APPENDIX 8C. ESTIMATION OF POTENTIAL EQUIPMENT PRICE TRENDS FOR AUTOMATIC COMMERCIAL ICE MAKERS

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APPENDIX 8C. ESTIMATION OF POTENTIAL EQUIPMENT PRICE TRENDS FOR AUTOMATIC COMMERCIAL ICE MAKERS

8C.1 INTRODUCTION

In developing the proposed standards, the U.S. Department of Energy (DOE) assumes that the manufacturer costs and retail prices of products meeting various efficiency levels remain fixed, in real terms, after 2010 (the year for which the engineering analysis estimated costs) and throughout the period of the analysis. 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. Consistent with the NODA, DOE examined historical producer price indices (PPI) for automatic commercial ice makers.

In the following paragraphs, another potential method for forecasting long-term price trends is presented. DOE expects that improvements in the presented methods will be made in future revisions to its analysis.

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 the assumption of constant real prices and costs may, in many cases, over-estimate long-term appliance and equipment 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, or alternatively that the price trends for certain sectors of the U.S. economy may be different than the price trends for the economy as a whole. A draft paper, "Using the Experience Curve Approach for Appliance Price Forecasting," posted on the DOE website at 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.[1] In the experience curve method, the real cost of production is related to the cumulative production or "experience" with a manufactured product. To explain the empirical relationship, DOE would use the theory of technology learning to substantiate a decline in the cost of producing a given product as firms accumulate experience with the technology. 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).
DOE examined historical prices through the use of the Bureau of Labor Statistics' (BLS) Producer Price Index (PPI) and gross domestic product (GDP) deflator, available from the Bureau of Economic Analysis (BEA). The PPI data for air conditioning, refrigeration, and forced air heating is available for 1978–2010 and is used to represent aggregate automatic commercial ice maker prices.

Figure 8C.1.1 shows the PPI data series used. Table 8C.1.1 provides the PPI data.

