THE NEMS CONFERENCE

INDUSTRIAL DEMAND PANEL

February 1, 1993 - 3:15 pm

PRESENT:

Edward J. Flynn, Moderator
T. Crawford Honeycutt, Presenter
Richard B. Howarth, Reviewer
Frank A. Monforte, Reviewer
F. Tom Sparrow, Reviewer

AUDIENCE PARTICIPANTS:

Mark Schipper
Bob Adler
Bernard Gelb
Gale Boyd

EIA

PROCEEDINGS

MR. FLYNN: The Industrial Demand Section encompasses manufacturing, agriculture, mining and construction categories. As such, it is extremely diverse and encompasses virtually every modeling issue in a multitude of variations. The NEMS model for the industrial sector is designed to represent the major industrial groupings by type of industry, as well as by the general categories of energy use -- process assembly, buildings, boilers, steam, and cogeneration. The structure of the model is intended to provide a capability for expansion as more data become available and as new policy issues are identified.

In this afternoon's session, we have Crawford Honeycutt, from the Energy Demand Analysis Branch of EIA, who will provide an overview of the NEMS model and address some of the key design issues. He will be followed by three expert reviewers, who will provide comments on both the model and the central issues of projecting energy demand, and will also discuss their own research in the area of industrial energy modeling. These reviewers include Frank Monforte from RER, Tom Sparrow from Purdue, and Richard Howarth from Lawrence Berkeley Laboratory. Their presentations will follow in the sequence of the program.

Crawford recently assumed the challenging position of Team Leader for the Industrial Model Development, and with his staff has been moving it skillfully through final design, programming, and early testing. Much remains to be done, and your suggestions are welcome.

If possible, please hold your questions until the end of the session, after all reviewers have had their presentation, and then we'll take questions from the reviewers and the floor.

Crawford?

MR. HONEYCUTT: Okay. Thanks, Ed.

Well, my goal today is to provide an overview of the NEMS Industrial Model. I'll describe the general modeling structure and highlight some of the issues that are still under development. I want to emphasize that point, that the model is still under development, so your comments and suggestions are of genuine interest and potential use for me.

The first slide just shows that the Industrial Sector Demand Model is one of about a dozen major model components. The demand models are on the right-hand side and industrials is one of them.

Most of the industrial energy related issues are fairly obvious. The industrial sector consumes a large amount of energy, about 30 percent of total energy consumption. This implies that consumption trends in industry might be of some interest.

But, for the industrial sector, just how important is energy? Well, it depends. They spend a couple of trillion dollars a year on a variety of things, but only about 3 percent of

Industrial Demand
in the
National Energy Modeling System

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T. Crawford Honeycutt

Energy Information Administration

EIA

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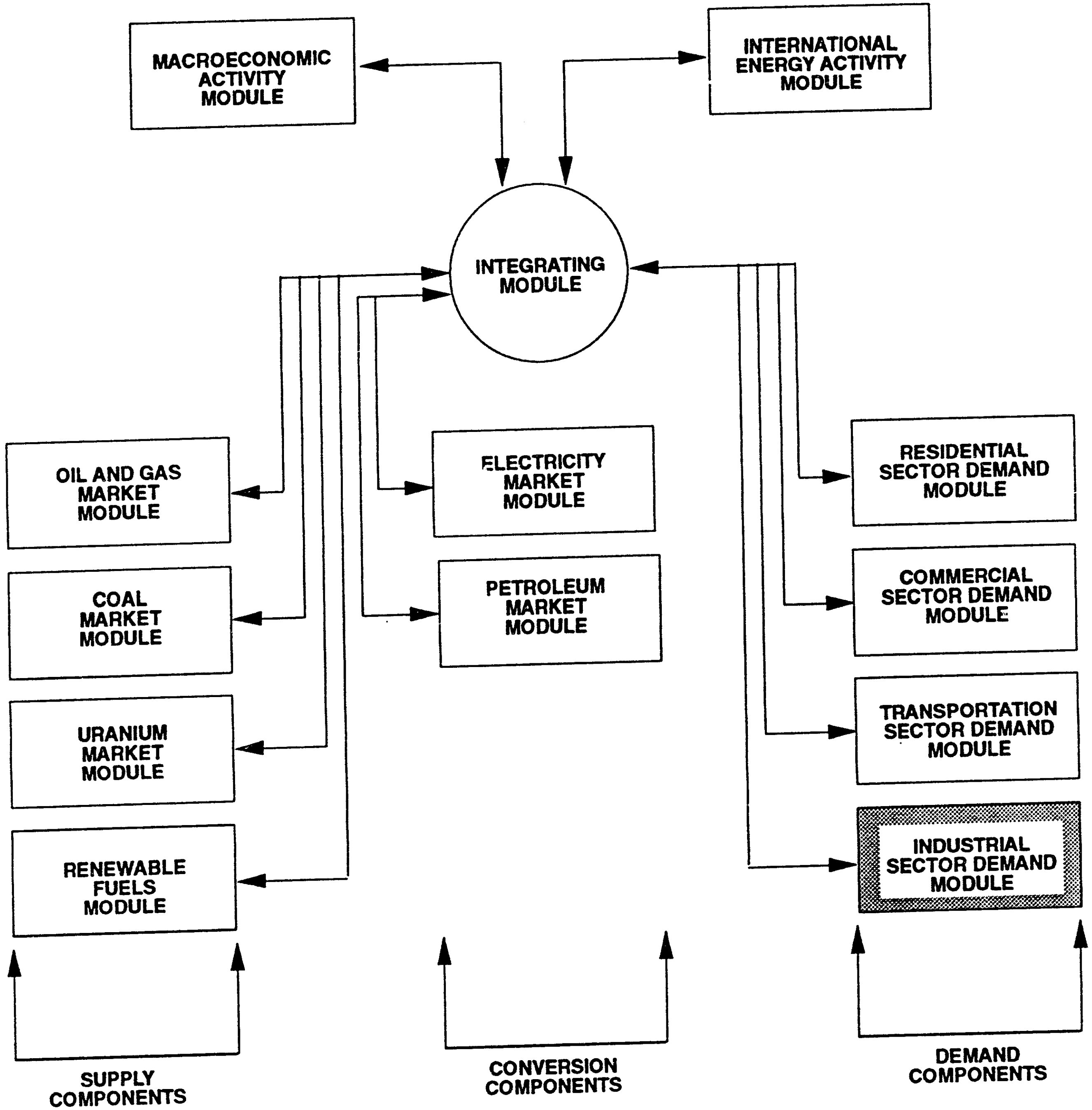
Industrial Sector Demand Module in the NEMS



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that is for energy.

Now, in some industries, of course, it's several multiples of that, in aluminum, or in cement, about a third of their expenditures may be for energy.

There are a variety of factors that might affect energy consumption, and even though they may be small in relative terms, they may have a big impact over time. So, that's why we want to look at energy efficiency trends, demand side management issues, and one other issue. We know that over the past couple of decades there's been a substantial increase in energy efficiency, but a great deal of that change has been due to what you might call compositional changes in industry. I believe one of our reviewers will talk about that question in some detail.

The industrial sector also produces about 15 percent of its electricity requirements through cogeneration. Again, this is concentrated in three or four industries. About 90 percent of it is produced by four industries. Directly related to this cogeneration activity is extensive use of byproducts and renewables, and everyone is interested in renewables.

Greenhouse gas emissions are important because of concern about greenhouse gases affecting global climate.

Well, in our model we'll calculate emissions, but we won't try to characterize their impacts. I know that another one of our reviewers will talk about emissions in a lot more detail.

The industrial model interacts with several other NEMS models. In NEMS, all this interaction actually takes place through the integrating module, rather than directly from one model to another.

Here are some of the examples of the information that we receive. When I say we get information from this model or that model, we actually get it from the integrating module, and only indirectly from the model referred to.

The most important models for our purposes are the macroeconomic models, because, after all, they determine the value of output for our industry. So, in effect, output is exogenous to our modeling effort.

The integrating module is also important because it sends us the prices that we are trying to react to in order to minimize our costs.

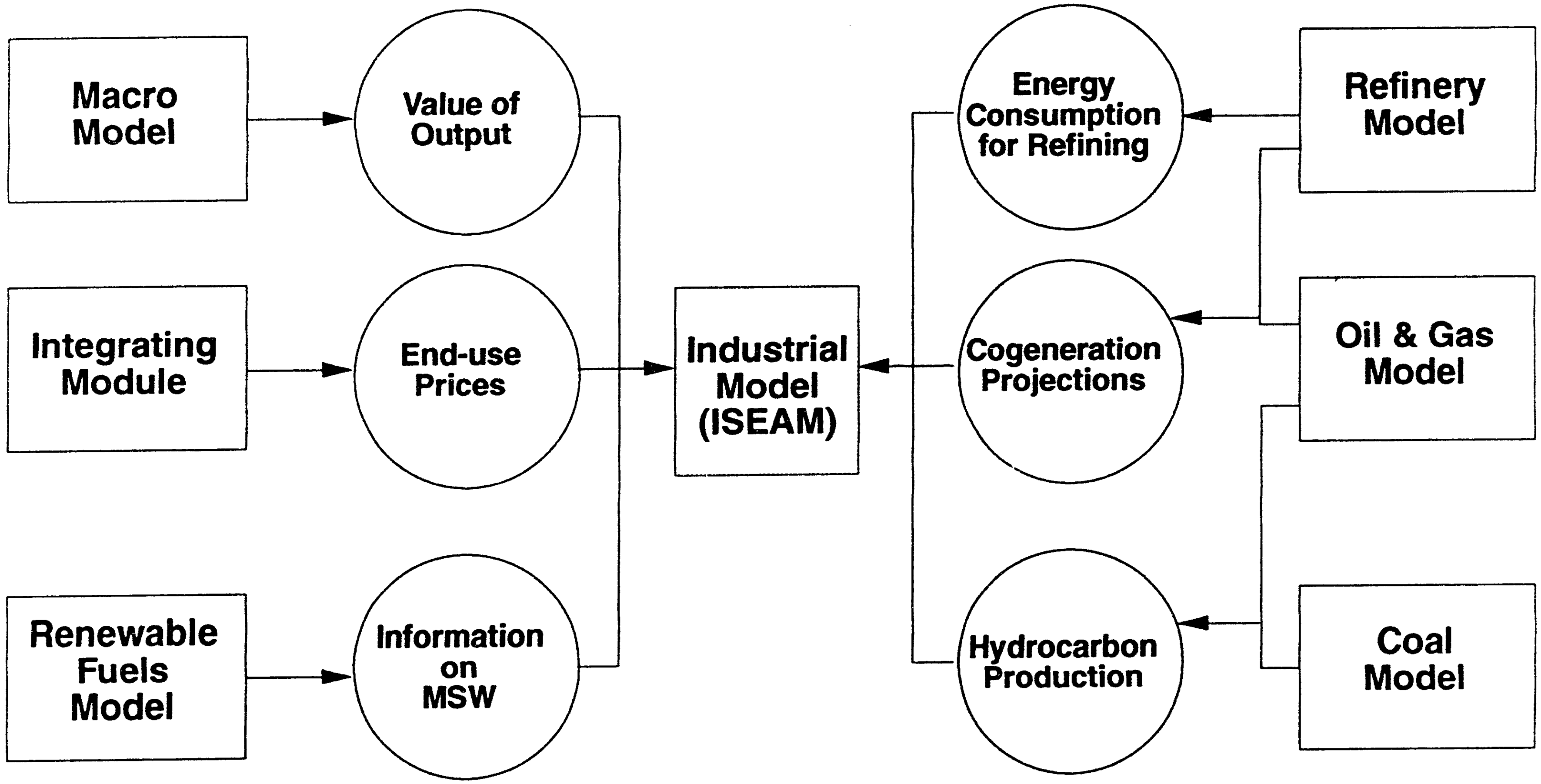
I want to say one thing about the refining model. We interact with the refining model, because in refining, which is actually the petroleum market module, energy consumption is estimated there, not in the industrial model.

