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Technical Support Document: Energy Conservation Standards for Consumer Products: Dishwashers, Clothes Washers, and Clothes Dryers

including
Environmental Assessment (DOE/EA-0386)
Regulatory Impact Analysis

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ENVIRONMENTAL ASSESSMENT FOR PROPOSED ENERGY CONSERVATION STANDARDS FOR THREE TYPES OF CONSUMER PRODUCTS: DISHWASHERS, CLOTHES WASHERS AND CLOTHES DRYERS

1 INTRODUCTION AND SUMMARY

This environmental assessment (EA) evaluates the environmental impacts resulting from new or amended energy-efficiency standards for dishwashers, clothes washers and clothes dryers as mandated by the National Appliance Energy Conservation Act of 1987 (1). A complete description of the Engineering and Economic Analysis of the proposed standards may be found elsewhere in the Technical Support Document (TSD) (2). All eleven of the scenarios for product design changes described in the Engineering Analysis of the TSD are analyzed in the environmental assessment in the form of levels of pollutant reduction. Level 1 represents the least amount of pollutant reduction, while higher numbered levels represent increasingly more stringent standards, with correspondingly greater reductions in pollutants. Values for energy savings that result from product design changes are taken from the TSD. These energy savings are based on recent data on actual usage rather than DOE test procedures.

The main environmental concern addressed is emissions from fossil fueled electricity generation. Each of the design options for dishwashers, clothes washers and clothes dryers result in decreased electricity use and, therefore, reduced power plant emissions. The proposed efficiency standards will decrease air pollution by decreasing future energy demand. The greatest decreases in air pollution will be in sulfur oxides (listed in equivalent weight of sulfur dioxide, or SO_2). Some design options for dishwashers also reduce water consumption, resulting in lower in-house emissions from fuel-burning water heaters.

Although the quantity of raw materials used per appliance will remain relatively constant, in most scenarios increased initial cost is expected to slightly decrease the number of appliances sold, resulting in small decreases in raw materials used. This demand decrease is estimated by the Consumer Impact Analysis in the TSD. The main effect of decreased appliance production is the

SO_2 emitted in steel production. The decrease is small, however, in comparison to the SO_2 decreases from fuel burning avoided at power plants. The contribution from steel production is not included in the estimates for net SO_2 decreases resulting from design changes in these three products.

The design changes are described fully in the Technical Support Document. For dishwashers, the design changes analyzed are: improved food filter, improved motor efficiency, and improved fill control. For clothes washers, the design changes are: eliminate warm rinse, thermostatic mixing valves, improved motor efficiency, and plastic tub. For clothes dryers, the design changes are: temperature termination, moisture termination, recycle exhaust, and insulation.

When the most efficient scenarios for each product are combined, the maximum decrease of SO_2 emissions is 0.45% of SO_2 in the U.S. power plant emissions for the year 2005. That represents a total of 77,000 tons of SO_2 abated for that year, 54% coming from the clothes dryers standard (level 4), 31% from the clothes washers standard (level 4) and 15% from the dishwashers standard (level 3).

Combining the most efficient scenarios of each product, the maximum decrease in NO_2 emissions is equal to 0.54% of the U.S. power plant emissions for the year 2005. This represents 51,000 tons of NO_2 abated for that year, 52% coming from the clothes dryers standard level 4, 33% from the clothes washers standard level 4 and 15% from the dishwashers standard level 3.

Another consequence of the candidate standards would be a reduction of carbon dioxide (CO_2) emissions. CO_2 from fossil fuel burning is considered an environmental hazard because it contributes to the "greenhouse effect" by trapping heat from the sun that has been absorbed by the Earth and emitted as infrared radiation. This "greenhouse effect" is expected gradually to raise the mean global temperature. Combining the most energy efficient scenarios for each of the three products, results in a total reduction of CO_2 in 2005 of 4,800 thousand tons of carbon, which represents 0.28% of the projected total U.S. emissions for that year.

Other environmental effects, such as effects on particulate emissions, related to a standards-induced decrease in electricity generation would be minor compared to effects on decreases in SO_2, NO_2, and CO_2. For example, in 1984, power plants contributed only 7% of U.S. total particulate emissions as compared to contributions of 83% and 34% to total SO_2 and NO_2 emissions, respectively (3).

