APPENDIX 10-C. NATIONAL NET PRESENT VALUE OF CONSUMER BENEFITS USING ALTERNATIVE PRODUCT PRICE FORECAST

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10-C.1   INTRODUCTION

The net present value (NPV) results presented in chapter 10 reflect a product price trend based on historic prices of electric motors. DOE also investigated the impact on the NPV for the considered CSLs for furnace fans of a product price forecast based on the experience curve approach. In DOE's 2011 furnace standards rulemaking, it derived a forecast of furnace prices based on an analysis of the historic trend in the producer price index (PPI) for furnaces. In the sensitivity analysis described in this appendix, DOE applied the experience curve developed for furnaces to the price of furnace fans.

The extensive literature on the "learning" or "experience" curve phenomenon is typically based on observations in the manufacturing sector.[a] 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 experience 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 experience rate (ER), given by:

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

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

10-C.2   DATA EVALUATION AND ANALYSIS

To derive an experience rate for furnace fan products, DOE obtained historical Producer Price Index (PPI) data for furnaces from the Bureau of Labor Statistics' (BLS). For warm air furnaces, DOE used PPI data spanning the period 1990-2010. An inflation-adjusted price index for warm air furnaces 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 10-C.2.1) was used in subsequent analysis steps.

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[a] Weiss, M., Junginger, H.M., Patel, M.K., Blok, K., (2010a). A Review of Experience Curve Analyses for Energy Demand Technologies. Technological Forecasting & Social Change. 77:411-428.
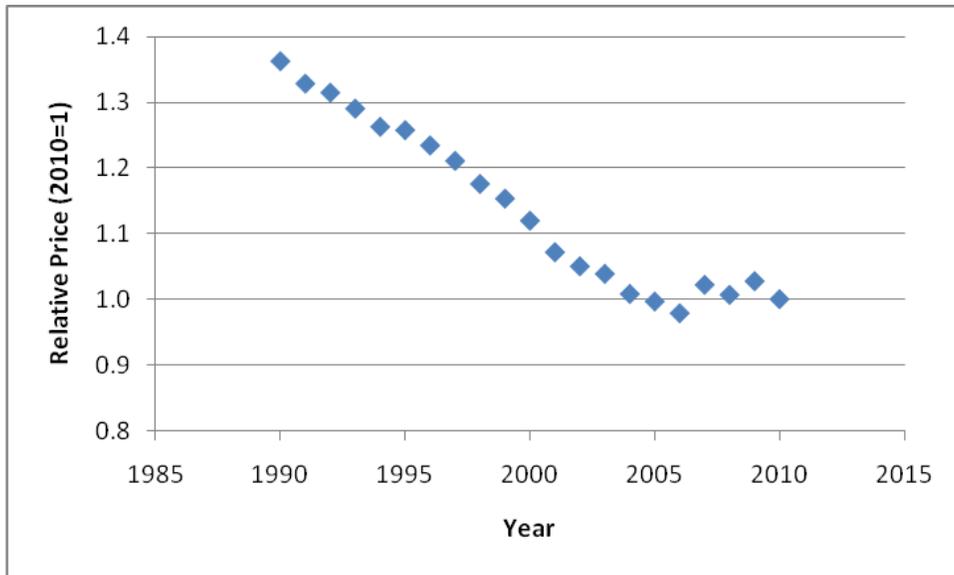
Figure 10-C.2.1　Historical Normalized Prices of Warm Air Furnaces

DOE assembled a time-series of annual shipments for 1953-2009 for furnaces using data from AHRI and the Gas Appliance Manufacturers Association. For furnaces, shipments prior to 1953 were extrapolated backward based on a linear trend to the historical shipments. The annual shipments data were used to estimate cumulative shipments (production). Projected shipments after 2009 were obtained from the base case projections made for the NIA (see chapter 9 of this TSD). Figure 10-C.2.2 shows the shipments time series used in the analysis.

