CHAPTER 6. MARKUPS ANALYSIS

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6.1 INTRODUCTION

This chapter of the technical support document (TSD) presents the U.S. Department of Energy's (DOE's) method for deriving electric motor prices. The objective of the equipment price determination is to estimate the price paid by the customer or purchaser for an installed electric motor. Purchase price and installation cost are necessary inputs to the life-cycle cost (LCC) and payback period (PBP) analyses. Chapter 8 presents the LCC calculations; section 8.2.1 describes how the LCC uses purchase price and installation cost as inputs.

Purchase prices for electric motors are not generally known. Electric motors are often sold as part of a project, sometimes custom-built with unlisted prices. The engineering analysis (Chapter 5) provides the manufacturer selling prices (MSPs) for the representative units included in the LCC analysis. DOE derived a set of prices, for each electric motor representative unit produced by the engineering analysis, by applying markups to the manufacturer selling price in the form of markup equations.

6.1.1 Distribution Channels

The appropriate markups for determining the end-user equipment price depend on the type of distribution channels through which equipment moves from manufacturers to purchasers. At each point in the distribution channel, companies mark up the price of the equipment to cover their business costs and profit margin.

Distribution channels vary depending on the size of the electric motor. Because smaller electric motors used as components in larger pieces of equipment constitute the majority of the market, much of the market passes through original equipment manufacturers (OEMs) who design, assemble, and brand equipment that contain electric motors. OEMs in turn obtain their motors either directly from the motor manufacturers or from manufacturers via distributors. In larger horsepower ranges (more than 50 horsepower), direct sales to the end-user and sales to contractors become more significant.

Based on market research[1] and input from interested parties, DOE identified six main distribution channels for electric motors and estimated their respective shares of shipments per electric motor horsepower range. The six channels are from the manufacturer to:

(1) OEMs and then to end-users (50 percent of sales);
(2) distributors to end-users (24 percent of sales);
(3) distributors to OEM and then to end-users (23 percent of sales);
(4) contractors and then to end-users (less than one percent of sales);
(5) distributors to end-users through contractors (less than one percent of sales); and
(6) end-users (less than two percent of sales).

Other distribution channels exist (e.g., from manufacturer to OEMs, to end-users through distributors) but are estimated to account for a minor share of the motor sales (less than one percent).

In addition to these distribution chain markups, DOE estimated the shipping costs of the motors and added these to the end-user equipment prices. These costs are a significant factor because more efficient motors are often larger and heavier than less efficient motors, so this is a cost that needs to be included in an accurate cost analysis.

6.2 MARKUP CALCULATION METHODOLOGY

As addressed above, at each point in the distribution channel, companies mark up the price of the equipment to cover their business costs and profit margin. In financial statements, gross margin is the difference between the company revenue and the company cost of sales or cost of goods sold (CGS). Inputs for calculating the gross margin are all corporate costs, including: overhead costs (sales, general, and administration), research and development (R&D), interest expenses, depreciation, taxes, and profits. For sales of equipment to contribute positively to company cash flow, the markup of the equipment must be greater than the corporate gross margin. Individual pieces of equipment may command a lower or higher markup, depending on their perceived added value and the competition they face from similar equipment in the market.

In developing markups for OEMs and distributors, DOE obtained data about the revenue, CGS, and expenses of firms that produce and sell the equipment of interest. DOE determined that markups are neither fixed-dollar nor proportional to all direct costs, which means that the selling price of a piece of equipment may not be strictly proportional to the purchase price of the equipment. Using the available data, DOE has found measurable differences between incremental markups on direct equipment costs and the average aggregate markup on direct business costs. Additionally, DOE discovered significant differences between average and incremental markups for electric motor OEMs and distributors. Section 6.3 and Section 6.4 further discusses the differences between average and incremental markups.

The main reason that the selling price of a piece of equipment may not be strictly proportional to the purchase price of the equipment is that businesses incur a wide variety of costs. When the purchase price of equipment and materials increases, only a fraction of the business expenses increase, while the remainder of the businesses' expenses stays relatively constant. For example, if the unit price of an electric motor increases by 30 percent, it is unlikely that the cost of secretarial support in an administrative office will increase by 30 percent also. Certain business expenses are uncorrelated with the cost of equipment or cost of goods.

DOE's approach categorizes the expenses into two categories: invariant costs (IVC), which are those costs that are not expected to vary in proportion to the change in manufacturer selling price, and variant costs (VC), which are the costs that scale with the change in manufacturer selling price. Together, IVC and VC represent the gross margin.