Reduced hot water use will decrease the amount of gas or oil burned within some homes, thereby decreasing combustion effects on indoor air quality. Indoor air problems are usually due to a combination of factors, including a tight house envelope, insufficient ventilation for cooking appliances, presence of sources such as cigarette smokers or formaldehyde containing products, and radon diffusion from soil. In comparison to the above factors, and because fuel-burning water heaters are normally vented to the outside, the projected changes in water heater use have little effect on indoor air quality.

2 METHODS OF ESTIMATING ENVIRONMENTAL IMPACTS

The greatest impacts of the proposed standards would be the result of generating less electricity. The main environmental effects of power plants on air and water quality result from emissions of sulfur oxides (SO_x), nitrogen oxides (NO_x), and carbon dioxide (CO_2). The symbols SO_2 and NO_2 represent all emissions of SO_x and NO_x expressed in the equivalent weights of SO_2 and NO_2, respectively. Carbon dioxide emissions are commonly expressed in tons of carbon. A second source of these pollutants is fuel-burning household water heaters. The proposed standards would also reduce these emissions. Since water heaters are normally vented to the outside, the sum of the power plant and in-house emissions are reported. Furthermore, reduced water consumption for dishwashers will result in a lower volume of waste water to be treated and in a reduced need for fresh water.

Table 3.1 U.S. CO_2, SO_2 and NO_2 Emissions

Year	CO_2 US Emissions 10^6 Tons	SO_2 US Power Plant Emissions 10^6 Tons	NO_2 US Power Plant Emissions 10^6 Tons
1995	1600	17.25	8.25
2000	1680	18.00	8.79
2005	1750	17.50	9.62
2010	1820	17.10	10.24
2015	1900	16.13	10.65

The estimates of emissions of SO_2 and NO_2 are also expressed as a percentage of U.S. power plant emission for the year under consideration. The estimates of emissions of CO_2 are expressed as a percentage of U.S. total emission. Table 3.1 summarizes the U.S. emissions for the three compounds (4).

2.1 Sulfur and Nitrogen Oxide Emissions

For each of the scenarios analyzed, emissions abated from fossil fuel-burning power plants are estimated. In analyzing the impacts of design changes to dishwashers, clothes washers and dryers, lower sulfur emissions resulting from decreased steel production are not considered. As mentioned earlier in this report, these decreases in steel production result from a reduction in the number of appliances sold. No changes in the amount of steel used per unit are expected. Analysis of the impacts resulting from several design options for dishwashers, clothes washers and dryers includes the consideration of SO_2, NO_2 and CO_2 from in-home combustion of gas and oil.

Estimates of energy saved by reduced electricity generation are taken from the TSD. Primary energy saved from electricity generation at the margin is allocated among the categories of coal on the one hand, and gas plus oil on the other, by the ratios of 0.53 and 0.47, respectively, as estimated in supporting material for the Electric Utility Analysis, also in the TSD. This disaggregation into coal and oil-plus-gas is depicted in Figure 1 for dishwashers. In order to capture the effects of cleaner-burning power plants in future years, emission rates for power plant fuel burning are calculated from projected emissions data and the projected quantities of the corresponding fuels used, as described in a report by Placet, *et al.* Gas and oil are combined because, from an electric utility perspective, they are often interchangeable. Linear interpolation and extrapolation are used to derive emissions rates for years not covered in the report.

The values for reduction of SO_2 and NO_2 emissions from in-home gas and oil combustion are produced by multiplying in-home fuel savings for gas and oil by the corresponding emission rates. Emissions factors for water heaters were only available for natural gas (5). For oil-fired water heaters, the oil-fired space heater emission factors were used as default values (6). All of these emission factors are consistent with theoretical emission factors from another source (7).

2.2 Carbon Dioxide Emissions

Values for CO_2 abated are the sum of the CO_2 savings from coal-, gas-, and oil-fired power plants and, for dishwashers and clothes washers, the CO_2 emissions from in-home combustion of gas and oil. The energy saved from electricity generation is apportioned between coal and gas or oil as in the calculation of SO_2 and NO_2 emissions. In addition, gas and oil are disaggregated into relative shares of 0.70 and 0.30, respectively. These shares are the averages of the relative quantities of these fuels to be used for electricity generation in the years 1990 through 1995, as estimated by the North American Electric Reliability Council (8). The energy values of the fuels saved are translated into tons of carbon using carbon/Btu values from the *Carbon Dioxide Review* (9). The data for a more accurate method of estimating relative gas and oil shares concerning order of dispatch in the various NERC regions are not available. This disaggregation into fuel shares should therefore be taken only as a rough representation of power plant fuel choices on the margin.

