CHAPTER 7. MARKUPS FOR EQUIPMENT PRICE DETERMINATION

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CHAPTER 7. MARKUPS FOR EQUIPMENT PRICE DETERMINATION

7.1 INTRODUCTION

This chapter of the technical support document (TSD) presents the Department's method for deriving transformer prices. The objective of the equipment price determination is to estimate the price paid by the customer/purchaser for an installed transformer. 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 distribution transformers are not generally known. Transformers are specialty items, often custom-built with unlisted prices. The engineering analysis (Chapter 5) provided the manufacturer selling prices for the units analyzed by the LCC. The Department derived a set of prices for each transformer design produced by the engineering analysis by applying markups to the manufacturer selling price in the form of markup equations. These markups represent all the costs associated with bringing a manufactured transformer into service as an installed piece of electrical equipment at a customer's site.

7.2 OVERVIEW OF MARKUP EQUATIONS

Depending on the purchasing environment, the Department used different markup equations to capture the various markups in the supply chain between the manufacturer and the customer. For example, electric utilities (except for the rural electric cooperatives) typically purchase liquid-immersed transformers through manufacturer representatives or distributors. The manufacturer selling price plus the small distributor markup is generally the utilities' price for transformers. Dry-type transformers go through several additional marketing and/or handling steps before they are installed by the end-use purchaser.

The Department adjusted the advance notice of proposed rulemaking (ANOPR) distributor markup assumptions based on stakeholder feedback. Liquid-type distribution transformers have a seven percent markup, accounting for distributor markup. The manufacturer selling prices for dry-type transformers include two price markups: a distributor markup of 15 percent and a contractor materials markup of 10 percent. The Department based these markups (expressed as average multipliers) on *RS Means Electrical Cost Data 2002*.[1] The distributor markup converts the manufacturer selling price to the distributor price, the price paid by the electrical contractor. This distributor markup covers the costs of the distribution business, including sales labor, warehousing, overhead, and profit. Then the contractor applies a markup to the distributor price to cover contractor overhead and profit.

For both liquid-immersed and dry-type transformers, the Department added shipping costs, sales tax, an installation labor and equipment markup, and weight-dependent installation costs. Distribution transformers can be very heavy (some weigh more than a ton) and costly to

ship. It is common practice for transformers to be shipped directly to a construction site with no intermediate warehousing. The Department estimated shipping costs by collecting a small sample of quotations for transporting transformers. Based on an average shipping distance of 1,000 miles, the Department estimated shipping costs of $0.20/pound for large shipments. Using *RS Means Electrical Cost Data 2002,* DOE estimated an installation labor and equipment markup of 52 percent. By weighting the sales tax for each individual State by its population, the Department calculated a national average sales tax of 5.6 percent. Finally, the Department added installation costs. The installation cost is the cost of labor, equipment, and materials (other than the transformer itself) needed to install a distribution transformer. The Department developed several empirical equations for estimating installation costs as a function of transformer weight.

7.3 ESTIMATION OF INSTALLED PRICE

The Department estimated the installation costs and contractor markups on transformers by fitting a linear cost function to the *RS Means* electrical cost data. The *RS Means* data break down the total installed cost for transformers in terms of four cost components:

1. Materials: transformer purchase price, including mounting hardware.

2. Labor: labor cost required for installation, including unloading and uncrating, hauling within 200 feet of the loading dock, setting in place, connecting to the distribution network, and testing.

3. Equipment: equipment rentals necessary for completion of the installation.

4. Overhead and Profit: installation overhead and profit expenses for the contractor (for dry-type transformers only).

The Department disaggregated its installation costs into these four cost components. *RS Means* lists the transformer price as a "material" cost. The Department performed a regression to disaggregate the overhead and profit associated with installation labor and equipment rental from the overhead and profit associated with the transformer (material) cost. The regression equation is:

$$O\&P = a \times Mat + b \times L\&E + c \qquad \textbf{Eq. 7.1}$$

where:

$O\&P$	=	the overhead and profit expense (2001$),
Mat	=	the material cost (i.e., transformer and hardware) (2001$),
$L\&E$	=	the direct labor and equipment costs of installation (2001$), and

a, b, and c = the computed linear regression coefficients.