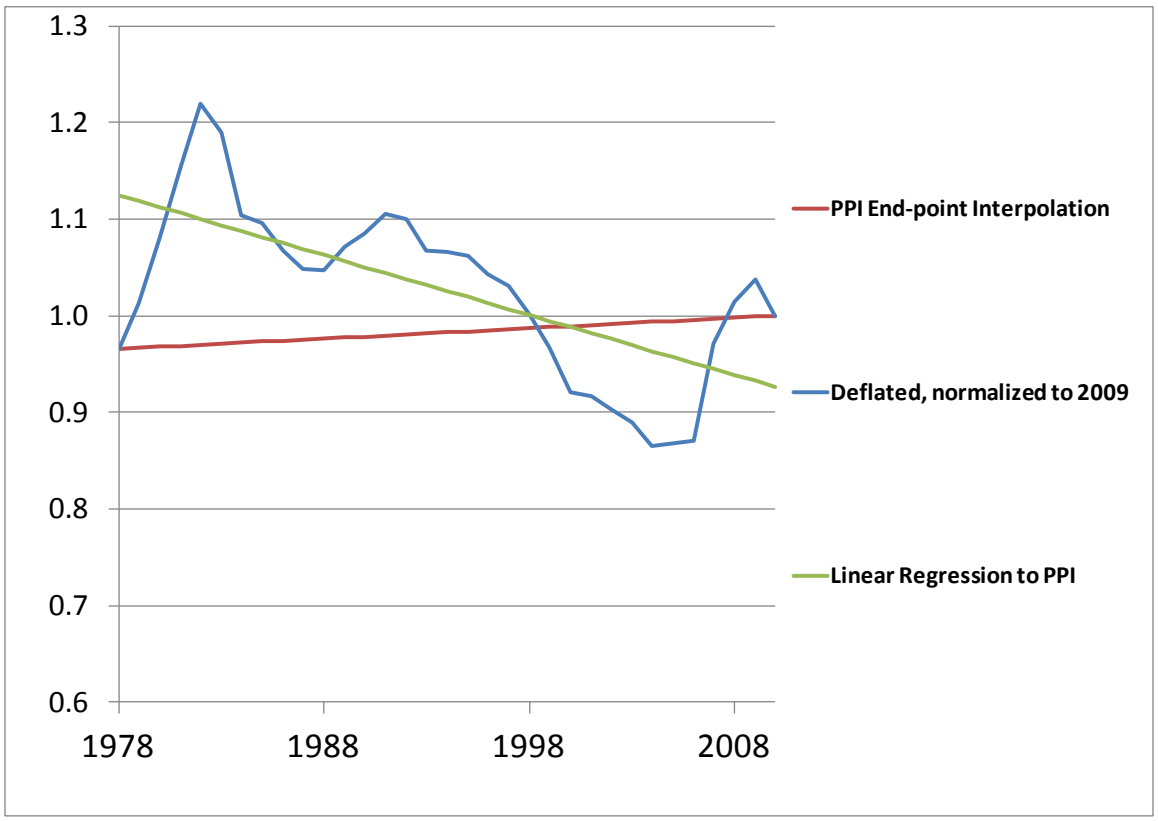

Figure 8C.1.1 PPI Data for Automatic Commercial Ice Makers

Inflation-adjusted price indices were calculated by dividing the fitted PPI series by the GDP deflator for the same years. The GDP deflator was used as opposed to the consumer price index because nearly all automatic commercial ice makers are shipped to commercial customers and to be consistent with energy price forecast assumptions by Energy Information Administration (EIA).

Table 8C.1.1 Producer Price Index for Air Conditioning, Refrigeration, and Forced Air Heating

Year	Annual Producer Price Index	PPI, Inflation Adjusted (2010=1.000)	Linear Regression to PPI*	PPI, End-point Interpolation**
1978	75.700	0.966	1.125	0.966
1979	81.900	1.013	1.118	0.967
1980	87.200	1.082	1.112	0.968
1981	95.400	1.154	1.106	0.969
1982	98.800	1.219	1.100	0.970
1983	100.800	1.190	1.094	0.971
1984	100.300	1.104	1.087	0.972
1985	103.600	1.095	1.081	0.973
1986	104.500	1.068	1.075	0.974
1987	105.900	1.049	1.069	0.975
1988	110.100	1.047	1.063	0.976
1989	116.700	1.072	1.056	0.977
1990	120.300	1.084	1.050	0.978
1991	122.300	1.105	1.044	0.980
1992	125.800	1.099	1.038	0.981
1993	125.600	1.067	1.032	0.982
1994	130.600	1.066	1.025	0.983
1995	133.300	1.062	1.019	0.984
1996	135.900	1.043	1.013	0.985
1997	140.200	1.030	1.007	0.986
1998	142.100	1.001	1.001	0.987
1999	144.000	0.967	0.995	0.988
2000	142.800	0.921	0.988	0.989
2001	143.600	0.916	0.982	0.990
2002	144.100	0.903	0.976	0.991
2003	145.400	0.889	0.970	0.992
2004	146.600	0.866	0.964	0.994
2005	151.500	0.868	0.957	0.995
2006	155.900	0.870	0.951	0.996
2007	177.500	0.972	0.945	0.997
2008	185.300	1.014	0.939	0.998
2009	184.600	1.038	0.933	0.999
2010	182.900	1.000	0.926	1.000

* PPI data smoothed using regression techniques.
** PPI data smoothed by simply interpolating between the 1978 and 2010 values.

8C.2 DATA EVALUATION AND ANALYSIS

Figure 8C.1.1 shows an apparent price trend in automatic commercial ice making equipment that is trending slightly upward from 1978 to 2010, but shows a decrease in the real PPI during two significant periods: 1982−1988 and1999−2004. Based on these price trends shown above, DOE expects that, in the future, the PPI is likely to resume a downward trend.

In order to perform an experience curve fit, DOE assembled a time-series of annual shipments for 1975−2009 for automatic commercial ice makers (for calculating cumulative production) from the Census Bureau.[2] Historical shipments are shown on Table 8C.2.1.

Projected shipments after 2009 were obtained from the base-case projections made for the NIA (see chapter 10 of this preliminary technical support document). Projected annual shipments are depicted on Figure 8C.2.1.

