DOE/EIA-0566
CONF-930223--

PROCEEDINGS OF THE NATIONAL ENERGY MODELING SYSTEM CONFERENCE

February 1 - 2, 1993

CRYSTAL GATEWAY MARRIOTT
1700 JEFFERSON DAVIS HIGHWAY
ARLINGTON, VIRGINIA

May 1993

ENERGY INFORMATION ADMINISTRATION
OFFICE OF INTEGRATED ANALYSIS & FORECASTING
U.S. DEPARTMENT OF ENERGY
WASHINGTON, D.C. 20585

The National Energy Modeling System Component Design Reports listed below may be obtained from:

THE NATIONAL ENERGY INFORMATION CENTER, EI-231
Energy Information Administration
U.S. Department of Energy
Forrestal Building, Room 1F-048
Washington, DC 10585
(202) 586-8800

National Energy Modeling System Background Reports

Requirements for a National Energy Modeling System
System Design for the National Energy Modeling System
Development Plan for the National Energy Modeling System
Integrating Module
International Energy Module

Macroeconomic Activity

National
Interindustry
Regional

Demand

Residential
Transportation
Industrial
Commercial

Electricity Market Module

Overview of the Electricity Market Module
Electricity Fuel Dispatch
Nonutility Generation
Electricity Finance and Pricing
Electricity Capacity Planning
Load and Demand-Side Management
Electricity Transmission and Trade
Modeling Technology Penetration

Coal Market Module

Overview of the Coal Market Module
Coal Production and Pricing
Coal Distribution
Coal Synthetics
Coal Export

Renewable Fuels Module

Overview of the Renewable Fuels Module
Hydropower
Biofuels (Ethanol) Supply
Geothermal Electricity
Biomass Supply
Solar and Wind

Oil and Gas Supply Module

Basic Framework and Onshore Lower 48 Conventional Oil and Gas
Alaska Oil and Gas
Offshore Lower 48 Conventional Oil and Gas
Unconventional Gas Recovery
Foreign Natural Gas
Enhanced Oil Recovery

Natural Gas Transmission and Distribution Model

Natural Gas Annual Flow
Capacity Expansion
Pipeline Tariff
Distributor Tariff

Refineries

Detailed Refinery Model
Petroleum Market Module

Released for Printing: May 28, 1993

Dear Reader:

In an effort to provide information about the National Energy Modeling System that is relevant and useful to you, we would appreciate your response to the following questions.

1. What is your subject area of interest?
   - _____ NEMS Development
   - _____ Macroeconomic Activity
   - _____ Energy Demand
   - _____ Electric Power
   - _____ Nuclear Power
   - _____ Coal
   - _____ Renewable Fuels
   - _____ Oil and Gas Supply
   - _____ Gas Transmission and Distribution
   - _____ Refineries and Petroleum Markets
   - _____ Other (Please Specify) _________

   ____

2. Organization Type:
   - _____ Government
   - _____ Non-profit/Educational
   - _____ Consulting/Research
   - _____ Energy Producing
   - _____ Publishing
   - _____ Other (Please Specify)

   ____

   ____

3. What is your interest in the model?
   - _____ Model Methodology
   - _____ Results/Forecasts
   - _____ Model Performance
   - _____ Personal Use of Model
   - _____ Model Demonstrations
   - _____ General Knowledge
   - _____ Other (Please Specify) _________

   ____

4. Did you attend the NEMS Conference February 1-2, 1993?

   _____ Yes _____ No

5. Did you find these Proceedings useful?
   - _____ Useful
   - _____ Very Useful
   - _____ Not Useful

6. Comments: ______________________________

   ____

   ____

   ____

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WASHINGTON, D.C. 20585

Printed with soy ink on recycled paper

Contacts

The National Energy Modeling System (NEMS) Conference focused on individual components of the new modeling system under development in the Energy Information Administration. These Proceedings include presentations of those components, reviews, and the discussion that followed for each of the Conference's 15 concurrent panels. Readers are invited to direct comments about the National Energy Modeling System to Mary J. Hutzler, Director, Office of Integrated Analysis and Forecasting, EI-80, Energy Information Administration, U.S. Department of Energy, Forrestal Building, Room 2F-081, Washington, DC 20585. Information about the NEMS Conference and the Conference Proceedings may be obtained from the NEMS Conference Coordinator, Louise K. Bonadies (202-586-9648). Questions and requests for detailed information related to the individual NEMS components may be addressed to the following analysts:

Oil and Gas Supply . . . . William Trapmann (202-586-6408)

Buildings Demand . . . . Barry N. Cohen (202-586-5359)

Macroeconomic Activity . . . . Ronald F. Earley (202) 586-1398)

Gas Transmission and Distribution . . . . James M. Kendell (202-586-9646)

Renewable Fuels . . . . Edward J. Flynn (202-586-5748)

International Oil . . . . G. Daniel Butler (202-586-9503)

Industrial Demand . . . . T. Crawford Honeycutt (202-586-1420)

Electricity Planning . . . . J. Alan Beamon (202-586-2025)

Refineries and Petroleum Markets . . . . Bruce Bawks (202-586-6579)

Electricity Operations . . . . Jeffrey Jones (202-586-2038)

System Integration and User Interface . . . . Susan H. Shaw (202-586-4838)

Transportation Demand . . . . David Chien (202-586-3994)

Coal Supply and Coal Synthetics . . . . Robert Manicke (202-586-2157)

Electricity Pricing and Competition . . . . Arthur S. Holland (202-586-2026)

Foreword

The Office of Integrated Analysis and Forecasting in the Energy Information Administration sponsored a National Energy Modeling System Conference, February 1 - 2, 1993. The purpose of the conference was two-fold: 1) to give potential users of the National Energy Modeling System (NEMS) under development in the Energy Information Administration a detailed look at the components of the new modeling system, and 2) to afford the opportunity for critical analysis of the system by recognized experts in the modeling field and input from potential users about how the system can best address their needs.

The Conference brought together nearly 400 representatives of industry, trade associations, government agencies, academia, and public interest groups to address these issues. During the Conference 43 reviewers participated in panel discussions of the various components of the NEMS. Questions and comments from attendees added to the discussion and provided valuable input for the continued development of the NEMS as participants shared model methodologies and discussed developments affecting energy markets.

This document sets forth the Proceedings from the Conference. I would like these Proceedings to continue to stimulate discussion of the concepts and development efforts of the individual components of NEMS. That dialogue is critical to the development and maintenance of a modeling system that will be used in planning for our Nation's energy future.

I invite you to provide us with your comments on the topics discussed in these Proceedings and on NEMS in general. Component Design Reports for the individual NEMS modules are available for your review and can be obtained by contacting the National Energy Information Center at 202-586-8800. The NEMS development is an ongoing process. A meaningful dialogue with the users of the system can help ensure that NEMS will meet your needs and provide the basis for credible analysis of alternative energy policies.

Mary J. Hutzler
Director, Office of Integrated
Analysis and Forecasting
Energy Information Administration

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THE NEMS CONFERENCE

WELCOME AND OPENING REMARKS

February 1, 1993 - 8:30 a.m.

Welcome and Opening Remarks

Mary J. Hutzler, EIA, Chairman
L. A. Pettis, Acting Administrator, EIA

EIA

PROCEEDINGS

MS. HUTZLER: Good morning. I'm Mary Hutzler. I'm Director of the Office of Integrated Analysis and Forecasting in the Energy Information Administration. I am pleased that you have come to attend this conference on the National Energy Modeling System.

The purpose of this conference is two-fold. First, we want to tell you about the National Energy Modeling System, or NEMS as we call it. We want you to understand what we are doing so you will be able to put NEMS to work for you. By the time you leave here tomorrow afternoon, we hope to have given you a clear picture of how NEMS is being put together, what it can do and what its limitations are so you will be able to make effective use of it and its outputs.

Our second objective for the conference is to obtain your feedback. We are building NEMS for you and we want your input. Over the next day and a half, there will be 15 separate sessions dealing with the individual modules of this system. These are intended to be interactive sessions to give you the opportunity for questions and discussion. We encourage you to participate fully. There also will be comment sheets available at each session, if you prefer to use them. You may hand them to your panel moderators or deposit them in the box at the registration table. Without your input, we will only be accomplishing half of our goal for this conference.

It is now my pleasure to introduce to you EIA's Acting Administrator, Lawrence A. Pettis. Mr. Pettis has been EIA's Deputy Administrator since 1985. In this position he is responsible for the day-to-day management of the organization that serves as the U.S. Government's primary source of comprehensive national energy statistics and objective energy analysis. Prior to coming to EIA, Mr. Pettis served as the Associate Deputy Assistant Secretary for the Strategic Petroleum Reserve in the Department of Energy's Office of Fossil Energy. In his nine years with the Strategic Petroleum Reserve Program, he held various management positions with responsibility for program planning, design construction management, crude oil acquisition and transportation, and energy preparedness activities.

Mr. Pettis has played an active role in the development of NEMS since its inception. He served as the Director of the Office of Integrated Analysis and Forecasting until my appointment in May of 1992. His wide energy background and his professional insights have added greatly to the NEMS development.

MR. PETTIS: Thank you, Mary.

Good morning to everyone here. It's my pleasure to be here this morning to welcome you to the Energy Information Administration's National Energy Modeling System Conference. I must admit that the Superbowl with Garth Brooks and Michael Jackson is a tough act to follow, but I think we do have an interesting two days planned for you.

I also might mention that we had over 400 people registered for the conference and I fear that some of those may have been Buffalo fans who are in remorse this morning.

The National Energy Modeling System, or NEMS as we refer to it, is grounded in the recognition of the importance of comprehensive analysis of the energy issues that lie before us. There must be extensive public dialogue on the alternative policy options if we are to balance our energy, environmental, and economic goals, and to work with our global neighbors towards a cleaner, more productive, and more secure energy future. Credible energy analysis and forecasting will provide the basis for making this an informed discussion.

In looking over the roster of attendees today, I was very pleased to see that we have a wide range of individuals represented from State and Federal government, business and industry associations, to academic and public interest groups. The representation is varied because energy is important to all sectors of our society. The diversity of views represented by this wide range of interests is a very important ingredient to this conference. As Mary mentioned, we are very interested in your inputs.

Most of you are acquainted with the data collection and analysis activities of the Energy Information Administration and our support for policymakers through data analysis and forecasting programs. Many of you already use the projections in the EIA's Annual Energy Outlook and International Energy Outlook and other reports that we produce.

Today's program is focused on the work underway in EIA to build on and improve the existing modeling systems used in support of these efforts. As you know, we are developing a new modeling system that will greatly enhance our mid and long-range forecasting capabilities.

EIA's analysis and forecasting system last underwent a major update and complete revamping in the 1980s. Developments in the energy markets over the past decade have dramatically changed many of the assumptions about energy supply, demand, and pricing embodied in EIA's forecasting system. It is important that these developments be incorporated into EIA's models. Certainly not the least of those changes is the movement from a highly regulated oil and natural gas industry to complete decontrol at the wellhead. But more recent industry changes such as the unbundling of pipeline services in the natural gas industry also need to be reflected. These important changes in the regulation of the industry by the Federal Energy Regulatory Commission were designed to foster competition. Their effects need to be taken into account in modeling for the future.

In the electric utility industry, demand-side management programs are becoming an alternative to building new generators to supply electricity. Also, non-utility generators have become an important source of electricity supply in recent years. This source is also expected to grow with the entry of a new class of suppliers, exempt wholesale generators, created by the Energy Policy Act of 1992, or EPACT, which will allow utilities to operate independent wholesale generating plants outside their service territories.

EPACT has brought about other changes as well. This legislation promotes the use of alternative fuels and revises energy efficiency standards for buildings. It simplifies the licensing process for nuclear power plants. It also promotes advanced coal use technologies. EPACT authorizes research to reduce consumption of imported oil, supports development of renewable energy technologies and grants U.S. oil and gas producers more favorable tax treatment for percentage depletion and intangible drilling costs.

The effects of this legislation will be felt across a wide range of energy-related industries with feedback effects throughout the economy. EIA's new modeling system, NEMS, as you will hear it referred to many times over the next two days, includes industry and regulatory developments such as these. It factors in new technologies. It focuses on environmental issues and it takes into account conservation efforts and renewable energy sources that will become ever more important in the future.

Starting with its current modeling system, EIA has been developing new models and making major changes to existing models so that they can include these developments as well as extend the forecast horizon. In the sessions that follow in this conference, you will be hearing about how we are trying to address these and other developments in energy markets. We hope the resulting NEMS will serve as a powerful tool to aid government and corporate policymakers alike in analyzing energy policy issues and planning for our energy future.

Many of you, the potential users of NEMS, have been involved from the start in developing this comprehensive modeling system. We want to ensure that NEMS will meet as many of your policy analysis needs as possible. To this end, we have held many meetings with groups of NEMS users, both inside and outside the Department of Energy. Your input has tremendous value as we move through the development phase and into the testing phase of NEMS. Our program today and tomorrow includes recognized experts in the modeling field who will be critiquing the progress we have made thus far and allows for a continuing dialogue about the direction we are taking.

I would like to give a special thanks to those of you who have agreed to be reviewers in the conference and have taken time from your busy schedules to do so.

It is gratifying to see all of you at the conference today. After all, it's February and this is not the Caribbean, so that's a pretty good sign that you're interested in the substance of this conference. So, we do thank you all for coming.

