AIR STRATEGY ASSESSMENT PROGRAM: AN INTEGRATED SCREENING TOOL FOR AIR QUALITY PLANNING

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1. INTRODUCTION

The US Environmental Protection Agency (EPA) is developing a PC-based screening tool known as the Air Strategy Assessment Program (ASAP). ASAP is intended to allow users to: identify and compare the cost-effectiveness of alternative multi-pollutant emissions control strategies; assess air quality and health impacts of emissions reductions for source sectors; and compare the costs and benefits of alternative control strategies.

ASAP links versions of three EPA tools, specifically:

- AirControlNET: allows users to estimate the emissions reductions and control costs associated with broad categories of control strategies.
- Response Surface Metamodel (RSM): allows for a rapid estimation of the air quality changes expected from selected emissions controls strategies.
- BenMAP: estimates health impacts and associated economic benefits associated with air quality improvements.

In addition, ASAP includes customized mapping, graphing and reporting capabilities and a user-friendly graphical interface.

The initial release of the ozone demonstration version of ASAP, currently scheduled for the end of summer 2005, demonstrates features that support the development of cost-effective ozone control strategies for the Chicago/Milwaukee and Northeast Corridor ozone nonattainment areas. Users can identify the relative efficacy of emissions reductions across broad categories of sources (e.g. mobile, utility, and non-utility point source) and pollutants (VOC and NO_x). This information can be used to develop more specific control options and quickly assess their implications on emissions, costs, ambient pollutant levels, and health benefits.

In future versions ASAP will be able to analyze multipollutant strategies (e.g. simultaneous attainment of ozone and PM standards) so that air quality planners can identify cost-effective and potentially innovative control strategies in their air quality planning process.

It is important to note that ASAP is intended to be used as a screening tool to evaluate the relative efficacy and cost-effectiveness of broad, multi-pollutant control strategies across the nation or for a specific non-attainment area. ASAP is not a tool for assessing individual controls for specific sources, for comparing relative impacts across small areas, nor for meeting any regulatory or legal modeling requirements. It *can* assist analysts in narrowing the scope of their assessment and be used as part of a “weight-of-evidence” determination to support attainment demonstration modeling.

In this paper, we provide a detailed description of ASAP. Next, details of the current version are provided, as well as the conceptual design of future versions. Then we describe the Phoenix Framework and the individual models contained in ASAP.

2. ASAP DESIGN

ASAP is EPA’s first application of the Phoenix Framework for Integrated Air Quality Assessment and Policy Analysis. Phoenix supports air quality research and policy analysis activities through linkages of various models (e.g., energy, economic, emissions, air quality, and benefits models) and tools (e.g., geographical information systems, visualization systems, and report generators) to support integrated assessments. While Phoenix is a generic framework, it can be customized for a particular application; ASAP is Phoenix, customized with the models, tools, and graphical

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interface to facilitate the screening of ozone and particulate matter control strategies by policy analysts and decision-makers. Figure 1 shows the components of ASAP.

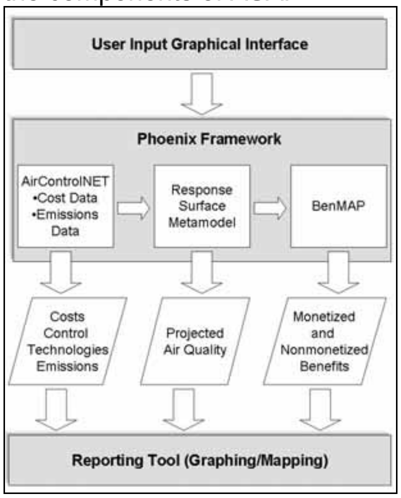

Figure 1. ASAP Flow Chart.

Users interact with ASAP through a user-friendly graphical interface, in which they select either specific emissions reductions or control technologies across classes of sources. These selections are communicated to the Phoenix Framework, which automates the execution of an AirControlNET module (or extracted cost curves, as in the case of the initial demonstration version of ASAP), the Response Surface Metamodel, and the BenMAP model, accounting for data dependencies within the models. The resulting outputs are sent to a reporting tool, which outputs tables and figures that characterize the cost-effectiveness of the selected controls. Descriptions of the development and functionality of each of the ASAP components are provided later in this paper.

This design is important for several reasons: (i) users do not have to learn how to setup and use the individual model components, (ii) automation of the modeling steps ensures that data is passed correctly from model to model, eliminating sources of error, (iii) the report generator conveys key outputs to the user and saves time and effort in generating report-ready tables and graphics, and (iv) the system provides quick turnaround time, requiring only minutes to evaluate a control strategy.