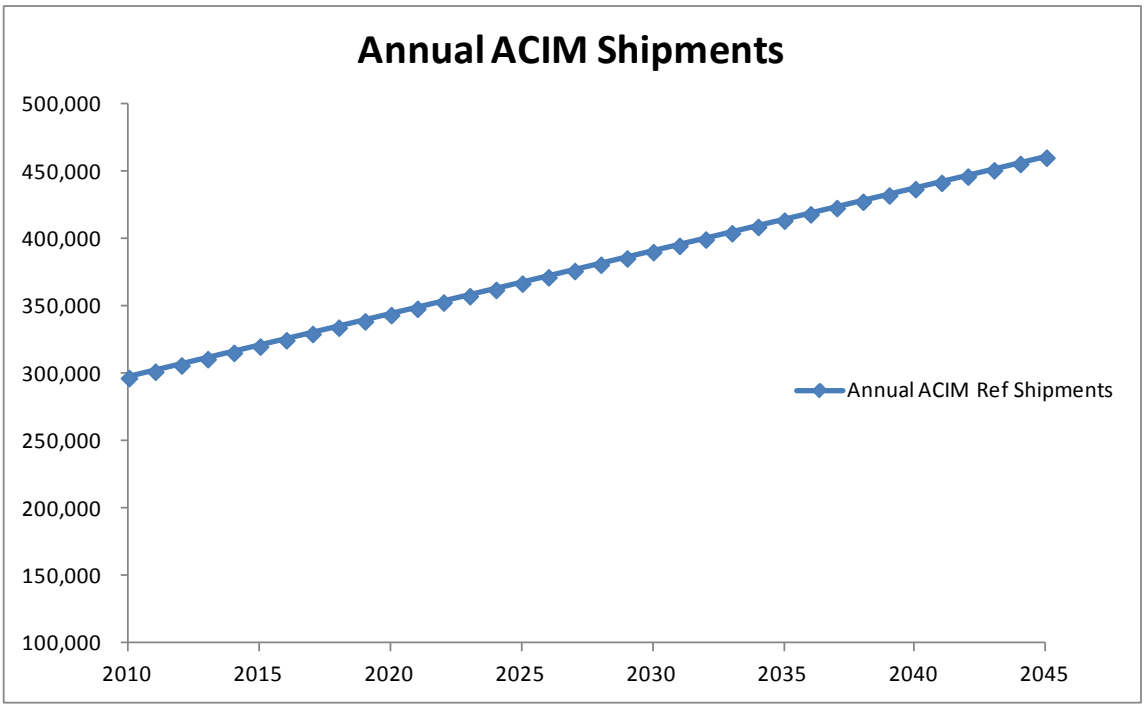

Figure 8C.2.1 Projected Annual Shipments for Automatic Commercial Ice Makers

Table 8C.2.1 Historical Automatic Commercial Ice Maker Shipments

Year	Shipments (*units*)
1975	113,525
1976	166,312
1977	156,496
1978	162,969
1979	187,406
1980	156,699
1981	152,511
1982	136,131
1983	153,271
1984	204,622
1985	187,644
1986	190,174
1987	231,739
1988	236,776
1989	188,012
1990	164,192
1991	158,104
1992	148,826
1993	172,396
1994	186,665
1995	192,929
1996	187,028
1997	192,796
1998	260,267
1999	328,237
2000	352,495
2001	246,062
2002	296,332
2003	292,577
2004	274,348
2005	288,108
2006	306,999
2007	305,042
2008	276,546
2009	213,426

* Source: U.S. Census Bureau, Current Industrial Reports, 1975 - 2009.

To estimate potential product price trends, DOE performed a least-squares power-law fit on the automatic commercial ice makers price index versus cumulative shipments. The form of the fitting equation is:

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

where 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 depend 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.

After modeling the data to the fitting equation, DOE estimated the learning rate (defined as the fractional reduction in price expected from each doubling of cumulative production) as 7 percent.

With cumulative shipments through 2045 projected to reach 21.12 million units (compared with 7.77 million units in 2010), the modeled trend predicts a drop of 4 percent in real price compared to the 2010 prices in the economy as a whole. Figure 8C.2.2 shows the model fit for the projected values for the period after 2009.