I would just like to close by reminding you that this conference is for you. It's our chance to tell you about what we're doing with NEMS, but it is your chance to give us feedback. We invite your comments, questions and ideas. Your input is important to us and vital to the success of this conference. Without you, the NEMS users, we cannot achieve our goal of developing the best modeling system that we can employ to analyze the energy issues that we face.

Thank you and I hope you enjoy the next two days of the conference.

MS. HUTZLER: Thank you, Larry.

THE NEMS CONFERENCE

OVERVIEW

February 1, 1993 - 8:30 a.m.

Overview of the National Energy Modeling System

Mary J. Hutzler, EIA
Andy S. Kydes, EIA

Logistics

Louise K. Bonadies, EIA

EIA

MS. HUTZLER: Our next agenda item is to provide you with an overview of NEMS, to tell you how we're building it in simple terms, and to provide you the schedule for its development. Today's conference is focused on the design of the system, not on the results from it.

As you can see from the next chart, the objective of NEMS is to illustrate the energy, economic, environmental and energy security consequences on the United States of various energy policies and assumptions by providing a forecast of alternative energy futures in the mid and long-term periods, using a unified system. In this vein, we are developing NEMS as a policy analysis tool rather than a forecasting tool. It will replace the system we currently use to produce the Annual Energy Outlook, which was originally designed in the early 1980s and which was built around the energy issues of ten years ago.

Although we have made modifications to that system, the current AEO forecasting system was not designed around the energy issues of the 1990s. Modeling methodologies too have changed which can better handle today's energy issues. Environmental issues have also come to the forefront in recent years with the passage of the Clean Air Act Amendments of 1990 and concerns over global warming. NEMS is being built to handle these issues.

The NEMS framework is displayed in this next chart. As you can see at the top of the chart, it starts with the macroeconomic activity module and the international energy activity module. These are fed into the integrating module which is the core of the system. These two modules (international and macro) are internal to the system. As a result, in NEMS, there will be feedback effects to the international oil market module as U.S. energy consumption levels for oil change.

If you take a look at the left-hand side of the chart, you'll see our supply modules. We have an oil and gas market module, a coal market module, a uranium market module, and a renewable fuels market module. These modules pass information, in particular fuel prices, to the conversion modules which are in the center of the chart and to the demand modules which are on the right-hand side of the chart. The conversion modules take the primary fuels and the prices for them and then produce prices for the converted energy sources, electricity, refined petroleum products and synthetic fuels. These too are fed into the demand modules. There are four of those, one for each of the end use sectors: residential, commercial, transportation and industrial. The end-use sector models then determine the quantities demanded of each of the energy fuels. This information is passed between these modules until a market equilibrium is reached. Although this chart shows a simple framework for NEMS, there is actually much more depth within each of these modules.

The next chart provides an example for the electricity market module which is composed of six submodules. At the top of this chart you will see that the non-utility generation supply submodule, the load and demand side management submodule and the electricity, transmission and trade submodule pass information to each of the three major submodules in the electricity market module. The non-utility generation supply submodule provides information on independent power producers and exempt wholesale generators, growing sources of electricity. The load and demand side management submodule provides information on DSM programs and their impact on utility load shapes. The electricity transmission and trade submodule provides

The National Energy Modeling System

Mary J. Hutzler
Energy Information Administration

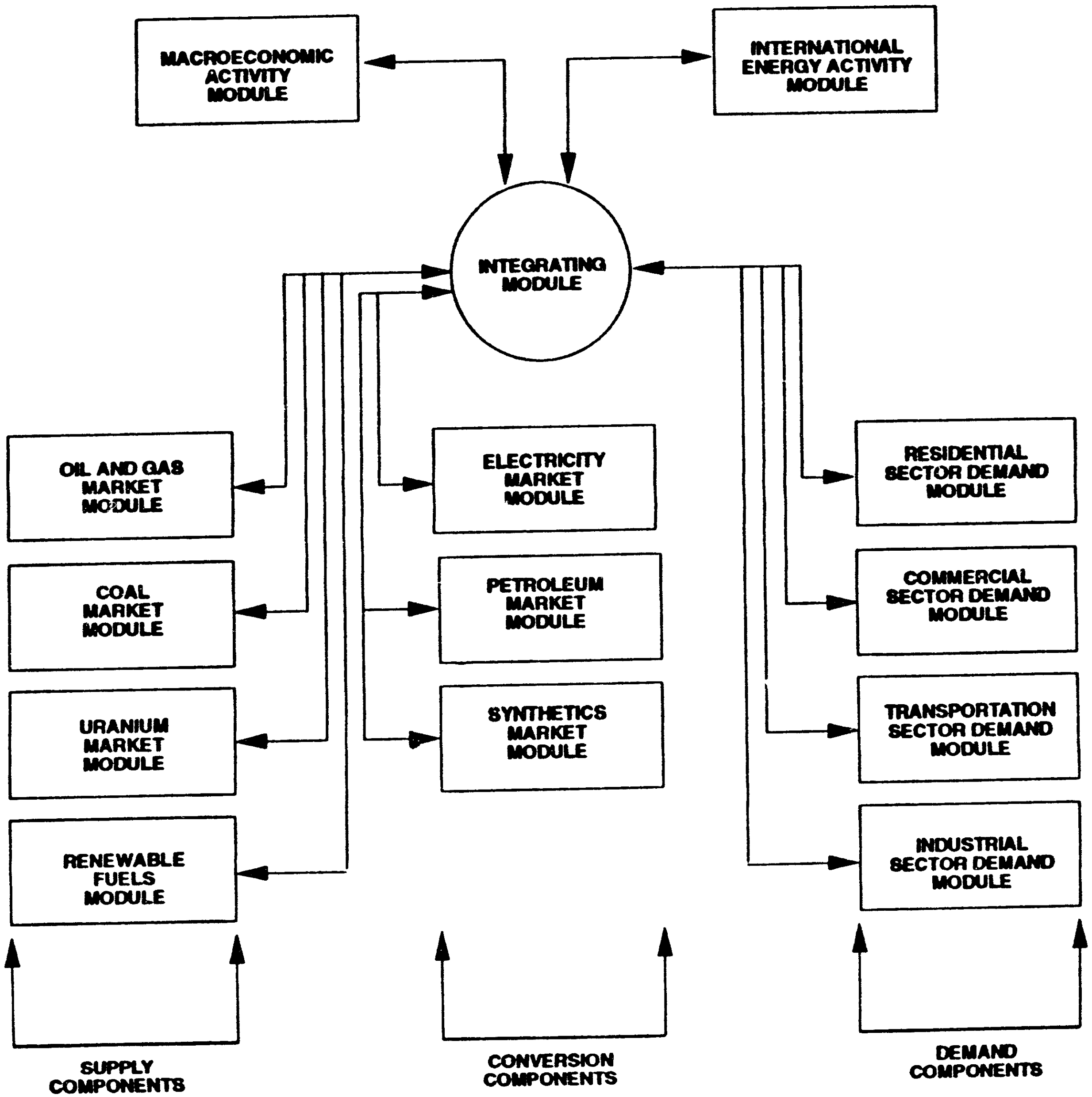
February 1, 1993

OIAF 5/92

Objective of NEMS

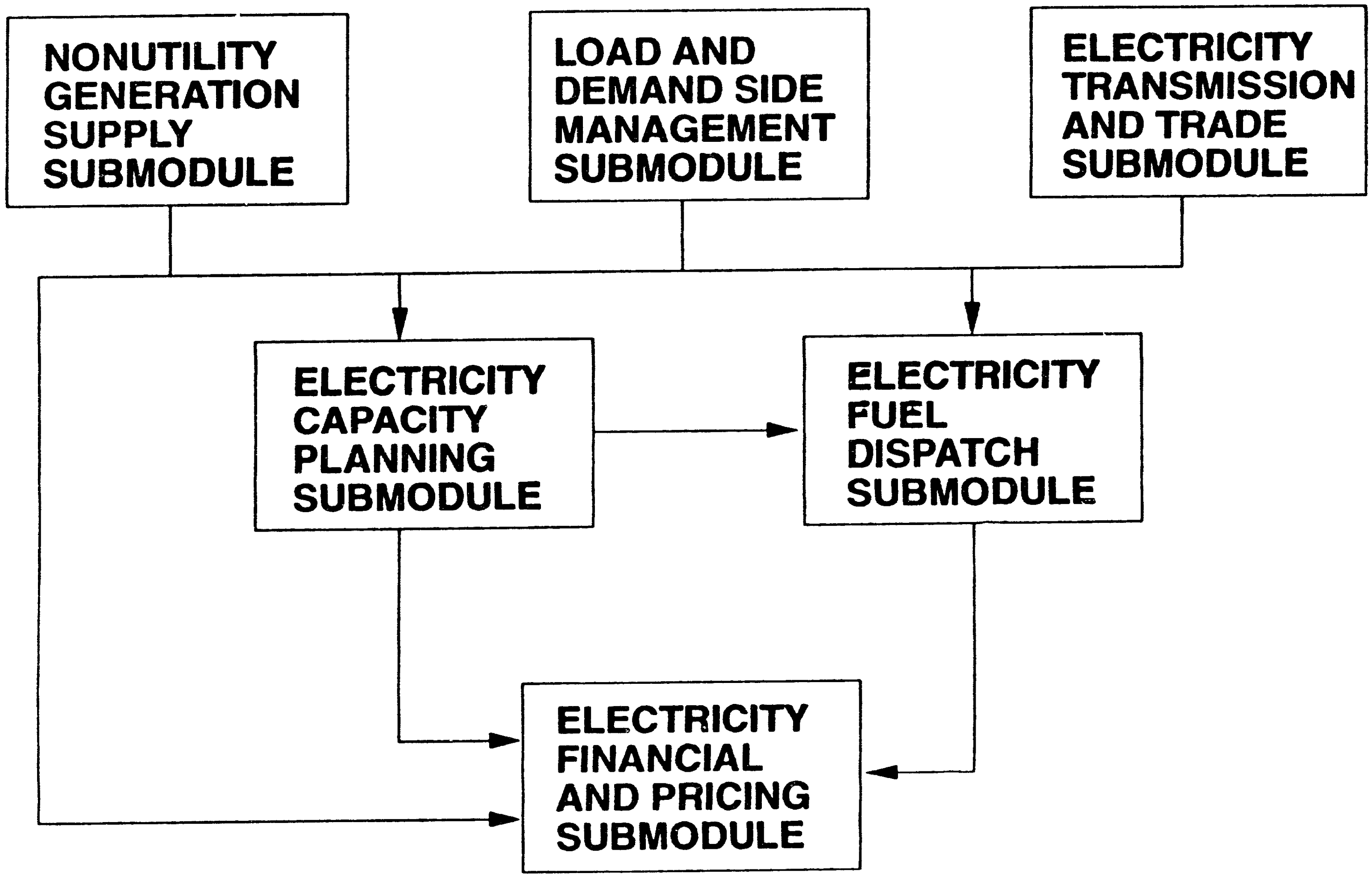
To illustrate the energy, economic, environmental, and energy security consequences on the United States of various energy policies and assumptions by providing forecasts of alternative energy futures in the mid- and long-term periods, using a unified modeling system.

NEMS Framework



OIAF 5/92

Submodules of the Electricity Market Module



information on the regional trade of electricity between utilities and on power coming from Canada and Mexico.

The information then is used by the two models that you see in the center. The electricity capacity planning submodule determines the amount of capacity that utilities will build once it takes into account the anticipated levels of DSM programs, purchases from both foreign and domestic utilities, purchases from non-utilities, capacity that will be retired or life extended, and capacity that is needed to maintain a reliable system.

The electricity fuel dispatch submodel decides what capacity should be dispatched in what order based on economic reasons and based on the level of demand. Both of these models make their decisions subject to the provisions of the Clean Air Act Amendments of 1990.

Finally, this information is fed into the electricity finance and pricing submodule which determines the prices that are passed to end use consumers.

. We are building NEMS with a number of attributes in mind. These attributes are very closely related to those published in the National Academy of Science's report on NEMS which was released early in 1992. First of all, we want NEMS to be modular. ..'e want it to have the ability to plug in other modules besides the ones that you will be hearing about today. We want it to be transparent. That is, we want the logic to be explicitly defined and we want the implementation to be through structured design. We are also planning to have a regional structure that's appropriate to the specific industry.

For example, you can see in this next chart that for the electricity supply regions, we are using the North American Electric Reliability Council regions and subregions. In this case, we have detail on certain state areas such as California, Florida and New York. There is also regional structure to the other supply regions. We have 13 oil and gas supply regions, 16 coal supply regions, and 12 natural gas transmission and distribution regions. The regional structure of the Integrating Model and the Demand Models is the nine Census divisions.

The time horizon for NEMS is twofold. We're planning a mid-term model that goes to the year 2015 and also a long-term model that will be going out 40 to 50 years into the future. NEMS is also being designed with a foresight capability that allows the user to select a system-wide assumption. That assumption can be either myopic, adaptive, or perfect foresight. In case the user does not want to specify an assumption on foresight, the model will have a default assumption that is the best fit for the industry that it is analyzing.

