APPENDIX D. ENVIRONMENTAL ANALYSIS FOR FLUORESCENT LAMP BALLASTS

D.1 SUMMARY

The fluorescent ballast environmental analysis uses a variant of the Energy Information Administration (EIA) National Energy Modeling System (NEMS), plus some minor additional analysis. The environmental analysis is similar to the power sector analysis described in Chapter 7 of the TSD.[1] Outputs of the environmental analysis are in a format similar to the results of the EIA's Annual Energy Outlook for 1999 (AEO99).

D.2 PURPOSE OF THE ANALYSIS

The environmental analysis is intended to provide information about the effect that new ballast standards would have on pollutant and other emissions, fulfilling the requirement that the environmental effects of all new federal rules be properly quantified and considered. For each of the standard levels, total emissions are calculated using NEMS-BRS.[2] The environmental analysis considers only one pollutant, NO_x, and one emission, carbon. Because emissions of SO_2 are subject to caps imposed by clean air legislation, physical emissions of this pollutant will be only minimally affected by possible appliance standards. It appears from trial simulation that reporting of changes in allowance prices and banking behavior for SO_2 does not provide useful information because the energy savings from ballast standards are so small that the effects can not be detected.

D.3 ASSUMPTIONS

The environmental analysis uses the same basic assumptions as the AEO99 and changes resulting from standards are modeled as deviations from current policy. For example, the emissions characteristics of an electricity generating plant in the environmental analysis are the same as those used in AEO99, but the fuel mix used for generation and the construction program for new plants may change slightly as a result of reduced generation requirements under the standard; this, in turn, affects pollution results. As with the power sector analysis in Chapter 7, effects are assumed to be linear in the range of the energy reductions from standards and results are extrapolated.

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[1] For further explanation about NEMS, please refer to the U.S. Department of Energy, Energy Information Administration. *National Energy Model System: An Overview 1998.* DOE/EIA-0581(98), February 1998.

[2] EIA approves use of the name *NEMS* to describe only an AEO version of the model without any modification to code or data. Because our analysis entails some minor code modifications, and the model is run under various policy scenarios that deviate from AEO assumptions, the Department refers to the model as used here as NEMS-BRS.

D.4 METHODS

Carbon emissions are tracked in NEMS-BRS by a detailed carbon module that provides good results because it covers all sectors of the economy and their interactions . Past experience with carbon results from NEMS suggests it produces emissions estimates that are somewhat lower than emissions based on simple average factors for two reasons. First, the marginal fuel displaced by reduced generation tends to be natural gas, the combustion of which emits less carbon than coal combustion. Secondly, lowered electricity demand tends to slow down construction of power generation capacity, thereby slowing the improvement in energy conversion efficiency and emissions rates that typically result from deployment of new generating technologies. NO_x results are based on forecasts of compliance with existing legislation and have proven stable and reasonable.

The two airborne pollutant emissions that have been reported in past analyses, NO_x and SO_2, are reported by NEMS-BRS. The Clean Air Act Amendments of 1990 set an SO_2 emissions cap on all power generation. The attainment of this target is flexible among generators, however, and is enforced by applying market forces through the use of emissions allowances and tradable permits. SO_2 trading makes it likely that physical emissions effects will be virtually zero because emissions will always be at or near the ceiling. This fact has caused considerable confusion in the past. There is virtually no real possible SO_2 environmental benefit from conservation as long as there is enforcement through emissions ceilings. A tiny economic benefit can be inferred only if coal generation falls and the reduced demand for SO_2 emission allowances lowers the allowance price. Because the effects considered here are too small to deliver reasonable estimates, we do not consider this possibility.

Because the size of the energy reductions from standards are too small to produce stable results in NEMS-BRS, it has been necessary to estimate results in the range of the standard levels effects using extrapolation. Reductions to the Commercial Demand Module lighting load were implemented at levels of approximate 2.96, 5.92, 11.83, and 17.75 times the level of the most extreme standard, 2b. They were chosen to be roughly equivalent to 50, 100, 200, and 300 TWh, respectively, in the peak year of the standard. This process was carried out separately for the a and b cases; the a cases are modeled on standard 2a .

