CHAPTER 11: NATIONAL IMPACT ANALYSIS

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CHAPTER 11. NATIONAL IMPACT ANALYSIS

11.1 INTRODUCTION

This chapter describes the method for estimating national impacts for cooking products and commercial clothes washers, i.e., the quantity and net value to consumers of future national energy savings (NES) (and water savings for commercial clothes washers) from possible trial standard levels (TSL). Chapter 9 provides identifies and describes the TSLs for cooking products and commercial clothes washers. Results described here include: (1) national energy (and water) consumption and savings, (2) monetary value of energy savings to the Nation due to TSLs, (3) increased total installed costs to the Nation due to TSLs, and (4) the net present value (NPV) of energy savings (difference between value of energy savings and increased total installed costs). For commercial clothes washers, when NES is discussed throughout this chapter, it includes national water savings in addition to national energy savings.

DOE determined both the NES and NPV for all of the TSLs considered for cooking products and commercial clothes washers. It performed all calculations for each of the considered products using a Microsoft Excel spreadsheet model, which is accessible on the Internet (http://www.eere.energy.gov/buildings/appliance_standards/). Each product's spreadsheet model, referred to as the National Impact Analysis (NIA) Model, combined the calculations for determining the NES and NPV as well as input from the relevant Shipments Model. Details and instructions for using each of the NIA Models are provided in Appendix 10A.

The important facets of national energy consumption of the considered products include: (1) shipments of the equipment, (2) customer response to changes in total installed cost (i.e., purchase price plus installation costs), operating expense, and household income, and (3) voluntary programs promoting higher energy efficiency of equipment.

Chapter 10 provides a detailed description of the Shipments Models that DOE used to forecast future purchases of the considered products. Included in the discussion are detailed descriptions of consumers' sensitivities to total installed cost, operating expense, and income (otherwise known as elasticities), and how DOE captured them within the model.

Concerning voluntary programs, although they may increase the share of energy efficient equipment prior to the implementation date of any new TSLs, DOE was not able to obtain information that quantified how such programs affect equipment efficiencies on a national basis. Consequently, DOE did not explicitly incorporate the impact of market-based initiatives into the shipments forecasts detailed in Chapter 10.

11.2 BASE CASE AND STANDARDS CASE FORECASTED EFFICIENCIES

A key component of DOE's estimates of NES and NPV is the energy efficiencies forecasted over time for the base case (without new standards) and each of the standards cases (with new standards). The forecasted efficiencies represent the annual shipment-weighted energy efficiency of the products under consideration over the forecast period (i.e., from the assumed effective date of a new standard to 30 years after the standard becomes effective). Because key inputs to the calculation of the NES and NPV are dependent on the estimated efficiencies, these efficiencies are of great importance to the analysis. In the case of the NES, the per-unit annual energy (and water) consumption is a direct function of product efficiency. Chapter 6, Energy and Water Use Determination, describes how the per-unit energy (and water) consumption vary as a function of efficiency for each of the considered products. With regard to the NPV, two inputs, the per-unit total installed cost and the per-unit annual operating cost, are dependent on efficiency. The per-unit total installed cost is a direct function of efficiency while the per-unit annual operating cost, because it is a function of the per-unit annual (and water) consumption, is indirectly dependent on product efficiency. Section 8.2.1 of Chapter 8, Life-Cycle Cost (LCC) and Payback Period (PBP) Analysis, describes how per-unit total installed costs vary as a function of efficiency for each of the considered products. The above NES and NPV inputs, as well as all other inputs to the calculation of the NES and NPV, are also discussed below in sections 10.3.1 and 10.4.1.

For each of the products considered, DOE based the development of the product efficiencies in the base case on the assignment of equipment efficiencies in the base case for the year 2005. In other words, DOE determined the distribution of product efficiencies currently in the marketplace to develop a shipment-weighted efficiency for the year 2005. For a complete discussion of the assignment of efficiencies in the base case for each of the considered products, refer to section 8.2.6 of Chapter 8, LCC and PBP Analysis.

Using the shipment-weight efficiency for the year 2005 as a starting point, DOE developed base case forecasted efficiencies based on assumptions regarding future efficiency growth. For the period spanning 2005–2012 (2012 being the assumed effective date of a new standard), DOE assumed that there would be no growth in the shipment-weighted efficiency (i.e., no change in the distribution of product efficiencies). Because there are no historical data to indicate how product efficiencies have changed over time, DOE estimated that forecasted efficiencies remained frozen at the 2012 efficiency level until the end of the forecast period (30 years after the assumed effective date—the year 2042). Although DOE recognizes the possibility that product efficiencies may change over time, DOE does not want to speculate as to how these product efficiencies may change without historical information. As described below in Section 11.2.1, DOE did forecast the market share of gas standard ranges equipped with standing pilots to estimate the impact of eliminating standing pilots for gas cooktops and gas standard ovens.

For its determination of standards-case forecasted efficiencies, DOE assumed a "roll-up" scenario to establish the shipment-weighted efficiency for the year that standards are assumed to become effective (i.e., 2012). DOE assumed that product efficiencies in the base case that did not meet the standard under consideration would "roll up" to meet the new standard level. Also, DOE assumed that all product efficiencies in the base case that were above the standard under consideration would not be affected. Using the shipment-weighted efficiency in the year 2012 as a starting point, DOE developed standards-case forecasted efficiencies based on assumptions regarding future efficiency growth. For all of the considered products, DOE made the same assumptions regarding standards-case efficiency growth rates as for the base case— namely, that forecasted efficiencies remain frozen at the 2012 efficiency level until the end of the forecast period. By maintaining the same growth rate for forecasted efficiencies in the standards case as in the base case (i.e., zero growth), DOE retained a constant efficiency difference or gap between the two cases over the length of the forecast period. Although frozen trends may not reflect what happens to base case and standards case product efficiencies in the future, DOE believes that maintaining a frozen efficiency difference between the base case and standards case provides a reasonable estimate of the impact that standards have on product efficiency.

With the exception of cooktops and ovens, the NIA spreadsheet models for each of the considered products also incorporated user options of one percent and two percent for the growth rates of the base-case and standards-case forecasted efficiencies. The following sections detail the base-case and standards-case forecasted efficiencies that DOE developed for each of the four sets of products.

11.2.1 Cooking Products – Cooktops and Ovens

DOE first presented the market share of efficiencies in the base case for cooktops and ovens in sections 8.2.6.1 and 8.2.6.2, respectively, of Chapter 8, LCC and PBP Analysis. As noted in Chapter 8, DOE did not have the data to develop efficiency distributions for any of the electric cooktop and oven product classes or the gas self-cleaning oven product class. Thus, DOE assumed that 100 percent of the current market was at the baseline level for these product classes. Because DOE assumed a roll-up scenario for forecasting product efficiency distributions once a standard became effective, the effect of any standard level was to move 100 percent of the market to that standard level.

In the case of gas cooktops and gas standard ovens, data were available to allow DOE to identify the percentage of the market in the base case that was already equipped with pilotless ignition. As described in Chapter 8, DOE allocated that percentage of the market that already had pilotless ignition. Therefore, knowing the market share of gas cooktops and standard ovens already equipped with pilotless ignition allowed DOE to accurately estimate the national impacts of requiring a standard that no longer allowed standing pilots.

For the year 2012, Tables 11.2.1, 11.2.2, and 11.2.3 show the base case and standards case product efficiency distributions that DOE used in its national impact analysis for electric coil, electric smooth, and gas cooktops. The standards cases correspond to the candidate standard levels analyzed in the LCC and PBP Analysis. The TSLs for each product class are also shown in the following tables. Note that the TSLs do not consider all of the candidate standard levels that DOE analyzed in the LCC and PBP analysis. Also included in the tables below are the shipment-weighted efficiencies (SWEF) associated with the base case and each standards case (candidate standard level).

Table 11.2.1 Electric Coil Cooktops: Base Case and Standards Case Efficiency Distributions in 2012

Candidate Standard Level	TSL	EF	Market Shares	
				Candidate Standard Level
			Base Case	1
Baseline	1	0.737	100%	-
1	2, 3, 4	0.769	0%	100%
		SWEF (EF)	0.737	0.769

Table 11.2.2 Electric Smooth Cooktops: Base Case and Standards Case Efficiency Distributions in 2012

Candidate Standard Level	TSL	EF	Market Shares	
				Candidate Standard Level
			Base Case	1
Baseline	1, 2, 3	0.742	100%	-
1	4	0.753	0%	100%
		SWEF (EF)	0.742	0.753

Table 11.2.3 Gas Cooktops: Base Case and Standards Case Efficiency Distributions in 2012

Candidate Standard Level	TSL	EF	Market Shares		
				Standard Case	
			Base Case	1	2
Baseline	-	0.156	6.8%	-	-
1	1, 2, 3	0.399	93.2%	100%	-
2	4	0.420	0%	0%	100%
		SWEF (EF)	0.379	0.399	0.420

Tables 11.2.4, 11.2.5, 11.2.6, and 11.2.7 show the base case and standards case product efficiency distributions in 2012 that DOE used for electric standard, electric self-cleaning, gas standard, and gas self-cleaning ovens. As with the cooktop product classes, the standards cases for the oven product classes correspond to the candidate standard levels analyzed in the LCC and PBP Analysis. The TSLs for each product class are also shown in the following tables. Note that the TSLs do not consider all of the candidate standard levels that DOE analyzed in the LCC and PBP analysis. Also included in each of the tables is the SWEF associated with the base case and each standards case.

In the case of gas standard ovens (Table 11.2.6), DOE analyzed standard levels 1 and 1a in a similar manner. That is, because both are non-standing pilot ignition options, DOE allocated the market share at the baseline level (standing pilot) to the candidate standard level under consideration without affecting the market share allocated to the other standing pilot option. Therefore, when DOE analyzed candidate standard level 1 (glo-bar ignition system), the 17.6 percent of the market at the baseline level was rolled-up into candidate standard level 1 (to arrive at a market share of 91.8 percent) without affecting the market share at candidate standard level 1a (spark ignition). When DOE analyzed candidate standard level 1a, the 17.6 percent of the market at the baseline level was rolled-up into candidate standard level 1a (to arrive at a market share of 25.8 percent) without affecting the market share at candidate standard level 1. For candidate standard levels 2 through 6, because they included design options beyond a non-standing pilot ignition system, the market shares at the baseline level and candidate standard levels 1 and 1a (for a total of 100 percent) were allocated to the candidate standard level under consideration.

Table 11.2.4 Electric Standard Ovens: Base Case and Standards Case Efficiency Distributions in 2012

Candidate Standard Level	TSL	EF	Market Shares					
			Base Case	Candidate Standard Level				
				1	2	3	4	5
Baseline	1	0.1066	100%	-	-	-	-	-
1	-	0.1113	0%	100%	-	-	-	-
2	2, 3	0.1163	0%	0%	100%	-	-	-
3	-	0.1181	0%	0%	0%	100%	-	-
4	-	0.1206	0%	0%	0%	0%	100%	-
5	4	0.1209	0%	0%	0%	0%	0%	100%
		SWEF (EF)	0.1066	0.1113	0.1163	0.1181	0.1206	0.1209

Table 11.2.5 Electric Self-Cleaning Ovens: Base Case and Standards Case Efficiency Distributions in 2012

Candidate Standard Level	TSL	EF	Market Shares		
			Base Case	Candidate Standard Level	
				1	2
Baseline	1, 2, 3	0.1099	100%	-	-
1	-	0.1102	0%	100%	-
2	4	0.1123	0%	0%	100%
		SWEF (EF)	0.1099	0.1102	0.1123

Table 11.2.6 Gas Standard Ovens: Base Case and Standards Case Efficiency Distributions in 2012

Candidate Standard Level	TSL	EF	Market Shares							
			Base Case	Candidate Standard Level						
				1	2	3	4	5	6	1a
Baseline	-	0.0298	17.6%	-	-	-	-	-	-	-
1*	-	0.0536	74.2%	91.8%	-	-	-	-	-	74.2%
2	-	0.0566	0%	0%	100%	-	-	-	-	0%
3	-	0.0572	0%	0%	0%	100%	-	-	-	0%
4	-	0.0593	0%	0%	0%	0%	100%	-	-	0%
5	-	0.0596	0%	0%	0%	0%	0%	100%	-	0%
6	4	0.0600	0%	0%	0%	0%	0%	0%	100%	0%
1a*	1, 2, 3	0.0583	8.2%	8.2%	0%	0%	0%	0%	0%	25.8%
SWEF (EF)			0.0498	0.0540	0.0566	0.0572	0.0593	0.0596	0.0600	0.0548

* Candidate Standard Levels 1 and 1a correspond to designs that are utilized for the same purpose—eliminate the need for a standing pilot. Level 1 is a glo-bar hot surface ignition device while level 1a is a spark ignition device.

Table 11.2.7 Gas Self-Cleaning Ovens: Base Case and Standards Case Efficiency Distributions in 2012

Candidate Standard Level	TSL	EF	Market Shares			
			Base Case	Candidate Standard Level		
				1	2	3
Baseline	1, 2	0.0540	100%	-	-	-
1	3	0.0625	0%	100%	-	-
2	-	0.0627	0%	0%	100%	-
3	4	0.0632	0%	0%	0%	100%
SWEF (EF)			0.0540	0.0625	0.0627	0.0632

For gas cooktops and gas standard ovens, DOE developed base case efficiency trends to estimate the future market share of products with pilotless ignition. As described in Chapter 8, only gas standard ranges (which are a combination of a gas cooktop and a gas standard oven) are still shipped with standing pilots. Based on the data first presented in sections 8.2.6.1 and 8.2.6.2 of Chapter 8, Figure 11.2.2 shows the historical market share of gas cooking products with standing pilots. The figure below also provides trend lines to the historical data. Note that the market share of gas built-in ovens with standing pilots zeroed out in 1991 while the market share of gas built-in cooktops with standing pilots is zero out by the year 2000. That leaves standard ranges as the only gas cooking products shipped with standing pilots. By the end of the forecast period in the year 2042, DOE estimated that less than five percent of gas standard ranges in the market would still be shipped with standing pilots. DOE used the trend line for gas standard ranges presented below in Figure 11.2.2 to forecast the percentage of gas range shipments with standing pilots. Refer back to section 10.3.1.1 of Chapter 10, Shipments Analysis, for a description of how DOE allocated the gas standard range shipments into gas cooktop and gas standard oven product classes.