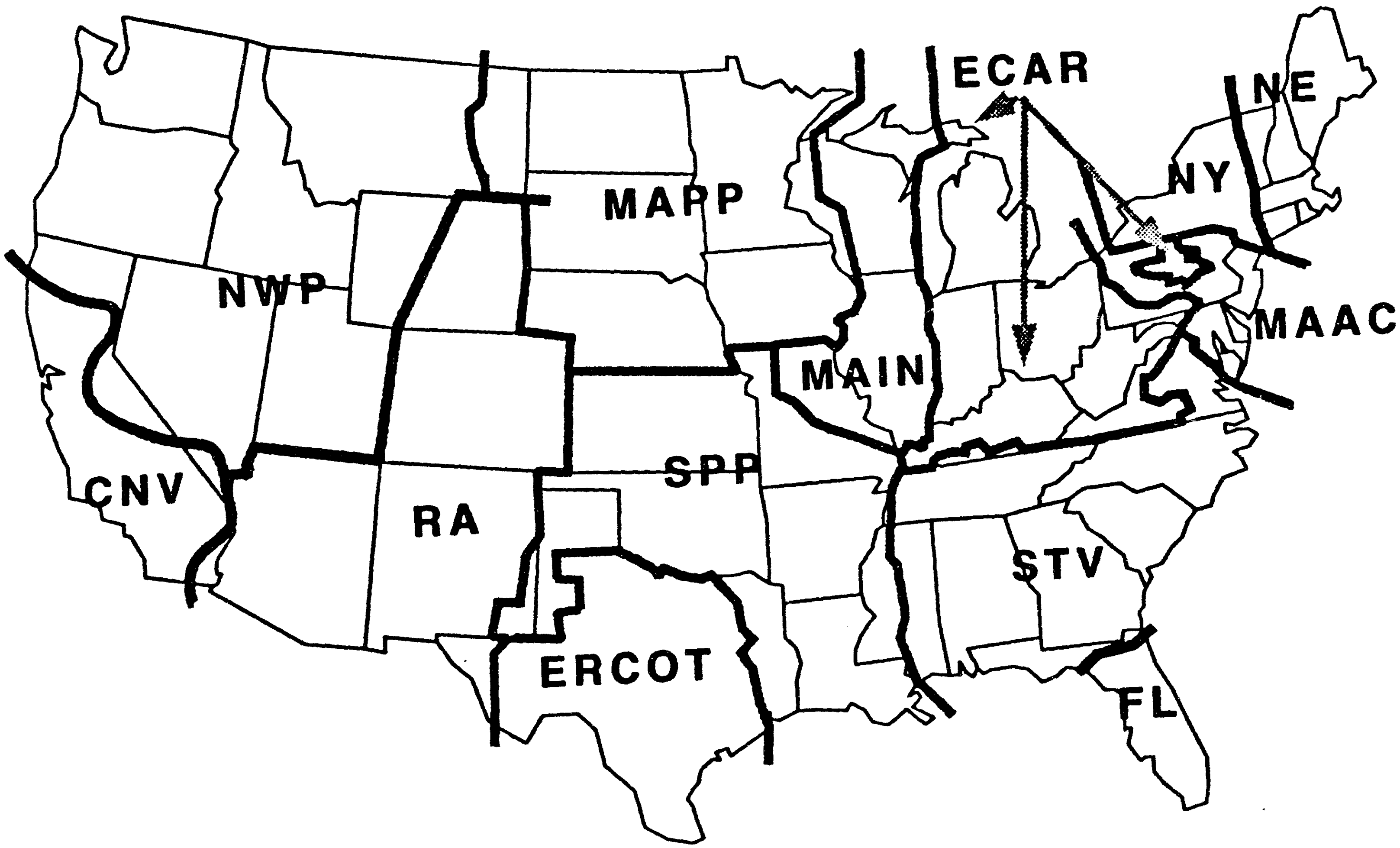
Finally, on uncertainty, in the past we have used scenario analysis in our reports to deal with this issue. However, in line with the National Academy of Science's report, we are researching an expanded approach to the issue of uncertainty.

Regarding enhancements to NEMS over our existing model, we first have greater structural detail, such as an embedded refinery model and fuel transportation networks in several modules. You'll be hearing about this throughout today's and tomorrow's sessions. Second, we have internalized factors that have previously been external to our modeling system. These include such things as the international oil market module and renewables, which were

Attributes

- **Modular:** Ability to plug in different modules
- **Transparency:** Logic explicitly defined and implementation through structured design
- **Regionality:** Appropriate to the specific industry
- **Time Horizon:** Mid-term (20-25 yrs) and Long-term (40 yrs)
- **Foresight:** Ability to use a system wide assumption
- **Uncertainty:** Researching an expanded approach

Electricity Supply Regions of the United States



OIAF 9/92

Enhancements Over Existing Model

- Greater Structural Detail
- Internalization of Factors Previously External (eg. International and Renewables)
- Environmental Capability
- Representation of New Technologies
- Long-Term Forecasting Capability
- Reduced Form Modules for Faster Turnaround

exogenous to our old system and which now will be internal to NEMS. This allows us to speed up the analysis process on issues that affect these factors.

We are also adding environmental capability into NEMS. We will be tracking six emissions: carbon, carbon monoxide, carbon dioxide, sulphur dioxide, nitrogen oxides and volatile organic compounds. We will be able to place a tax on emissions and also constrain environmental emissions within the system.

The next new feature is the representation of new technologies. For example, in the utility sector, we will be representing clean coal technologies, new nuclear technologies, gas technologies and renewable technologies.

The long-term forecasting capability is also an enhancement to our system. The long-term capability is there to analyze issues dealing with the environment, new technology penetration, resource depletion, and capital stock turnover.

. Finally, we're planning to do reduced form modules for faster turnaround. These are simple representations of our mid-term model components. The reduced form modules can be used in lieu of a specific mid-term module when that sector is not being the focus of the analysis.

The next question I'd like to answer is: What is the schedule for the development of NEMS? We started this effort in January of 1992. Our first phase was to design the system and document it in 39 component design reports. Phase 1 of that process is now complete and there are 24 component design reports available.

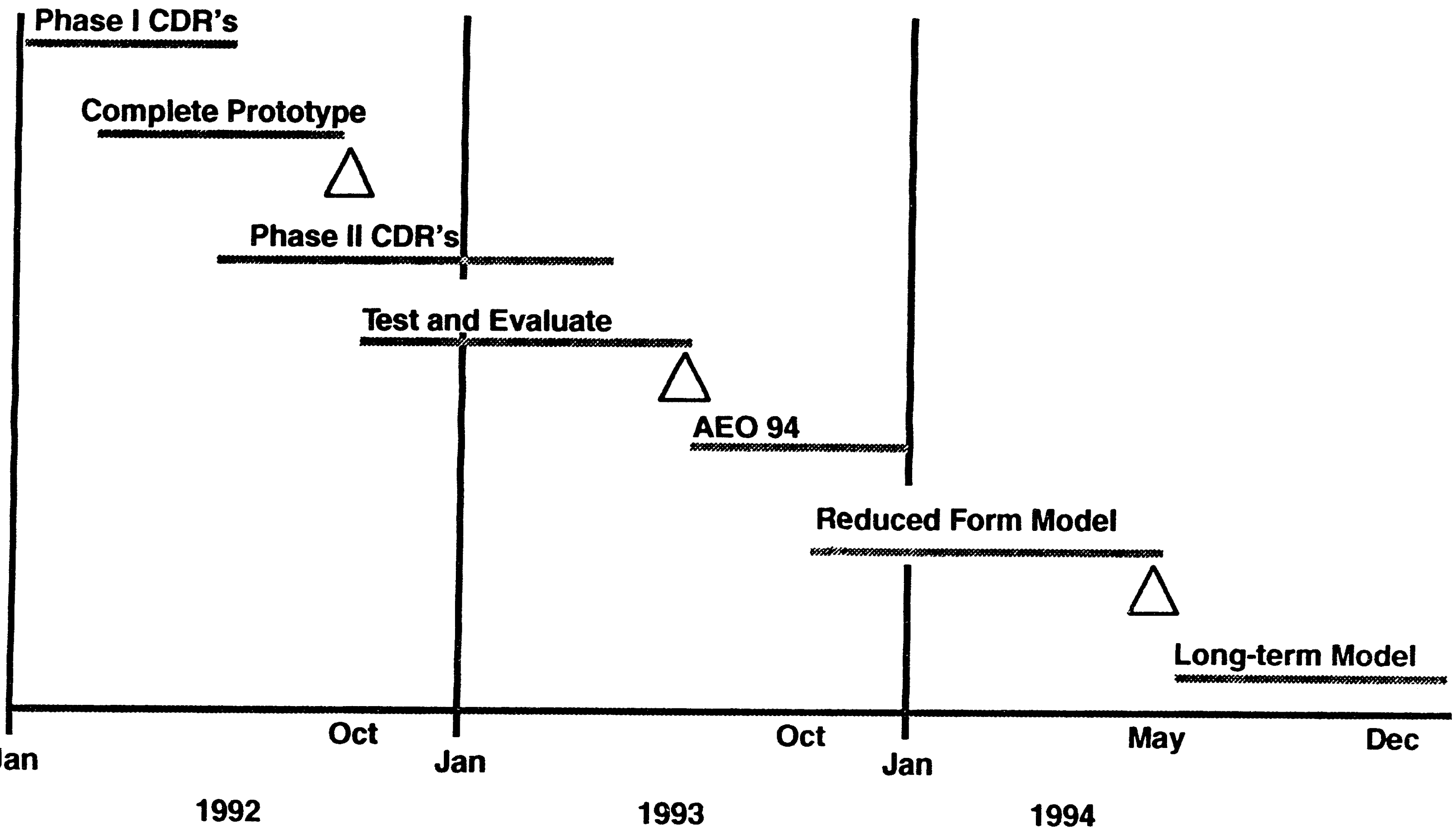
We then worked on a prototype system. That system is designed as a testbed that contains all the linkages between the individual component modules so that as these modules are developed, we can add them to the system and we can test them.

The next phase was phase 2 of our component design reports (CDRs). There are 15 CDRs in this phase. We've now completed eight of those. The remaining seven are all in draft form. We are currently in the implementation, test, and evaluation mode of the system. This will be ongoing until early summer when we will begin using NEMS to produce the forecasts for the Annual Energy Outlook 1994. We will run NEMS concurrent with our current AEO modeling system so that we can contrast and review the results between the two systems. Once that's done, we will begin our effort on the reduced form modules, which are scheduled for May of 1994, and our effort on the long-term module, which is scheduled for the end of 1994.

These modules will all be available to you. We are planning to have PC versions of the individual modules. Many of those will be available by the end of this year. We're also planning to eventually move the integrated system to a PC environment or a work station environment and that will also be available to you.

In summary, the status of the NEMS mid-term model is that we have 32 CDRs complete. These are on a table outside and you can take a look at them. There's also an order form in your registration packet that you can fill out and we will be happy to mail the CDRs to you.

NEMS Development Schedule



Seven CDRs are in progress and should be available within the next month or so. The prototype is complete, so all the linkages between the individual modules have been established. We now have a NEMS national level report writer that consists of 16 tables. There are an additional 21 tables that are under development and should be available over the next few months. Each of the individual modules are in various stages of development. The target date for completion is April 30th, at which point we will start our detailed integrated testing.

The next issue is: What input have we gotten to this process? First of all, I want to tell you about the Users Group that we established. The first meeting was held on July 1, 1992. At that meeting, we laid out the goals for the Users Group and we prepared for this conference. The members of the Users Group represent industry trade associations, such as the Edison Electric Institute, the Gas Research Institute and the National Association of Manufacturers. We also have representatives from the Council of Economic Advisers, Congressional organizations such as the Office of Technology Assessment, environmental groups such as the Tellus Institute, and Federal government agencies, such as the Departments of Agriculture and Interior and the Office of Management and Budget.

We held a second meeting on September 24. That meeting was a day-long meeting of briefings on each of the different components of NEMS. Finally last month, we had demonstrations of five of the different NEMS submodules. Later this spring we will be demonstrating additional submodules to the users group. We have certainly learned and gained from their participation and their interaction in this process.

Other outreach functions have dealt with working closely with the Department of Energy. We have organized ten working groups, which meet monthly to keep the Department abreast of what we're doing on NEMS and also to brief them on the design. We also provide them with copies of the component design reports as they are released and solicit their comments.

We've received substantial technical review through a number of sources. First, EIA's independent expert review program, which is set up and administered by the Office of Statistical Standards in EIA, has provided us with expert reviewers in each of the areas. These experts are following the process through from initial design to implementation, to testing, to the final documentation. Stanford University's Energy Modeling Forum has also provided general oversight and has provided experts in particular fields to work with us. We have also sent our component design reports out to academics working in the area and asked them for their comments. Users outside of DOE have participated in the process through our users group and also by reviewing the CDRs.

At this point in time, we have distributed over 5,000 component design reports to analysts, modelers, and users, both within the United States and in foreign countries, including Canada, Mexico, Yugoslavia, Israel, the OPEC countries, China and Japan. A number of these have been solicited by people who are interested in the NEMS process as the result of our NEMS brochure. A copy of the brochure is in your registration packets.

