THE NEMS CONFERENCE

SYSTEM INTEGRATION AND USER INTERFACES PANEL

February 2, 1993 - 8:30 am

PANELISTS:

Mark E. Rodekohr, Moderator
Susan H. Shaw, Presenter
Frederic H. Murphy, Reviewer
James L. Sweeney, Reviewer
Milton Gutterman, Reviewer

AUDIENCE PARTICIPANTS:

Gary Goldstein
Mike Lehr
Saul Gass
Steve Mack

PROCEEDINGS

MR. RODEKOHR: My name is Mark Rodekohr. I am the Director of the Energy Demand and Integration Division at EIA. The topic of this session is on Systems Integration and User Interfaces.

Our presenter is Susan Shaw, who is the branch chief of the National Energy Modeling System Branch.

We have three distinguished reviewers. The first is Fred Murphy, a Professor in the Department of Management Science and Operations Management in the School of Business at Temple University; followed by Jim Sweeney, who is Professor and Chairman of the Department of Engineering-Economic Systems at Stanford University; and last but not least is Milt Gutterman, who is an independent consultant, recently retired from Amoco Oil.

I would hope that people could hold their questions until the end of the talk. When you do ask questions, talk into the microphone and identify yourself, as the proceedings are being recorded.

I would like to introduce Susan Shaw.

MS. SHAW: I would like to begin by introducing Dan Skelly, who is responsible for the integration methodology of NEMS; and Mike Lehr, who is responsible for the user interface and reporting issues.

We do have a few copies of the integrating model component design report on the back table, or you can use the order form to get them.

I am going to talk about the integrating framework of NEMS, some overall system design issues, and plans in the area of user interfaces for the system.

This should be a familiar flow chart by now. It shows the overall structure of the midterm model for NEMS. It is important to realize that this isn't just a conceptual flow diagram but really is a design of how the models and the data interact within the system. I will return to that point later.

We do have an existing system that we use for our forecasting and analysis, the Intermediate Future Forecasting System. From a systems perspective, here are a few things that are the significant enhancements over the current system.

First, more of the modeling and analysis activities are endogenous within NEMS. These are not just the inclusion of some of the major blocks and modules that you saw in the flow chart, like international markets or renewable sources, but also some of the algorithms within the modules, such as coal exports and natural gas tariffs.

We will also be paying explicit attention to techniques to accelerate convergence within the modeling system. The system has also been designed and implemented to include alternative

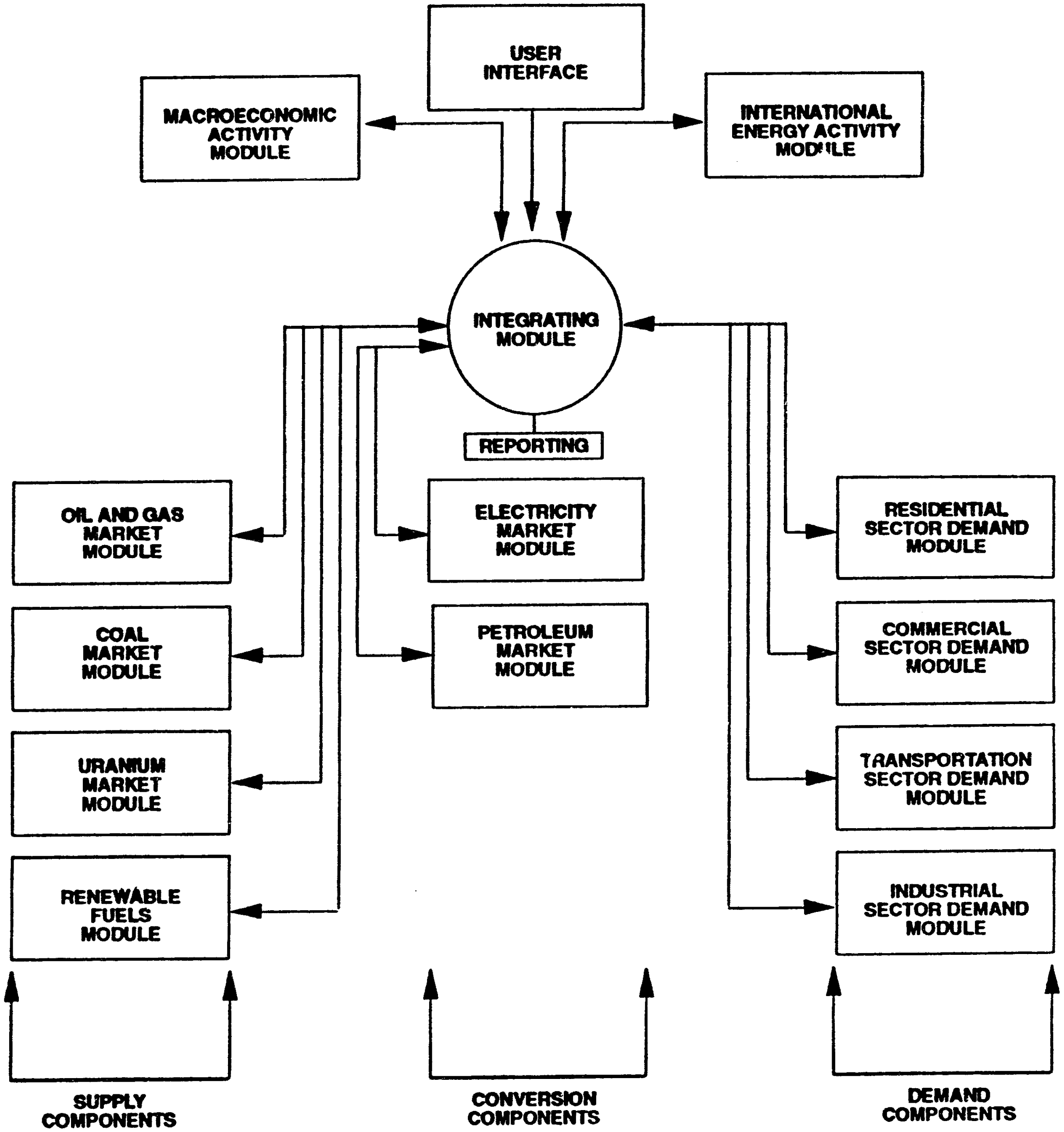
System Integration and User Interfaces
in the
National Energy Modeling System

Susan H. Shaw
Energy Information Administration

February 2, 1993

OIAF 1/93

National Energy Modeling System



OIAF 2/93

Enhancements Over the Current System

- More modeling activities endogenous
- Techniques to accelerate model convergence
- Alternative approaches to foresight
- Well-defined data structure

approaches to foresight within NEMS. Finally, NEMS contains a well defined data structure. This is an aid to model management and also to user access for the model.

There are some general characteristics of NEMS. It is a unified modeling system, with each supply, demand, or conversion sector represented as an independent module within the system, but interactive. Each of the modules is programmed as an independent collection of subroutines, with a single entry point. This implementation achieves a desired modularity within the system.

As you have heard several times, NEMS solves annually through 2015, for our midterm system. In general, for each forecast year, the model solves by iterating between the modules until convergence is obtained. I will discuss what I mean by that a bit later.

Looking at the system from an implementation perspective, the integrating model controls the independent execution of the component models. The modules are executed directly from the integrating module, and all data flows occur through the integrating module.

If you refer to the flow chart I showed earlier, none of the lines, representing data flows, are going between the modules. They are all going through the integrating module.

The modules can be switched on and off independently for a particular configuration of the modeling system or during the course of the run. Also, alternative or test versions can be easily invoked.

This modular design promotes decentralized development of the model and also is an aid to model management. Looking at it from the operations perspective, we frequently have 50, and right now many more than 50, hands-on people working on various parts of the modeling system.

Our current IFFS system has ten modules and approximately 60 data sets. In order to do the last Annual Energy Outlook, AEO-1993, on the order of 1,500 runs of the modeling system were made. Some of these runs consisted of only one module being executed in a test mode. Still, the system was invoked 1,500 times.

Model management becomes a real issue for us in our day-to-day operations. NEMS has 13 modules and approximately 80 data sets at this point, which is likely to increase as more of the models are implemented. In addition, once we are beyond the development stage, we would likely be in a situation of having multiple studies taking place at one time.

Another thing that the modularity does is allow us to have some flexibility in the methodologies of the different modules and also in the levels of detail in the component modules.

From other sessions, you will have learned that some of the modules are econometric, some of them are linear programs, and some of them are algebraic. There is no single overarching methodology that is imposed on all the modules in the system.

General Characteristics of NEMS

- Unified modeling system with each sector represented as an independent module
- Each module programmed as an independent collection of subroutines
- Model solves annually through 2015
- For each year, model solves by iterating between modules until convergence is obtained

Integrating Module Structure

- Integrating module controls independent execution of component modules

- Modular design promotes decentralized development and improved model management

- Provides flexibility in methodological approaches and levels of detail among component modules

As an example of differences in the level of detail, some of the modules incorporate transportation networks within them, since that is an important component of that sector. For other sectors, it is not, and those modules don't explicitly include a network. The modularity allows a certain flexibility in the modules.

NEMS solves by looking for a market clearing price for all fuels to achieve a supply-demand equilibrium.

In our model design, the supply models take as input the end-use demands for the fuels and compute the delivered prices. They also compute the supply necessary to meet demand from domestic production and from imports.

Demand models, on the other hand, take the delivered, end-use prices of the competing fuels and calculate the consumption of each fuel in that sector.

The key interface variables between the modules are these end-use regional prices and quantities of each of the fuels, which are called the energy market variables.

The modules are called in sequence within the forecast year. The shared energy market values and a few other solution values are updated within a central location. The modules are executed until all the solution values stabilize between iterations.

The solution values include these end-use prices and quantities as well as some of the key macroeconomic, international market, and environmental values. Convergence in NEMS will be accelerated through the use of certain relaxation techniques or heuristic routines. We will proceed further into research in that area as more of the modules are implemented and we gain experience with their convergence characteristics. There are a number of simple tricks we can employ. For example, as the system interates through the modules, it can stop executing those modules that have already converged. Some of the modules are more stable than others and settle down to an answer quicker than others.

There are several systemwide design features within NEMS to address, first regionality. For some of the energy sectors and for many of the policy issues, regional analysis becomes important. The market integration is done for the nine Census divisions. The end-use prices and quantities are defined for those regions and the integrating model functions at that level.

The demand modules operate at the nine Census division levels and all the fuel supply modules map to that level.

However, other regional structures specific to the individual sectors are employed in NEMS. The Petroleum Market Module uses the five Petroleum Allocation for Defense Districts. That is the major subdivision for the refinery data sources. The coal module uses 16 supply regions; electricity, the 13 North American Electric Reliability Council regions and subregions; natural gas transmission and distribution uses 12 regions which are the Census divisions with some subdivisions that are appropriate for transportation issues; and oil and gas supply has 12 supply regions.

Integrating Module Solution Methodology

- Solves for market clearing prices for all fuels
- Modules called in sequence, updating shared energy market values and other solution values
- Modules executed until solution values stabilize between iterations
- Solution values include energy prices and consumption, as well as macroeconomic, international market, and environmental values
- Convergence accelerated through the use of relaxation and heuristic routines

System-Wide Design Features

- Regionality
- Reduced Form Modeling
- Uncertainty
- Foresight
- Environment

The regional transformations occur within the sectors and are accomplished either by explicit mapping and sharing algorithms or, in a few cases, by representations of transportation networks, as in the coal and natural gas markets where the fuels are actually delivered through a transportation network to the Census divisions.

The next topic is reduced-form models. The modularity of NEMS and the model management system we employ allows very easy substitution of alternative modules, as long as the inputs and the outputs of the substitute module match or can be easily adjusted.

The larger modules within NEMS will have reduced-form versions that simulate the aggregate response of the module. There are several different alternatives that might be employed to come up with these reduced-form versions. One is a response surface model where the modules are run over a wide range of inputs, and then an econometric fit is made to the pseudo-data that results from those simulations.

Another approach that has been suggested is called a nonparametric approximator, in which a set of previous solutions are stored and the reduced-form model selects the closest solutions and computes a combination of those results.

A third alternative that sometimes has been suggested is that of compact structural models; however it is likely to be too resource intensive to maintain both a larger model and a more compact model and have them function with some degree of compatibility.

