CHAPTER 9. SHIPMENTS ANALYSIS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 9. SHIPMENTS ANALYSIS

9.1 INTRODUCTION

The U.S. Department of Energy (DOE) analyzes shipments of affected products as part of every rulemaking regarding new or amended energy efficiency standards for appliances. Product shipments estimates are a necessary input to the national energy savings (NES) and net present value (NPV) calculations, which are required to justify potential new energy efficiency standards. Shipments are also a necessary input to the manufacturer impact analysis (MIA). This chapter describes DOE's method and results for projecting annual shipments for standard-sized dishwashers and compact-sized dishwashers under base- and standards-case efficiency levels.

DOE estimated shipments for each product class with a computer model that was calibrated against historical shipments. To estimate the impacts of prospective standard levels on product shipments, the model accounts for the combined effects of changes in purchase price, annual operating costs, and household income on the consumer purchase decision.

The shipments model considers specific market segments to estimate shipments. These results are then aggregated to estimate total product shipments. DOE accounted for two market segments: (1) shipments to new construction, and (2) replacement shipments going into existing buildings.

The shipments models are prepared as Microsoft Excel spreadsheets that are accessible on the Internet (http://www.eere.energy.gov/buildings/appliance_standards/). The rest of this chapter explains the shipments model in more detail. Section 9.2 describes the method that underlies the development of the model; section 9.3 describes the data inputs and the model calibration; section 9.4 discusses impacts on shipments from changes in equipment purchase price, operating cost, and household income; and section 9.5 discusses the affected stock. Section 9.6 presents the model results for different energy-efficiency standard levels, identified as trial standard levels (TSLs), for standard-sized and compact-sized dishwashers.

9.2 SHIPMENTS MODEL METHODOLOGY

DOE developed a model of the national stock of in-service appliances for estimating annual shipments for this standards rulemaking. The model considers market segments as distinct inputs to the shipments forecast. As represented by the following equation, the two primary market segments are new installations and replacements.

$$Ship_p(j) = Rpl_p(j) + NI_p(j)$$

Where:

$Ship_p(j)$ = Total shipments of product p in year j,
$Rpl_p(j)$ = Units of product p retired and replaced in year j, and
$NI_p(j)$ = Number of new installations of product p in year j.

DOE's shipments model takes an accounting approach, tracking market shares of each product class, vintage of units in the existing stock, and expected construction trends. In principle, each market segment and product class responds differently to both the demographic and economic trends in the base case (i.e., the case without new standards) than in any of the standards cases. Furthermore, retirements, early replacements, and efficiency trends[a] are dynamic and can vary among product classes. Rather than simply extrapolating a current shipments trend, the base case shipments analysis uses driver input variables, such as construction forecasts and product lifetime distributions, to forecast sales in each market segment. For example, the model assumes that construction (i.e., new housing units) drives new installations. Therefore, the product shipments for the new construction market segment are equal to the number of new housing units built times the purchase rate, which is determined by the product class market share and the market saturation of the product under consideration.

The model estimates shipments of replacement units using shipments data from previous years and assumptions about the lifetime of the equipment. Therefore, estimated sales of replacement units in a given year are equal to the total stock of the appliance minus those units shipped in previous years that still remain in the stock. DOE determined the useful service life of each appliance to estimate how long the appliance is likely to remain in stock. The following equation shows how DOE estimated replacement shipments.

$$Rpl_p(j) = Stock_p(j-1) - \sum_{age=0}^{ageMax} \sum_{j=N}^{j-1} Ship_j \times prob_{Rtr}(age)$$

Where:

$Stock_p(j\text{-}1)$ = Total stock of in-service appliances in year $j\text{-}1$,
$prob_{Rtr}(age)$ = Probability that an appliance of a particular *age* will be retired, and
N = year in which the model begins its stock accounting.