3. CURRENT AND FUTURE ASAP RELEASES

3.1 Ozone Demonstration Version

The initial release of ASAP is a “proof-of-concept” and is designed to demonstrate the utility of an integrated modeling decision support system for EPA, state and regional air quality managers. This initial version focuses solely on ozone air quality, and users are limited to choosing three regions for analysis: i) those areas of the eastern U.S. that are projected to attain the 8-hour ozone National Ambient Air Quality Standards (NAAQS) by 2015, ii) the Chicago and Milwaukee projected residual nonattainment areas, and iii) multiple projected residual nonattainment areas within the Northeast Corridor (New York City, Philadelphia, & Baltimore).

The initial ASAP release uses a response surface metamodel that was based on multiple simulations of the Comprehensive Air Quality Model with Extensions (CAMx). These simulations were based on a 2015 scenario that incorporated growth estimates as well as all Federal control measures in place by that year, including the emissions reductions from the Clean Air Interstate Rule (CAIR). CAMx was utilized in a nested-grid mode over the 36- and 12-km resolution domains shown in Figure 1. Additional information on the CAMx model configuration used in the RSM development is contained within the CAIR Technical Support Document (US EPA, 2005).

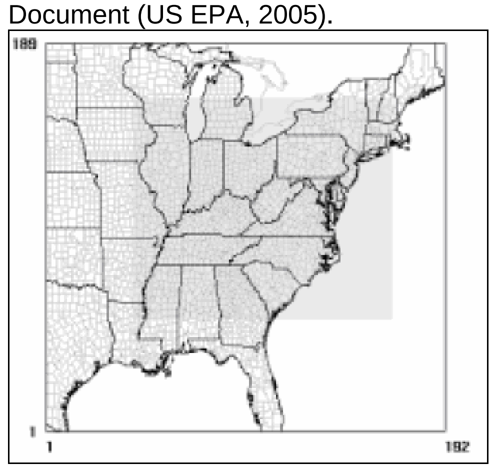

Figure 2. Plot of the modeling domain used in the RSM for the initial ASAP release. The shaded area represents the 12-km resolution fine grid.

For this analysis, we selected an experimental design that covered three key areas: i) type of precursor emission, ii) emission source type, and iii) location in or out of a 2015 projected residual ozone nonattainment area after implementation of the Clean Air Interstate Rule. (Six areas are projected to be nonattainment for ozone in 2015: Chicago,

Milwaukee, Houston, New York City, Philadelphia, and Baltimore.) In all, 14 dimensions were considered:
1) nonroad mobile source VOC emissions in residual O_3 nonattainment areas;
2) nonroad mobile source VOC emissions in O_3 attainment areas;
3) area source VOC emissions in residual O_3 nonattainment areas;
4) area source VOC emissions in O_3 attainment areas;
5) nonroad mobile source NOx emissions in residual O_3 nonattainment areas;
6) nonroad mobile source NOx emissions in O_3 attainment areas;
7) electricity generating utility (EGU) NOx emissions in residual O_3 nonattainment areas;
8) EGU NOx emissions in O_3 attainment areas;
9) non-EGU point source NOx emissions in residual O_3 nonattainment areas;
10) non-EGU point source NOx emissions in O_3 attainment areas;
11) onroad mobile source VOC emissions in residual O_3 nonattainment areas;
12) onroad mobile source VOC emissions in O_3 attainment areas;
13) onroad mobile source NOx emissions in residual O_3 nonattainment areas; and
14) onroad mobile source NOx emissions in O_3 attainment areas.

3.2 Future Multipollutant ASAP

Although the current demonstration version of ASAP focuses on ozone precursors, EPA has already begun planning for the expanded multipollutant version of ASAP.
This next version of ASAP, expected to be released in late 2006, will support simultaneous consideration of additional pollutants, including: particulate matter (PM), visibility, nitrate and sulfate deposition. We also anticipate adding the ability to examine impacts for a limited set of toxics or hazardous air pollutants (HAPs). This version will provide national coverage for PM by using a 36km modeling grid and the Community Multi-scale Air Quality model (CMAQ). This version will also allow users to separately assess the impacts of local controls in nine large urban regions. Controls will be available for five pollutant categories (NO_x, SO_x, NH3, elemental and organic carbons, and VOC), covering EGU, non-EGU point, area, and mobile source categories. In addition to the above assessment, other additional features will include: incorporation of more features from AirControlNET, including flexibility with control technologies and least-cost approaches; the ability to optimize across several parameters such as cost, benefits, or a specific air quality target; and, allow users to input different emissions inventories to customize ASAP.