The substitution of reduced-form modules allows for rapid turn-around for a single sector, a single fuel analysis where the analyst might invoke the one sector and use reduced-form versions for the other sectors, or for simple testing and debugging.

Depending on the method of the reduced-form module that is chosen, and its size, and speed, it is possible that some reduced-form modules could be used as convergence enhancers within the system. However, that may complicate system design, and must be approach rather carefully. In the past we have used very highly simplified convergence enhancers successfully.

There are several issues to be addressed in the area of reduced-form models. First, is the form that is appropriate to each of the modules. A second question is whether or not the reduced-form modules should include any of the policy options or modeling levers; or should we assume that any policy analysis would always use the full version for the sector being studied. A third issue is, the degree of compatibility of the results between the reduced-form and the full model.

If you are using reduced-forms for some testing, compatibility is not quite that important; however, if you are using them as convergence enhancers, they will be of little value unless the results are fairly close.

Another recurring issue is uncertainty. It has been requested that NEMS provide measures of uncertainty associated with the projections. We are currently researching methods to analyze the uncertainty in the major outputs of NEMS associated with either the key model inputs and parameters or with some critical model relationships. We are not trying to capture

Regionality

- Energy market integration for the 9 Census Divisions

- Other regional structures specific to the sectors

- Regional transformations by explicit mapping and sharing algorithms or by representations of transportation networks

Reduced Form Models

- Modularity allows easy substitution of alternative modules

- Larger modules will have reduced form versions that simulate the aggregate response of the module

- Substitution of reduced form modules allows rapid turnaround for single-sector analysis or for testing and debugging

Uncertainty

- Requested that NEMS provide measures of uncertainty associated with the projections

- Researching methods to analyze the uncertainty associated with key model parameters and assumptions or with critical model relationships all sources of uncertainty, such as unanticipated events in the real world.

We most likely will address uncertainty through off-line uncertainty analysis of the various modules. In Andy Kydes' talk yesterday, he went into some detail on the research being done in that area.

Rigorous sensitivity testing of the entire system may be done, but it is probably not efficient as a technique to be redone as the model evolves.

A third alternative that has been suggested, is performing uncertainty analysis with a collection of the reduced-form models; however the uncertainty in the reduced-form representations may swamp the uncertainty in the modeling system.

By incorporating this uncertainty analysis, we would gain some measure of the error bounds around the key outputs of the model. This would also qualitatively provide some measure of the robustness of the policy options that are being analyzed.

Some of the modules within NEMS require assumptions about future prices and/or demands in order to make capacity expansion decisions. NEMS has the capability to impose a centralized control over the assumptions about the future prices and quantities.

There are three alternative options for centralized foresight within NEMS. One is myopic: for the current forecast year it is assumed that those prices and quantities hold into the future. With extrapolative growth, it is assumed that prices and quantities increase by a specified percentage which is a user input. Finally, there is an option for perfect foresight, which has been suggested as a useful area for experimentation with the system.

If none of the centralized foresight options are chosen, the individual modules will default to the foresight methodology that seems best for that particular module. There are some good reasons that people put forward about different sectors actually using different assumptions about the future in making decisions.

In order to do perfect foresight, the normal order of execution of the models will be revised. Rather than each model being solved within a particular forecast year until convergence, each module will be called for all years and the iteration cycle will step through the modules in that fashion. This option has been implemented. It is likely to be more time consuming but may provide some useful insights into energy markets.

To address environmental issues, NEMS will account for six airborne emissions: SOx, NOx, CO, CO_2, carbon and volatile organic compounds. The tabulation will be for those emissions resulting from energy combustion and a few production-related activities, such as coal stockpiles, not the emissions from chemical processes in the industrial sector, for example.

NEMS also represents current regulations such as the Clean Air Act Amendments of 1990 and other regulations.

It is important to note that even some of the emissions that are not tabulated are taken

Foresight

- NEMS has centralized control over the assumptions for future prices and demands for capacity expansion decisions

- Three alternative options for foresight:
  - Myopic
  - Extrapolative growth
  - Perfect

- For perfect foresight, the order of execution of the modules through the time horizon will be changed

Environment

- NEMS accounts for the following emissions: SOx, NOx, CO, CO_2, C, and Volatile Organic Compounds

- NEMS incorporates a capability to constrain emissions by recursively solving for a shadow cost on emissions that achieves the specified limit into consideration in the model. The various parts of the model incorporate costs, such as the cost of double- hulled tankers or the increased operating costs of oil and gas drilling due to toxic discharge regulations.

NEMS will incorporate a capability to constrain emissions when necessary for a particular policy analysis. It will do this by recursively solving for a cost on emissions that forces emissions down to a specified level.

Although taxes or other costs are easy to apply to the modeling system, this systemwide constraint is a new feature.

NEMS includes a global data structure that defines the information shared among the modules and other centralized data. This includes the energy market variables, the end-use prices and quantities, variables for communication and reporting and model operation, and key input parameters and assumptions for each module.

We have identified for each module those inputs that may be important as options for analysis. This is an aid to later user access.

Not all the data in NEMS is centrally organized, although all the flows between the modules are defined and organized in the global data structure.

The integrating model includes routines to organize and manage the flow of information within NEMS. The data exchange is generally done through the sharing of common global variables. The data management utilities store and retrieve the contents of the global data structure and provide the support for data exchange through files as needed.

There is a data dictionary that explicitly defines the variables and subscripts. This is in a clearly presented, readable format with units of measure and data descriptions, all as a future aid to accessibility.

The solution of any run is stored in this readable format, which is called a restart data file. This can be the starting point for a future run. Also, if a run does not include all the modules, then the restart file used to initiate the run provides the missing values from the modules not being run.

Stand-alone model operation on PC's is supported through the use of the files that are generated by the global data management system. Data utilities strip down the restart data file to a file tailored to a particular module, for use in PC operation.

This brings us to the issue of system access, a topic of recurring interest throughout this conference and at user group meetings.

For a number of pragmatic reasons, the initial implementation of NEMS is on EIA's mainframe. We have enhanced tools for managing the runs and providing the results to users for personal computer analysis. We have had a structured set of programs for tracking runs and maintaining version control over the data and the code. These have already been greatly

Flows of Information

- The Global Data Structure defines the information shared among modules and other central data:
  - Energy market variables
  - Variables for communications and reporting
  - Key input parameters and assumptions for each module

- All information flows between modules are clearly defined and organized in the Global Data Structure

Data Management System

- Integrating module includes routines to organize and manage the flow of information in NEMS

- Data exchange accomplished through sharing of common, global variables

- Data management utilities store/retrieve the contents of the Global Data Structure and provide support for data exchanges through files as needed

- Stand-along module operation on PCs

System Access

- Initial implementation on EIA's mainframe with enhanced tools for managing runs and providing results to users for personal computer analysis

- Each module will be executable on a PC. Data system provides capability for each module to be easily detached from NEMS

- Researching the feasibility of executing entire NEMS on PCs enhanced, we have also developed tools for readily downloading the results and doing comparative analysis on the PC's.

In addition, each of the modules will be executable on a PC. The data system that has been developed and the modularity of NEMS allows each module to be very easily detached from NEMS for wider distribution.

We are beginning a system design for a user interface on the modules, to include some data scanning and editing features and graphical representation of the results.

In addition, we have a separate effort underway to research the feasibility of executing the entire NEMS on a PC. We are taking into account measures such as space requirements and speed of execution, plus some considerations that are of interest to us, such as storage space for a number of simulations and also central file storage and communication between analysts. That capability is necessary for model development and operation within our organization.

Some of the early results on PC feasibililty appear promising and show that it may be able to function on a very high end personal computer, but we will know more as more of the modules are implemented in the April time frame.

Thank you.

MR. RODEKOHR: Thank you, Susan.

I would like to note that with the way prices are dropping and with IBM's fortunes, you can probably buy our mainframe, which we are replacing, for about the cost of a high end PC.

I would like to introduce Fred Murphy from Temple University.

MR. MURPHY: What I am going to talk about is more of the management issues. Why I am going to talk about them is that I have been through this, because I was the person in charge of developing IFFS. So I understand what went on with the predecessor model and I can see the kinds of things that are happening with NEMS.

What I want to do first is to address why these models are complex. To some extent, it is a little late in this conference to actually ask this question, because if you attended the sessions yesterday you heard many people say we want more of this and we want more of that. This is why models are complex.

Looking at this slide you see a Julia curve. This is a fractal. What you see on the top is at one level of resolution. If you take this little piece here and you magnify it, you get the picture at the bottom.

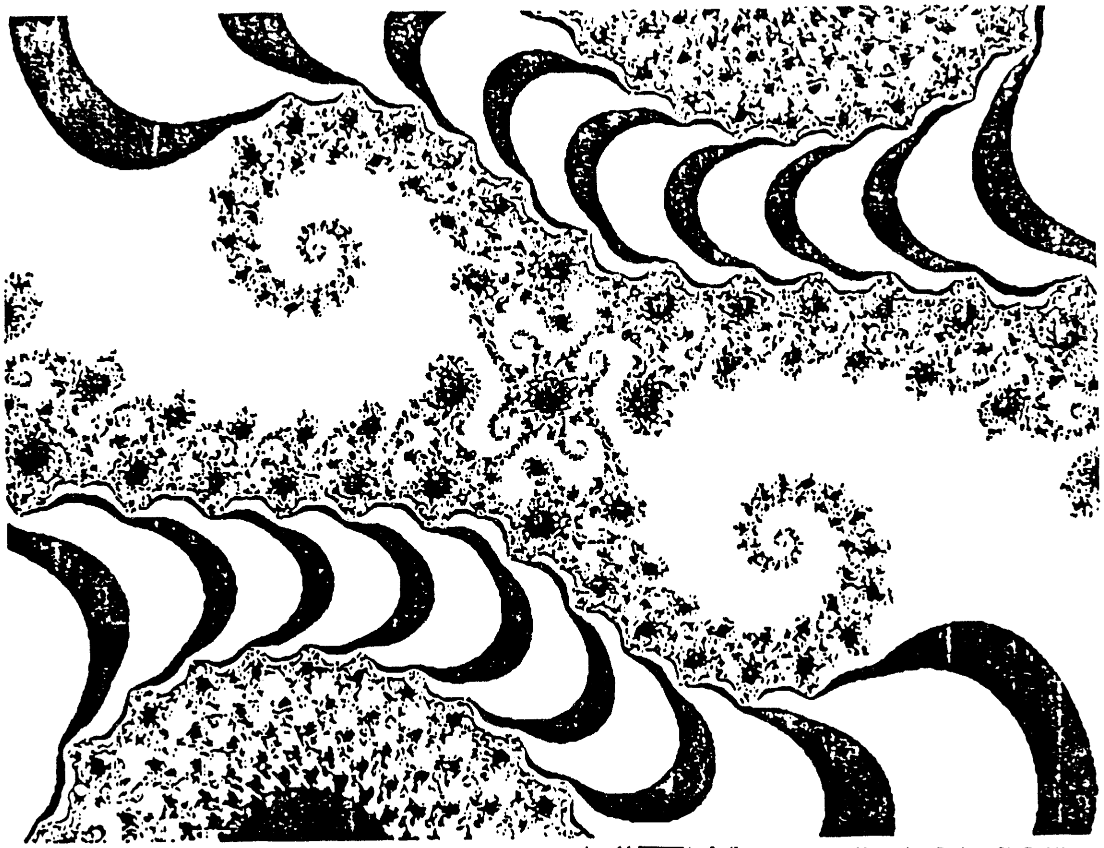
We are looking at successive layers of structure that people want to understand.

