THE NEMS CONFERENCE

COAL SUPPLY AND COAL SYNTHETICS PANEL

February 2, 1993 - 10:45 am

PANELISTS:

Scott Sitzer, Moderator
Robert Manicke, Presenter
Edward Julian, Reviewer
Jerry Karaganis, Reviewer
Michael Kuby, Reviewer

AUDIENCE PARTICIPANTS:

Richard Newcomb
John Broderick

EIA

PROCEEDINGS

MR. SITZER: Okay. Why don't I go ahead and get started? I just heard in the last session that EIA is nothing if not on time. So I don't want to do anything to disturb that.

My name is Scott Sitzer, and I'm with the Energy Supply and Conversion Division of EIA, and I want to welcome you to the session on the Coal Market Module of the National Energy Modeling System.

I have three coal experts on the panel this morning who are going to give us their thoughts and suggestions on how we can proceed from here based on the material we sent them, and which maybe some of you have also seen.

Before I dc that, I'll give a brief overview of the Coal Market Module, and then Bob Manicke of my staff will discuss each of the four components of the module in some detail, but still cursory since we're limited to about 20 to 25 minutes per presentation.

The three people on my panel are Dr. Michael Kuby of Arizona State University, who's involved in coal analysis, has worked on the National Coal Model and derivations of it; Jerry Karaganis, who is with the National Coal Association, and has been involved in coal analysis and statistics for quite a number of years; and Dr. Ed Julian of the Tennessee Valley Authority, who's been involved in fuel procurement and that being one of the largest purchasers of coal in the country, certainly knows coal markets well.

I guess those are the preliminaries, and maybe I'll just go ahead and move into the Coal Market Module itself.

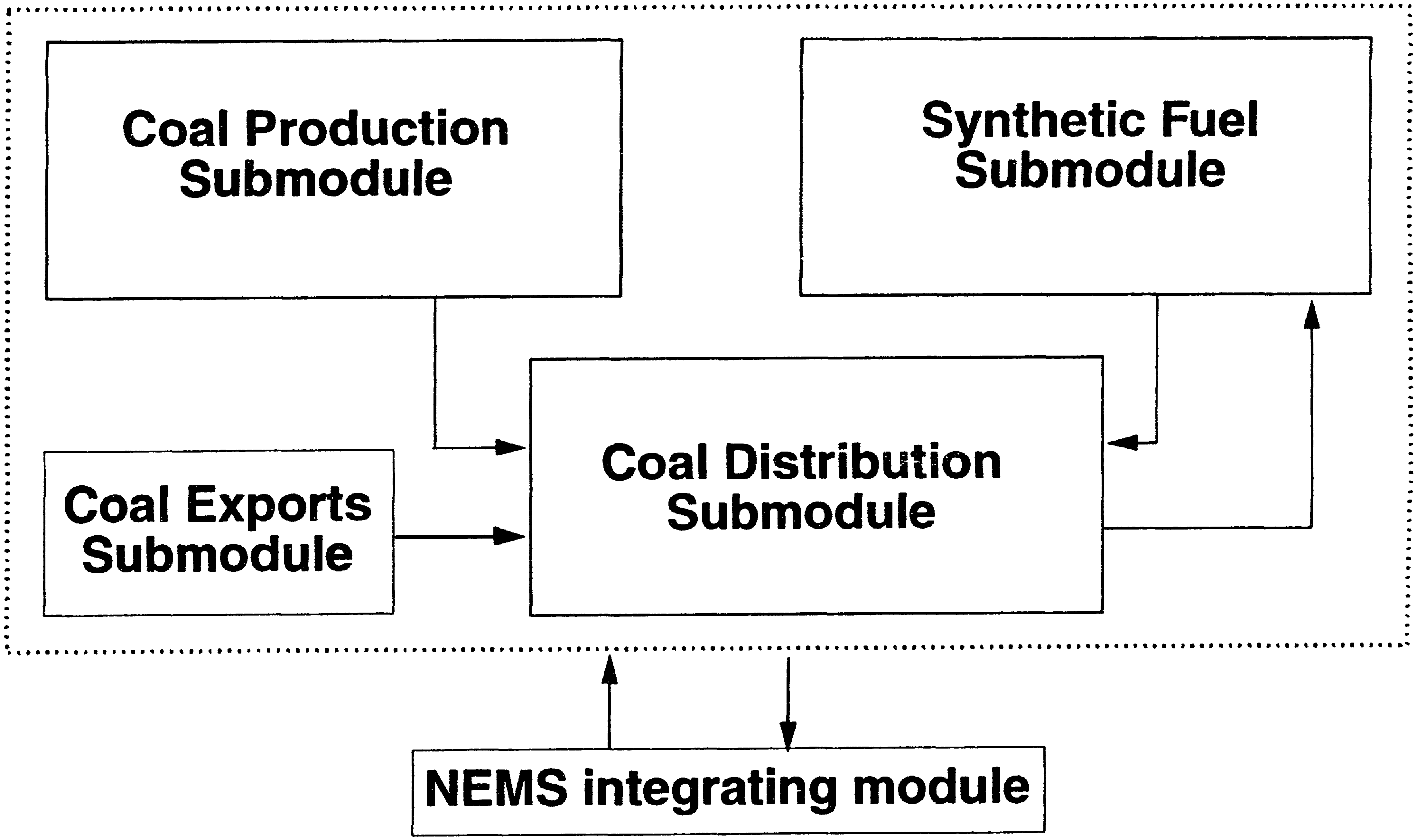
The Coal Market Module of NEMS has been designed to have four major components in it: production and pricing; coal distribution; coal synthetics, which is a new submodule in our energy modeling system; and coal exports.

Three of these are lineal descendants of our current modeling system, the Intermediate Future Forecasting System. The fourth, synthetics, we've had only off-line analysis to date, and eventually we hope to include synthetics as an integrated portion of the Coal Market Module. Although we've developed a design report, it's probable that it will not be in Version I of NEMS because of the difficulties of assigning resources to it. However, it will be a part of NEMS in future versions.

Some of the enhancements that we have made over the current system -- and I'm aware that some of you may not be aware of the current system, so I'll try to brief you as I go along -- include: Coal supply curves will respond dynamically to other NEMS variables, such as production, coal mining capacity, utilization, diesel fuel prices, labor costs. This is in contrast to the current system where coal supply curves essentially are computed off line and fed as inputs into the coal supply and transportation model.

And while I don't think that the effects are major, I think it is an enhancement that we'll be able to allow coal supply curves and consequently coal prices to respond to other variables

The Coal Market Module



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Coal Market Module

- Major components: production, distribution, synthetics, exports
- Coal supply curves will respond dynamically to other NEMS variables
- Streamlined supply and demand regions
- Streamlined sulfur and Btu coal supply categories
- Updating of coal transportation rates
- Streamlined coal export structure

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being produced by the system.

We have streamlined the supply and demand regions from our current system. Our current model has 48 demand regions and 32 supply regions, and we have roughly cut those in half. I'll show a map in a couple of minutes.

What we have tried to do is to maintain the requirements for fast operation of the model, transparent operation of the model, without giving up too much in the way of analytical capability, and I'm sure we'll have some comments on that from the reviewers.

We've also reduced the number of sulfur and Btu supply categories. In our current model we have 30. In the new model we'll have 16. Basically what we're trying to do is, again, maintain analytical capability while allowing the model to execute more quickly.

In terms of sulfur categories, we're trying to make sure that we can capture the effects of the Clean Air Act Amendments of 1990, and I think that that's an important issue for us to maintain our capability in.

We're currently in the process of updating coal transportation rates, which, of course, are an important aspect of the coal distribution problem. The last comprehensive updating of coal transportation rates was probably done five or six years ago, and we're looking at various sources of data to make sure that we have the latest available transportation cost between supply and demand regions, which should facilitate our analysis of coal distribution.

Finally, we're going to integrate and streamline the coal export structure. Some of you may be familiar with our current international coal trade model, which has been an off-line modeling exercise in which we determined what world coal trade was, what the share of the U.S.'s exports was in it, and inserted those in the coal supply and transportation model to solve for distribution.

Now it will be an integrated part of the model, which should help facilitate feedback between domestic coal prices and share of U.S. exports in world coal trade.

This is kind of an overall diagram of what the CMM is. I guess at the heart of the coal problem is distribution, and therefore, it's more or less in the center of this diagram.

The Coal Distribution Submodule is where the solution for distribution and delivered prices will take place. It will get demands from the NEMS Integrating Module, which in turn are derived from the electric utility model primarily, as well as the industrial demand model.

It will obtain coal supply curves from the Coal Production Submodule; synthetic demands from the Synthetic Fuel Submodule; and coal exports from the Coal Export Submodule.

In turn, it will provide delivered prices to the NEMS integrating module which will go to the demand and electricity modules, which need them in order to determine what coal demand is.

These are the coal supply regions, and this chart has gone through some modifications over the past year. What we have made sure that we have is separate regions for the three largest states, corresponding to the types of coal that they produce.

We have separate regions for northern and southern West Virginia, for eastern and western Kentucky, and for eastern and western Wyoming. We'll be able to do some analysis with this kind of a breakdown on the three largest states, and I think it's important that we maintain that capability, and so did other reviewers that we've already made our presentations to.

In other cases, we've done quite a bit of aggregation. The West Interior area is now one region, whereas before it was five. Texas and Louisiana are one region. We've done some consolidation of Virginia, Tennessee and some of the other Appalachian regions. Northern Appalachia is somewhat more consolidated than it was in the current model.

And, again, our goal is to maintain a reasonable speed of execution while we also try to keep the capability of doing national and some regional analysis.

These are the coal demand regions, and the way we went about this was to try to accommodate both the need of the NEMS system -- and I assume most of you have been to some of the other sessions -- in terms of integrating the NEMS regions or the Census divisions, plus California. At least nine regions will be involved in the integration of NEMS, and those are also the regions upon which the demand modules are operating.

On the other hand, coal is, of course, extremely important in electric generation, and the regional classification used by the Electricity Market Module is the North American Electric Reliability Council (NERC) regions and some subclassifications thereof. That involves approximately 13 separate regions.