Stock accounting provides an estimate of the age distribution of product stocks for all years using product shipments, a retirement function, and initial product stock as inputs. The age distribution of in-service product stocks is a key input to both the NES and NPV calculations because the operating costs for any year depend on the age distribution of the stock. Operating cost depends on the product age distribution under a standards-case scenario that produces increasing efficiency over time; this means that older, less efficient units may have higher operating costs than younger, more-efficient units, which will have lower operating costs. In the

[a] Efficiency trends affect shipments only in the standards case. A change in the efficiency distribution of the stock results in a change in the purchase price and operating cost, which impacts shipments. This is discussed further in section 9.4.

case of early replacements, some units are removed from the in-service stock before expected the end of their lifetime and replaced with more efficient units.

DOE calculated total in-service stock of equipment by integrating historical shipments data starting from a specific year. The start year depended on the historical data available for the product. As units are added to the in-service stock, some of the older ones retire and exit the stock. To estimate future shipments, DOE developed a series of equations that define the dynamics and accounting of in-service stocks. For new units, the equation is:

$$\boldsymbol{Stock(\,j, age} = 1\boldsymbol{)} = \boldsymbol{Ship(\,j} - 1\boldsymbol{)}$$

Where:

Stock(j, age) = Number of in-service units of a particular age,
j = Year for which the in-service stock is being estimated, and
Ship (j) = Number of units purchased in year *j*.

The above equation states that the number of one-year-old units is simply equal to the number of new units purchased the previous year. Slightly more complicated equations, such as the following equation, describe the accounting of the existing in-service stock of units:

$$Stock(j+1, age+1) = Stock(j, age) \times \left[1 - prob_{Rtr}(age)\right]$$

In the above equation, as the year is incremented from *j* to *j+1*, the age is also incremented from *age* to *age+1*. Over time, a fraction of the in-service stock is removed, and that fraction is determined by a retirement probability function, $prob_{Rtr}(age)$, which is described in section 9.3. Because the products considered in this rulemaking are common appliances that have been used by U.S. consumers for a long time, replacements typically constitute the majority of shipments. Most replacements occur when equipment wears out and fails.

9.3 DATA INPUTS AND MODEL CALIBRATION

As noted above, shipments are driven primarily by two market segments: new construction and replacements.

DOE used two inputs – new housing forecasts and market saturation data – to estimate shipments driven by new construction. New housing includes newly constructed single- and multi-family units, termed "new housing completions," and mobile home placements. For new housing completions and mobile home placements, DOE used recorded data through 2007 and adopted the projections from the DOE Energy Information Administration (EIA)'s *Annual Energy Outlook 2011* (*AEO2011*) for the period of 2008–2035.[1] To determine new construction shipments for dishwashers, DOE used forecasts of market saturations combined with forecasts of housing starts.

DOE estimated replacements using product retirement functions that it developed from product lifetimes. The retirement function is described in detail in chapter 8.

DOE designed its shipments model for residential dishwashers by developing a single model for all dishwashers and then disaggregating the shipments into its two product classes—standard-sized and compact-sized dishwashers.

9.3.1 Historical Shipments

DOE used historical shipments data (both domestic and imports) to calibrate its shipments model. It used four sources to establish historical shipments: (1) data provided by the Association of Home Appliance Manufacturers (AHAM) for the period 2000–2010,[2] (2) data provided by the Association of Home Appliance Manufacturers (AHAM) for the period 1995–2000,[3] (3) data from the 2000 AHAM *Factbook* for the period 1989–1994,[4] and (4) data from *Appliance Magazine*[5,6,7] for the period 1972–1988. [b] Table 9.3.1 summarizes the historical dishwasher shipments data. DOE built up a total stock of dishwashers by integrating historical shipments starting in the year 1972. Over time, some of the units will be retired and removed from the stock, thus triggering the shipment of a new unit. Because of the relationship between retirements and total stock, there is a strong correlation between past and future shipments, independent of efficiency standards.