3 RESULTS

3.1 DISHWASHERS

Decreases in the amounts of CO_2, SO_2 and NO_2 emitted at trial standards levels 1 through 3 are summarized in Tables 3.2 through 3.4. The figures in the tables include reductions in emissions from in-house water heaters.

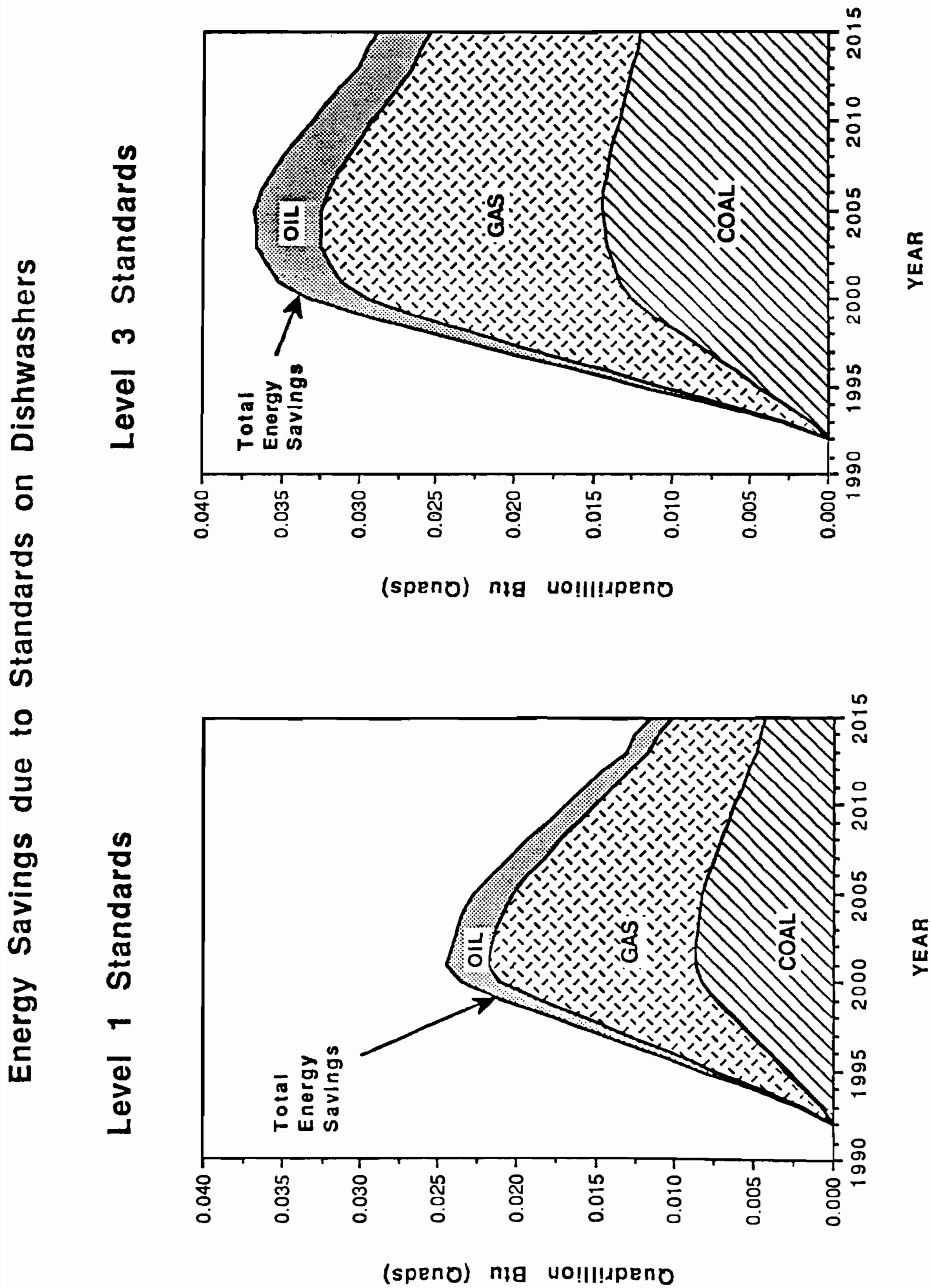

Figure 1. Electricity Savings Due to Standards on Dishwashers

Table 3.2 Reduction of Pollutants for Dishwashers Level 1

CO_2 Reduction (10^3 Tons of Carbon)

