Technical Support Document
For EPA's Multi-Pollutant Analysis

Electricity Demand Response to Changes in Price in EPA's Power Sector Model

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The EPA has conducted a comprehensive analysis of various multi-pollutant proposals that have been introduced in the Senate. The proposals are designed to reduce emissions from the power sector, and EPA has agreed to perform detailed modeling for five legislative proposals and to present that information along with modeling results of EPA's recent regulatory approach to reducing emissions from the power sector. The analysis is based on air quality, health benefits, and power sector modeling projections and estimates for each proposal for the years 2010, 2015, and 2020. The following proposals and regulations were analyzed:

1. The Clean Power Act (Jeffords, S.150 in 109th)
2. The Clean Air Planning Act (Carper, S.843 in 108th)
3. The Clear Skies Act of 2005 (Inhofe, S.131 in 109th)
4. The Clear Skies Act of 2003 (Inhofe, S.485 in 108th)
5. The Clear Skies Act of 2005 (Manager's Mark of S.131 in 108th)
6. The Clean Air Interstate Rule, The Clear Air Mercury Rule, and The Clean Air Visibility Rule (EPA promulgated rules, 2005)

This technical support document reports the method used for developing EPA's 'demand response' sensitivities as part of the multi-pollutant analysis. Various sensitivities were conducted to the power sector modeling to better understand the impacts of the various proposals that were analyzed. One such sensitivity was the impact of increased electricity prices on demand, commonly referred to as 'demand response.' The power sector model that EPA uses for both regulatory and legislative analytical support is the Integrated Planning Model (IPM), a dynamic linear programming model that can be used to examine air pollution control policies for sulfur dioxides (SO_2), nitrogen oxides (NO_x), mercury, and carbon dioxide (CO_2) throughout the contiguous U.S. for the entire power system. Documentation for IPM can be found at www.epa.gov/airmarkets/epa-ipm.

In general, 'demand response' refers to the change in the quantity demanded by consumers in response to pricing signals. For example, as a price of a good rises, demand for that good will decrease as consumers use substitutes and/or curtail their consumption of that good. The magnitude of this change in quantity demanded is represented by the coefficient of price elasticity of demand. For example, a price elasticity of demand of 0.15 indicates that an increase in price of one percent will result in a 0.15 percent reduction in quantity demanded. In the electricity markets, such a change in quantity demanded in response to increasing electricity price is referred to as electricity load reduction. Electricity prices could increase due to changes in factors such as increases in fuel prices and the changes in compliances costs for meeting various environmental requirements. EPA's power sector model, the Integrated Planning Model (IPM), can incorporate such load reduction endogenously through an assumed price elasticity of demand. Since less electricity is demanded during times of high prices and less is produced, the result is a lower total system cost of electricity production than would otherwise be the case.

After surveying several studies on explicit and implicit[1] estimates of the price elasticity of demand for the power sector, EPA developed the price elasticity based on the average of the implied elasticities that were estimated based on the electricity sales and retail price data in the EIA May 2004 study (*Analysis of S. 1844, the Clear Skies Act of 2003; S. 843, the Clean Air Planning Act of 2003; and S. 366, the Clean Power Act of 2003*). The elasticity estimates used in this analysis are listed in the following table:

Elasticity Estimates
(Retail Price Elasticities of Demand)

Year	Elasticity
2010	0.16
2015[2]	0.20
2020	0.25

The elasticity estimates in the above table were applied in IPM at a wholesale market level based on the Energy Information Administration's 'Annual Energy Outlook 2004' electricity price data at the generation, transmission, and distribution component level. Since all electricity prices within IPM are at a wholesale market level, EIA's retail elasticity estimates were then appropriately scaled for use in IPM to represent wholesale prices. The results of the demand response sensitivities can be found in Section #6 of the various multi-pollutant analyses ('Additional Analyses of Key Provisions and Modeling Assumptions').

The demand response function is incorporated into IPM in two steps. In the first step, the energy demanded at a certain price is estimated based on the assumed elasticity estimates in the above table at the region level and for each season in the model. In the second step, the peak load (demand), after accounting for the change in energy demanded in the first step, is calculated at the IPM region level by applying the implied load factor from the Base Case demand and peak load projections. These two adjustments in the model result in an adjusted demand level, dependant upon the change in electricity price, for a particular modeling scenario.

[1] Implicit elasticities are calculated by observing the changes in quantity demanded with respect to a given change in price.
[2] Elasticity estimate for 2015 were linearly interpolated.