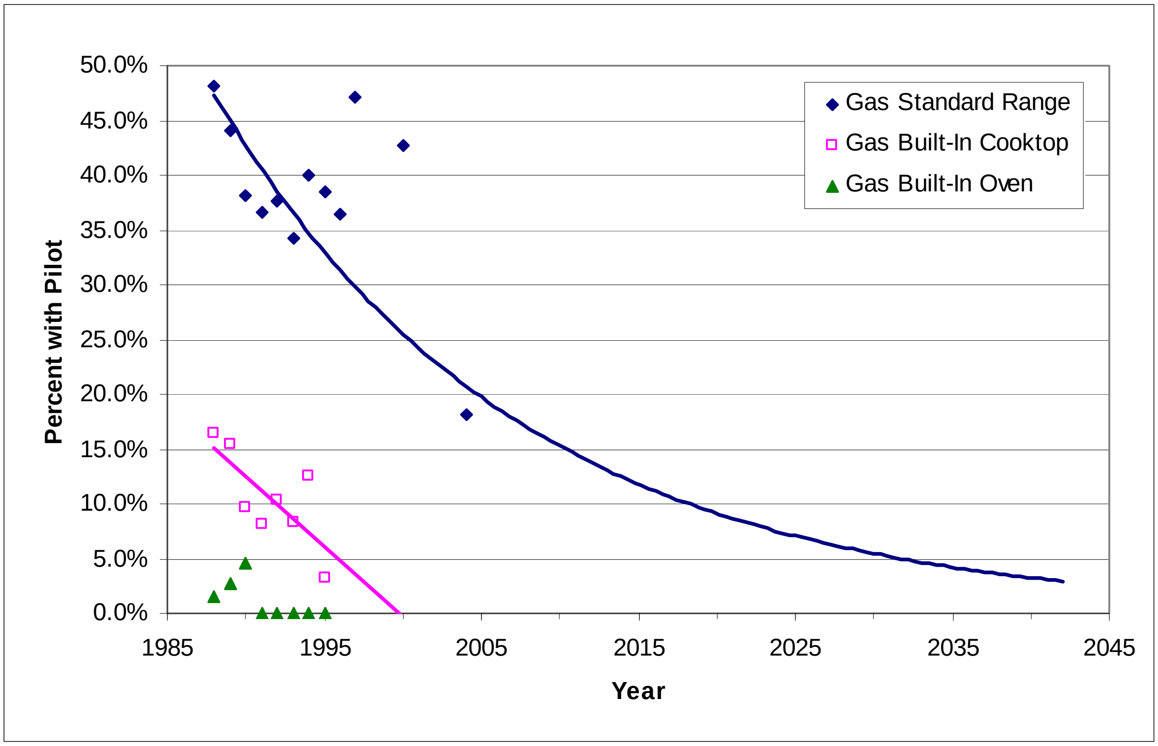

Figure 11.2.1 Gas Cooking Products: Forecast of Products with Standing Pilots

With regard to the base case and standards case forecasted efficiencies, as noted previously, DOE assumed that equipment efficiencies remain frozen at the levels in the year 2012 for all standard levels and for all product classes, with the exception of gas cooktops and gas standard ovens. For gas cooktops and gas standard ovens, as noted above, DOE used the forecasted trend in gas ranges with standing pilots in the base case (as shown in Figure 11.2.2) to estimate the impacts from moving to a candidate standard level that eliminated standing pilots (i.e., candidate standard levels 1 and 1a). For all gas cooktop and gas standard oven candidate standard levels, DOE assumed that equipment efficiencies remain frozen at the levels in the year 2012.

11.2.2 Cooking Products – Microwave Ovens

DOE first presented the market share of efficiencies in the base case for microwave ovens in section 8.2.6.3 of Chapter 8, LCC and PBP Analysis. Table 11.2.8 shows the base case and standards case product efficiency distributions in the year 2012 that DOE used in its national impact analysis for microwave ovens. The standards cases correspond to the candidate standard levels analyzed in the LCC and PBP Analysis. The TSLs are also shown in Table 11.2.8. Note that DOE considered all the candidate standard levels in the TSLs that it developed for microwave ovens. Table 11.2.8 presents both the market shares by energy factor level and standby power level. While DOE conducted separate national impact analyses for the energy factor and standby power, the base case efficiency distributions have been developed to account for the percentage of the market that are represented by efficiency levels in both the 'energy factor' and 'standby power' groupings. Specifically, the baseline efficiency level represents 46.2 percent of the market and is comprised of an energy factor of 0.557 and standby power consumption of 4.0 watts with a corresponding annual energy consumption of 165.8 kWh/year. Because all efficiency levels under consideration to improve the energy factor have an annual energy use which is greater than all of the efficiency levels under consideration to limit standby power, DOE conducted the NIA on the energy factor by retaining the base case market share assignments for standby power. For example, in analyzing TSL 1a, DOE specified that 46.2 percent of consumers would purchase microwave ovens with an energy factor of 0.586. For those consumers already purchasing products with a standby power consumption of 2.0 Watts (34.6 percent market share at TSL 1b) and 1.5 Watts (19.2 market share at TSL 2b), DOE estimated that these consumers would be unaffected as they already owned microwave ovens with an energy consumption lower than TSL 1a.

Table 11.2.8 shows the resulting shipment-weighted efficiency for the energy factor, standby power, and annual energy use for each standard level considered.

Table 11.2.8 Microwave Ovens: Base Case and Standards Case Efficiency Distributions by Energy Factor Level in 2012

TSL	EF	Standby Power (W)	Annual Energy Use (kWh/yr)	Market Shares								
				Base Case	Trial Standard Level							
					1a	2a	3a	4a	1b	2b	3b	4b
Baseline	0.557	4.0	165.8	46.2%	-	-	-	-	-	-	-	-
1a	0.586	4.0	159.3	0%	46.2%	-	-	-	-	-	-	-
2a	0.588	4.0	158.8	0%	0%	46.2%	-	-	-	-	-	-
3a	0.597	4.0	157.0	0%	0%	0%	46.2%	-	-	-	-	-
4a	0.602	4.0	156.0	0%	0%	0%	0%	46.2%	-	-	-	-
1b	0.557	2.0	148.4	34.6%	34.6%	34.6%	34.6%	34.6%	80.8%	-	-	-
2b	0.557	1.5	144.0	19.2%	19.2%	19.2%	19.2%	19.2%	19.2%	100%	-	-
3b	0.557	1.0	139.7	0%	0%	0%	0%	0%	0%	0%	100%	-
4b	0.557	0.02	131.2	0%	0%	0%	0%	0%	0%	0%	0%	100%
SWEF (EF)				0.557	0.586	0.588	0.597	0.602	0.557	0.557	0.557	0.557
SWEF (Standby Power)				2.83	2.83	2.83	2.83	2.83	1.90	1.50	1.00	0.02
SWEF (Annual Energy Use)				155.6	152.6	152.4	151.5	151.1	147.6	144.0	139.7	131.2

Based on the assumption of a zero-percent growth rate in the forecasted efficiencies for the base case and all standards cases, DOE maintained the SWEFs shown above in Table 11.2.8 throughout the entire forecast period, i.e., from 2012 to 2042.

11.2.3 Commercial Clothes Washers

DOE first presented the market share of efficiencies in the base case for commercial clothes washers in section 8.2.6.4 of Chapter 8, LCC and PBP Analysis. Tables 11.2.9 and

11.2.10 show the base case and TSL product efficiency distributions in the year 2012, corresponding to the modified energy factor (MEF) and water factor (WF) of top-loading and front-loading clothes washing equipment, respectively, that DOE used in its national impact analysis for commercial clothes washers. The TSLs are comprised of the candidate standard levels analyzed in the LCC and PBP Analysis. The TSLs are also shown in Tables 11.2.9 and 11.2.10. Note that DOE considered all the candidate standard levels in the TSLs that it developed for commercial clothes washers. Also included in the table below is the SWEF associated with the base case and each TSL.

Table 11.2.9 Top-Loading Commercial Clothes Washers: Base Case and Standards Case Efficiency Distributions in 2012

		Efficiencies		**Market Shares**					
					Trial Standard Level				
CSL	**TSL**	**MEF**	**WF**	**Base Case**	**1**	**2**	**3**	**4**	**5**
Baseline	-	1.26	9.50	63.6%	-	-	-	-	-
1	1	1.42	9.50	33.3%	97.0%	-	-	-	-
2	2	1.60	8.50	0.0%	0%	97.0%	-	-	-
3	3, 4, 5	1.76	8.30	3.0%	3.0%	3.0%	100%	100%	100%
			SWEF (MEF)	1.33	1.43	1.60	1.76	1.76	1.76
			SWEF (WF)	9.46	9.46	8.49	8.30	8.30	8.30

Table 11.2.10 Front-Loading Commercial Clothes Washers: Base Case and Standards Case Efficiency Distributions in 2012

		Efficiencies		**Market Shares**					
					Trial Standard Level				
CSL	**TSL**	**MEF**	**WF**	**Base Case**	**1**	**2**	**3**	**4**	**5**
Baseline	-	1.72	8.00	7.4%	-	-	-	-	-
1	1	1.80	7.50	4.4%	11.8%	-	-	-	-
2	2, 3	2.00	5.50	85.3%	85.3%	97.0%	97.0%	-	-
3	4	2.20	5.10	1.5%	1.5%	1.5%	1.5%	98.5%	-
4	5	2.35	4.40	1.5%	1.5%	1.5%	1.5%	1.5%	100%
			SWEF (MEF)	1.98	1.98	2.01	2.01	2.20	2.35
			SWEF (WF)	5.75	5.71	5.48	5.48	5.09	4.40

Based on the assumption of a zero-percent growth rate in the forecasted efficiencies for the base case and all standards cases, DOE maintained the SWEFs shown above in Table 11.2.9 throughout the entire forecast period, i.e., from 2012 to 2042.

11.3 NATIONAL ENERGY SAVINGS

11.3.1 NES Definition

As shown in the following equation, DOE calculates annual national energy savings as the difference between two projections: a base case (without new standards) and a standards case (with new standards). Positive values of NES correspond to energy savings (i.e., national energy consumption with standards is less than national energy consumption in the base case).

$$NES_y = AEC_{BASE} - AEC_{STD}$$

Cumulative energy savings are the sum over the forecast period, extending from the assumed effective date, i.e., 2012, to 30 years after the effective date, i.e., 2042, of the annual national energy savings. This calculation is represented by the following equation:

$$NES_{cum} = \sum NES_y$$

DOE calculated the national annual energy consumption by multiplying the number or stock of the given product (by vintage) by its unit energy consumption (also by vintage). The calculation of the national annual energy consumption is represented by the following equation:

$$AEC = \sum STOCK_V \times UEC_V$$

For the above expressions, DOE defined the various quantities as follows:

AEC =	Annual national energy consumption each year in quadrillion British thermal units (Btus) – or quads, summed over vintages of the product stock, $STOCK_V$,
NES =	Annual national energy savings (quads),
$STOCK_V$ =	Stock of product (millions of units) of vintage *V* surviving in the year for which DOE calculated annual energy consumption (vintages range from five to approximately 28 years, depending on the retirement function of the product),
UEC_V =	Annual energy consumption per product in either kilowatt-hours (kWh) or million Btus (MMBtu) (electricity and gas consumption are converted from site energy to source energy (quads) by applying a time-dependent conversion factor),
V =	Year in which the product was purchased as a new unit, and
y =	Year in the forecast (i.e., 2012 to 2042).

The stock of equipment is dependent on annual shipments and the lifetime of the equipment. As described in Chapter 10, DOE conducted shipments projections under the base case and standards cases. DOE determined that the shipments projections under the standards cases were slightly lower than those in the base case projection, due to the higher purchase prices of the more-efficient equipment. In other words, DOE believes that the higher purchase prices would cause some consumers to forego new equipment purchases.

Due to the drop in shipments caused by standards, for microwave ovens, DOE used the standards case shipments projection and, in turn, the standards case stock, to calculate the annual energy consumption in the base case to avoid the inclusion of savings due to displaced shipments. However, in the case of commercial clothes washers, because DOE explicitly accounted for the energy and water consumption of the displaced shipments, it maintained the use of the base case shipments to determine the annual energy consumption in the base case. For commercial clothes washers, DOE assumed that any drop in shipments caused by standards would result in the purchase of used machines. Finally, in the case of electric and gas cooking products, because the housing market is fully saturated (i.e., all households have cooking appliances), DOE assumed that standards would neither impact shipments nor cause shifts in electric and gas cooking product market shares. Therefore, DOE's projected standards case shipments for electric and gas cooking products were identical to its base case shipments.

11.3.2 NES Inputs

Table 11.3.1 lists the inputs for the determination of NES.

Table 11.3.1 National Energy Saving Inputs

Annual Energy Consumption per Unit (*UEC*)
Shipments
Equipment Stock ($STOCK_V$)
National Annual Energy Consumption (*AEC*)
Site-to-Source Conversion Factor (*src_conv*)

11.3.2.1 Annual Energy Consumption per Unit

For each of the considered products, DOE presented the per-unit annual energy (and water) consumption as a function of product efficiency in both Chapter 6, Energy and Water Use Determination, and section 8.2.2.1 of Chapter 8, LCC and PBP Analysis. Because the per-unit annual energy (and water) consumption is directly dependent on efficiency, DOE used the base case and standards case SWEFs presented above in section 10.2, in combination with the annual energy (and water use) data presented in Chapters 6 and 8, to estimate the shipment-weighted average annual per-unit energy (and water) consumption under the base case and standards cases. The following sections describe the shipment-weighted average annual per-unit energy (and water) consumption for each of the considered products.

Cooking Products – Cooktops and Ovens

DOE based its per-unit annual energy consumption of cooktops and ovens on data presented in section 8.2.2.1 of Chapter 8. Using the relationship between cooktop and oven EF and annual energy consumption described in Chapter 8, Tables 11.3.2 and 11.3.3 present the per-unit annual energy consumption based on the SWEFs corresponding to the base case and each candidate standard level for each of the three product classes of cooktops and the four product classes of ovens.

