



Project Summary

Advanced Utility Simulation Model

Larry G. Jones

The Advanced Utility Simulation Model (AUSM) is one of four stationary source emission and control cost forecasting models developed by EPA for the National Acid Precipitation Assessment Program. The AUSM projects air pollution emissions (SO_2 and NO_x), generating technology types and costs of operation, and combinations of fuels and emission control technologies to simultaneously meet electric demand and emission constraints on a least cost basis for each year through 2010. Thirteen electric demand regions are simulated, and output is provided for each of the contiguous 48 states.

This document summarizes the 11 reports in this series, describing the initial development of the AUSM by the Universities Research Group on Energy (URGE) and its continued development by the Science Applications International Corporation (SAIC) research team. The initial version of AUSM, designated Version 1.0, was delivered by URGE in November 1984 and August 1985. Further development of the AUSM by the SAIC between 1985 and 1988 resulted in the development of Versions 2.0 and 3.0. Reports describing these revisions by SAIC to the initial Version 1.0 of AUSM and a magnetic tape of Version 3.0 are also part of this series.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in 11 separate volumes (see Project Report ordering at back).

Introduction

The National Acid Precipitation Assessment Program (NAPAP) has developed emission forecast models for all U.S. sources of the acid deposition precursors, sulfur dioxides (SO_2), nitrogen oxides (NO_x), and volatile organic compounds (VOC). One of these models, the Advanced Utility Simulation Model (AUSM), projects SO_2 and NO_x emissions from electric power generating stations operated by private utility companies and by state, federal, or local governmental authorities.

The Environmental Protection Agency (EPA) commissioned the the Universities Research Group on Energy (URGE) to construct a new state-of-the-art computer simulation model that would rely on nonproprietary data bases and methodology. This model would be released to the user community for evaluating public policy proposals for control of SO_x and NO_x emissions from the nation's largest stationary source category of these emissions.

The URGE research team consisted of researchers from the University of Illinois (the lead office), Carnegie-Mellon University, and Cornell University. The URGE research team delivered to EPA the major portion of the program code and documentation they had developed in November 1984. An additional module, the coal supply module, was delivered in August 1985. This initial version of the AUSM model was designated Version 1.0.

The URGE design for AUSM divided the model into two major sections: the State Level Model and the National Loop. The National Loop, as it is now configured, is designed to iterate between a utility module, the Multi-Period

Multi-State (MPMS) module, and the Coal Supply Module (CSM) until an equilibrium has been reached between coal supply and demand by coal sulfur and calorific value categories for each of 13 power supply regions. The power supply regions used in AUSM are approximately the same as the Electric Reliability Council's power pools. Coal prices are determined as a function of coal demand, mining costs, depletion effects of coal reserves, and rail or water transportation costs. Coal demands are determined as a function of electric demand, minimization of the net present value of life cycle generating costs including fuel and emission control costs, emission standards, and choices among generating technologies for new capacity additions (e.g., nuclear units, conventional coal-fired steam generators, and gas-fired combined cycle units).

After the National Loop develops a strategic plan of future utility operations (including capacity additions) and has simultaneously projected coal prices for a region, the information is passed to the State Level Model for a more detailed simulation utilizing unit specific parameters. The State Model can also be run in a stand-alone mode if the information that usually is passed to it from the National Loop can be supplied by the user from another source.

Upon receipt, EPA initiated testing of Version 1.0. This testing showed that the computer code needed additional development to produce a fully integrated model. A research team consisting of the Science Applications International Corporation (SAIC) (the lead research group), E.H. Pechan & Associates, and Energy and Resource Consultants was chosen to undertake this task under the guidance of EPA's Air and Energy Engineering Research Laboratory at Research Triangle Park, N.C. The SAIC research team completed the National Loop, revised significant portions of the State Level Model, integrated the National Loop with the State Level Model, and conducted a series of calibration and sensitivity test runs. Several data bases were also revised. These modifications produced an operational AUSM capable of producing forecasts of emissions, costs of emissions control, and electricity rate impacts. This revised AUSM, designated Version 2.0 in August 1987, was constructed to operate in the exogenous demand mode (i.e., the user supplies a forecast of future electric demand). Work is continuing on testing and debugging of other portions of the model's code including the endogenously

generated forecast of future electric demand determined as a function of electric rate/demand elasticity factors. Recent modifications to the State Level Model Financial Module have produced AUSM Version 3.0.

