APPENDIX 8-E. ESTIMATION OF EQUIPMENT PRICE TRENDS FOR MICROWAVE OVENS

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APPENDIX 8-E. ESTIMATION OF EQUIPMENT PRICE TRENDS FOR MICROWAVE OVENS

8-E.1 INTRODUCTION

In its Notice of Data Availability (NODA) published on February 22, 2011 (76 FR 9696), DOE stated that it may consider improving regulatory analysis by addressing equipment price trends. DOE stated in the NODA that examination of historical price data for certain appliances and equipment that have been subject to energy conservation standards indicates that an assumption of constant real prices and costs may over-estimate long-term price trends. Economic literature and historical data suggest that the real costs of these products may in fact trend downward over time according to "learning" or "experience" curves. A draft paper, "Using the Experience Curve Approach for Appliance Price Forecasting," posted on the DOE web site at http://www1.eere.energy.gov/buildings/appliance_standards/supplemental_info_equipment_price_forecasting.html, provides a summary of the data and literature currently available to DOE that is relevant to price forecasts for selected appliances and equipment.

The extensive literature on the "learning" or "experience" curve phenomenon is typically based on observations in the manufacturing sector. In the experience curve method, the real cost of production is related to the cumulative production or "experience" with a manufactured product. This experience is usually measured in terms of cumulative production. A common functional relationship used to model the evolution of production costs in this case is:

$$Y = aX^{-b}$$

where a is an initial price (or cost), b is a positive constant known as the learning rate parameter, X is cumulative production, and Y is the price as a function of cumulative production. Thus, as experience (production) accumulates, the cost of producing the next unit decreases. The percentage reduction in cost that occurs with each doubling of cumulative production is known as the learning rate (LR), given by:

$$LR = 1 - 2^{-b}$$

In typical learning curve formulations, the learning rate parameter is derived using two historical data series: cumulative production and price (or cost).

Consistent with the NODA, DOE used the experience curve method to derive learning rates to forecast future prices of microwave ovens at each considered efficiency level. This appendix describes the method used to derive learning rates and to project future product prices.

8-E.2 LEARNING RATE ESTIMATION

To derive a learning rate parameter for microwave ovens, DOE obtained historical Producer Price Index (PPI) data for electric cooking equipment from the Bureau of Labor Statistics' (BLS). DOE understands that electric cooking equipment is a higher aggregation level to microwave ovens only; however, because PPI data specific to microwave ovens were not available, DOE used PPI data for electric cooking equipment as representative of microwave ovens. Additionally, microwave oven shipments have become a significant part of the total electric household cooking equipment shipments since 1975. For electric cooking equipment, DOE used PPI data spanning the time period 1969-2010. An inflation-adjusted price index for electric cooking equipment was calculated by dividing the PPI series by the Consumer Price Index (CPI) "all items" index for the same years. This inflation-adjusted price index (shown in Figure 8-E.2.1) was used in subsequent analysis steps.