Year	Abated from Coal Use	Abated from Gas Use	Abated from Oil Use	Net Change	Percent of US Emissions
1995	83	73	18	174	0.01%
2000	234	203	52	489	0.03%
2005	230	191	51	472	0.03%
2010	174	140	36	350	0.02%
2015	122	95	26	243	0.01%

Cumulative CO_2 reduction, 1993-2015 = 8,023 thousand tons of C

SO_2 Reduction (Tons of SO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US SO_2 Power Plant Emissions
1995	2496	399	2896	0.02%
2000	6473	1125	7599	0.04%
2005	5412	1177	6590	0.04%
2010	3610	833	4442	0.03%
2015	2218	567	2785	0.02%

Cumulative SO_2 reduction, 1993-2015 = 113,561 tons

NO_2 Reduction (Tons of NO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US NO_2 Power Plant Emissions
1995	1129	643	1772	0.02%
2000	3091	1809	4900	0.06%
2005	2883	1751	4634	0.05%
2010	2129	1170	3299	0.03%
2015	1447	828	2276	0.02%

Cumulative NO_2 reduction, 1993-2015 = 78,505 tons

Table 3.3 Reduction of Pollutants for Dishwashers Level 2

CO_2 Reduction (10^3 Tons of Carbon)

Year	Abated from Coal Use	Abated from Gas Use	Abated from Oil Use	Net Change	Percent of US Emissions
1995	106	83	23	212	0.01%
2000	302	228	65	595	0.04%
2005	329	229	70	628	0.04%
2010	287	184	60	531	0.03%
2015	243	144	49	437	0.02%

Cumulative CO_2 reduction, 1993-2015 = 10,997 thousand tons of C

SO_2 Reduction (Tons of SO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US SO_2 Power Plant Emissions
1995	3210	511	3720	0.02%
2000	8346	1442	9788	0.05%
2005	7737	1669	9406	0.05%
2010	5965	1379	7344	0.04%
2015	4409	1117	5526	0.03%

Cumulative SO_2 reduction, 1993-2015 = 165,308 tons

NO_2 Reduction (Tons of NO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US NO_2 Power Plant Emissions
1995	1452	778	2230	0.03%
2000	3985	2185	6171	0.07%
2005	4121	2307	6427	0.07%
2010	3519	1725	5244	0.05%
2015	2877	1449	4326	0.04%

Cumulative NO_2 reduction, 1993-2015 = 111,897 tons

Table 3.4 Reduction of Pollutants for Dishwashers Level 3

CO_2 Reduction (10^3 Tons of Carbon)

Year	Abated from Coal Use	Abated from Gas Use	Abated from Oil Use	Net Change	Percent of US Emissions
1995	124	97	26	247	0.02%
2000	351	271	74	696	0.04%
2005	401	290	86	777	0.04%
2010	373	255	77	704	0.04%
2015	334	215	69	619	0.03%

Cumulative CO_2 reduction, 1993-2015 = 13,832 thousand tons of C

SO_2 Reduction (Tons of SO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US SO_2 Power Plant Emissions
1995	3745	594	4339	0.03%
2000	9689	1669	11359	0.06%
2005	9437	2040	11477	0.07%
2010	7739	1784	9523	0.06%
2015	6065	1544	7609	0.05%

Cumulative SO_2 reduction, 1993-2015 = 203,500 tons

NO_2 Reduction (Tons of NO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US NO_2 Power Plant Emissions
1995	1694	909	2603	0.03%
2000	4627	2562	7189	0.08%
2005	5026	2862	7888	0.08%
2010	4566	2304	6869	0.07%
2015	3958	2069	6027	0.06%

Cumulative NO_2 reduction, 1993-2015 = 139,243 tons

3.1.1 Sulfur and Nitrogen Oxide Emissions

Sulfur dioxide emissions would be decreased by a cumulative total of 203,500 tons between 1993 and 2015 in the Level 3 scenario. In the year 1995, decreases in sulfur dioxide represent roughly 0.03% of the SO_2 emissions estimated to come from power plants in that year. In the year 2005, decreases in SO_2 emissions represent about 0.07% of the SO_2 emissions estimated to come from power plants in that year if standards are not established. The savings peak around 2005 then decrease as the existing stocks of dishwashers turns over.