Table 11.3.2 Cooktops: Base Case and Standards Case Shipment-Weighted Average Per-Unit Annual Energy Consumption in 2012

Product Class		Base Case	Candidate Standard Level	
			1	2
Electric Coil	SWEF (EF)	0.737	0.769	
	Electric (kWh/yr)	128.2	122.9	
Electric Smooth	SWEF (EF)	0.742	0.753	
	Electric (kWh/yr)	128.2	126.3	
Gas	SWEF (EF)	0.379	0.399	0.420
	Gas (MMBtu/yr)	0.83	0.72	0.68

Table 11.3.3 Ovens: Base Case and Standards Case Shipment-Weighted Average Per-Unit Annual Energy Consumption in 2012

Product Class		Base Case	Candidate Standard Level						
			1*	2	3	4	5	6	1a*
Electric Standard	SWEF (EF)	0.1066	0.1113	0.1163	0.1181	0.1206	0.1209		
	Electric (kWh/yr)	166.5	160.1	153.9	151.8	149.0	148.6		
Electric Self-Clean	SWEF (EF)	0.1099	0.1102	0.1123					
	Electric (kWh/yr)	171.0	170.6	167.9					
Gas Standard	SWEF (EF)	0.0498	0.0540	0.0566	0.0572	0.0593	0.0596	0.0600	0.0548
	Electric (kWh/yr)	15.7	19.4	21.1	21.1	22.9	22.9	22.9	15.7
	Gas (MMBtu/yr)	1.02	0.84	0.80	0.79	0.75	0.75	0.74	0.84
Gas Self-Clean	SWEF (EF)	0.0540	0.0625	0.0627	0.0632				
	Electric (kWh/yr)	53.33	55.13	55.13	55.13				
	Gas (MMBtu/yr)	0.86	0.73	0.73	0.72				

* For gas standard ovens, levels 1 and 1a correspond to designs that are utilized for the same purpose—eliminate the need for a standing pilot—but the technologies for each design are different. Level 1 is a hot surface ignition device while level 1a is a spark ignition device.

For all classes except gas cooktops and standard ovens, as noted above in section 11.2, DOE assumed that forecasted efficiencies in the base case and standards cases remain frozen at the efficiency levels in 2012. Therefore, because the per-unit annual energy consumption is a function of efficiency, DOE held the values shown above in Tables 11.3.2 and 11.3.3 constant over the forecast period (2012–2042).

For gas cooktops and standard ovens, DOE tracked the percentage of gas standard ranges (which are composed of a cooktop and standard oven) with standing pilots. Because the percentage of ranges with standing pilots changes over time (as shown above in section 11.2, Figure 11.2.1), the base case annual energy consumption will change over time as well. Figure 11.3.1 shows how the annual gas energy use for both base case gas cooktops and gas standard ovens decreases over time as more gas standard ranges are forecasted to be shipped with pilotless ignition. Also note in Figure 11.3.1 that, because standard ovens without standing pilots are assumed to use globar ignition devices that use a non-significant amount of electricity, the amount of electricity use for standard ovens increases over time.

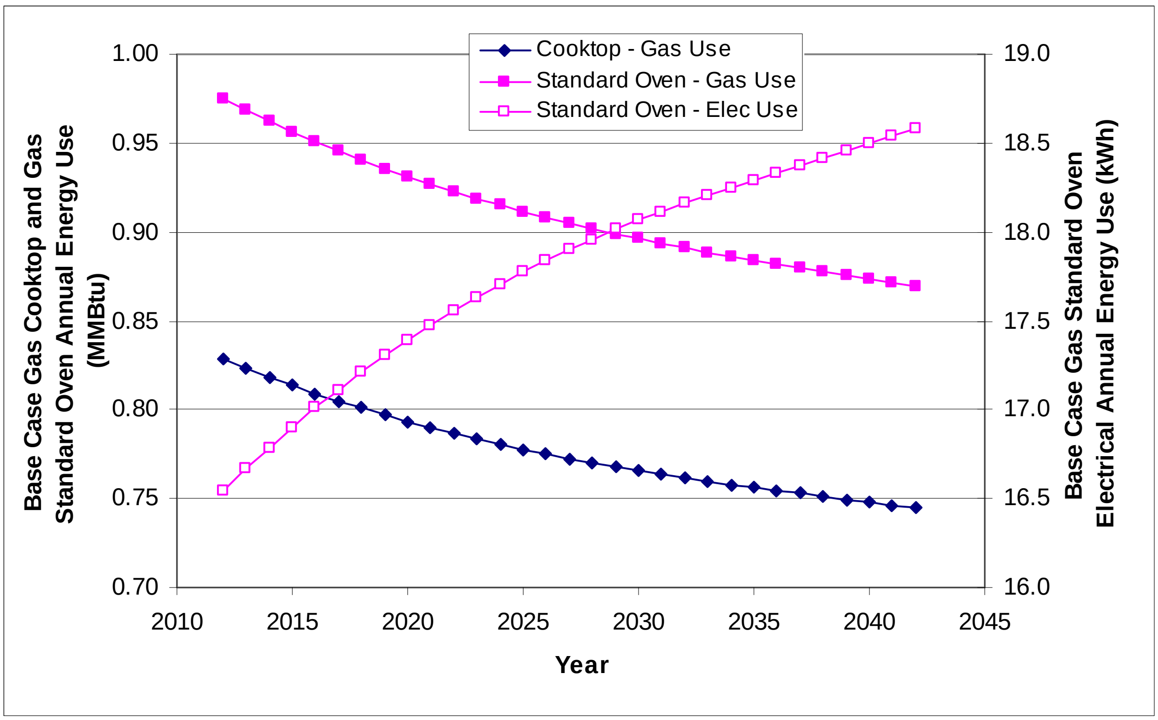

Figure 11.3.1 Gas Cooktops and Gas Standard Ovens: Forecasted Base Case Annual Energy Consumption

DOE assumed that forecasted efficiencies for gas cooktops and standard ovens in the standards cases remain frozen at the efficiency levels in 2012. Therefore, because the per-unit annual energy consumption is a function of efficiency, DOE held the gas cooktop and standard oven values shown above in Tables 11.3.2 and 11.3.3 constant over the forecast period (2012–2042) for all standards cases.

Cooking Products – Microwave Ovens

DOE based its per-unit annual energy consumption of microwave ovens on data presented in section 8.2.2.1 of Chapter 8. Using the relationship between microwave oven EF, standby power, and annual energy consumption described in Chapter 8, Table 11.3.4 presents the per-unit annual energy consumption based on the SWEFs and shipment-weighted standby power corresponding to the base case and each TSL.

Table 11.3.4 Microwave Ovens: Base Case and Standards Case Shipment-Weighted Average Per-Unit Annual Energy Consumption in 2012

	Base Case	Trial Standard Level							
		1a	**2a**	**3a**	**4a**	**1b**	**2b**	**3b**	**4b**
SWEF (EF)	0.557	0.586	0.588	0.597	0.602	0.557	0.557	0.557	0.557
SWEF (Standby Power)	2.83	2.83	2.83	2.83	2.83	1.90	1.50	1.00	0.02
Annual Energy Use (kWh/yr)	155.6	152.6	152.4	151.5	151.1	147.6	144.0	139.7	131.2

As noted above in section 11.2, DOE assumed that forecasted efficiencies in the base case and standards cases remain frozen at the efficiency levels in 2012. Therefore, because the per-unit annual energy consumption is a function of efficiency, DOE held the values shown above in Table 11.3.4 constant over the forecast period (2012–2042).

Commercial Clothes Washers

DOE based its per-unit annual energy and water consumption of commercial clothes washers on data presented in section 8.2.2.1 of Chapter 8. Using the relationship between clothes washer MEF and WF and annual energy and water consumption described in Chapter 8, Tables 11.3.5 and 11.3.6 present the per-unit annual electrical and gas energy use, and water consumption, based on the SWEFs corresponding to the base case and each TSL for top-loading and front-loading washers, respectively. Because establishments that use commercial clothes washers use either electric or gas water heaters and dryers, the per-unit annual energy use values in the table below are provided by fuel type. The energy and water use values shown in Tables 11.3.5 and 11.3.6 are weighted-average values reflecting the market share of washers in multi-family buildings (85 percent) and laundromats (15 percent), as provided by the Consortium for Energy Efficiency (CEE).[1] The water heating and drying energy consumption data reflect the percentage of gas and electric water heaters and dryers in the combined multi-family and laundromat market. Based on data from the CEE, in the combined market, 17 and 83 percent of water heaters are electric and gas, respectively, while 34 and 66 percent of dryers are electric and gas, respectively.[1]

Table 11.3.5 Top-Loading Commercial Clothes Washers: Base Case and Standards Case Shipment-Weighted Average Per-Unit Annual Energy and Water Consumption in 2012

		Base Case	Trial Standard Level				
			1	**2**	**3**	**4**	**5**
SWEF (MEF)		1.33	1.43	1.60	1.76	1.76	1.76
SWEF (WF)		9.46	9.46	8.49	8.30	8.30	8.30
Annual Energy Use	**Electric (kWh/yr)**	946	899	810	759	759	759
	Gas (MMBtu/yr)	8.25	7.49	6.58	5.88	5.88	5.88
Annual Water Use (1000 gal/ yr)		36.8	36.8	33.0	29.1	32.2	32.2

Table 11.3.6 Front-Loading Commercial Clothes Washers: Base Case and Standards Case Shipment-Weighted Average Per-Unit Annual Energy and Water Consumption in 2012

		Base Case	Trial Standard Level				
			1	**2**	**3**	**4**	**5**
SWEF (MEF)		1.98	1.98	2.01	2.01	2.20	2.35
SWEF (WF)		5.75	5.71	5.48	5.48	5.09	4.40
Annual Energy Use	**Electric (kWh/yr)**	698	696	690	690	642	610
	Gas (MMBtu/yr)	5.12	5.10	5.02	5.02	4.51	4.19
Annual Water Use (1000 gal/ yr)		22.3	22.2	21.3	21.3	19.8	17.1

As noted above in section 11.2, DOE assumed that forecasted efficiencies in the base case and standards cases remain frozen at the efficiency levels in 2012. Therefore, because the per-unit annual energy and water consumption are a function of efficiency, DOE held the values shown above in Tables 11.3.5 and 11.3.6 constant over the forecast period (2012–2042).

As described in section 10.4 of Chapter 10, Shipments Analysis, DOE forecasted a slight drop in commercial clothes washer shipments due to purchase price increases caused by standards-related efficiency increases. DOE assumed that those establishments forgoing the purchase of a commercial clothes washer due to standards would instead purchase a used clothes washer with an efficiency equal to the baseline level, i.e., 1.26 MEF/9.5 WF for top-loading washers and 1.72 MEF/8.0 WF for front-loading washers. In the NIA Model for commercial clothes washers, DOE accounted for the number of used washers purchased in order to quantify the energy and water impacts of those establishments that were estimated to forgo a new commercial clothes washer purchase.

11.3.2.2 Shipments

DOE forecasted shipments for the base case and all standards cases. Several factors, including total installed costs (purchase price plus installation costs), operating cost, household income, and equipment lifetime, all impact forecasted shipments. Of the above factors, total installed cost was the primary driver in forecasting the impact of standards on shipments. As noted earlier, the increased total installed cost of more-efficient equipment causes some customers to forego equipment purchases. Consequently, shipments forecasted under the standards cases are lower than under the base case. An extensive description of the methodology for conducting and generating the shipments forecasts for each of the considered products can be found in Chapter 10, Shipments Analysis.

11.3.2.3 Equipment Stock

The equipment stock in a given year is the number of products shipped from earlier years that survive in the given year. The NIA Models keep track of the number of units shipped each year. DOE assumes that the products have an increasing probability of retiring as they age. The probability of survival as a function of years-since-purchase is the survival function. See the specific product sections in Chapter 10, Shipments Analysis, for further details on the survival functions that DOE used in its analysis.

11.3.2.4 National Annual Energy Consumption

The national annual energy consumption is the product of the annual energy consumption per unit and the number of units of each vintage. This approach accounts for differences in unit energy consumption from year to year. The equation for determining the annual energy consumption was shown above in section 11.3.1 and is repeated below.

$$AEC = \sum STOCK_V \times UEC_V$$

In determining national annual energy consumption, DOE initially calculated the annual energy consumption at the site, and then applied a conversion factor to calculate primary energy consumption (see section 11.3.2.5).

11.3.2.5 Energy Site-to-Source Conversion Factors

In determining national annual energy consumption, DOE initially calculated the annual energy consumption at the site (e.g., for electricity, the energy in kWh consumed at the household or establishment). It then calculated primary (source) energy consumption from site energy consumption by applying a conversion factor to account for losses associated with the generation, transmission, and distribution of electricity and gas. The site-to-source conversion factor is the multiplicative factor used for converting site energy consumption into primary or source energy consumption, expressed in quads. DOE used annual site-to-source conversion factors based on the version of the National Energy Modeling System (NEMS) that corresponds to EIA's *Annual Energy Outlook 2008* (*AEO2008*). The factors used are marginal values, which represent the response of the system to an incremental decrease in consumption. Natural gas losses include pipeline leakage, pumping energy, and transportation fuel. The *AEO2008* forecasts losses of about seven percent for the natural gas used on site, with only slight variation from year to year. For electricity, the conversion factors vary over time, due to projected changes in generation sources (i.e., the power plant types projected to provide electricity to the country). DOE assumed that conversion factors remain constant at 2030 values throughout the remainder of the forecast. Table 11.3.7 shows the site-to-source conversion factors from 2005 to the end of the forecast period (2042).

Table 11.3.7 Site-to-Source Conversion Factors for Electricity and Natural Gas

Year	Electricity *Btu/kWh*	Natural Gas *Btu/Btu*	Year	Electricity *Btu/kWh*	Natural Gas *Btu/Btu*
2005	11500	1.097	2019	8300	1.087
2006	11500	1.066	2020	8088	1.091
2007	11200	1.086	2021	8088	1.093
2008	10250	1.082	2022	7949	1.094
2009	10000	1.084	2023	7200	1.094
2010	10000	1.086	2024	6966	1.094
2011	10000	1.086	2025	6500	1.095
2012	10000	1.086	2026	6309	1.095
2013	10000	1.086	2027	6309	1.095
2014	10000	1.086	2028	6309	1.096
2015	10000	1.086	2029	6309	1.096
2016	10000	1.086	2030	6309	1.096
2017	9700	1.086	2031–2042	6309	1.096
2018	9000	1.087			

Source: NEMS, 2006.

