

## CHAPTER 14. UTILITY IMPACT ANALYSIS

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## CHAPTER 14. UTILITY IMPACT ANALYSIS

### 14.1 INTRODUCTION

DOE analyzed the effects of its amended standard levels on the electric utility industry using a variant of the DOE/Energy Information Administration (EIA)'s National Energy Modeling System (NEMS).<sup>a</sup> NEMS is a public domain, multi-sectored, partial equilibrium model of the U.S. energy sector. Each year, DOE/EIA uses NEMS to produce an energy forecast for the United States, the *Annual Energy Outlook (AEO)*. The *AEO* for 2010 (*AEO2010*) forecasts energy supply and demand through 2035.<sup>1</sup> DOE used a variant of this model, referred to as NEMS-BT,<sup>b</sup> to account for the impacts of standby power energy conservation standards for microwave ovens. DOE's utility impact analysis consists of a comparison between model results for the *AEO2010* Reference Case and for cases in which standards are in place, and applies the same basic set of assumptions as the *AEO2010*. The *AEO2010* reference case corresponds to medium economic growth.

The utility impact analysis reports the changes in electric installed capacity and generation that result for each trial standard level (TSL) by plant type, as well as changes in residential electricity consumption.

NEMS-BT has several advantages that have led to its adoption as the forecasting tool in the analysis of energy conservation standards. NEMS-BT uses a set of assumptions that are well known and fairly transparent, due to the exposure and scrutiny each *AEO* receives. In addition, the comprehensiveness of NEMS-BT permits the modeling of interactions among the various energy supply and demand sectors, producing a complete picture of the effects of energy conservation standards. Perhaps most importantly, NEMS-BT can be used to estimate marginal effects, which yield a better estimate of the actual impact of energy conservation standards than considering only average effects.

### 14.2 METHODOLOGY

NEMS provides reference case load shapes for several end uses. The model uses predicted growth in demand for each end use to build up a projection of the total electric system load growth for each region, which it uses in turn to predict the necessary additions to capacity. DOE uses NEMS-BT to account for the implementation of energy conservation standards by decrementing the appropriate reference case load shape. For microwave oven standby power the refrigeration end use was decremented. The refrigeration end use is the best representation of a baseline energy load, which is characteristic of the standby power in microwave ovens. The

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<sup>a</sup> For more information on NEMS, refer to the U.S. Department of Energy, Energy Information Administration documentation. A useful summary is *National Energy Modeling System: An Overview 2003*, DOE/EIA-0581(2003), March, 2003.

<sup>b</sup> DOE/EIA approves use of the name NEMS to describe only an official version of the model without any modification to code or data. Because this analysis entails some minor code modifications and the model is run under various policy scenarios that are variations on DOE/EIA assumptions, DOE refers to it by the name NEMS-BT (BT is DOE's Building Technologies Program, under whose aegis this work has been performed). NEMS-BT was previously called NEMS-BRS.

energy conservation decrement is divided amongst the nine U.S. Census divisions based upon their shares of energy consumption in the specific end use, as given in NEMS.

DOE used the site energy savings developed in the national impact analysis (chapter 10) for each TSL as input to NEMS-BT. The magnitude of the energy decrement that would be required for NEMS-BT to produce stable results out of the range of numerical noise is larger than the highest efficiency standard under consideration. Therefore, DOE estimated results corresponding to each TSL using interpolation. DOE ran higher energy use reduction levels in NEMS-BT, representing multipliers of each TSL, and used these outputs to linearly interpolate the results to estimate actual changes in generation and capacity due to the standard.

Although the current time horizon of NEMS-BT is 2035, other parts of the energy conservation standards analysis extend through the year 2043. It is not feasible to extend the forecast period of NEMS-BT for the purposes of this analysis, nor does DOE/EIA have an approved method for extrapolation of many outputs beyond 2035. While it might seem reasonable to make simple linear extrapolations of results, in practice this is not advisable because outputs could be contradictory. An analysis of various trends sufficiently detailed to guarantee consistency is beyond the scope of this work, and, in any case, would involve a great deal of uncertainty. Therefore, all extrapolations beyond 2035 are simple replications of year 2035 results. To emphasize the extrapolated results wherever they appear, they are shaded in gray to distinguish them from actual NEMS-BT results.