The industrial model also passes information to several models. We take cogeneration estimates from refining, from the oil and gas model, and we combine that with our own cogeneration estimates and send it back out for the electricity model to deal with.

Industrial Sector Issues

- Consumption Trends
- Energy Efficiency
- Demand Side Management
- Renewables
- Greenhouse Gas Emissions
- Cogeneration

The Industrial Model Receives Information from Several Models



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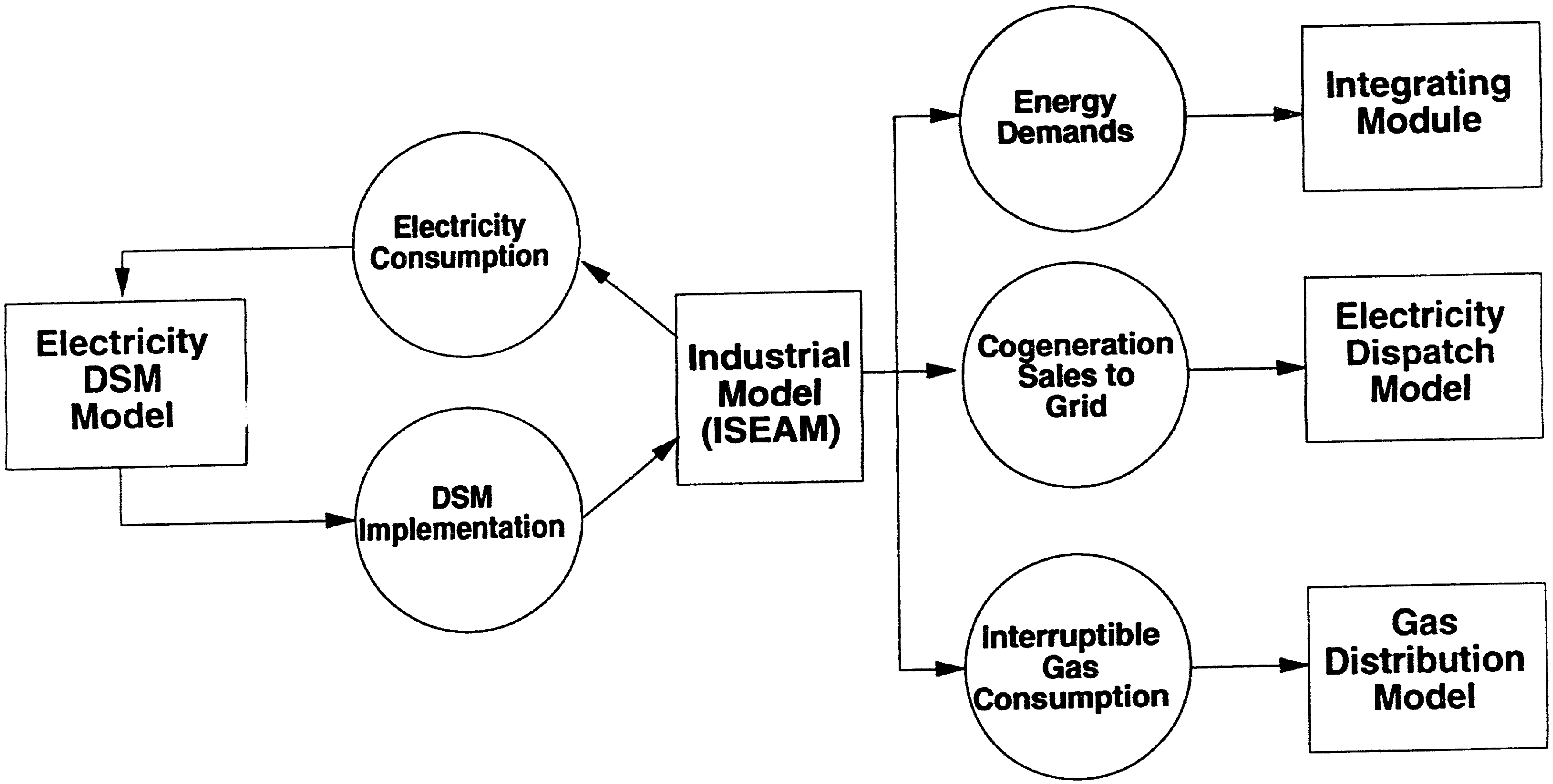
The Industrial Model Passes Information to Several Models



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The total cogeneration sales to the grid are then passed to the electricity dispatch model, and optimally dispatched from there.

We also interface with the electricity models to implement the demand side management. It's actually done in the electricity model, not the industrial model.

At the end of all this, we send the quantities back to the integrating module, and this process continues to iterate back and forth until there is some equilibrium achieved.

In the industrial model, we have about 35 industry groups. The energy intensive industry groups are aggregated at the three or four-digit SIC level, and the other manufacturing groups are aggregated at the two-digit SIC level. We've tried to aggregate the energy intensive industries into more homogeneous groups to make it easier to model them, and also to address the impact of compositional changes over time.

Now, a basic variable used in the model is something we call unit energy consumption, which is just the consumption over value of output, or UEC. We estimate this unit energy consumption, or UEC, with econometric techniques, except in the energy intensive industries, where we use engineering estimates rather than our econometric analysis.

We have five energy-intensive groups. They are the food, paper, chemicals, primary metals, and the stone, clay, and glass industries. The sixth energy intensive industry, refining, as I noted, was taken care of elsewhere. Together, these six industries account for about 80 percent of manufacturing energy consumption.

This leads us to believe that we can concentrate our efforts on these few industries and still have a reasonable representation of industrial energy consumption.

The other manufacturing industries are modeled at the two-digit SIC level, and there's no process detail there.

The non-manufacturing groups, agriculture, mining, and construction, initially will also be aggregated at the two-digit level. In future development, we will be breaking them down further as shown in this slide.

Each of the industry groups contain three components. We call these components buildings, process and assembly (PA), and boilers, steam, cogeneration (BSC). In each industry, if it's appropriate, we will also have a representation of energy byproducts and cogeneration.

For the energy-intensive industries, we'll have explicit engineering modeling. Food, however, is modeled using an end-use concept, such as heating, cooling, rather than processes. So, Tom, we do use some end-use concepts.

Chemicals, I will say parenthetically, will not be modeled using processes, but by

Energy-Intensive Manufacturing

-- Food (SIC 20)

-- Paper and Allied Products (SIC 26)

-- Chemicals and Allied Products (SIC 28)
  - Inorganic (SIC 281)
  - Plastics and Synthetics (SIC 282)
  - Organic (SIC 286)
  - Agricultural Chemicals (SIC 287)

-- Stone, Clay, and Glass (SIC 32)
  - Glass (SIC 321, 322, 323)
  - Cement (SIC 324)

-- Primary Metals (SIC 33)
  - Iron and Steel (SIC 331, 332)
  - Aluminum (SIC 3334, 3341, 3353, 3354, 3355)

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Other Manufacturing

-- Tobacco (SIC 21)
-- Textile Mill Products (SIC 22)
-- Apparel and Other Textile Products (SIC 23)
-- Lumber and Wood Products (SIC 24)
-- Furniture and Fixtures (SIC 25)
-- Printing and Publishing (SIC 27)
-- Other Chemicals (SIC 283, 284, 285, 289)
-- Asphalt and Miscellaneous (SIC 295, 299)
-- Rubber and Miscellaneous Plastics (SIC 30)
-- Leather (SIC 31)
-- Other Stone, Clay, and Glass (SIC 325-329)
-- Other Primary Metals (all but iron/steel & aluminum)
-- Fabricated Metals (SIC 34)
-- Industrial and Commercial Machinery and Computer Equipment (SIC 35)
-- Electronics, except Computers (SIC 36)
-- Transportation Equipment (SIC 37)
-- Instruments (SIC 38)
-- Miscellaneous Manufacturing (SIC 39)

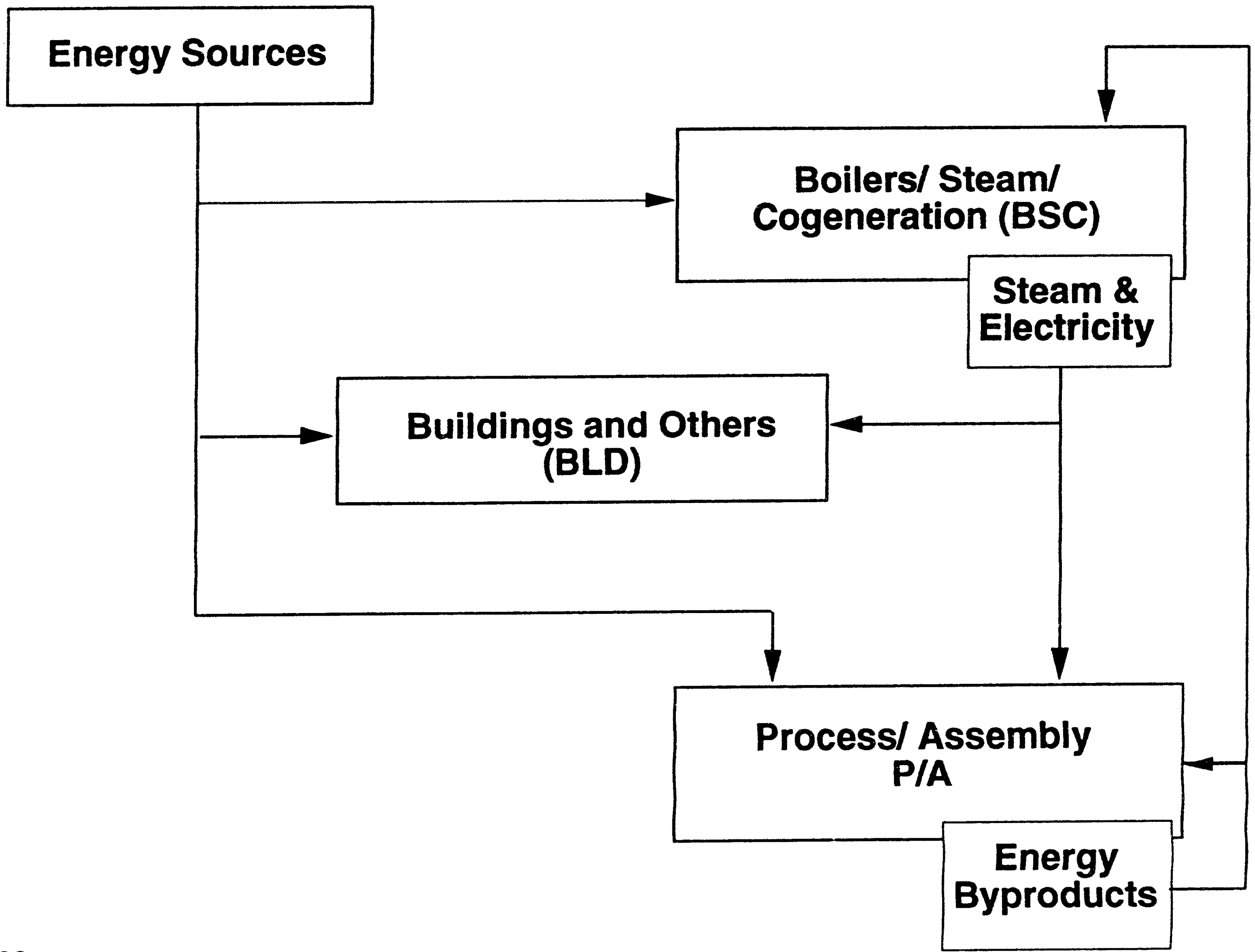
Non-Manufacturing

-- Agriculture
   Agricultural Crops (SIC 01)
   Other Agriculture (SIC 02, 07, 08, 09)

-- Mining
   Coal Mining (SIC 12)
   Oil and Gas (SIC 13)
   Other Mining (SIC 10, 14)

-- Construction (SIC 15, 16, 17)

Industrial Model Components



Process and Assembly

-- Energy-intensive industries are modeled using engineering process flows.