So we overlaid these two onto a map and came up with about 29 or 30 regions, but many of those did not have coal demand. So when we combined those and did some other consolidation where we have very little demand, we came up with 22 demand regions.

So what we now have are 22 demand regions, and what we will have to do is as the Coal Market Module receives its demands from the other models, it will essentially share them out to these regions in a manner determined largely by the historical shares.

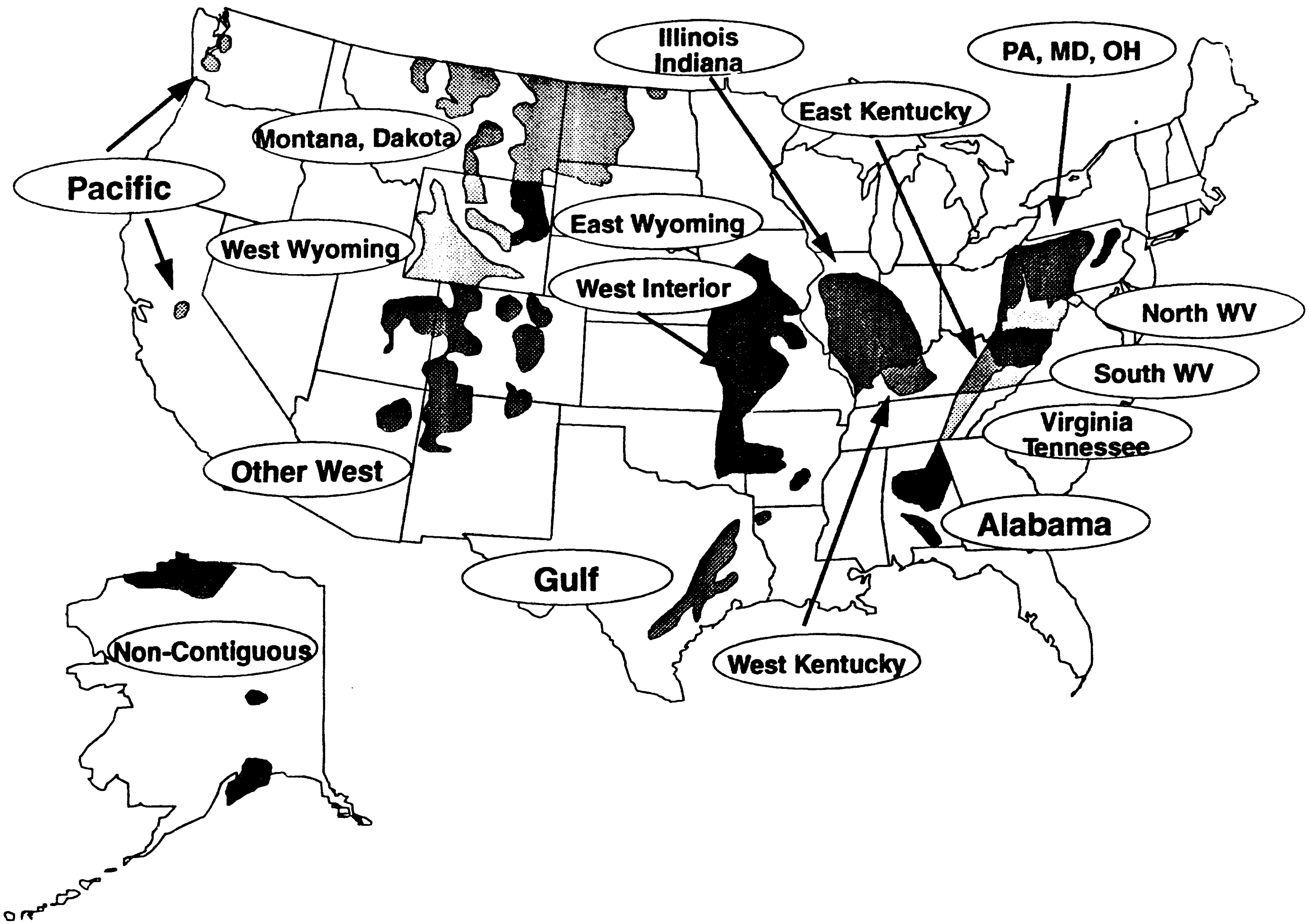
But the important thing is that the distribution problem will be one of solving coal distribution from the previous supply regions to these demand regions.

That essentially is an overview of the Coal Market Module, and now I'd like to turn it over to Bob Manicke, who is the team leader of the coal analysis team in our group, to give you a rundown of the four coal submodules.

MR. MANICKE: Thank you, Scott.

The first submodule I'm going to talk about is the Coal Production Submodule (CPS).

Coal Supply Regions



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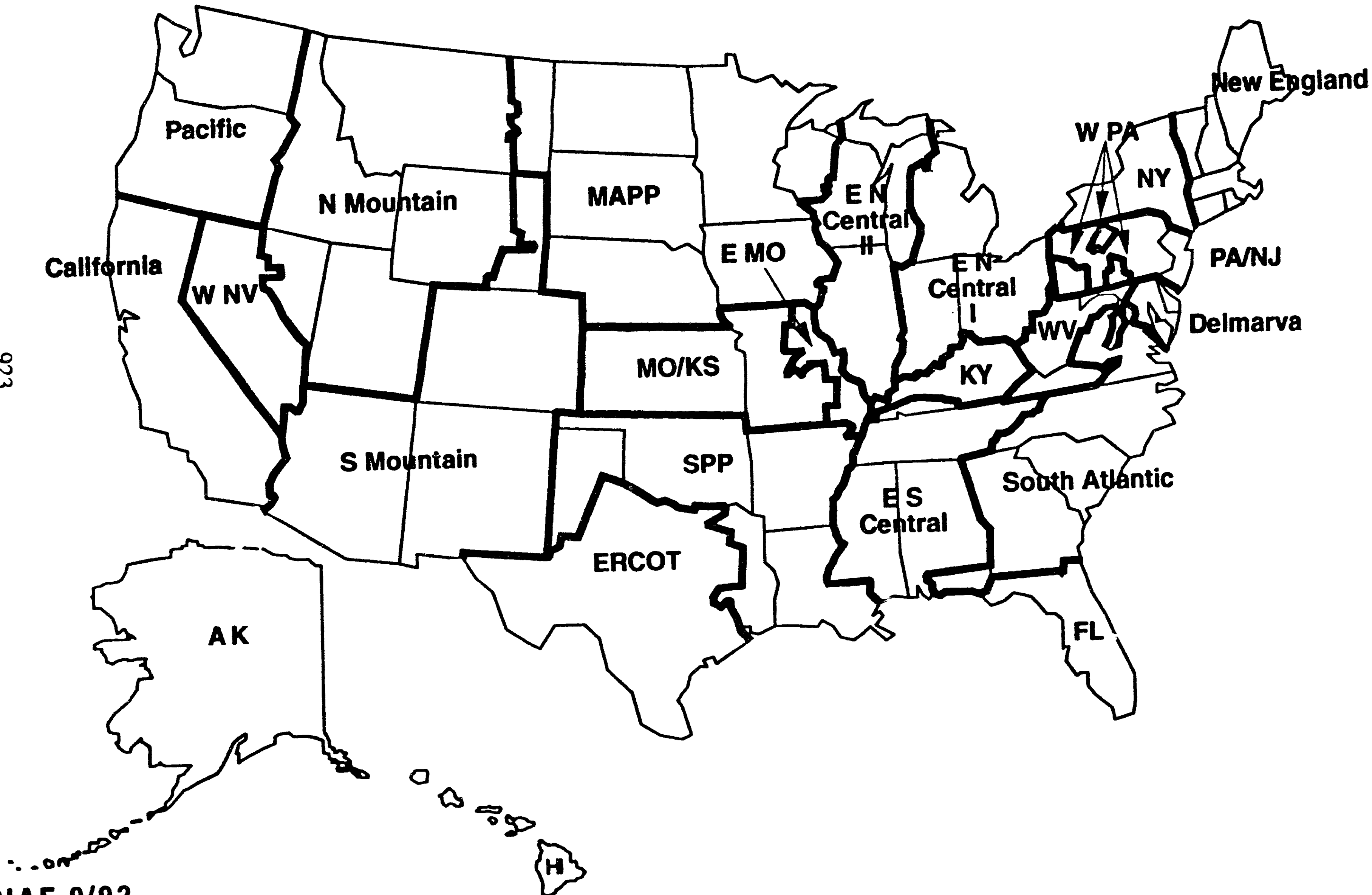
Coal Demand Regions



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Coal Supply and Coal Synthetics in the National Energy Modeling System

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Robert Manicke
Energy Information Administration

EIA

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It basically supplies the annual coal supply curves to the other submodules, such as the coal distribution and coal exports submodules. It has a new capability now of projecting coal mining capacity, as well as the old capability of projecting coal minemouth prices.

Incorporated in these supply curves now as stated is the new capability of minemouth capacity restraints, the old capability of reserve depletions similar to the Resource Allocation and Mine Costing model of the old IFFS system, and a new capability of dealing with new technology as correlated and derived from labor productivity.

It will also factor in the labor costs and other factor inputs, such as diesel fuel prices.

The structure of the CPS, as Scott alluded to, is the structure of the Coal Market Module basically, with the 16 supply regions broken down into the two mining methods as in the old system, of surface and underground, and in which we will now consider carefully longwall new technology.

And the streamlined coal categories now are the four Btu and the four sulfur categories. The four sulfur categories will basically correspond to the Clean Air Act Amendment categories.

The CPS methodology is based on a regression technique. It will, as the old method, project quantity and prices forward, but it will also project mine capacity by mining method, and it now has an established relationship between minemouth prices and capacity utilization.

From this, we will construct the price and production schedules, the annual supply curves, short run supply curves, and then respond to changes in labor productivity and factor input costs, such as diesel fuel, and reserve depletion, then adjust the supply curves up or down depending on higher or lower costs as the data would require.

The second submodule that I'm going to discuss is the Coal Distribution Submodule (CDS). Again, it will get its supply curves from the Coal Production Submodule. Its basic function is to compute the distribution and delivered coal prices.