### 14.3 RESULTS

This utility impact analysis reports NEMS-BT forecasts for residential sector electricity consumption, total electricity generation by fuel type, and installed electricity generation capacity by fuel type. Results are presented in five-year increments through 2035. Beyond 2035, an extrapolation through 2043 for each TSL represents a simple replication of the 2035 results.

The results from the *AEO2010* Reference Case are shown in Table 14.3.1. The results for microwave oven standby power TSLs are presented in Tables 14.3.2 through 14.3.5. Each table shows forecasts using interpolated results, as described in section 14.2, for total U.S. electricity generation and installed capacity.

The considered TSLs reduce only electricity consumption compared to the *AEO2010* Reference Case. The electricity savings predicted by the NIA Model range from 0.073 to 0.223 percent of total residential electricity consumption in the year 2035.

**Table 14.3.1 AEO 2010 Reference Case Forecast**

<b>NEMS-BT Results: AEO2010 Reference</b>							
	<b>2005</b>	<b>2010</b>	<b>2015</b>	<b>2020</b>	<b>2025</b>	<b>2030</b>	<b>2035</b>
<i>Residential Sector Energy Consumption</i> <sup>1</sup>							
Electricity Sales (TWh) <sup>2</sup>	1,359	1,388	1,400	1,472	1,553	1,637	1,707
<i>Total U.S. Electric Generation</i> <sup>3</sup>							
Coal (TWh)	2,013	1,828	2,038	2,090	2,130	2,209	2,305
Gas (TWh)	759	857	690	769	886	1,018	1,095
Petroleum (TWh)	122	45	46	47	48	48	49
Nuclear (TWh)	782	813	834	883	886	886	895
Renewables (TWh)	358	462	649	714	797	850	890
Total (TWh) <sup>4</sup>	4,034	4,005	4,257	4,503	4,746	5,012	5,234
<i>Installed Generating Capacity</i> <sup>5</sup>							
Coal (GW)	314	321	325	326	326	330	337
Other Fossil (GW) <sup>6</sup>	439	468	445	446	467	501	534
Nuclear (GW)	100	102	105	111	111	111	113
Renewables (GW)	99	133	171	177	186	196	209
Total (GW) <sup>7</sup>	952	1,024	1,046	1,059	1,091	1,138	1,192

<sup>1</sup> Comparable to Table A2 of AEO2010: Energy Consumption, Residential

<sup>2</sup> Comparable to Table A8 of AEO2010: Electricity Sales by Sector

<sup>3</sup> Comparable to Table A8 of AEO2010: Electric Generators and Cogenerators

<sup>4</sup> Excludes "Other Gaseous Fuels" cogenerators and "Other" cogenerators

<sup>5</sup> Comparable to Table A9 of AEO2010: Electric Generators and Cogenerators Capability