-- Recycling of post-consumer scrap is explicitly included where appropriate.

-- Accounts for about 53 percent of energy consumption.

ISEAM Models 35 Industry Groups

- Uses econometric and process techniques
- Industry is divided into three categories for analysis
    - Energy-Intensive Manufacturing
    - Other Manufacturing
    - Non-Manufacturing

some sort of end-use approach.

Later on, I'll show you an example of the process flows for one of the industries.

The process assembly component accounts for a little over half of the direct manufacturing energy consumption. However, as far as total energy consumption in the PA component, about 40 percent of it is actually steam, and this steam is generated in the BSC, the boiler component.

The boiler component consumes fuels to meet the steam demands from the PA and Buildings Components and in some cases sends back to them internally generated electricity.

The BSC component consumes a little more than 40 percent of the total in industry. It's interesting, though, within the boilers, natural gas and byproducts, or renewables, each account for about a third. Actually, byproducts probably account for a little more than natural gas. There's a small amount of coal and petroleum.

Cogeneration, my favorite subject. The exact representation of cogeneration has not yet been determined in the model. Most industry groups do not engage in cogeneration at all, but a few of them use it extensively. We think that the industries that use cogeneration extensively, in fact, use it as a method to minimize their overall input costs, rather than as a profit center. This may affect the way we want to model cogen.

Fuel switching is also in the boiler component. We don't know exactly how we are going to do fuel switching there, but we will do it. But, the first thing the boiler component will do is consume all the byproduct fuels that are available. Then it will proceed, using relative prices and consume purchased fuels.

The buildings component is divided into consumption for lights and for all other uses, basically, HVAC. Buildings are not really all that interesting. They consume about three percent of the energy in manufacturing.

This is an example of a process flow for an industry, it's cement. For those of you familiar with industrial modeling, you've probably seen a similar schematic very often. Basically, you start by crushing up the raw materials, aggregate, and then you can produce the clinker in two different ways. It's interesting in this case, because the two different ways, the wet process and the dry process, have distinctly different energy consumption characteristics. The wet process consumes maybe 40 percent more energy per ton than the other. Currently, and this varies depending on which year you look at this, the dry process accounts for about 60 percent or nearly two-thirds, and the wet process about a third. The remainder is imported clinker. For our modeling purposes, we will assume that any new plants will use the dry process.

Regarding technical change, or maybe a better phrase would be "energy intensity changes," our approach is to incorporate autonomous and price-induced energy-intensity changes. For the energy-intensive industries, the autonomous trends will be based on engineering judgments and analysis. For the remaining industries econometric estimates will

Boilers, Steam, Cogeneration

-- Consumes fuel to meet steam demands of other two components.

-- Cogenerates electricity where steam load is appropriate.

-- Fuel switching occurs in this component.

-- Accounts for about 44 percent of energy consumption.

Buildings

-- Lighting

-- Heating, Ventilation, Air Conditioning

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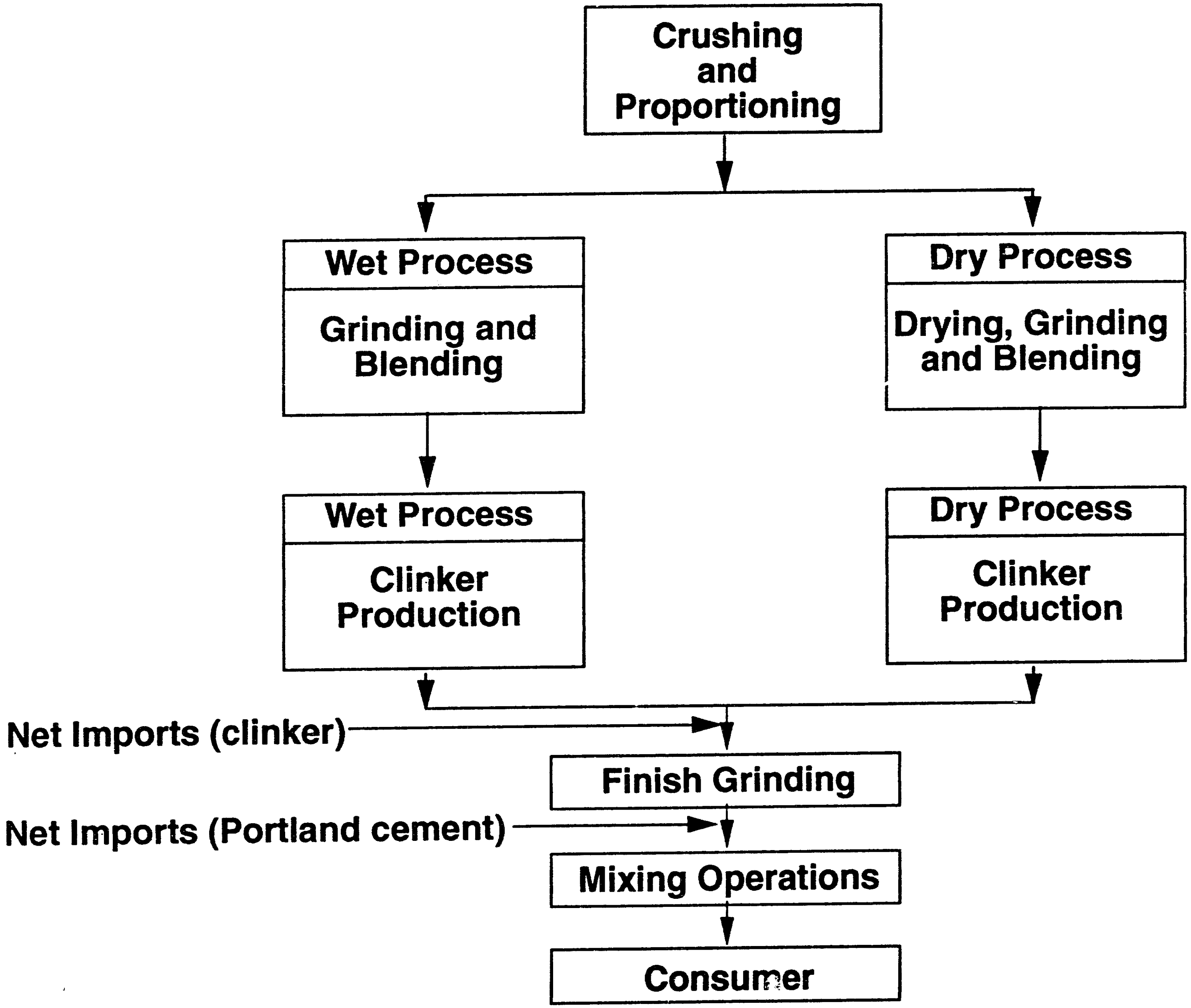
-- Accounts for about 3 percent of energy consumption

Cement Industry Process Flows



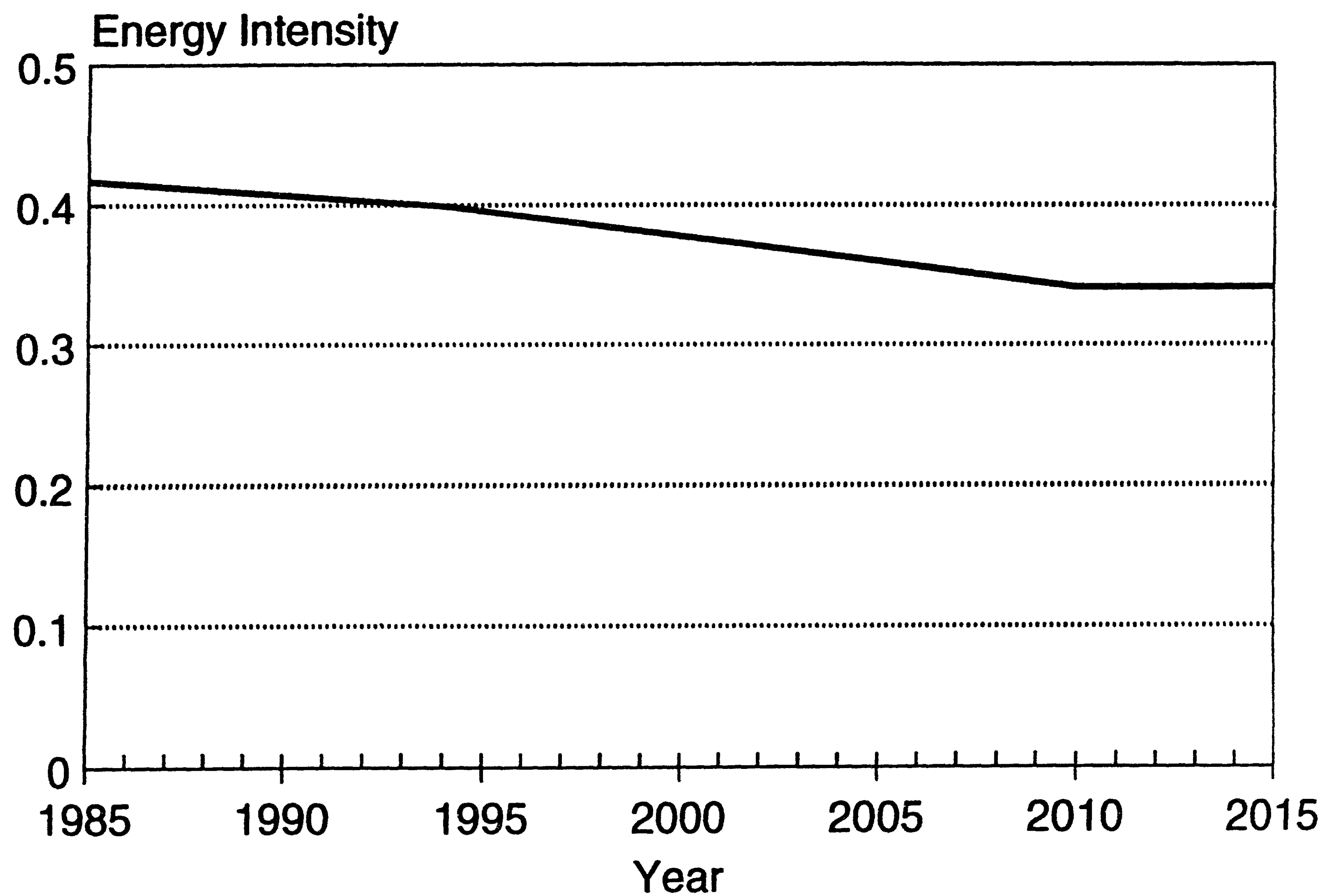
Technical Change

- Autonomous technical change.
  - -- Energy-intensive manufacturing will be based on engineering estimates.
  - -- Other Manufacturing and Non-Manufacturing will be based on econometric analysis.

- Price-induced technical change.
  - -- Based on econometric analysis.

- Putty-Clay Approach
  - -- Existing capacity uses relatively fixed input ratios.
  - -- New capacity uses optimal input ratios based on current price expectations.

New Cement Plants



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be used.

The price-induced technical changes will all be based on econometric analysis, at least in the beginning.

We have, in the past, characterized our modeling approach as a putty clay approach. By that we don't mean anything more than that existing plants have fairly small scope for energy changes. New plants, with new capacity, can incorporate newer technologies using current price expectations and have considerable scope for energy changes for the new capacity.

Let me give you one example of how new plants may be different from old plants. This is for new cement plants. This is an example, but I'm told it's realistic. The Y axis there actually represents the energy intensity of the new plant relative to the energy intensity of old plants, actually, the average for plants in 1985. You can see that the new plant is a good deal more energy efficient.

So, the question is, how do we add this new capacity? That is a good question. It's added to fill the gap created by retirement of old plants and the exogenous output that we receive from the macro model.

Now, this aspect of the model is still being developed, but I think we'll come up with a reasonable solution.