Our latest NEMS outreach activity is this conference. This conference, which is designed to tell you about the NEMS mid-term model, is for you. We want you to understand NEMS. We want you to use NEMS, either directly or by using the results we publish. We want your

Status of NEMS Mid-term Model

- 32 CDR's complete
- 7 CDR's in progress
- Prototype complete
- NEMS national-level report writer (16 tables) available
- Individual modules in various stages of development

NEMS Users Group Meetings

- Initial meeting on July 1, 1992

  Trade Associations (e.g., Edison Electric Institute, Gas Research Institute)

  Council of Economic Advisers

  Congressional Organizations (e.g., Office of Technology Assessment)

  Environmental Groups (e.g., Tellus Institute)

  Federal Government Agencies (e.g., Office of Management and Budget).,

- A day-long briefing on September 24, 1992

- Demonstrations of 5 NEMS modules on January 14 and 15, 1993

NEMS Outreach

- Department
  - Monthly Working Group Meetings
  - Review of Component Design Reports (CDR's)

- Technical
  - EIA's Independent Expert Review Program
  - Energy Modeling Forum
  - Academic Review of CDR's

- Users Outside DOE
  - Users Group
  - Review of CDR's

- NEMS Conference

knowledge and expertise. We want you to participate in this conference, to tell us if we're on track in designing NEMS or whether we should be making changes to our design.

Although this conference is focused on the mid-term design of NEMS, I did want to give you a snapshot of our future plans regarding the reduced form and the long-term models and on our work on uncertainty.

Andy Kydes, who is my senior technical advisor, will provide you with that overview. Dr. Kydes performs quality assurance for the design and development of NEMS and other matters relating to mid and long-term forecasting and analysis, including the development of our recently published Annual Energy Outlook 1993.

Dr. Kydes came to EIA last year from the Consolidated Edison Company of New York where he served as the Manager of Forecasting, Planning and Financial Matters for the Gas Supply Department and was responsible for the gas working group that developed Con Edison's integrated energy strategy.

Dr. Kydes has served as an advisor to the Gas Research Institute and the American Gas Association. He has managed policy studies conducted by the Argonne National Laboratory for the Department of Energy.

He is no stranger to EIA's modeling efforts. He served as the Director of the Energy Economy Systems Analysis Division at Brookhaven National Laboratory's National Center for the Analysis of Energy Systems where he was heavily involved in the design, development, and implementation of models for EIA.

DR. KYDES: Thank you and good morning.

What I'd like to do this morning is to summarize some of the other NEMS-related activities that we've recently initiated. We believe these activities are going to enhance our ability to perform energy policy analysis using the NEMS system. I also want to emphasize that the activities that Mary Hutzler referred to were recommended strongly by the National Research Council.

These activities include efforts to characterize uncertainty in NEMS, efforts to model, measure, and constrain certain energy-related activities, efforts to develop reduced form models for those modules in NEMS that are going to be too slow, and efforts to develop a long-term modeling capability.

In the uncertainty area, we all recognize that models are simplified descriptions of reality. In fact, there are a number of factors that affect a model's accuracy. I've listed what I think are some of the more important ones on the screen here (e.g., model structure, omission of relevant factors, poor data). These factors certainly introduce uncertainty in the model forecasts wherever they're introduced. The approach we've taken to characterize the uncertainty in the NEMS modules is to develop and test our methodologies regarding characterizing uncertainty first in those IFFS modules that have similar structure to the NEMS modules that we're building. Then as the NEMS modules are completed, we would replace the IFFS modules by

NEMS OVERVIEW
THE LOOK AHEAD

Andy S. Kydes
Energy Information Administration

February 1, 1993

OIAF 1/93

OTHER NEMS-RELATED MODELING

- CHARACTERIZE UNCERTAINTY IN NEMS
- MONITORING ENVIRONMENTAL EMISSIONS (SO_2, CO_2, NO_x, VOC, CO, C)
- REDUCED FORM MODELS
- LONG-TERM MODELING

FACTORS AFFECTING MODEL ACCURACY

- OVERALL MODEL STRUCTURE
- OMISSION OF RELEVANT FACTORS
- LACK OF DYNAMICS IN MODEL STRUCTURE
- USE OF INHERENTLY POOR DATA AND INFORMATION

the NEMS modules and continue the methodological refinements.

The project to date is focused on characterizing uncertainty in model outputs with respect to the model inputs. There is certainly uncertainty due to model form, model structure, and even coding errors that creep into the development; they are certainly going to be an important part of our research. We simply haven't gotten to them yet, primarily because the NEMS modules haven't been ready yet.

To start the uncertainty analysis, we chose two of the IFFS module structures (a linear programming module and an econometric module) to test our methodologies. After we got partway through the LP analysis, we discovered that the optimizer that we were using was not a full featured optimizer and we needed some post optimality information to continue the development. Therefore we decided to postpone that development until the new NEMS optimization package and the NEMS LP model were ready to be integrated.

Now, before I go on, let me identify for you what I mean by an "important output" of the model, a working definition if you will. An output is important if it is important from a policy perspective, but at the same time, since we're talking about uncertainty, it needs to be sensitive to at least one of the model inputs.

We have three goals with respect to the uncertainty effort. The first is to identify the important drivers that determine the important outputs. The second is to develop an efficient experimental design technique. The reason for this is fairly obvious. If any of you have looked at the component design reports, there are thousands of inputs and thousands of outputs and we expect substantial computer resources to be required to solve any of these problems. So, efficiency is, in fact, an absolute necessity here.

Finally, we need to quantify and relate the uncertainty of the output variables to the uncertainty of the input variables.

Before I summarize all of the accomplishments that we have made with regard to characterizing uncertainty in linear programming models, I want to make two observations that are useful here. The first is that in a linear programming model, the objective function is typically not an important policy variable. It is simply the criteria by which the important policy variables are determined. That's its importance.

Secondly, cross variable effects are typically not available from a linear programming solution. We need to do this kind of experimental design in order to be able to get at that. What we have accomplished in the linear program characterization effort is that we've identified two successive screening techniques that we would use to reduce or identify the most important inputs to the model before we go forward with further experimentation.

Having done that, the next logical step would have been to use a stratified fractional sampling technique, an efficient sampling technique like Latin hypercube sampling, on the remaining inputs; that is, on those important inputs to develop our uncertainty analysis.

As I mentioned, we didn't have the opportunity to finish that analysis, but we do have

UNCERTAINTY IN MODEL INPUTS AND OUTPUTS

Uncertainty in Inputs

Unbiased And Independent Inputs (By Assumption)

Latin Hypercube Sampling Plan on Inputs

Inputs 1,	m samples
Inputs 2,	m samples
Inputs n,	m samples

m vectors input of dimension "n"

NEMS
MODULE

Implied Output Distributions

Output 1 Output 2 Output 3... Output 4

Uncertainty in Outputs

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GOALS OF CURRENT UNCERTAINTY EFFORT

- IDENTIFY IMPORTANT INPUTS OF NEMS WITH RESPECT TO IMPORTANT OUTPUTS
  - ASSUMPTIONS
  - DATA

- DEVELOP EFFICIENT EXPERIMENTAL DESIGN TECHNIQUES

- RELATE UNCERTAINTY OF IMPORTANT OUTPUT VARIABLES TO UNCERTAINTY IN INPUT VARIABLES AND ASSUMPTIONS

UNCERTAINTY APPROACH FOR LP'S

- VALUE OF OBJECTIVE FUNCTION IS UNIMPORTANT
- LP's DO NOT PROVIDE CROSS VARIABLE EFFECTS
- PHASE I: COARSE SCREENING TO DETECT IMPORTANT INPUT VARIABLES
- PHASE II: DETERMINE RANGE OF INSENSITIVITY
- USE STRATIFIED FRACTIONAL SAMPLING (LHS) ON REMAINING INPUTS

something I think that we can show you on the econometric side. On the econometric side, we tested the U.S. Industrial Energy Demand Model, which was used for the 1993 Annual Energy Outlook. It runs integrated within the IFFS system and we also have a stand-alone version of it which is convenient. It is a mature system, transparent, very well documented and all of the statistics are available that were derived during the estimation process.

For this experiment, we identified three sources of uncertainty -- namely the model specification, coefficient estimation and the exogenous inputs. In this case we have identified the variances from each of these three sources of uncertainty. This is an example of the kind of output we're trying to prepare via uncertainty analysis -- to communicate to policy makers how the outputs are influenced by errors or uncertainties on the input side.

Since we assumed that the random variables here were independent, and because of the particular model structure in the econometric model, it turns out that the variances or the uncertainties are approximately additive, which was very nice.

On the environmental side, we're incorporating some environmental modeling, as Mary Hutzler alluded to earlier, and we're doing it for three reasons. We want to incorporate current law and legislation that has or imposes environmental restrictions and also laws that provide efficiency incentives. What I'm referring to obviously are the Clean Air Act Amendments of 1990 and the Energy Policy Act of 1992. We also feel that we need to be prepared to analyze the impact of imposing environmental or emissions taxes or constraints on the energy system. So, that's the second reason. Finally, because there is a growing concern that energy-related activities are contributing to global warming, or at least to the risks of global warming, we felt that, at least from a policy perspective, we ought to provide the option to limit system-wide emissions within NEMS system. So, we're doing that.

We are implementing an emissions accounting system in NEMS to measure the six emissions (SO_2, NO_x, VOC, CO_2, CO, C) that Mary Hutzler has already mentioned by sector, by fuel type, and by energy process. Let me add parenthetically we're talking about combustion applications for the most part here. We are also in the process of implementing and testing an option to limit system-wide emissions of carbon dioxide. I want to emphasize that it's an option which is not going to be imposed unless it's requested for policy analysis. The utility and refinery sectors have special structures. Components of them happen to be linear programming models, and that means that it's particularly easy in those instances to limit any of our emissions from those sectors to any level we want. The Clean Air Act emissions and the allowance trading provisions, of course, are going to be directly incorporated within the NEMS model.

Let's get on to reduced form models. What's a reduced form model? Probably most of you know, but just to be sure, it is a small model which is derived typically from a larger model, or the information from a larger model. It's intended to capture the essential features of the larger model. I want to emphasize a very important point -- that replication or near-perfect replication of the behavior of the larger model is neither feasible usually nor, in our case, necessary for the purposes that we intend to use reduced form models.

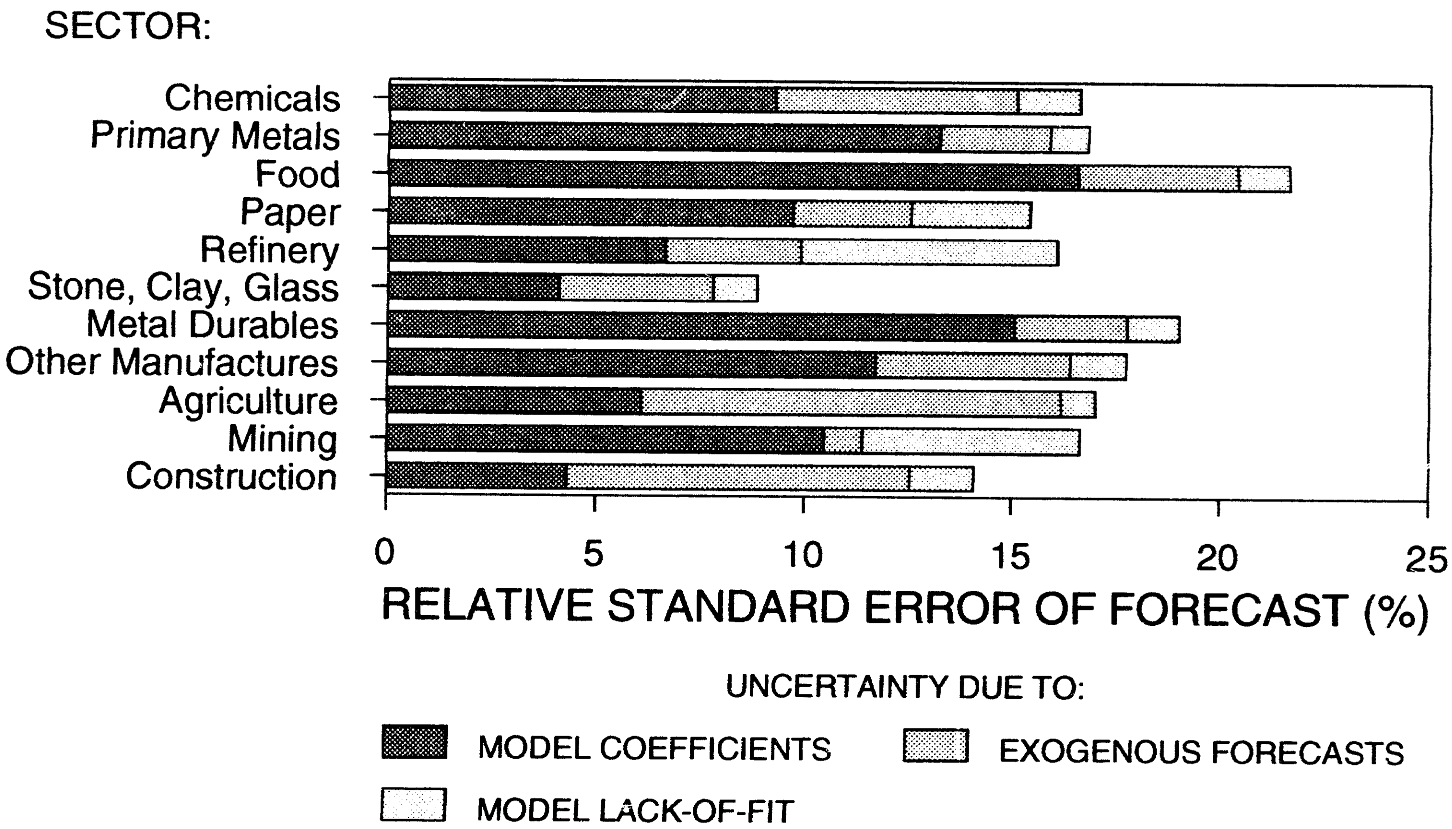
In the NEMS context, a reduced form model, however, has to be "plug-compatible" with the large model in order for us to be able to easily swap them with the large models as needed.