<sup>6</sup> Includes "Other Gaseous Fuels" cogenerators

<sup>7</sup> Excludes Pumped Storage and Fuel Cells

**Table 14.3.2 Microwave Oven Standby Power: Trial Standard Level 1 Forecast**

<b>NEMS-BT Results:</b>							<b>Difference from AEO2010 Reference Case</b>								
	2010	2015	2020	2025	2030	2035		2010	2015	2020	2025	2030	2035	<b>Extrapolation</b>	
	2010	2015	2020	2025	2030	2035		2010	2015	2020	2025	2030	2035	2040	2043
<i>Residential Sector Energy Consumption</i>							<i>Residential Sector Energy Consumption</i>								
Electricity Sales (TWh)	1,388	1,400	1,471	1,552	1,636	1,706	Electricity Sales (TWh)	0.00	-0.24	-0.80	-1.15	-1.20	-1.24	-1.28	-1.30
<i>Total U.S. Electric Generation</i>							<i>Total U.S. Electric Generation</i>								
Coal (TWh)	1,828	2,038	2,090	2,129	2,209	2,304	Coal (TWh)	-0.01	-0.01	-0.21	-0.26	-0.33	-0.33	-0.33	-0.33
Gas (TWh)	857	690	769	885	1,018	1,095	Gas (TWh)	0.06	0.04	-0.31	-0.65	-0.54	-0.44	-0.44	-0.44
Petroleum (TWh)	45	46	47	48	48	49	Petroleum (TWh)	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01
Nuclear (TWh)	813	834	883	886	886	895	Nuclear (TWh)	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04
Renewables (TWh)	462	648	714	797	850	890	Renewables (TWh)	-0.05	-0.28	-0.29	-0.38	-0.35	-0.38	-0.38	-0.38
Total (TWh)	4,005	4,257	4,502	4,745	5,011	5,233	Total (TWh)	0.00	-0.25	-0.81	-1.29	-1.22	-1.20	-1.20	-1.20
<i>Installed Generating Capacity</i>							<i>Installed Generating Capacity</i>								
Coal (GW)	321	325	326	326	330	336	Coal (GW)	0.000	-0.010	-0.012	-0.012	-0.020	-0.021	-0.021	-0.021
Other Fossil (GW)	468	445	446	467	501	534	Other Fossil (GW)	0.000	-0.026	-0.045	-0.095	-0.096	-0.082	-0.082	-0.082
Nuclear (GW)	102	105	111	111	111	113	Nuclear (GW)	0.000	0.000	0.000	0.000	0.000	-0.005	-0.005	-0.005
Renewables (GW)	133	171	177	186	196	209	Renewables (GW)	-0.015	-0.079	-0.078	-0.074	-0.074	-0.089	-0.089	-0.089
Total (GW)	1,024	1,046	1,059	1,091	1,138	1,192	Total (GW)	-0.016	-0.115	-0.135	-0.181	-0.190	-0.196	-0.196	-0.196

**Table 14.3.3 Microwave Oven Standby Power: Trial Standard Level 2 Forecast**

<b>NEMS-BT Results:</b>							<b>Difference from AEO2010 Reference Case</b>								
	2010	2015	2020	2025	2030	2035		2010	2015	2020	2025	2030	2035	<b>Extrapolation</b>	
	2010	2015	2020	2025	2030	2035		2010	2015	2020	2025	2030	2035	2040	2043
<i>Residential Sector Energy Consumption</i>							<i>Residential Sector Energy Consumption</i>								
Electricity Sales (TWh)	1,388	1,400	1,470	1,552	1,635	1,706	Electricity Sales (TWh)	0.00	-0.35	-1.15	-1.67	-1.74	-1.80	-1.85	-1.89
<i>Total U.S. Electric Generation</i>							<i>Total U.S. Electric Generation</i>								
Coal (TWh)	1,828	2,038	2,090	2,129	2,209	2,304	Coal (TWh)	-0.01	-0.02	-0.31	-0.37	-0.47	-0.48	-0.48	-0.48
Gas (TWh)	857	690	769	885	1,017	1,094	Gas (TWh)	0.09	0.06	-0.44	-0.93	-0.78	-0.64	-0.64	-0.64
Petroleum (TWh)	45	46	47	48	48	49	Petroleum (TWh)	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Nuclear (TWh)	813	834	883	886	886	895	Nuclear (TWh)	0.00	0.00	0.00	0.00	0.00	-0.05	-0.05	-0.05
Renewables (TWh)	462	648	713	796	850	890	Renewables (TWh)	-0.08	-0.41	-0.42	-0.54	-0.50	-0.55	-0.55	-0.55
Total (TWh)	4,005	4,257	4,501	4,744	5,010	5,232	Total (TWh)	0.00	-0.37	-1.17	-1.86	-1.76	-1.74	-1.74	-1.74
<i>Installed Generating Capacity</i>							<i>Installed Generating Capacity</i>								
Coal (GW)	321	325	326	326	330	336	Coal (GW)	0.000	-0.014	-0.017	-0.017	-0.028	-0.030	-0.030	-0.030
Other Fossil (GW)	468	445	446	467	501	534	Other Fossil (GW)	0.000	-0.038	-0.065	-0.137	-0.138	-0.119	-0.119	-0.119
Nuclear (GW)	102	105	111	111	111	113	Nuclear (GW)	0.000	0.000	0.000	0.000	0.000	-0.007	-0.007	-0.007
Renewables (GW)	133	171	176	186	196	209	Renewables (GW)	-0.022	-0.114	-0.113	-0.108	-0.107	-0.128	-0.128	-0.128
Total (GW)	1,024	1,046	1,059	1,091	1,138	1,192	Total (GW)	-0.022	-0.166	-0.195	-0.261	-0.274	-0.284	-0.284	-0.284