Figure D-1 shows an example of the extrapolation for NO_x emissions rates. In this case, marginal rates for NO_x emissions are shown for each year. Note that the marginal emissions rates incorporate both effects of the standards: the emissions saved by the reduction in total generation and the slight change in the emissions characteristics of the whole power sector that result from the slight change in dispatch and capacity expansion plan. The net effect on the entire system is very small and, typically, the overall effect on emissions can be fully attributed to the decrease in generation. In Figure D-1, the effect of statistical noise is clear. With small decreases in demand, the emissions rate is quite variable. The dashed plots (years 2003 to 2010) show the earlier years of the imposed standard, in which the demand reductions are smallest. In most cases, these curves are so close to flat that regression of the points out of the noisy range gives a curve very close to the simple average of values. Therefore, the constant emission rates when the decrease in demand is larger are assumed to hold in the range of the small reductions for the various standards, and the implied marginal emission rates are used to estimate emissions reductions. The marginal emission rates are derived by averaging the marginal rates of the three largest reductions (100, 200, and 300 TWh).

D.5 RESULTS

As described above, the results for the environmental analysis are comparable to a complete NEMS-BRS run. Although energy savings from the proposed appliance standards continue through 2030, the effects of these savings are reported through 2020 because this is the time horizon of NEMS-BRS. Total carbon and NO_x emissions for each of the 12 possible standards are reported in Tables D-1 and D-2. The annual carbon emission reductions range up to 2.3 Mt in 2020 and the NO_x emissions reductions up to 5.7 kt in 2015.[3, 4]

[3]million metric tons (Mt)

[4]thousand metric tons (kt)