That's a quick overview. I'm available for questions, but I just want to wind up with a couple of thoughts. Most of you who know anything about industrial modeling know it's mostly limited by the data that are available. I think the best way to improve industrial modeling is to expand systematic data collection. This should be viewed as a long-term effort with long-term payoffs. Examples of such a data collection effort would include revising and updating the national energy accounts, continuing to expand the MECS, making it an annual survey, or, perhaps, as John Holte once recommended, creating a specific set of industrial sector energy accounts.

Thank you.

MR. FLYNN: Our next speaker will be Frank Monforte. Frank is the Manager of Industrial Research at Regional Economic Research in California. He is a principal developer of the INFORM industrial model of EPRI, and he's the curator of the model right now. He has some very interesting things to say regarding the NEMS model and requirements for industrial modeling in general.

Thanks.

MR. MONFORTE: First off, I will agree with Mr. Honeycutt that a key difficulty in modeling industrial energy consumption is lack of data. We will back any effort that EIA or the DOE comes up with in developing detailed industrial data.

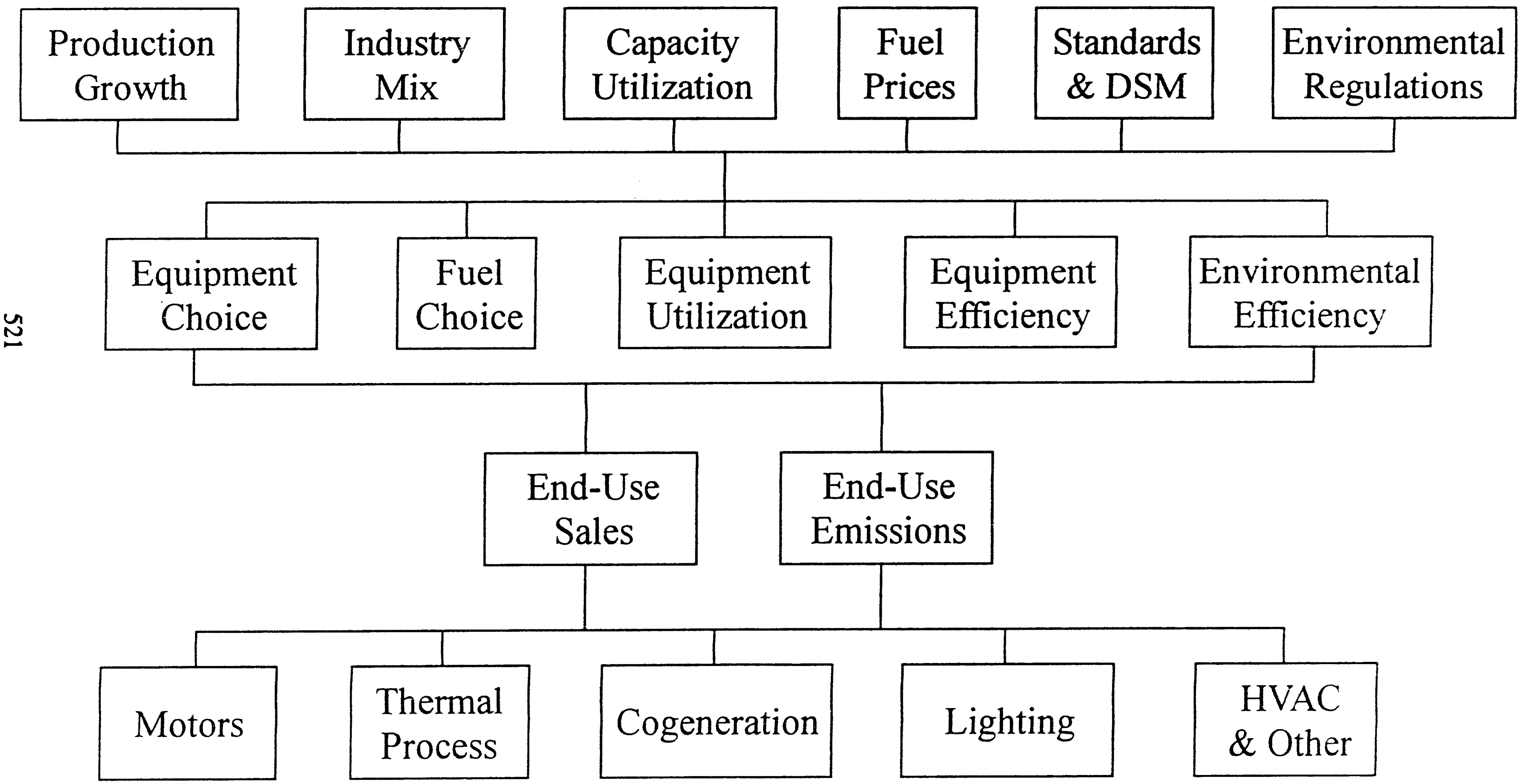
Integrating Emissions into an Industrial Energy Forecast

A Comparison to Electric Power Research Institute's INFORM

Presented by

Frank A. Monforte, Ph.D.
Regional Economic Research, Inc.

EPRI'S Industrial End-Use Forecasting Model (INFORM)



The title of my talk is "Integrating Emissions into an Industrial Energy Forecast -- A Comparison to Electric Power Research Institute's INFORM." INFORM is EPRI's industrial end-use forecasting model. Recently, INFORM was enhanced to provide an integrated energy and emissions forecast. The purpose of my review is to compare the emissions forecasting framework proposed in NEMS to the one in place in INFORM.

Over the past ten years, EPRI has developed a family of end-use forecasting models. They are REEPS-PC, COMMEND, and INFORM, for the residential, commercial and industrial sectors, respectively. INFORM, which was first released in August of 1992, is the newest of the three models. The following is a list of INFORM end uses: motors, melting, process heating, drying and curing, electrolytics, process steam generation, cogeneration, lighting, HVAC, and miscellaneous uses. The key forecast drivers are industrial production, capacity utilization, and energy prices. The user provides base-year market profiles, which include energy consumption by end use, equipment inventories, technology and fuel shares, and equipment efficiency option shares. INFORM forecast results include end-use energy consumption, cogenerated electricity, technology and fuel share trends, and efficiency option shares.

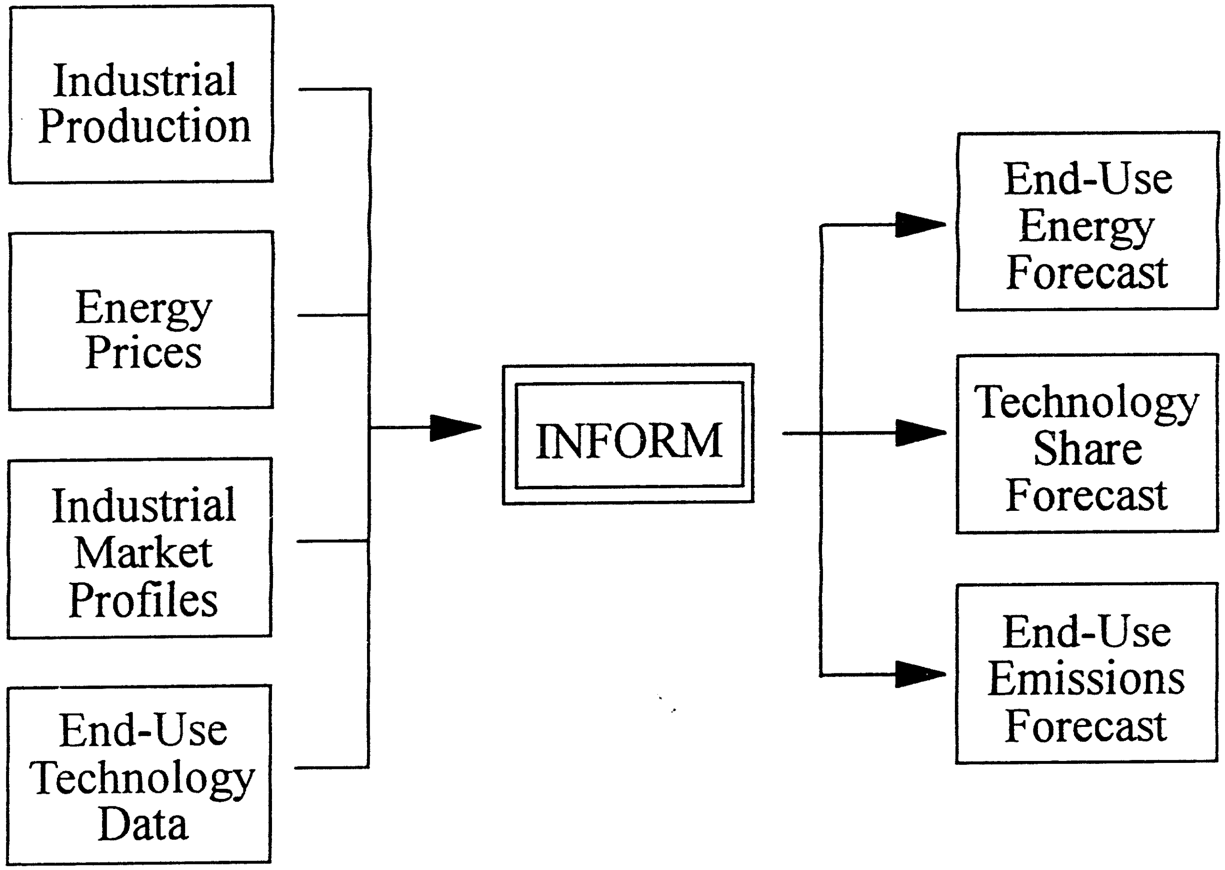
The modeling capability that is new to INFORM is the forecasting of industrial emissions. The INFORM effort started at the request of the Los Angeles Department of Water and Power (LADWP). LADWP required a tool for estimating the energy impacts associated with industrial customers complying with air quality regulations. For example, LADWP wanted the capability to estimate the energy impacts from companies reducing their NO_x emissions by half by 2005. The model development was sponsored by EPRI. A task force that included participants from LADWP, EPRI, California Energy Commission, and San Diego Gas & Electric Company contributed to the model development.

Both NEMS and INFORM provide forecasts of combustion and non-combustion emissions. Combustion emissions are byproducts of fossil fuel combustion. Production process emissions are byproducts of a production process that does not require energy consumption. An example of non-combustion emissions would be the vapors given off from drying paint. The two models, however, differ in how the emission forecasts are generated.

The NEMS framework can be thought of as two black boxes. In the first black box, forecasts of energy consumption by fuel and industry are produced. These data, along with the industrial production forecast, are passed to the second black box which performs the emissions accounting. Estimates of combustion emissions are given by the product of total fuel consumption (million Btu) and an emission factor (lbs/million Btu). Estimates of non-combustion emissions are given by the product of industrial production ($million) and a non-combustion emission factor (lbs/$million).

In INFORM, there is one black box. The energy consumption forecast engine and the emissions accounting engine are combined into one framework. By combining both components, forecasts of the energy consumption associated with the use of emission abatement equipment can be made. This is the key difference between the two modeling approaches.