**Table 14.3.4 Microwave Oven Standby Power: Trial Standard Level 3 Forecast**

<b>NEMS-BT Results:</b>							<b>Difference from AEO2010 Reference Case</b>								
	2010	2015	2020	2025	2030	2035		2010	2015	2020	2025	2030	2035	<b>Extrapolation</b>	
	2010	2015	2020	2025	2030	2035		2010	2015	2020	2025	2030	2035	2040	2043
<i>Residential Sector Energy Consumption</i>							<i>Residential Sector Energy Consumption</i>								
Electricity Sales (TWh)	1,388	1,400	1,470	1,551	1,635	1,705	Electricity Sales (TWh)	0.00	-0.48	-1.58	-2.29	-2.39	-2.47	-2.55	-2.59
<i>Total U.S. Electric Generation</i>							<i>Total U.S. Electric Generation</i>								
Coal (TWh)	1,828	2,038	2,090	2,129	2,209	2,304	Coal (TWh)	-0.01	-0.02	-0.42	-0.52	-0.65	-0.66	-0.66	-0.66
Gas (TWh)	857	690	768	884	1,017	1,094	Gas (TWh)	0.12	0.08	-0.61	-1.28	-1.07	-0.88	-0.88	-0.88
Petroleum (TWh)	45	46	47	48	48	49	Petroleum (TWh)	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Nuclear (TWh)	813	834	883	886	886	895	Nuclear (TWh)	0.00	0.00	0.00	0.00	0.00	-0.07	-0.07	-0.07
Renewables (TWh)	462	648	713	796	849	890	Renewables (TWh)	-0.11	-0.56	-0.58	-0.75	-0.69	-0.76	-0.76	-0.76
Total (TWh)	4,005	4,257	4,501	4,743	5,009	5,231	Total (TWh)	0.00	-0.51	-1.62	-2.56	-2.42	-2.39	-2.39	-2.39
<i>Installed Generating Capacity</i>							<i>Installed Generating Capacity</i>								
Coal (GW)	321	325	326	326	330	336	Coal (GW)	0.000	-0.020	-0.023	-0.024	-0.039	-0.041	-0.041	-0.041
Other Fossil (GW)	468	445	446	467	501	534	Other Fossil (GW)	0.000	-0.052	-0.089	-0.188	-0.190	-0.164	-0.164	-0.164
Nuclear (GW)	102	105	111	111	111	113	Nuclear (GW)	0.000	0.000	0.000	0.000	0.000	-0.009	-0.009	-0.009
Renewables (GW)	133	171	176	186	196	209	Renewables (GW)	-0.031	-0.156	-0.155	-0.148	-0.148	-0.176	-0.176	-0.176
Total (GW)	1,024	1,046	1,059	1,090	1,138	1,192	Total (GW)	-0.031	-0.228	-0.268	-0.359	-0.377	-0.390	-0.390	-0.390