UNCERTAINTY ANALYSIS IN ECONOMETRIC MODELS

- SOURCES OF UNCERTAINTY EXAMINED AND MEASURES

  - MODEL SPECIFICATION - LACK OF FIT OF THE ESTIMATED EQUATION
  - COEFFICIENT ESTIMATION - STANDARD ERRORS
  - EXOGENOUS INPUTS - INTERRELATED COVARIANCES

SOURCES OF UNCERTAINTY IN FORECASTS OF TOTAL MAJOR FUEL DEMAND IN 2010, BY SECTOR



ENVIRONMENTAL MODELING INCENTIVES

- CURRENT LAWS (CAAA AND EPACT OF 1992)

- GLOBAL WARMING CONCERNS

- NEED TO ANALYZE IMPACTS OF EMISSIONS TAXES (OR CONSTRAINTS) ON ENERGY USE PATTERNS, ECONOMY,AND ENVIRONMENT

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ENVIRONMENTAL MODELING

- EXPLICIT ACCOUNTING OF SO_2, CO_2, VOC, NO_x, C, CO EMISSIONS
  - MEASURE ENERGY RELATED EMISSIONS (PRIMARILY COMBUSTION APPLICATIONS)
- NEMS MODELING APPROACH ALLOWS SETTING ANNUAL LIMITS ON ANY EMISSION: ONLY CO_2 LIMIT WILL INITIALLY BE IMPLEMENTED AND TESTED
- UTILITY SECTOR CAN SET LIMITS ON ANY EMISSION: CONSTRAINT ON SO_2 WILL BE SET TO ADHERE TO CAAA
- PRICE PENALTY ($/LB OF EMISSION) IS PRINCIPLE MECHANISM TO SATISFY EQUILIBRATED SOLUTION SATISFYING EMISSION CONSTRAINT

USES OF REDUCED FORM MODELS

- FOCUS ON QUICK TURN-AROUND POLICY ANALYSIS
  - STUDY FOCUSES ON LIMITED SECTOR(S)
  - STUDY FOCUSES ON SINGLE FUEL

- CONVERGENCE ENHANCERS
  - START WITH SMALL FAST MODELS TO GET CLOSE
  - SWITCH TO FULL SYSTEM TO GET FINAL

- UNCERTAINTY ANALYSIS (POSSIBLY)
  - RAPID TURN-AROUND ENHANCES ANALYSIS OF ERROR
  - CAVEAT - UNCERTAINTY IN MODEL APPROXIMATION MAY SWAMP UNCERTAINTY ON LARGE MODEL SYSTEM

REDUCED FORM MODELS

- SMALL MODEL DERIVED FROM PSEUDO-DATA FROM THE LARGE MODEL

- CAPTURE THE ESSENTIAL FEATURES OF THE LARGER MODEL

- PERFECT REPLICATION OF LARGE COMPLEX MODELS IS USUALLY NOT POSSIBLE OR NECESSARY

- IN NEMS CONTEXT, REDUCED FORM MODEL MUST BE "PLUG-COMPATIBLE" -- SAME INPUT SET AND SAME OUTPUT SET

Only models which are deemed to be too slow are going to be candidates for reduced form modeling. If models are fast enough, we're going to leave them alone.

Why do we bother with reduced form models? Well, we have three reasons really. The first is that we want to develop a quick turnaround energy policy analysis capability. The second is that we want to optimize the convergence of the NEMS system so that it will be more used and useful to the people who want to use it. Third, and this is something that I guess I have a little bit of reservation of whether we'll succeed or not, is the possibility of using the reduced form models to develop a characterization of uncertainty in the integrated NEMS system.

Let's take a look at an example of a quick turnaround policy analysis application. You've all probably seen energy tax proposals in newspapers and you may have also seen the disclaimer in the Sunday's Times that gasoline taxes and a broad based carbon tax are not going to be part of this Administration's economic package. Now, that's a quote from the New York Times. I can't tell you whether it's going to be true or not. But in any case, let's ask the question, "What's the impact of imposing a gasoline tax on, say, gasoline consumption or oil imports, vehicle efficiency standards, and on various components of the economy like unemployment and disposable income?" If you want to apply it to the national debt, "What will it do to the national debt and GNP?" Of course I've omitted the fact that it has impacts on emissions that cause smog.

Well, presumably in this situation, what you would do is take the full transportation, full refinery and the full economic components of the NEMS system but then integrate those with the reduced forms for everything else and run the scenario through the NEMS system. That would give you, if you're pressed for time and needed a quick turnaround, a reasonably accurate answer.

Now, there are two general approaches that I know of for developing a quick approximate solution to a large model. The first approach is identified as econometric or statistical. The second is identified as a non-parametric approximator. The econometric or statistical approach was, I believe, popularized by Dr. Griffin in the 1970s. The idea here is that you would use a large model as a source of "data" by systematically changing its inputs and running those through the large model until you developed a large "sample data set." Some people call this "othogonal sampling." Then you'd use your standard regression techniques to develop the simple model you're interested in. That's a fairly general description of it. Most of us are familiar with that approach.

The second approach which is not as familiar, I would bet, is the non-parametric approximator approach. The non-parametric approximator shares the first step with the statistical approach, at least conceptually. That is, you would build a history of relationships by running a model over the input sample space that you're interested in to develop a history of inputs and corresponding outputs. But in this particular case, whenever you wanted to get the approximate solution to a new scenario, you would try to find the closest previously run scenarios to the one that you're seeking a solution for and properly weight the corresponding outputs to get the new estimate. So, it's a two step process. Find the closest previous solutions or scenarios and then find the right weights to combine the corresponding outputs.

USES OF REDUCED FORM MODELS

- QUICK TURN-AROUND POLICY ANALYSIS

  EXAMPLE: GASOLINE TAX STUDY

  POTENTIAL MAJOR IMPACTS ON

  - TRANSPORTATION SECTOR
  - REFINERY OPERATIONS
  - ECONOMY

  SECONDARY IMPACTS ON THE REST OF THE U.S. SYSTEM

  - USE REDUCED FORM MODELS FOR THE REST OF THE SYSTEM

REDUCED FORM MODELING

- PRODUCED REDUCE FORM MODELS ONLY IF ORIGINAL NEMS MODULE IS TOO SLOW

- ECONOMETRIC/STATISTICAL
  - RUN LARGE MODEL SYSTEMATICALLY -- DEVELOP INPUT/OUTPUT "DATA" (PSEUDO-DATA)
  - USE REGRESSION TO DEVELOP SIMPLE MODELS

- NON-PARAMETRIC APPROXIMATOR
  - KEEP PREVIOUS SOLUTIONS
  - ESTIMATE OUTPUT RESULTING FROM A NEW SCENARIO BY FINDING CLOSEST EXISTING SOLUTIONS AND COMBINING THEM
  - USE SMALL LP TO FIND WEIGHTS AND SOLUTIONS TO COMBINE

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Well, a rather nice, simple linear programming problem will give you all those answers. For any of those who are interested, I do have at least one copy of the equations, if you'd like to look at them. Or I can send them to you if you'll leave your names.

In any case, what sort of comparisons can we make between these two approaches from the point of view of speed and accuracy? From the point of view of speed, it turns out that the non-parametric approximator is a little bit slower. I want to emphasize that we don't have a lot of experience yet. This is simply anecdotal evidence that I'm quoting. But it looks like the non-parametric approximator is a little bit slower, on the order of 10 to 20 percent, but very fast in any case. Certainly fast enough.

How do they do from the point of view of accuracy? Well, when we're looking for a solution to the large model, where the large model is well behaved, smoothly varying, relatively stable, then both approaches do very well. In the case where we're trying to find a scenario where the large model is particularly sensitive to changes in some inputs, it turns out that the non-parametric approximator seems to do better and sometimes much better than the statistical approach. I want to emphasize that this is anecdotal evidence. It is a very small sample size. What we intend to do over the next three or four months is to identify which of the NEMS modules are too slow and then to test both techniques essentially on each of these modules to see which ones we're going to use. The decision process is going to require a compromise between speed and accuracy. As Mary Hutzler has mentioned, we intend to complete that work by May of 1994.

In the long-term modeling area, the effort is aimed at developing an action plan. We're really at the very beginning of this process. The long-term for us is 25 years and beyond and it's characterized by at least five facts. And I'm sure you could add your own to these facts.

But certainly, in my mind, uncertainty dominates both the inputs and the outputs of any forecast during this period. However, there are some important factors that we can and would want to deal with. Over the long-term period virtually all of the equipment that we have today will have been retired. This means there's a significant opportunity for new technologies to play a major role in the evolution of the future energy-economy system. If history is any guide, we're going to see fundamental structural changes in the economy. We should see in the long term the beginnings of depletion of exhaustible resources. It would be my guess that environmental constraints and social concerns may also begin to limit our energy choices in the future.

There are a lot of key issues in the long-term, but I think if I were to pick the one that's most important, I would say that it's the role of new energy technologies in the energy-economy system. New technologies are likely to play a critical role in the long-term in ways which directly affect the energy economy and environmental balance. New technologies will affect labor productivity, our success at controlling emissions, the cost of producing our goods and services in the economy, and fundamentally then, if you take all those together, new technologies are going to affect our competitiveness in the international markets.

So, what have we done? We've basically identified a preliminary strategy for developing the long-term model capability. That strategy has the steps that I'm sure all of you have thought

DESIRABLE LONG-TERM MODEL FEATURES

- CAPTURE ENERGY - ECONOMY INTERACTIONS (ENERGY COSTS AFFECT ECONOMIC GROWTH AND CAPITAL FORMATION)

  CAPTURE STRUCTURAL CHANGE IN ECONOMY. (CHANGES IN THE MIX OF GOODS AND SERVICES PRODUCED IN THE ECONOMY)

- CAPTURE COST-EFFECTIVE CONSERVATION

- CAPTURE INTERFUEL SUBSTITUTION POTENTIAL

- CAPTURE MARKET PENETRATION OF NEW ENERGY TECHNOLOGIES

- CAPTURE ENVIRONMENTAL CONSTRAINTS ON EMISSIONS

- CAPTURE FUNDAMENTAL SHIFTS IN ENERGY SUPPLY SOURCES

CHARACTERISTICS OF THE LONG-TERM

- MOST OF CURRENT EQUIPMENT WILL BE RETIRED - POTENTIALLY SIGNIFICANT IMPACT OF NEW TECHNOLOGIES
- POTENTIAL FOR FUNDAMENTAL STRUCTURAL CHANGES IN THE ECONOMY
- POTENTIALLY SIGNIFICANT DEPLETION OF EXHAUSTIBLE RESOURCES
- ENVIRONMENTAL CONSTRAINTS
- UNCERTAINTY DOMINATES INPUTS AND FORECAST OUTPUTS

KEY LONG TERM ENERGY ISSUES

- ROLE OF NEW ENERGY TECHNOLOGIES PLAY ON

  - LABOR PRODUCTIVITY
  - EMISSIONS CONTROL
  - PRICE/COST OF DELIVERED ENERGY SERVICES
  - EXPORTS OF U.S. TECHNOLOGIES AND PRODUCTS
  - R&D SPENDING/BUDGETING

- WHAT IS THE ECONOMIC IMPACT OF APPLYING AN EMISSIONS TAX AT END-USE?

- WHAT ARE THE ENERGY BOTTLENECKS TO LONG-TERM ECONOMIC GROWTH?

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PLAN FOR LONG-TERM MODEL DEVELOPMENT AND ANALYSIS STRATEGY

- IDENTIFY THE KEY INTEGRATED ISSUES THAT MUST BE ADDRESSES BY A LONG-TERM MODEL

- IDENTIFY THE KEY MODEL CHARACTERISTICS REQUIRED

  FOCUS ON TECHNOLOGICAL CHANGE APPEARS TO BE KEY

- IDENTIFY CANDIDATE MODELS TO EVALUATE THAT MAY SATISFY SOME OF KEY REQUIREMENTS

  - J. EDMONDS MODEL
  - WILCOXEN - JORGENSEN (DEGEM MODEL)
  - ETA - MACRO, PILOT/WEM , TESOM/DGEM
  - MARKAL/MACRO, BALANCE/MACRO

CONCLUSIONS

- IMPLEMENT EMISSIONS MEASUREMENT AND CONTROL BY OCTOBER 1993
  - o MEASURE SIX EMISSIONS
  - o IMPLEMENT AND TEST CO_2 LIMITING METHODOLOGY
  - o IMPLEMENT AND TEST CAAA RESTRICTIONS

- DEVELOP AND TEST REDUCED FORM MODELS BY MAY 1994
- DEVELOP LONG-TERM MODELING CAPABILITY BY DECEMBER 1994
- CONTINUE RESEARCH IN CHARACTERIZING UNCERTAINTY IN NEMS

of: to identify the key issues that the model must address in the long-term, and we've done some of that; to identify the model characteristics that are necessary to address those issues, and we've done some of that; to identify and evaluate models that may be close to what we need, and we've done some of that; and to eventually select a model, if one is close enough, that we would want to modify or tailor to our needs.

Some of the models that we've looked at, at least identified for further review, are listed at the bottom of the next slide. I apologize to our friends in the Policy Office. We did not include the FOSSIL2 Model and its successor but it will be looked at, let me assure you. I would also encourage any of you in the audience that have other models that you think are well documented and valuable to use in the long-term, to let us know. I would welcome such recommendations.