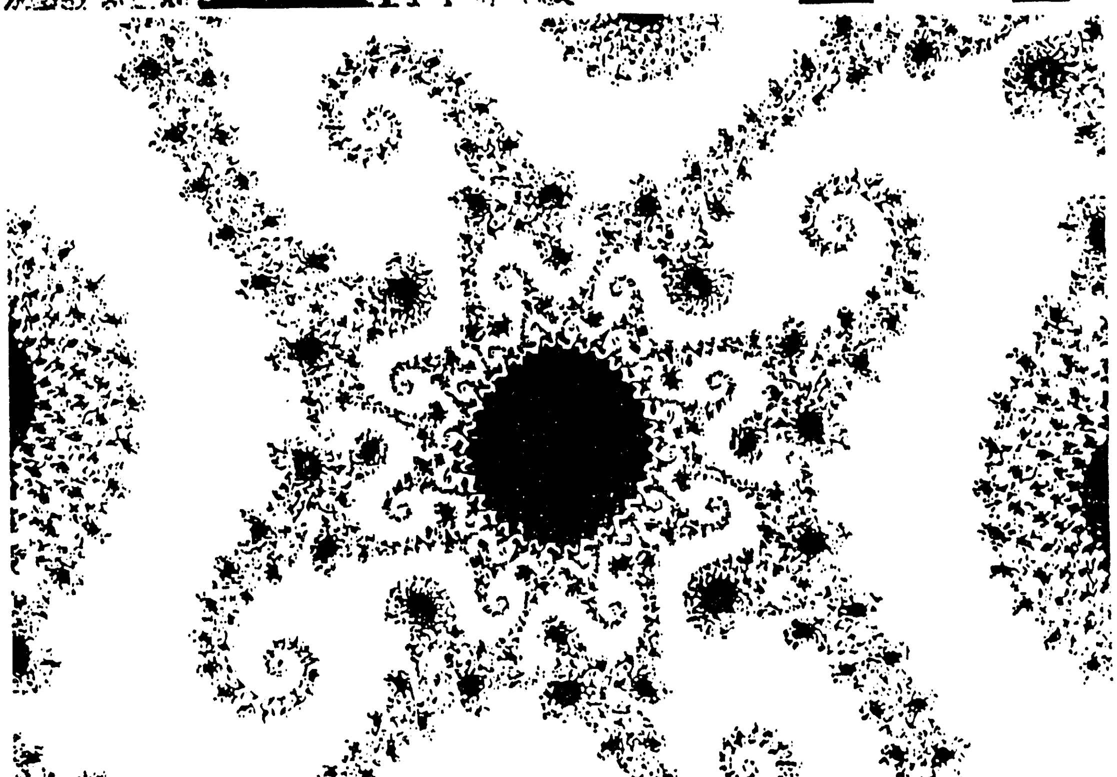
The next slide is another fractal. This is a fractal mountain. Whenever you see any of these high-tech movies now with all the fancy computer graphics doing the background, it is

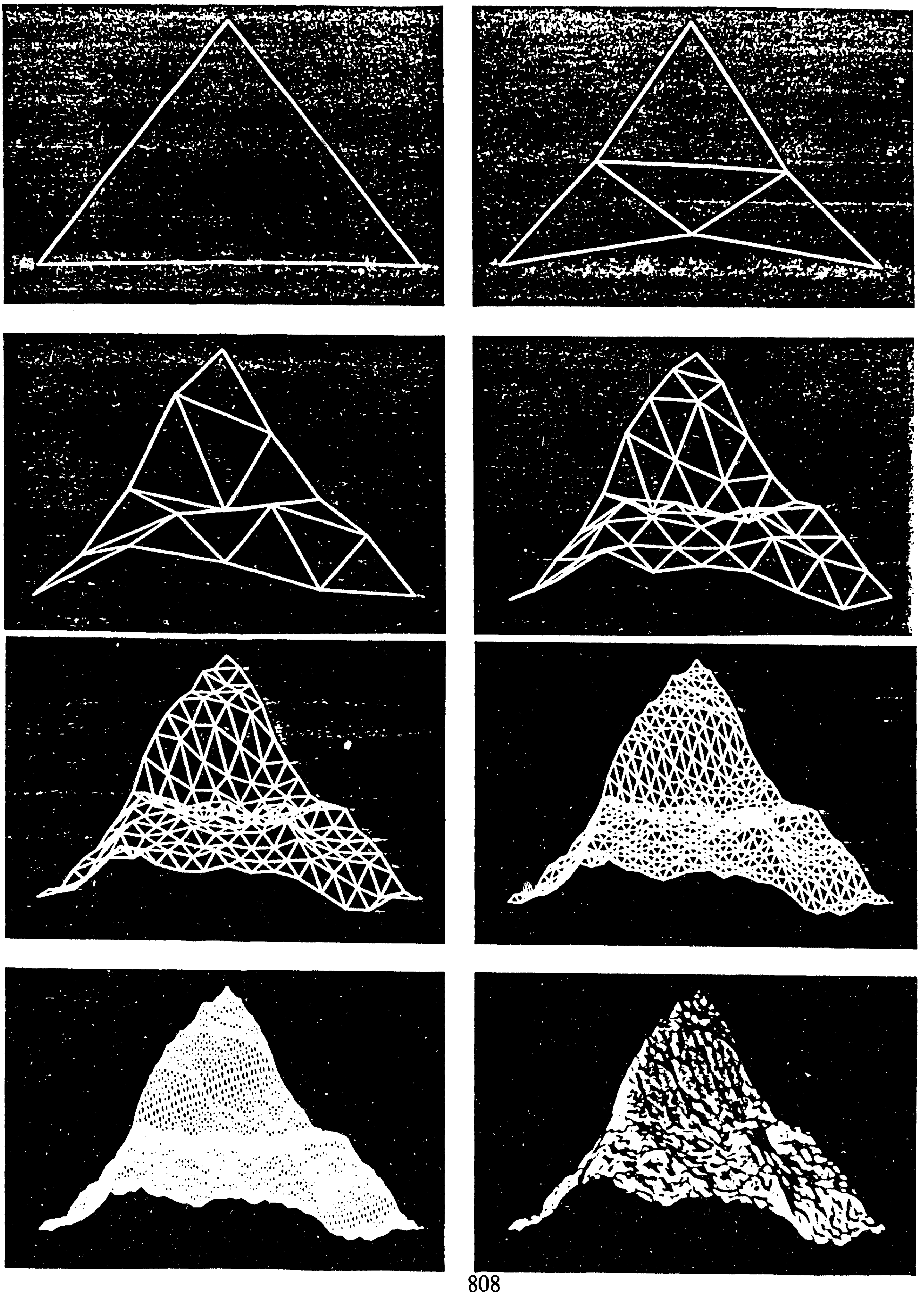
MANAGING THE DEVELOPMENT AND OPERATIONS OF COMPLEX MODELS

Frederic H. Murphy
School of Business and Management
Temple University
Philadelphia PA 19122

WHY DO MODELS BECOME COMPLEX?







basically starting out with a triangle, more and more triangles, until eventually you get something that looks like a mountain.

Let's look at a set of questions that people ask. Jim Sweeney, our next discussant, and Susan were around for the very early days of the original questions associated with Project Independence. For those of you who have gray hair or no hair, you remember that Project Independence was Richard Nixon asking, how can we eliminate oil imports? Ironic now that we import far more than at that time. But that was the question, when you have to look back. It was very broad: are we running out of oil and will prices increase again?

I remember after coming home late one evening and turning on the TV, and watching a special on energy. There was a woman being interviewed and she said, "God gave us automobiles, God will provide gasoline."

So we have gone from a world where that is the question which we still have to be able to address. Now we have questions of finer and finer granularity. For example, we are having discussions of energy taxes.

Now EIA is in the position where EIA has to be consistent about this broad view and at the same time answer the detailed questions within that consistent broad view.

So the modeling activities here have to attack problems at all levels. This automatically implies large, complex models. Unlike what Tom Woods was saying about side analyses, you can't do that, because you have to maintain consistency and provide documentation. You have got to have your history to be able to understand what you did and hopefully do better next time.

So, again, EIA needs the finest granularity, needs consistency, and it needs to respond in a timely and cost effective manner.

Now I include cost effective. That doesn't typically enter into the government lexicon. But it is very important because we all hear this talk about budget deficits. EIA's budget is the round-off for one day's expenditures. But still, you have got to be thoughtful about these things, especially since the private sector has been doing so much to get cost effective in the past decade. And it is important, imperative that the government follow if not lead.

Now how do you deal with this? Well, Susan touched on one of the issues, modularity. You want an architecture that partitions the work into meaningful modules.

Now the key operative word is meaningful. If you divide the work up too finely, you are on the auto assembly line view of the world and you cannot deal with that in an analysis context. You have to have a conceptual whole that you work with.

And you cannot have too many interactions of people during operations. It gets very messy. Stuff gets forgotten, things get dropped.

After you start with that main architecture -- and NEMS has the appropriate main architecture -- the next step is to look at the operations.

QUESTIONS BY GRANULARITY

1a. Are we running out of oil?
 b Will prices increase again?

2a When will we run out of oil?
 b How high can the price go?

3 Can you project U.S. oil production and imports and market prices for the next 40 years?

4a What are the effects of several synthetic fuel options over the next 40 years?
 b What will be the impact of a new gasoline tax on consumption, the refining industry, and imports?

CONSEQUENTLY

EIA needs to address issues at the finest granularity needed by its clients.

EIA needs to maintain consistency in projections and integrity of systems.

EIA needs to respond in a timely and cost-effective manner.

SOLUTIONS

1. Adopt an architecture that partitions the work into meaningful modules.

2. Study and improve the operations of the modules and the system.

3. Plan for ongoing model research and development.

4. Apply the lessons learned by the private sector in new product development to model development.

If the model is too big, rework it and rework it. What has been the big change in the auto industry? It is applying traditional industrial engineering techniques to the set-up costs of changing over from producing one model to another.

For those of us who teach operations management the changes have been impressive. The Japanese apply traditional industrial engineering techniques to set-up activities. They reduced the time it takes to change the dies and stamp a fender, from 16 hours to two minutes.

EIA has the same potential for productivity improvements. EIA has been doing this for 20 years now when one includes predecessor agencies. The auto industry has been buiding cars for, say, 80 years. And they still can find those kinds of improvements. EIA can do the same thing here.

The other task is that you have to plan for ongoing research and development. One of the reasons why this is such a large enterprise is that throughout the 1980's EIA had no planned R&D activities in the modeling area. It was chaotic, badly organized, and disastrous so far as keeping up with technological improvements. Modeling wasn't managed properly, because of the way the organization was designed.

Apply the lessons learned by the private sector in new product development to model development. You know, what makes Chrysler's LH cars so impressive now? It is not their technology. They really are not cutting edge in incorporating new technology.

For 15 years Chrysler was basically putting new sheet metal on old cars. And now the LH cars have come in. What is impressive about the LH cars is that they had one third the staff and half the time, and developed the cars far more efficiently. And they modeled it after the way Honda managed the design of automobiles.

In terms of the number of changes that had to take place between the final design and actual production, there was a hundredfold reduction in the number of changes necessary. The savings came from managing the process, by putting together teams that focused on producing a product rather than organizational conflict.

What is not managed does not get done or is done wastefully. The reorganization at EIA parallels the changes at Chrysler, and, in the long run, will be more important than the current activity with NEMS.

Now let me illustrate the issues of modularity. First I will put up the standard schematic of energy markets. You can see the demand and the various supply sectors there. Remember that dashed line for the way it separates the figure.

The next figure is a diagram of the operations of PIES, the original Project Independence Evaluation System. The circles represent actions that humans take. The squares or rectangles are actions that computers take. The diamonds are the standard flow chart of IFFS. And then the arrows are what is important.