4. ASAP MODEL COMPONENTS

Each of the models incorporated into the ASAP tool are stand alone models, although only certain aspects of AirControlNET were incorporated into ASAP, and BenMAP has been modified to run in a standard EPA configuration. These modifications reduce both training requirements and the potential for user error. First, we will discuss the Phoenix Framework that was utilized to link the underlying models, and will then discuss of each of the components of ASAP.

4.1 Phoenix Framework

The EPA's research and regulatory analyses of ambient air quality often make use of computer models to simulate requisite elements of the system. For example, in a regulatory impact analysis of a proposed policy, we employ a number of models to do the following:

- project future economic growth and generate the associated future emissions levels;
- develop and apply control factors to future baseline emissions and process these baseline and controlled emissions (i.e., temporal and spatial allocation);
- conduct air quality modeling to characterize future ambient concentrations of pollutants such as PM and/or ozone; and,
- evaluate the incremental health and environment effects associated with changes in air quality and value those benefits for comparison with the cost of control requirements.

Although performing analyses using a suite of models is not difficult to envision, it has proven to be challenging in practice. For example, various models employ different data formats, use different time and spatial scales, execute on different computing platforms (e.g., PC versus Linux/Unix workstation), and have sufficiently long run times that make their use for 'timely' analyses difficult. Another factor is that many of the models are sufficiently complicated that they are run by different teams that are in different parts of the overall organization. This may lead to problems of inconsistency if the data and assumptions made by the various teams are not in agreement.

An alternative modeling approach is to make use of an integrated modeling environment that links the various modeling activities or analytical components of the system. Such an environment would include explicitly defined interfaces between models, would automate data transfers and model execution (across computing platforms, if necessary), would facilitate optimization as well as sensitivity and uncertainty analysis, and would provide a toolbox of analysis techniques for accessing and visualizing data inputs, intermediate outputs, and policy results.

EPA's Office of Research and Development (ORD) and the Office of Air and Radiation (OAR) collaborated to develop an integrated modeling environment, called Phoenix, built upon the EPA's Multimedia Integrated Modeling System (MIMS) framework.

4.2 AirControlNET

AirControlNET is a PC-based relational database tool for conducting control strategy and costing analysis. It overlays a detailed control measure database on EPA emissions inventories to compute source- and pollutant-specific emission reductions and associated costs at various geographic levels (national, regional, local). It contains a database of control measures and cost information for reducing the emissions of criteria pollutants (e.g., NOx, SO2, VOC, PM10, PM2.5, NH3) as well as CO and Hg from point (utility and non-utility), area, nonroad and onroad mobile sources as provided in EPA's National Emission Inventory (NEI).

The underlying data for the control measures comes from reports such as the EPA Air Pollution Control Cost Manual, and from reports issued by EPA's ORD and other EPA references. AirControlNET's primary purpose is to assist EPA in carrying out control strategy applications in support of implementation of the National Ambient Air Quality Standards (NAAQS), standards that are designed to protect public health and improve environmental quality by limiting concentrations of criteria pollutants throughout the U.S.

AirControlNET was utilized for ASAP to develop a database of elements to allow users to:

- view emissions changes by percentages;
- calculate control costs based on user-defined emissions reduction scenarios; and,
- compare scenarios, produce difference tables, and rank various strategies.

The data elements used to develop this database included emissions control factors, emissions inventories, control costs, and cost-effectiveness in ($/ton). The emissions changes output from AirControlNET are aggregated across source categories to match the control factor definitions within the RSM. Cost information was processed such that the ambient cost-effectiveness and relative cost-effectiveness of each control strategy can displayed to the user as they select emissions reductions using the RSM.

In future versions of ASAP, AirControlNET will be more fully incorporated to give users additional functionality to develop cost-effective strategies for mulitpollutant air quality analysis.

4.3 Response Surface Metamodel (RSM)

The RSM is a powerful tool that allows users to instantaneously determine the modeled impacts of emissions reductions on air quality. The RSM uses a limited number of photochemical model runs for a set of statistically selected points in a design space. For example, in the case of the initial ASAP application, control levels of 0 to 120 percent of 2015 CAIR levels were investigated for a set of 14 emissions factors (7 broad sectors and 2 broad geographic areas). The response-surface method uses statistical techniques to relate a response variable (e.g., eight-hour predicted maxima) to a set of factors that are of interest (e.g., emissions of precursor pollutants from particular sources and locations). Air quality responses are fit using a multidimensional kriging model (Sacks et al, 1989; Srivastava, et al, 2004), implemented through the MIXED procedure in SAS. Essentially, the changes in air quality at each receptor location are modeled as a function of the weighted average of the modeled responses in the experimental design. In the case of the 2015 CAMx RSM, the metamodel replicates the responses of the "true" air quality model with a high degree of accuracy, with fractional bias and error well below one percent for a variety of output metrics. As such, it provides an excellent air quality modeling proxy for use in evaluating the impacts of hypothetical emission control strategies.