For each step in equipment distribution, DOE estimated both a baseline markup and an incremental markup. For electric motors, DOE understands that no increase in distribution labor is necessary for the distribution of more-efficient equipment, while the non-labor-scaling cost does increase with increasing equipment costs. This allowed DOE to estimate the incremental markup given a breakdown of distribution and manufacturing business expenses for a particular industry.

6.2.1 Assumptions

DOE derived the OEM and motor distributor markups from three key assumptions about the costs associated with motor-related industrial series. DOE used the financial data from the 2007 U.S. Economic Census's manufacturing industrial series and 2007 Business Expenses Survey to determine OEM and motor distributor markups, respectively. These income statements break down the components of all costs incurred by firms that assemble and distribute electric motors. The key assumptions used to estimate markups using these financial data are:

1. The firm income statements faithfully represent the various average costs incurred by firms designing, assembling, and distributing electric motors.

2. These costs can be divided into two categories: (1) costs that vary in proportion to the manufacturer selling price (MSP) of electric motors (variant costs); and (2) costs that do not vary with the MSP of electric motors (invariant costs).

3. Overall, OEM and distributor sales prices vary in proportion to OEM and distributor costs that are included in the balance sheets.

In support of the first assumption, the income statements itemize firm costs into a number of expense categories, including CGS, operating labor and occupancy costs, and other operating costs and profit. Although OEMs and motor distributors tend to handle multiple commodity lines, the data provide the most accurate available indication of the expenses associated with electric motors.

In the following discussion, DOE assumes a division of costs between those that do not scale with the manufacturer price (labor and occupancy expenses), and those that do (operating expenses and profit). This division of costs led to the estimate of incremental markups addressed below.

In support of the third assumption, the wholesaler industries are relatively competitive, and end-user demand for motors and equipment with motors is relatively inelastic—i.e., the demand is not expected to decrease significantly with a relatively small increase in price. Following standard economic theory, competitive firms facing inelastic demand either set prices in line with costs or quickly go out of business.[2]

6.3 APPROACH FOR ORIGINAL EQUIPMENT MANUFACTURER MARKUPS

Using the above assumptions, DOE developed baseline and incremental markups for OEMs using the firm income statement from several manufacturing industries which design, assemble, and brand equipment that contain electric motors. The *2007 Economic Census Manufacturing Industry Series* reports the payroll (production and total), cost of materials, capital expenditures and total value of shipments, and miscellaneous operating costs for manufacturers of various types of machinery. DOE collected this data for 25 types of OEMs:

- Farm machinery and equipment manufacturing;
- Construction machinery manufacturing;
- Mining machinery and equipment manufacturing;
- Oil and gas field machinery and equipment manufacturing;
- Sawmill and woodworking machinery manufacturing;
- Plastics and rubber industry machinery manufacturing;
- Paper industry machinery manufacturing;
- Textile machinery manufacturing;
- Printing machinery and equipment manufacturing;
- Food product machinery manufacturing;
- Semiconductor machinery manufacturing;
- Other industrial machinery manufacturing;
- Air-purification equipment manufacturing;
- Industrial and commercial fan and blower manufacturing;
- Heating equipment (except warm air furnaces) manufacturing;
- Air conditioning and warm-air heating and commercial/industrial refrigeration equipment manufacturing;
- Machine-tool (metal cutting types) manufacturing;
- Machine-tool (metal forming types) manufacturing;
- Rolling mill machinery and equipment manufacturing;
- Pump and pumping equipment manufacturing;
- Air and gas compressor manufacturing;
- Elevator and moving stairway manufacturing;
- Conveyor and conveying equipment manufacturing;
- Packaging machinery manufacturing; and
- Fluid-power pump and motor manufacturing.

DOE used the baseline markups, which cover all of the OEM's costs (both variant and invariant costs), to determine the sales price of baseline models. Variant costs were defined as costs that vary in proportion to the change in MSP induced by increased efficiency standards; in contrast, invariant costs were defined as costs that do not vary in proportion to the change in MSP due to increased efficiency standards. The baseline markup relates the MSP to the OEM selling price. For each of the 25 OEMs identified above, DOE calculated the OEM baseline markup as follows:

$$\frac{\text{SALES}}{\text{PAY} + \text{MAT} + \text{CAP}} = \text{MU}_{\text{BASE}}$$

Where:

SALES =	value of shipments,
PAY =	payroll expenses,
MAT =	material input expenses,
CAP =	capital expenses,
MU_{BASE} =	baseline markup.

The baseline markups range between 1.32 (machine-tool manufacturing) and 1.63 (semiconductor machinery manufacturing), with the sales-weighted average of 1.44.