Level 3 design changes to dishwashers would result in an estimated decrease in NO_2 emissions of 139,000 tons between 1993 and 2015. NO_2 decreases would represent 0.03% and 0.08% of the NO_2 emissions estimated to come from power plants in the years 1995 and 2005, respectively.

3.1.2 Carbon Dioxide Emissions

The cumulative reduction in CO_2 emissions from Level 3 design changes is 14,000 thousand tons of carbon. For the year 2005, the estimated CO_2 reduction is 777 thousand tons of carbon or about 0.05% of estimated U.S. total CO_2 emissions for 2005.

3.1.3 Water Savings

The new dishwasher standards would also save water. The following table summarizes the cumulative amount of water (in 10^9 gallons) consumed at each design level during the period 1993-2015.

		Standard Level		
	Baseline	1	2	3
Water Consumed	3086	2889	2882	2810
Water Saved		197	204	276

Level 1, improved food filter, has the highest water savings potential. Level 2, improved motor efficiency, has no direct potential for additional water reduction. The decrease shown in the table corresponds to a lower number of appliances sold under this scenario. Level 3 shows water use savings from the use of an improved fill control.

3.2 CLOTHES WASHERS

Decreases in the amounts of CO_2, SO_2 and NO_2 emitted at trial standards levels 1 through 4 are summarized in Tables 3.5 through 3.8

3.2.1 Sulfur and Nitrogen Oxide Emissions

Sulfur dioxide emissions would be decreased by a cumulative total of 434,000 tons between 1993 and 2015 in the Level 4 scenario. In the year 1995, decreases in sulfur dioxide will represent about 0.05% of the SO_2 emissions estimated to come from power plants in that year. In the year 2005, decreases in SO_2 emissions will represent about 0.14% of the SO_2 emissions estimated to come from power plants in that year if standards are not established.

Level 4 design changes to clothes washers would result in an estimated decrease in NO_2 emissions of 305,000 tons between 1993 and 2015. NO_2 decreases would represent 0.07% and 0.18% of the NO_2 emissions estimated to come from power plants in the years 1995 and 2005, respectively.

3.2.2 Carbon Dioxide Emissions

The cumulative reduction in CO_2 emissions from Level 4 design changes is 31,000 thousands tons of carbon. For the year 2005, the estimated CO_2 reduction is 1700 thousands tons of carbon or about 0.10% of estimated U.S. total CO_2 emissions in 2005.

Table 3.5 Reduction of Pollutants for Clothes Washers Level 1

CO_2 Reduction (10^3 Tons of Carbon)

Year	Abated from Coal Use	Abated from Gas Use	Abated from Oil Use	Net Change	Percent of US Emissions
1995	125	129	30	284	0.02%
2000	323	316	73	712	0.04%
2005	377	353	84	814	0.05%
2010	349	311	76	736	0.04%
2015	290	246	65	601	0.03%

Cumulative CO_2 reduction, 1993-2015 = 14,454 thousand tons of C

SO_2 Reduction (Tons of SO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US SO_2 Power Plant Emissions
1995	3789	621	4411	0.03%
2000	8916	1559	10475	0.06%
2005	8882	1933	10815	0.06%
2010	7250	1693	8943	0.05%
2015	5264	1363	6627	0.04%

Cumulative SO_2 reduction, 1993-2015 = 191,612 tons

NO_2 Reduction (Tons of NO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US NO_2 Power Plant Emissions
1995	1714	1060	2774	0.03%
2000	4258	2658	6915	0.08%
2005	4731	3046	7776	0.08%
2010	4277	2483	6759	0.07%
2015	3435	2066	5501	0.05%

Cumulative NO_2 reduction, 1993-2015 = 136,944 tons

Table 3.6 Reduction of Pollutants for Clothes Washers Level 2

CO_2 Reduction (10^3 Tons of Carbon)

Year	Abated from Coal Use	Abated from Gas Use	Abated from Oil Use	Net Change	Percent of US Emissions
1995	199	205	47	451	0.03%
2000	523	513	118	1154	0.07%
2005	639	596	143	1378	0.08%
2010	628	558	139	1324	0.07%
2015	560	474	123	1157	0.06%

Cumulative CO_2 reduction, 1993-2015 = 24,864 thousand tons of C

SO_2 Reduction (Tons of SO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US SO_2 Power Plant Emissions
1995	6018	979	6998	0.04%
2000	14453	2527	16979	0.09%
2005	15057	3283	18340	0.10%
2010	13031	3051	16083	0.09%
2015	10154	2622	12776	0.08%