Upon completion of Version 2.0 of AUSM, which had been tested and shown to produce results comparable to other models currently in use by the user community, EPA decided to publish documentation for the latest version of AUSM available (i.e., Version 3.0) and release it for use. The following series of reports is intended to accomplish this objective. The approach taken to document Version 3.0 is to supplement rather than duplicate the original documentation developed by URGE for Version 1.0. Additional reports by the SAIC research team describe the revisions made to the AUSM methodology, computer code, and data bases and the results of sensitivity and model comparison testing. Much of the documentation of Version 1.0 by the URGE research team remains applicable to Version 3.0.

Seven reports prepared by the URGE research team, with minimal editorial changes by EPA, and four reports by the SAIC research team have been produced. A magnetic tape was also prepared to release the model for use.

URGE Research Team Reports

EPA Report 600/8-88-071a. The Advanced Utility Simulation Model, Analytical Documentation, State Level Model (Version 1.0).

This report describes the operation of the State Level Model and the data bases it uses. An overview of its operation is given in Chapter 1, and a description of the seven primary modules is given in Chapters 2 through 8. The extensive unit-specific electric generating capacity inventory of technical and cost parameters is described in Appendix A. Appendices B and C describe the coal reserves data base and coal cleaning methodology used in AUSM.

EPA Report 600/8-88-071b. The Advanced Utility Simulation Model, Program Documentation, State Level Model (Version 1.0).

This report documents the formatting of the computer code and provides variable descriptions for the parameters used in the Fortran code. Flow logic diagrams and a listing of default parameters are described. This report is

essential to the user preparing a model run. The user should review the list of default inputs in the parameter files prior to exercising AUSM to analyze a scenario. The report is also essential to the programmer who wishes to trace the execution steps in the model.

EPA Report EPA-600/8-88-071c. The Advanced Utility Simulation Model, Documentation of System Design, State Level Model (Version 1.0).

This report provides an overview of the URGE design of the AUSM model structure. Particular attention is given to the format of input/output files and various data bases that support operation of the State Level Model modules.

EPA Report EPA-600/8-88-071d. The Advanced Utility Simulation Model, The Multi-Period Multi-State Model Design Documentation (Version 1.0).

This report describes the initial design of the utility planning module of the National Loop. This module, the Multi-Period Multi-State (MPMS) module, was substantially revised and enhanced between Version 1.0 documented in this report and Version 3.0 documented in the Description of the National Loop (Version 3.0) report in this series.

EPA Report EPA-600/8-88-071e. The Advanced Utility Simulation Model, Model Operations (Version 1.0).

This report provides instructions for operating Version 1.0 of AUSM and sorting output. Several routines for producing specific reports are described. Parameter switches for executing a report are also described. To operate Version 3.0, the version being released by EPA, review the updated instructions in the Advanced Utility Simulation Model User Guide (Version 3.0) in this series.

EPA Report EPA-600/8-88-071f. The Advanced Utility Simulation Model, Data Base Maintenance (Version 1.0).

This report describes the permanent data base supporting the State Level Model modules that must be periodically updated to keep AUSM current. The material in this report is oriented toward programmers and others who will be asked to operate and update the model. Each chapter in the report (covering demand, capacity planning, and financial and coal price data) provides information on the sources of primary data, criteria for updating the AUSM data base, and explanations of how input files are generated from initial data sources.

EPA Report EPA-600/8-88-071g. The Advanced Utility Simulation Model, Energy and Employment Impacts Module (Version 1.0).

This report describes the methodology for computing the energy and employment impacts directly and indirectly attributable to electric utility operations. The report also documents the program code. Impacts are summed for related support industries (e.g., mining, transportation, and construction) as well as for electric utility operations.

SAIC Research Team Reports

EPA Report EPA-600/8-88-071h. The Advanced Utility Simulation Model, Description of the National Loop (Version 3.0).