EPRI'S Industrial End-Use Forecasting Model (INFORM)



An Integrated Energy & Emissions Forecasting Framework

- Requested by the Los Angeles Department of Water & Power
- Model Development Sponsored by EPRI
- Emissions Model Task Force:

  LADWP
  EPRI
  CEC
  SDG&E

- Model is Currently Under Review by:

  LADWP
  CEC
  SDG&E
  PG&E
  WEPCO
  WP&L
  NMPC
  TVA
  PNL

Sources of Air-Borne Emissions

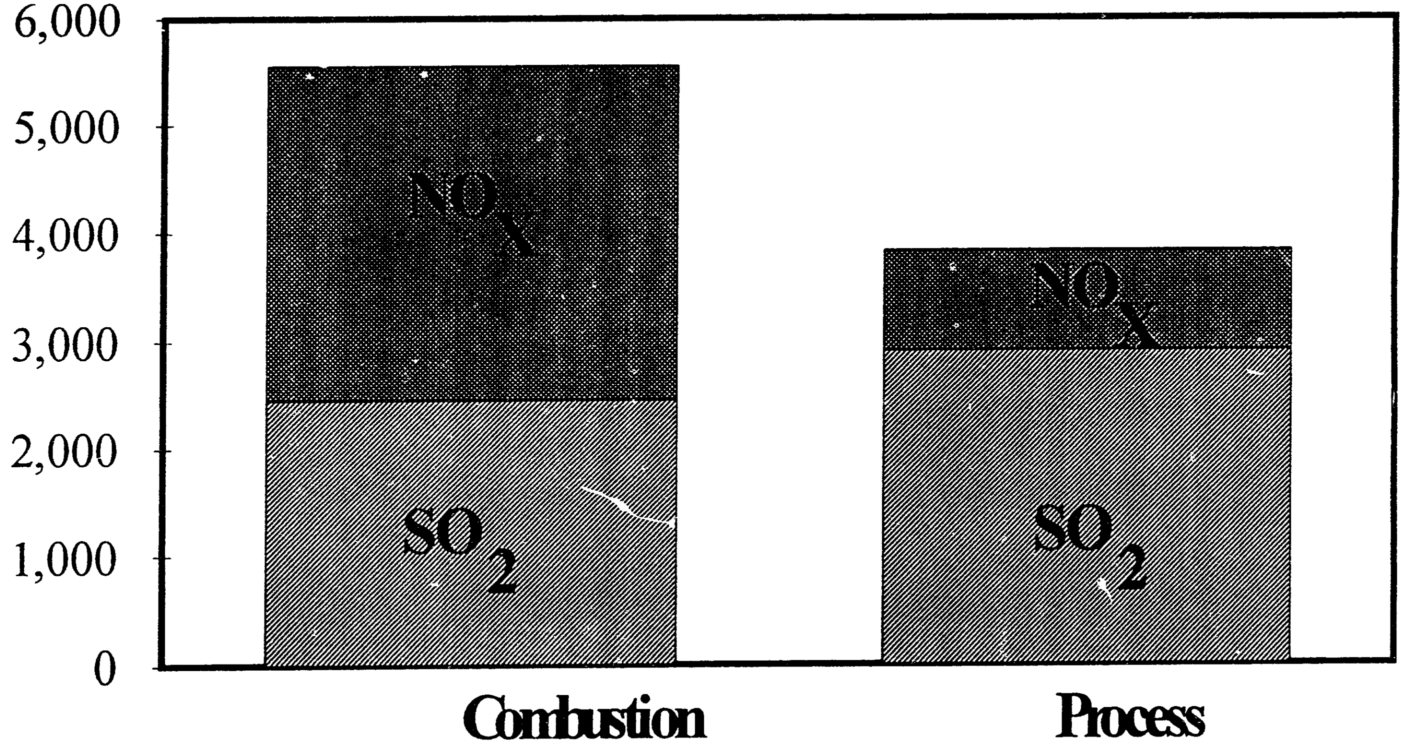
- Combustion Emissions

  Emissions that are by-products of fossil fuel combustion.

- Production Process Emissions

  Emissions that are by-products of a production process.

1985 U.S. Combustion and Production Emissions for SO_2 and NO_x (thousand tons)



Source: Table 12 Industrial Sector Component Design Report

Combustion Emissions Modeling Issues

Forecasting Energy and Emissions Impacts from:

- Trends in Fuel "Cleanliness"
- "Combustion Efficiency" Improvements
- Equipment Operating Efficiency Improvements
- Fuel Switching
- Process Changes
  (e.g. electric arc vs. coal-fired cupola)
- Market Adoption of Control Technologies
  (e.g. scrubbers, incinerators)

INFORM Combustion Emissions Model Framework

$$\text{Emissions}^{t}_{i,u,e,f,p} = \text{Energy}^{t}_{i,u,e,f} \times \text{EF}^{t}_{i,u,e,f,p}$$

Emissions	Energy	EF
lbs	mmBtu	lbs/mmBtu

- i : industry
- f : fuel type
- p : emissions type
- t : forecast year
- u : process use (e.g. steam generation)
- e : equipment option

NEMS Combustion Emissions Model Framework

$$\text{Emissions}^{t}_{i,f,p} = \text{Energy}^{t}_{i,f} \times \text{EF}^{t}_{i,f,p}$$

Emissions	Energy	EF
lbs	mmBtu	lbs/mmBtu

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i : industry

f : fuel type

p : emissions type

t : forecast year

Combustion Emissions Modeling Capabilities

Emissions Impacts from:

	NEMS	INFORM
Trends in Fuel "Cleanliness"	√	√
"Combustion Efficiency" Improvements	√	√
Equipment Operating Efficiency Improvements	?	√
Fuel Switching	?	√
Process Changes	?	√
Market Adoption of Control Technologies	?	√

Combustion Emissions Modeling Capabilities

Energy Impacts from:

	NEMS	INFORM
Trends in Fuel "Cleanliness"	√	√
"Combustion Efficiency" Improvements	√	√
Equipment Operating Efficiency Improvements	?	√
Fuel Switching	?	√
Process Changes	?	√
Market Adoption of Control Technologies	N/A	√

Production Process Emissions Modeling Issues

Forecasting Energy and Emissions Impacts from:

- Trends in "Process Efficiency" Improvements
- Market Adoption of Control Technologies

NEMS Production Process Emissions Model Framework

$$\text{Emissions}^{t}_{i,u,p} = Q^{t}_{i,u} \times EF^{t}_{i,u,p}$$

$$\uparrow \qquad\qquad\qquad \uparrow \qquad\qquad \uparrow$$

lbs | $mil | lbs/$mil

i : industry

u : process type

p : emissions type

t : forecast year

INFORM Production Process Emissions
Model Framework

$$\text{Emissions}^{t}_{i,u,p} = Q^{t}_{i,u} \times EF^{t}_{i,u,p}$$

Emissions	Q	EF
lbs	\$mil	lbs/\$mil

i : industry

u : process type

p : emissions type

t : forecast year

Production Process Emissions Modeling Capabilities

Emissions Impacts from:

	NEMS	INFORM
Trends in "Process Efficiency" Improvements	√	√
Market Adoption of Control Technologies	√	√

Production Process Emissions Modeling Capabilities

Energy Impacts from:

	NEMS	INFORM
Trends in "Process Efficiency" Improvements	√	√
Market Adoption of Control Technologies	N/A	√

Summary

Key Differences Between NEMS and INFORM

- INFORM captures the energy consumption associated with abatement control equipment.

- INFORM provides the forecaster with the flexibility to forecast energy and emissions at the process equipment level of detail.

NEMS and INFORM each provide a framework for addressing the following factors that impact emission levels. First, the reduction in emissions associated with the consumption of "cleaner" fuels are modeled as improvements in emission factors. Second, trends in combustion efficiency improvements stemming from process changes that improve chemical reactions are modeled as improvements in emission factors. Third, equipment operating efficiency improvements lead to less fuel consumption, and hence, lower combustion emission levels. Fourth, process changes, such as the replacement of BOF based melting with electric arc melting, will change the composition of the fuels consumed, and hence, the level of emissions. Finally, the addition of pollution control equipment is modeled as an improvement in emission factors.

What INFORM handles, but the proposed NEMS framework does not, is the energy consumed by pollution control equipment. For example, scrubbers that are used to lower SOx emissions use electricity. Both NEMS and INFORM account for the lower SOx emissions through an improvement in the SOx emissions factor. INFORM accounts for the energy required by the scrubber by adding pollution control to the list of end uses. The NEMS framework, as currently proposed, does not account for the scrubber energy.

The NEMS framework could be extended to handle the energy used by pollution control equipment. Pollution control could be added to the current list of end uses in the NEMS end-use models. In a similar fashion, pollution control could be modeled as an additional process step in the process models. The framework in place for tracking byproduct fuels could be extended to track emissions associated with each process step.

In conclusion, NEMS and INFORM forecast the emission impacts of fuel "cleanliness" trends, process efficiency improvements, and the market adoption of control technologies. Currently, only INFORM accounts for the energy associated with the use of pollution control equipment.

Thank you.

MR. FLYNN: Thank you, Frank.

Our next speaker is Dr. Tom Sparrow. He has long experience in the energy field, energy modeling, and energy analysis, which goes back to his days with the Atomic Energy Commission. He's now a Professor of Industrial Engineering at Purdue. He's also a leading expert in the field of electrotechnologies.

Dr. Sparrow?

DR. SPARROW: Thank you, Crawford.

My review of EIA's Industrial Energy Demand Model focuses on the problem of meeting user requirements. We need to keep in mind that energy models must meet two user requirements -- first, that the model produce a valid, reliable forecast of the variables of interest, and second, that the model structure allow energy policy makers to easily determine the impact of scenario changes upon the forecast in a transparent way.

Unfortunately, the two requirements call for substantially different model structures. If one is mainly interested in a reliable forecast which can easily be internally and externally validated, then an aggregate econometric model is called for. If, on the other hand, the goal is a forecast tool which can be used to predict the impact of, say, increases in the end-use efficiency of specific energy using equipment, then a highly disaggregated energy end-use forecasting model is more appropriate.

This conflict in model structure has been resolved in two generic ways -- a single hybrid model with elements of both econometric and end-use model structure, and the "two-model" approach, where separate econometric and end-use models are run in tandem with sufficient cross-linkages to ensure consistency. EIA has chosen the hybrid route for their industrial modeling effort; I would propose they use the alternate approach. Such a system would use an aggregate econometric model with little or no end-use detail which is given the major responsibility for the forecast values, and a highly disaggregated end-use model whose control totals are determined by the econometric model capable of displaying the impact of a wide range of energy policy options on forecast energy demand.

It should be emphasized that we are not proposing a "master-slave" relationship between the two models, with the econometric model responsible for all the predicting, and the end-use model simply disaggregating the econometric forecast. The strengths of the two approaches are best maintained by interacting two "stand-alone" models, reconciling the control totals on the basis of known strengths and weaknesses of the two modeling systems.

The reason I believe the "two-model" approach is superior is that the Indiana State Utility Forecasting Group, which I direct, has been using this approach in the residential and commercial sectors for some years now with great success. To date, we have not used the approach in the industrial sector for a very simple reason -- no industrial end-use forecasting model now exists for national, state, or utility service territory prediction.

There is also a very simple reason for the situation -- industrial end-use model construction and validation will be a very expensive and time-consuming operation, despite the existence of a group of databases (ISTUM-2, IMIS, Dunn & Bradstreet) and a pioneering effort by EPRI to create such a model (INFORM, and before that, INDEPTH).

The key to industrial end-use modeling is to recognize that the mix of industrial end uses exhibits more and more variability as one moves from two-digit SIC analysis to three- and finally four-digit analysis. To say the same thing in a different way, two-digit end-use data sets conceal more than they reveal about industrial end use. To do it right, one must start at the four-digit SIC level, and develop models of four-digit disaggregate energy use at an end-use level of detail similar to that in ISTUM-2 shown in Table 1.

Obviously, some organization with an interest in improving the state-of-the-art in forecasting the impact of changes in energy regulations or advances in energy technologies is going to have to come forward with substantial resources. These resources will first be

NATIONAL ENERGY MODELING SYSTEMS CONFERENCE

F.T. Sparrow, Reviewer

Purdue University

February 1, 1993

Arlington, Virginia

- Conflict between forecast and policy usefulness resolved in two ways:

  - Single hybrid model

  - Two separate models

- EIA has chosen hybrid route. I would urge consideration of the separate model route.

- Use an aggregate econometric model with little or no end-use detail to forecast demand.

- Use an end-use model calibrated to the econometric forecast to disaggregate demand, allowing policy "what if" questions to be answered.