Table 9.3.1 Standard and Compact Dishwashers: Historical Shipments, Domestic plus Imports

Year	Shipments (thousands)	Year	Shipments (thousands)
1972	3.040	1992	3.597
1973	3.518	1993	3.914
1974	3.155	1994	4.353
1975	2.568	1995	4.346
1976	2.984	1996	4.606
1977	3.189	1997	4.826
1978	3.380	1998	5.144
1979	3.314	1999	5.712
1980	2.602	2000	5.828
1981	2.360	2001	5.627
1982	2.062	2002	6.207

[b] Shipments estimates from *Appliance Magazine* included exports. Thus, DOE reduced total shipments by 4.1 percent (the average percentage of exports for the years 1989–1993 based on the five-year average difference between the AHAM *Fact Book* 2000 and *Appliance Magazine* data) to estimate total domestic shipments plus imports.

Year	Shipments (thousands)	Year	Shipments (thousands)
1983	2.966	2003	6.428
1984	3.317	2004	7.106
1985	3.397	2005	7.424
1986	3.723	2006	7.252
1987	3.831	2007	6.977
1988	3.713	2008	5.995
1989	3.588	2009	5.404
1990	3.485	2010	5.710
1991	3.375		

The shipment data from AHAM and Appliance Magazine did not differentiate between standard-sized and compact-sized dishwashers. To determine the portion of the shipments that are compact dishwashers, DOE used data from The NPD Group, Inc, which revealed that 0.1% of dishwasher shipments were compact-sized dishwashers.8

9.3.2 Markets and Model Calibration

The shipments market for dishwashers primarily comprises units for new construction and replacement units for equipment that has been retired. DOE's shipments model also assumes that some existing households without dishwashers will purchase the equipment (i.e., become first time owners (FTOs)). Total dishwasher shipments are represented by the following equation:

$$Ship_{DW}(j) = Rpl_{DW}(j) + NI_{DW}(j) + FTO_{DW}(j)$$

Where:

$Ship_{DW}(j)$ = Total shipments of dishwashers in year j,
$Rpl_{DW}(j)$ = Replacement shipments in year j,
$NI_{DW}(j)$ = Shipments to new households in year j, and
$FTO_{DW}(j)$= Shipments to existing households without dishwashers in year j.

The following sections discuss the new construction, replacement markets, and first-time owners in further detail.

9.3.2.1 New Housing

DOE forecasted shipments to the new construction market based on forecasts of housing starts coupled with market saturation data for dishwashers. To forecast the shipments to new construction for any given year, DOE multiplied the housing starts forecasts by the forecasted

saturation of dishwashers for new housing. DOE used historical and forecasted new housing starts to calibrate its model.

Table 9.3.2 presents historical and forecasted new housing starts based on EIA's *AEO2011* for the period 2008–2035. *AEO2011* provides three scenarios for housing starts: a reference case, a high economic growth case, and a low economic growth case. Table 9.3.2 shows quantities based on three of these forecasts. DOE used only the forecasts from the reference case to estimate its shipments to new construction. For 2036−2047, DOE froze completions at the level in 2035.

New housing is comprised of single- and multi-family units (also referred to as "new housing completions") and mobile home placements. For new housing completions and mobile home placements, the *AEO2011* data are based on actual completions through the year 2005.

Table 9.3.2 Historical and Forecasted Housing Starts (millions)

Year	Reference	High	Low	Year	Reference	High	Low
2008	0.98	0.98	0.98	2022	1.93	2.31	1.54
2009	0.60	0.60	0.60	2023	1.92	2.31	1.53
2010	0.65	0.65	0.65	2024	1.91	2.33	1.51
2011	0.85	0.85	0.85	2025	1.93	2.37	1.50
2012	1.72	1.96	1.55	2026	1.93	2.39	1.48
2013	1.85	2.13	1.61	2027	1.90	2.38	1.44
2014	1.78	2.07	1.51	2028	1.86	2.36	1.39
2015	1.85	2.16	1.54	2029	1.83	2.35	1.35
2016	1.90	2.23	1.58	2030	1.83	2.37	1.32
2017	1.91	2.26	1.58	2031	1.81	2.37	1.29
2018	1.91	2.29	1.57	2032	1.77	2.33	1.23
2019	1.91	2.29	1.54	2033	1.75	2.30	1.20
2020	1.90	2.27	1.53	2034	1.75	2.30	1.20
2021	1.89	2.27	1.53	2035	1.74	2.29	1.20

Source: EIA, AEO2011.