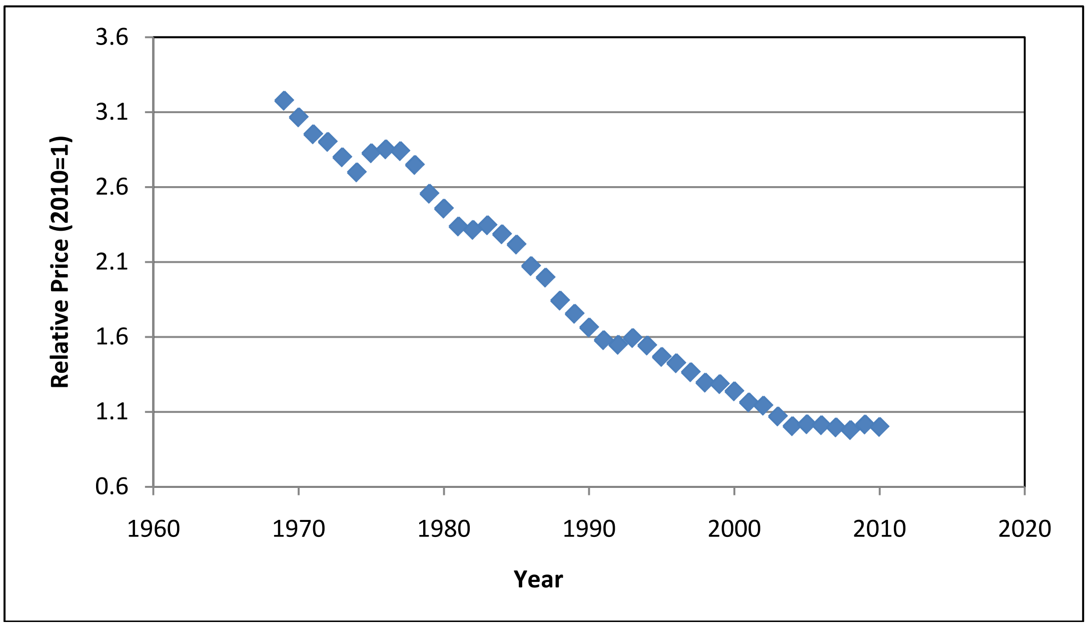

Figure 8-E.2.1 Historical Real Price Index for Electric Cooking Equipment

DOE assembled a time-series of annual shipments for 1969-2009 for electric household cooking equipment (including microwave ovens, cooktops, and ranges), referred as "electric cooktops, ranges, and ovens" in the following context, and for 1972-2009 for microwave ovens from data submittals from AHAM, AHAM Fact Books, and Appliance Magazine. The shipments data were used to estimate cumulative shipments (production). Figure 8-E.3.2 shows the shipments time series used in the analysis.

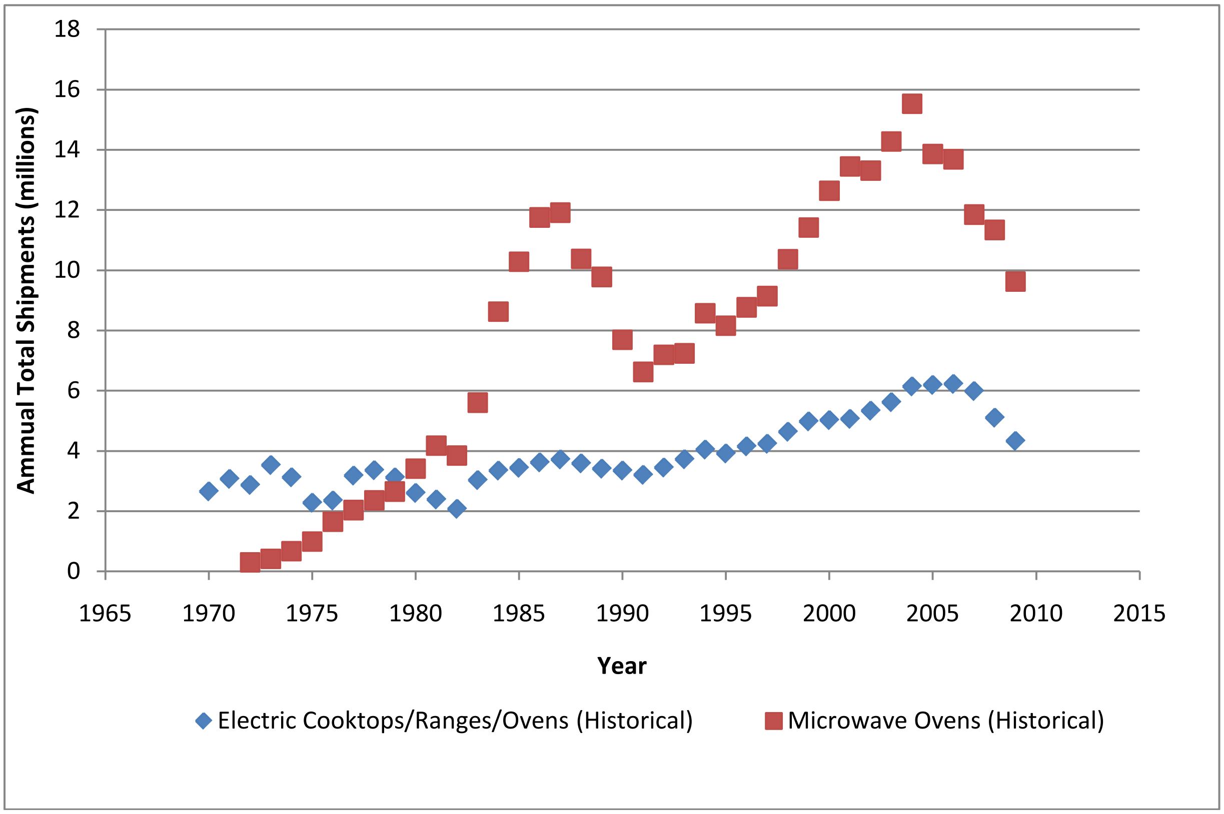

Figure 8-E.2.2 Historical Total Shipments of Electric Cooktops, Ranges, and Ovens and Microwave Ovens