The Department fitted the labor and equipment costs as a function of transformer weight. This relationship is justified because transformer weight (and its correlated size) is a significant factor in determining installation costs for labor and equipment. For pole-mounted transformers, the Department assumed pole costs did not vary with changes in efficiency but recognized that, in some cases, a more efficient, heavier transformer could require a stronger pole. Because the *RS Means* data do not specify transformer weight, the Department inferred the approximate weight of a transformer from its kVA (kilovolt-ampere) capacity, as described below.

For use in the LCC analysis, the Department adjusted these 2001$ to 2004$ using the gross domestic product (GDP) price deflator from the Energy Information Administration (EIA)'s *Annual Energy Outlook 2005* (*AEO2005)*.

7.3.1 Estimation of Transformer Weights and Pole Costs

The Department derived the weight-versus-capacity relationship for typical transformers from the design data produced by the engineering analysis. It used the weight-versus-capacity relationship to estimate the transformer weight corresponding to the transformer costs reported in *RS Means*. The Department estimated a scaling relationship between transformer weight and direct installation labor and equipment costs by fitting the correlation between weight and installation costs to a power-law equation.

In evaluating design options and the impact of potential standard levels, the Department examined the potential for new standards for distribution transformers to lessen the utility or performance of these products. Stakeholders mentioned in their comments to the Department that heavy, more-efficient transformers could have lessened utility due to impacts on utility pole requirements for overhead transformers. For single-phase, pole-mounted, liquid-immersed transformers, the Department estimated the additional installation costs for those designs that would require an upgrade to the pole based on cost data provided by stakeholders.

For the NOPR analysis, the Department added a pole-replacement cost function to the installation cost equation for design line 2, which covers pole-mounted transformers. This analysis assumed that a pole change-out cost of $2,000 occurs for up to 25 percent of pole-mounted transformers when the weight of the transformer exceeds 1,000 pounds. The Department also included a transformer pole support cost of $0.12/lb to account for the cost of a sturdier pole. The pole cost equation is included in the LCC spreadsheet tool for DL2 so that stakeholders can conduct sensitivity analyses regarding pole replacement costs. Because not all transformer installations require a change-out of existing equipment even in the most extreme case, the Department assumed a maximum change-out fraction. The Department selected 25 percent as the maximum change-out fraction estimate based on stakeholder input.[2]

The method for deriving the weight-versus-capacity relationship uses a *typical* transformer weight from the engineering analysis. The Department defined the *typical* weight as the minimum weight plus 20 percent times the weight range, where the weight range is the difference between the minimum and maximum transformer weight for the selected designs.

From these data, the Department obtained the following power-law relationship for transformer weight as a function of capacity and basic impulse insulation level (BIL) rating:

$$Weight = 13.13 \times kVA^{0.765} \times BIL^{0.244} \quad \textbf{Eq. 7.2}$$

where:

Weight	=	the weight of the transformer (lbs),
kVA	=	the capacity of the transformer (kVA), and
BIL	=	the BIL rating of the transformer (kV).

Although *RS Means* does not provide transformer weights, it does provide transformer capacity and primary voltage. The Department estimated weight from capacity and BIL, which it estimated using primary voltage. The Department then compared the weight to the direct installation costs from the labor and equipment to obtain a power-law relationship.

The first regression performed was the installation direct labor and equipment costs as a function of transformer weight. Data analyzed included all 115 distribution transformer kVA ratings spanning the three *RS Means* electrical equipment categories: "dry type transformer" (16270-200), "oil-filled transformer" (16270-600), and "transformer, liquid-filled" (16270-610). The resulting correlation equation is:

$$L\&E = 42.08 \times Weight^{0.46} \quad \textbf{Eq. 7.3}$$

where:

L&E	=	the installation, direct labor, and equipment costs (2001$), and
Weight	=	the transformer weight (lbs).

The regression, performed as a power-law trend line fit in Excel, resulted in an R-square of 0.95, indicating a good fit to the data.