It will do this with the least cost hierarchical algorithm for meeting input exogenous demands from the NEMS system. Again, it will basically give the distribution of coal from the input demands, but it will now also give or analyze pre-combustion emissions and coal mining employment impacts and coal transportation in terms of the ton-mileage variable.

In creating this model, we had to meet requirements from NEMS of it being somewhat user friendly or more user friendly than the old system, but still sufficiently detailed to do some policy analysis, particularly in the area of transportation rates and flows, and had to be within the specified execution time of NEMS.

The CDS solution algorithm is a heuristic flow analysis that basically finds a least cost source for each demand in each supply region, and then by shifting around this source slightly, we will converge to a ratio of the high cost to low cost over all -- in a multi-variable sense -- suppliers at a ratio that we can preselect to make the ratio very small or not so small.

Coal Production Submodule (CPS) Functions

- Generate annual coal supply curves
  - Coal Distribution Submodule
  - Coal Exports Submodule

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- Project coal mining capacity

- Project coal minemouth prices

CPS Supply Curves Will Respond To

- Mine capacity constraints
- Reserve depletion
- New technology and labor productivity
- Labor costs and diesel fuel prices

CPS Structure

- 16 supply regions

- 2 mining methods
  - Surface
  - Underground (continuous and longwall)

- 16 coal types
  - 4 Btu categories
  - 4 sulfur categories

CPS Methodology

- Project regional mine capacity by mining method

- Establish relationship between minemouth prices and capacity utilization

- Construct annual supply curves (price/production schedules)

- Adjust annual supply curves for changes in reserve depletion, labor productivity, and factor input costs

Functions of NEMS Coal Distribution Module

- Computes delivered coal prices

- Selects least-cost coal source(s) for each demand

- Forecasts
  - Pre-combustion emissions
  - Coal mining employment impacts
  - Coal transportation ton-mileage

Requirements for NEMS CDS

- Operationally transparent
- Sufficiently detailed to support policy-oriented analysis
- Fast execution time when integrated in NEMS

CDS Solution Algorithm

- Find least-cost coal source in each supply region for each demand
- Shift supply volume toward least-cost source in small increments
- Iterate until ratio of high and low delivered costs meets convergence criteria
- Supply costs vary with quantity demanded, so volume reassignment is required to reach equilibrium

It also will consider the market factor that supply costs should vary with quantity demanded, and so for equilibrium volume reassignment is required in each iteration.

We are now considering coal transportation with a data oriented method based on FERC Form 580 and on the EIA Form 423. We're going to project this interregional transportation cost by mode. It will take into consideration intermodal competition based on relative prices. That is, the mix will not be fixed throughout the forecast periods, but will vary relative to prices. And it will include all of the standard modes of truck, barge, pipeline, and mixed modes.

The third submodule is the Coal Export Submodule. Its purpose is, of course, to forecast world coal flows from predefined supply regions to predefined major demand regions. In doing this, it will also forecast U.S. coal exports by supply region and forecast prices of U.S. coal exports by our predefined domestic demand regions.

This is a representation of the flows in and out of the Coal Export Submodule. It will obtain the annual U.S. supply curves from the Coal Production Submodule, obtain distribution and transportation rates from the coal distribution submodule, and some macroeconomic variables, such as gross national product, from the Macroeconomic Activity Submodule, and then as output give demand of U.S. coal for world export into the Coal Distribution Submodule.

The structure as defined now, which may change in terms of the import and export regions as we experiment and look at the market more carefully, are 12 import and 13 export regions. We will analyze steam coal and metallurgical coal, and the model will minimize total delivered costs of the traded world coal under the constraints of maximum deliveries from any one region (or a supply diversity constraint) which allows us to prespecify a maximum that an export supplier can supply, and the sulfur dioxide limits of a demand region, and the constraint of the available coal from the coal supply curves.

The final coal submodule is coal synthetics, which we will do later. This will provide forecasts for gas and liquids from coal. We will analyze alternative price paths on synthetic production and analyze impacts of various policies on synthetic production.

The structure of the Coal Synthetics Submodule will represent two technologies that we feel may penetrate the market in the time frame of NEMS, coal liquefaction, and coal gasification.

The regionality we're going to use is the same as the coal distribution and coal supply submodules, and we are going to assume the liquefaction plants produce finished products rather than synthetic crude, that is, that synthetic crude is not the interim product to produce these other products.

The outputs from the Coal Synthetics Submodule are the production of synthetic natural gas by the oil and gas supply module regions; and the production of coal-based petroleum liquids by the Petroleum Allocation for Defense Districts, and demand for coal feedstocks to synthetic plants in the coal distribution demand regional structure.

Coal Transportation in the CDS

- Base and projected inter-regional transportation costs by mode
- Inter-modal competition based on relative prices
- Modes include rail, barge, truck, pipelines, and "mixed" modes of transport

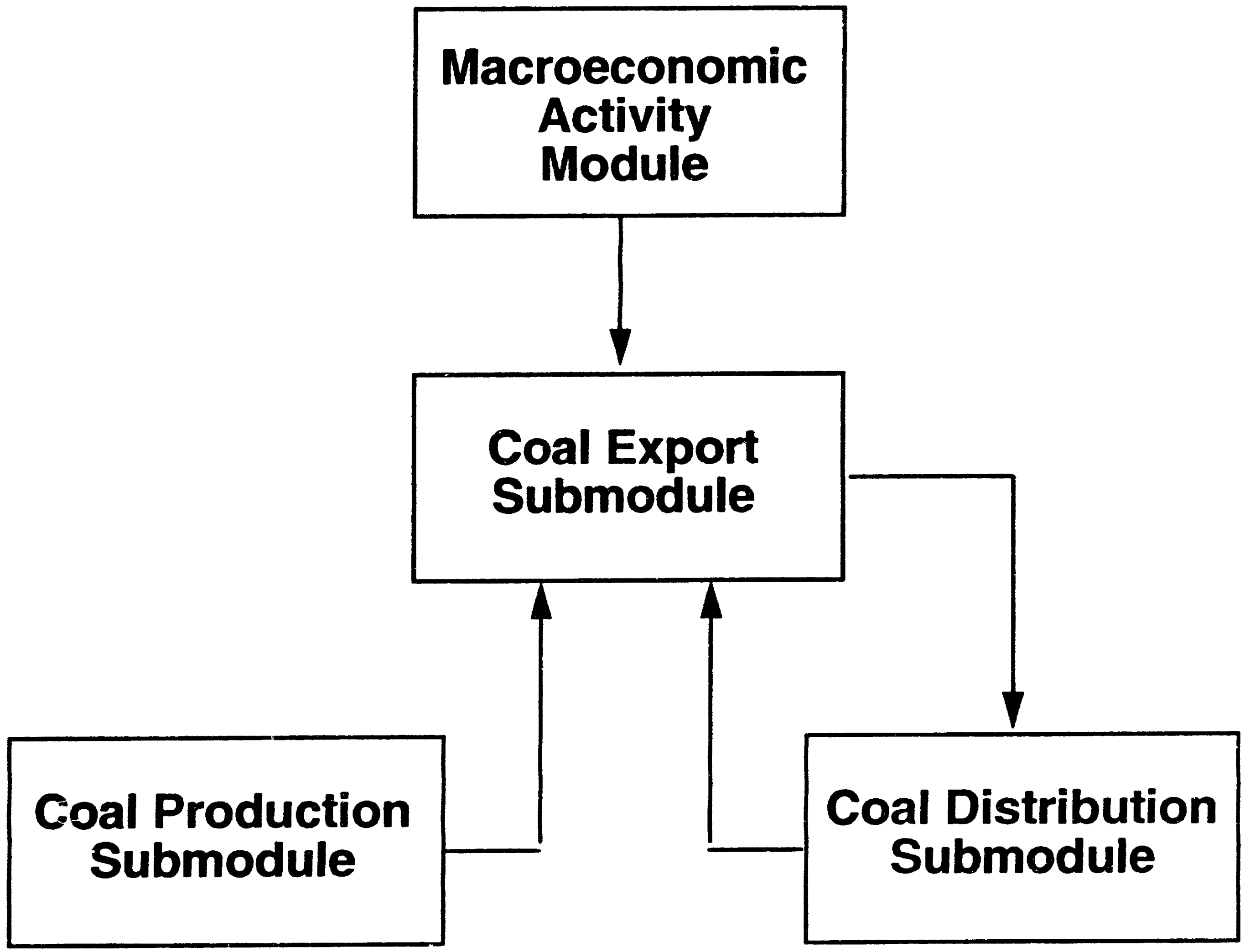
Purpose of Coal Export Submodule

- Forecast world coal flows from major supply to major demand regions

- Forecast U.S. coal exports by domestic supply region

- Forecast prices of U.S. coal exports by domestic demand region

Input/ Output Flows for the Coal Export Submodule



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Structure of Coal Export Submodule

- Twelve import and thirteen major export regions
- Steam coal and metallurgical coal
- Total delivered cost of traded coal minimized
- Constraints:
  - Maximum deliveries from any one region
  - Sulfur dioxide limits
  - Coal supply curves

Purpose of Coal Synthetics Submodule (CSS)

- Provide Forecasts of Synthetic Gas and Liquids from Coal

- Analyze Impa[illegible] of Alternative Price Paths on Synthetics [illegible]duction

- Analyze Impacts of Alternative Policies on Synthetics Production

Structure of CSS

- Technologies Represented:
  - Coal Liquefaction (Direct and Indirect)
  - Coal Gasification

- Regionality: Coal Supply Regions

- Liquefaction Plants Produce Products Rather than Syncrude

Outputs From CSS

- Production of Coal Synthetic Natural Gas by OGSM region

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- Production of Coal-based Petroleum Liquids by PADD region

- Demand for Coal Feedstocks to Synthetics Plants by CDS Demand Region

CSS Solution Algorithm

- Capacity Operating Decision

- Capacity Delay Decision

- Capacity Planning Decision

As I mentioned a little bit earlier, the solution algorithm will be based on decision theory, analytical studies that allow the analysis and synthesis of market penetration of new technologies. It will use these capacity operating decisions, capacity delay decisions, and capacity planning decision functions with economic variables, but it will also use them with noneconomic variables, such as learning curve characteristics and delay characteristic functions to consider when the model will build a particular liquefaction or gasification plant.