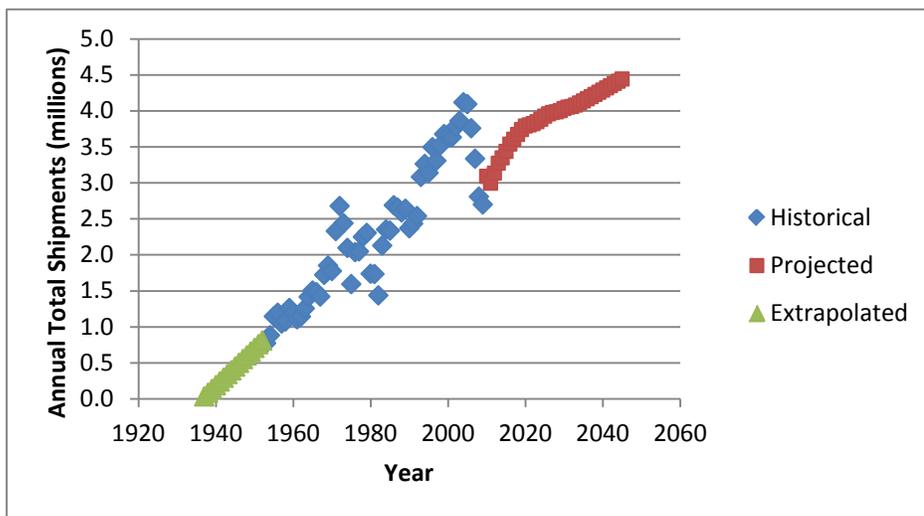
**Figure 10-C.2.2　Historical and Projected Total Shipments of Warm
Air Furnaces**

To estimate an experience rate parameter, a least-squares power-law fit was performed on the unified price index versus cumulative shipments (See Figure 10-C.2.3).
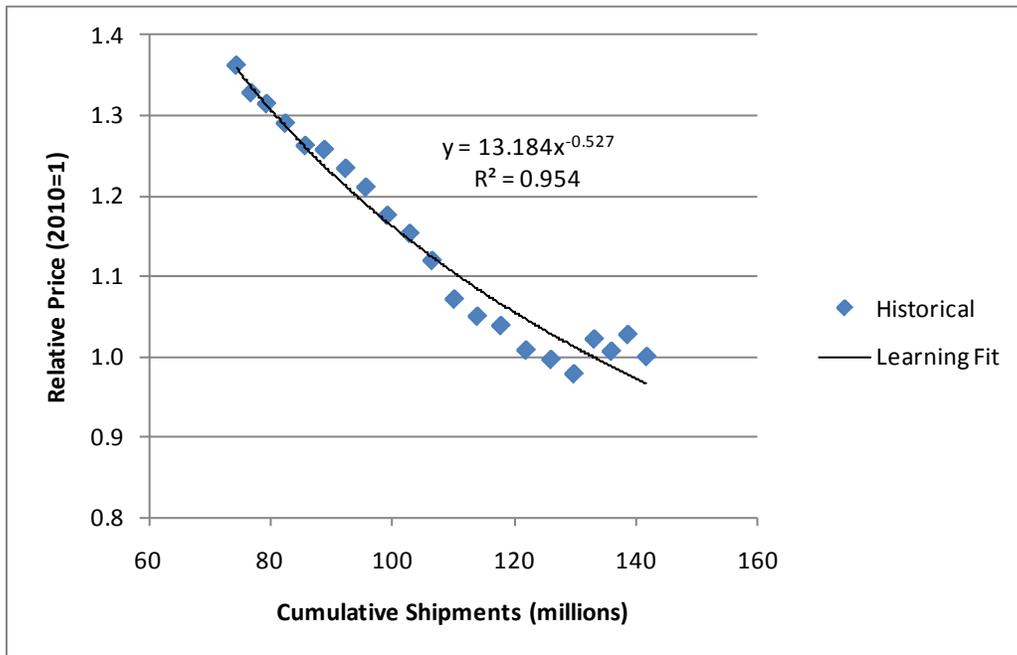
$$y = 13.184x^{-0.527}$$
$$R^2 = 0.954$$

Figure 10-C.2.3   Relative Price versus Cumulative Shipments of Warm Air Furnaces, with Power Law Fit

The form of the fitting equation is:

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

where the two parameters, b (the experience 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.

The parameter values obtained are:

$P_o = 13.18^{+3.92}_{-3.02}$ (95% confidence), and
$b = 0.527 \pm 0.056$ (95% confidence).

For warm air furnaces, the estimated experience rate (defined as the fractional reduction in price expected from each doubling of cumulative production) is $30.6^{+2.6}_{-2.7}\%$ (95% confidence).

DOE then derived a price factor index, with 2010 equal to 1, to forecast prices in each future year in the analysis period. The index value in a given year is a function of the LR and the cumulative production forecast through that year. DOE applied the same value to forecast prices for each furnace fan product class at each considered efficiency level.