Cumulative SO_2 reduction, 1993-2015 = 327,954 tons

NO_2 Reduction (Tons of NO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US NO_2 Power Plant Emissions
1995	2722	1683	4405	0.05%
2000	6902	4310	11212	0.13%
2005	8020	5155	13175	0.14%
2010	7687	4463	12150	0.12%
2015	6626	3977	10603	0.10%

Cumulative NO_2 reduction, 1993-2015 = 235,312 tons

Table 3.7 Reduction of Pollutants for Clothes Washers Level 3

CO_2 Reduction (10^3 Tons of Carbon)

Year	Abated from Coal Use	Abated from Gas Use	Abated from Oil Use	Net Change	Percent of US Emissions
1995	237	222	54	513	0.03%
2000	625	557	138	1320	0.08%
2005	775	652	169	1596	0.09%
2010	766	613	166	1545	0.08%
2015	691	528	149	1368	0.07%

Cumulative CO_2 reduction, 1993-2015 = 28,813 thousand tons of C

SO_2 Reduction (Tons of SO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US SO_2 Power Plant Emissions
1995	7177	1160	8337	0.05%
2000	17262	3002	20263	0.11%
2005	18249	3959	22208	0.13%
2010	15907	3706	19613	0.11%
2015	12532	3219	15751	0.10%

Cumulative SO_2 reduction, 1993-2015 = 396,498 tons

NO_2 Reduction (Tons of NO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US NO_2 Power Plant Emissions
1995	3246	1905	5152	0.06%
2000	8243	4899	13142	0.15%
2005	9720	5933	15653	0.16%
2010	9384	5146	14529	0.14%
2015	8178	4654	12832	0.12%

Cumulative NO_2 reduction, 1993-2015 = 279,400 tons

Table 3.8 Reduction of Pollutants for Clothes Washers Level 4

CO_2 Reduction (10^3 Tons of Carbon)

Year	Abated from Coal Use	Abated from Gas Use	Abated from Oil Use	Net Change	Percent of US Emissions
1995	258	234	58	550	0.03%
2000	682	590	149	1422	0.08%
2005	849	696	184	1728	0.10%
2010	841	656	180	1677	0.09%
2015	762	566	163	1491	0.08%

Cumulative CO_2 reduction, 1993-2015 = 31,205 thousand tons of C

SO_2 Reduction (Tons of SO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US SO_2 Power Plant Emissions
1995	7801	1257	9059	0.05%
2000	18849	3270	22119	0.12%
2005	19984	4326	24310	0.14%
2010	17467	4061	21528	0.13%
2015	13814	3541	17355	0.11%

Cumulative SO_2 reduction, 1993-2015 = 434,353 tons

NO_2 Reduction (Tons of NO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US NO_2 Power Plant Emissions
1995	3529	2038	5567	0.07%
2000	9001	5268	14269	0.16%
2005	10644	6414	17058	0.18%
2010	10304	5571	15875	0.16%
2015	9015	5057	14072	0.13%

Cumulative NO_2 reduction, 1993-2015 = 304,640 tons

3.3 CLOTHES DRYERS

Decreases in the amounts of CO_2, SO_2 and NO_2 emitted at trial standards levels 1 through 4 are summarized in Tables 3.9 through 3.12.

3.3.1 Sulfur and Nitrogen Oxide Emissions

Sulfur dioxide emissions would be decreased by a cumulative total of 694,000 tons between 1993 and 2015 in the Level 4 scenario. In the year 1995, decreases in sulfur dioxide will represent about 0.07% of the SO_2 emissions estimated to come from power plants in that year. In the year 2005, decreases in SO_2 emissions will represent about 0.24% of the SO_2 emissions estimated to come from power plants in that year if standards are not established.

Level 4 design changes to clothes dryers would result in an estimated decrease in NO_2 emissions of 446,000 tons between 1993 and 2015. NO_2 decreases would represent 0.08% and 0.28% of the NO_2 emissions estimated to come from power plants in the years 1995 and 2005, respectively.

3.3.2 Carbon Dioxide Emissions

The cumulative reduction in CO_2 emissions from Level 4 design changes is 40,000 thousands tons of carbon. For the year 2010, the estimated CO_2 reduction is 2400 thousands tons of carbon or about 0.13% of estimated total U.S. CO_2 emissions.