Incremental markups are coefficients that relate the change in the MSP of more energy-efficient models, or that equipment that meets the requirements of new energy conservation standards, to the change in the OEM selling price. Incremental markups cover only those costs that scale with a change in the manufacturer's sales price (VC). It calculated the incremental markup (MU_{INCR}) for each of the 25 OEMs using the following equation:

$$MU_{INCR} = \frac{CGS_{OEM} + VC_{OEM}}{CGS_{OEM}}$$

Where:

MU_{INCR} =	incremental OEM markup,
CGS_{OEM} =	OEM's cost of goods sold, and
VC_{OEM} =	OEM's variant costs.

The incremental markups range between 1.27 (machine-tool manufacturing) and 1.56 (pump and pumping equipment manufacturing), with the sales-weighted average of 1.39.

6.4 APPROACH FOR MOTOR DISTRIBUTOR MARKUPS

The type of financial data used to estimate markups for OEMs is also available for distributors. DOE based its distributor markups on financial data from *the 2007 U.S. Census Business Expenses Survey* (BES). DOE organized the financial data into income statements that break down cost components incurred by firms that sell equipment with electric motors or replacement motors, "Electrical Goods Merchant Wholesalers" (NAICS 4236).[a]

Using the above assumptions, DOE developed baseline and incremental markups and applied them in calculating end-user equipment prices from manufacturer sales prices. The BES

[a] The distributors to whom these financial data refer handle multiple commodity lines.

provides gross margin (GM) as percent of sales for the electrical goods merchant wholesalers industry; therefore, baseline markups can be derived with the following equation:

$$\mathrm{MU}_{\mathrm{BASE}} = \frac{Sales(\%)}{Sales(\%) - GM(\%)}$$

DOE used financial data from the BES for the categories "Electrical Goods Merchant Wholesalers" to calculate incremental markups used by wholesalers of motors. Incremental markups are coefficients that relate the change in the MSP of higher-efficiency models to the change in the wholesaler selling price. Hence, incremental markups cover only those costs that scale with a change in the manufacturer's sales price (i.e., VC). DOE considers higher-efficiency models to be equipment sold under market conditions with new efficiency standards. It calculated the incremental markup (MU_{INCR}) for distributors using the following equation:

$$MU_{INCR} = \frac{CGS_{DISTRIBUTOR} + VC_{DISTRIBUTOR}}{CGS_{DISTRIBUTOR}}$$

Where:

MU_{INCR} = incremental wholesaler markup,
$CGS_{DISTRIBUTOR}$ = distributor's cost of goods sold, and
$VC_{DISTRIBUTOR}$ = distributor's variant costs.

Table 6.4-1 shows the data from the BES and the markups DOE estimated using the procedures described above.

Table 6.4-1 Business Expenses Survey Data Used to Calculate Distributor Markups

Items	Amount ($1,000,000)
Sales	348,960
Cost of goods sold (CGS)	258,579
Gross Margin	90,381
Total Operating Expenses	55,785
Labor & Occupancy Expenses	**Amount ($1,000,000)**
Annual payroll	26,785
Employer costs for fringe benefit	5,008
Contract labor costs including temporary help	894
Purchased utilities, total	628
Cost of purchased repair and maintenance services	691
Cost of purchased management consulting administrative services and other professional services	1,863
Purchased communication services	790
Lease and rental payments	2,164
Taxes and license fees (mostly income taxes)	707

Other Operating Expenses & Profit	Amount ($1,000,000)
Expensed computer related supplies	335
Cost of purchased packaging and containers	335
Other materials and supplies not for resale	644
Lease and rental payments for machinery and equipment	347
Cost of purchased transportation, shipping and warehousing services	2,486
Cost of purchased advertising and promotional services	1,890
Expense purchases of software	353
Cost of data processing and other purchased computer services, except communications	268
Depreciation and amortization charges	2,170
Commissions paid	1,444
Other Operating Expenses	6,004
Net profit before taxes	34,575
Baseline Markup=(CGS+GM)/CGS	1.350
Incremental Markup=(CGS+Total Other Operating Expenses and Profit)/CGS	1.197

Source: 2007 Business Expenses Survey, Electrical Goods Merchant Wholesalers (NAICS 4236)

6.5 CONTRACTOR OR INSTALLER MARKUP

DOE used information from RSMeans *Electrical Cost Data*[3] to estimate markups used by contractors in the installation of equipment with small motors or replacement motors. RSMeans *Electrical Cost Data* estimates material expense markups for electrical contractors as 10 percent, leading to a markup factor of 1.10. DOE recognizes that contractors are not used in all installations, as some firms have in-house technicians who would install equipment or replace a motor. However, DOE has no information on the extent to which this occurs, so it applied a markup of 1.10 in all cases.