**Table 14.3.5 Microwave Oven Standby Power: Trial Standard Level 4 Forecast**

<b>NEMS-BT Results:</b>							<b>Difference from AEO2010 Reference Case</b>								
	2010	2015	2020	2025	2030	2035		2010	2015	2020	2025	2030	2035	<b>Extrapolation</b>	
	2010	2015	2020	2025	2030	2035		2010	2015	2020	2025	2030	2035	2040	2043
<i>Residential Sector Energy Consumption</i>							<i>Residential Sector Energy Consumption</i>								
Electricity Sales (TWh)	1,388	1,399	1,469	1,550	1,633	1,704	Electricity Sales (TWh)	0.00	-0.74	-2.44	-3.53	-3.68	-3.80	-3.92	-3.99
<i>Total U.S. Electric Generation</i>							<i>Total U.S. Electric Generation</i>								
Coal (TWh)	1,828	2,038	2,090	2,129	2,208	2,304	Coal (TWh)	-0.02	-0.04	-0.65	-0.79	-1.00	-1.02	-1.02	-1.02
Gas (TWh)	857	690	768	884	1,017	1,094	Gas (TWh)	0.18	0.13	-0.94	-1.98	-1.65	-1.36	-1.36	-1.36
Petroleum (TWh)	45	46	47	48	48	49	Petroleum (TWh)	0.00	0.00	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02
Nuclear (TWh)	813	834	883	886	886	895	Nuclear (TWh)	0.00	0.00	0.00	0.00	0.00	-0.11	-0.11	-0.11
Renewables (TWh)	462	648	713	796	849	889	Renewables (TWh)	-0.16	-0.87	-0.89	-1.15	-1.06	-1.16	-1.16	-1.16
Total (TWh)	4,005	4,256	4,500	4,742	5,008	5,230	Total (TWh)	0.00	-0.78	-2.49	-3.94	-3.72	-3.68	-3.68	-3.68
<i>Installed Generating Capacity</i>							<i>Installed Generating Capacity</i>								
Coal (GW)	321	325	326	326	330	336	Coal (GW)	0.000	-0.030	-0.036	-0.036	-0.060	-0.063	-0.063	-0.063
Other Fossil (GW)	468	445	446	467	501	534	Other Fossil (GW)	0.000	-0.080	-0.137	-0.289	-0.293	-0.252	-0.252	-0.252
Nuclear (GW)	102	105	111	111	111	113	Nuclear (GW)	0.000	0.000	0.000	0.000	0.000	-0.015	-0.015	-0.015
Renewables (GW)	133	171	176	186	196	209	Renewables (GW)	-0.047	-0.241	-0.239	-0.228	-0.227	-0.271	-0.271	-0.271
Total (GW)	1,024	1,046	1,059	1,090	1,138	1,192	Total (GW)	-0.048	-0.351	-0.412	-0.553	-0.581	-0.601	-0.601	-0.601

Table 14.3.6 presents the estimated reduction in electricity generating capacity in 2043 for the TSLs that DOE considered in this rulemaking.

**Table 14.3.6 Reduction in Electric Generating Capacity in 2043 Under Microwave Oven Standby Power and Off Modes Trial Standard Levels**

TSL 1	TSL 2	TSL 3	TSL 4
<b>Gigawatts</b>			
0.196	0.284	0.390	0.601

#### **14.4 IMPACT OF STANDARDS ON ELECTRICITY PRICES AND ASSOCIATED BENEFITS**

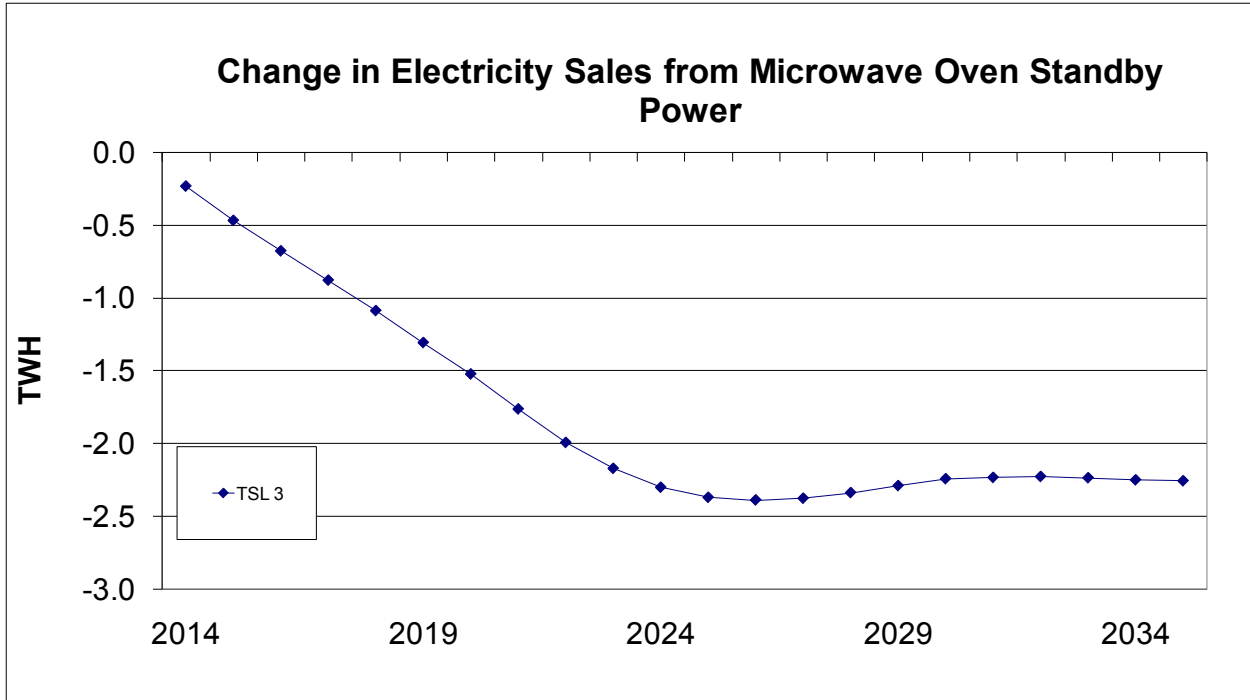
Using the framework of the utility impact analysis, DOE analyzed the potential impact on electricity prices resulting from the standards on microwave oven standby power. Associated benefits for all electricity users in all sectors of the economy are then estimated from these price impacts.