Let me conclude then with our priorities and schedule. We will be implementing emissions measurement and control within NEMS by October of 1993. We will be developing and testing the reduced form models and providing them for use by May of 1994. We hope to develop a long-term modeling capability by December of 1994. There are a lot of uncertainties here. However, we will continue to do the research and characterize the uncertainty analysis in NEMS because that effort provides valuable information to policymakers which I believe will enhance policymaking.

Thank you.

MS. HUTZLER: Thank you, Andy.

We had originally planned to have time for questions during this session. However, because the hotel has informed us that they need a half hour to reconstruct this room into three separate rooms that will be used for the concurrent panels, we had to delete that portion of the program. Andy and I will be available to answer questions throughout the conference. Please do not hesitate to come and see us. Also, please remember that you can ask questions during each of the sessions and provide comments in written form, if you so desire.

Before we break into groups for our first set of concurrent panels, I would like to have Louise Bonadies, who is EIA's coordinator for this conference, give you a brief rundown on logistics for the next day and a half. She's going to let you know how she's going to keep this conference on schedule.

MS. BONADIES: Thank you.

The first thing that I'm going to do to keep on schedule is not show you any slides. But I do want to let you know that we have extra copies of the ones from both of the earlier presentations available in the back. If you did not get a copy earlier and you would like one, please pick one up on your way out.

We do have a full schedule. If you'll look at the agenda in your registration packets, you will see that we break now for half an hour while the hotel sets up these rooms. In the meantime, please help yourself to coffee. Rest rooms and telephones are down the corridor, to the right of the registration area.

You might also check the registration area for messages. If someone needs to reach you, they should call the hotel and say that you are attending the NEMS conference. A message will be delivered to the registration desk and, if you check that table, you'll be sure to get it.

I also want to caution you about the tape that's used to hold down the cables. I have been told that these are newly redecorated rooms and the tape does not stick well to the new carpet. Please watch your step. If you have to cross a cable, be careful not to trip.

When we meet back here at 10:00 sharp, the Oil and Gas Supply Panel will be meeting in Salon H. The Macroeconomic Activity National Submodule will be meeting in Salon J, and the Buildings Demand Panel will be meeting in Salon K. Look for the signs designating the panel locations.

We'll break for lunch at 12:00 and you will be on your own for lunch, except the panelists who are to report to the working session should come to Salon G directly across from the registration table.

There are a number of places to eat in the hotel and in the Crystal City Underground. In your packets you'll find a brochure that describes the different locations and a map to help you find them. As you're exploring the eateries, please remember to be back by 1:00 sharp so the afternoon sessions can begin on time.

We have two sets of panels separated with a 15-minute break at 3:00. There's virtually no slack, so please be prompt in returning to the panels after the break so that we can finish by 5:15.

Tomorrow morning we're going to dispense with all of these preliminary remarks and begin the first concurrent session at 8:30 instead of 8:45. This will allow us to take our 15 minute break at 10:30. Then, if we keep on schedule, we will be able to conclude the conference at 12:45, giving those of you with afternoon flights a few extra minutes to get to the airport.

Some of you are interested in the individual component design reports. We have sample copies available on a table in the registration area. Please do not remove the reference copies. Fill out an order form and either place it in the box or mail it back to us and we'll be happy to send you the reports that you want.

You'll see another form in the meeting rooms. This is for your comments about the panel that you're attending, about the conference itself, about NEMS, etc. You can place these forms in the box in the registration area or give them to a panel moderator or give them to me. I'll be here and there will be someone at the registration area throughout the conference if you should need assistance.

That's all I have to say, except thank you for coming and enjoy the conference.

OIL AND GAS SUPPLY PANEL

February 1, 1993 - 10:00 am

PANELISTS:

James M. Kendell, Moderator
William Trapmann, Presenter
Leon L. Tucker, Reviewer
Dr. Emil P. Attanasi, Reviewer
Joseph B. Corns, Reviewer

AUDIENCE PARTICIPANTS:

Bernard Gelb
Alebsaudt Rudkevich

PROCEEDINGS

MR. KENDELL: Good morning.

The modules that we're going to be talking about in this panel are the oil and gas supply modules. Actually we're talking about a family of six modules. There are component design reports prepared for five of these modules, and we're working on the final one right now.

This morning Bill Trapmann is here to make a presentation, followed by three reviewers, two economists and an engineer, who will respond to Bill's presentation.

My name is Jim Kendell. I am the Chief of the Oil and Gas Analysis Branch. I've been with EIA almost 10 years now and Bill has been here almost 15 years. Bill is the Team Leader for the Oil and Gas Supply Team of the NEMS modeling group. In that capacity, he's responsible for the design and implementation of the models that he will present this morning.

Before the Office of Integrated Analysis and Forecasting was organized, Bill was an analyst concentrating on oil and gas supply issues. I've worked with Bill on studies of natural gas use in the electric utility industry and a study of the effects of interruptible natural gas contracts in the 1989 heating oil crisis.

Bill has also been involved in NPC studies and numerous EIA studies. I give you Bill Trapmann.

MR. TRAPMANN: Thank you, Jim.

Good morning. Thank you all for coming. This is especially impressive in light of the fact that it's the morning after the Super Bowl. I suppose it's a non-sports fan who set up the schedule.

The subject for today is oil and gas supply modeling. I will describe what we are doing in the midterm oil and gas supply model.

I will give an overview of the model approach so you have some framework for the subsequent discussion. The entire model is rather complex, and I think it would take well beyond the time I have here to give you all the details.

Could I have the first slide, please?

I did want to note that in light of Andy Kydes' comments about reduced form modeling and long-term modeling you might have questions about those subjects. I think that goes beyond the scope of what we've got planned for this session. If you'd like, after this session if there's time before lunch we could discuss it. It is a very interesting area of modeling.

We feel that the oil and gas supply module, or OGSM as I might refer to it during my remarks, has a number of enhancements over the current supply modeling system. One of the key features is a short-term supply representation for the regional supply of oil and gas within

Oil and Gas Supply Module
in the
National Energy Modeling System

William Trapmann
Energy Information Administration

EIA

February 1, 1993

the year, the parameters of which will be statistically estimated.

The regional supply curves allow for regional market equilibration. The short-term supply curves support the explicit determination of regional prices and quantities in the integrating modules.

The OGSM generates supply representations. The integration occurs for natural gas in the natural gas transmission and distribution module; for crude oil in petroleum markets, the equilibration occurs in the petroleum market module.

I would encourage those of you who are interested in the pricing and some of the general market aspects of the analysis to attend those sessions later today and tomorrow morning.

Another enhancement within the model is an improvement in our resource accounting. We are enhancing our resource representation to be more consistent with recent thinking on the nature of reservoirs and recovery. I am referring specifically here to the concept of extensive field growth over a long period of time.

This is consistent with the work that appeared in the USGS assessment back in 1980. We within EIA have done some subsequent update to that analysis. The nature of Bill Finger's work, among others, provides some theoretical underpinnings for this new perspective.

We have recognized differences within the model in exploratory drilling, particularly new field search versus old field search. New field search discovers new fields, and the search in old fields yields additional reserves. The results of both are consistent with this concept of reserve appreciation.

Let me say I think we have a good first step in this direction, but it's a relatively new area for modeling, and there is a lot of additional work we will need to perform even after this first generation of the model is implemented.

We have improved computational efficiency. The predecessor model, PROLOG, as we called it, had at its core a linear programming framework. We think that our new strategy of econometric determination of aggregate drilling and subsequent disaggregation with a sharing procedure allows for more efficient computation.

A last enhancement concerns a review of all our parameter estimates. In particular, the estimate of the economically recoverable resources of oil and gas is always very controversial.

The purpose of the model: well, no surprise. We would like to model domestic crude oil and natural gas supplies. We will do this on a yearly basis through 2015. As I mentioned earlier, the equilibration occurs within the NGTDM module or the PMM, and so the actual production and prices are determined in those modules. We only generate the supply representation, which is a schedule of volumes available at alternative prices.

This model will include the representation of foreign natural gas availability. Imports are certainly a very important source of natural gas. Net imports have risen to about nine

Enhancements

- Short-Term Supply Representation
- Regional Market Equilibration
- Improved Resource Accounting
- Improved Computational Efficiency
- Review of Parameter Estimates

Purpose

- Model Domestic Crude Oil and Natural Gas Supplies
- Model Availability of Foreign Natural Gas
- Provide Integrated Supply Analysis Capabilities
- Model the Flow of Funds between Investment Opportunities

percent of current consumption.

The module provides an integrated supply analysis capability. The generation of the aggregate level of activity and sharing it allows us to reflect the interrelatedness of the markets and the industry itself.

One example would be the Section 29 tax credit, which was available to coal bed methane production and tight gas production. The tax credit may have favored those activities perhaps at the expense of the more conventional producers' activities.

Technology can arise to benefit activity in a particular area. If one were to see that, you would expect to see a shift in effort, a redirection of resources to the more profitable endeavor.

The model as planned will also model the flow of funds between different investment opportunities. We have a discounted cash flow approach which determines the expected profitability for representative prospects. The profit measures will drive the aggregate level of investment and also the allocation of funds between regions and fuel types.

Submodules within the OGSM include five on the domestic oil and gas production side and a set of three on the foreign natural gas supply, but within our organization plan, foreign natural gas supply is envisioned as only one submodule.

The foreign natural gas supply submodule and the enhanced oil recovery submodule will not be highlighted in today's discussion. We have recently developed the component design report for the foreign natural gas supply submodule. That is available upon request.

The enhanced oil recovery submodule component design report is almost ready.

In today's presentation, we'll be looking at the domestic side, with the lower 48 conventional submodule as a representative sample of the general logic of the model.

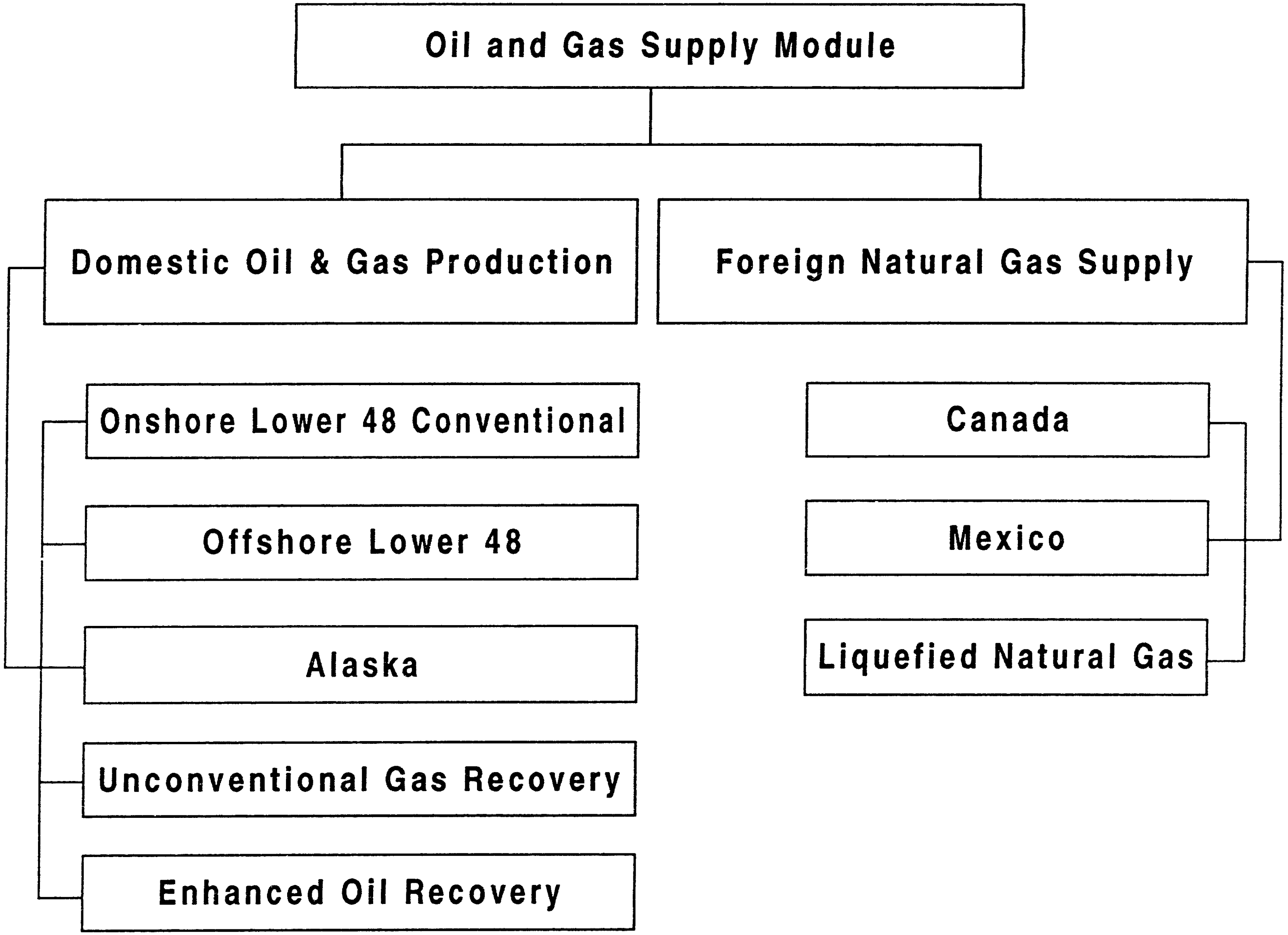
Now, like most people, I don't know geography very well. So I thought I'd put the map up here for you. We have six on-shore supply regions. The particular groupings are a general attempt to reflect the occurrence of basins within the geology of the lower 48.