Once generated, the RSM allows for estimation of changes in air quality concentrations for any combination of the factors defined in the experimental design. To facilitate analysis of the impacts of different combinations of emission factor levels, we developed a graphical interface to the RSM, called the Visual Policy Analyzer (VPA). This software tool allows users to manipulate the factor levels in the experimental design using slider bars, and immediately view the resulting impacts on pollutant concentrations across the modeling domain. Figure 2 shows an example of a VPA screenshot.

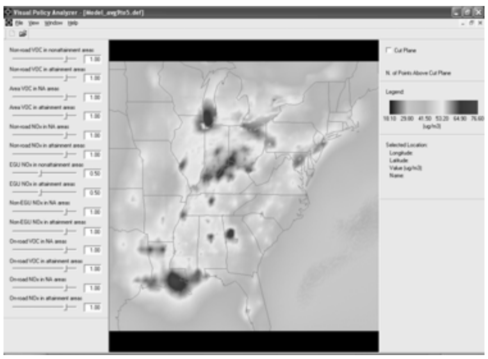

Figure 3. Sample screenshot from VPA built into initial ASAP release.

4.4 BenMAP

BenMAP, the Environmental Benefits Mapping and Analysis Program, is the EPA's premier tool for estimating benefits associated with air pollution reduction strategies, and has recently been used in evaluating EPA's Clean Air Nonroad Diesel Rule and Clean Air Interstate Rule. BenMAP has recently undergone peer review and EPA is developing a revised version which incorporates responses to a number of peer review comments as well as other model enhancements. BenMAP currently estimates benefits from changes in particulate matter and ozone concentrations, but can be used for other pollutants as well.

BenMAP can be used for a variety of purposes, including:

- generation of population/community level ambient pollution exposure maps;
- comparing benefits associated with regulatory programs;
- estimating health impacts and costs of existing air pollution concentrations;
- estimating health benefits of alternative ambient air quality standards;
- performing sensitivity analyses of health or valuation functions, or of other inputs; and
- screening analyses.

The key elements of BenMAP are 1) calculation of community-level population exposures to air pollution, 2) generation of incidence estimates for selected health effects, 3) pooling of incidence results from individual concentration-response functions, 4) valuation and aggregation of results, and 5) generation of maps and reports.

BenMAP combines air pollution monitoring data, air quality modeling data, census data, and population projections to calculate a population's potential exposure to ambient air pollution. Using these different types of data BenMAP can estimate population exposure for any particular year of interest. Typically, users specify baseline and control scenarios, and BenMAP estimates the change in population exposure. Given this change in population exposure, BenMAP calculates the associated change in health effect incidence using concentration-response functions derived from the epidemiological literature and pooling methods specified by the user. BenMAP then allows the user to place an economic value on these incidences using a wide range of valuation approaches from the economic literature. BenMAP can provide both the mean and distribution of benefits. BenMAP allows the user a wide degree of flexibility when conducting an analysis and reporting the results.

Version 2.2, released in 2005, adds a number of new features, including the ability to manage multiple databases of populations, health incidence rates, and air quality data; printing of reports and maps; addition of custom air quality metrics, and enhanced portability of databases. BenMAP version 2.2 also allows for regional and international analyses by allowing users to load in custom population data, health effect incidence rates, impact functions, and valuation data.

The customized version of BenMAP included in ASAP:

- reads in air quality data produced by the RSM;
- produces air quality grids based directly on the RSM data;
- produces gridded estimates of health effect incidence for a predefined set of health effects (based on the health impact functions used in the benefits analysis of the Clean Air Interstate Rule);
- produces gridded estimates of monetized values for health effects for a predefined set of valuation functions (based on the valuation

functions used in the benefits analysis of the Clean Air Interstate Rule); and

- produces interactive maps of incidence and valuation results and generates summary statistics for specific geographic regions, county, state, and/or national aggregations.

5. CONCLUSIONS

The Air Strategy Assessment Program (ASAP) is a PC-based screening tool that allows users to screen the costs, benefits, and air quality impacts of control strategies, evaluate the relative efficacy of controls on different source categories, and identify and compare multi-pollutant control strategies with respect to cost, air quality impacts, and health benefits.

As an integrated framework, ASAP allows EPA to leverage the best science for timely screening across multiple policy alternatives. By linking these data, tools, and models ASAP facilitates multi-pollutant assessments and identification of most cost-effective and beneficial control strategies to address complex air quality problems. If appropriate, the results of an ASAP screening exercise can be followed up with a full air quality modeling and health benefits study for a more rigorous analysis.

6. REFERENCES

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