The arrows represent transfers among people. And each of these transfers is a place

MANAGING RESEARCH AND DEVELOPMENT

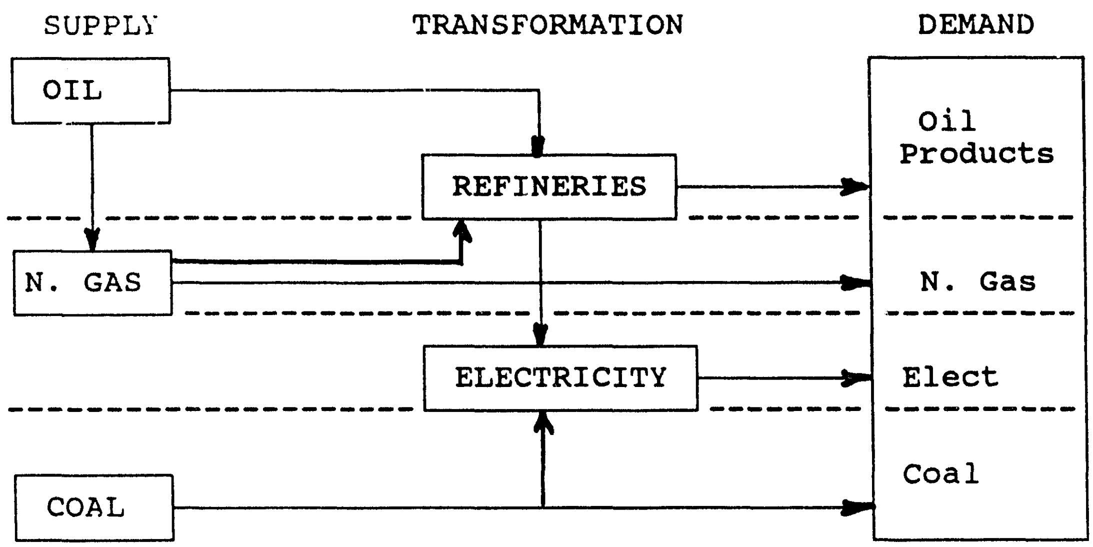
LESSON FROM PREVIOUS ORGANIZATIONAL STRUCTURE:

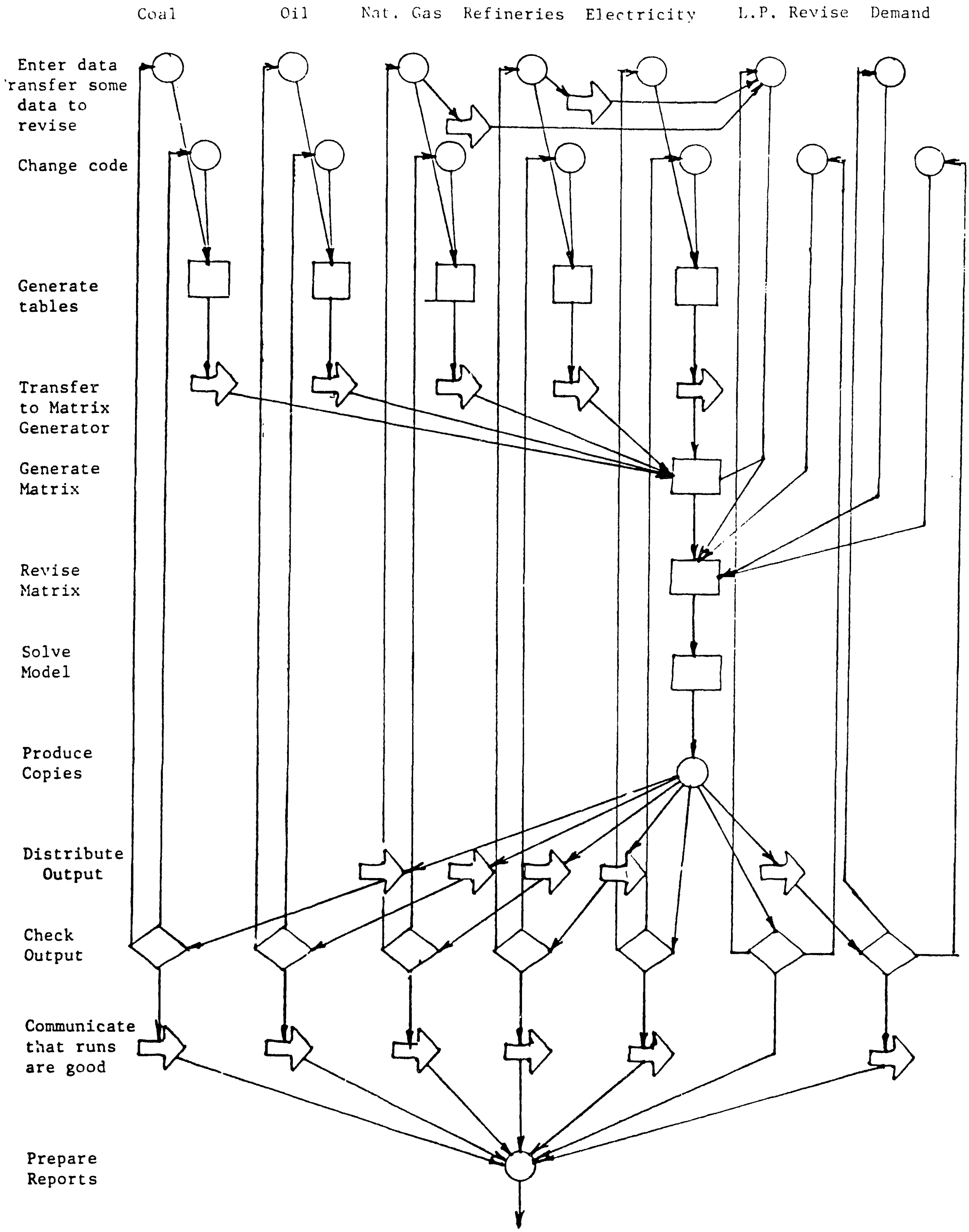
What is not managed does not get done or is done wastefully.

LESSON FROM THE AUTO INDUSTRY:

PRODUCT DEVELOPMENT MUST BE DONE IN TEAMS FOCUSED ON THE PRODUCT AND NOT COMPONENTS INDEPENDENT OF THE PRODUCT

SCHEMATIC OF ENERGY MARKETS





Workflow Diagram for PIES

where the ball could be dropped.

The way PIES worked is that there was a lot of entering of data, changing of code in what were known as preprocessors that fed a matrix generator. The preprocessors were handled by individual fuel experts.

PIES was a big linear programming model. The revise was a file that overwrote the matrix to create specialized scenarios.

The arrows represent transfers between people. The people, who generated their tables, really couldn't look at their tables to see whether they were any good or not. They had to do the hand transfer to the person who then set everything up to run through the matrix generation and solution phases of the model. That person then wound up carrying tons of output back to all these people so they could then make their changes, and rerun over and over again. So not a meaningful breakdown in the workload.

Now I am going to show an individual fuel module from IFFS, the system NEMS is replacing. Notice the only transfer that takes place is after there is a lot of checking that goes on. The next slide shows how the overall system works. This is basically the same structure as NEMS.

There is always the repeat loop going back because there are funny interactions that you have to check through running the whole system. But notice how few transfers are taking place there versus the mess with PIES.

What is important is to understand the actual operations of the model. These diagrams are nothing more than the extension of the diagrams that industrial engineers use that are called product flow process charts for looking at production processes to improve them.

Now when you look at an operation, the key thing with improving the operations to make this system viable is breaking habits. You know, that is what the auto industry has had to learn, is to always examine and re-examine what they are doing from an operational perspective.

The way you break habits is you just ask these four simple questions: what are you doing; why are you doing it; how are you doing it; can you do it better? An example of the second question, why, is the use of accountants at Ford to check that what the suppliers delivered actually matched what was on the invoice.

Ford looked at the Mazda plant. And Mazda had no one checking. Ford asked, how do you know the suppliers deliver the right number? And the people at Mazda said, we know how many cars we make and we know how many of those parts go in each car, so we know how many parts were delivered. If they shorted us, we will find out very quickly.

Eliminate things that you don't need to do. And then, if you justify the why, go in and ask, how are you doing them. And if you look at it in detail, you will find out that there are many ways in which you can do it better.

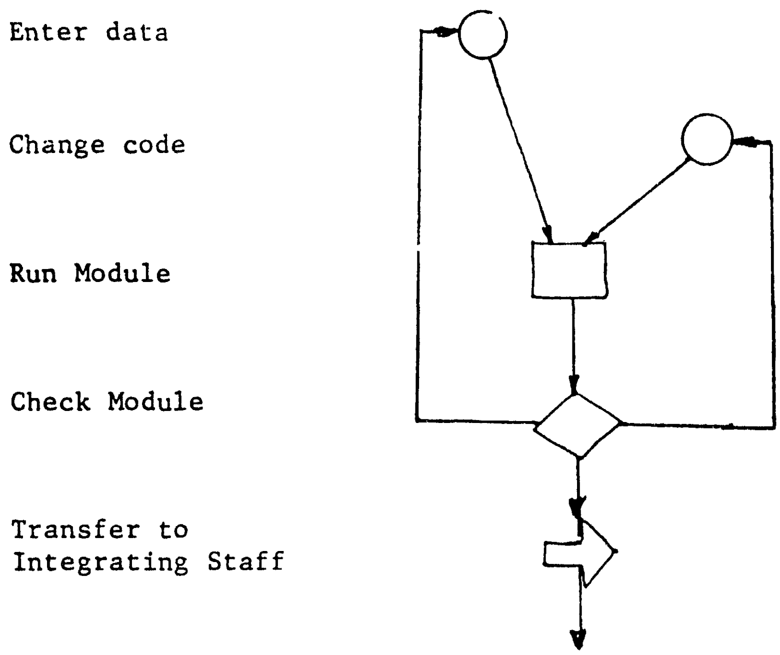


Figure 6a Workflow Diagram for Each IFFS Fuel Module

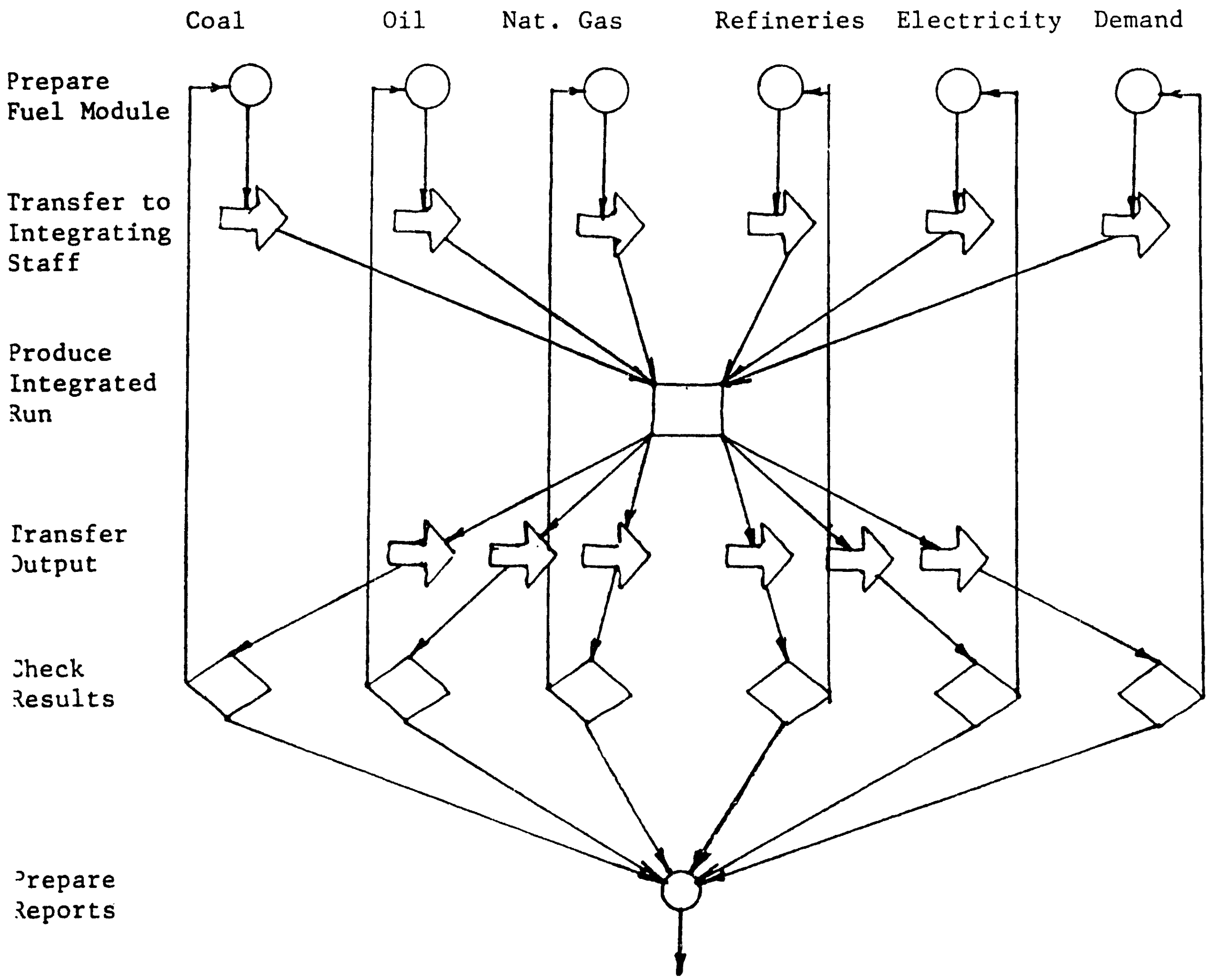


Figure 6b Workflow Diagram for IFFS Integrating Module

QUESTIONS FOR STUDYING OPERATIONS

1. What are you doing?
2. Why are you doing it?
3. How are you doing it?
4. Can you do it better?

WHERE TO LOOK FOR IMPROVEMENTS

1. In the operations
2. In the process
3. In the sequencing of actions

RULE FOR IMPROVING OPERATIONS:

Computers are cheap and labor is expensive.