11.4 NET PRESENT VALUE

11.4.1 NPV Definition

The NPV is the value in the present of a time series of costs and savings. The NPV is described by the equation:

$$NPV = PVS - PVC$$

where:

PVS = Present value of operating cost savings (including energy, water, repair, and maintenance costs), and
PVC = Present value of increased total installed costs (including equipment and installation).

DOE determined the PVS and PVC according to the following expressions:

$$PVS = \sum OCS_y \times DF_y$$

$$PVC = \sum TIC_y \times DF_y$$

DOE calculated the total annual operating cost savings by multiplying the number or stock of the given product (by vintage) by its per-unit operating cost savings (also by vintage). DOE calculated the total annual installed cost increases by multiplying the number or stock of the given product (by vintage) by its per-unit total installed cost increase (also by vintage). The calculation of the annual operating costs savings and total annual installed cost increases is represented with the following equations:

$$OCS_y = \sum STOCK_V \times UOCS_V$$

$$TIC_y = \sum STOCK_V \times UTIC_V$$

For the above expressions, DOE defined the various quantities as follows:

OCS =	Total annual operating cost savings each year summed over vintages of the product stock, $STOCK_V$,
TIC =	Total annual installed cost increases each year summed over vintages of the product stock, $STOCK_V$,
DF =	Discount factor in each year,
$STOCK_V$ =	Stock of product (millions of units) of vintage *V* surviving in the year for which DOE calculated annual energy consumption (vintages range from five to approximately 28 years, depending on the retirement function of the product),
$UOCS_V$ =	Annual operating cost savings per unit,
$UTIC_V$ =	Annual total installed cost increase per unit,
V =	Year in which the product was purchased as a new unit, and
y =	Year in the forecast (i.e., 2012 to 2042).

DOE determined the *PVC* for each year, from the effective date of the standard to the year 2042. It determined the *PVS* for each year, from the effective date of the standard to the year when units purchased in 2042 retire. DOE calculated costs and savings as the difference between a standards case and a base case (i.e., without new standards).

DOE calculated a discount factor from the discount rate and the number of years between the “present” (i.e., year to which the sum is being discounted) and the year in which the costs and savings occur. The NPV is the sum over time of the discounted net savings.

11.4.2 NPV Inputs

Table 11.4.1 summarizes the inputs to the NPV calculation.

Table 11.4.1 Net Present Value Inputs

Total Installed Cost per Unit
Annual Operating Cost Savings per Unit
Total Annual Installed Cost Increases
Total Annual Operating Costs
Discount Factor
Present Value of Costs
Present Value of Savings

The increase in the *total annual installed cost* is equal to the annual change in the per-unit total installed cost (difference between base case and standards case) multiplied by the shipments forecasted in the standards case. As with the calculation of the NES, DOE did not calculate total annual installed costs for all of the products using base case shipments. Rather, in the case of dehumidifiers and microwave ovens, DOE used the standards case shipments projection and, in turn, the standards case stock, to calculate the costs to avoid the inclusion of savings due to displaced shipments. In the case of commercial clothes washers, DOE assumed that any drop in shipments caused by standards would result in the purchase of used machines. Electric and gas cooking products are the notable exception. For these products, because the market is fully saturated, DOE assumed that standards would neither impact shipments nor cause shifts in electric and gas cooking product market shares. Therefore, for electric and gas cooking products, DOE used the base case shipments to determine costs for all standards cases.

The *total annual operating cost savings* are equal to the change in the annual operating costs (difference between base case and standards case) per unit multiplied by the shipments forecasted in the standards case. As noted above for the calculation of total annual installed costs, DOE did not necessarily calculate operating cost savings using the base case shipments. The annual operating cost includes energy, water, repair, and maintenance costs.

11.4.2.1 Total Installed Cost per Unit

For each of the considered products, DOE first presented the per-unit total installed cost as a function of product efficiency in section 8.2.1 of Chapter 8, LCC and PBP Analysis. Because the per-unit total annual installed cost is directly dependent on efficiency, DOE used the base case and standards case SWEFs presented above in section 11.2, in combination with the total installed costs presented in Chapter 8, to estimate the shipment-weighted average annual per-unit total installed cost under the base case and standards cases. The following sections describe the shipment-weighted average annual per-unit total installed cost for each of the considered products.

Cooking Products – Cooktops and Ovens

DOE based its per-unit total installed cost of cooktops and ovens on data presented in sections 8.2.1.1 and 8.2.1.2 of Chapter 8. The total installed cost includes both the equipment price and the installation cost. For gas cooktops and standard ovens, the installation cost for standard levels beyond the baseline level accounts for consumers that need to install an electrical outlet to accommodate a cooking product that now requires electricity to operate. Details on the determination of this added installation costs and the percentage of consumers that are estimated to need an outlet are provided in sections 8.2.1.1 for gas cooktops and 8.2.1.2 for gas standard ovens. DOE based average equipment prices on average manufacturer costs multiplied by average overall markup values. Using the relationship between cooktop and oven EF and total installed cost presented in Chapter 8, Tables 11.4.2 and 11.4.3 show the per-unit total installed cost for cooktops and ovens, respectively, based on the SWEFs corresponding to the base case and each candidate standard level.

Table 11.4.2 Cooktops: Base Case and Standards Case Shipment-Weighted Average Per-Unit Total Installed Costs in 2012

Product Class		Base Case	Candidate Standard Level	
			1	2
Electric Coil	SWEF (EF)	0.737	0.769	
	Total Installed Cost (2006$)	$272	$276	
Electric Smooth	SWEF (EF)	0.742	0.753	
	Total Installed Cost (2006$)	$309	$550	
Gas	SWEF (EF)	0.379	0.399	0.420
	Total Installed Cost (2006$)	$385	$391	$420

Table 11.4.3 Ovens: Base Case and Standards Case Shipment-Weighted Average Per-Unit Total Installed Costs in 2012

Product Class		Base Case	Candidate Standard Level						
			1*	2	3	4	5	6	1a*
Electric Standard	SWEF (EF)	0.1066	0.1113	0.1163	0.1181	0.1206	0.1209		
	Total Installed Cost (2006$)	$414	$416	$421	$426	$484	$489		
Electric Self-Clean	SWEF (EF)	0.1099	0.1102	0.1123					
	Total Installed Cost (2006$)	$485	$491	$548					
Gas Standard	SWEF (EF)	0.0498	0.0540	0.0566	0.0572	0.0593	0.0596	0.0600	0.0548
	Total Installed Cost (2006$)	$500	$515	$520	$522	$554	$556	$562	$516
Gas Self-Clean	SWEF (EF)	0.0540	0.0625	0.0627	0.0632				
	Total Installed Cost (2006$)	$550	$566	$573	$574				

* For gas standard ovens, levels 1 and 1a correspond to designs that are utilized for the same purpose—eliminate the need for a standing pilot—but the technologies for each design are different. Level 1 is a hot surface ignition device while level 1a is a spark ignition device.

For all classes except gas cooktops and standard ovens, as noted above in section 11.2, DOE assumed that forecasted efficiencies in the base case and candidate standard levels remain frozen at the efficiency levels in 2012. Therefore, because the per-unit total installed cost is a function of efficiency, DOE held the values shown above in Tables 11.4.4 and 11.4.5 constant over the forecast period (2012–2042).

For gas cooktops and standard ovens, DOE tracked the percentage of gas standard ranges (which are composed of a cooktop and standard oven) with standing pilots. Because the percentage of ranges with standing pilots changes over time (as shown above in section 11.2, Figure 11.2.1), the base case total installed cost will change over time as well. Figure 11.4.1 shows how the total installed cost for both base case gas cooktops and gas standard ovens increases over time as more gas standard ranges are forecasted to be shipped with pilotless ignition.

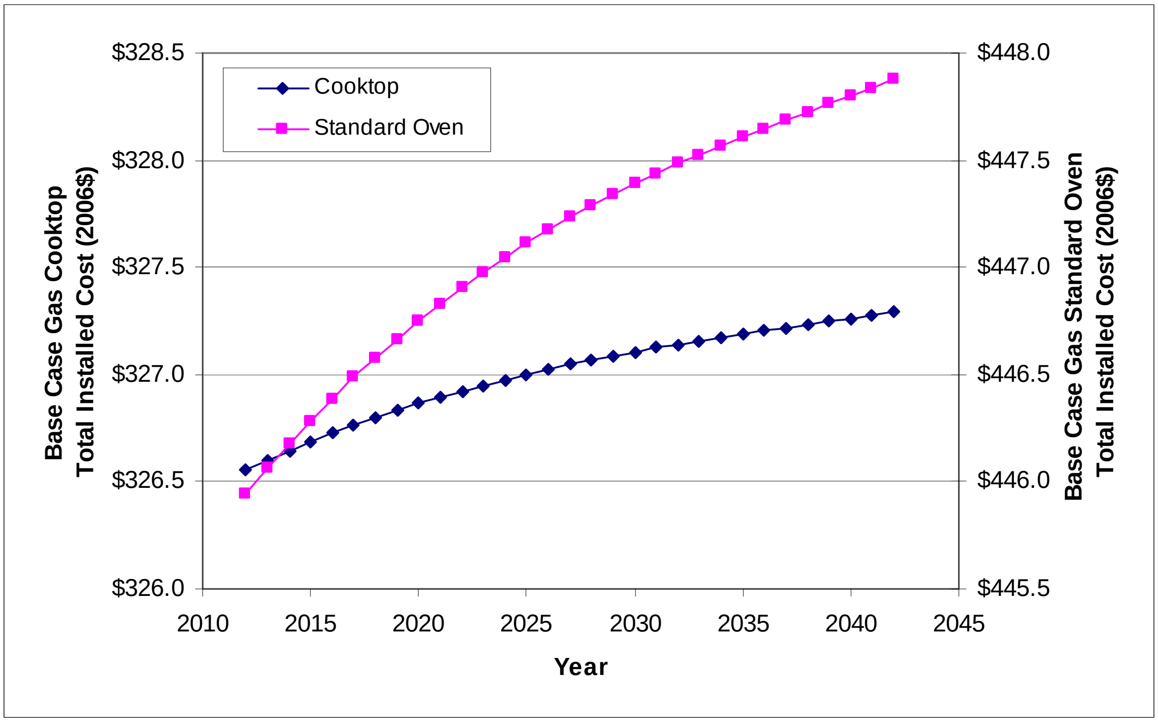

Figure 11.4.1 Gas Cooktops and Gas Standard Ovens: Forecasted Base Case Total Installed Costs

DOE assumed that forecasted efficiencies for gas cooktops and standard ovens in the standards cases remain frozen at the efficiency levels in 2012. Therefore, because the per-unit total installed cost is a function of efficiency, DOE held the gas cooktop and standard oven values shown above in Tables 11.4.2 and 11.4.3 constant over the forecast period (2012–2042) for all candidate standard levels.

Cooking Products – Microwave Ovens

DOE based its per-unit total installed cost of microwave ovens on data presented in section 8.2.1.3 of Chapter 8. For microwave ovens, the total installed cost includes only the equipment price, since the installation cost for these products is zero. DOE based average equipment prices on average manufacturer costs multiplied by average overall markup values. Using the relationship between microwave oven EF and total installed cost presented in Chapter 8, Table 11.4.4 shows the per-unit total installed cost for microwave ovens based on the SWEFs corresponding to the base case and each TSL.

Table 11.4.4 Microwave Ovens: Base Case and Standards Case Shipment-Weighted Average Per-Unit Total Installed Costs in 2012

	Base Case	Trial Standard Level							
		1a	**2a**	**3a**	**4a**	**1b**	**2b**	**3b**	**4b**
SWEF (EF)	0.557	0.586	0.588	0.597	0.602	0.557	0.557	0.557	0.557
SWEF (Standby Power)	4.0	4.0	4.0	4.0	4.0	2.0	1.5	1.0	0.02
Total Installed Cost (2006$)	$220	$226	$232	$242	$255	$220	$221	$222	$228

As noted above in section 11.2, DOE assumed that forecasted efficiencies in the base case and TSLs remain frozen at the efficiency levels in 2012. Therefore, because the per-unit total installed costs are a function of efficiency, DOE held the values shown above in Table 11.4.4 constant over the forecast period (2012–2042).

Commercial Clothes Washers

DOE based its per-unit total installed cost of commercial clothes washers on data presented in section 8.2.1.4 of Chapter 8. The total installed cost includes both the equipment price and the installation cost. DOE based average equipment prices on average manufacturer costs multiplied by average overall markup values. Using the relationship between commercial clothes washer MEF and WF and total installed cost presented in Chapter 8, Tables 11.4.5 and 11.4.6 show the per-unit total installed cost based on the SWEFs corresponding to the base case and each TSL for top-loading and front-loading washers, respectively.

Table 11.4.5 Top-Loading Commercial Clothes Washers: Base Case and Standards Case Shipment-Weighted Average Per-Unit Total Installed Costs in 2012

	Base Case	Trial Standard Level				
		1	**2**	**3**	**4**	**5**
SWEF (MEF)	1.33	1.43	1.60	1.76	1.76	1.76
SWEF (WF)	9.46	9.46	8.49	8.30	8.30	8.30
Total Installed Cost (2006$)	$781	$857	$942	$964	$964	$964

Table 11.4.6 Front-Loading Commercial Clothes Washers: Base Case and Standards Case Shipment-Weighted Average Per-Unit Total Installed Costs in 2012

	Base Case	Trial Standard Level				
		1	**2**	**3**	**4**	**5**
SWEF (MEF)	1.98	1.98	2.01	2.01	2.20	2.35
SWEF (WF)	5.75	5.71	5.48	5.48	5.09	4.40
Total Installed Cost (2006$)	$1,339	$1,339	$1,341	$1,341	$1,379	$1,419

As noted above in section 11.2, DOE assumed that forecasted efficiencies in the base case and TSLs remain frozen at the efficiency levels in 2012. Therefore, because the per-unit total installed costs are a function of efficiency, DOE held the values shown above in Table 11.4.5 constant over the forecast period (2012–2042).

11.4.2.2 Annual Operating Cost Savings per Unit

The per-unit annual operating cost includes the energy, water, repair, and maintenance costs.

