constrained users achieve substantially lower LCC savings at high efficiency levels, where space constraints result in significantly different motor designs, technology, materials, and costs than unconstrained motors. Non-space constrained customers receive greater benefits (or lower burdens) than the overall sample, consistent with their lower incremental cost of efficiency.

Table 11.3.1 Polyphase Small Electric Motors: LCC and PBP Results for Space-Constrained Customers

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		
Baseline	78.8%	$512	1903	$140.60	$1,318					
1	80.6%	$524	1853	$136.90	$1,308	$9	45.6%	54.4%	21.5	6.8
2	82.0%	$531	1807	$133.49	$1,296	$22	40.2%	59.8%	17.5	5.5
3	83.4%	$543	1748	$129.13	$1,282	$36	39.6%	60.4%	17.4	5.4
4	84.0%	$552	1732	$127.96	$1,284	$34	43.7%	56.3%	20.0	6.3
4B	86.1%	$582	1650	$121.98	$1,280	$37	49.7%	50.3%	24.2	7.5
5	87.6%	$756	1610	$119.00	$1,437	-$120	84.8%	15.2%	71.8	22.3
6	88.4%	$769	1590	$117.55	$1,441	-$123	84.3%	15.7%	70.7	22.1
7	89.7%	$3,548	1543	$114.11	$4,201	-$2,883	100.0%	0.0%	728.2	226.0

Table 11.3.2 Polyphase Small Electric Motors: LCC and PBP Results for Non-Space-Constrained Customers

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		
Baseline	78.8%	$516	1888	$137.84	$1,308					
1	80.6%	$529	1838	$134.21	$1,299	$9	46.3%	53.7%	22.0	6.9
2	82.0%	$536	1792	$130.85	$1,287	$21	41.2%	58.8%	18.0	5.6
3	83.4%	$548	1733	$126.54	$1,274	$34	40.6%	59.4%	17.9	5.5
4	84.0%	$556	1718	$125.39	$1,276	$32	44.7%	55.4%	20.6	6.3
4B	86.1%	$588	1639	$119.67	$1,275	$33	50.8%	49.2%	25.2	7.7
5	87.6%	$625	1606	$117.26	$1,298	$10	59.8%	40.2%	33.6	10.3
6	88.4%	$691	1585	$115.72	$1,355	-$47	72.9%	27.1%	50.1	15.4
7	89.7%	$948	1563	$114.07	$1,604	-$296	95.1%	4.9%	114.5	35.3

Table 11.3.3 Polyphase Small Electric Motors: LCC and PBP Results for Small Companies

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
Baseline	78.8%	$516	1888	$137.84	$1,192					
1	80.6%	$529	1838	$134.21	$1,186	$6	51.9%	48.1%	22.0	6.9
2	82.0%	$536	1792	$130.85	$1,177	$15	46.1%	54.0%	18.0	5.6
3	83.4%	$548	1733	$126.54	$1,167	$25	45.5%	54.5%	17.9	5.5
4	84.0%	$556	1718	$125.39	$1,170	$22	49.7%	50.3%	20.6	6.3
4B	86.1%	$588	1639	$119.63	$1,174	$18	56.5%	43.5%	25.1	7.7
5	87.6%	$652	1604	$117.13	$1,226	-$34	69.6%	30.4%	41.8	12.2
6	88.4%	$708	1584	$115.60	$1,274	-$82	80.2%	19.9%	54.7	16.7
7	89.7%	$1,460	1557	$113.63	$2,017	-$825	97.4%	2.6%	243.1	50.2

Table 11.3.4 Capacitor-Start Induction-Run Small Electric Motors: LCC and PBP Results for Space-Constrained Customers

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
Baseline	49.9%	$494	1274	$92.66	$923					
1	53.2%	$503	1190	$86.56	$903	$20	26.7%	73.3%	8.5	2.6
2	55.7%	$509	1133	$82.42	$890	$33	27.5%	72.5%	8.8	2.6
3	58.1%	$511	1079	$78.48	$873	$49	23.6%	76.4%	7.5	2.2
4	63.5%	$539	976	$71.00	$867	$56	37.2%	62.8%	12.9	3.9
5	64.8%	$544	955	$69.45	$864	$58	38.0%	62.0%	13.4	4.0
6	66.3%	$665	925	$67.28	$976	-$53	74.0%	26.0%	42.3	12.6
7	71.5%	$2,559	848	$61.68	$2,843	-$1,921	100.0%	0.0%	418.9	124.7

Table 11.3.5 Capacitor-Start Induction-Run Small Electric Motors: LCC and PBP Results for Non-Space-Constrained Customers