In some sense what I am describing is not the exciting policy issues. It is about the boring day-to-day operations. But this is what makes or breaks industry in America. And the manufacturing industries in America are now finally world competitive, after a period of terrible decline.

So where do you look for improvements? One is in the actual operations. You know, what are you doing with each task. The interface, for example, is going to be terribly important for this because the interface has to be designed to minimize errors in job submission. You want to have every operation that a person does to actually produce a run thought out very carefully.

The diagrams that I showed are what one should look at when sequencing the steps. There is no natural order, or there is only some natural order, to the tasks that are going on. Consequently, there are opportunities to alter the work flow.

Computers are cheap and labor is expensive. If you take one senior analyst at EIA, with salary, benefits, and overhead, you can buy 50 high end PC's. You have to be very careful here and not talk small modeling strategies where things separate and people hand fiddle, because you are just going to waste incredible amounts of time.

I recommend looking at the work flow for everything that is going on, see where the elaborate loops are, and minimize the frequency with which you go through the large loops. You can change the order of tasks, and look at human transfers, because that is going to be a major source of error. Eliminate a lot of the human intervention.

There are some ideas that do not work. We experimented with PIES to figure out ways to make that more operationally survivable. One of the things we tried is run a stripped down LP for every sector other than the one we were testing.

For those of you who know linear programming, this turns out to be very problematical. First, you have to double the staff devoted to this integrating function because the person has to maintain two models now.

Secondly, given the nature of LP's, we got many more infeasible LP's slowing the testing process. In the end we just went back to the original LP.

Be very, very careful in the use of reduced-form models. They should never, ever be used to determine a number in a final solution, unless you have a hierarchy of passing of information rather than a circularity. When you have a circularity, you are going to come back and you are going to hand fiddle. Then when you do a new scenario, you will have to re-hand fiddle to fit again.

That doesn't mean that reduced-form models aren't useful. They can be used to accelerate convergence. If you don't have to return to the original model to do any subsequent analysis, they are fine. As soon as you have to go back to the original model, you are going to start trying to mess around with the parameters of the original model to reproduce what the smaller reduced-form model created for you. That is very problematical.

USING WORKFLOW DIAGRAMS

1. Look for elaborate loops with several human interventions to see if they can be replaced by a sequence of shorter loops. This catches errors sooner and eliminates inefficient iterative interactions.

2. Leave larger loops only if they consist of checks on problems that can be discovered only through component interactions.

3. Do not take the sequence of tasks as given, since there is less likely to be a natural order, unlike physical production. This may allow the work flow to be simplified and workload balance to be improved.

4. Examine each task that involves human intervention and ask if it is necessary, and, if necessary, whether or not it can be simplified. Modeling systems, like production systems, suffer from carrying over formerly efficient work methods to new environments where they are no longer appropriate.

WHAT NOT TO DO

1. Maintain a stripped-down version for testing.

2. Use reduced-form models when you have to return to the original, complete model for offline analysis.
   - they can be used to accelerate convergence or when you do not have to return to the original model.

3. Use reduced-form models for quick-turnaround analyses.

I don't think you really need reduced-form models for quick turn-around analysis. The people who are running these large models can look at a solution, pick a few elasticities that they know from experience, and do adjustments on an envelope in a few minutes.

MR. RODEKOHR: Thank you, Fred. Very interesting comments.

However, I can't let it ride completely, Fred. I don't know if using the automobile companies, judging from the financial performance of General Motors, is such a good guide.

MR. MURPHY: Ford is the number two auto maker in the world, after Toyota.

MR. RODEKOHR: I noticed you didn't use General Motors and you used Ford, as an example.

You should know that some people would differ in opinion about poor management at EIA in the 80's.

MR. MURPHY: Not at your level.

MR. RODEKOHR: Now to introduce, Jim Sweeney.

MR. SWEENEY: Thank you. I promise I won't comment on how well the organization was managed in the 80's or in the 70's. However, we expect in the 90's that it will be spectacularly well managed.

We see already a modeling approach that in one sense, as Fred very correctly points out, is very reflective of IFFS. The concepts that have been developed, starting from the PIES period to IFFS, through the National Academy of Science study, to this development, have been a process of continuing growth of the ideas. So in some sense, this is just a little step, this is a continuum.

But in another way, I think we are seeing a very radical departure from history. And the departure is not in the concepts. We are all doing fixed point algorithms. Even the LP model of the PIES system was iteratively going through to find a type of fixed point solution in a way that you depended an awful lot upon an optimization algorithm to integrate many large parts of it. But we were iterating to find a fixed point to the system.

We have had a progressive movement away from one big integrated system that you had to run together to more and more separate modules which can be run iteratively to search for a fixed point, that is, a set of prices which go through supply and demand, so that those supply and demands cleared at the prices that you started with.

But what I see going on now is an attempt to deliberately manage the process to allow flexibility of concepts and flexibility of different modules to take into account the continuing evolution of the various modules and the various modeling components in this system.

That is not a discrete change from what has happened in the past because there was always, even at the PIES stage, a recognition that there were modules. But I view what is now happening as a deliberate understanding that there is going to be a process of change and adjustment and growth of the modeling system, and that there is a deliberate understanding that the system should be developed in a flexible way, so that you can continue to find fixed points in a very dependable way, even though your various components of the model will change over time. And I think that is a very important image of what is happening.

I very much appreciate this image and I think EIA has to be very much commended for the ambitious project that they have set on to do, a very ambitious project because you are taking a whole group of people and saying you have go to spend a lot more time and attention in modeling now than you had over the past few years. It is a big task. I find personally that if I want to get hold of EIA people on the weekend, I just call their offices on Sunday and I can reach people there. And it is a testament to the amount of work that is going into it.

As part of this strategy, I think the notion of reduced-form models is actually essential or very important to what is going on. And Fred and I differ in that regard.

You will always have a problem in large scale modeling in that large scale modeling will get too big, no matter how hard you try to stop it.

I happen to like small models. I want to be able to think my way through the model. I don't want the computer to do all the number crunching without me being able to think through the numbers. That is my bias here.

But I also know that models get big because people ask questions and they say things like: there is an important policy issue to deal with, we are thinking about carbon taxes and some Btu taxes and gasoline taxes, we have a revenue raising goal, and we want to be able to examine all of those together and compare them.

Therefore you can either do one of two things. You say, "I am not going to play the game. Mr. President, what is EIA's goal in deciding the fundamental tax strategies that you are examining?" or you can say, "Hey, I have got a modeling structure that I can start modifying and adjusting and have the capability to address this broad range of different taxes," and try to examine the differences among th(taxes.

Well, I think if you want to be relevant, you have got to take the latter approach. You have got to go in there. That means you end up developing components to the model that you need to develop.

Then once they are in there, you don't want to throw them in there. It is too much work to strip them back out again.

And then you have some people from NREL (National Renewable Energy Laboratory) coming in who say, "Look, you have missed the point about these renewables because they are not quite the same as the structure of large scale electric generating facilities, because there is a regional heterogeneity that you have got to take into account, and there are some different concepts, some different timing issues." So you say, "Yes, I guess you are right. How do you put them in?" You go through a process of improving that. By the time you are done in each individual sector, you have a very complicated model.

Then you have another pressure that goes on. You have people that come in and say, "Well, how come you don't have in X sector, how come you don't have the entire structure of the noncompetitive developments of the electric generating industry to take into account the role of the regulations in the state level?" And they do that to undercut your model, to say it is useless. And usually it is nice to have an answer: "Oh, yes, it is in there."

Sometimes getting it in there doesn't help the model but there is this pressure to make it more and more complicated. We have all seen that.

How do you deal with the pressure? Well, one of the ways you deal with it is you keep stripping those things back out again. But if you do, then you are going to spend your whole time stripping things out of the model. It is a big managerial effort, and you have a moving target. The model keeps changing.

The other way of doing it is allow your individual modules to get complex as appropriate, without having the whole integrating model get complex at the same time. The only way I am aware of to do that is to have a deliberate strategy of developing reduced-form models that capture the essential elements of these complex modules.

So the strategy here, which I think is a very healthy one in EIA, is to allow you to get complexity as appropriate in the various modules, but to recognize when you are examining a gasoline tax you may not want to carry along all the burden of having a detailed representation of all of the renewable and nonrenewable technologies for generating electricity, because you may believe that the feedbacks through that sector are not that important, or the details aren't that important.

But you may also recognize that there is some importance about supply and demand feedback, that maybe the operations of the refineries are important in understanding a gasoline tax. So you want to have some representation of refineries but maybe not the details of everything you need for analyzing the Clean Air Act and its relationship to refineries.

The way you make it work is to use reduced- form representations of all the rest of the components and leave that in the model while you examine very closely the gasoline supply and demand elements of the model. I think that is a very healthy strategy.

Now as Fred points out, there are some pitfalls. You want to make sure the reduced-form representations are truly reduced-form representations of the models in the important elements. So you have got to decide what are the important elements, of course. And the important elements are those elements that are relevant for the feedback through the rest of the system.

You don't have to have all of the details. You don't have to go through the problem that Ron Howard in our department called verisimilitude. Think of a model railroad buff. A good model railroad not only has a train, it has a bar car. In the bar car there are actual little people, and those people actually should be holding drinks. And the drink should have an olive. If you have a pimento in that olive, now there you have a railroad system that is worth it.

That same phenomenon is pushed in models. But having the pimento doesn't give you a representation of the mass of the whole train moving down the track. What you really need for the feedback often is to see whether this train is going to hit another train that is crossing. You don't need the pimentos in the olives to see whether they are going to crash.

Well, that is really the system that we are talking about in this modeling. What are the feedbacks?

So the feedbacks are usually price to quantity feedbacks. So what you want is a reduced-form representation that says if the prices change, what will be the quantities output, a very simple response surface. And you want to be able to take those in and out so you don't have to carry around those pimentos all the time. Because while it is absolutely true that labor is expensive and computers are cheap, if you go through a process of interpreting the model runs and have the pimentos all the time, that is labor. That is not computers, that is labor.

And computers aren't so cheap that if you are doing a wide range of sensitivity tests and you have to examine everything, those runs aren't instant. And waiting around time and waiting to figure out what is going to happen is expensive human labor.

So you want quick response. And I believe that this modular representation gives you a chance.

Now that doesn't mean you can do it stupidly. EIA is going to have to do some careful thought in automating the process of getting the reduced-form representation.

Now it may be as simple as a matrix of elasticities from prices to quantities outputs. It may have to be a little bit more complicated than that.

I don't have the answer to that question. I think there is some real careful thought needed. But I would say go with it, keep doing that reduced-form modeling.

The next set of points I would like to address has to do with a direction that they are going, again that I laud, in the environmental-energy interfaces.

Susan has made the point that the models always have taken into account the impact to the environment. That is, if some environmental intervention increases the cost, that can be incorporated in the model. True. But that is not the action that we are talking about. That is only half of the action.

The other half of the action is energy sector changes which influence the impacts on the environment and influence the state of our environment. And I believe EIA is going to have to become a larger and more significant player in that debate.

EIA is now moving towards including those environmental coefficients in the model.

That is, what are the impacts on the environment of energy sector changes. And again, I laud that because I believe that an important part of the policy action in this administration, and hopefully future administrations, will be in understanding energy and environmental relationships. Those are the big policy debates when you get outside of the government and they should be those inside the government.

One of the types of things that are happening in the environmental area is the creation of markets, the allocation of property rights for commodities that are environmentally related. The Clean Air Act marketable permits for acid rain precursors are good examples of that.