Annual Energy and Water Costs

DOE determined the per-unit annual energy and water cost savings by taking the per-unit annual energy (and water) consumption savings developed for each product and multiplying it by the appropriate energy (and water) price.

For all of the considered products, estimates of the per-unit annual energy (and water) consumption for the base case and each standards case were presented earlier in section 11.3.2.1. As described previously, DOE forecasted the per-unit annual energy (and water) consumption for the base case and each standards case for all products by freezing the consumption at levels estimated for the year 2012.[a]

Energy and water prices are described in section 8.2.2.2 of Chapter 8. DOE forecasted energy prices based on EIA's *AEO2008*. DOE forecasted water prices based on trends in the national water price index as provided by the Bureau of Labor Statistics. The energy and water price trends are described in section 8.2.2.3 of Chapter 8.

Annual Repair and Maintenance Costs

As described in section 8.2.2.4 of Chapter 8, DOE estimated increased repair and maintenance costs for gas cooktops, gas standard ovens, and commercial clothes washers. DOE assumed no increase in repair and maintenance costs due to standards for all electric cooking products (including microwave ovens), and gas self-cleaning ovens.

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[a] The one exception pertains to the base case per-unit annual energy consumption of gas cooktops and gas standard ovens.

For gas cooktops and gas standard ovens, DOE determined the repair and maintenance costs for the three types of ignition systems considered for these products: standing pilot (baseline level), electric glo-bar ignition (candidate standard level 1 for standard gas ovens), and electronic spark ignition (candidate standard level 1 for gas cooktops and candidate standard level 1a for gas standard ovens). For standing pilot ignition systems, DOE determined that repair and maintenance are needed once every 10 years to clean valves. For electric glo-bar/hot surface ignition systems, the glo-bar requires replacement approximately every five years. In the case of electronic ignition systems, control modules tend to last 10 years. The electrodes/igniters can fail due to hard contact from pots or pans, although failures are rare. As defined in section 11.4.1, for the calculation of annual operating cost savings, DOE kept track of the vintage of products entering the stock. Therefore, DOE was able to properly account for when gas cooktops and gas standard ovens incurred costs for the repair and maintenance of ignition systems.

For commercial clothes washers, DOE estimated that repair costs would increase as a function of equipment efficiency. Using the relationship between clothes washer MEF and WF and repair described in Chapter 8, Tables 11.4.7 and 11.4.8 present the per-unit annualized repair cost based on the SWEFs corresponding to the base case and each TSL for top-loading and front-loading washers, respectively. The repair costs shown in Tables 11.4.7 and 11.4.8 are weighted-average values reflecting the market share of washers in multi-family buildings (85 percent) and laundromats (15 percent), as provided by the Consortium for Energy Efficiency (CEE).

Table 11.4.7 Top-Loading Commercial Clothes Washers: Base Case and Standards Case Shipment-Weighted Average Per-Unit Annualized Repair Costs in 2012

	Base Case	Trial Standard Level				
		1	2	3	4	5
SWEF (MEF)	1.33	1.43	1.60	1.76	1.76	1.76
SWEF (WF)	9.46	9.46	8.49	8.30	8.30	8.30
Annualized Repair Cost (2006$)	$29	$32	$37	$38	$38	$38

Table 11.4.8 Front-Loading Commercial Clothes Washers: Base Case and Standards Case Shipment-Weighted Average Per-Unit Annualized Repair Costs in 2012

	Base Case	Trial Standard Level				
		1	2	3	4	5
SWEF (MEF)	1.98	1.98	2.01	2.01	2.20	2.35
SWEF (WF)	5.75	5.71	5.48	5.48	5.09	4.40
Annualized Repair Cost (2006$)	$56	$56	$56	$56	$58	$60

As noted above in section 11.2, DOE assumed that forecasted efficiencies in the base case and TSLs remain frozen at the efficiency levels in 2012. Therefore, because the per-unit total installed costs are a function of efficiency, DOE held the values shown above in Tables 11.4.7 and 11.4.8 constant over the forecast period (2012–2042).

11.4.2.3 Total Annual Installed Cost Increases

The total annual installed cost increase for any given standards case is the product of the total installed cost increase per unit due to the standard and the number of units of each vintage. This approach accounts for differences in total installed cost from year to year. The equation for determining the total annual installed cost increase for a given standards case was shown in section 11.4.1 and is repeated below.

$$\boldsymbol{TIC} = \sum \boldsymbol{STOCK_V} \times \boldsymbol{UTIC_V}$$

As noted earlier for commercial clothes washers, DOE accounted for the total installed cost of those establishments that were forced into purchasing used clothes washers due to standards. Therefore, the total annual installed cost increase takes into account the total installed cost of the used washers that were purchased in lieu of the purchase of new washers.

11.4.2.4 Total Annual Operating Cost Savings

The total annual operating cost savings for any given standards case is the product of the annual operating cost savings per unit due to the standard and the number of units of each vintage. This approach accounts for differences in annual operating cost savings from year to year. The equation for determining the total annual operating cost savings for a given standards case was shown above and is repeated below.

$$\boldsymbol{OCS} = \sum \boldsymbol{STOCK_V} \times \boldsymbol{UOCS_V}$$

As noted earlier for commercial clothes washers, DOE accounted for the energy and water use of those establishments that were forced into purchasing used washers due to standards. Therefore, the total annual operating cost savings take into account the energy and water costs of the used washers that were purchased in lieu of the purchase of new washers.

11.4.2.5 Discount Factors

DOE multiplies monetary values in future years by a discount factor to determine the present value. The discount factor (DF) is described by the equation:

$$\boldsymbol{DF} = \frac{1}{(1+\boldsymbol{r})^{(y-yp)}}$$

where:

r = discount rate,
y = year of the monetary value, and
y_P = year in which the present value is being determined.

DOE estimated national impacts with both a three-percent and a seven-percent real discount rate as the average real rate of return on private investment in the U.S. economy. It used these discount rates in accordance with the Office of Management and Budget (OMB)'s guidance to Federal agencies on the development of regulatory analysis (OMB Circular A-4, September 17, 2003), and section E., "Identifying and Measuring Benefits and Costs," therein. DOE defines the present year as 2007.

11.4.2.6 Present Value of Costs

The present value of increased installed costs is the annual installed cost increase in each year (i.e., the difference between the standards case and base case), discounted to the present, and summed for the time period over which DOE is considering the installation of equipment (i.e., from the effective date of standards, 2012, to the year 2042).

The increase in total installed cost refers to both equipment cost and installation cost associated with the higher energy efficiency of equipment purchased in the standards case compared to the base case. DOE calculated annual increases in installed costs as the difference in total installed cost for new equipment purchased each year, multiplied by the shipments in the standards case.

11.4.2.7 Present Value of Savings

The present value of operating cost savings is the annual operating cost savings (i.e., the difference between the base case and standards case) discounted to the present, and summed over the period from the effective date, 2012, to the time when the last unit installed in 2042 is retired from service.

Savings are decreases in operating costs (including electricity, repair, and maintenance costs) associated with the higher energy efficiency of equipment purchased in the standards case compared to the base case. Total annual operating cost savings are the savings per unit multiplied by the number of units of each vintage surviving in a particular year. Equipment consumes energy over its entire lifetime, and for units purchased in 2042, the consumption includes energy consumed until the unit is retired from service.

11.4.3 Fuel Switching

Fuel switching describes the occurrence of consumers switching from a product that consumes one type of fuel to another product that provides the same utility and service but consumes a different fuel. Fuel switching is caused when the purchase price or operating cost of a product is so high that it causes the consumer to alter their purchase decision and buy the like product that operates off the alternative fuel.

As described in Chapter 8, sections 8.2.1.1 and 8.2.1.2, some gas cooktop and gas standard oven consumers that use products with standing pilot ignition devices would need to install an electrical outlet to accommodate a product that would require electricity to operate. As detailed in Chapter 8, DOE estimated an installation cost of $235 to install an electrical outlet for a gas cooking product that needed electricity to operate. Because the added installation cost is high, DOE needed to assess whether those gas product consumers that would need to install an outlet would change their purchase decision and acquire an electric cooking product.

If a consumer were to switch from a gas cooking product to an electrical appliance due to the prospect of this installation cost, an outlet would still be needed to accommodate the electrical appliance. Based on the *RS Means Mechanical Cost Data, 2008*,[2] the cost of installing only an outlet suitable for an electrical cooking appliance, which requires a 50-amp, 240-volt receptacle, is $305 (see Table 11.4.9).

Table 11.4.9 Installation Cost for an Electrical Outlet to accommodate an Electric Cooking Product

Indiv. Line #	Description	Crew	Daily Output	Person-Hours	Unit	Mat.	Labor	Equip.	Total	Total incl. O&P
2008 Mechanical Cost Data: 2008 Base Costs										
4730	Range Outlet, 50 amp-240 volt recpt. 30' of #8/3, EMT & wire	1 Elect	2.96	2.703	Ea.	$111	$123	$0	$234	$305
									Average (2006$)*	$305
Total Installation Cost (2006$)										**$305.00**

* Cost in 2008$ assumed to be representative of 2006$.

Sources: Bare Costs: RS Means, *Mechanical Cost Data, 2008.*

Due to the amperage and voltage requirements of the receptacle as well as the age of the household in which the outlet would be installed (pre-1960), a separate branch circuit coming off the fuse box or circuit breaker panel would be necessary to accommodate the electrical cooking appliance. Also, because of the additional amperage required by the electrical cooking appliance, it is highly likely that the fuse box or circuit breaker panel would need to be upgraded. Based on material costs from the *Craftsman 2008 National Home Improvement Estimator*[3] and *2008 National Repair & Remodeling Estimator*[4] and labor costs from the *RS Means, Mechanical Cost Data, 2008,*[2] DOE estimated an installation cost of $1247 for installing a branch circuit and upgrading a breaker panel from 50 amps to 100 amps (see Table 11.4.10). Combined with the $305 installation cost of the receptacle, the total installation cost to accommodate an electrical cooking appliance is estimated to be $1562 or over six times the cost of installing a standard 120-volt outlet for a gas cooking product. Therefore, there is no financial incentive for a consumer to switch from gas cooking to electric cooking. Thus, DOE believes the probability of fuel switching is so low that DOE is not considering it in the national impact analysis of cooktops and ovens.

Fuel switching was not considered for either microwave ovens or commercial clothes washers.

Table 11.4.10 Installation Cost for a Branch Circuit to accommodate an Electric Cooking Product

Description	Qty	Crew	Labor Hours	Unit	2008 Bare Costs Mat.	Labor (given)	Equip.	Total (given)	Calculated Values Labor Hours (Calc.)	Mat. (incl. 10% Profit)	Labor (incl O&P)	Equip	Total incl. O&P
Fishing electrical cable through a stud wall (assume 2 foot wired per stud walls)*													
Job Setup	1	1 Elec	0.270	Ea.	$0	$12	$0	$12	0.270	$0	$18	$0	$18.32
per foot of cable fished	20	1 Elec	0.050	LF	$0	$2	$0	$2	1.000	$0	$68	$0	$67.87
per electrical box set	1	1 Elec.	0.761	Ea.	$0	$35	$0	$35	0.761	$0	$52	$0	$51.65
per stud notched and hole patched	10	1 Elec	0.400	Per Stud	$0	$18	$0	$18	4.000	$0	$271	$0	$271.48
Branch Circuit Installation													
Panel (100 AMP service - 12-circuit, Installation)**	1	1 Elec	1.600	Ea.	$160	$73	$0	$233	1.600	$176	$109	$0	$284.59
Disconnect and remove distribution panel (50-100 Amps, Frame Wall)***	1	1 Elec.	0.220	Ea.	$0	$10	$0	$10	0.220	$0	$15	$0	$14.93
Per Circuit Disconnect***	10	1 Elec.	0.063	Per Circuit	$0	$3	$0	$3	0.630	$0	$43	$0	$42.76
Ground-fault interrupter plug-on circuit breaker, QO-GFI Qwik-Gard®, Square D® (50 AMP, 2 Pole)***	1	1 Elec.	0.150		$163	$7	$0	$170	0.150	$179	$10	$0	$189.48
Grounding rod with clamp (100 AMP Service Installation)**	1	1 Elec	2.670	Ea.	$16.50	$122	0	$138	2.670	$18	$181	$0	$199.36
Ground Cable (typcical Allowance is 10 LF)**	10	1 Elec.	0.080	LF	$0.18	$4	$0	$4	0.800	$2	$54	$0	$56.28
Electrical Permit Charge**	1	1 Elec	0.000	CLF	$0.00	$0	0	$0	0.000	$0	$0	$0	$50.00
Total Installation Cost (2006$)†													$1246.72

* **Sources –** Labor Hours and Material Costs: Craftsman, *National Home Improvement Estimator*, 2008; Labor Costs and Overhead & Profit (O&P) Multiplier: RS Means, *Mechanical Cost Data, 2008.*

** **Sources –** Labor Hours and Material Costs: Craftsman, *Repair and Remodel Estimator*, 2008; Labor Costs and Overhead & Profit (O&P) Multiplier: RS Means, *Mechanical Cost Data, 2008.*

*** **Sources –** Labor Hours and Material Costs: Craftsman, *Home Improvement*, 2008; Labor Costs and Overhead & Profit (O&P) Multiplier: RS Means, *Mechanical Cost Data, 2008.*

† Cost in 2008$ assumed to be representative of 2006$.

11.5 NES AND NPV RESULTS

The NIA Model provides estimates of the NES and NPV due to various candidate standards levels. The inputs to the NIA Model have been discussed earlier in sections 11.3.2 (NES Inputs) and 11.4.2 (NPV Inputs). DOE generated the NES and NPV results using a Microsoft Excel® spreadsheet, which is accessible on the Internet (http://www.eere.energy.gov/buildings/appliance_standards/). Details and instructions for using the spreadsheet are provided in Appendix 11A.

11.5.1 NES and NPV Input Summary

Table 11.5.1 summarizes the inputs to the NIA Model. For each input a brief description of the data source is given.