Table 9.3.3 presents historical market saturations of dishwashers based on various sources, including the AHAM 2005 *Fact Book*,[9] *Appliance Magazine*,[10] NFO World Group,[11] and EIA's Residential Energy Consumption Survey (RECS) for the years 1993,[12] 1997,[13] and 2001.[14] The table presents market saturations for the overall housing stock and for new households. Because the forecast of shipments for the new housing market depends on the saturation of dishwashers in new housing, DOE focused its attention on the market saturations for new housing. According to RECS, dishwasher saturation in new housing for 1997, 2001, and 2005 was 78.1 percent, 81.5 percent, and 96.7 percent, respectively. DOE decided to use the most recent RECS data point because of the much higher rate of saturation to forecast saturations over the forecast period.

Table 9.3.3 Dishwashers: Historical Market Saturations

Year	Overall Household				New Households
	AHAM*	Appl**	NFO***	RECS†	RECS†
1970	18.9%				
1978		41.9%			
1982	44.5%				
1983		45.0%			
1987		47.7%			
1990	53.9%		45.4%		
1991		47.7%			
1992		50.0%			
1993		51.0%		45.4%	74.9%
1994		52.2%			
1995		54.4%			
1996		54.9%	49.9%		
1997		55.6%		50.3%	78.1%
1998		56.3%			
1999		56.5%			
2000		59.0%			
2001	59.3%	59.3%	53.6%	53.0%	81.5%
2002		59.5%			
2003		59.5%			
2004		60.0%			
2005	73.7%	60.5%		58.3%	96.7%
2006		61.0%			
2007		61.0%			
2008		61.0%			
2009				59.3%	
2010					

*** Source:** AHAM, *Fact Book,* 2005; **** Source:** Appliance Magazine, "The Saturation Picture," and "Market Research Report," January 2010, September issues; ***** Source:** NFO World Group, 2001; † **Source:** DOE-EIA, RECS 1997, 2001, and 2005.

9.3.2.2 Replacements

To determine shipments to the replacement market, DOE used an accounting method that tracks the total stock of units by vintage. DOE estimated a stock of dishwashers by vintage by

integrating historical shipments starting from the year 1972. Over time, some units are retired and removed from stock, triggering the shipment of a replacement unit. Depending on the vintage, a certain percentage will fail and need to be replaced. To estimate how long a unit will function before failing, DOE used a survival function based on a product lifetime distribution with an average value of 15.4 years. For a more complete discussion of dishwasher lifetimes, refer back to section 8.2.3.3. Figure 9.3.1 shows the survival and retirement functions that DOE used to estimate replacement shipments.