To estimate a learning rate parameter, a least-squares power-law fit was performed on the unified price index versus cumulative shipments; see Figure 8-E.2.3. The form of the fitting equation is:

$$P(X) = P_o X^{-b},$$

where the two parameters, b (the learning rate parameter) and P_o (the price or cost of the first unit of production), are obtained by fitting the model to the data. DOE notes that the cumulative shipments on the right hand side of the equation can have a dependence on price, so there is an issue with simultaneity where the independent variable is not truly independent. DOE's use of a simple least squares fit is equivalent to an assumption of no significant first price elasticity effects in the cumulative shipments variable.

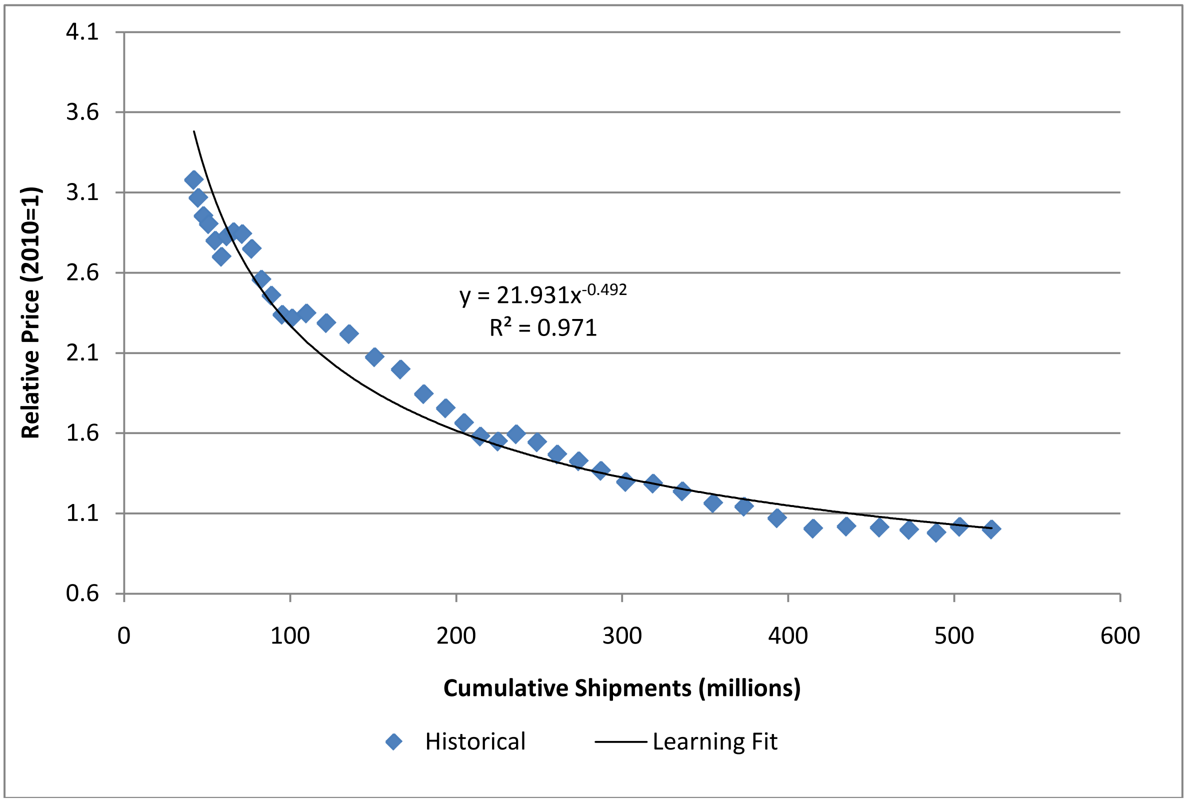

Figure 8-E.2.3 Relative Price versus Cumulative Shipments of Electric Cooking Equipment

The parameter values obtained are:

$P_o = 21.93^{+3.31}_{-2.87}$ (95% confidence) for electric cooking equipment
b = 0.492±0.027 (95% confidence) for electric cooking equipment

Tthe estimated learning rate (defined as the fractional reduction in price expected from each doubling of cumulative production) is 28.9±1.3% (95% confidence).