- Econometric model would be of the form

$$\begin{array}{l}\text{Purch Fuel "i"}\\ \text{in industry "j"}\end{array} = \overset{(1)}{\left(\frac{\text{Purch (i,j)}}{\text{Total use (i,j)}}\right)} \overset{(2)}{\left(\frac{\text{Total use (i,j)}}{\text{Total energy use (j)}}\right)}$$

$$\overset{(3)}{\left(\frac{\text{Total energy use (j)}}{\text{Value added (j)}}\right)} \overset{(4)}{\left(\frac{\text{Value added (j)}}{\text{GNP}}\right)} \overset{(5)}{\text{GNP}}$$

where

(1) Governed by co/self-generation economics, feedstock and waste steam value.

(2) Governed by economics of interfuel competition.

(3) Governed by conservation, DSM economics, CSCs.

(4) Governed by sector competition, imports, outsourcing.

(5) Governed by S, I, productivity.

ECONOMETRIC MODEL ISSUES

- Feedstocks?

- Value added or value of shipments?

- Manufacturing or industrial use?

- End-use model would be at ISTUM-2/IMIS level of disaggregation (≈ 60 end uses).

- Issues:
  - End-Use Demand Estimation
  - Technology Competition
  - Capital Stock Vintaging
  - Feedback Effects
  - Data Base Creation

ENERGY SERVICE CATEGORIES IN ISTUM-2

No.	Name
1	Boiler generated steam
2	Cogenerated steam
3	Machine drive
4	Space H, V, and AC
5	Electricity generation
6	Refrigeration
7	Transportation
8	Lighting
9	Direct steam
10	Heating, dirty
11	Heating, direct clean
12	Drying, dirty
13	Drying, direct clean
14	Lime calcining
15	Concentration
16	Paint drying
17	Textile drying
18	Food drying
19	Metal melting
20	Forging
21	Heat treating, generic
22	Feedstocks
23	Aluminum melting
24	Aluminum heating
25	Aluminum electrolysis
26	Brick firing
27	Cement making

No.	Name
28	Glass melting
29	Pulping
30	Bleaching
31	Paper making
32	Chemical recovery
33	Pulp drying
34	Lime calcining, paper
35	Concentration, paper
36	Distillation
37	Cracking
38	Alkylation
39	Hydrogen production
40	Hydrotreating
41	Reforming
42	Other petroleum products
43	Agglomeration
44	Iron making
45	Coking
46	Steel making
47	Primary finishing
48	Secondary, finishing
49	Heat treating
50	Organic chemicals
51	Inorganic chemicals
52	Plastics and resins
53	Chemical fertilizers
54	Chemical feedstocks

ADVANTAGES

- Allows models to specialize in what each does best:

	Forecast	Policy
Econometric	Good	Poor
End Use	Poor	Good

- Parallels a common approach taken in residential/ commercial sectors.

Electricity Demand

	Econometric	End Use
Residential	In house	REEMS
Commercial	In house	CEDMS

DISADVANTAGES

- Someone must fund construction and/or refurbishing of an industrial end-use model.

- Conceptual Problems: impact of "what ifs" on econometric model? Price effect ≈ direct effect in many situations (DSM).

CONCLUSION

- Cannot say which approach is best -- hybrid or multiple model -- since "one approach becomes better than another (only) within the context of what the modeling is to be used for" (page 1 of Report).

needed to liberate the now largely proprietary industrial end-use data sets that exist around the country, this despite the fact that the government paid for a good deal of their initial creation. Next, these databases, in combination with knowledge about what fuels compete for end-use energy services would be used to construct four-digit end-use models. These models would capture the ways energy processes compete with other factors of production for the value added in a typical plant, and the way the different fuels compete to meet the given energy service demands of a given process in the typical plant.

The magnitude of such an undertaking should not be underestimated; this is an undertaking that will cost millions, not thousands, of dollars. On the other hand, if we could recapture all of the money spent on funding researchers to squeeze out conclusions using econometric techniques from the aggregate databases that are now accessible, the total would easily surpass the amount required to do this right.

The time has come to bite the bullet, and find the front-end cash to construct a comprehensive, disaggregate, industrial end-use model. I look to EIA to provide the leadership in this endeavor and to "pass the hat" to the groups inside and outside (EPRI, GRI, etc.) the government who have a need for the results of such a modeling system.

Thank you.

MR. FLYNN: Thank you. We appreciate your looking out for our interests.

Our next speaker will be Richard Howarth, from the Lawrence Berkeley Laboratory. Richard has published widely in the area of energy utilization changes, compositional effects, structural changes, and he's here to tell us about his recent research.

MR. HOWARTH: I'll start out by noting that I'm not an energy modeler. I am involved in a number of different fields. Energy economics is one of them. I do some theoretical work in environmental economics, and my work in theory -- well, in theory one can construct models, and the models are nice and self-contained, and you can get some positive results. In empirical modeling, one is stuck with the fact that there's an enormous degree of slop in the world. One can fit a model to the data, but there are all kinds of different alternative specifications, which, unfortunately, seem to describe the data equally well. This is to say that there's a trap in modeling, that if one is not very careful to look hard at what the reality is, to understand what the underlying processes are, one can use statistical techniques to project one's beliefs onto the world, so to speak.

I'm not suggesting that that's the case here with the NEMS model, on the contrary. But, I would say that as a student of industrial energy demand, perhaps, more than with other end-use sectors, we are in a certain degree of difficulty. Frankly, we lack basic data concerning how much energy is used in particular end-use processes and what not. We know the breakdown of energy use by main SIC group. We don't know the disposition by physical process with any degree of accuracy, and there are holes in the time series on just the raw data from the next series, for example.

I remember when I was working on a Master's thesis on the subject in 1987, my most recent data point was 1981, because there was a lag in the industrial energy series related to a political decision that this wasn't something that we really needed to focus on.

So, the modeling is inhibited by the fact that we have a paucity of data. It is a very rich sophisticated system, but the data basically are not rich enough to allow us to really construct a model which is rigorously estimated from the data and still remain consistent with all of that.

Now, of course, we can look at process models, we can look at econometric models. My feelings about the econometric work are, I suppose, clear. One can construct different models which give different results, and all of which fit the data.

The econometric models are often rooted tightly in economic theory. You specify a cost function, or you specify a production function, and you minimize costs, you maximize profits, and so forth.

Now, recent developments in theory tell us that the firms are more complicated than that. At one time an economist viewed firms as monolithic entities which were clearly trying to maximize profits, and the assumption was that firms could go ahead and do that. Today there's a view of the firm which takes the firm as an institution, a set of agents, people who are involved -- it's an organization.

The fact that firms are organizations means that firms can't be viewed as monoliths. Firms certainly have an incentive to maximize profits, but how successful they are in doing that depends upon the relationships between the people who are the firm. That introduces a level of analysis where the firm's behavior may not be cost optimal.

So, I guess that when I look at the NEMS model, at least the description of the NEMS model in the document that I've seen, what I see is a smorgasbord approach of sorts. I see the authors looking towards neoclassical demand analysis. I see them looking towards engineering analysis. I think that's very appropriate.

I think that to construct a model which is useful and that speaks to the realities, one has to use the full range of information that's available.

On the other hand, there's a certain trap here, and that is that this is going to be a very complicated, sophisticated model, and because there's a paucity of data and an inability to pin down the parameters of the model exactly based upon statistical techniques, that means that a lot of expert judgment goes into the specification of the model. I worry about what happens when we construct a black box where the results of the model are driven by all of the many assumptions that go into it, and where users aren't in a position to decide for themselves what their views are.

I'm going to shift gears now, and I'm going to talk a little about what my group's work on industrial energy demand is about. I said that we're not modelers, and that's true. We are, basically, involved in the descriptive analysis of energy use trends. I work in an

Manufacturing Energy Trends*

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Presentation to the
National Energy Modeling System Conference
Arlington, Virginia

February 1, 1993

* For a discussion of the data and methods on which this presentation is based, see R.B. Howarth and L.J. Schipper, "Manufacturing Energy Use in Eight OECD Countries: Trends through 1988," Energy Journal 12. 15-40 (1991); and R.B. Howarth, "Energy Use in U.S. Manufacturing: The Impacts of the Energy Shocks on Sectoral Output, Industry Structure, and Energy Intensity," Journal of Energy and Development 14: 175-191 (1991).

Energy Studies Group that looks at energy demand trends, not only in the United States, but also in Europe, Japan, the former Eastern Bloc. So, in the industrial sector, we work at a fairly high level of aggregation.

What I'm going to do is to try and describe what some of the stylized facts of energy use in U.S. manufacturing are. Now, the time series that I have here is manufacturing energy use from 1958 out to 1988. This is based, primarily, on the national energy accounts, and, let's see, a couple of points should be borne in mind.

My Y axis is exajoules, and an exajoule is roughly the same thing as a quad. It's a somewhat smaller unit, and when I count manufacturing, what I have here is delivered or final energy use. I've cast petroleum refining out of the manufacturing sector because, along with the people who are constructing the NEMS model, I think it's more useful to think of petroleum as part of the energy sector than as part of the industrial sector. That's a question of taste.

Now, of course, there are a number of things that jump out when one looks at the graph. One is the strong growth in energy in the '50s and '60s. Another is the peak around 1973, and then the vacillation in more recent years. One sees the growth of gas over the whole period of the analysis, a shift away from coal and electrification occurring in the '50s and '60s, and, of course, the crash in oil demand in more recent years.

Now, of course, at an aggregate level energy use is driven by two things. There is production and then there is energy use per unit of production. This slide shows the total level of manufacturing activity, measured in terms of value added, real value added.

I'm not cheating here exactly, but I should point out that there are two different ways of counting value added. One way is to take the information from the National Income and Products Accounts. The other is to use the Federal Reserve Board Production Indices to construct a real value-added sequence. This is based on the FRB valued-added concept.

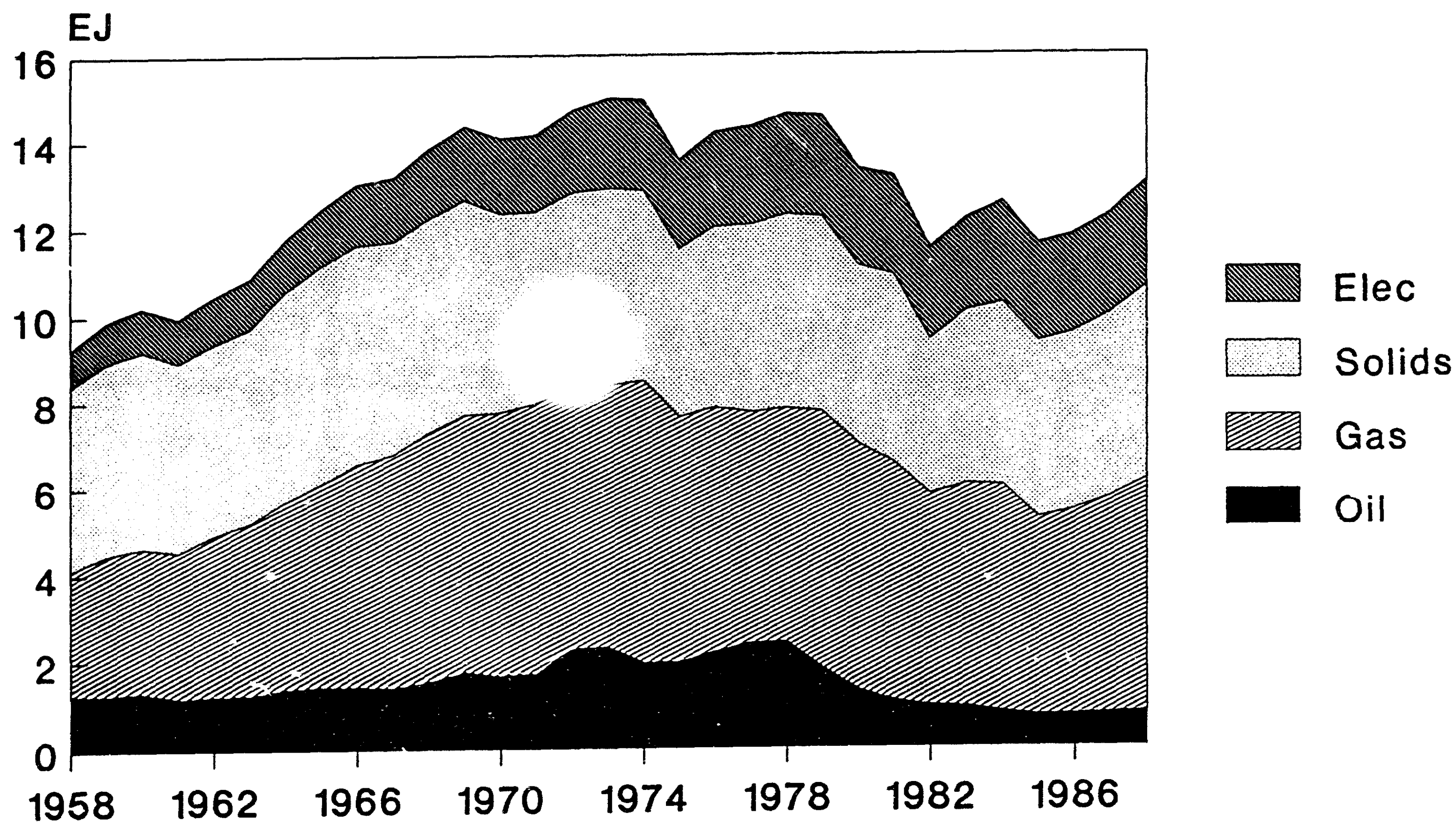
What we see here is sustained growth in manufacturing value added. There's a perception among many people that manufacturing hasn't kept up with the economy as a whole, and that the U.S. is de-industrializing.