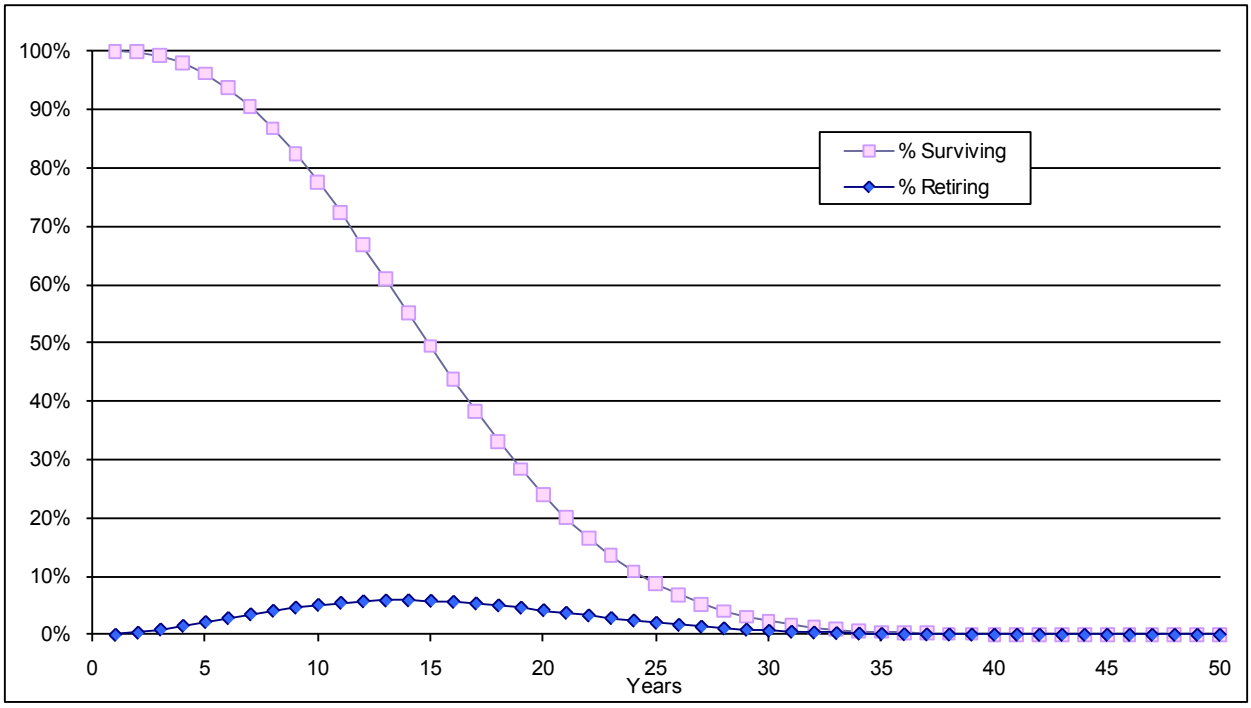

Figure 9.3.1 Dishwashers: Survival and Retirement Functions

Base Case Shipments

Figure 9.3.2 shows the forecasted shipments in the base case (i.e., the case without new energy efficiency standards) and the historical shipments DOE used to calibrate the forecast.

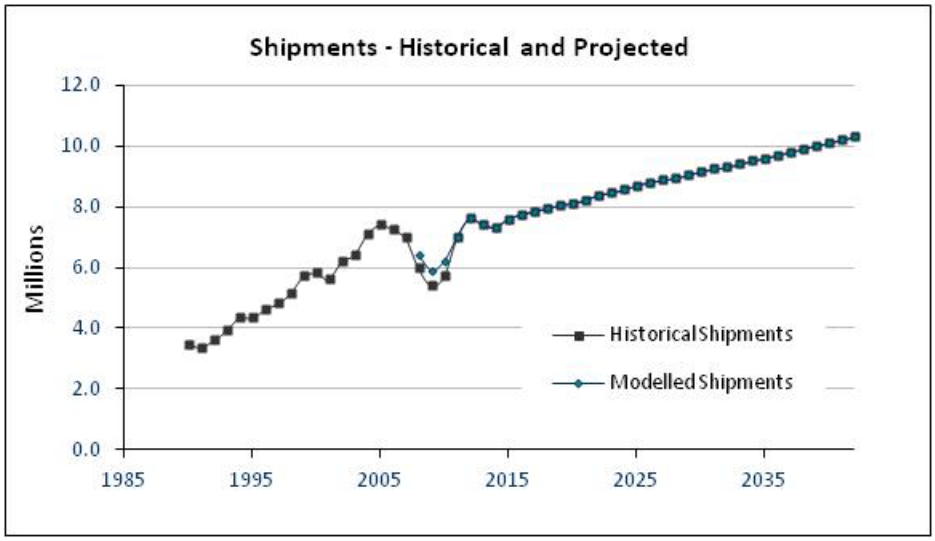

Figure 9.3.2 Standard-Sized and Compact Dishwashers: Historical and Base Case Shipments Forecast

9.4 IMPACTS OF STANDARDS ON SHIPMENTS

DOE conducted a literature review and an analysis of appliance price and efficiency data to estimate the combined effects on product shipments from increases in equipment purchase price, decreases in equipment operating costs, and changes to household income. Appendix 9A explains the method DOE used to quantify the impacts from the above variables.