DOE recognizes that there is uncertainty in its estimates of equipment price trends. Uncertainty arises from potentially systematic long term changes in the trend. To provide a potential indication of long term changes in the trend, DOE performed price trend fits to two component periods in the historical data, equal to the first and second half of the total time period. For electric cooking equipment, the selected periods were 1969-1989 and 1990-2010. Table 8-E.2.1 shows the estimated learning parameters for these periods.

DOE performed a sensitivity calculation using data specific for microwave ovens. Nominal price data for microwave ovens of various sizes were collected from Consumer Reports (1981, 1983, 1985-86, 1988-90, 1992, and 1994-2010). DOE assumed that the average prices of large and medium size microwave ovens in each year available are representative of the overall microwave oven price trend. DOE generated an inflation-adjusted price index for microwave ovens by deflating the nominal price series from Consumer Reports with the CPI and normalizing it at 2010 level. Learning parameters were then calculated from the "microwave ovens only" price index, combined with microwave oven cumulative production. The LR estimated for microwave ovens only was not used as the default case because the estimate is not particularly robust due to the limited price data from Consumer Reports.

Table 8-E.2.1 Learning Parameter as a Function of Time Period

Product	Period	Learning Parameter (%)
Electric Cooking Equipment	1969-2010	28.9 (Medium) →Default
Electric Cooking Equipment	1969-1989	21.3±2.1 (Low)
Electric Cooking Equipment	1990-2010	34.7±2.3 (High)
Microwave Ovens Only	1981-2010	39.6

8-E.3 EQUIPMENT PRICE TRENDS FORECAST

DOE derived a price factor index, with 2010 equal to 1, to forecast prices in each future year in the analysis period. The default index value in a given year is a function of the learning parameter and the cumulative production forecast through that year, which is based on the shipments forecast described in chapter 9. DOE applied the same value to forecast prices for each microwave oven product class at each considered efficiency level.

For the LCC and PBP analysis, DOE used the medium learning rate to forecast product prices in 2014. This rate was also used as a default value to forecast prices through 2043 for the national impact analysis (NIA).

For the NIA, DOE also examined the impacts of potential standards using high and low values of the learning rate parameter. The low learning rate is the lower of (1) the low end of the 95% confidence range for the time period with the lowest value, or (2) the low end of the 95% confidence range of the full period learning estimate. The medium (default) value is the estimate for the full time period. The high value is the higher of (1) the upper end of the 95% confidence interval for the time period with the highest value, or (2) the upper end of the 95% confidence interval for the full period estimate. As a result, for electric cooking equipment, the low LR equals 19.2%, and the high LR equals 37.0%.

In addition to using the above learning parameters, DOE examined a constant real price sensitivity case. DOE also used a forecast based on the "chained price index--other consumer durable goods except ophthalmic" that was forecasted for *AEO2010.* This index is the most disaggregated category that includes appliances. To develop an inflation-adjusted index, DOE normalized the above index with the chained price index--gross domestic product forecasted for *AEO2010.*[a]

[a] To extend the adjusted index past 2035, DOE used the average annual growth rate in 2026-2035.

Figure 8-E.4.1 shows the default price factor index and the indexes corresponding to each of the sensitivities for microwave ovens. All indexes are adjusted for inflation. For the indexes based on learning parameters, the index partially depends on the shipments forecast for either electric cooking equipment or microwave ovens.