Those are the four submodules of the Coal Market Module.

MR. SITZER: Thank you, Bob.

Three of the four design reports that we've worked on are out and available, and if you have an order blank in your packet, you're welcome to request those. I believe coal exports is in there, too. It's not yet available. We should have it completed by the end of this month.

So with that overview, I'd like to turn it over to the reviewers, and the first person to speak will be Jerry Karaganis of the National Coal Association. Jerry.

MR. KARAGANIS: Good morning.

Last week I was reading the newspaper, and I saw a political cartoon that had two gentlemen from an asylum holding a man who was shaking and totally distraught. One attendant said to the other, "That's what happens when you hear 'don't stop thinking about tomorrow' 10,000 times."

Last week I started hearing this song in my head after about five readings of the module reports, "Don't stop thinking about the coal modules," and I got very concerned, and I said, "I'll have to be very careful how I expose my mind to this thing! So I'll keep my comments very brief and to the point."

I just have a few exhibits, and I'll leave it to the other technical experts to give you the details you need. I know they have some very good comments.

I know from my own experience, and from people out in the audience there, that they've been through this modeling experience many times starting in the '70's. Back then people started with aggregate coal models, and when they got into the policy arena with them, someone would say, "Sorry. You don't have reserves from that little corner in Utah taken into account, and it's going to screw up your whole analysis." The typical response would be, "Okay. We'll put that in." Eventually, through a series of interactions, the process usually would end up with detailed models.

As a result, two types of models have emerged over time; one is a detailed representation of an energy sector of the energy system and the other is a screening model. Typically they are run in conjunction with the more detailed models used to calibrate the screening models.

One of the concerns I have with the NEMS process is that NEMS is a screening model, and I would hate to see people be deluded into thinking that it's not. If they were, they might

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GENERAL COMMENTS

1.) OVERALL EFFORT IS OF HIGH QUALITY AND SHOULD YIELD USEFUL RESULTS. REPRESENTS FIRST REAL EIA EFFORT IN 10 YEARS TO PUT MORE REALISM IN COAL PRODUCTION MODELING. MODELING TRANSPORTATION REMAINS A SORE SPOT, BUT OVERALL DEMAND MODELING APPEARS MUCH IMPROVED.

2.) COAL MODULE IS BASICALLY A SCREENING MODEL AND THERFORE NEEDS MORE DETAILED BACKUP MODELS FO QUALITY CONTROL AND CALIBRATION. THIS IS ESPECIALLY SO FOR THE DISTRIBUTION MODEL.

3.) ALTHOUGH OF REASONABLE QUALITY, THE COMPONENT DESIGN REPORTS NEED ADDITIONAL FOCUS, PARTICULARLY WITH RESPECT TO WHAT CHARACTERISTICS OF THE COAL INDUSTRY ARE BEING MODELLED. FOR EXAMPLE, JUST HOW ARE SUPPLY REGIONS COMPETING WITH EACH OTHER FOR EXISTING AND FUTURE MARKET SHARES. IN ADDITION, IT WOULD BE USEFUL TO HAVE THE RESULTS OF A WORKING MINI VERSION OF THE MODEL TO SEE HOW COAL MODULE WILL ACTUALLY WORK.

4.) THE SYNTHETICS MODULE LOOKS IN GOOD SHAPE. I AM SURPRISE THAT IT IS NOT UP AND RUNNING AND AVAILABLE FOR TESTING.

therefore assume it has all the answers so that they can dispense with the more detailed models that are needed for calibration and revisiting analytical methods and data every couple of years.

So with these thoughts in mind, I offer you four general comments on the model. But first let me say I have taken the time to read the report several times, and I do think it's a conceptually beautiful effort. It's an attempt to get at some of the nagging problems that people face, particularly on coal's production side.

However, I don't think it reflects, and I don't think it will ever reflect, all the nuances involved in coal production, contracting, and so forth. When people win the contract, they have to deal with minimum and maximum takes and they end up delivering certain amounts somewhere in between. As a result, producers end up dealing with prices instead of costs and excess exports. So you're never going to really be quite happy with what comes out of this model when you mix prices and costs.

But I think you can get around some of the problems with the production model if there's more interaction using RAMC, the detailed production model. For example, looking at the marginal costs the way RAMC's capable of, and looking at the supply options in more detail, reporting that kind of off-line analysis, and then seeing what kind of approximation you're creating with the regression analysis will lead to an acceptable representation of supply.

Scott, I don't know the last time RAMC was run. Is it run annually?

MR. SITZER: Yes.

MR. KARAGANIS: And there is a new reserve study coming out, and I assume that all the new reserve estimates will go into RAMC, and that will be rerun for the analysis.

MR. SITZER: Yes.

MR. KARAGANIS: On the transportation side, I would like to see network models because you're never going to get transportation linkages to work right if you don't know where the coal flows are. Moreover, there are other experts, such as A.L. Kornheiser who heuristically look at coal flows. They take ICC waybills and then flow the coals and look at revenues and delivered prices. NEMS should draw on these sources of information.

So there are opportunities independent of your own network model to look at the calibration and the realism of what you're attempting. But as things currently stand, I see the representation of coal transportation a problem.

Again, let me repeat, what I had said about the limits of screening models must be considered. For the coal modules to work, they must be calibrated. Further, there has to be quality control; The NEMS model results have to stand against more detailed models results.

I thought that the component design reports were very good. There was an effort to try to get the reader involved in the process. I found all subscripts disconcerting. Additionally, I'd like to see a mini-model of the coal modeling process. Take the minimum amount of information and show people how the flows work with that minimum set of supply and demand regions.

There were discussions of the ICF and the DRI model, and while they were interesting, they weren't pulled together. For example, DRI uses a network model on a smaller number of supply and demand regions. That was noted, but there was no development or comparison to see whether that was good or bad. I'm sure when NEMS is run and the output is there, there will be ICF and DRI model results compared right next to it.

So I'd like to see a better assimilation of the comparison information into the component reports.

My fourth observation is on the synthetic module. I was very impressed with it in terms of completeness and I think in this overall process, where people want to involve users in using some of these models, that the synthetic submodule offers that opportunity.

From reading the report, it appeared to me that it could have been ready at this point and have been running. Further, there are other parties in the Department of Energy that would find it useful to have. I recommend you move it up in the NEMS completion schedule.

If I can just have the last exhibit, I'll go through this quickly and turn to the other panelists.

This is the NEMS flow diagram for coal. I'll just mention a couple of things I looked at in some detail. I just couldn't be that critical because not enough work has been done to say one way or the other whether it's good or bad, but I did look at the capacity planning part of it and the use of lags in it. Although it was conceptually attractive, I didn't think it showed that great an insight for capacity expansion.

I couldn't see how the Clean Air Act was represented in it. In other words, if massive switching of coal takes place in Phase 2, I could not see how the production model anticipated the future demand changes.

Now, there may be something in the electric utility model that handles this. But I just didn't see how a massive coal substitution shift got passed through.

Coal imports, which utilities are looking at as a Clean Air Act option, do not appear to be represented as a supply option. Maybe imports should go in as a production region or as a separate fuel quality that could compete in certain demand regions.

Additionally, the export market has typically been a swing market in terms of steam coal. I wonder whether in the model, when looking at the optimum production level and trying to figure out how people are building coal mines, are they really dedicating a portion of the production for export demand? Or, is that part of the overall adjustment process between minimums and maximums takes on contracts, or how they run mines? Take the West for example, the rather large swing in coal production that can occur with adverse hydro? You can have a lot of coal getting consumed one year, and the next year it's available for shipment into

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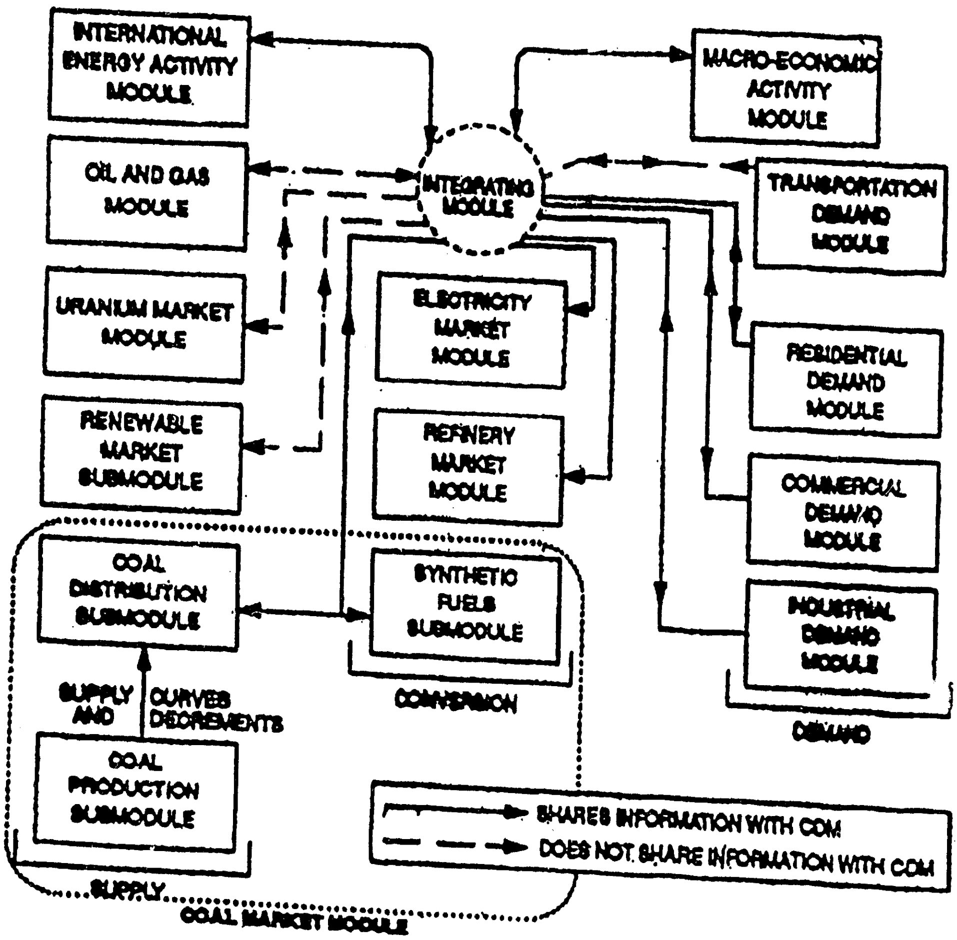


the spot market.