DOE found only a few studies of appliance markets that are relevant to this rulemaking analysis and identified no studies that use time-series data of equipment price and shipments data after 1980. The information that can be derived from the literature suggests that the demand for appliances is price-inelastic (i.e., price does not affect demand). Other information in the literature suggests that appliances are a normal good, such that rising incomes increase the demand for them. Finally, the literature suggests that consumers exhibit relatively high implicit discount rates when comparing the price of an appliance to its operating costs.[c]

DOE found too few data on equipment purchase price and operating costs to perform a thorough analysis of dynamic changes in the appliance market. Rather, it used purchase price and efficiency data specific to residential refrigerators, clothes washers, and dishwashers during 1980–2002 to evaluate broad market trends and conduct simple regression analyses. These data indicate that, during that period, shipments of appliances increased while purchase prices and operating costs decreased. In addition, household income increased during that time period. To

[c] A high implicit discount rate with regard to operating costs suggests that consumers do not put high economic value on the operating cost savings expected from more-efficient appliances. In other words, consumers are much more concerned with higher purchase prices than with lower operating costs.

simplify the analysis, DOE combined the available economic information into one variable, termed the *relative price*, and used this variable to analyze market trends and conduct a regression analysis. DOE used the following expression to define *relative price*:

$$RP = \frac{TP}{Income} = \frac{PP + PVOC}{Income}$$

Where:

RP =	Relative price,
TP =	Total price,
Income =	Household income,
PP =	Appliance purchase price, and
PVOC =	Present value of operating cost.

In the above equation, DOE used real prices, as opposed to nominal, and an implicit discount rate of 37 percent to estimate the present value of operating costs. The rate of 37 percent is based on a survey of several studies of different appliances suggests that the consumer implicit discount rate has a broad range and averages about 37 percent.[15]

DOE's analysis of market trends suggests that the demand for the three appliances is relatively price inelastic (i.e., under 1.0) (See appendix 9-A for further description). DOE's regression analysis suggests that the *relative price* elasticity of demand, averaged over the three appliances, is -0.34. For example, a *relative price* increase of 10 percent results in a shipments decrease of 3.4 percent. Note that, because the *relative price* elasticity incorporates the impacts from three effects (i.e., purchase price, operating costs, and household income), the impact from any single effect is mitigated by changes from the other two effects.

The *relative price* elasticity of -0.34 is consistent with estimates in the literature. Nevertheless, DOE stresses that the measure is based on a small data set, using simple statistical analysis. More important, the measure is based on an assumption that economic variables, including purchase price, operating costs, and household income, explain most of the trend in appliances per household in the United States since 1980. Changes in appliance quality and consumer preferences may have occurred during this period, but DOE did not account for them in this analysis. Despite these uncertainties, DOE believes that its estimate of the relative price elasticity of demand provides a reasonable assessment of the impact that purchase price, operating costs, and household income have on product shipments.

Because DOE's forecasts of shipments and national impacts attributable to standards is over a lengthy time period, it needed to consider how the *relative price* elasticity is affected after a new standard takes effect. DOE considered the *relative price* elasticity, described above, to be a short-term value. It was unable to identify sources specific to household durable goods, such as appliances, to indicate how short-run and long-run price elasticities differ. Therefore, to estimate how the *relative price* elasticity changes over time, DOE relied on a study pertaining to

automobiles.[16] This study shows that the automobile price elasticity of demand changes in the years following a purchase price change. As the number of years increases after the purchase price change, the price elasticity becomes more inelastic until it reaches a terminal value around the tenth year after the price change. Several economic textbooks support the concept that price elasticity of demand for durable goods, such as appliances and automobiles, declines in the long run.[17] [18] [19] Table 9.4.1 shows the relative change in the price elasticity of demand for automobiles over time. DOE developed a time series of *relative price* elasticities for home appliances based on the relative change in the automobile price elasticity of demand. For years not shown in the table below, DOE performed a linear interpolation to obtain the *relative price* elasticity.