Table 11.5.1 NES and NPV Inputs

Input	**Data Description**
Shipments	Annual shipments from Shipments Model. (See Chapter 10.)
Effective Date of Standard	2012.
Base Case Forecasted Efficiencies	SWEF determined in the year 2005 for each of the considered products. SWEF held constant over forecast period of 2005–2042. (See Section 11.2.)
Standards Case Efficiencies	Roll-up scenario assumed for determining SWEF in the year 2012 for each standards case and for each of the considered products. SWEF held constant over forecast period of 2012–2042. (See Section 11.2.)
Annual Energy Consumption per Unit	Annual weighted-average values are a function of SWEF. (See Section 11.3.2.1.)
Total Installed Cost per Unit	Annual weighted-average values are a function of SWEF. (See Section 11.4.2.1.)
Energy and Water Cost per Unit	Annual weighted-average values are a function of the annual energy consumption per unit and energy (and water) prices. (See Section 8.2.2.3 of Chapter 8 for energy and water prices.)
Repair Cost and Maintenance Cost per Unit	For gas cooktops and gas standard ovens, repair and maintenance costs specified for different types of ignition systems. For commercial clothes washers, annual weighted-average values are a function of SWEF. For all electric cooking products, including microwave ovens, and gas self-cleaning ovens, no changes in repair and maintenance cost assumed due to standards. (See Section 8.2.2.4 of Chapter 8 for repair and maintenance costs.)
Escalation of Energy and Water Prices	Energy Prices: EIA *AEO2008* forecasts (to 2030) and extrapolation to 2042. (See Section 8.2.2.3 of Chapter 8.) Water Prices: Linear extrapolation off historical trend in national water price index. (See Section 8.2.2.3 of Chapter 8.)
Energy Site-to-Source Conversion	Conversion varies yearly and is generated by DOE/EIA's NEMS* program (a time series conversion factor; includes electric generation, transmission, and distribution losses).
Discount Rate	3 percent and 7 percent real.
Present Year	Future expenses are discounted to year 2007.

* Chapter 14 on the Utility Impact Analysis and the Environmental Assessment Report provide more detail on NEMS.

11.5.2 NES Results

The following sections provide NES results (and national water savings (NWS) results for commercial clothes washers) for the TSLs analyzed for the considered products. NES results are cumulative to 2042 and are shown as primary energy savings. NWS results are expressed in billions of gallons. DOE based the inputs to the NIA Model on weighted-average values, yielding results that are discrete point values, rather than a distribution of values as in the LCC and PBP Analysis.

11.5.2.1 Cooking Products – Cooktops and Ovens

This section provides NES results for the efficiency levels considered for the three product classes of cooktops and the four product classes of ovens. Tables 11.5.2 and 11.5.3 show the NES results for the candidate standard levels and TSLs analyzed for cooktops and ovens, respectively.

Table 11.5.2 Cooktops: Cumulative NES Results

CSL	Electric Coil			Electric Smooth			Gas		
	TSL	EF	NES *quads*	TSL	EF	NES *quads*	TSL	EF	NES *Quads*
Baseline	1	0.737	-	1, 2, 3	0.742	-	-	0.156	-
1	2, 3, 4	0.769	0.04	4	0.753	0.02	1, 2, 3	0.399	0.10
2							4	0.420	0.15

Table 11.5.3 Ovens: Cumulative NES Results

CSL	Electric Standard			Electric Self-Clean			Gas Standard			Gas Self-Clean		
	TSL	EF	NES *quads*	TSL	EF	NES *quads*	TSL	EF	NES *quads*	TSL	EF	NES *quads*
Base	1	0.1066	-	1, 2, 3	0.1099	-	-	0.0298	-	1, 2	0.0540	-
1*	-	0.1113	0.03	-	0.1102	0.01	-	0.0536	0.04	3	0.0625	0.09
2	2, 3	0.1163	0.05	4	0.1123	0.04	-	0.0566	0.06	-	0.0627	0.09
3	-	0.1181	0.06				-	0.0572	0.07	4	0.0632	0.10
4	-	0.1206	0.07				-	0.0593	0.08			
5	4	0.1209	0.07				-	0.0596	0.09			
6							4	0.0600	0.09			
1a*							1, 2, 3	0.0583	0.05			

* For gas standard ovens, candidate standard levels 1 and 1a correspond to designs that are utilized for the same purpose—eliminate the need for a standing pilot—but the technologies for each design are different. Candidate standard level 1 is a hot surface ignition device while level 1a is a spark ignition device. Candidate standard level 1a is presented at the end of the table because levels 2 through 6 are derived from level 1.

Tables 11.5.4 and 11.5.5 show the magnitude of the NES if the savings are discounted at rates of seven percent and three percent for cooktops and ovens, respectively.

Table 11.5.4 Cooktops: Cumulative NES Results Discounted at Seven Percent and Three Percent

CSL	Electric Coil				Electric Smooth				Gas			
	TSL	EF	NES (*quads*)		TSL	EF	NES (*quads*)		TSL	EF	NES (*quads*)	
			7% disc.	3% disc.			7% disc.	3% disc.			7% disc.	3% disc.
Base	1	0.737	-	-	1, 2, 3	0.742	-	-	-	0.156	-	-
1	2, 3, 4	0.769	0.01	0.02	4	0.753	0.00	0.01	1, 2, 3	0.399	0.03	0.05
2									4	0.420	0.04	0.08

Table 11.5.5 Ovens: Cumulative NES Results Discounted at Seven Percent and Three Percent

CSL	Electric Standard				Electric Self-Clean				Gas Standard				Gas Self-Clean			
	TSL	EF	NES (*quads*)		TSL	EF	NES (*quads*)		TSL	EF	NES (*quads*)		TSL	EF	NES (*quads*)	
			7% disc.	3% disc.			7% disc.	3% disc.			7% disc.	3% disc.			7% disc.	3% disc.
Base	1	0.1066	-	-	1,2,3	0.1099	-	-	-	0.0298	-	-	1,2	0.0540	-	-
1*	-	0.1113	0.01	0.01	-	0.1102	0.00	0.00	-	0.0536	0.01	0.02	3	0.0625	0.02	0.04
2	2, 3	0.1163	0.01	0.03	4	0.1123	0.01	0.02	-	0.0566	0.02	0.03	-	0.0627	0.02	0.05
3	-	0.1181	0.01	0.03					-	0.0572	0.02	0.04	4	0.0632	0.02	0.05
4	-	0.1206	0.02	0.04					-	0.0593	0.02	0.04				
5	4	0.1209	0.02	0.04					-	0.0596	0.02	0.04				
6									4	0.0600	0.02	0.05				
1a*									1,2,3	0.0583	0.01	0.03				

* For gas standard ovens, candidate standard levels 1 and 1a correspond to designs that are utilized for the same purpose—eliminate the need for a standing pilot—but the technologies for each design are different. Candidate standard level 1 is a hot surface ignition device while level 1a is a spark ignition device. Candidate standard level 1a is presented at the end of the table because levels 2 through 6 are derived from level 1.

11.5.2.2 Cooking Products – Microwave Ovens

This section provides NES results for the efficiency levels considered for microwave ovens. Tables 11.5.6 and 11.5.7 show the NES results for the two sets of TSLs analyzed for microwave ovens—one set only for the energy factor (EF) and one set only for standby power.

Table 11.5.6 Microwave Ovens by EF: Cumulative NES Results

TSL	EF	NES *Quads*
1a	0.586	0.08
2a	0.588	0.09
3a	0.597	0.11
4a	0.602	0.12

Table 11.5.7 Microwave Ovens by Standby Power: Cumulative NES Results

TSL	Standby Power *Watts*	NES *Quads*
1b	2.0	0.23
2b	1.5	0.33
3b	1.0	0.45
4b	0.02	0.69

Tables 11.5.8 and 11.5.9 showsthe magnitude of the NES if the savings are discounted at rates of seven percent and three percent.

Table 11.5.8 Microwave Ovens by EF: Cumulative NES Results Discounted at Seven Percent and Three Percent

TSL	EF	NES (*quads*)	
		7% discounted	**3% discounted**
1a	0.586	0.02	0.05
2a	0.588	0.02	0.05
3a	0.597	0.03	0.06
4a	0.602	0.03	0.07

Table 11.5.9 Microwave Ovens by Standby Power: Cumulative NES Results Discounted at Seven Percent and Three Percent

TSL	Standby Power *Watts*	NES (*quads*)	
		7% discounted	**3% discounted**
1b	2.0	0.06	0.13
2b	1.5	0.09	0.18
3b	1.0	0.12	0.25
4b	0.02	0.19	0.38

11.5.2.3 Commercial Clothes Washers

This section provides NES and NWS results for the TSLs considered for commercial clothes washers. Table 11.5.10 shows the NES and NWS results for the TSLs analyzed for commercial clothes washers.

Table 11.5.10 Commercial Clothes Washers: Cumulative NES and NWS Results

CSL	Top-Loading Washers				Front-Loading Washers			
	TSL	**MEF/WF**	**NES** *quads*	**NWS** *billion gallons*	**TSL**	**MEF/WF**	**NES** *quads*	**NWS** *billion gallons*
1	1	1.42/9.50	0.05	0	1	1.80/7.50	0.00	2
2	2	1.60/8.50	0.11	150	2, 3	2.00/5.50	0.00	12
3	3, 4, 5	1.72/8.00	0.15	179	4	2.20/5/10	0.01	30
4					5	2.35/4.40	0.02	60

Table 11.5.11 shows the magnitude of the NES and NWS if the savings are discounted at rates of seven percent and three percent.

Table 11.5.11 Commercial Clothes Washers: Cumulative NES and NWS Results Discounted at Seven Percent and Three Percent

CSL	Top-Loading Washers						Front-Loading Washers					
			7% Disc Rate		3% Disc Rate				7% Disc Rate		3% Disc Rate	
	TSL	**MEF/WF**	**NES** *quads*	**NWS** *billion gallons*	**NES** *quads*	**NWS** *billion gallons*	**TSL**	**MEF/WF**	**NES** *quads*	**NWS** *billion gallons*	**NES** *quads*	**NWS** *billion gallons*
1	1	1.42/9.50	0.01	0	0.03	0	1	1.80/7.50	0.00	0	0.00	1
2	2	1.60/8.50	0.03	38	0.06	80	2, 3	2.00/5.50	0.00	3	0.00	7
3	3, 4, 5	1.72/8.00	0.04	45	0.08	95	4	2.20/5/10	0.00	8	0.01	16
4							5	2.35/4.40	0.00	15	0.01	32

11.5.3 Annual Costs and Savings

To illustrate the basic inputs to the NPV calculations, Figure 11.5.1 presents the non-discounted annual installed cost increases and annual operating cost savings at the national level for TSL 3b for microwave ovens. The figure also shows the net savings, which is the difference between the savings and costs for each year. The annual equipment cost is the increase in the total installed cost for products purchased each year over the period 2012–2042. The annual operating cost savings is the savings in operating costs for products operating in each year. The NPV is the difference between the cumulative annual discounted savings and the cumulative annual discounted costs. DOE could create figures like the one shown below for each of the considered products' standard cases.

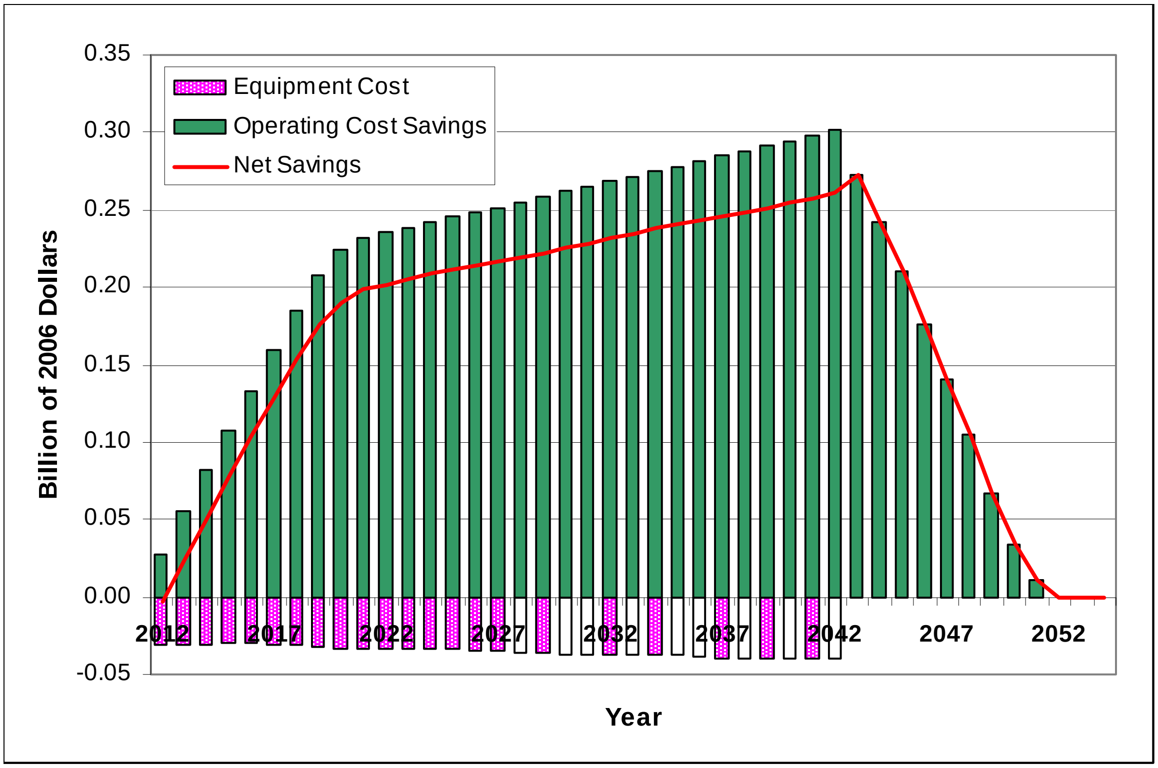

Figure 11.5.1 Non-Discounted Annual Installed Cost Increases and Annual Operating Cost Savings for Microwave Ovens, TSL 3b

11.5.4 NPV Results

The following sections provide NPV results for the candidate standards levels considered for the product classes of each considered product. Results are cumulative and are shown as the discounted value of these savings in dollar terms. DOE based the inputs to the NIA Model on weighted-average values, yielding results that are discrete point values, rather than a distribution of values as in the LCC and PBP Analysis.

The present value of increased total installed costs is the total annual installed cost increase (i.e., the difference between the standards case and base case), discounted to the present, and summed over the time period in which DOE evaluates the impact of standards (i.e., from the effective date of standards, 2012, to the year 2042).