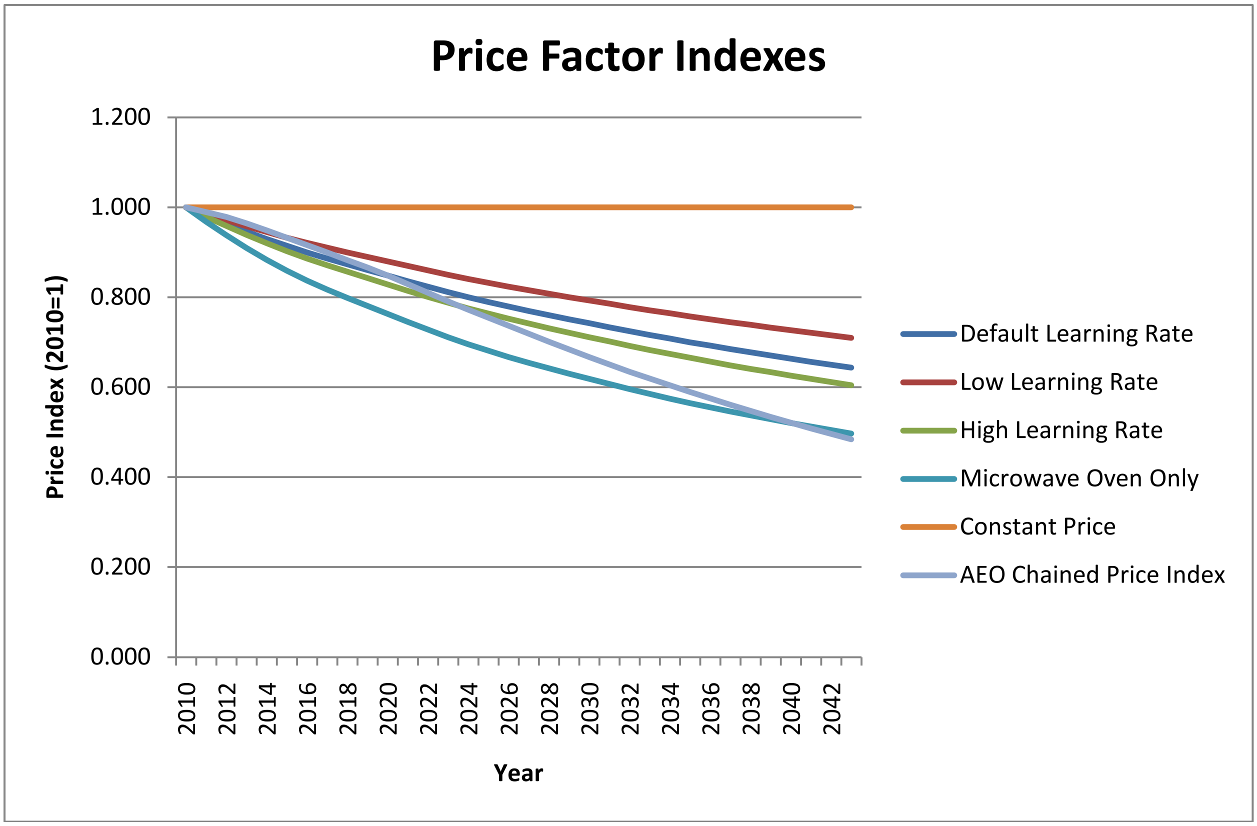

Figure 8-E.3.1 Electric Cooking Equipment Price Factor Indexes for the Default Case and Sensitivity Cases

8-E.4 DISCUSSION OF ANALYTICAL ISSUES

DOE uses a cost-based analysis in estimating equipment prices. To estimate equipment prices in both the standards and the base (no-standards) case, DOE develops engineering cost estimates that DOE then uses to estimate manufacturer selling price. The manufacturer selling price includes direct manufacturing production costs (labor, material, and overhead estimated in DOE's manufacturer production costs) and all non-production costs (SG&A, R&D, and interest), along with profit. The process of the cost-based method for developing the manufacturer selling prices is described in the engineering analysis described in chapter 5 of this TSD. To convert the manufacturer selling price to an equipment price for the consumer, DOE performs an analysis of distribution chain markups and estimates markups on both the baseline and incremental manufacture selling prices to determine equipment prices after distribution to the consumer.

In analyzing experience curves to estimate price trends, DOE uses producer price indices as a key data input and analyzes this data to estimate the experience curve exponent. This approach has only one model parameter to describe the price trend and assumes a simple relationship between producer price and retail equipment price. Specifically, the approach assumes that producer prices, distribution chain markups and equipment prices all scale proportionally over time for the same product.

DOE could have developed a more complex price trend forecasting model with more parameters that could explain different trends in different equipment price and cost components over time. But the relatively few available data points present a risk that a fit with multiple parameters would "overfit" the data. Overfitting occurs when there are too many degrees of freedom in a statistical model compared to the data and the fits are sensitive to random noise unrelated to long term trends. Due to the risk of overfitting the available data, DOE has decided to not develop a more complex multi-parameter price trend estimation model at this time.

Due to the simple nature of the price trend estimation model, there are several well known economic and market phenomenon that will not be captured in detail by the price trend forecast. Some effects might lead to an overestimate of the long term price trend and other effects may lead to an underestimate. For example, if there has been increasing market concentration historically on the part of manufacturers, this may have resulted in increasing manufacturer and wholesale markups over time. This would result in an observed historical producer price trend that did not decrease as fast as the underlying industrial learning rate. Depending on whether market concentration accelerated or decelerated into the future this could lead to an over- or under-estimation of future price trends.

Similarly, if there are cost components that have relatively slow long term price trends that have an increasing impact on price over time, the decreasing share of costs that are declining rapidly can result in a change in the empirically estimated experience curve exponent over time.