Table 9.4.1 Change in *Relative Price* Elasticity Following a Purchase Price Change

	Years Following Price Change					
	1	**2**	**3**	**5**	**10**	**20**
Change Relative to 1st year	1.00	0.78	0.63	0.46	0.35	0.33
Relative Price Elasticity	-0.34	-0.26	-0.21	-0.16	-0.12	-0.11

9.4.1 Impact from Increase in Relative Price

DOE used the following equation to estimate shipments under each standards case for the two product classes of dishwashers. The equation incorporates the impact of the *relative price* into the forecast of the base case shipments. In the equation, the *relative price* and the *relative price* elasticity are functions of the year because both change with time.

$$Ship_{STD\_p}(j) = \left(Rpl_{BASE\_p}(j) + NI_{BASE\_p}(j) + M_{BASE\_p}(j)\right) \times \left(1 - e_{RP}(j) \times \Delta RP(j)\right)$$

Where:

$Ship_{STD\_p}(j)$ = total shipments of product p in year j under a given standards case;
$Rpl_{BASE\_p}(j)$ = units of product p retired and replaced in year j under the base case;
$NI_{BASE\_p}(j)$ = number of new construction installations of product p in year j under the base case;
$M_{BASE\_p}(j)$ = units of product p installed in market M in year j (M represents early replacements) under the base case;
$e_{RP}(j)$= relative price elasticity in year j (equals -0.34 for year 1); and
$\Delta RP(j)$= change in relative price due to the given standard in year j.

9.5 AFFECTED STOCK

The affected stock is the in-service stock of the product that is affected by a potential energy efficiency standard. In addition to the forecast of product shipments under both the base case and each standards case (TSL), a key output of DOE's shipments model is the affected

stock, which represents the difference in the stock under the base case and each TSL. DOE calculates the affected stock to quantify the effect attributable to a TSL that new product shipments have on the appliance stock. Therefore, the affected stock consists of those in-service units that are purchased in or after the year a standard takes effect, as described by the following equation:

$$Aff\ Stock_p(j) = Ship_p(j) + \sum_{age=1}^{j - Std\_yr} Stock_p(age)$$

Where:

$Aff\ Stock_p(j)$=	Affected stock of product *p* units of all vintages that are operational in year *j*,
$Ship_p(j)$ =	Shipments of product *p* in year *j*,
$Stock_p(j)$ =	Stock of product *p* units of all vintages that are operational in year *j*,
age =	Age of the units (years), and
Std_yr =	Effective date of the standard.

As the above equation shows, DOE must define the effective date of the standard to calculate the affected stock. For the NES and NPV results presented in Chapter 10, DOE assumed that new energy efficiency standards would become effective in 2018 (2013 for TSL 2). Thus, the standard level would affect all appliances purchased beginning the first day of 2018 (2013 for TSL 2). Further discussion of the TSLs is provided in Chapter 10, Section 10.1.1.

9.6 SHIPMENTS IMPACTS CAUSED BY STANDARDS

This section presents the shipments impacts resulting from the four trial standard levels (TSLs) that DOE considered for dishwashers. TSL 2 consists of the efficiency levels recommended in the Joint Petition. TSL 3 consists of the efficiency level that is one level below the max-tech efficiency level. TSL 4 consists of the max-tech efficiency level.