I don't know how significant this actually is, but I think it's something that should be counted.

On the distribution model, which uses EIA-6 data, I was again puzzled. When it apportions coal distribution to different areas, how does the transportation network react to something like the Clean Air Act where a major shift in coal flows will occur in the future but that shift is not embedded in the past patterns. Perhaps there is a straightforward resolution to these probable changes.

Finally, the export market, which many people see as the boon of the 21st Century for coal, wasn't available. Having it as a separate module, more or less, was troublesome to me. I'm troubled by hard wiring a growth market, and again, perhaps there is some way to produce better linkages between the coal modules and the international model.

Let me close by saying that EIA, as always, is competent in model building and open-minded in dealing with its reviewers' comments. I compliment them on their fine NEMS effort and look forward to working with them in the future.

Thank you.

MR. SITZER: Okay, Jerry. I'll digest your comments and give you answers as best I can when everybody's had a chance to speak.

And now I'd like to turn it over to Ed Julian of TVA.

DR. JULIAN: Good morning. Good to see you.

I'm going to work a little backwards. I usually think of production, then distribution and then usage, but I wanted to start more with the distribution and make a few short comments on that.

I'd like to say I second everything Jerry said at the first. I'm going to be a little bit more specific on a few things than Jerry was.

I'm going to be a little bit picky -- one of the things that struck me as I read through the distribution portion of the components was a statement that there would be less contract data and of lower quality, which struck me as a bit problematic for doing the model.

The reason I have a problem with that is that they suggest they will estimate contracting behavior in the future by utilities by regression methodologies. The reason I am struck by that is no problem with regression methodology and estimation techniques, but that I expect a change in behavior. Using the methodology as I would understand it, I doubt that it would capture the change in behavior until well after the behavior has taken place.

Utilities in this country recognize that they are going to be in a very competitive

MAJOR EASTERN COMPLIANCE COAL SEAMS

State	County	Number of Major Seams
Kentucky	Floyd	1
	Harlan	2
	Knott	1
	Letcher	1
	Martin	1
	Perry	2
	Pike	2
Virginia	Dickenson	2 or 3
	Wise	2 or 3
West Virginia	Boone	7
	Kanawha	2
	Logan	9
	Mingo	7
	Nicholas	2

environment with or without further deregulation emphasis. We find ourselves on a daily basis competing with each other for power sales. We recognize that more and more. We recognize that our growth potential depends on our competitiveness, and more and more utilities are recognizing that their competitiveness rests in their fuels groups; that their variable costs on which they're going to be able to do their day-to-day and week-to-week and month-to-month competition with each other is by and large fuel cost.

So I expect that the fuels departments will change some of their strategies -- and I know that TVA is. In the past there has been a lot of emphasis on risk reduction, the avoidance of risk, high stockpiles. TVA's are certainly coming down as far as our policy goes. I expect that other utilities will do the same, even further than the reductions that have been made.

We also enter into long-term contracts to reduce risk, primarily the risk associated with coal quality. I expect that the amount of long-term contracting by utilities will become less. TVA is looking at percentages as high as 30 percent spot right now. We aren't doing that, but we are certainly looking at doing that in the future.

So some way to capture the risk reduction in contracting seems necessary, and I don't see that by looking at past data.

Getting to the production side, which I'll spend a little more time on, I heartily applaud the attempts to bring a great deal more market emphasis -- that's how I would characterize the changes being made -- into the estimation of production components.

They recognize this. I always like to bring it up to any group I see. This is market behavior. We have not had -- as models have shown in the past -- just a steadily rising price. We have had three peaks in the 20th Century, in 1920, 1948, and 1975 in 1987 constant dollars per ton, and three troughs essentially, if you call 1915 the beginning trough. It's hard to call it that, but that's the way I suggest a prior trough to be -- 1932 and then 1968.

And as you see, we're also sliding back down to another trough where some people would suggest maybe sliding down forever. I know there's a bottom there because it's zero. I know there's a trough there. It won't go below zero. I suspect it will not reach it either.

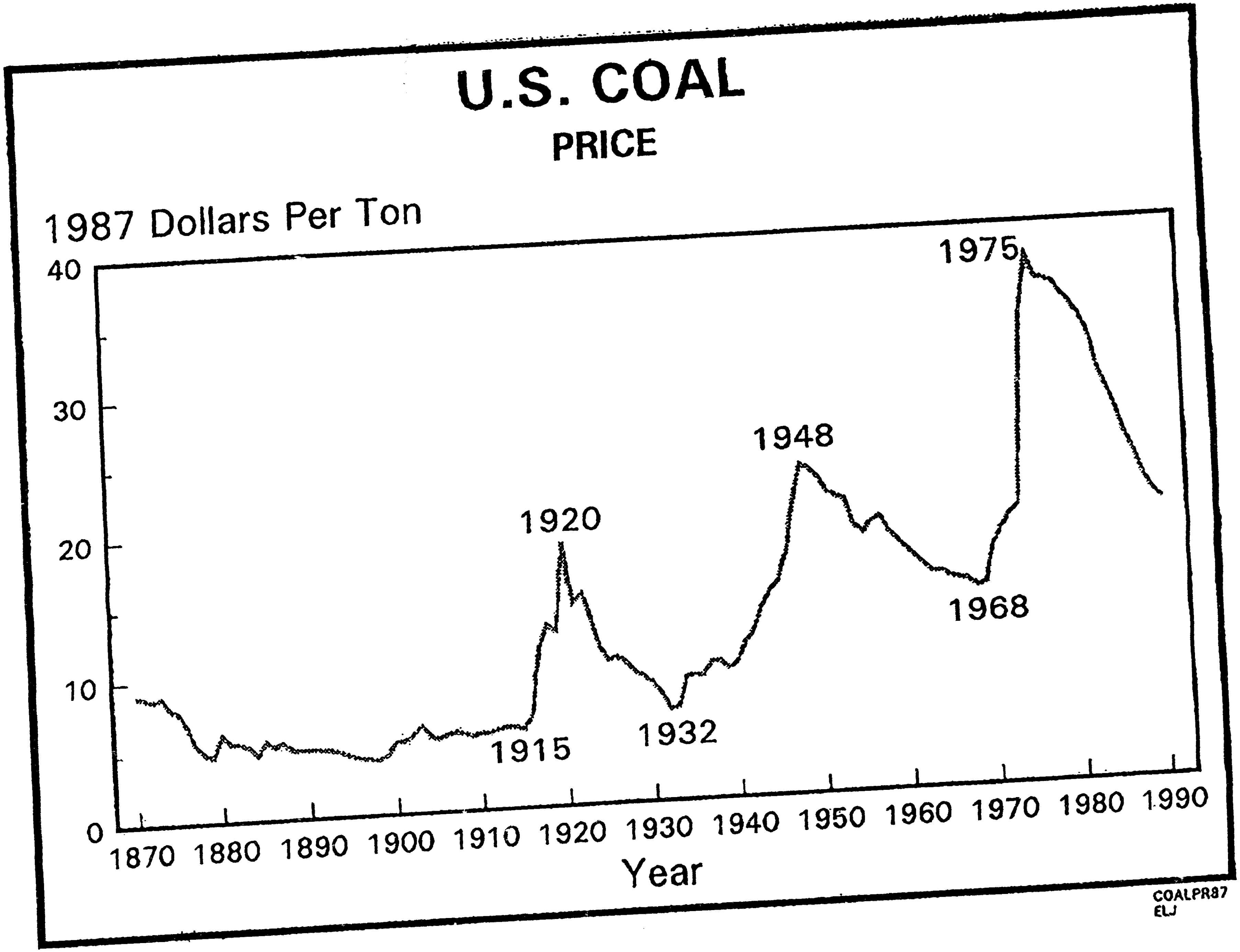
I think there are fundamental causes for that. The first fundamental cause of the rise is insufficient capacity, at which time the utilities compete like the devil with each other to get the coal that they need to meet their demands. Then, during that time when the price is rising, expectations of the coal miners are that "I'm going to make a lot of money," and during that time of rising prices, they certainly do make a lot of money.