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
Baseline	49.9%	$497	1261	$91.33	$921					
1	53.2%	$506	1178	$85.28	$901	$20	27.8%	72.2%	8.5	2.6
2	55.7%	$512	1121	$81.16	$888	$33	28.5%	71.5%	8.7	2.7
3	58.1%	$514	1067	$77.25	$872	$49	24.4%	75.6%	7.4	2.3
4	63.5%	$530	978	$70.82	$858	$63	30.6%	69.4%	9.8	3.0
5	64.8%	$554	952	$68.86	$872	$49	41.5%	58.5%	15.3	4.7
6	66.3%	$579	918	$66.43	$887	$34	49.5%	50.5%	20.0	6.1
7	71.5%	$618	860	$62.20	$906	$15	56.5%	43.5%	25.1	7.7

Table 11.3.6 Capacitor-Start Induction-Run Small Electric Motors: LCC and PBP Results for Small Companies

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
Baseline	49.9%	$497	1261	$91.33	$869					
1	53.2%	$506	1178	$85.28	$852	$16	31.3%	68.7%	8.5	2.6
2	55.7%	$512	1121	$81.16	$842	$27	32.4%	67.6%	8.7	2.7
3	58.1%	$514	1067	$77.25	$828	$41	28.0%	72.0%	7.4	2.3
4	63.5%	$533	976	$70.63	$819	$50	35.8%	64.2%	10.4	3.2
5	64.8%	$553	950	$68.75	$832	$37	45.3%	54.7%	14.9	4.6
6	66.3%	$597	917	$66.37	$866	$3	58.6%	41.4%	24.7	7.1
7	71.5%	$995	855	$61.89	$1,246	-$377	68.5%	31.5%	108.4	11.9

Table 11.3.7 Capacitor-Start Capacitor-Run Small Electric Motors: LCC and PBP Results for Space-Constrained Customers

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		
Baseline	73.2%	$579	2313	$167.74	$1,355					
1	76.7%	$591	2212	$160.38	$1,331	$24	29.2%	70.8%	10.9	3.3
2	80.9%	$633	2053	$148.85	$1,320	$35	47.4%	52.6%	19.0	5.8
3	83.0%	$645	1998	$144.88	$1,312	$43	47.2%	52.8%	19.2	5.9
4	84.0%	$653	1991	$144.36	$1,316	$40	49.3%	50.7%	21.1	6.5
5	85.2%	$671	1981	$143.61	$1,330	$26	55.4%	44.6%	25.3	7.8
6	85.9%	$839	1914	$138.80	$1,476	-$121	84.3%	15.7%	60.1	18.4
7	87.8%	$854	1862	$135.02	$1,473	-$118	82.5%	17.5%	56.3	17.1
8	89.0%	$3,992	1815	$131.61	$4,597	-$3,242	100.0%	0.0%	634.4	193.1

Table 11.3.8 Capacitor-Start Capacitor-Run Small Electric Motors: LCC and PBP Results for Non-Space-Constrained Customers

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		
Baseline	73.2%	$586	2339	$169.80	$1,369					
1	76.7%	$598	2236	$162.36	$1,345	$24	29.8%	70.2%	10.8	3.3
2	80.9%	$628	2059	$149.51	$1,314	$55	37.2%	62.8%	13.9	4.2
3	83.0%	$641	1984	$144.05	$1,303	$67	39.0%	61.0%	14.5	4.3
4	84.0%	$657	2003	$145.45	$1,322	$48	45.7%	54.4%	19.4	5.9
5	85.2%	$678	1980	$143.78	$1,335	$34	52.3%	47.7%	23.5	7.1
6	85.9%	$693	1952	$141.72	$1,340	$29	54.8%	45.3%	25.4	7.7
7	87.8%	$727	1902	$138.07	$1,358	$12	60.8%	39.2%	29.6	9.0
8	89.0%	$1,049	1852	$134.45	$1,663	-$293	93.6%	6.4%	87.6	26.3

Table 11.3.9 Capacitor-Start Capacitor-Run Small Electric Motors: LCC and PBP Results for Small Companies

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
Baseline	73.2%	$586	2339	$169.80	$1,273					
1	76.7%	$598	2236	$162.36	$1,253	$20	33.6%	66.4%	10.8	3.3
2	80.9%	$630	2062	$149.73	$1,234	$39	43.4%	56.6%	15.0	4.4
3	83.0%	$643	1991	$144.55	$1,226	$47	44.7%	55.3%	15.5	4.6
4	84.0%	$657	2005	$145.59	$1,241	$32	51.1%	48.9%	19.7	6.0
5	85.2%	$678	1985	$144.09	$1,256	$17	58.0%	42.0%	23.9	7.3
6	85.9%	$723	1949	$141.51	$1,290	-$17	65.1%	34.9%	32.8	9.1
7	87.8%	$754	1898	$137.82	$1,306	-$33	69.7%	30.4%	35.4	10.2
8	89.0%	$1,633	1849	$134.23	$2,171	-$898	96.0%	4.0%	205.3	37.3

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