The scheme also had to accommodate or concede the nature of the available data. Not all the data are available on a geologic province basis. So at certain points we recognize state lines even though it might cut across a geologic province.

There are three offshore regions: the Pacific on the West Coast, the Gulf of Mexico, and the Atlantic regions. If we do receive the supporting data from the Minerals Management Service that we are hoping to get, the Gulf of Mexico will be divided within six subregions: the shallow water and then the deeper water in offshore Texas, offshore Louisiana, and then offshore Mississippi, Alabama, Florida.

As a side note, there are four LNG facilities: one in Lake Charles, Louisiana, one in Elba Island, Georgia, another one in Cove Point, Maryland, and then lastly, there's one up in

Submodules within the Oil and Gas Supply Module



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Lower-48 Supply Regions

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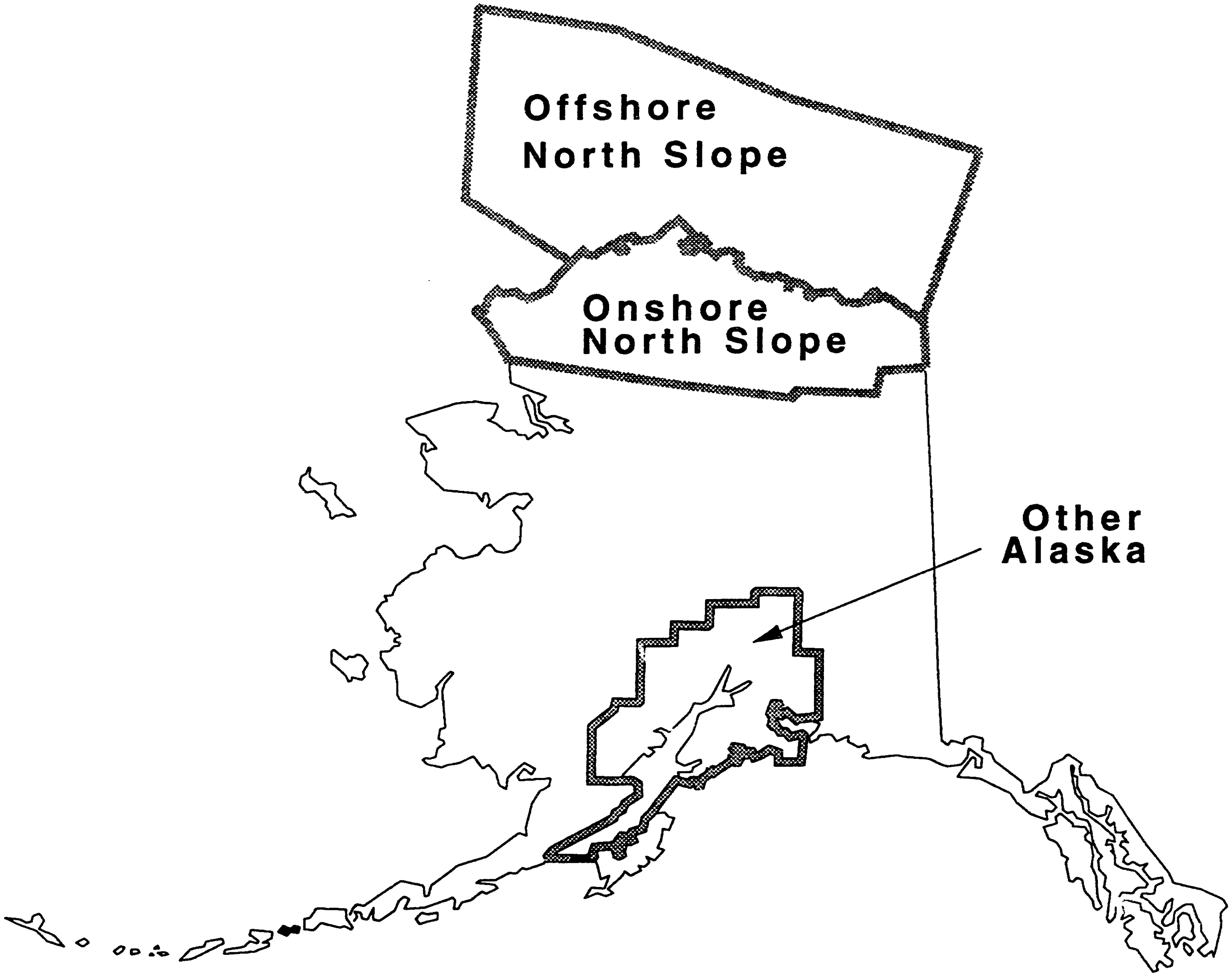
Alaska Supply Regions



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Everett, Massachusetts.

Here are the Alaska supply regions. We have indentified the regions which have the greatest likelihood of being developed and providing supplies to the U.S. or the world within our time frame. Those regions are the offshore North Slope area, which has the Chukchi Sea and the Beaufort Sea; the on-shore North Slope, which is roughly the Brooks Range and everything north of that; and other Alaska.

For those of you who are interested, ANWR is this corner of Alaska. The actual wildlife refuge itself is a rather big area. The controversial ANWR area is a little piece right on the edge, but size isn't everything.

Prudhoe Bay is about there somewhere, and then the TAPS line flows down to the south. The other Alaska region is roughly the Cook Inlet area.

This is a general system overview of the OGSM itself. It's a stylized schematic of what happens within a single iteration in a given year. The National Energy Modeling System will call the modules in this order.

Initially the NGTDM will be called. It accesses gas supply representations for the market equilibration, which determines the prices and quantities within each regional market in that time period.

For purposes of simplicity, we left off the other side, which is the demand modules, which will provide the information from the other side of the marketplace.

Upon determination of the prices and volumes within the NGTDM, control passes to the petroleum market module. The petroleum market module takes the natural gas production levels that were estimated to generate estimates for the natural gas liquids associated with that. It will use the natural gas prices for the industrial sector as inputs in the refinery calculations because gas can be used as a fuel input at the refinery level.

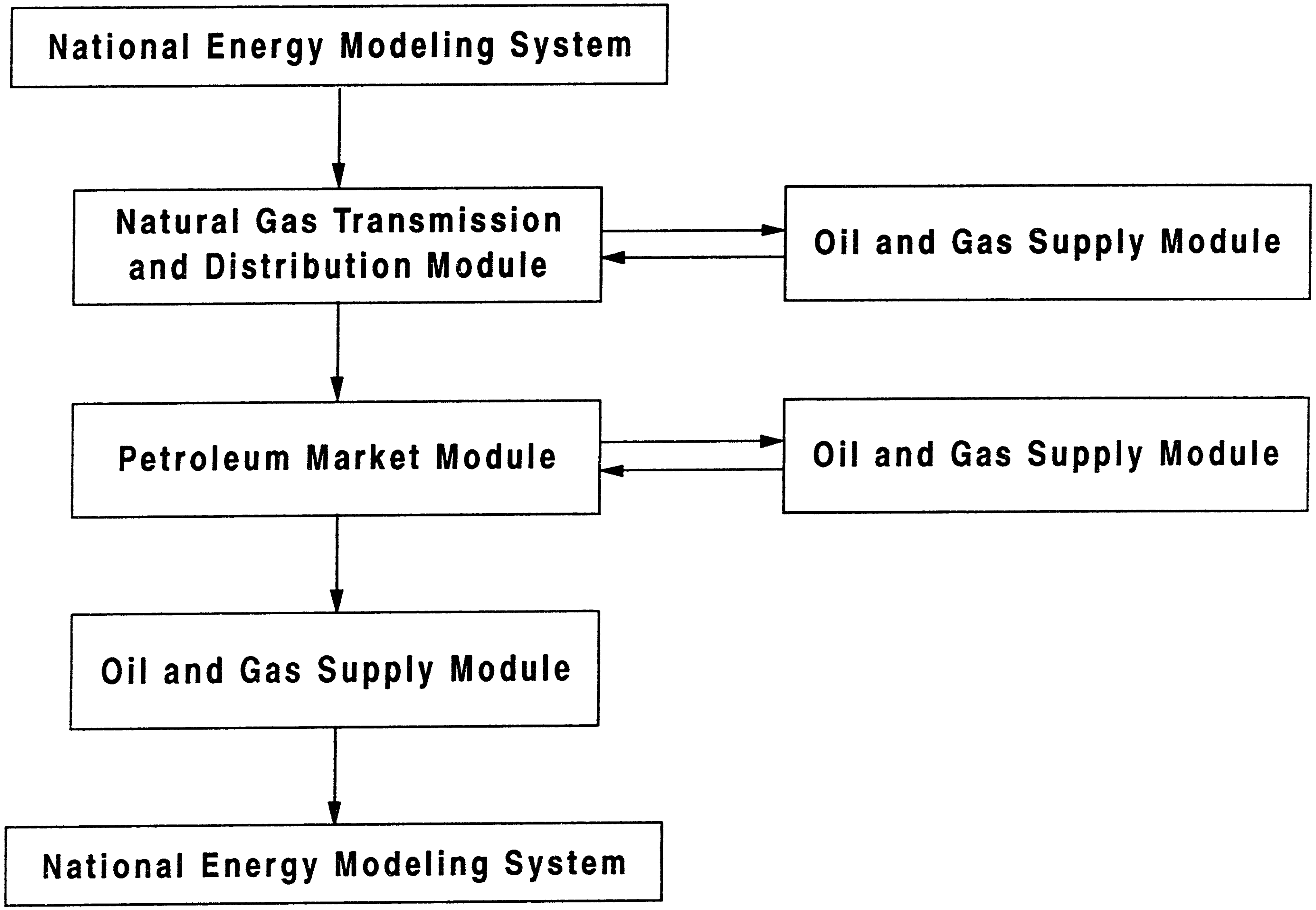
The petroleum market module, in addition to domestic petroleum demand, also recieves international estimates. The international module will provide foreign crude oil and petroleum products supply representations, representing the availability of world oil and petroleum products to the domestic refineries.

Once those two modules have completed, we then know the prices and quantities produced of crude oil and natural gas in the U.S. At that point control reverts to the OGSM proper. The prices are used in the discounted cash flow analysis to generate levels of drilling. Drilling leads to reserve additions and additional production capacity. There's a resource accounting procedure to keep track of production draw-down and the addition of reserves.

There are some estimates for secondary variables that will be generated. Capital expenditures go to the macro module for a determination of macro activity.

Electricity cogeneration occurs with EOR activity, enhanced oil recovery production.

Oil and Gas Modules



That will be passed through the electricity sections of the model. Another variable of interest is emissions. Control then goes back to the system itself.

A generic representation of the OGSM is provided here. This is, as I said before, a simplified schematic. The details here certainly apply to the on-shore conventional submodule, but not necessarily to all of the modules. I think it's illustrative and useful to give you an understanding of what we're trying to do in general.

This schematic is a representation of the procedure that is executed once the prices and volumes have been determined.

OGSM receives the prices. We have a discounted cash flow routine which generates the expected profitability from representative prospects on a regional and a fuel type basis.

The exploration and development expenditures are determined with an econometrically estimated set of equations. The expected profitability determines the aggregate level of activity in exploration and development.

Subsequent to the generation of that estimate, the expenditures are shared out between regions and fuel type.

The new field wildcats are those exploratory wells that are directed towards new fields. They generate new discoveries. The other exploratory wells are those wells that are directed into already known fields. We generically call the outcome of that drilling "extensions." It's somewhat of a simplification, and I'll even concede somewhat of a misuse of the term.