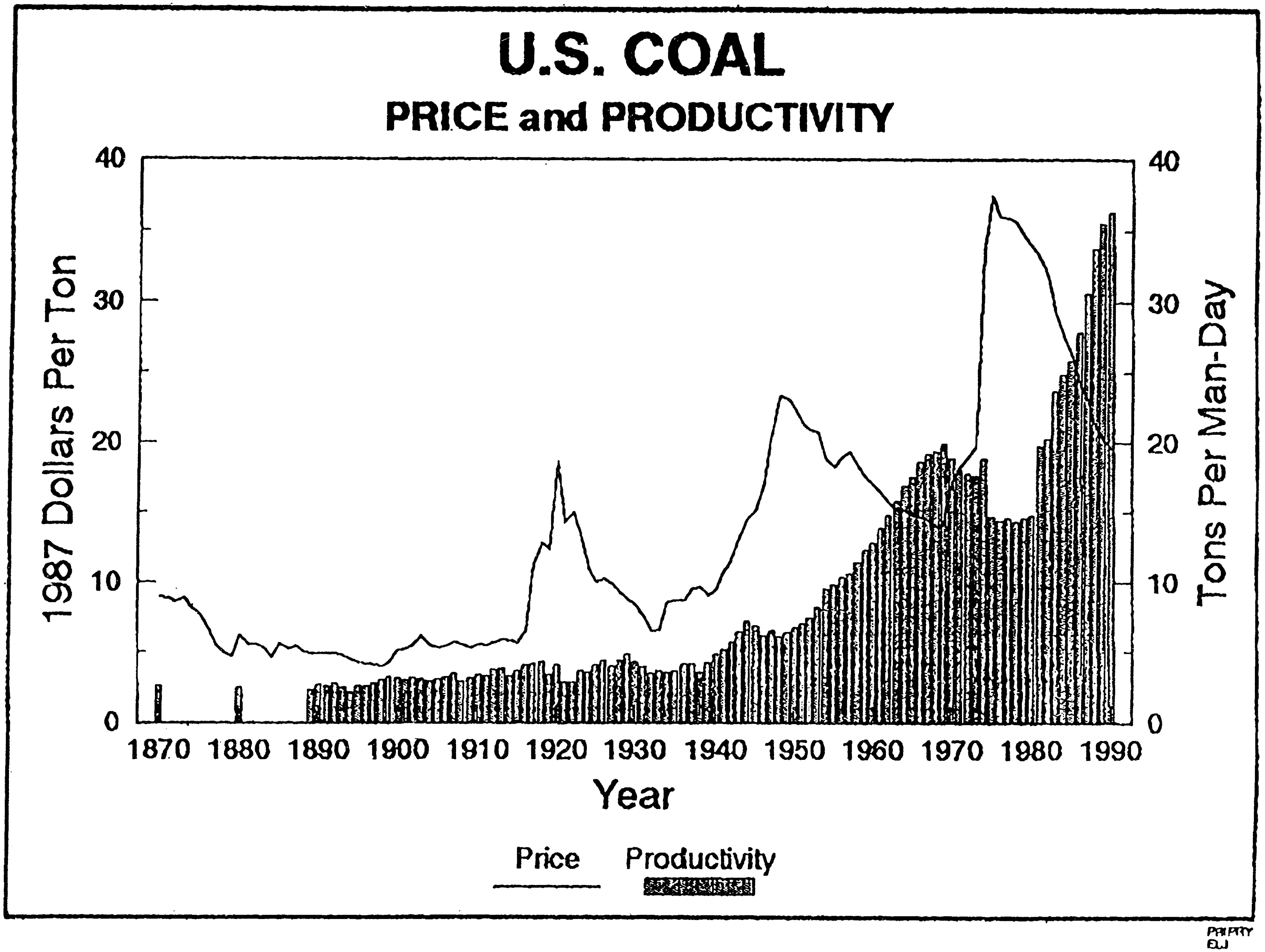
Along with that, now I'm showing productivity. This is average productivity in the U.S., not accounting for differences in coal types and so forth, as that changed especially with the additions of the Powder River coals in the 1970s and 1980s.

But I'm struck there -- and this is especially true for the last cycle -- that prices and productivity are very connected. When prices go up, productivity goes down. I don't see this connection in what is proposed.

DOE/EIA 1987 ESTIMATES OF RECOVERABLE COMPLIANCE RESERVES

State	Million Tons
Kentucky (East)	2,475
Virginia	971
West Virginia	7,738
Total	11,184


U.S. COAL
PRICE
1987 Dollars Per Ton
40
30
20
10
0
1975
1948
1920
1968
1915
1932
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
Year
COALPR87
ELJ


U.S. COAL
PRICE and PRODUCTIVITY
1987 Dollars Per Ton
Tons Per Man-Day
0
10
20
30
40
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
Year
Price
Productivity
PRI PRTY
EJ

As I understood it, the primary determinant of productivity expectations would be the amount of capacity utilization. I would suggest that that is true, but I think that a stronger correlation probably would be with price.

I am aware of some work done by my wife in the '70's that showed a very strong correlation between productivity and price, but as price has risen or as price has declined, we see a very steep rise in productivity. That's survival tactics. I don't think that had much to do with anything other than survival.

They made money during the price rise, and then as prices fell, they had to find a way to keep making a little bit of money. Certainly coal companies' profits declined, but I think that the only way they could find was to increase productivity.

In the 1980s, I did a number of studies relating to productivity and prices and did some surveys of various suppliers of TVA, and what I definitely found was pretty much that. They were after productivity, and they were after it because they couldn't make any money unless they got it. So I think that the correlation there is very strong, and I think theoretically very defensible.

I'm going to talk a little bit about my pet peeve, and this relates back also to the distribution side where we talked a little bit about having less data on contracts and lower quality data in the future.

I want to talk a little bit about the DRB, which is a driver in this model as well as in RAMC. I'm going to focus on Eastern low-sulfur coal because we have information that I think is fairly clear in its indications about the DRB.

During the 1970s, when I was working with EPRI and Jeremy Platt, we spent a good bit of time trying to get people interested in the deficiencies in the DRB. We haven't been very successful, but if we can, I'm just going to say if we look at the compliance reserves in central Appalachia, we really don't have many seams at all that meet those reserve quality characteristics.

Now, of course, if we assume advance coal cleaning is economical, we might be able to throw in some more, but that's a big "if" as to its economics.

These are 1987 EIA estimates of recoverable compliance reserves as best as I could interpret. Eleven billion tons.

Those are the reserves by county as estimated by Hill & Associates in their studies of Eastern low-sulfur coal. They have done independent studies, partly speculative and through clients' support, and they have estimated those numbers.

In those particular counties, without Dickenson and Wise or Nicholas or Perry, they come up with 2.4 billion tons. The dominant counties are already done.

You can see the lives of the mine over there to the right: essentially 50 years at current levels of consumption.

However, this is what bothers me. You will notice there was a big difference between the EIA numbers and the Hill & Associates numbers, but let's look at the implications of what happens, if we take Hill & Associates' work and extrapolate it to other areas that have compliance coal, taking the differences between EIA and what Hill & Associates had done, and we come up with 10 billion. So, at 1989 production levels, we hit 28 years. That's significantly below 50.

On the other hand, we know that with the Clean Air Act, we're going to expand the production of compliance coal in this country, and I'm speaking in particular about Eastern coal. A lot of the expansion will be Powder River coal, although that's more difficult as we found out in TVA. It's fairly expensive to make an Eastern plant work with Powder River coal, but that increases the amount that's going to come out of compliance coal in the East.

Recognizing that the law doesn't require in any way a compliance level coal, most coals will be at or near compliance levels without scrubbers eventually, but taking what I think are the really likely producers for Eastern compliance coal, I have about three billion tons. This is according to Hill & Associates.

Subtracting out the pre-Phase 2 consumption that may occur -- and this is using the lower production levels, not assuming any increase in '95 for Phase 1 since that level of quality is not needed, although some of the coals moving for an increase in tonnages, coals moving from '95 to 2000, I expect, will be compliance coals -- the coal companies have certainly invested a lot of money in compliance reserves, and I don't think they want to sit on them until 2000.

So that left us with about two and a half billion tons going into Phase 2. Now, the reserve life, it depends on what you estimate for the expansion of consumption, but if the demand is 65 million tons, we've got about 40 years. That still is fairly close relative to saying we've got 100 years worth of coal.

If demand goes to 120 million tons, there's 21 years of reserves left. That says that in approximately 2020 you have to do something for some other coal type. Maybe we have advanced cleaning that brings the cost down to a reasonable realm. Maybe we don't.

If the demand goes to 200, you've got 12 years. That has implications about pricing. One estimate I've done is that if you were to take a rational monopolist and say he had those reserves and could control them, or if I assume that utilities will try to seek out and capture, recognizing that there aren't many years of reserves left, all of those reserves for themselves -- let's say they have several plants that they really don't want to put a scrubber on. They want to retire it at some point out in time, but they want a life for a while.

Either of those activities leads to some price run-up well above what various estimates of pricing behavior would be. I think most pricing behavior now would say $30 a ton for well out in time.

Looking at that as a monopolist behavior, I would hold production levels to about 65

EASTERN COMPLIANCE RESERVES
(MILLION TONS)

State	County	Salable Tons	Production	Years/Life at 1989 Production Levels
Kentucky	Floyd	23	0.8	29
	Harlan	134	2.4	56
	Knott	54	1.3	42
	Letcher	156	6.0	26
	Martin	25	1.0	25
	Perry	*		
	Pike	475	8.4	57
Virginia	Dickenson	*		
	Wise	*		
West Virginia	Boone	261	8.0	33
	Kanawha	88	1.0	88
	Logan	650	12.0	54
	Mingo	544	10.0	54
	Nicholas	*		
	Total	2410	50.9	46

EXTRAPOLATION OF HILL & ASSOCIATES RESULTS

(million tons & years)

State	1989 Production	EIA Total Recoverable	EIA Life	Extrapolated Salable	Extrapolated Life
Alabama	28.5	3114.5	109	983.5	34
Kentucky (East)	116.3	5453.9	47	1722.3	15
Tennessee	6.6	523.2	79	165.2	25
Virginia	51.2	1608.7	31	508.0	10
West Virginia	151.2	21115.9	140	6668.2	44
Total	353.9	31816.2	90	10047.2	28

EXPANDED EASTERN COMPLIANCE COAL CONSUMPTION IMPLICATIONS FOR ACID RAIN PHASE 2

Available Coal:

3 Billion Tons

Pre-Phase 2 Consumption:

(10 years X 51 million tons per year)

0.51 Billion tons

2.49 Billion tons Available

When Consumption Expands

Reserve Life at Expanded Consumption Levels

	Demand = 65	Demand = 120 (million tons)	Demand = 200
Years:	38	21	12

million tons and raise the price to about $45 a ton, and a utility might be willing to pay it if they wished to retire a plant rather than put in a scrubber. If they've got ten years' worth of life left, they might be very willing to pay that rather than to go to the expense of a scrubber.

So those are the numbers that bother me, and all those numbers boil down to one thing: data. The data in the DRB, I think, if you ask most anybody from a coal company, is not defensible, and then everything that comes out of this effort, I would argue, depends upon that data.

When we look at the distribution of energy sources among nuclear, oil and gas, and coal, I certainly think that whatever happens, if there is a next generation of nuclear plants, I think that that coal pricing implication caused by the reserve estimates -- it will play an influence on how you estimate how much nuclear penetration there is for second generation nuclear.

Certainly in the utility business right now, almost any utility is looking at gas versus coal, and we have to look at these decisions as longer term. I think that that price of coal determines the gas penetration in the utility markets, as well as the gas price, of course, and how well that's being done also.