So I believe we will be creating more market or marketlike instruments in the environmental area. And therefore, the movement that we see of allowing the opportunity for examining such instruments I think is very important and again should be encouraged.

Such instruments involve a market clearing process where you may be choosing a quantity target and asking what will be the prices that will cause a supply and demand equilibrium.

This is a framework, a fixed point framework that allows you to go through that right within the same concepts that you are using for doing the rest of the analysis. And the fact that they are now building in the capability for doing that is positioning them for the future debates that they are going to see. And again, I think the effort should be continuing along that line.

There is an area that I think is probably going to require a lot of thought, both within EIA and outside of EIA. And this is expectations formation.

Susan has said you can have perfect foresight but what we usually do, if I interpret her carefully, is say each module has the representation of expectations that somehow seems appropriate in that module.

Now I am not exactly sure what that means. But I think it means we have different brands of irrational expectations in different modules and that we are letting the model builders decide which type of irrational expectations to put in their modules.

I am not sure that fully addresses the question of how to deal with real issues of uncertainty and expectations about the future. But what I am convinced about is that if we systematically have models that are run in a deterministic way and have expectations of the future systematically different than the model results, that something is not right there, that those such irrational expectations, even if it is done differently in each sector, really aren't the final answer.

Now is there a final answer? Well, unfortunately there isn't, because the basic research on how to represent rational expectations is a long way from being completed.

We know that perfect foresight is not what we mean by rational expectations, because nobody has perfect foresight. Somehow we mean that the probability distribution held by the actors in the model is consistent with the outputs for the model. But to do that you have to have a rich ability to deal with uncertainty in probability distribution. There you get to real complexity in modeling. And to do that you need to have some way of generating a lot of runs without taking years to do it.

I happen to think that reduced-form modules may be part of that answer. But again, I don't know. This is a hard research problem. And again, I think that is something that they should put attention to.

The final thing I would like to comment on is PC's versus mainframes, something that Susan and I have talked about from time to time.

I think that EIA has to have a very explicit goal of moving to a situation in which the whole system is on PC's. Whether they be upper end or not, I think they have to move to that because I believe that there is a broad potential user community that will never be able to get insights that they want from the model if they have to depend upon runs being done in EIA; that would like to be able to put up the model in their own computers and decide whether the model is any damn good, run it, work it over and decide, is it a useful tool for me or is it a piece of junk for me; and if it wants, to give that feedback to EIA.

EIA might not want to hear if you say this component is a piece of junk. But in the long run we are all better off if they hear it from you directly, rather than around the grapevine if that is why nobody is using it.

But hearing that creates a process of improving things that are a piece of junk, but also has a process for displaying the real quality work that is going on in EIA.

I think for the richness of the broad understanding, EIA has to move to a situation where there is broad real accessibility.

I am enough of a PC generation to know if somebody says, well, it can be put up on a mainframe, I can say, oh, and I will never get involved in it. If you say, here, you can put it up on your PC and work with it, I will do it. It is that difference between yes and no.

High end PC's are cheap now, as Fred pointed out. I have just gone through some upgrading. I just took some older ones that I had and it is a fairly trivial task to rip out the motherboard and put a new motherboard in it, put in memory and things. So I can tell you what the cost.

You can get a 66 megahertz 486 motherboard and microprocessor for about $1,000. And memory, DRAM memory is $30 a meg.

You can get all the random access memory you need and you can get as fast a speed as you need for a pretty damn modest price, in comparison to analysts' time. And hard disk storage is cheap. You know, you could get 200 megs for $300. You could get bigger ones for roughly proportional cost.

I don't believe storage issues, the need for high end PC's or whatever should be a fundamental constraining factor towards moving to an overall PC system.

Now there are managerial issues. There are the issues of how EIA manages its time in a transition from what they had to what they have in the future and how they allocate their own individual workload. That is a real legitimate issue, because they have got a very big job and very few people to do it.

But I hope that they have as a long term goal -- and what I mean by long term is two years -- to have everything on PC's, high end or not, so that you could use the whole system on PC's and that the user community is really part of that user community.

And at that point I will stop. But a comment. It is a great job you are doing. Keep doing it. You know, this is more life than I have seen in a long time, because I see a lot of action going on. So keep it up.

MR. RODEKOHR: Thank you, Jim.

According to the paper, you are going to have to redo your computer in a year anyway, with the new Intel chip.

Also, I am going to use your pimento story somewhere. It might be in a budget meeting, but I will find a place for it.

Now I would like to introduce Milt Gutterman.

MR. GUTTERMAN: I don't have any deep philosophies to talk about the way all the previous speakers did. I am going to be talking from the point of view of a dirty fingernails user and what he is going to do over these long weekends and how he is going to do it.

The NEMS requirements imply a number of important considerations in the user interface area. The statements in the requirements working paper was "NEMS will have a user interface that, along with a simple user's guide, will enable a reasonably knowledgeable energy analyst to operate model scenarios, choose which modules to execute, scan the assumptions, and vary the key assumptions for a revised model simulation."

That is a simple statement of a goal for the user interface. The designers of spreadsheet programs, word processing programs, and other widely used applications have met such goals very effectively. Their products can be used with minimal reference to the printed manuals and very limited use of the on-line help facilities.

It would be wonderful if NEMS could be made as easy to use as WordPerfect or as easy as 1-2-3. I think it is unlikely that such extreme ease of use can be implemented for NEMS.

The remainder of my talk will be divided into two main sections. The first of these will give the reasons for my negative attitude about the possibility of such simplicity. The second section will be more constructive. It will describe the type of user interface that I think is practicable and will give my opinions on the ease of use of such an interface.

Slide 1 is that old diagram again. This shows the relationship between the integrating and control module and the other NEMS modules. The figure shows that 13 modules may be invoked by the integrating and control module. Each of these modules may be switched on or off during any particular run. All the modules are independently developed and can be run on a stand-alone basis.

On Slide 2 the first difficulty for the user interface: the sheer number of modules that must be handled, 14 modules including the user interface module itself.

Most or all of the modules of NEMS contain regional models which represent geographical influences on various energy aspects. I heard about regionality from several of yesterday's presenters. The regionality for the integrating and control module is to be the regional organization of the nine Census divisions (shown on Slide 3), possibly with a tenth region reserved for future separation of California from the rest of the Pacific Division.

All the data that must be exchanged between modules passes through the integrating and control module. And luckily for the people who are doing the integrating and control module, the translation from the regional organizations in other modules to this one is the responsibility of the other modules. There are some exceptions to that.

So Slide 4 shows that a second complexity that must be addressed by the user interface is the geographical complexity of NEMS.

The tables on pages 21 and 22 of the report, on the design report, list approximately 240 arrays, consumption, product and price arrays, which are necessary for the model equilibration methodology. Each of these is a two dimensional floating point array. The first dimension is geographic, representing these regional divisions. The second is temporal, representing years from 1990 to 2015.

That is not all the data of NEMS. Pages 24 through 29 of the design report list a large number of additional array variables. Some of them may be local variables. But the users may still have to communicate with them, scan them, modify them. And most of these are dimensioned geographically and practically all are dimensioned chronologically.

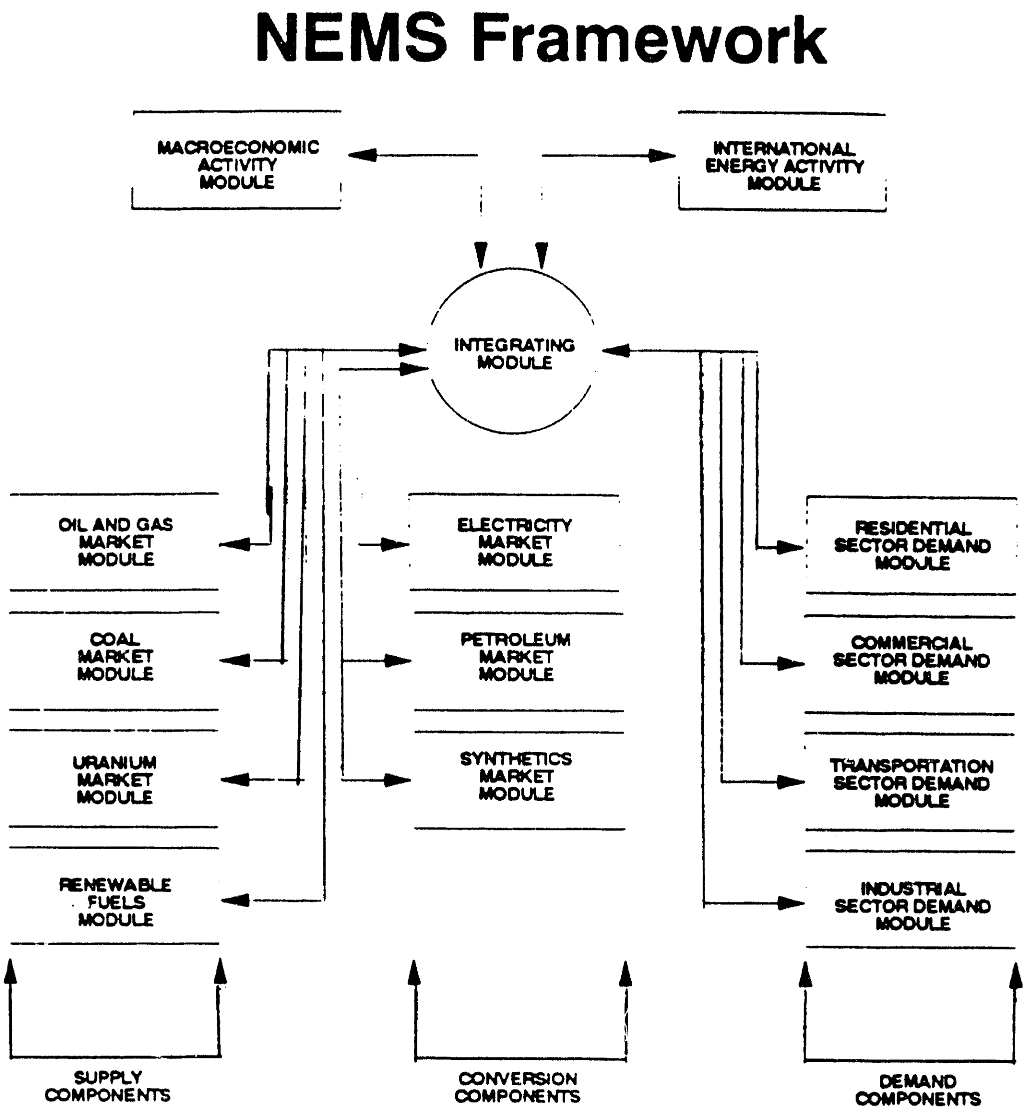
Also, I didn't read this section very thoroughly but I didn't see any variables relating to qualities or specifications of various things. And while I don't know what goes on in the other sectors, I have a feeling that at least in the refining sector there has to be some attention paid to qualities and specifications.

Particular users will usually be only interested in a subset of the variables. The user interface must serve the needs of all users. It must contain facilities to display and modify all of the variables and allow the users to check the validity of such modifications.

So, Slide 5 adds a the third difficulty in the design of the user interface: the sheer volume of the data.

