Section H:

Summary of the Models Used for the Analysis

Description of the Integrated Planning Model (IPM)

Analytical Framework of IPM

- EPA uses the Integrated Planning Model (IPM) to analyze the projected impact of environmental policies on the electric power sector in the 48 contiguous states and the District of Columbia. Developed by ICF Resources Incorporated and used to support public and private sector clients, IPM is a multi-regional, dynamic, deterministic linear programming model of the U.S. electric power sector.
- The model provides forecasts of least-cost capacity expansion, electricity dispatch, and emission control strategies for meeting energy demand and environmental, transmission, dispatch, and reliability constraints. IPM can be used to evaluate the cost and emissions impacts of proposed policies to limit emissions of sulfur dioxide (SO_2), nitrogen oxides (NOx), carbon dioxide (CO_2), and mercury (Hg) from the electric power sector.
- IPM was a key analytical tool in developing the President's Clear Skies proposal.

IPM Is Well Suited to Model Multi-Emission Control Programs

- Among the factors that make IPM particularly well suited to model multi-emissions control programs are (1) its ability to capture complex interactions among the electric power, fuel, and environmental markets, (2) its detail-rich representation of emission control options encompassing a broad array of retrofit technologies along with emission reductions through fuel switching, changes in capacity mix, and electricity dispatch strategies, and (3) its capability to model a variety of environmental market mechanisms, such as emissions caps, allowances, trading, and banking.
- IPM is particularly well suited for modeling Clear Skies because the program relies on the operation of an allowance market, the availability of a broad range of emissions reduction options, and empowerment of economic actors to achieve emission limits.

Extensive documentation of the IPM and updated EPA 2003 IPM modeling assumptions are available at http://www.epa.gov/airmarkets/epa-ipm/index.html.

Description of Air Quality Modeling

- The results for fine particle concentrations, visibility, sulfur deposition, nitrogen deposition, and mercury deposition are based on the Regional Modeling System for Aerosols and Deposition (REMSAD).
- REMSAD is an Eulerian air quality model developed to simulate regional-scale distributions, sources, formation, transport, and removal processes for fine particles and other airborne pollutants. This analysis used REMSAD version 7.06 with meteorological inputs previously developed for 1996 using the Mesoscale Meteorological Model (MM-5).
- The results for ozone concentrations are based on the Comprehensive Air Quality Model with Extensions (CAMx).
- CAMx is an Eulerian air quality model developed to simulate local and regional-scale distributions, sources, formation transport, and removal processes for ozone and other photochemical pollutants. This analysis used CAMx version 3.1 with meteorological inputs previously developed using the Regional Atmospheric Modeling System (RAMS) for episodes in June, July, and August 1995.
- The Integrated Planning Model (IPM) was used to derive all future projections of electricity generation source emissions.
- The base inventory year to evaluate model performance for REMSAD and CAMx was 1996. The base year for air quality projections was 2001. The 2001 inventory was developed through a combination of ratios and interpolations between the 1996 inventory and a 2010 inventory. Inventories prepared for the Heavy Duty Diesel Engine rulemaking and the Nonroad Diesel Engine proposed rulemaking were the basis for future year emissions projections.
- For the most part, the modeling results are analyzed in terms of the change in future year air quality relative to predictions under baseline conditions. In this way, effects of any uncertainties in emissions forecasts and air quality modeling are minimized.
- Results for projected annual PM2.5 and 8-hour ozone nonattainment were determined by applying a “relative reduction factor” to current air quality levels. This was based on the percentage change in air quality between the 2001 base year and each future year scenario. Future year Eastern PM2.5 values were derived from relative reduction factors applied to each of the PM2.5 component species (speciated modeled attainment test). Due to the lack of available ambient data, the Western PM2.5 values were derived using a single reduction factor for PM2.5. Future year Western 8-hour ozone values were estimated from previous modeling completed for the Nonroad Diesel engine rule.
- Maps which display the impacts on PM2.5 concentrations and deposition are reported as a percent reduction. A positive percent reduction (e.g. 30%) is a decrease in concentration or deposition compared to current conditions (an improvement); a negative percent reduction (e.g. -30%) is an increase in concentration or deposition compared to current conditions.
- Visibility results are reported as a change in deciviews. “Perfect” visibility is represented by a deciview of zero, so a decrease in deciview is an increase or improvement in visibility. An increase in deciview is a decrease in visibility.

Description of Benefits Modeling

Health Benefits

- The Environmental Benefits and Mapping System (BenMAP) is used to quantify benefits due to the changes in a population’s exposure to fine particulate matter and ozone.
- Using the air quality modeling results, the change in pollutant concentration based on modeling for each BenMAP grid cell is determined. This is the level at which the population living in that grid cell is assumed to have reduced exposure.
- Concentration-response functions from epidemiological studies are applied to each grid cell to predict the changes in incidences of health outcomes (e.g., ER visits for asthma) that would occur with the projected changes in exposure.
- The grid cells are aggregated to estimate the health impact of the change in air quality across the study region.
- The estimated economic value of an avoided health outcome (e.g. $275 per ER visit for asthma) is multiplied by total change in events (e.g., number of visits) to determine the health benefits of air quality improvements for the entire region.

Visibility Benefits

- BenMAP was also used to quantify visibility benefits based on changes in fine particle concentrations, presented as deciviews, which are provided by the REMSAD air quality model.
- Individuals place a value on visibility improvements in recreational areas, such as National Parks and wilderness areas
- To obtain recreational visibility monetary benefits, the economic value that people place on improved visibility on a day that they visit a selected set of Class I areas (subject to past study) is applied to the predicted deciview changes and the projected number of park visitors affected.
- The primary analysis of visibility benefits quantifies benefits in Class I areas in the Southeast, Southwest, and California. Benefits in residential areas and in Class I areas outside of the study region are not presented here and are quantified only as as sensitivity analysis.