Savings are decreases in operating costs (including energy and water) associated with the higher energy efficiency of equipment purchased in the standards case compared to the base case. Total operating cost savings are the savings per unit multiplied by the number of units of each vintage (i.e., the year of manufacture) surviving in a particular year. Equipment consumes energy and must be maintained over its entire lifetime. For units purchased up through 2042, the operating cost includes energy and water consumed until the last unit is retired from service.

11.5.4.1 Cooking Products – Cooktops and Ovens

This section provides NPV results based on discount rates of seven percent and three percent for the standard levels considered for cooktops and ovens. Tables 11.5.12 and 11.5.13 show the NPV results for the candidate standard levels analyzed for cooktops and ovens, respectively. Under the base case (i.e., without standards), the cumulative national equipment and operating costs of cooking products based on a seven-percent discount rate equal $61.7 billion and $56.6 billion, respectively. Based on a three-percent discount rate, the cumulative national equipment and operating costs equal $118.0 billion and $122.3 billion, respectively. Detailed results showing the breakdown of the NPV into national equipment costs and national operating costs are provided in Appendix 11B.

Table 11.5.12 Cooktops: Cumulative NPV Results based on Seven-Percent and Three-Percent Discount Rates

	Electric Coil				**Electric Smooth**				**Gas**			
CSL	**TSL**	**EF**	**NPV @ 7%** *billion 2006$*	**NPV @ 3%** *billion 2006$*	**TSL**	**EF**	**NPV @ 7%** *billion 2006$*	**NPV @ 3%** *billion 2006$*	**TSL**	**EF**	**NPV @ 7%** *billion 2006$*	**NPV @ 3%** *billion 2006$*
Base	1	0.737	-	-	1, 2, 3	0.742	-	-	-	0.156	-	-
1	2, 3, 4	0.769	0.07	0.23	4	0.753	-7.26	-13.89	1, 2, 3	0.399	0.19	0.50
2									4	0.420	-0.73	-1.11

Table 11.5.13 Ovens: Cumulative NPV Results based on Seven-Percent and Three-Percent Discount Rates

	Electric Standard				**Electric Self-Clean**				**Gas Standard**				**Gas Self-Clean**			
CSL	**TSL**	**EF**	**NPV @ 7%** *billion 2006$*	**NPV @ 3%** *billion 2006$*	**TSL**	**EF**	**NPV @ 7%** *billion 2006$*	**NPV @ 3%** *billion 2006$*	**TSL**	**EF**	**NPV @ 7%** *billion 2006$*	**NPV @ 3%** *billion 2006$*	**TSL**	**EF**	**NPV @ 7%** *billion 2006$*	**NPV @ 3%** *billion 2006$*
Base	1	0.1066	-	-	1,2,3	0.1099	-	-	-	0.0298	-	-	1,2	0.0540	-	-
1*	-	0.1113	0.07	0.21	-	0.1102	-0.27	-0.50	-	0.0536	-0.18	-0.34	3	0.0625	-0.01	0.19
2	2, 3	0.1163	0.11	0.34	4	0.1123	-2.77	-5.21	-	0.0566	-0.38	-0.81	-	0.0627	-0.12	-0.01
3	-	0.1181	0.06	0.28					-	0.0572	-0.38	-0.81	4	0.0632	-0.14	-0.04
4	-	0.1206	-0.74	-1.24					-	0.0593	-0.82	-1.60				
5	4	0.1209	-0.81	-1.37					-	0.0596	-0.84	-1.64				
6									4	0.0600	-0.91	-1.76				
1a*									1,2,3	0.0583	0.02	0.11				

* For gas standard ovens, candidate standard levels 1 and 1a correspond to designs that are utilized for the same purpose—eliminate the need for a standing pilot—but the technologies for each design are different. Candidate standard level 1 is a hot surface ignition device while level 1a is a spark ignition device. Candidate standard level 1a is presented at the end of the table because levels 2 through 6 are derived from level 1.

11.5.4.2 Cooking Products – Microwave Ovens

This section provides NPV results based on discount rates of seven percent and three percent for the standard levels considered for microwave ovens. Tables 11.5.14 and 11.5.14 show the NPV results for the candidate standard levels analyzed for microwave ovens. Under the base case (i.e., without standards), the cumulative national equipment and operating costs of microwave ovens based on a seven-percent discount rate equal $36.4 billion and $22.9 billion, respectively. Based on a three-percent discount rate, the cumulative national equipment and operating costs equal $69.6 billion and $46.4 billion, respectively. Detailed results showing the breakdown of the NPV into national equipment costs and national operating costs are provided in Appendix 11B.

Table 11.5.14 Microwave Ovens by EF: Cumulative NPV Results based on Seven-Percent and Three-Percent Discount Rates

TSL	EF	NPV	
		7% Discount Rate *billion 2006$*	**3% Discount Rate** *billion 2006$*
1a	0.586	-0.61	-1.07
2a	0.588	-1.60	-2.96
3a	0.597	-3.06	-5.72
4a	0.602	-4.94	-9.28

Table 11.5.15 Microwave Ovens by Standby Power: Cumulative NPV Results based on Seven-Percent and Three-Percent Discount Rates

TSL	Standby Power *Watts*	NPV	
		7% Discount Rate *billion 2006$*	**3% Discount Rate** *billion 2006$*
1b	2.0	0.91	2.03
2b	1.5	1.25	2.79
3b	1.0	1.56	3.52
4b	0.02	1.61	3.90

11.5.4.3 Commercial Clothes Washers

This section provides NPV results based on discount rates of seven percent and three percent for the standard levels considered for commercial clothes washers. Table 11.5.16 shows the NPV results for the candidate standard levels analyzed for commercial clothes washers. Under the base case (i.e., without standards), the cumulative national equipment and operating costs of commercial clothes washers based on a seven-percent discount rate equal $1.5 billion and $8.4 billion, respectively. Based on a three-percent discount rate, the cumulative national equipment and operating costs equal $2.9 billion and $17.1 billion, respectively. Detailed results showing the breakdown of the NPV into national equipment costs and national operating costs are provided in Appendix 11B.

Table 11.5.16 Commercial Clothes Washers: Cumulative NPV Results based on Seven-Percent and Three-Percent Discount Rates

	Top-Loading Washers				Front-Loading Washers			
CSL	**TSL**	**MEF/WF**	**NPV @ 7%** *Billion 2006$*	**NPV @ 3%** *Billion 2006$*	**TSL**	**MEF/WF**	**NPV @ 7%** *Billion 2006$*	**NPV @ 3%** *Billion 2006$*
1	1	1.42/9.50	-0.006	0.03	1	1.80/7.50	0.004	0.01
2	2	1.60/8.50	0.29	0.77	2, 3	2.00/5.50	0.03	0.06
3	3, 4, 5	1.72/8.00	0.43	1.10	4	2.20/5/10	0.07	0.16
4					5	2.35/4.40	0.12	0.29

11.6 IMPACT OF STANDARDS ON NATURAL GAS AND ELECTRICITY PRICES AND ASSOCIATED CONSUMER BENEFITS

11.6.1 Impact on Natural Gas Prices

DOE conducted an analysis on the potential impact on natural gas prices resulting from the promulgation of new standards on cooking products and commercial clothes washers at maximum technologically feasible (i.e., “Max Tech”) standard levels. “Max Tech” standard levels correspond to TSL 4 for cooktops and ovens, TSL 4b for microwave ovens, and TSL 6 for commercial clothes washers. The analysis used a version of NEMS called NEM-BT, modified to account for energy savings associated with the proposed standards. As described in Chapter 14 on the utility impact analysis, using NEMS-BT for such an analysis typically involves using higher-decrement runs to isolate the impacts of the standards from numerical noise. DOE derived the price effect results associated with the energy savings resulting from the Max Tech standards using a regressed interpolation toward the origin.

DOE examined two Max Tech scenarios: one for cooking products consisting of TSL 4 for cooktops and ovens and TSL 4b for microwave ovens and one for commercial clothes washers consisting of TSL 6.

Figure 11.6.1 shows the change in total natural gas consumption for the year 2030 (on the x-axis) resulting from Max Tech standard levels and the corresponding change in U.S. average wellhead natural gas price (on the y-axis). The points in Figure 11.6.1 that are labeled with “50x”, “60x”, “75x”, “100x” or “125x” represent the results for a series of higher decrement runs assuming various multiples of the savings resulting from the Max Tech scenarios. Decrement runs for cooking products are labeled as “Cook” while decrement runs for commercial clothes washers are labeled as “CLW”. Each scenario has multiple points that represent the results using the Annual Energy Outlook (AEO) 2008 Reference Case.[5] The interpolated results for the Max Tech standard levels are shown in the upper right hand corner of Figure 11.6.1. For the Max Tech standard levels, NEMS predicts that the 2030 average wellhead natural gas price will remain unchanged for both the cooking product and commercial clothes washer standards. As shown in Table 11.6.1, relative to AEO 2008 Reference Case values, the forecasted wellhead price decline in 2030 is zero percent. Other outputs from NEMS show that the predicted reduction in the average-customer natural gas price in 2030 is also unchanged.[b]

Because the results shown in Table 11.6.1 show that cooking product and commercial clothes washer energy efficiency standards at the Max Tech level have no impact on average well head prices, efficiency standards for cooking products and commercial clothes washers, even at the Max Tech level, will have no effect on natural gas consumer prices.

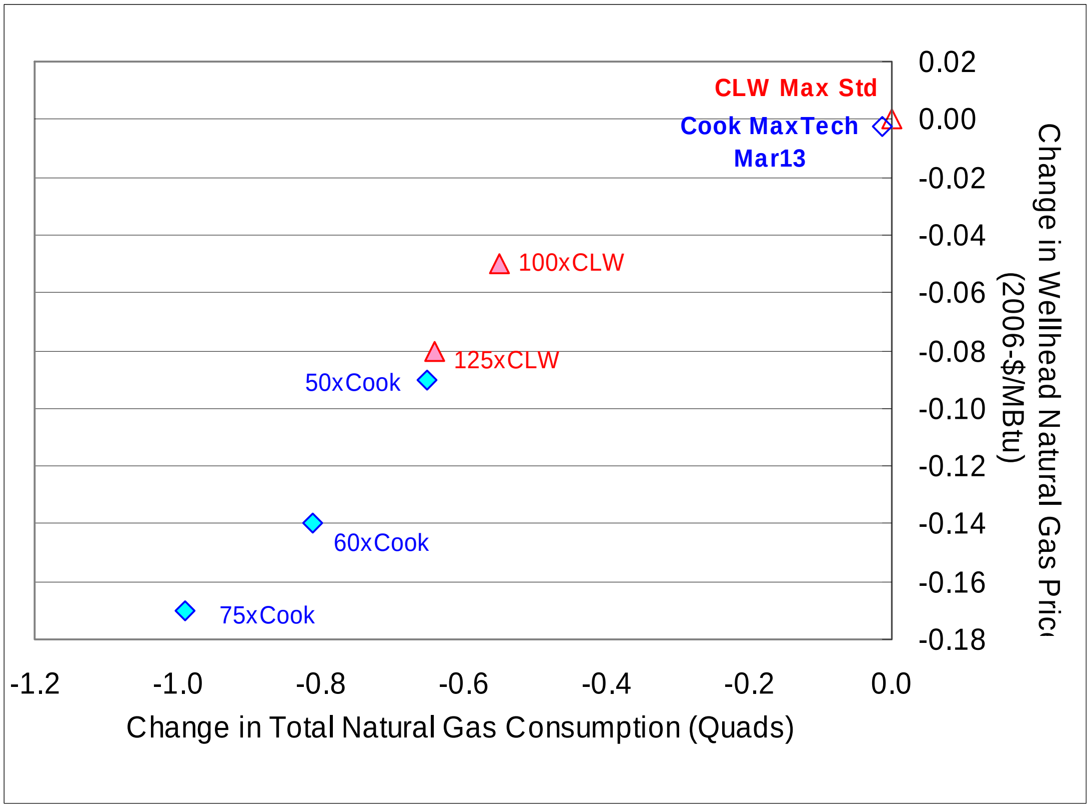

Figure 11.6.1 Wellhead Natural Gas Price Change in 2030 Resulting from Reduced Natural Gas Consumption Associated with Max Tech Standard Levels

[b] The main customer sectors are electric power, industry, residential and commercial.

Table 11.6.1 Impact of Max Tech Standard Levels on Natural Gas Consumption and Average Wellhead Price in 2030

	No-Standard Case		Max Tech Scenario Result					
	Nat Gas Consumption	**Nat Gas Price**	**Nat Gas Consumption**	**Change in Consumption**		**Nat Gas Price**	**Change in Price**	
	Quads	2006$/ MMBtu	Quads	Quads	%	2006$/ MMBtu	2006$/ MMBtu	%
Cooking Product Max Tech	21.4	6.63	21.4	-0.01	-0.1	6.63	0.00	0.0
Commercial Clothes Washer Max Tech	21.4	6.63	21.4	0.00	0.0	6.63	0.00	0.0

The inverse price elasticity seen in NEMS to estimate the effect of consumption on price varies over the forecast period due to the dynamics of natural gas supply and demand in NEMS (Figure 11.6.2).[c] The average value over the forecast period is 0.61 and 0.02 for cooking product standards (labeled as “Cook” in Figure 11.6.2) and commercial clothes washer standards (labeled as “CLW” in Figure 11.6.2), respectively.