6.6 SALES TAXES

The sales tax represents state and local sales taxes that are applied to the end-user equipment price of the equipment. The sales tax is a multiplicative factor that increases the end-user equipment price.

DOE derived state and local taxes from data provided by the Sales Tax Clearinghouse.[4] These data represent weighted averages that include county and city rates. DOE then derived population-weighted average tax values for each Census division and large state, as shown in Table 6.6-1 below. This provides a national average tax rate of 7.12 percent, which DOE used for each of the distribution channels.

Table 6.6-1 Average Sales Tax Rates by Census Division and Large State

Census Division/State	2011 Population	Tax Rate (2011) %
New England	14,492,360	5.64
Middle Atlantic	21,564,041	6.62
East North Central	46,519,084	6.85
West North Central	20,639,751	7.15
South Atlantic	41,167,090	6.27
East South Central	18,553,961	7.93
West South Central	11,304,323	8.47
Mountain	22,373,411	6.80
Pacific	12,799,425	5.24
New York	19,465,197	8.45
California	37,691,912	8.20
Texas	25,674,681	8.00
Florida	19,057,542	6.65
Population Weighted Average		7.12

6.7 OVERALL MARKUP

The overall markup for each distribution channel is the product of the relevant markups, as well as the sales tax. DOE used the overall baseline markup to estimate the end-user equipment price of baseline models, given the MSP of the baseline models. As stated above, DOE considers baseline models to be equipment sold under existing market conditions (i.e., without new energy efficiency standards).

DOE used the overall incremental markup to estimate changes in the end-user equipment price, given changes in the manufacturer cost above the baseline model cost resulting from a standard to raise equipment efficiency. The total end-user equipment price for higher-efficiency models is composed of two components: the end-user equipment price of the baseline model and the change in end-user equipment price associated with the increase in manufacturer cost to meet the new efficiency standard. The following equation shows how DOE used the overall incremental markup to determine the end-user equipment price for higher-efficiency models (i.e., models meeting new efficiency standards).

$$EQP_{STD} = MSP_{MFG} \times MU_{OVERALL\_BASE} + \Delta MSP_{MFG} \times \left(MU_{INCR} \times Tax_{SALES}\right)$$
$$= EQP_{BASE} + \Delta COST_{MFG} \times MU_{OVERALL\_INCR}$$

Where:

EQP_{STD} = end-user equipment price for models meeting new efficiency standards,
EQP_{BASE} = end-user equipment price for baseline models,
MSP_{MFG} = manufacturer selling price for baseline models,
ΔMSP_{MFG} = change in manufacturer selling price for higher-efficiency models,
MU_{INCR} = incremental OEM or distributor markup,
Tax_{SALES} = sales tax,
$MU_{OVERALL\_BASE}$ = baseline overall markup (product of manufacturer markup, baseline OEM or distributor markup, and sales tax), and
$MU_{OVERALL\_INCR}$ = incremental overall markup (product of manufacturer markup, incremental OEM or distributor markup, and sales tax).

Table 6.7.1 summarizes the markups and the overall baseline and incremental markups for each of the three main identified channels. Weighting the values by the respective shares of each channel yields an average overall baseline markup of 1.63 and an overall incremental markup of 1.50.

Table 6.7.1 Summary of Markups for Three Primary Distribution Channels for Electric Motors

Markup	OEM to End-User (50%)		Distributor to End-User (24%)		Distributor to OEM to End-User (23 %)	
	Baseline	Incremental	Baseline	Incremental	Baseline	Incremental
Distributor	-	-	1.35	1.20	1.35	1.20
OEM	1.44	1.39	-	-	1.44	1.39
Contractor/Installer	-	-	-	-	-	-
Sales Tax	1.0712	1.0712	1.0712	1.0712	1.0712	1.0712
Overall	1.54	1.49	1.45	1.29	2.08	1.79

6.8 SHIPPING COSTS

DOE examined freight shipping costs to evaluate the impact of increased motor weight on installed cost. DOE collected quoted shipping costs from 16 freight shipment companies for single shipments by “less than truckload” (LTL) ground service weighing between 50 and 2,600 pounds and over shipping distances between 350 and 3,000 miles. Marginal shipment costs per pound varied from 7.1 cents to $1.44, depending on the total weight, distance shipped, and guaranteed delivery times. DOE used a median marginal shipment cost of 65 cents per pound.

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