Table 3.9 Reduction of Pollutants for Clothes Dryers Level 1

CO_2 Reduction (10^3 Tons of CO_2)

Year	Abated from Coal Use	Abated from Gas Use	Abated from Oil Use	Net Change	Percent of US Emissions
1995	102	42	20	164	0.01%
2000	302	110	59	471	0.03%
2005	483	170	94	747	0.04%
2010	414	144	81	638	0.04%
2015	287	99	56	442	0.02%

Cumulative CO_2 reduction, 1993-2015 = 11,360 thousand tons of C

SO_2 Reduction (Tons of SO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US SO_2 Power Plant Emissions
1995	3076	479	3555	0.02%
2000	8346	1410	9756	0.05%
2005	11380	2409	13789	0.08%
2010	8596	1957	10552	0.06%
2015	5210	1307	6518	0.04%

Cumulative SO_2 reduction, 1993-2015 = 205,905 tons

NO_2 Reduction (Tons of NO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US NO_2 Power Plant Emissions
1995	1391	569	1960	0.02%
2000	3985	1653	5638	0.06%
2005	6061	2646	8707	0.09%
2010	5071	1949	7020	0.07%
2015	3400	1400	4800	0.05%

Cumulative NO_2 reduction, 1993-2015 = 130,146 tons

Table 3.10 Reduction of Pollutants for Clothes Dryers Level 2

CO_2 Reduction (10^3 Tons of CO_2)

Year	Abated from Coal Use	Abated from Gas Use	Abated from Oil Use	Net Change	Percent of US Emissions
1995	178	74	35	287	0.02%
2000	527	193	103	824	0.05%
2005	844	298	165	1307	0.07%
2010	723	252	141	1116	0.06%
2015	502	173	98	774	0.04%

Cumulative CO_2 reduction, 1993-2015 = 19,867 thousand tons of C

SO_2 Reduction (Tons of SO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US SO_2 Power Plant Emissions
1995	5394	840	6234	0.04%
2000	14575	2462	17037	0.09%
2005	19880	4208	24088	0.14%
2010	15020	3419	18438	0.11%
2015	9112	2286	11398	0.07%

Cumulative SO_2 reduction, 1993-2015 = 359,843 tons

NO_2 Reduction (Tons of NO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US NO_2 Power Plant Emissions
1995	2440	997	3437	0.04%
2000	6960	2889	9848	0.11%
2005	10588	4625	15213	0.16%
2010	8860	3407	12267	0.12%
2015	5946	2450	8396	0.08%

Cumulative NO_2 reduction, 1993-2015 = 227,482 tons

Table 3.11 Reduction of Pollutants for Clothes Dryers Level 3

CO_2 Reduction (10^3 Tons of CO_2)

Year	Abated from Coal Use	Abated from Gas Use	Abated from Oil Use	Net Change	Percent of US Emissions
1995	211	89	41	341	0.02%
2000	617	235	120	973	0.06%
2005	984	362	192	1538	0.09%
2010	900	334	175	1409	0.08%
2015	701	265	137	1103	0.06%

Cumulative CO_2 reduction, 1993-2015 = 24,455 thousand tons of C

SO_2 Reduction (Tons of SO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US SO_2 Power Plant Emissions
1995	6375	993	7368	0.04%
2000	17058	2882	19940	0.11%
2005	23176	4906	28082	0.16%
2010	18690	4255	22945	0.13%
2015	12719	3192	15911	0.10%

Cumulative SO_2 reduction, 1993-2015 = 435,674 tons

NO_2 Reduction (Tons of NO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US NO_2 Power Plant Emissions
1995	2883	1181	4065	0.05%
2000	8146	3402	11548	0.13%
2005	12344	5428	17772	0.18%
2010	11026	4290	15316	0.15%
2015	8300	3477	11777	0.11%

Cumulative NO_2 reduction, 1993-2015 = 277,029 tons

Table 3.12 Reduction of Pollutants for Clothes Dryers Level 4

CO_2 Reduction (10^3 Tons of CO_2)

Year	Abated from Coal Use	Abated from Gas Use	Abated from Oil Use	Net Change	Percent of US Emissions
1995	324	140	63	528	0.03%
2000	927	375	181	1482	0.09%
2005	1460	577	285	2322	0.13%
2010	1500	605	292	2398	0.13%
2015	1373	570	268	2211	0.12%