DOE’s analysis of energy price impacts used NEMS-BT in a similar manner as described in section 14.2. Like other widely-used energy-economic models, NEMS uses elasticities to estimate the energy price change that would result from a change (increase or decrease) in energy demand. The elasticity of price to a decrease in demand is the “inverse price elasticity.” The calculated inverse price elasticity based on NEMS-BT simulations differs throughout the forecast period in response to the dynamics of supply and demand for electricity.

##### **14.4.1 Impact on Electricity Prices**

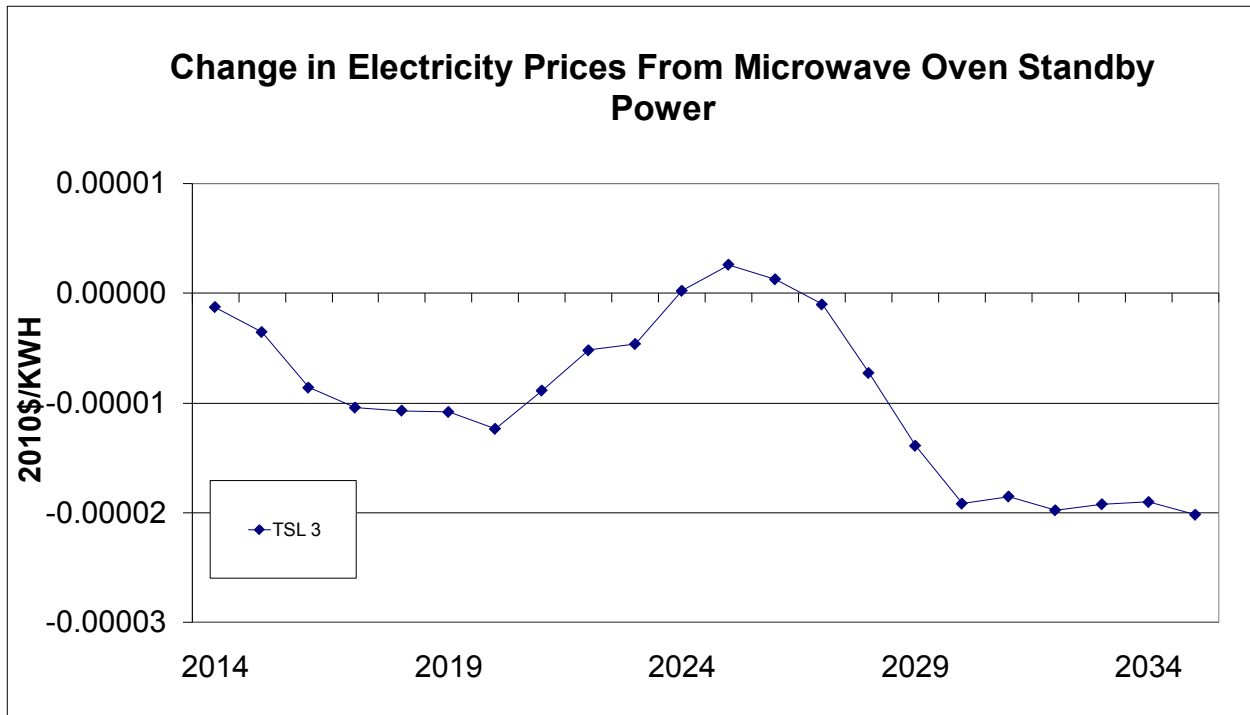
After generating results using higher decrements to energy consumption, a regressed interpolation toward the origin derived the price effects associated with the energy savings of the TSLs. Results were then scaled to the appropriate TSL. The selected standard for microwave oven standby power is TSL 3. The electricity price impacts are presented below.