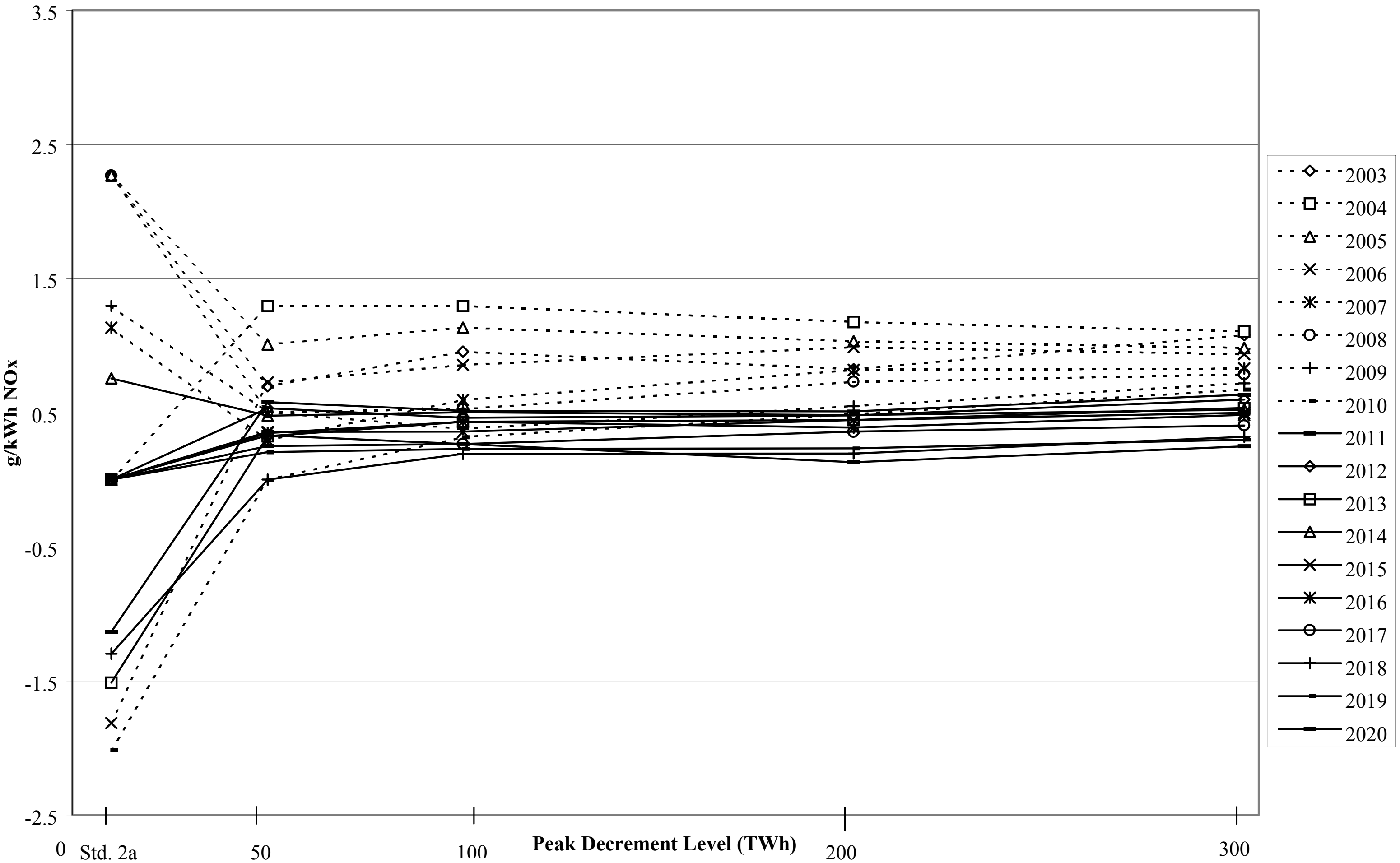

Figure D-1. Standard Level 2a Marginal NOx Emissions

Table D-1. Power Sector Emissions: Standards Level A Cases

NEMS-NAECA Results						Difference from AEO99 Reference					
	2000	2005	2010	2015	2020		2000	2005	2010	2015	2020
AEO99 Reference											
Carbon (Mt/a)[1,3]	588.9	612.9	653.2	704.6	744.6						
NOx (kt/a)[2,3]	4,191.2	3,547.1	3,665.0	3,819.2	3,882.8						
Standards Level 1a											
Carbon (Mt/a)	588.9	612.5	652.5	703.8	743.9	Carbon (Mt/a)	0.0	-0.4	-0.7	-0.8	-0.7
NOx (kt/a)	4,191.2	3,544.7	3,662.5	3,816.6	3,881.8	NOx (kt/a)	0.0	-2.4	-2.5	-2.7	-0.9
Standards Level 2a											
Carbon (Mt/a)	588.9	612.2	652.1	703.2	743.4	Carbon (Mt/a)	0.0	-0.7	-1.1	-1.4	-1.2
NOx (kt/a)	4,191.2	3,543.2	3,660.9	3,814.9	3,881.2	NOx (kt/a)	0.0	-3.9	-4.1	-4.4	-1.5
Standards Level 3a											
Carbon (Mt/a)	588.9	612.3	652.3	703.4	743.6	Carbon (Mt/a)	0.0	-0.6	-0.9	-1.2	-1.0
NOx (kt/a)	4,191.2	3,543.8	3,661.6	3,815.5	3,881.5	NOx (kt/a)	0.0	-3.3	-3.5	-3.7	-1.3
Standards Level 4a											
Carbon (Mt/a)	588.9	612.3	652.2	703.3	743.5	Carbon (Mt/a)	0.0	-0.6	-1.0	-1.3	-1.1
NOx (kt/a)	4,191.2	3,543.5	3,661.2	3,815.1	3,881.3	NOx (kt/a)	0.0	-3.6	-3.8	-4.1	-1.4
Standards Level 5a											
Carbon (Mt/a)	588.9	612.7	652.9	704.2	744.3	Carbon (Mt/a)	0.0	-0.2	-0.3	-0.4	-0.3
NOx (kt/a)	4,191.2	3,546.0	3,663.8	3,818.0	3,882.3	NOx (kt/a)	0.0	-1.1	-1.2	-1.3	-0.4
Standards Level 6a											
Carbon (Mt/a)	588.9	612.4	652.5	703.7	743.8	Carbon (Mt/a)	0.0	-0.5	-0.7	-0.9	-0.8
NOx (kt/a)	4,191.2	3,544.5	3,662.3	3,816.3	3,881.7	NOx (kt/a)	0.0	-2.6	-2.8	-3.0	-1.0