On page 18 of the design report it stated that quantities will be stored in millions of Btu's

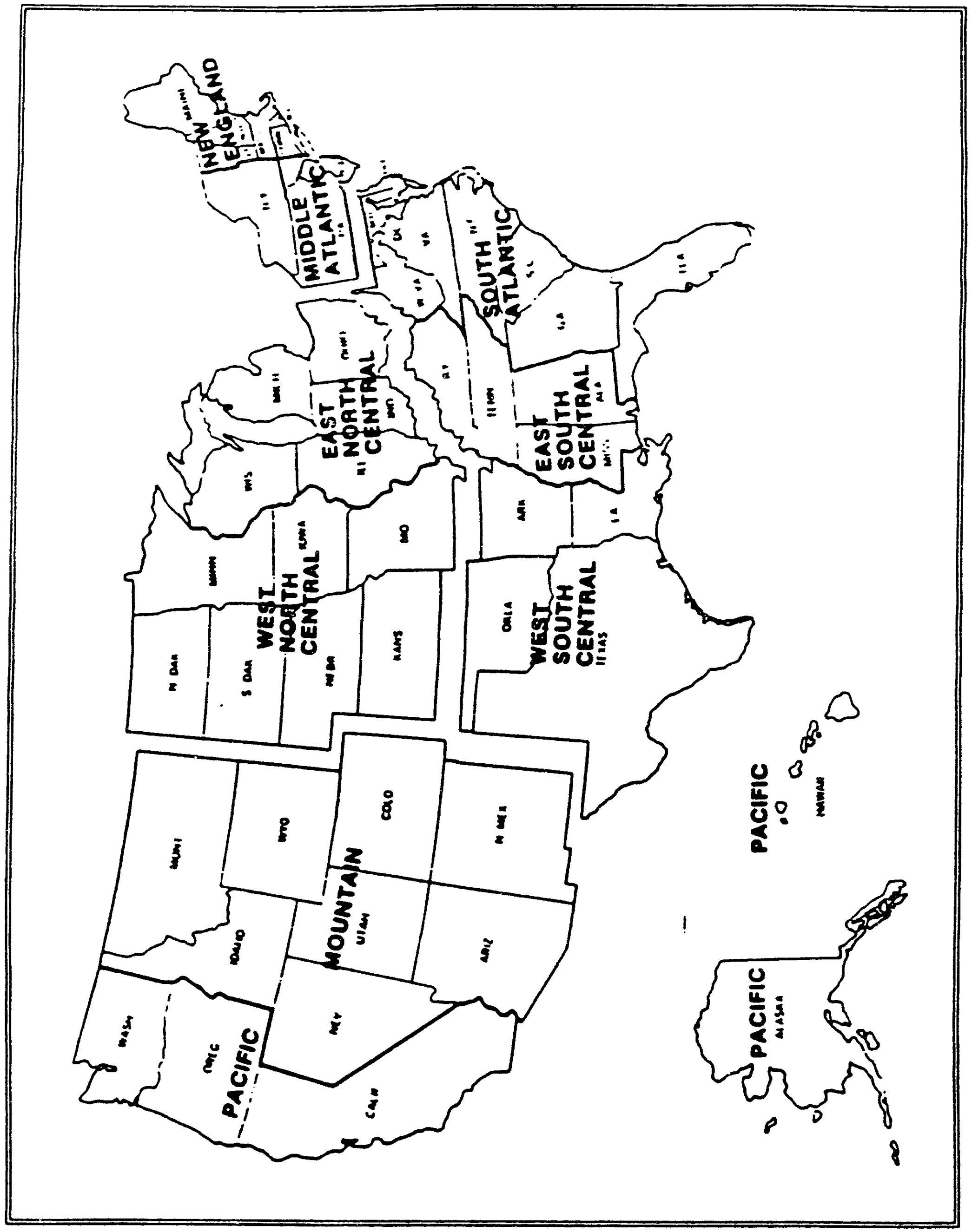
Figure 1. Relationship between the Integrating and Control Module and other NEMS Modules



Milton M. Gutterman 5049 Lee Street Skokie, IL 60077-2336 Slide 1

1. Number of models in NEMS

Figure 2. Map of NEMS Integrating Module Regions



Milton M. Gutterman 5049 Lee Street Skokie, IL 60077-2336 Slide 3

834

1. Number of models in NEMS

2. Geographic complexity of NEMS

1. Number of models in NEMS

2. Geographic complexity of NEMS

3. Volume of data for NEMS

and that prices will be stored in 1987 dollars per million Btu.

Were you here yesterday? I was. I heard people looking at lots and lots of other types of quantity units. I heard people talking 1990 dollars. I may have heard other types of economics. I know I always wind up being asked the question of what is it like in current dollars.

We need unit transformation. The user interface ought to be able to do such unit transformations automatically for the user. And so Slide 6 lists a fourth area of complexity, the units quantities and prices.

The requirements working paper discussed external use of NEMS. And we heard some things earlier this session about external use of NEMS, as well as use internal to EIA.

People outside EIA who wish to use NEMS will usually be doing it on a part time basis. Therefore, the user interface will have to give them stronger support than that necessary for the EIA personnel who are using NEMS more constantly.

This difference and other differences among users of NEMS means that the user interface must support a very diverse user population. Slide 7 shows this as the fifth major difficulty in the design of the user interface.

So to summarize, the five major difficulties that I have described, which are listed on Slide 7, are: the number of models in NEMS; the geographical complexity of NEMS; the volume of data for NEMS; units for quantities and prices; and the diversity of the population of NEMS users.

The type of user interface that seems practicable for NEMS treats each of these difficulties as a design opportunity.

In order to start a run, a user would choose a base model. This would set values for most or all variables, determine which modules should be used, which should be set up for reduced-form models and make many, many other basic decisions.

Then the user would have the opportunity to go in and change things. And perhaps he would initially be presented with a menu, like on Slide 8, which would list all of the modules of the system and ask him to choose the module in which he wishes to make changes.

On a mainframe implementation, that menu might look like this, listing all of the modules and asking the user to enter the number of the module that he wants to work in, and hit the enter key.

In a more user friendly environment, such as a work station or a PC, he might move a cursor to one of these and press a button, instead of having to enter a number.

The next menu that he would get after this (shown on Slide 9) could perhaps list all the regions that were to be used for that module and might be a list of this form. Or it might, if

1. Number of models in NEMS

2. Geographic complexity of NEMS

3. Volume of data for NEMS

4. Units for quantities and prices

1. Number of models in NEMS

2. Geographic complexity of NEMS

3. Volume of data for NEMS

4. Units for quantities and prices

5. Diversity of population of NEMS users

0. Integrating and Control
1. Macroeconomic Activity
2. International Energy Activity
3. Oil and Gas Market
4. Coal Market
5. Uranium Market
6. Renewable Fuels
7. Electricity Market
8. Petroleum Market
9. Synthetics Market
10. Residential Sector Demand
11. Commercial Sector Demand
12. Transportation Sector Demand
13. Industrial Sector Demand

ENTER NUMBER OF MODULE FOR WHICH DATA IS TO BE EXAMINED AND/OR MODIFIED

1. New England
2. Middle Atlantic
3. East North Central
4. West North Central
5. South Atlantic
6. East South Central
7. West South Central
8. Mountain
9. Pacific
10. [California] - not implemented

ENTER NUMBER OF REGION FOR WHICH DATA IS TO BE EXAMINED AND/OR MODIFIED you were doing it a good way, might actually show a map and say position the cursor anywhere in the region that you want to work in. And this would be a more user friendly thing. But even this isn't too bad. It gives the user the control that is needed to select the region.

The next menu (shown on Slide 10) might ask the user to select a time period, which could be a single year or a group of years. But in the mainframe implementation you could be asked to enter the number of a starting year and the number of an ending year. In a PC implementation with a windows-type environment, you might highlight all the years from the beginning to the end of the period. You might be shown a time line instead of a list of years. There are lots of opportunities for improving the friendliness of the selection of the time.

Then the menu (shown on Slide 11) might give a choice among variable groups, asking the user, say we were in a petroleum refining situation, the user might be asked to select whether he wants to look at light ends, gasolines, distillates or residuals.

We have to take one more choice (shown on Slide 12) because we might also have to select a sector and so be given a menu of the sectors that are relevant for the choices that have been made up to this point and be asked to select one.

And then after that is made, finally we are set up with a menu (shown on Slide 13) that contains data. And let's say we are at gasoline prices in dollars per gallon in 1987 dollars of regular, intermediate and premium for each of four years.

To modify, enter the line number and the year and a new value, separated by commas; or move your cursor to the value that you want to modify, push the button and you are then ready to change that field; or move the cursor to the place where the units are shown and push the button, and be given a display that [illegible] you to change units to whatever you want to.

So that if you wanted to talk in te[illegible] dollars per barrel instead of dollars per gallon, or whatever amount, units of currency per million Btu's or what have you, you could do that and have the data display changed to that, and then make your modifications.

So these are the sorts of things that could well be in the user interface to allow you to control particular variables for your run.

Now notice, please, I did not show you any Fortran variable names here in these menus. If you are in love with the Fortran variable names, I suppose you could have an option to be displaying them as well as these descriptions. Or if you just wanted to check and make sure you are doing it absolutely right, you could do it.

But the general user, who is not primarily interested in the model's structure, but is interested in the answers, doesn't know, and doesn't want to know what the Fortran variable names are. In some environments he has to know. It is a burden on him, rather than an opportunity.

So the user can make the changes here and then would select another variable group, another time period, another region, another module, work his way through these possibilities,

1.	1990	16.	2005
2.	1991	17.	2006
3.	1992	18.	2007
4.	1993	19.	2008
5.	1994	20.	2009
6.	1995	21.	2010
7.	1996	22.	2011
8.	1997	23.	2012
9.	1998	24.	2013
10.	1999	25.	2014
11.	2000	26.	2015
12.	2001	27.	2020
13.	2002	28.	2025
14.	2003	29.	2030
15.	2004		

ENTER NUMBER OF STARTING YEAR OF PERIOD

ENTER NUMBER OF ENDING YEAR OF PERIOD

1. Light Ends
2. Gasolines
3. Distillates
4. Residuals

ENTER NUMBER OF PRODUCT GROUP WHOSE DATA IS TO BE INSPECTED AND/OR MODIFIED

1. Residential
2. Commercial
3. Transportation
4. Industry
5. Refinery
6. Electric
7. Synthetic

ENTER NUMBER OF SECTOR FOR WHICH DATA IS TO BE EXAMINED AND/OR MODIFIED

Gasoline price ($/gal)(1987 $)

	2001	2002	2003	2004
1. Regular	xx.xx	xx.xx	xx.xx	xx.xx
2. Intermed.	xx.xx	xx.xx	xx.xx	xx.xx
3. Premium	xx.xx	xx.xx	xx.xx	xx.xx

TO MODIFY, ENTER LINE NUMBER, YEAR, NEW VALUE SEPARATED BY COMMAS.
TO CHANGE QUANTITY UNIT, ENTER 4
TO CHANGE MONEY DESIGNATION, ENTER 5
WHEN FINISHED, ENTER 0

and make all the changes needed for the case he wants to study.

You need to help the user more. You need data checking facilities. Because you have got to be sure -- well, as sure as you can be -- that the data that the user has entered will be meaningful and consistent and will converge. Or at least you have got to give him good odds for it. The user doesn't want to set off a long run and come back and find that it didn't get him the answers he wanted.

Many of the data checks can be done as the values are being entered, sort of on the fly. There is lots of time for the computer to do things while the user is thinking about what he wants to do next or actually keying things in.

After the run has been executed, you need more data checks. You have to do data checks on the results of the run. And this is vitally important.

If the user is somebody who is primarily interested in refining, he will not want to, or perhaps will not have the ability to, check that the electricity generation portion of the model has not gotten into some nonsensical trouble. And so you need automatic checking to take account of these problems and be able to flash bright red lights on his screen, or something alarming, saying, hey, there is something wrong with this run in such and such an area, check it or have somebody check it before you try to use the results.

You can get standard reports produced by each run. You can get additional reports. You can cause the generation of additional reports by interactive processes similar to what I have shown on handling data. And for these additional reports, you can probably set things up so that you can produce the results in our old fashioned tabular forms, in entries into spread sheets, which is another variant on tabular forms, get the reports in graphical form, get maps.

I have seen a demonstration of a beautiful system for doing some network flows in which the output gets reported on a map of the United States with arrows showing the flows from supply to demand points, and the size of the arrow is proportional to the amount of the flow. Maps are a tool that I think can help the user understand results very easily.

You have to set up a system of defaults in the user interface and perhaps customize the defaults to the needs of various segments of the user population. And these defaults might include a rapid invocation of the specific data editing items.

I am sure I haven't mentioned all of the features that are wanted in a good user interface for NEMS. These ideas are a sort of first cut at making the system accessible to a user community.

As the user interface is developed and implemented, other ideas will surface which will make NEMS easier to use. I don't think it will ever get to be as simple as a spreadsheet or as a word processing program. But, maybe our right objective is to make it as easy to use as a programming language. To most of us here, making it as easy to use as Fortran would make it wonderful. Making it as easy to use as PL-1, well, maybe it is acceptable. It is not quite as good as Fortran. It is a little more complicated. But that is the sort of level at which I think ease of use is a practical, realistic desire for the NEMS system.