Description of Freshwater Acid Modeling

- The Model of Acidification of Groundwater in Catchments (MAGIC) is used to examine changes in surface freshwater chemistry as indicated by changes in acid neutralizing capacity (ANC) in the waterbody.
- ANC represents the ability of a lake or stream to neutralize, or buffer, acid. The condition of a lake or stream improves as the the ANC increases, moving from chronically acidic episodically acidic not acidic.
- Episodically acidic lakes (ANC of 0-50 µeq/l) have a greater capacity to neutralize acid deposition than chronically acidic ones. However, these lakes remain susceptible to becoming chronically acidic if acid deposition increases.
- Watershed characteristics (e.g., soils, bedrock type, geologic history) affect the rate of water chemistry response to acid deposition.
- “Direct response” lakes or streams manifest changes more quickly, whereas “delayed response” lakes or streams manifest changes over a longer period of time.
- MAGIC results show the distribution of lakes and streams (by percentage) over the three ANC classes.
- Three regions were modeled (the Adirondacks, the Northeast (including the Adirondacks), and the Southeast).
- Results are reported for current conditions (2000) and in 2030 under the Base Case and the Clear Skies Act.

Results are based on a model called the “Model of Acidification of Groundwater in Catchments” (MAGIC) used by the National Acid Precipitation Assessment Program (NAPAP) to estimate the long-term effects of acidic deposition (sulfur) on lakes and streams. The model simulates the size of the pool of exchangeable base cations in the soil. As the fluxes to and from the pool change over time due to changes in atmospheric deposition, the chemical equilibria between soil and soil solution shift to give changes in surface water chemistry. Changes in surface water chemistry are characterized by changes in Acid Neutralizing Capacity (ANC) – the ability of a waterbody to neutralize strong acids added from atmospheric deposition.

Description of the Technology Retrofit and Updating Model

Uses of the Technology Retrofit and Updating Model

- At this time, IPM does not model price elasticity of demand and the effect of multiple allowance allocation mechanisms. To study the effect of these variables on electricity prices and markets, ICF developed a macro-driven spreadsheet program termed the “technology retrofit and updating model.”
- The model is used to discern trends in marginal costs and retrofits, the approximate magnitudes of those trends, and the reasons for those trends.

Modeling Approach

- The technology retrofit and updating model consists of a set of approximately six hundred “sample” generating units with varying characteristics. The mix of generation types and sizes was chosen to mirror, in general terms, the nationwide mix of capacities. Each unit is assumed to choose emission control retrofit options, fuels, and generation levels so as to maximize its own net profit in response to fuel prices, emission allowance prices, and prices of electricity for various demand segments. Prices of fuels can be adjusted in the model in response to demand; prices of electricity by demand segment is set in the model so as to meet demand; and allowance prices can be adjusted to cause the industry to meet given caps.
- To simulate the effects of demand elasticity, the quantity of electricity demanded in each segment can be set as a function of electricity prices using an elasticity value that is entered as an input to the model. Finally, to simulate the effects of allowance updating, the value of reallocated allowances can be calculated and subtracted from each unit’s cost of generation – thereby inducing each unit to change its profit-maximizing level of generation in response to a given set of fuel, allowance, and electricity prices. Readjusting the allowance prices to meet the same emission caps then generates results showing the costs of meeting given caps with and without updating.
- An important limitation of this model is that it does not simulate changes over time in the demand for electricity, prices, technology, or other factors considered within IPM. Instead, it is run as though every year is the same as every other year and is therefore static in its outlook. In addition, it does not recognize the distinctions among electricity demand regions and the transmission constraints that can keep them separate. Thus, only one price of electricity is determined for each demand segment for the entire set of sample plants.

Description of the Retail Electricity Price Model

Primary Attributes of the Model

- The Model provides a forecast of average retail electricity prices from 2005 to 2020 for 13 regions and the contiguous U.S., and considers areas of the country that (1) will have competitive pricing of power generation and, (2) are likely to price retail power based on a cost-of-service basis.
- Combines IPM and EIA cost information (AEO2002) with data from EIA, the National Regulatory Research Institute, Edison Electric Institute, and Center for Advanced Energy Markets regarding the restructuring of the power industry.
- “Main Case” is EPA’s forecast of “likely deregulation” considering areas of the country that should price generation services for retail customers competitively and those that most likely to use cost-of-service pricing principles.
- The Model readily analyzes alternative multi-pollutant and base case scenarios modeled with IPM, alternative assumptions on deregulation and future savings/costs, and the implications of different allowance allocation approaches. The strongest application of the Calculator occurs from examining the relative price differences between two or more scenarios.

The Limitations of the Model Include

- The Model combines IPM and EIA cost elements that use similar -- but not identical -- assumptions on capital recovery and aggregate cost data in a similar -- but not identical -- regional manner that needs adjustment.
- The Model assumes public and private companies seek the same return and have the same tax treatment, which overstates prices in areas where there are large amounts of public power.
- The Model focuses on major costs. It assumes for cost-of-service areas (where most of power sales are likely to occur) that allowance allocations will not alter pricing of electricity.
- Uses EIA’s limited (but best available) data in some areas (e.g. rate base with stranded assets).
- The Model cannot address the uncertainty of deregulation created by California’s experience -- where competition may increase or decrease in the future. With the phasing in of competition and limited experience, the full benefits and costs of deregulation still remain unknown.