7.3.2 Overhead and Profit for Installation Expenses

The next regression targeted contractor overhead and purchase profit expenses in terms of a markup on materials (i.e., the transformer), and labor and equipment (i.e., direct installation). Initially, the Department performed a linear regression with a constant term. When it found that the constant term was not significantly different from zero, it ran the regression again. The resulting equation is:

$$O\&P = 0.10 \times Mat + 0.52 \times L\&E \quad \textbf{Eq. 7.4}$$

The Department used equation 7.4 to allocate overhead and profit expenses to a markup on the distributor price and a separate markup on the direct labor and equipment costs for the installation.

7.3.3 Dry-Type Transformer Installed Price Equation

For dry-type transformers, the result of these analytical steps is a total installed cost equation as a function of the manufacturer selling price and transformer weight:

$$Installed\_Price = M_{tax} \times (M_{L\&E} \times L\&E + M_{Mat} \times (M_{Ship} \times Weight + M_{Dist} \times ManPrice)) \quad \textbf{Eq. 7.5}$$

where:

$Installed\_Price$	=	the final installed price of the transformer (2004$),
M_{tax}	=	the factor that accounts for sales tax, estimated as 1.054,
$M_{L\&E}$	=	the factor that accounts for the markup on direct installation labor and equipment costs, estimated as 1.52,
$L\&E$	=	the installation, direct labor, and equipment costs (2001$), adjusted to 2004$ using the GDP price deflator from *AEO2005*,
M_{Mat}	=	the factor that accounts for the contractor markup on the purchase of the transformer from the distributor, estimated as 1.10,
M_{Ship}	=	the shipping cost, estimated as $0.20/lb,
$Weight$	=	the transformer weight (lbs),
M_{Dist}	=	the average distributor markup factor, estimated as 1.15, and
$ManPrice$	=	the manufacturer's selling price (2004$).

The Department applied the installed cost equation by using the manufacturer price and weight from the engineering analysis. For example, the engineering analysis estimated that the design line 9 (three-phase, 300 kVA) transformer with the minimum manufacturer price weighs 491 pounds and has a manufacturer price of $4838.17. For this transformer, the Department estimated the installed cost to be $8935.41, where $2082.73 is the installation cost, and $6852.68 is the transformer retail price, including shipping costs, sales tax, and markups.

7.3.4 Liquid-Immersed Transformer Installed Price Equation

For liquid-immersed transformers, the Department removed the contractor markup from the cost equation to obtain :

$$Installed\_Price = M_{tax} \times (M_{L\&E} \times L\&E \times (M_{Ship} \times Weight + M_{Dist} \times ManPrice)) \quad \textbf{Eq. 7.6}$$

where:

$Installed\_Price$	=	the final installed price of the transformer (2004$),
M_{tax}	=	the factor that accounts for sales tax, estimated as 1.054,
$M_{L\&E}$	=	the factor that accounts for the markup on direct installation labor and equipment costs, estimated as 1.52,
$L\&E$	=	the installation, direct labor, and equipment costs (2001$), adjusted to 2004$ using the GDP price deflator from *AEO2005*,
M_{Ship}	=	the shipping cost, estimated as $0.20/lb,
$Weight$	=	the transformer weight (lbs.),
M_{Dist}	=	the average distributor markup factor, estimated as 1.07, and
$ManPrice$	=	the manufacturer's selling price (2004$).

As with the dry-type transformers, the Department applied the installed cost equation by using the manufacturer price and weight from the engineering analysis. For example, the engineering analysis estimated that the design line 1 (single-phase, 50 kVA) transformer with the minimum manufacturer price weighs 646 pounds and has a manufacturer price of $818.00. For this transformer, the Department estimated the installed cost to be $2381.42, where $1322.72 is the installation cost, and $1058.70 is the transformer price for the utility, including shipping cost, sales tax, and markups.

REFERENCES

1. RS Means Company Inc. *Electrical Cost Data: 26th Annual Edition*. 2003. ed. J.H. Chiang. Kingston, MA.

2. Rosenstock, S. *ANOPR for Distribution Transformers, Docket # EE-RM/STD-00-550, RIN #1904-AB08, comment No. 63.* November 8, 2004. Edison Electric Institute.