Both of these are difficult; reserves are difficult properties to deal with, but we haven't spent much money on looking at reserves in a very long time.

The coal industry can't afford to go out and do its studies. The utility business through EPRI has done a little bit, but the utilities are going to be more and more competitive, and utility funding for research may be harder and harder to come by.

If you're not aware, a number of utility commissions have denied EPRI dues to be put in the rate base after they've been members of EPRI for several years. Some utilities have had to drop out because of the utility commission's own behavior. That's scary.

But basically we don't have the money from the users of coal or the producers of coal to do the research, and I think that the decisions that will be made by DOE, I think the decisions made by coal companies, and I think the decisions made by utilities are certainly influenced by what we have.

I know I've digressed from a straight review of NEMS, but I think this is very important to what NEMS is capable of producing. I think it's very important to the accuracy of the modeling system.

I don't think that we can do a very good job of modifying for market reasons, though I think that's important; I don't think that will cover the exhaustion of particular coal reserves. We need to know more about how those coal reserves are laid out and how much there really is.

And with that I will pause and let you do yours.

MR. SITZER: Thank you, Ed. I wish we'd had some of our coal data people here to listen to your comments on the demonstrated reserve base, but I will talk a little bit about what we're doing in that area shortly.

Next I'd like to turn it over to Mike Kuby.

DR. KUBY: Well, in the interest of time, I'll skip the required joke about being the last speaker of the conference and proceed right to the thanking of the host for giving me the opportunity to comment on the NEMS coal modules.

I've learned a number of things both from the other reviewers and from reviewing the very thorough and very elegant coal modeling work done by EIA that I'll apply to my future work, and I hope that in return I can give a few worthwhile comments back to you.

It's interesting to see the different approaches that different reviewers take to reviewing the NEMS models. I thought the points about the lack of coal imports in the model by Jerry were very good, and all of Ed's points about the DRB and coal pricing projections were also very well taken.

I planned to start my presentation by giving you an idea of where I'm coming from because my most important comments are grounded in my prior modeling experience. I've worked on two quite different linear programming national level models of coal production and distribution, and I'll just introduce those very briefly.

The first model that I worked on was not the National Coal Model. It was a national coal model, called the Coal Logistics System, originally developed for the Maritime Administration and the Army Corps of Engineers. The purpose of the model was to study port expansion and dredging projects for export coal. So the purpose is important.

You can see the level of spatial disaggregation that we used in our modeling approach because it was important for the purpose of distinguishing between which ports are going to capture what shares of the export traffic. It's in great contrast to the highly aggregated NEMS approach.

We also went through a calibration exercise, and along the top you can see the export hinterlands, the coal production hinterlands for each port. I think one thing you can see here, which I'll bring up later, is the importance of the distance of the coal production zone to the inland waterways. We have coal coming -- and we've confirmed this with the Army Corps people -- we have coal coming from all the way up here in Pennsylvania down via New Orleans by barge because some of the coal mines were very, very close to the inland waterways. On the supply side, that's an important spatial aggregation issue.

Now, if you look on the bottom, we went through this calibration exercise where the Corps basically required us to calibrate the model so that the flows through the major ports would be within 15 percent of what actually flowed through those ports for a given base year. This was 1985, and that was an important exercise for finding problems in our model.

Then we'd change the harbor depth and see what the change in the flow patterns would

Coal Logistics System (COLS)

JEFFREY P. OSLEEB, SAMUEL J. RATICK, MICHAEL J. KUBY, HOWARD E. OLSON, LLOYD G. ANTLE, AND ARTHUR F. HAWNN

The Coal Logistics System (COLS) is a comprehensive coal transportation and transshipment model that solves for coal flows on a network from supply nodes through transshipment nodes to steam and metallurgical demand nodes on the basis of systemwide cost minimization. The model is solved for a representative time period for the system of ports, and all decision variables are solved for simultaneously. COLS is a constrained optimization model formulated as a linear program with some integer variables. Its solution indicates the sources of the various types of coal, the routes and modes of transportation, and the locations, activity levels, and types of transshipment facilities that together minimize the systemwide costs. Effectively, the COLS model minimizes the cost per delivered British thermal unit of U.S. coal. COLS was designed specifically for the evaluation of coal flows in a competitive multiport framework. Coal can be routed from virtually any mining region by any feasible mode to any port and then to any demand node. Thus, ports need not be restricted by a predefined supply hinterland or a limited destination area. From one scenario to the next, a single destination can receive coal of a different quality from a different origin via a different mode through a different port. Cost reductions from one scenario to the next can thus include transport cost savings, change of origin or destination benefits (including lower coal purchase costs), and change of mode savings as well as port improvements and the use of new technologies.

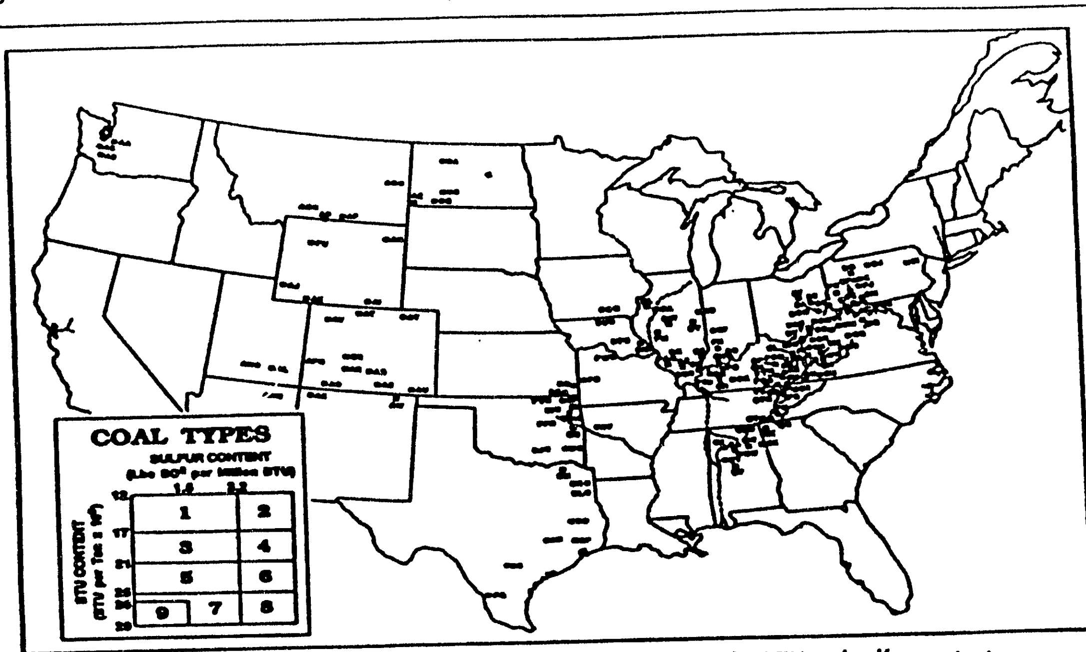


Figure 4. Supply nodes in the COLS. Inset shows coal types by BTU and sulfur content.

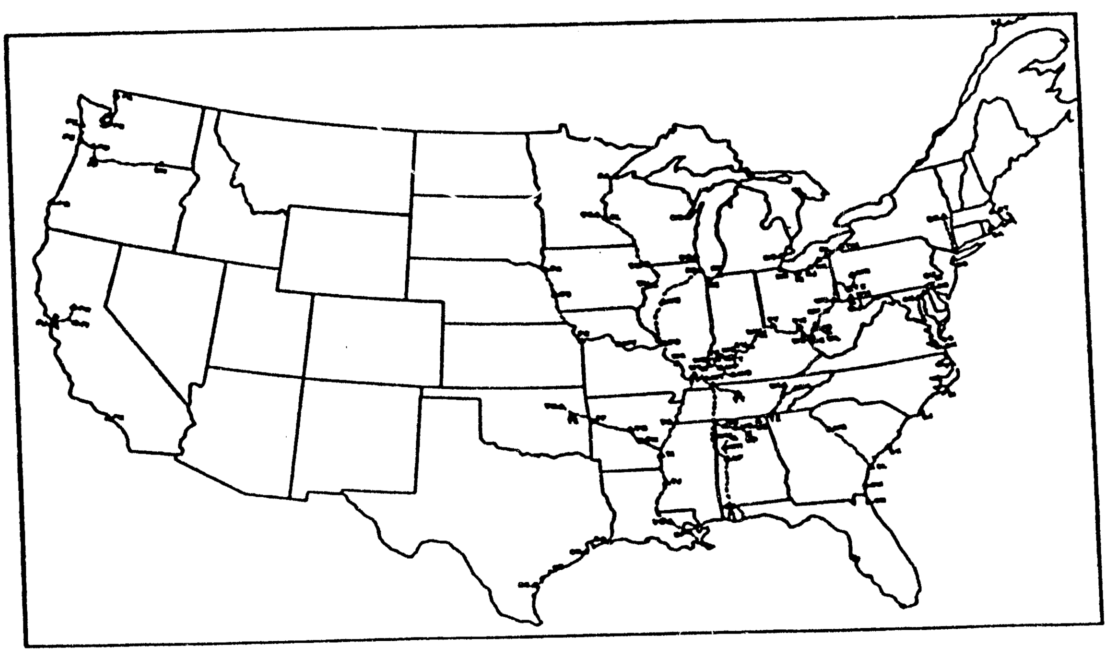


Figure 5. Inland waterways, inland ports, and export ports in the COLS.