In fact, if you look at the trends, the share of manufacturing and total GNP has remained fairly constant over time. Manufacturing has grown roughly as rapidly as GNP.

What has happened is that there have been massive improvements in labor productivity, and a huge shift of workers from the manufacturing sector into the service sector.

Now, there's one other thing to keep in mind in looking at this graph. Energy use is dominated by these five energy-intensive industries at the bottom of the chart: non-ferrous metals, iron and steel, building materials, chemicals, and the paper and pulp sector. In terms of their economic importance, these are only about 20 percent of value added.

U.S. Manufacturing
Energy Use by Fuel



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They are 20 percent of value added, but about 70 percent of energy use. Now, here again, we have the breakdown of energy use by SIC group. We have a mental model, a common perception that there's been a fundamental shift away from raw materials production towards light industry. I'll come back to that in a moment and look at what the recent trends have been, but if we look at this graph we see that the share of energy use in the heavy materials industries as a whole is staying about constant over time.

What's happened is that the steel industry has gone down a lot. Let's see, what else have we got. The steel industry has gone down, but chemicals have gone up. It looks as though paper went up in the mid-'80s, at least if you are looking at the energy trends.

This graph shows the relation between output growth in each of the sectors and total manufacturing value added. This shows the share of value added in each of these major industry groups, and what we see here is the rise of chemicals. We see the steady decline of the iron and steel sector, and we see some decline in non-ferrous metals, paper and pulp stays fairly constant.

Now, here we are struck with a bit of a problem. A number of my colleagues who are interested in energy, and materials, and what lies in store in the future, focus a lot on things that are easy to measure, tons of steel, tons of aluminum, tons of paper products.

The problem is that, we have undergone a transformation in the kinds of materials we use. We now use composite materials. We use a lot of plastics. We use chemicals of various sorts, and there are literally dozens, hundreds, maybe even thousands, of these different materials. It's difficult to construct an indicator of the physical production of the chemical sector in the same way that one can add up tons of steel and divide by GDP.

This graph shows an index number. The index number is based upon a hypothetical calculation. I say,"What would happen if the level of total production in manufacturing remained fixed at its 1973 level, and the energy intensities in each industry had remained fixed, but the composition of each industry, those product shares, had changed the way that they actually did over time?"

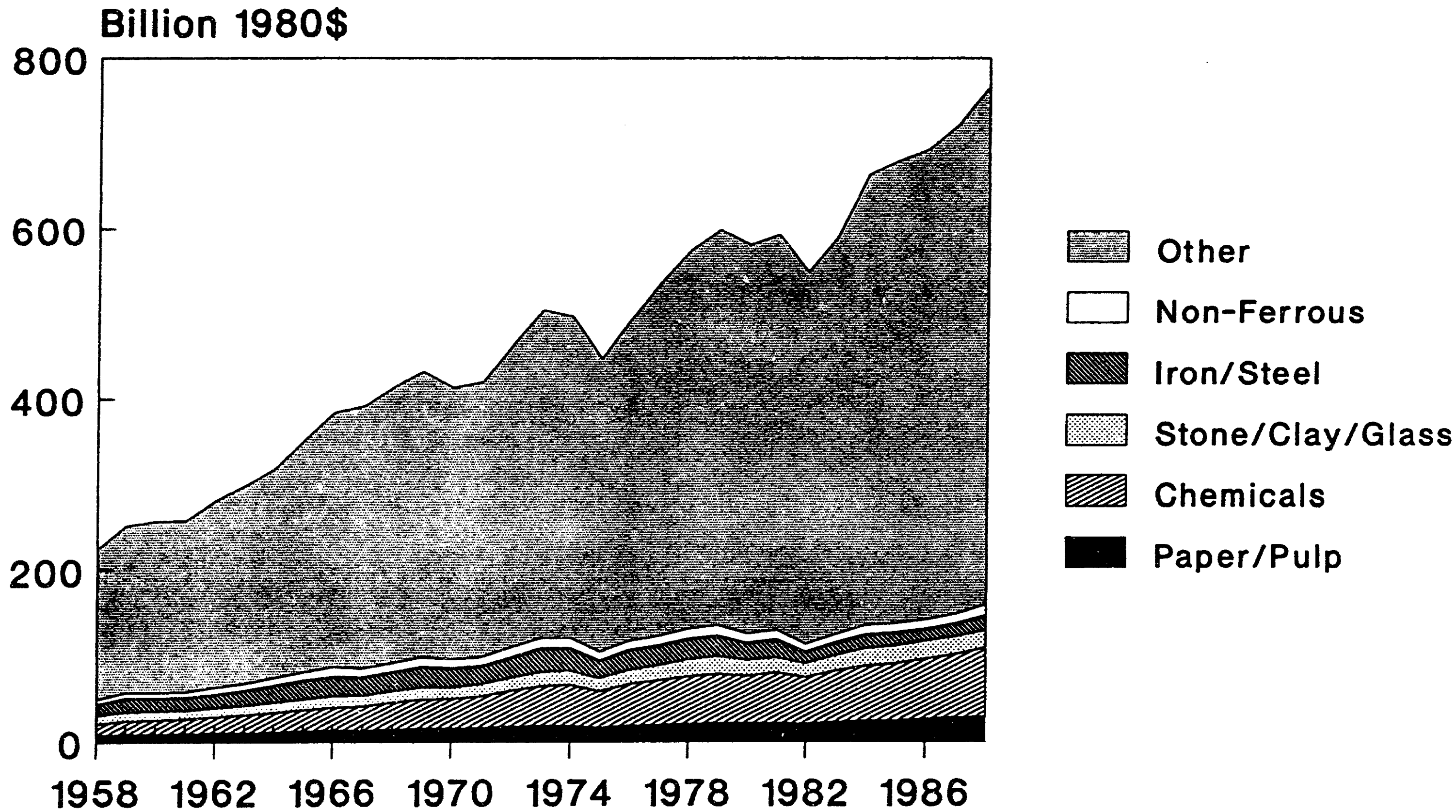
So, this index captures the movement away from energy-intensive industries that occurred after the energy shocks.

We see some movement in the '50s and '60s. What we really see, though, is a sharp decline starting around 1974, and pretty much petering out around 1982.

There were some papers that were published in the mid-'80s, which dealt with the post energy shock period, that were focusing rather a lot on the steep part of the curve. Here I think was one of the sources of the conventional wisdom that the economy is becoming less materials intensive.

If we look at what happened in the '80s, we see then that structural change had relatively minor impacts upon energy use in the manufacturing sector, while manufacturing output was growing along with GDP.

U.S. Manufacturing
Value Added by Industry



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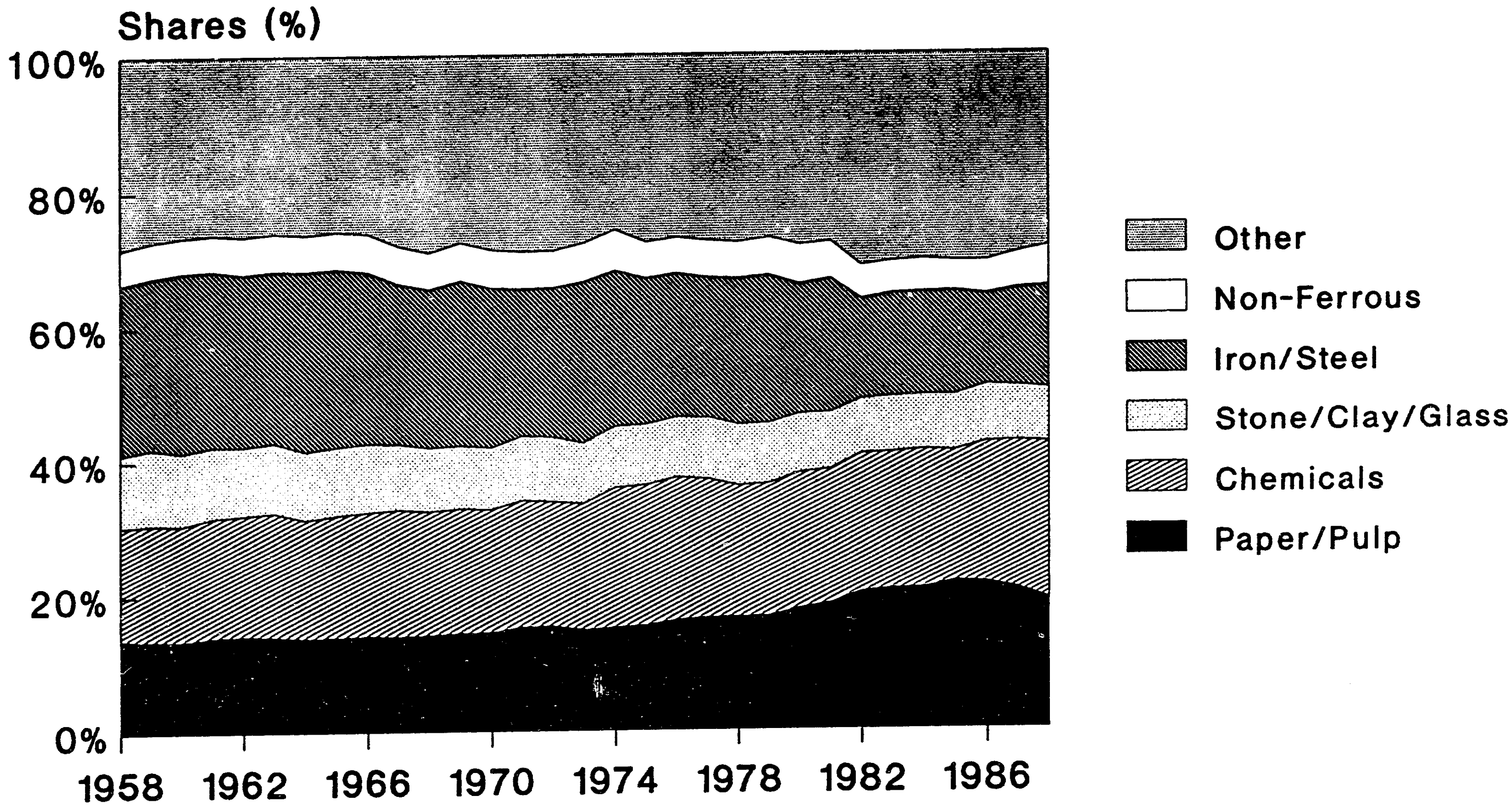
U.S. Manufacturing
Energy Use by Industry