This report describes work by the SAIC project team to complete and test the National Loop of the AUSM. The reformulation of the MPMS module is described. Methodologies employed in operating the National Loop and in achieving convergence of the solution are discussed. Relatively minor revisions to the Coal Supply module are documented. A new Coal Market Equilibrium module and files constructed to pass information from the National Loop to the State Level Model are also described.

EPA Report EPA-600/8-88-071i. The Advanced Utility Simulation Model, Description of Modifications to the State Level Model (Version 3.0).

This report describes work by the SAIC project team in testing, evaluating, and revising each State Level Model module. Major changes were implemented in the Dispatch and Finance modules. Less significant, but important, changes were made to the remaining modules.

EPA Report EPA-600/8-88-071j. The Advanced Utility Simulation Model User's Guide (Version 3.0).

This report describes the procedures for operating the revised AUSM model. Directions for operating the fully integrated AUSM model and the State Level Model (in a stand-alone mode) are provided. Detailed instructions on preparation of the model for run scenarios are given. Also included are instructions on operating an improved report writer and information on alternative reports that can be generated.

EPA Report EPA-600/8-88-071k. The Advanced Utility Simulation Model, Report of Sensitivity Testing, Calibration, and Model Output Comparisons (Version 3.0).

This report summarizes the tests conducted with the fully integrated AUSM model (i.e., the runs of the National Loop and those of the State Level Model utilizing information supplied by the National Loop).

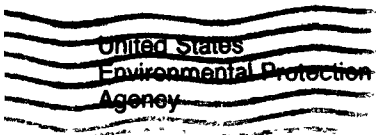
Extensive testing to determine both appropriate calibration constraints and the sensitivity of the model to alternative input parameters, and to compare the AUSM model's output with ICF, Inc.'s Coal and Electric Utilities Model are described. Special attention is given to identifying model parameters that the testing has shown to require attention by the user for particular scenarios.

Larry G. Jones is the EPA Project Officer (see below).

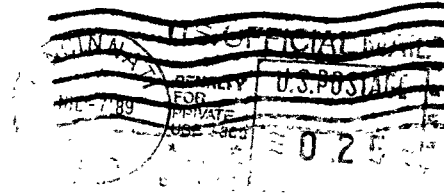
The complete report, consists of the following volumes: "Advanced Utility Simulation Model, Analytical Documentation (Version 1.0)," Order No. PB 89-161 772/AS; Cost: \$49.95; "Program Documentation, State Level Model (Version 1.0)," Order No. PB 89-166 631/AS; Cost: \$55.95; "Documentation of System Design, State Level Model (Version 1.0)" Order No. PB 89-101 208/AS; Cost: \$19.95; "The Multi-period Multi-state Module Design Documentation (Version 1.0), Order No. PB 89-204 268/AS; Cost: \$12.95; "Model Operations (Version 1.0)," Order No. PB 89-118 749/AS; Cost: \$21.95; "Data Base Maintenance (Version 1.0)," Order No. PB 89-204 276/AS; Cost: \$14.95; "Energy and Employment Impacts Module (Version 1.0)," Order No. PB 89-126 569/AS; Cost: \$13.95; "Description of the National Loop (Version 3.0)," Order No. PB 89-151 468/AS; Cost: \$15.95; "Description of Modifications to the State Level Model (Version 3.0)," Order No. PB 89-161 780/AS; Cost: \$15.95; "User's Guide (Version 3.0)," Order No. PB 89-126 577/AS; Cost: \$13.95; "Report of Sensitivity Testing, Calibration, and Model Output Comparisons (Version 3.0)," Order No. PB 89-166 649/AS; Cost: \$21.95; "A Mathematical Model of Electric Utility Company Operations, Version 3.0" Order No. PB 89-175 608/AS; Cost for Magnetic Tape (including paper copy) \$825.00; (all costs subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:
Air and Energy Engineering Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711



Center for Environmental Research
Information
Cincinnati OH 45268



Official Business
Penalty for Private Use \$300

EPA/600/S8-88/071

0000329 PS
U S ENVIR PROTECTION AGENCY
REGION 5 LIBRARY
230 S DEARBORN STREET
CHICAGO IL 60604