Table 9.6.1 and Table 9.6.2 show the cumulative impacts on shipments during 2018–2047 (2013–2047 for TSL 2) from each TSL for standard-sized and compact dishwashers. For standard-sized dishwashers, shipments are forecasted to slightly decrease under each TSL; that is, the effect of increased purchase price offsets the effect of decreased operating costs, resulting in a net decrease in shipments. For compact dishwashers, the impacts are negligible.

Table 9.6.1 Standard-sized Dishwashers: Cumulative Shipments Impacts Caused by Standards

TSL	Annual Energy Use (kWh/year)	Cumulative Impact (million)	Cumulative Impact (%)
1	324	-0.021	-0.01%
2	307	-0.176	-0.06%
3	234	-0.883	-0.28%
4	180	-0.310	-0.10%

Table 9.6.2 Compact-sized Dishwashers: Cumulative Shipments Impacts Caused by Standards

TSL	Annual Energy Use (kWh/year)	Cumulative Impact (million)	Cumulative Impact (%)
1	222	0.000	0.06%
2	222	0.000	0.06%
3	154	0.001	0.16%
4	154	0.001	0.16%

REFERENCES

[1] Energy Information Administration, *Annual Energy Outlook 2011 with Projections to 2035,* 2011. Washington, DC. Report Number: DOE/EIA-0383(2011). http://www.eia.gov/forecasts/aeo/index.cfm

[2] Association of Home Appliance Manufacturers (AHAM). *AHAM 2010*. Washington, D.C.

[3] Association of Home Appliance Manufacturers. *AHAM Data on Dishwashers for Efficiency Standards Rulemaking*, September 7, 2006. Letter to Building Technologies Program, U.S. Department of Energy.

[4] Association of Home Appliance Manufacturers. *AHAM 2000 Fact Book*, 2000. Washington, DC.

[5] Statistical Review. *Appliance Magazine*, April, 1993.

[6] Statistical Review. *Appliance Magazine*, April, 1990.

[7] Statistical Review. *Appliance Magazine*, April, 1982.

[8] The NPD Group, Inc., *The NPD Group/NPD Houseworld – POS, Dishwashers* 2004-2010. Port Washington, NY.

[9] Association of Home Appliance Manufacturers. *AHAM 2005 Fact Book*, 2005. Washington, DC.

[10] The Saturation Picture. *Appliance Magazine*, September, 1993, 1995, 2004, 2005.

[11] NFO World Group. *Final Report: Home Appliance Saturation and Length of First Ownership Study*, May, 2001. Prepared for Association of Home Appliance Manufacturers by NFO World Group, Boston, MA.

[12] U.S. Department of Energy-Energy Information Administration. *Residential Energy Consumption Survey, 1993 Public Use Data Files*, 1993. Washington, DC. <http://www.eia.doe.gov/emeu/recs/93publicuse.html>

[13] U.S. Department of Energy-Energy Information Administration. *Residential Energy Consumption Survey, 1997 Public Use Data Files*, 1997. Washington, DC. <http://www.eia.doe.gov/emeu/recs/public.html>

[14] U.S. Department of Energy-Energy Information Administration. *Residential Energy Consumption Survey, 2001 Public Use Data Files*, 2001. Washington, DC. <http://www.eia.doe.gov/emeu/recs/recs2001/publicuse2001.html>

[15] K. Train. Discount rates in consumer' energy related decisions: a review of the literature, *Energy*, 1985.

[16] S. Hymans. Consumer Durable Spending: Explanation and Prediction, *Brookings Papers on Economic Activity*, 1971. Vol. 1971, No. 1, pp. 234-239.

[17] D. R. Kamerschen, L. M. Valentine. *Intermediate Microeconomic Theory.* 1977. South-Western Publishing Company, 2nd edition. p.52.

[18] H. Köhler. *Intermediate Microeconomics*. 1990. Scott, Foresman, University of California. 3rd edition. pp. 82-83.

[19] R. Pindyck and D. Rubinfeld. *Microeconomics.* 2012. Pearson/Prentice Hall, 8th edition. Chapter 2.5.