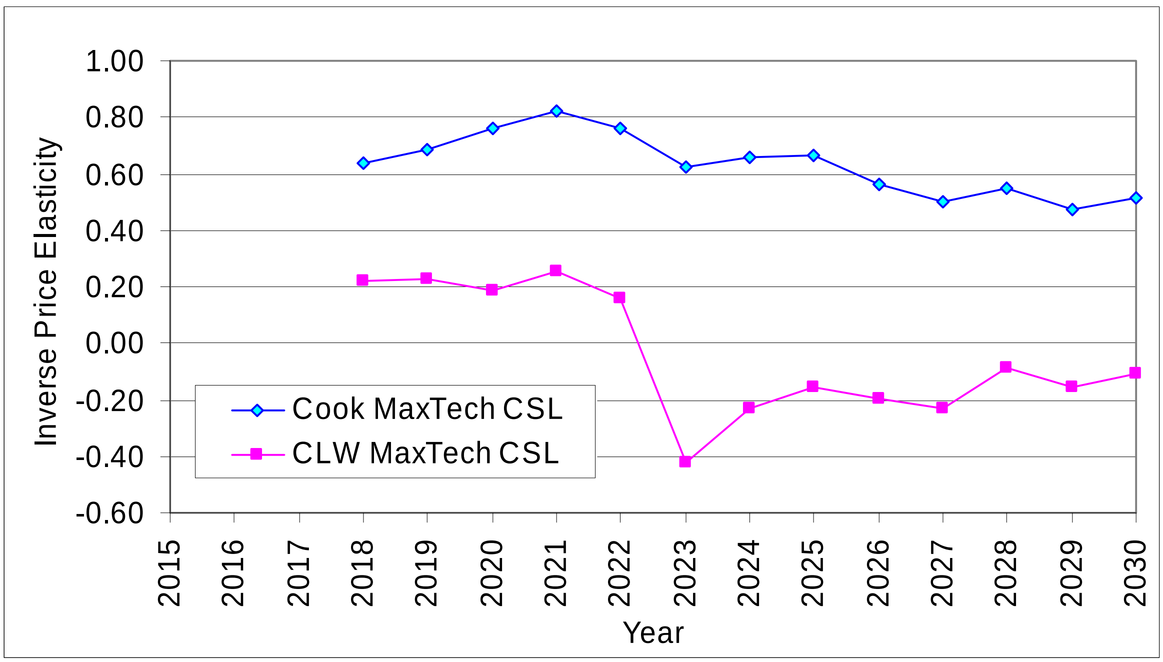

Figure 11.6.2 Inverse Natural Gas Price Elasticity from NEMS Analysis for Cooking Product and Commercial Clothes Washer Max Tech Standard Levels

[c] Since the demand reduction in the early years after the standard takes effect is small, the model results for those years may be less accurate than in later years.

The average inverse price elasticity (0.61 and 0.02) reported above is generally consistent with other studies that used various versions of NEMS to examine the impacts to natural gas prices resulting from reductions in natural gas demand. In a review of a number of such studies, Wiser and Bollinger[6] examined analyses that reported the reduction in national natural gas demand from certain energy policies and the resulting decline in the wellhead gas price. Examining the average values of the inverse price elasticity over the forecast period in each study, they found the average values to range from 0.7 to 4.7. It is important to note that the average inverse price elasticities in 13 of 19 analyses were between 0.8 and 2.0, and the average value from DOE's current analysis (0.90) falls in the lower end of this range.

Although NEMS provides a detailed characterization of natural gas supply, it is understandable that NEMS may not accurately represent the long-run supply of natural gas of the country since all aspects of the future are not certain. However, other widely used complex energy demand/supply models produce results that are similar to NEMS results, and NEMS is recognized as a reliable analytical tool. Table 11.6.2 compares the results of modeling studies of the response of natural gas price to change in gas consumption. These results are summarized in a 2003 study by Stanford's Energy Modeling Forum.[7] While the magnitude of the price response (as summarized by the inverse price elasticity) varies considerably among the models reviewed, in general, they confirm that a sizable price impact is associated with changes in natural gas consumption.[d] It is worth noting that the NEMS long-run (2020) response is smaller than that of most of the other models.

Table 11.6.2 Implicit Natural Gas Inverse Price Elasticity from Seven Energy Models

	2005	2010	2015	2020	Average
NEMS	1.8	2.2	0.53	0.11	1.2
POEMS	2.4	1.8	2.5	1.8	2.1
CRA	3.5	2.5	1.1	0.9	2.0
NANGAS	5.4	7.0	7.6	5.1	6.3
E2020	1.5	1.0	1.0	0.7	1.1
MARKAL	N/A	2.0	N/A	2.1	2.1
NARG	8.7	12.4	5.6	2.4	7.3

NEMS (National Energy Modeling System, 2002); POEMS (Policy Office Electricity Modeling System), CRA (Charles River Associates), NANGAS (North American Natural Gas Analysis System), E2020 (Energy 2020), MARKAL (MARKet ALlocation), NARG (North American Regional Gas model)

Source: Based on EMF, 2003

In addition to the models listed in Table 11.6.2, there exist studies conducted by the National Petroleum Council[8] and the National Commission on Energy Policy[9] that are based on the EEA model. The EEA model shows higher inverse price elasticities (between 4.0 and 16.8),

[d] The EMF scenarios actually modeled the impact of increased gas demand on price. Assuming a smooth supply curve over the long term, however, the elasticities implied by an increase in demand should be essentially equivalent to those implied by a decrease in demand. Two of the models (NANGAS and NARG) report somewhat anomalous inverse elasticities for undetermined reasons.

leading to larger natural gas price reductions for a given demand decrease, than those predicted by NEMS and most of the other national energy models.

11.6.2 Impact on Electricity Prices

DOE also conducted an analysis on the potential impact on electricity prices resulting from the promulgation of new standards on cooking products and commercial clothes washers at maximum technologically feasible (i.e., “Max Tech”) standard levels. “Max Tech” standard levels correspond to TSL 4 for cooktops and ovens, TSL 4b for microwave ovens, and TSL 6 for commercial clothes washers. The analysis used a version of NEMS called NEMS-BT, modified to account for energy savings associated with the proposed standards. Again, using NEMS-BT for such an analysis typically involves using higher-decrement runs to isolate the impacts of the standards from numerical noise. DOE derived the price effect results associated with the energy savings resulting from the Max Tech standards using a regressed interpolation toward the origin.

DOE examined two Max Tech scenarios: one for cooking products consisting of TSL 4 for cooktops and ovens and TSL 4b for microwave ovens and one for commercial clothes washers consisting of TSL 6.

Figure 11.6.3 shows the change in total electric power consumption for the year 2030 (on the x-axis) resulting from Max Tech standard levels and the corresponding change in U.S. average electricity price (on the y-axis). The points in Figure 11.6.3 that are labeled with “50x”, “60x”, “75x”, “100x”, “125x”, or “150x” represent the results for a series of higher decrement runs assuming various multiples of the savings resulting from the Max Tech scenarios. Decrement runs for cooking products are labeled as “Cook” while decrement runs for commercial clothes washers are labeled as “CLW”. Each scenario has multiple points that represent the results using the Annual Energy Outlook (AEO) 2008 Reference Case.[2] The interpolated results for the Max Tech standard levels are shown in the upper right hand corner of Figure 11.6.3. For the Max Tech standard levels, NEMS predicts that the 2030 average electricity price will remain unchanged for both the cooking product and commercial clothes washer standards. As shown in Table 11.6.3, relative to AEO 2008 Reference Case values, the forecasted electricity price decline in 2030 is zero percent. Other outputs from NEMS show that the predicted reduction in the average-customer electricity price in 2030 is also unchanged.[e]

Because the results shown in Table 11.6.3 show that cooking product and commercial clothes washer energy efficiency standards at the Max Tech level have no impact on average electricity prices, efficiency standards for cooking products and commercial clothes washers, even at the Max Tech level, will have no effect on the average electricity price to end users.

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[e] The main customer sectors are electric power, industry, residential and commercial.

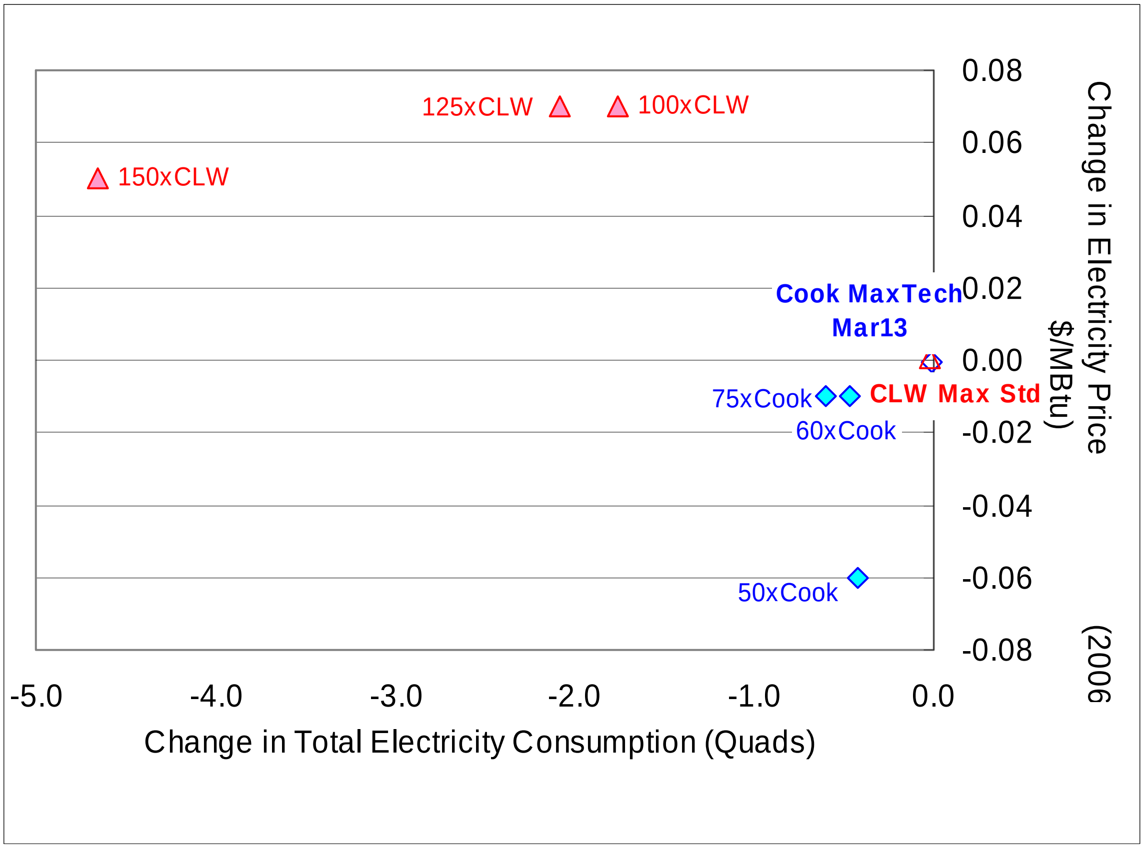

Figure 11.6.3 Electricity Price Change in 2030 Resulting from Reduced Electricity Consumption Associated with Max Tech Standard Levels

Table 11.6.3 Impact of Max Tech Standard Levels on Electricity Consumption and Price in 2030

	No-Standard Case		**Max Tech Scenario Result**					
	Electricity Consumption	**Electricity Price**	**Electricity Consumption**	**Change in Consumption**		**Electricity Price**	**Change in Price**	
	Quads	2006$/ MMBtu	Quads	Quads	%	2006$/ MMBtu	2006$/ MMBtu	%
Cooking Product Max Tech	49.21	25.93	49.20	-0.01	-0.02%	25.93	0.00	0.0
Commercial Clothes Washer Max Tech	49.21	25.93	49.19	-0.02	-0.02%	25.93	0.00	0.0

The inverse price elasticity seen in NEMS is used to estimate the effect of consumption on price varies over the forecast period due to the dynamics of energy supply and demand in

NEMS (Figure 11.6.4).[f] The average value over the forecast period is 0.67 and 0.30 for cooking product standards (labeled as "Cook" in Figure 11.6.4) and commercial clothes washer standards (labeled as "CLW" in Figure 11.6.4), respectively.

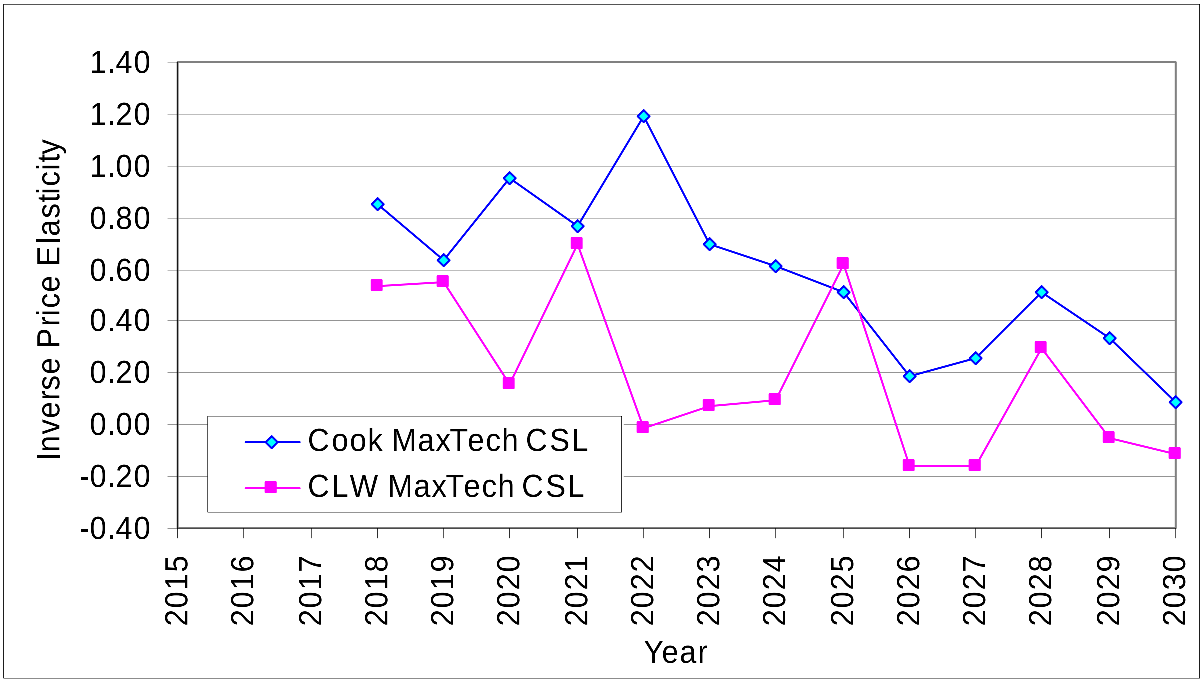

Figure 11.6.4 Inverse Electricity Price Elasticity from NEMS Analysis for Cooking Product and Commercial Clothes Washer Max Tech Standard Levels

[f] Since the demand reduction in the early years after the standard takes effect is small, the model results for those years may be less accurate than in later years.

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