Figure 14.4.1 shows the annual change in U.S. electricity sales for the selected standard, relative to the base case which involves no new standards.



**Figure 14.4.1 Change in U.S. Electricity Sales Associated with Proposed Microwave Oven Standby Power Standard**

Figure 14.4.2 shows the annual change in average U.S. price for electricity, relative to the Reference case, projected to result from the proposed standard. For TSL 3, the price reduction averages 0.001 cents per kWh (in 2010\$), or a price reduction of 0.01 percent, over the period from 2014 through 2035.



**Figure 14.4.2 Effect of Selected Microwave Oven Standby Power Energy Conservation Standard on Average U.S. Electricity Price (All Users)**

#### 14.4.2 Impact of Changes in Electricity Price on Electricity Users

Using the estimated electricity price impacts, DOE calculated the nominal savings in total electricity expenditures in each year by multiplying the annual change in the average-user price for electricity by the total annual U.S. electricity sales forecast by NEMS, adjusted for the impact of the standards. The amended standards would continue to reduce demand for electricity after 2035 (which is the last year in the NEMS forecast). DOE’s estimate for 2036–2043 (the period used to estimate the NPV of the national consumer benefits from amended standards) multiplied the average electricity price reduction in 2015–2035 by estimated total annual electricity sales in 2036–2043.<sup>c</sup> DOE then discounted the stream of reduced expenditures to calculate a NPV.

Table 14.4.1 shows the calculated NPV of the economy-wide savings in electricity expenditures for each considered TSL at 3-percent and 7-percent discount rates. The need to extrapolate price effects and electricity sales beyond 2035 suggests that one should interpret the post-2035 results as a rough indication of the benefits to electricity users in the post-2035 period.

<sup>c</sup> The estimation of electricity sales after 2035 uses the average annual growth rate in 2031-2035 of total U.S. electricity sales forecasted by NEMS. This forecast includes the impact of the standards.

**Table 14.4.1 Cumulative NPV of the Economy-Wide Savings in Electricity Expenditures Due to the Projected Decline in Electricity Prices Resulting from the Selected Standard for Microwave Oven Standby Power\***

<b>Discount Rate</b>	<b>MWO Standby Power (billion \$2009)</b>
3 percent	0.730
7 percent	0.384

\* Impacts for units sold from 2014 to 2043

### **14.4.3 Discussion of Savings in Electricity Expenditures**

Although the aggregate benefits for all electricity users are potentially large, there may be negative effects on the actors involved in electricity supply. The electric power industry is a complex mix of power plant providers, fuel suppliers, electricity generators, and electricity distributors. While the distribution of electricity is regulated everywhere, the institutional structure of the power sector varies, and has changed over time. For these reasons, an assessment of impacts on the actors involved in electricity supply from reduction in electricity demand associated with energy conservation standards is beyond the scope of this rulemaking.

In considering the potential benefits to electricity users, DOE takes under advisement the provided by the Office of Management and Budget (OMB) to Federal agencies on the development of regulatory analysis (OMB Circular A-4 (Sept. 17, 2003), section E, “Identifying and Measuring Benefits and Costs”). Specifically, at page 38, Circular A-4 instructs that transfers should be excluded from the estimates of the benefits and costs of a regulation. DOE is continuing to investigate the extent to which change in electricity prices projected to result from standards represents a net gain to society.

## REFERENCES

1. Energy Information Administration, *Updated Annual Energy Outlook 2010 Reference Case Service Report*, 2010. Washington, DC. Report No. DOE/EIA-0383(2010).  
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