Thank you.

MR. RODEKOHR: Thank you.

We now can take questions. I ask that you use the microphone and identify yourself before the questions. But please feel free to ask the reviewers or the presenter anything you want.

Susan would like to begin. Hold on.

MS. SHAW: I wanted to respond to a few points without cutting off time for questions here.

I do want to take exception, Fred, to your comment that all the things have to be done at the finest granularity. You know as well as I do that we get asked occasionally for state-level analysis, highly detailed results, where we simply say: sorry, we don't do it.

This may alleviate some of your concerns, Jim, we really do not try to be all things to all people. And that is one thing we have said very often throughout the development of NEMS. No, we are not going to put everything that somebody asks for within the system. No, we are not going to do it at the finest level of detail at which everybody thinks it should be done. We are just saying, there is a point beyond which we cannot go.

Sometimes people ask us questions we couldn't do even if we wanted to, because perhaps state level data isn't available to begin to model it, much less make it a component of NEMS.

Jim, you raised the question again of expectations. One of these days I will understand what you are trying to tell me about it. But we have been discussing this for two years.

Even the non-economist like me starts to understand the issue of rational expectations as opposed to perfect foresight, and what is meant about the probability distributions leading to a rational look at the future.

We don't have all the answers in this area. What we have done is set up the basic design of NEMS so that we can incorporate different types of expectations.

The way the data was handled in IFFS, for example, there is no way we could have incorporated anything remotely resembling a rational expectation or perfect foresight option, just because the way the data was stored.

In designing NEMS, we have at least left that flexibility for various alternatives. We don't intend to have all the answers right away.

I think we do have some explicit steps we are taking in the area of the PC's. We are investigating the feasibility question. We will know more come April when we have the first version of NEMS together and really can use the entire system and figure out if it will work, if it won't, and what needs to be done to make it work.

We have had meetings with members of the user community, trade associations, other government organizations, and people who use our analysis. Many of them are very interested in the model. They are usually, though, only interested in the one module, for their particular area, be it the coal module or the refining module.

So our first step is to take the individual modules and package them for the PC. It is the easier step and we think it will satisfy a lot of people, while we continue to investigate what needs to be done to have it run on PC's.

What we must avoid is creating a system that is going to put a lot of stumbling blocks in our paths, because we are likely to be the primary users in terms of runs.

Either the system has to be able to move back and forth very easily between the mainframe and the PC, so that we are not maintaining dual systems, or it has to be configured so that we ourselves can use it on the PC without having roadblocks.

And roadblocks are things like storage. On the mainframe we can stack up 25 runs in the system, let it run overnight, and walk away. If you can only store the results of two or three runs on a PC before you need to reload another storage medium, then we have a bit of a problem.

If we can solve it through a system where these results go out on a network and also use the network to maintain default versions in a central location, so that all analysts are always working from the same basic modeling system, we can solve our problem and we can work with the system too.

These are just some of the things that we have to think about that maybe the outside users don't think about. And that goes into the area of user interfaces, too.

We need a user interface that is helpful to the novice or the less experienced user, but that the experienced users in our organization can also get behind, bypass the menus, and submit a run quickly.

I won't say much about reduced-form models. You have heard both sides of the issue. I would suggest that if you are really doing a gasoline tax study, why not shut off the electricity sector if you don't think there is any significant feedback, rather than worry about running a reduced-form version of the electricity sector? It is another thing to consider.

The usefulness of reduced forms depends on how easily we can generate them, how efficiently we can update them as the models change, how many resources it takes to do that, and the compatibility question that results.

Gary Goldstein has a question here.

MR. GOLDSTEIN (Brookhaven National Laboratory): Thank you, Susan. I just have a couple of comments and maybe a little food for thought.

I have been talking with Susan and Mike Lehr on the user interface question, which I firmly believe has not been getting enough attention yet. I know the reasons why. There is an AEO this year that has to be there and that is the driving factor right now, it seems to me. But a few things to keep in mind.

User interface is not just a data input and submission activity. Probably the two most important things are quality control and the ability to analyze the results. And estimates might range anywhere from 30 percent to 60 percent of a software development task being dedicated to that activity, which is now just getting off the ground. So a lot of resources may need to be poured in to have a successful user interface.

We heard some talk about productivity and computer time versus analyst time. Well, the user interface is the single entity that really can contribute to analyst productivity more than anything else, more than turn-around time of the model itself. If it takes a long time to run it, the ability to quickly ascertain what is going on and have confidence in what you are looking at is a real key to being able to properly interpret those results.

Another thing, from some of the early naive looks I have had at some of the modules and looking to interface them, please keep in mind that in order to have an efficient and effective user interface there are probably going to be some implications on the models themselves, the peripheral part. Not the definition of the model, what it is doing and how it is doing it, but the information handling process. And the caveat associated with that is this implies retesting.

So you are going to hit a phase where you are going to change some aspects of the way the modeling system is being worked with and you can't make assumptions that everything is handshaking properly.

I really don't think the current way of getting information in and out is going to be conducive to putting on an effective and efficient user interface. There is going to need to be some thinking and some adjustments in that regard.

Another comment is just that I know within DOE, in energy policy, in buildings and conservation, and we have heard in academia and other people, there is a lot of interest in what is going on, a lot of support for what is going on, a lot of desire to get this into people's hands and get them to evaluate it, gain insight and things.

Again, user interface is the key to being able to do that. If it is only an EIA project, this is not an important issue. If it is a major goal to get it into people's hands, it is the key issue.

And when it comes to getting insight, I really would like to emphasize graphics. You know, the old picture is worth a thousand words is now a picture is worth ten thousand words.

Driving and thinking and looking at the problem as a graphical problem from the beginning is a way, again, of getting that analyst productivity up to its highest level.

Two last comments are don't estimate what is going on in the hardware and software world right now in terms of evolution and revolution.

I read last week that Silicone Graphics is introducing a $120,000 computer, the equivalent of a Cray. So, we have no idea about two years from now what is going to be sitting on the desktop. And $10,000 is going to buy you gigabytes of storage and hundreds of megabytes of RAM with no problem.

So all of this coming together, I think I would encourage maybe considering separating model integration from user interface much more so than is being talked about and looked at right now.

The only thing they have in common is that they touch all the modules. But after that, the thought processes, the concerns and the goals are very different activities.

So no questions, just some comments. I am willing to take the cracks back.

MR. LEHR: I am Mike Lehr, from EIA. And I just want to respond to some of the comments that have been made concerning the user interface.

First of all, James Sweeney mentioned that he thought it would be a good goal to put all of NEMS on a PC. And in my mind, I distinguish between entirely putting NEMS on the PC and making completely compatible versions of NEMS available on the PC.

I think that although we have different views about priorities, costs and ease of doing things and exactly what should be done, people generally agree that if compatible versions were available on the PC this certainly would be a big advantage.

We have done several things thus far and we are continuing to do things which will position us to make compatible versions available on the PC. The way data is handled on the mainframe is explicitly done, for example, so that it can be ported to the PC, and so forth.

One thing that I do want to point out is that we often talk about the cheap and inexpensive PC's that are available. And at one point Dr. Sweeney was talking about the management problem. And I thought about a chart that is on a wall in EIA. On one side of the chart there is an extremely complex set of boxes. On the other side of the chart there is a box which has the end result. And in between, between all the complex things flowing in and the line to the end result, there is a box that says: and then a miracle happens.

I thought as far as that management problem goes, those of us who have worked inside EIA have a real healthy appreciation that Dr. Murphy mentioned for how difficult it is to coordinate and communicate and avoid lost time and costs in between different runs, iterations, perturbations, and so forth and so on.

So for us, when we look at the cost of putting it on the PC, we are really talking about the cost of PC's and a network that has very sophisticated abilities to do the equivalent of batch processing on the mainframe, to support communication between people, to handle large volumes of data.

As Susan mentioned, for us in a major study like the AEO, where we do maybe 1,500 simulations, we have dozens of people involved. The communications abilities are really key. They are really a big part of the cost, being able to get things done right and properly coordinated. So I think that does have to be considered.

Secondly, if we were to create on the PC an interface that was just like the mainframe, it would probably be considered a flop, for one reason: it wouldn't support people outside of EIA who require more help than people inside of EIA. And that is a big reason for doing it on the PC.

We have software on the mainframe called SuperWylber. We would need to do a better job to meet the expectations that people have on the PC.

One last thing I would like to mention is that it is true that the user interface work lags behind the other models. But there are reasons other than some of them that have been mentioned for that.

And one in particular I want to call to your attention here is that, as Milton Gutterman pointed out, when you have an interface it has to be tailored to the module, and in this case probably to many different users with different ideas about the module and how it should be used.

So there is a natural lag between defining exactly what is going to be in a module and then planning for the interface that is going to accommodate these many different modules and have some kind of reasonably consistent look and feel across them. So I think that needs to be taken into account, too.

We do have an explicit plan. It is not finalized yet.

Thank you.

MS. SHAW: Saul.

MR. GASS: Thank you very much. Saul Gass, University of Maryland. I do have a question.

I understand a lot of EIA personnel are involved and a lot of contractor personnel are involved in developing the modules. And I was wondering whether or not you would discuss how you are going to do the acceptance testing, the validity checking, the verification, the testing.

How are you going to put it all together? Do you have a process within the organization, sort of a tiger team to go in, take a look at each module to see whether or not it is appropriate? How are you going to do that? I think that is the more important problem, more important than certainly user interfaces.

MR. RODEKOHR: We have developed a process to do that. This meeting is part of that larger process.

We have designed the individual modules. We have produced or will produce about 39 component design reports, a stack of paper about that big. We have sent those out. We have developed user groups to look at the modules, to comment on our design. We have the Energy Modeling Forum group to comment on our design.

We are now in the process of producing modules consistent with those designs and those comments. We will then document them in a very expensive documentation process.

So that is essentially the process we have designed that accomplishes what you have discussed.

MR. MACK: My name is Steve Mack, from Energetics. And I just have a question about the user interface.

It seems to me that the interface issue can be a trivial one, given the maturation and evolution of database management systems. I can't understand why these days people just don't sandwich between a DBMS. And then the issues of input data validation and output graphics become trivial.

MS. SHAW: I want to keep this short, but perhaps you want to talk with Mike later.

There were some experiments done with Oracle and some other databases that are compatible for the mainframe and the PC, using the volume of data that it is necessary to store for the NEMS. The access time was just very, very cumbersome. It didn't seem very suited to our needs.

There were some rather rigorous experiments done, which you might want to discuss with Mike afterward.

MR. GUTTERMAN: I have got some experience tying a DBMS to a modeling system. And our real users at the company I was with did not want to work directly with the DBMS. What we did was build things so that things were displayed from the DBMS in user oriented terminology, both on the input end and on the output end, so that they could understand things from the point of view of their view of the problem rather than from the point of view of the database management system.

MR. SWEENEY: I would like to partly comment on Saul's question. I think the issue of validation is extremely important but not as much as the invalidation process. It is getting opportunities for people to find glaring problems. Not finding that you missed a pimento but that there are glaring fundamental problems.

For the experience that I have seen in model validation, where you get a group to do it, the best group I was aware of was the MIT group, under the leadership of the late David Wood, that was really focusing on it.

It is a very expensive process that gets only a little bit of the action. And one of the things I have concluded from the Energy Modeling Forum experience is that you really need a lot of sunshine on models in order to get people to find ways of invalidating and finding problems. And this is really at the essence of my argument about the necessity of trying to go for something that allows the model to be broadly available to people to use in their own laboratories and their own offices.

My notion is putting it on a PC is a way of that happening. It points out that there is some cost and there are problems of doing it. I recognize that. And that is why I said maybe two years is the right time period.

And there may be other answers to how to get the sunshine. But without broad sunshine on models, you generally won't find the problems. Because you have the developers who are really scrambling, putting in an awful lot of work. And while you are scrambling, it is hard to sit back and take a thoughtful look at the fundamental implicit assumptions that are in models.

I think there is a real tight linkage between, one, easy interfaces that people can use, two, broad accessibility throughout a user group and the ability to validate or invalidate models.

MR. RODEKOHR: Thank you very much, Jim.

I would like to thank the reviewers and commenters. If you have any other questions that weren't answered, please come up and talk to us now.

Thank you very much.