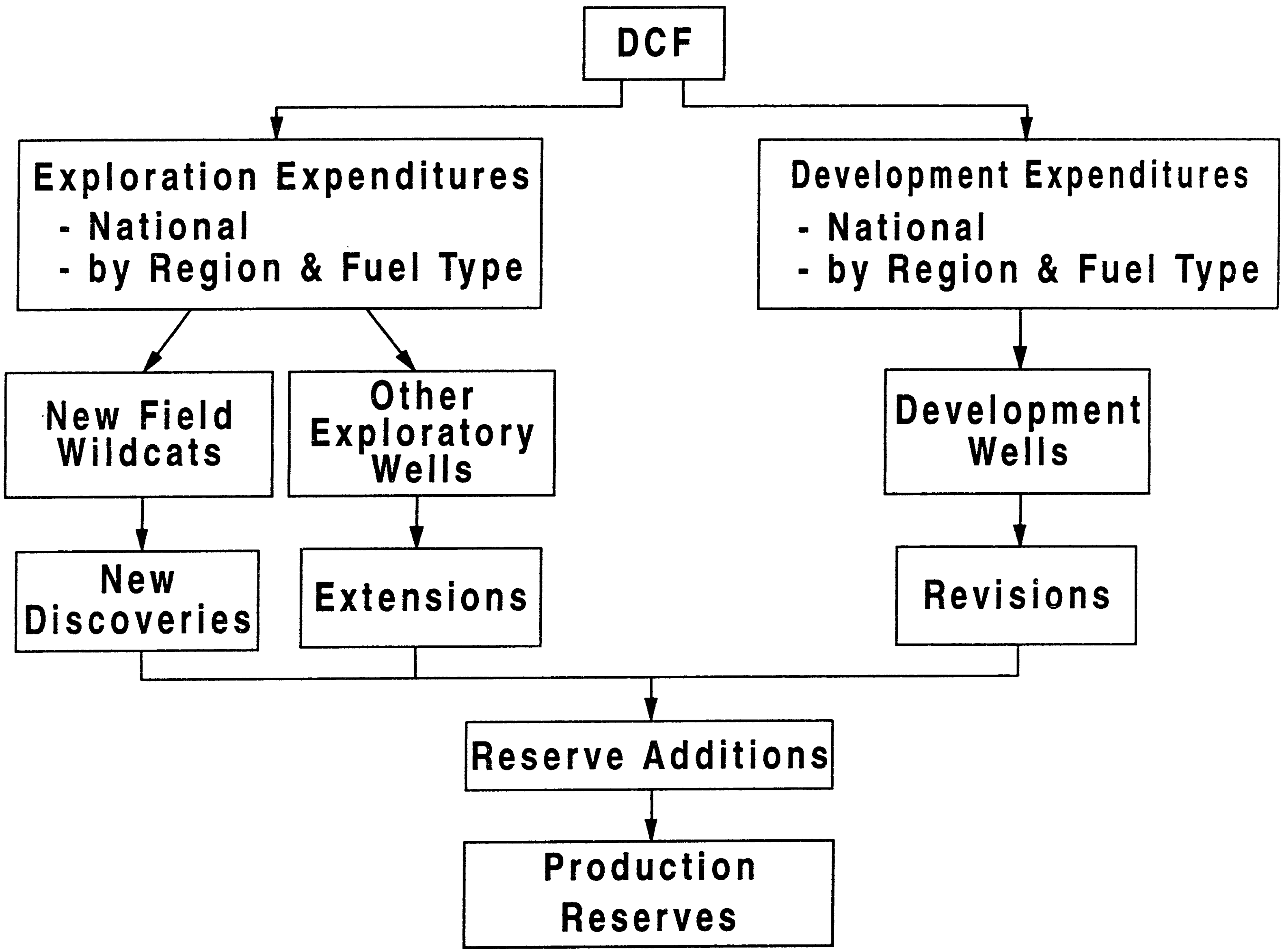
The developmental wells are, of course, directed into known fields, and that generates what we generically call "revisions."

The extensions and the revisions, labeled well or mislabeled, are coming from the stock of inferred reserves. New field discoveries access or allow access to a volume of previously undiscovered hydrocarbons. A small portion of that enters the proved reserves category -- 11 percent, 13 percent, not very much. The bulk of the hydrocarbons that will be recovered before the field is abandoned go into an inferred reserves category. I think you can get a sense from the relative magnitudes how important it is to make that distinction. The three categories of discoveries, extensions, and revisions all go into additions to proved reserves. We have a resource accounting scheme that will keep track of production, draw-downs from reserves, and additions to reserves. That information becomes the basis for the short-term supply functions for use in the subsequent period.

The main characteristics of the on-shore lower 48 conventional supply appear here. The drilling decision unit is an individual well, hopefully an individual successful well. The nature of conventional onshore activity is such that clusters of wells are not necessary for sharing infrastructure.

There are numerous drilling events in each period. This allows us to quantify the aggregate outcome for the group.

Oil and Gas Supply Module



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Onshore Lower 48 Conventional Supply

- Drilling Decisions Occur on the Basis of Individual Wells

- Numerous Drilling Events in Each Period

- Reserve Additions and Production Are Represented by Use of Appropriate Functions

The reserve additions and production are estimated by use of functions that take the aggregate measure of activity within that disaggregated cell. OGSM uses finding rates to determine reserve additions and flow functions to determine production.

We have the standard three major categories for unconventional gas recovery: tight sands gas, Devonian shale, and coal bed methane. These are the three that we feel have the most potential through the 2015 time period, and I think that while there may be some discussion about some other possibilities, most of them are relevant only after the next 20 years or so.

For example, there are gas hydrates, the estimates for which go into the tens of trillion cubic feet, maybe even more, but by the time we figure out how to get that out economically, many years will have passed.

Drilling opportunities in unconventional gas recovery are evaluated on a project basis for Devonian shale and for coal bed methane. The nature of the production involves a need to represent the sharing of the infrastructure for those activities.

For tight sands gas, however, we've reconsidered and decided that its primary distinction from conventional is a completion technique that can be evaluated on an individual well basis.

The projects themselves, as we've represented them within the model, reflect differing operating environments. At some point the issue is that distinct geologic conditions impact the productivity measures and the cost requirements; and, of course, this will impact expected profitability and subsequent production performance.

The main characteristics of offshore lower 48 supply are shown here. Exploration and development investments are evaluated on a project basis. There are large projects in which wells share infrastructure.

Multi-year programs are the nature of these investments. They are large projects, so it's simply hard to get them done in one year. Project development will perpetuate into subsequent years upon initiation. That means that some exploration or development is nondiscretionary, because once a project is started they have to go ahead.

The exploratory drilling is, of course, influenced by prior leasing, and as I mentioned, the Gulf of Mexico will be divided into multiple subregions.

Alaska. The basic unit of the discovery process is a large field. Large discrete fields do not allow for some of the other techniques that would be perhaps more attractive, if there were a large number of samples, reflecting many drilling events in one year. So we have identified the individual fields as the basis of our analysis.

The user may specify the set of fields and the schedule for occurrence or that will be left to the EIA analyst. We intend to employ USGS, United States Geological Survey, estimates to generate the distribution of fields.

Unconventional Gas Recovery

- Tight sands, Devonian shale, and coalbed methane
- Drilling Opportunities Are Evaluated on a Project Basis
- Projects Reflect Different Operating Environments

Offshore Lower 48 Supply

- Exploration and Development Are Evaluated on a 'Field' or 'Project' Basis

- Multi-Year Programs

- Some Exploratory or Developmental Activity Is Nondiscretionary

- Exploratory Drilling Is Influenced by Prior Leasing

- Gulf of Mexico Implementation Will Be Based on Multiple Subregions

Alaska Supply

- Discovery Process Is Based on a Set of Distinct Fields
- User May Specify the Set of Fields and the Schedule for the Occurrence of Discoveries
- Discovery & Development Occurs as a Succession of Large Discrete Events
- Economic Evaluation of the Resource Base Is Endogenous
- Multi-Year Programs
- Some Exploratory or Developmental Activity Is Nondiscretionary

The discovery and development occurs on the basis of these individual fields. By looking at the individual fields, we can conduct an endogenous economic evaluation of the resource base. We can't really do that in this version of the model for the other areas, but I think for this frontier area, in particular, that's an important advantage.

The large projects require multi-year programs which tend to set the level of activity for a certain number of years.

I will just touch on the enhanced oil recovery. We're still finalizing the draft of the component design report, but I thought a few comments would be worthwhile.

No surprise. EOR development is different from conventional. In some cases in the industry you'll see existing wells that were producing oil converted over for use in EOR projects. Conventional recovery requires new wells in order to access the accumulation of producible hydrocarbons.

With EOR, a lot of the wells will already be in place. Some of them will be used for production, some for injection. EOR techniques are introduced where production difficulties make other techniques uneconomic. In some sense it's almost like the difficulties have inverted. This is an oversimplification perhaps, but for most recovery, the problem is finding accumulations more than producing from them. For enhanced oil recovery, the difficulty is not so much finding accumulations, but getting the hydrocarbons out. Because drilling is not the basic activity, we have devised what we call an EOR incremental unit, or EIU. The EIU is essentially a single producing well with the associated capital and operating costs. So we have a representative project, a cluster of wells which includes some conversions of previously producing wells, the injection wells, shared equipment at the surface, and each one of those producing wells has to support its share of the supporting infrastructure.

EOR reserve additions are from the stock of inferred reserves. Operators in the model don't look for new fields, new EOR fields per se. In the search for other deposits, however, we are allowing the discovery of EOR fields.

The foreign natural gas component design report is available. There are some copies here. We can also take requests for them. I'd like to touch briefly on the foreign natural gas imports and exports model. The proposed methodology is designed to provide short-term supply functions at individual U.S. border points. This allows for an endogenous determination of the disaggregated flows.

We have more detail in our cost evaluation of the import activities to give us additional analytic flexibility.

The Canadian export availability to the U.S. will recognize Canadian demand. Clearly the available supplies to the U.S. are based on the net supply, not total supply. I think we have to concede the Canadians might want to satisfy their own country first.

Mexican gas trade in the model is an exogenous assumption. At this point we just feel there are too many noneconomic factors that have been and are expected to continue to

Enhanced Oil Recovery

- EOR Development Is Distinct from Conventional Activity
- EOR Incremental Unit Is the Basic Activity Unit
- Development Is Evaluated on a 'Field' or 'Project' Basis
- EOR Reserve Additions from Stock of Inferred Reserves

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Foreign Natural Gas Imports and Exports

- Provide Short-Term Supply Functions at Individual U.S. Border Points
- Detailed Cost Evaluation of Import Activities
- Canadian Export Availability to the U.S. Recognizes Domestic Canadian Demand
- Mexican Gas Trade is an Exogenous Assumption
- Capacity Expansion Decisions Are Endogenous

determine the nature of that trade. At this point they have an R/P ratio in excess of 50 to 1, compared to 10 or 11 to 1 in the United States. They have an extensive remaining recoverable resource base beyond that, yet they are importing our gas.

It would appear there are other important factors, including a number of institutional factors, that determine Mexican imports and exports.

The capacity expansion decisions for the Canadian pipelines and the LNG import facilities are endogenous.

The analysis capability we feel this module will offer us is that we can analyze issues generally that affect the relative profitability of drilling prospects, including drilling costs and production costs. Environmental costs can be included in the expected profitability calculation, as well as taxation changes, technology, and generally anything that affects the profitability.

OGSM will be useful for analysis of the issues impacting the level of financial investment. For example, return on foreign investment should be expected to divert funds from U.S. investments to foreign investments, presuming that the return on foreign investment goes up. Anything that would somehow impact the use of internal funds for U.S. firms could be included here.

We can analyze economically recoverable oil and gas resource estimates, which are highly uncertain. It's desirable to have the ability to at least use a scenario approach to accept alternative estimates for recoverable oil and gas to assess the impact on the outlook.

Access restrictions refer to limitations precluding the development of sensitive areas, such as ANWR or other sections of Alaska -- in fact, the bulk of Alaska -- and vast tracts in the offshore.

We feel that tracking environmental emissions will provide a valuable result that we can use for policy analysis.

The capability of OGSM is enhanced by the fact that it is part of this much larger whole which is NEMS itself. The benefit of the whole is greater than the sum of the parts. The ability to not only have the interrelatedness on the supply side, but the effects between all fuel markets is a distinct advantage that we have in the NEMS system.

So thank you for your attention, and I'd be happy to take questions after we hear from the discussants.

Thank you.

MR. KENDELL: With that overview, I'd like to introduce our first reviewer this morning, Lee Tucker from the American Gas Association.

Lee is the Director of Energy Marketing Services for AGA, and as such, he's responsible for the design and implementation of AGA's total energy resource analysis, or TERA, modeling

Analysis Capability

- Issues that Affect the Relative Profitability of Drilling Prospects
- Issues Impacting Level of Financial Investment
- Economically Recoverable Oil and Gas Resource Estimates
- Access Restrictions
- Environmental Emissions

system. Mr. Tucker has managed AGA's participation in the Stanford University energy modeling forum, a study of the natural gas market several years ago, and also managed AGA's recent participation in the National Petroleum Council's study of the gas markets' potentials.

Mr. Tucker.

MR. TUCKER: Thank you.

I'm Lee Tucker from the American Gas Association. We've been doing energy modeling ever since the very early 1970's, and my message here is that of "Gee, will it work?" Will a model, such as Bill's model, work? We don't know yet. We haven't seen it yet. It isn't in place. It isn't operating, at least not fully operating at this time.

So I can't really talk to you from any experience with Bill's model. The only model I can talk about is our own TERA model and its drilling side, which is vastly simpler than the structure that Bill is building, but has some very, very basic resemblances.

In the TERA drilling model system, we have representations of the costs, of drilling activities broken down into very familiar categories: drilling costs, equipment costs, land costs, geologic costs, and so on. TERA includes representations of resources added per successful well; representations of success ratios, and so on. They all draw together into a central measure of profitability. The profitability level leads to estimates of drilling levels, and then ultimately to estimates of reserve additions.

The structure is, as I say, simpler than Bill's, but has some very general resemblances. With that structure in mind, I'd like to address the question: Will a model that is like Bill's work? And I think the answer is yes.

Models can fail. Bill --

MR. TRAPMANN: I appreciate that. If the answer is no, you were supposed to call me.

MR. TUCKER: I didn't call and the answer is yes. I think it can.

Models can fail in a number of ways. This morning Andy Kydes mentioned three major sources of uncertainty. One is specification of the model itself. Another is data and behavior in the model, and the other is external factors, those things which are exogenous inputs into the modeling structure.

With a drilling model -- supplies of oil and gas originate in drilling -- your nightmares and my nightmares as a practicing modeler are that I might come up with something that projects that drilling will collapse and there will be no supply under any conceivable set of price-cost relationships or everything is going to go totally the other way and gas will become, to use the very tired expression, too cheap to meter, and the model will be simply insensitive.

Twenty years ago, there were drilling models that exhibited both of those behaviors.