[1]Comparable to Table A17 of AEO99: Electric Generators

[2]Comparable to Table A8 of AEO99: Emissions

[3]All results in metric tons (t), equivalent to 1.1 short tons

Table D-2. Power Sector Emissions: Standards Level B Cases

NEMS-NAECA Results	2000	2005	2010	2015	2020	Difference from AEO99 Reference	2000	2005	2010	2015	2020
AEO99 Reference											
Carbon (Mt/a)	588.9	612.9	653.2	704.6	744.6						
NOx (kt/a)	4,191.2	3,547.1	3,665.0	3,819.2	3,882.8						
Standards Level 1b											
Carbon (Mt/a)	588.9	612.4	652.4	703.3	743.2	Carbon (Mt/a)	0.0	-0.5	-0.8	-1.3	-1.4
NOx (kt/a)	4,191.2	3,544.2	3,662.1	3,815.2	3,880.5	NOx (kt/a)	0.0	-2.9	-2.9	-4.1	-2.2
Standards Level 2b											
Carbon (Mt/a)	588.9	612.1	651.8	702.5	742.3	Carbon (Mt/a)	0.0	-0.8	-1.4	-2.1	-2.3
NOx (kt/a)	4,191.2	3,542.4	3,660.3	3,812.6	3,879.1	NOx (kt/a)	0.0	-4.7	-4.7	-6.6	-3.6
Standards Level 3b											
Carbon (Mt/a)	588.9	612.2	652.0	702.7	742.6	Carbon (Mt/a)	0.0	-0.7	-1.2	-1.9	-2.0
NOx (kt/a)	4,191.2	3,542.9	3,660.8	3,813.3	3,879.5	NOx (kt/a)	0.0	-4.2	-4.2	-5.9	-3.2
Standards Level 4b											
Carbon (Mt/a)	588.9	612.1	651.9	702.5	742.4	Carbon (Mt/a)	0.0	-0.8	-1.3	-2.1	-2.2
NOx (kt/a)	4,191.2	3,542.6	3,660.4	3,812.8	3,879.2	NOx (kt/a)	0.0	-4.5	-4.6	-6.4	-3.5
Standards Level 5b											
Carbon (Mt/a)	588.9	612.7	652.8	704.0	743.9	Carbon (Mt/a)	0.0	-0.2	-0.4	-0.6	-0.7
NOx (kt/a)	4,191.2	3,545.7	3,663.6	3,817.3	3,881.7	NOx (kt/a)	0.0	-1.4	-1.4	-1.9	-1.1
Standards Level 6b											
Carbon (Mt/a)	588.9	612.4	652.3	703.2	743.1	Carbon (Mt/a)	0.0	-0.5	-0.9	-1.4	-1.5
NOx (kt/a)	4,191.2	3,543.9	3,661.8	3,814.8	3,880.3	NOx (kt/a)	0.0	-3.2	-3.2	-4.5	-2.4

Cumulative emissions savings over the 18-year period modeled are listed below:

Table D-3. Cumulative Emissions Reductions (2003-2020)

Emission	Range for Electronic Standards (standards 1 - 4)	Range for Cathode Cutout Standards (standards 5 and 6)
Carbon (Mt)	12.1 - 29.7	5.8 - 20.1
NOx (kt)	41.0 - 96.7	19.7 - 65.4

In addition, equivalent results for the high and low economic growth cases for standards level 2b are reported in Table D-4. The outcome of the analysis for each case is shown as both emissions and deviations from the AEO99 result.

Table D-4. Power Sector Emissions: Alternative Economic Assumptions and Standards Level 2b

NEMS-NAECA Results	2000	2005	2010	2015	2020	Differences	2000	2005	2010	2015	2020
AEO99 Reference - Low Economic Growth						**Difference from AEO99 Reference**					
Carbon (Mt/a)	586.1	596.3	632.4	670.1	694.6	Carbon (Mt/a)	-2.8	-16.6	-20.8	-34.5	-50.0
NOx (kt/a)	4,182.1	3,465.4	3,601.5	3,701.3	3,737.6	NOx (kt/a)	-9.1	-81.6	-63.5	-117.9	-145.1
Standards Level 2b - Low Economic Growth						**Difference from AEO99 - Low Economic Growth**					
Carbon (Mt/a)	586.1	595.5	630.5	667.8	692.4	Carbon (Mt/a)	0.0	-0.8	-1.9	-2.3	-2.2
NOx (kt/a)	4,182.1	3,461.0	3,591.6	3,692.2	3,731.6	NOx (kt/a)	0.0	-4.4	-10.0	-9.2	-6.0
AEO99 Reference - High Economic Growth						**Difference from AEO99 Reference**					
Carbon (Mt/a)	590.6	628.9	679.0	741.8	799.0	Carbon (Mt/a)	1.7	16.0	25.8	37.2	54.4
NOx (kt/a)	4,200.3	3,628.7	3,764.8	3,937.2	4,000.7	NOx (kt/a)	9.1	81.6	99.8	117.9	117.9
Standards Level 2b - High Economic Growth						**Difference from AEO99 - High Economic Growth**					
Carbon (Mt/a)	590.6	628.1	677.7	739.7	796.6	Carbon (Mt/a)	0.0	-0.8	-1.3	-2.1	-2.4
NOx (kt/a)	4,200.3	3,624.1	3,759.9	3,931.6	3,998.1	NOx (kt/a)	0.0	-4.7	-4.9	-5.5	-2.6