10-C-3

10-C.3 NET PRESENT VALUE RESULTS USING ALTERNATIVE PRODUCT PRICE TREND

This section presents the NPV results using the alternative product price forecast for each key product class. For non-weatherized gas furnace fans, it also compares the NPV using the default product price forecast with the NPV using the alternative product price forecast.

Table 10-C.3.1   NPV Using Alternative Product Price Forecast, Discounted at 3 Percent, for Furnace Fans Used in HVAC Products Other than Hydronic Air Handlers (billion 2011$)

Key Product Class	Candidate Standard Level				
	1	2	3	4	5
	Improved PSC	PSC w/ Controls	X13	ECM	ECM + Backward-curved Impeller
Non-weatherized, Non-condensing Gas Furnace Fan	0.113	0.077	4.536	0.865	1.776
Non-weatherized, Condensing Gas Furnace Fan	0.257	1.584	4.516	0.498	1.481
Weatherized Gas Furnace Fan	0.007	0.087	0.854	0.439	0.657
Oil Furnace Fan	0.024	0.206	0.145	-0.016	-0.032
Electric Furnace / Modular Blower Fan	0.010	-0.110	0.610	-0.461	-0.276
Manufactured Home Non-weatherized, Non-condensing Gas Furnace Fan	0.003	0.024	0.049	-0.044	-0.048
Manufactured Home Non-weatherized, Condensing Gas Furnace Fan	0.005	0.036	0.049	-0.084	-0.101
Manufactured Home Electric Furnace / Modular Blower Fan	-0.001	0.011	0.042	-0.075	-0.027

Table 10-C.3.2 Comparison of NPV Under Alternative Product Price Forecasts, Discounted at 3 Percent, for Furnace Fans Used in Non-Weatherized Gas Furnaces (billion 2011$)

	Candidate Standard Level				
	1	**2**	**3**	**4**	**5**
	Improved PSC	PSC w/ Controls	X13	ECM	ECM + Backward-curved Impeller
Non-weatherized, Non-condensing Gas Furnace Fan					
Default Price Trend	0.110	0.048	4.462	0.551	1.395
Price Trend Based on Experience Curve for Furnaces	0.113	0.077	4.536	0.865	1.776
Non-weatherized, Condensing Gas Furnace Fan					
Default Price Trend	0.254	1.559	4.449	0.089	0.944
Price Trend Based on Experience Curve for Furnaces	0.257	1.584	4.516	0.498	1.481

Table 10-C.3.3 NPV Using Alternative Product Price Forecast, Discounted at 7 Percent, for Furnace Fans Used in HVAC Products Other than Hydronic Air Handlers (billion 2011$)

Key Product Class	Candidate Standard Level				
	1	**2**	**3**	**4**	**5**
	Improved PSC	PSC w/ Controls	X13	ECM	ECM + Backward-curved Impeller
Non-weatherized, Non-condensing Gas Furnace Fan	0.037	-0.021	1.587	-0.138	0.091
Non-weatherized, Condensing Gas Furnace Fan	0.096	0.575	1.650	-0.323	-0.155
Weatherized Gas Furnace Fan	0.002	0.030	0.346	0.107	0.166
Oil Furnace Fan	0.008	0.071	0.040	-0.039	-0.052
Electric Furnace / Modular Blower Fan	0.003	-0.055	0.233	-0.301	-0.272
Manufactured Home Non-weatherized, Non-condensing Gas Furnace Fan	0.001	0.005	0.013	-0.041	-0.046
Manufactured Home Non-weatherized, Condensing Gas Furnace Fan	0.002	0.013	0.017	-0.058	-0.070
Manufactured Home Electric Furnace / Modular Blower Fan	-0.001	0.000	0.011	-0.064	-0.046

Table 10-C.3.4   Comparison of NPV Under Alternative Product Price Forecasts, Discounted at 7 Percent, for Furnace Fans Used in Non-Weatherized Gas Furnaces (billion 2011$)

	Candidate Standard Level				
	1	**2**	**3**	**4**	**5**
	Improved PSC	PSC w/ Controls	X13	ECM	ECM + Backward-curved Impeller
Non-weatherized, Non-condensing Gas Furnace Fan					
Default Price Trend	0.037	-0.021	1.587	-0.138	0.091
Price Trend Based on Experience Curve for Furnaces	0.037	-0.029	1.566	0.206	0.412
Non-weatherized, Condensing Gas Furnace Fan					
Default Price Trend	0.095	0.564	1.618	-0.505	-0.392
Price Trend Based on Experience Curve for Furnaces	0.096	0.575	1.650	-0.323	-0.155