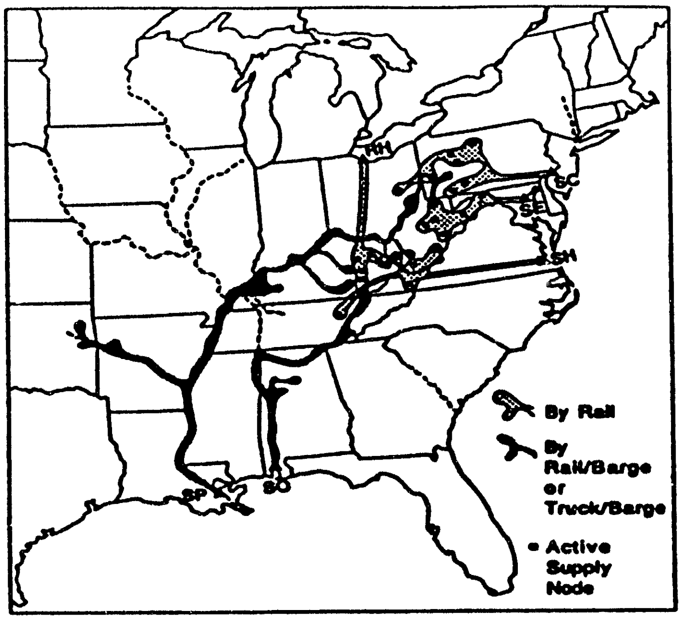


Figure 6. Eastern U.S. port hinterlands in the base case (RH = Toledo, SC = Philadelphia, SE = Baltimore, SH = Norfolk, SO = Mobile, SP = New Orleans).

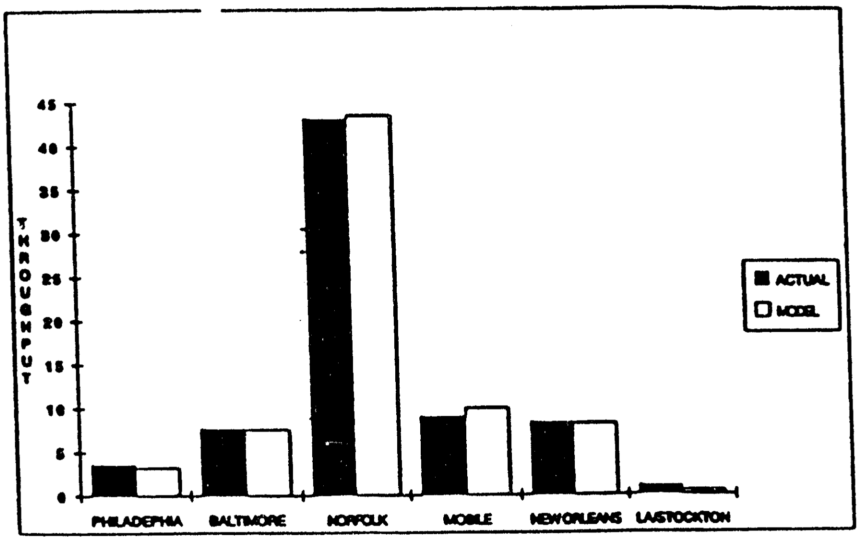


FIGURE 4 Comparison of model results with historical data (total coal. throughput: actual = 72.70 mtpa; model = 72.81 mtpa.

be with a deeper port at Norfolk or Baltimore or both.

The other model that I worked on, and I'm still engaged in this, is for the World Bank and the Chinese government, and it's called the China Coal Transport study.

A lot of other people are working on that with me. The purpose of this model was investment planning over a 15-year time horizon and to help China solve its coal shortages, which are primarily caused by transport bottlenecks. So obviously a network level analysis was dictated for this purpose.

I'm getting to where I'm heading with the DOE models, but I just want to point out one thing. The second step there is the coal preparation step where high ash steam coal has the option of being washed, and metallurgical coal is required to be washed.

Well, that gives you an idea of where I'm coming from. A model is a simplified representation of reality, and how the modeler goes about simplifying the system is dictated primarily by three things: first, the purpose of the model; second, the availability of the data; and, third, computational considerations. And these three have obviously all been taken into account by the EIA team.

Now, in my review, unless I notice something that really struck me as glaring wrong or problematic, I pretty much am giving it the okay because I know there are a lot of difficult choices in modeling, and there's no single right way to do it. So my comments are really focused on three or four key issues.

On the Coal Production Submodule, the purpose is to produce annual coal supply curves for the intermediate term, and the EIA model considers a number of factors: reserve depletion, labor productivity, capacity utilization, construction lead time, labor and fuel costs. I think we could also add geological factors in terms of seam width and depth.

And the classification system is by coal type, Btu and sulfur, mine type, surface or underground, and by region. I thought that was pretty thorough and considered most of the major factors, though Ed has brought up some additional ones.

I thought it was a big improvement over RAMC in that factor prices and technological change are now built in. They weren't before, and it gives an excellent capability for analyzing the issues. I think those plus the price and depletion factors that Ed brought up are the key issues.

They do a nice job of mixing engineering, accounting, geological, statistical, economic models in a multi-step process that comes up with pretty good coal supply curves, and the methodology used at each of those stages seemed reasonable to me.

So the one thing I'm going to key on is one of their stated limitations. This is from the limitations chapter of the design report. The third limitation is the CPS will not be capable of representing the impact of coal preparation activities on the cost and quality of the coal.

Energy Vol. 18, No. 1, pp. 1-24, 1993
0360-5442/93 $5.00 + 0.00

A STRATEGIC INVESTMENT PLANNING MODEL FOR CHINA'S COAL AND ELECTRICITY DELIVERY SYSTEM

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(Received 10 December 1991; received for publication 2 June 1992)

Abstract—In this paper, we describe a strategic investment planning model for China's coal and electricity delivery system, including the related sectors of the economy that offer non-transport strategies for reducing the demand for coal transportation. The model has been developed for policy analysis by the World Bank and China's State Planning Commission in order to deal with China's recurring coal and electricity shortages. Various aspects of the modeling system are described, including its precedents in the literature, its strengths and weaknesses, and its applications. An Appendix contains the mathematical formulation of the model, which involves mixed-integer programming.

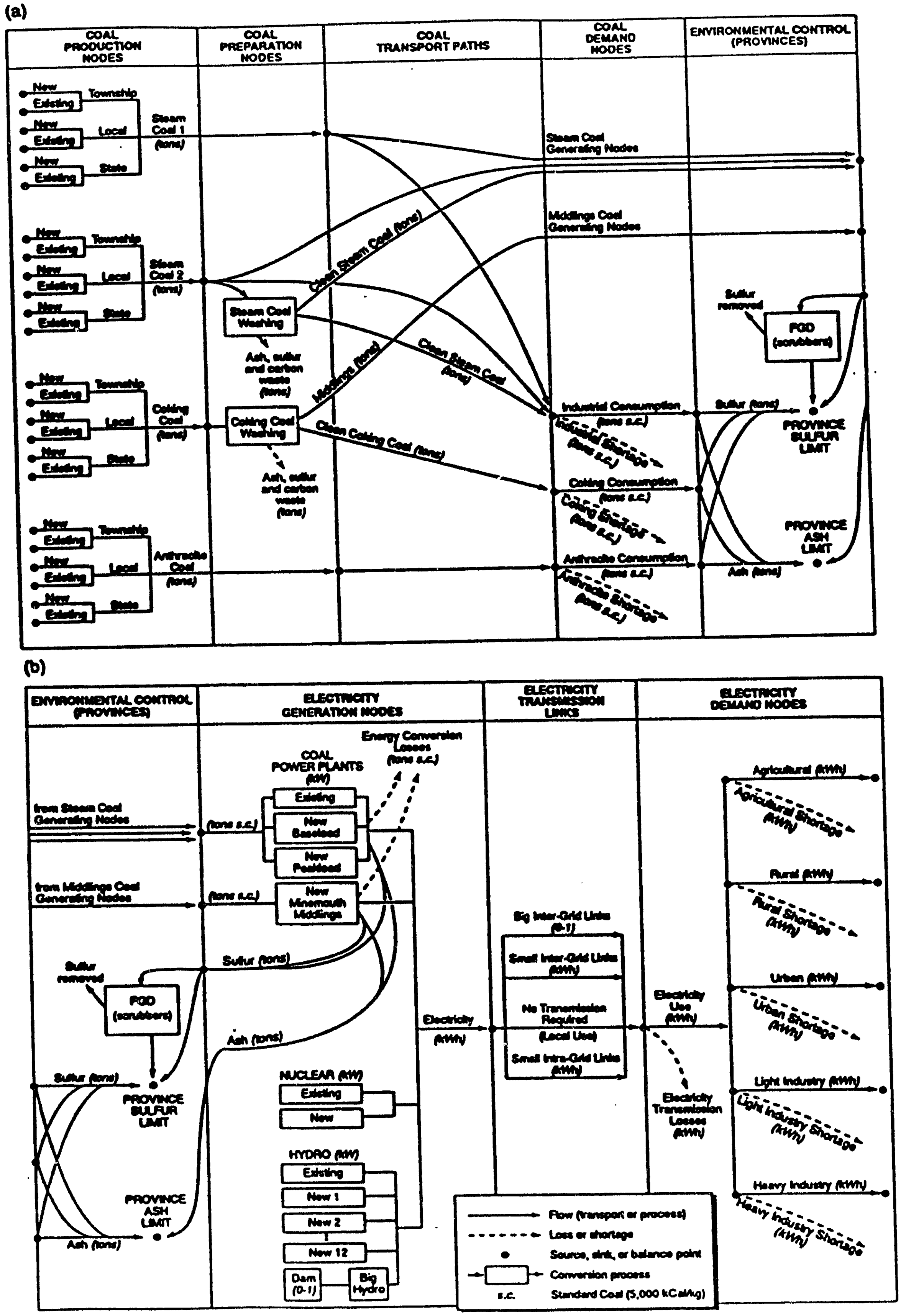

Fig. 1. Generalized network diagram of the coal–electricity delivery system in the Coal Transport Study: (a) the coal sector; (b) the electricity sector.

Coal Production Submodule (CPS)

Purpose

To produce annual coal supply curves for the intermediate term.

Overview

Factors considered:

- reserve depletion
- labor productivity
- capacity utilization
- construction lead time
- labor and fuel costs

Classification by

- coal type (BTU and sulfur)
- mine type (surface or underground)
- region

Comments on CPS Overview

- big improvement over RAMC in that factor prices and technological change are included.

- excellent capability for analyzing key issues.

- a mix of engineering, accounting, geologic, statistical, and economic models are tied seamlessly together.

- methodology used for each stage is appropriate.