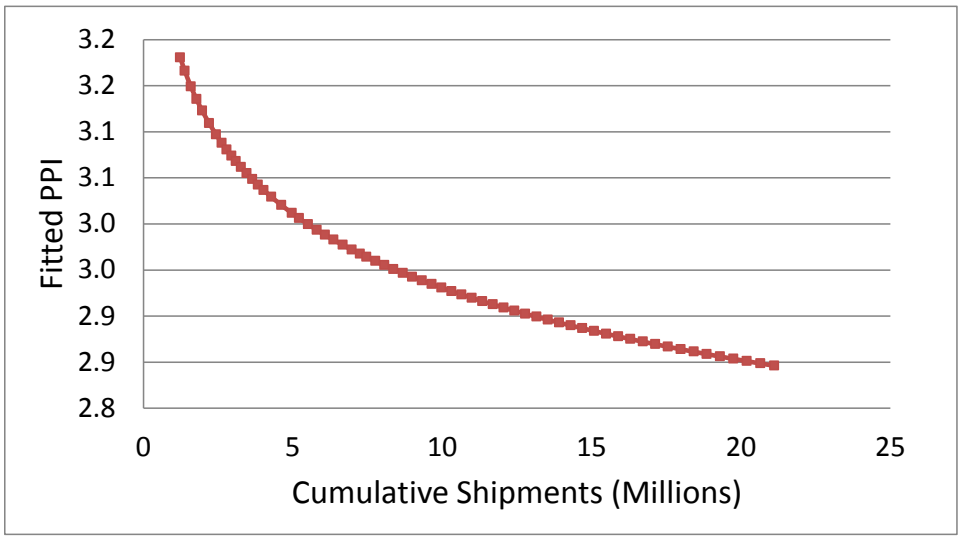

Figure 8C.2.2 Model Fit for Automatic Commercial Ice Makers

Table 8C.2.2 shows the price change values estimated through this analysis. The average annual rate of price decline in the default case for the 2016–2045 analysis period is 0.2 percent and is based on historical PPI data for refrigeration equipment between 1978–2010. Although not used in the preliminary analysis, DOE analyzed two additional sensitivity cases that also use a price trend based on an exponential-in-time extrapolation of refrigeration equipment PPI data. DOE developed a high price decline case and a low price decline case in this analysis. The high price decline case is based on the upper end of the 95 percent confidence interval for an exponential fit to the inflation-adjusted PPI series of 1978 to 2010. The low price decline case is based on the lower end of the 95 percent confidence interval for an exponential fit to the nominal PPI series of 1978 to 2010. The high and low cases are presented on Table 8C.2.2 along with the reference price change values used in the preliminary analysis.

Table 8C.2.2 Experience (Price) Learning Scenarios

Year	Historically Derived Changes		
	High Change	Reference Change	Low Change
2010	100.00%	100.00%	100.00%
2011	99.55%	99.70%	99.85%
2012	99.12%	99.41%	99.71%
2013	98.70%	99.13%	99.56%
2014	98.29%	98.85%	99.42%
2015	97.89%	98.58%	99.29%
2016	97.49%	98.32%	99.15%
2017	97.11%	98.06%	99.02%
2018	96.74%	97.81%	98.90%
2019	96.37%	97.56%	98.77%
2020	96.01%	97.32%	98.65%
2021	95.66%	97.09%	98.53%
2022	95.32%	96.85%	98.41%
2023	94.99%	96.63%	98.29%
2024	94.66%	96.40%	98.18%
2025	94.33%	96.18%	98.07%
2026	94.02%	95.97%	97.96%
2027	93.71%	95.76%	97.85%
2028	93.40%	95.55%	97.74%
2029	93.11%	95.35%	97.64%
2030	92.81%	95.15%	97.54%
2031	92.53%	94.95%	97.44%
2032	92.24%	94.75%	97.34%
2033	91.96%	94.56%	97.24%
2034	91.69%	94.38%	97.14%
2035	91.42%	94.19%	97.05%
2036	91.16%	94.01%	96.95%
2037	90.90%	93.83%	96.86%
2038	90.64%	93.66%	96.77%
2039	90.39%	93.48%	96.68%
2040	90.14%	93.31%	96.59%
2041	89.90%	93.14%	96.50%
2042	89.66%	92.98%	96.42%
2043	89.42%	92.81%	96.33%
2044	89.19%	92.65%	96.25%
2045	88.96%	92.49%	96.16%

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2. U.S. Census Bureau, *Current Industrial Reports, 1975 through 2009:NAICS 333415*: Refrigeration, Air Conditioning, and Warm Air Heating Equipment. (Last accessed July 2010.) <www.census.gov/manufacturing/cir/index.html.>