Cumulative CO_2 reduction, 1993-2015 = 40,018 thousand tons of C

SO_2 Reduction (Tons of SO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US SO_2 Power Plant Emissions
1995	9807	1528	11335	0.07%
2000	25608	4327	29935	0.17%
2005	34382	7279	41661	0.24%
2010	31140	7089	38230	0.22%
2015	24903	6250	31154	0.19%

Cumulative SO_2 reduction, 1993-2015 = 693,956 tons

NO_2 Reduction (Tons of NO_2)

Year	Abated from Coal Use	Abated from Gas/Oil Use	Net Change	Percent of US NO_2 Power Plant Emissions
1995	4436	1826	6262	0.08%
2000	12228	5162	17391	0.20%
2005	18312	8152	26464	0.28%
2010	18370	7270	25641	0.25%
2015	16251	6935	23186	0.22%

Cumulative NO_2 reduction, 1993-2015 = 445,541 tons

4 EVALUATION OF ENVIRONMENTAL IMPACTS

4.1 Effects of Acid Precipitation

Sulfur dioxide is the major contributor to acid precipitation in the U.S. After a series of reactions with atmospheric gases and water, SO_2 forms sulfuric acid. More than half of the domestic SO_2 emitted as a result of human activities comes from coal burned in power plants. The next greatest contributor to acid precipitation is nitrogen dioxide. One-third of the domestic NO_2 emitted from human activities comes from electricity generating facilities (4).

Attaching values to incremental changes in acid precipitation is difficult. The effects of acid deposition on a given lake or forest depend on a variety of factors, including distance from pollutant source, buffering capacity, surrounding topography, rate of snow melt, soil or sediment type, etc. Acid precipitation can have negligible effects in buffered natural systems—those containing substances that take up or react with acids—until the buffering capacity is used up. Continued acid precipitation brings water and forest ecosystems closer to their buffering capacity limits, which can greatly affect living systems. Allowing a body of water to return to its natural state of alkalinity (buffering capacity) may require tens to thousands of years. In attempting to quantify the effects of acid precipitation, it is therefore important to consider cumulative effects that may not currently be obvious.

Some effects on humans resulting from adding acid to ecosystems are: decreases in fishing productivity, forest productivity, farming productivity, recreational opportunities, and the degradation of susceptible buildings and monuments.

The impacts of implementing any of the candidate standards on the abatement of SO_2 and NO_2 would be relatively small (10). Implementing the most efficient standards for each product would reduce, between 1993 and 2015, 0.33% and 0.42% of cumulative U.S. power plant emissions of SO_2 and NO_2, respectively. In the year of highest abatement, 2005, such standards would reduce U.S. SO_2 and NO_2 power plant emissions by 0.45% and 0.54%, respectively. This is not considered significant in the context of total SO_2 and NO_2 emissions, and would not have a significant impact on acid rain precipitation.

4.2 Perspectives on Changes in Carbon Dioxide Emissions

Atmospheric CO_2 is relatively transparent to incoming solar energy (short-wave radiation) but impedes outgoing solar energy, which is in the form of heat (long-wave radiation). The net result of elevated CO_2 concentrations is a trapping of heat near the Earth's surface. This trapping of heat, referred to as the "greenhouse effect", raises the mean global temperature. Because of human activity, the CO_2 concentrations in the atmosphere have increased from 290 parts per million (ppm) before the industrial era to about 345 ppm in 1985 (11). Expected results of a global temperature change are: perturbed air and ocean currents, perturbed precipitation patterns, changes in the gaseous equilibrium between the atmosphere and the biosphere, and the melting of some of the ice now covering polar lands and oceans followed by a rise in sea level (12).

A doubling of the pre-industrial levels of CO_2 is projected to occur in the late part of the next century (11). The process of controlling CO_2 concentrations is dependent on two factors: lead times involved in changing current trends in fossil fuel use and lag times in environmental systems. If the goal were to keep CO_2 concentrations from exceeding 500 ppm, even a growth rate in fossil fuel use of 1.5% per year (compared to a growth rate of 2.3% in 1980) could not continue much beyond the end of this century (9).

The impacts of implementing any of the candidate standards on the abatement of CO_2 would be relatively small. Implementing the most efficient standards for each product would reduce, between 1993 and 2015, 0.21% of cumulative U.S. emissions of CO_2. In the year of highest abatement, 2005, such standards would reduce U.S. CO_2 emissions by 0.28%. This is not considered significant in the context of total CO_2 emissions, and would not have a significant impact on global warming.

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