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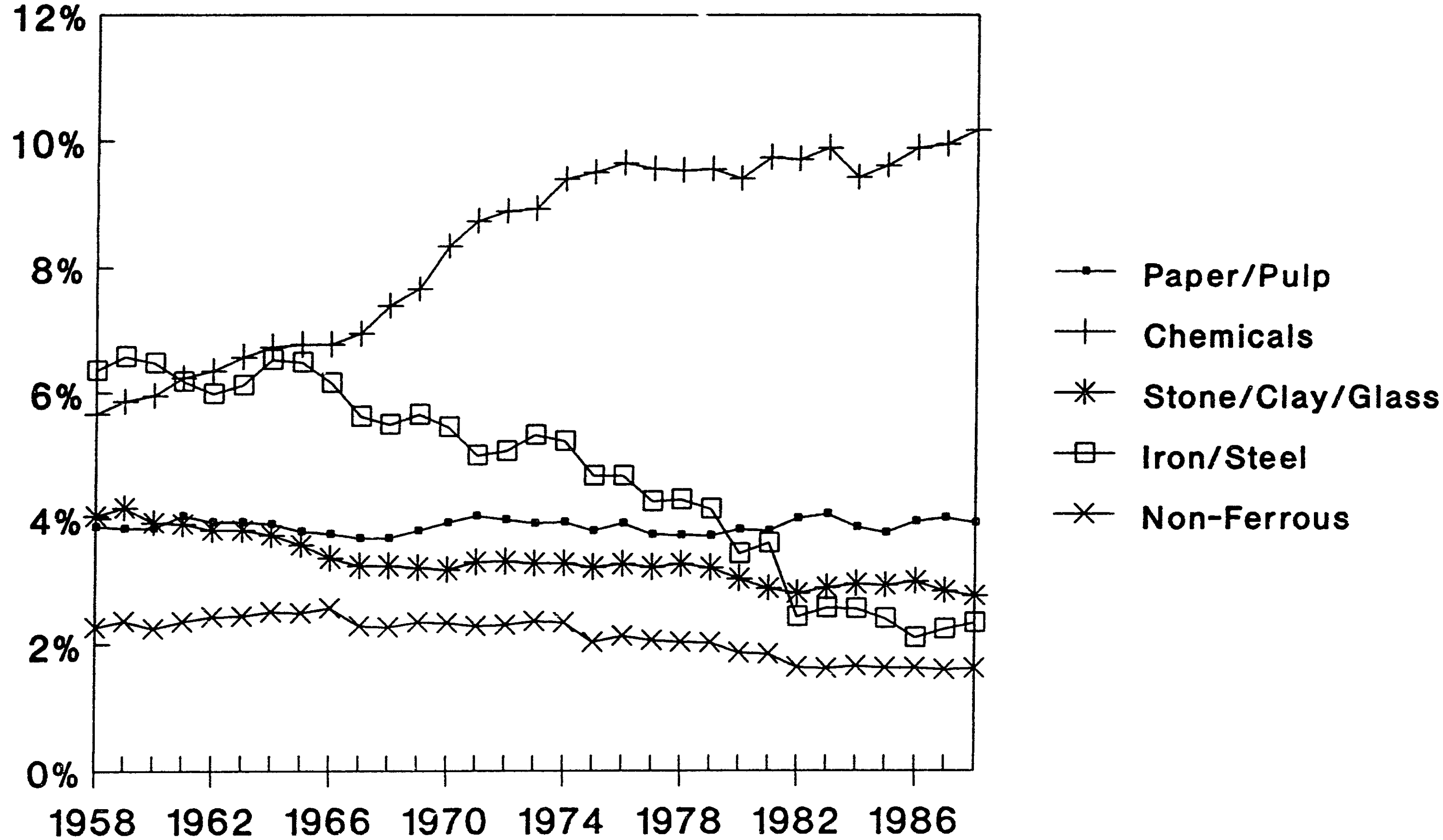
U.S. Manufacturing
Value-Added Shares by Industry



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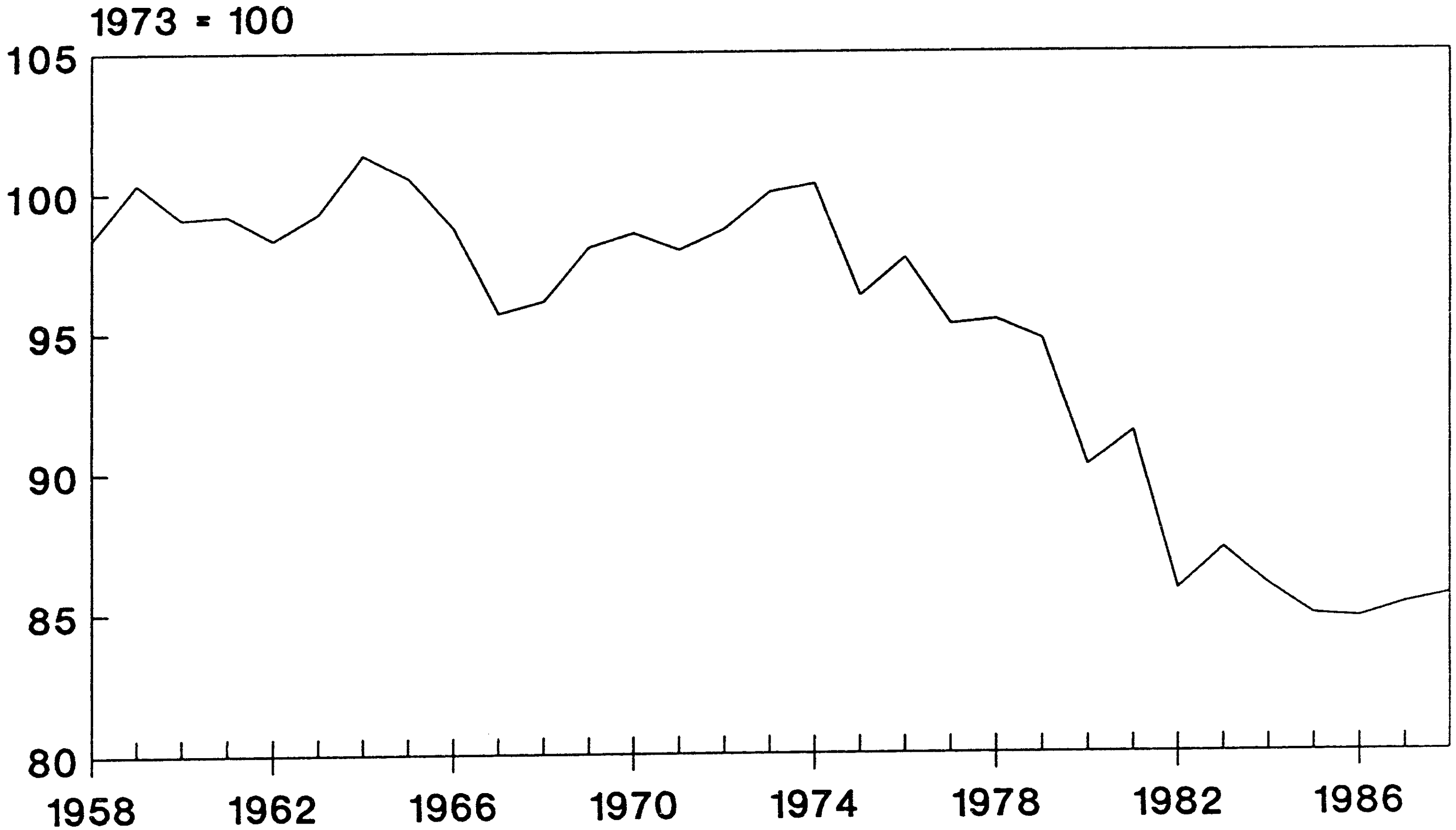
U.S. Manufacturing Energy Use
1973 Output and Energy Intensities
Actual Industry Structure



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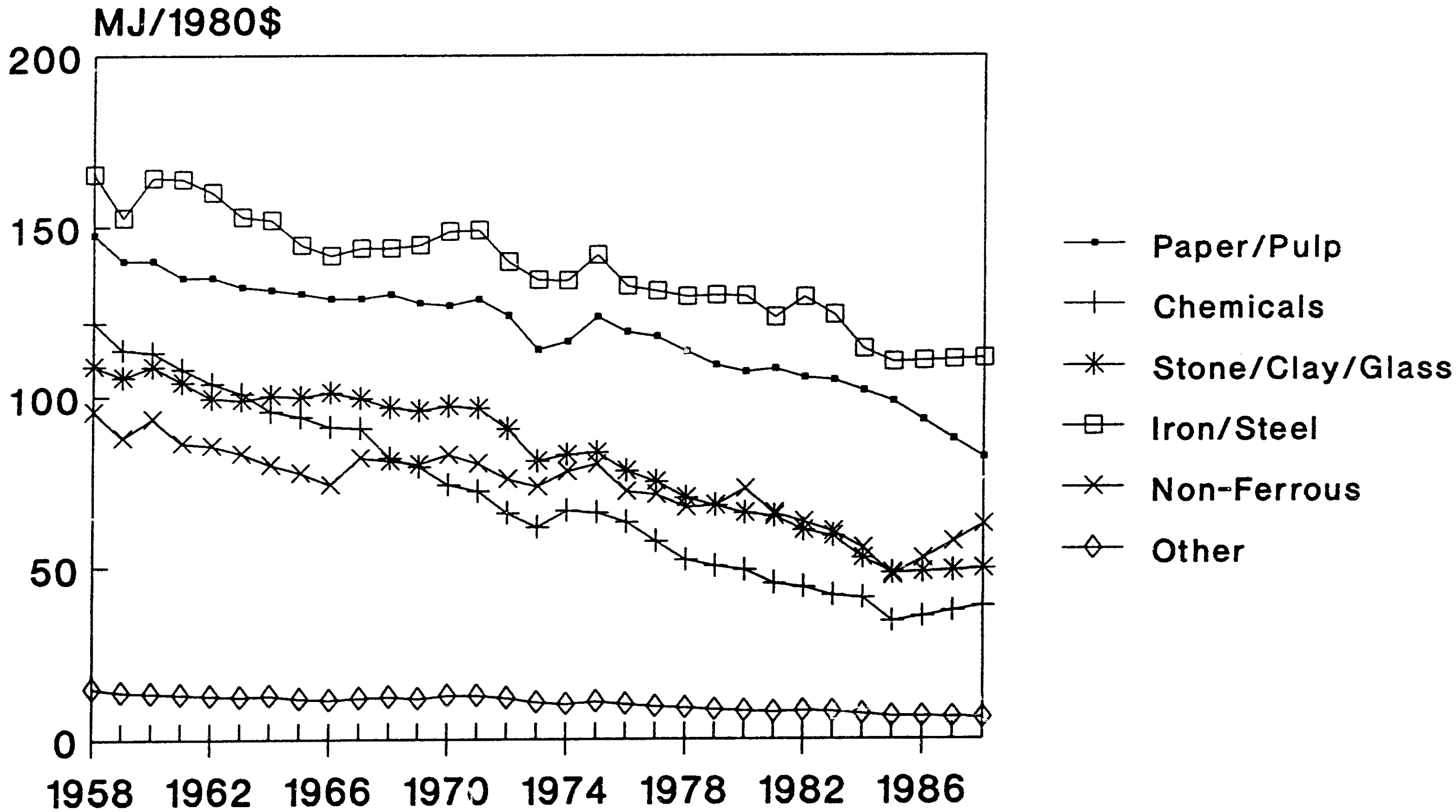
U.S. Manufacturing
Energy Intensity by Industry



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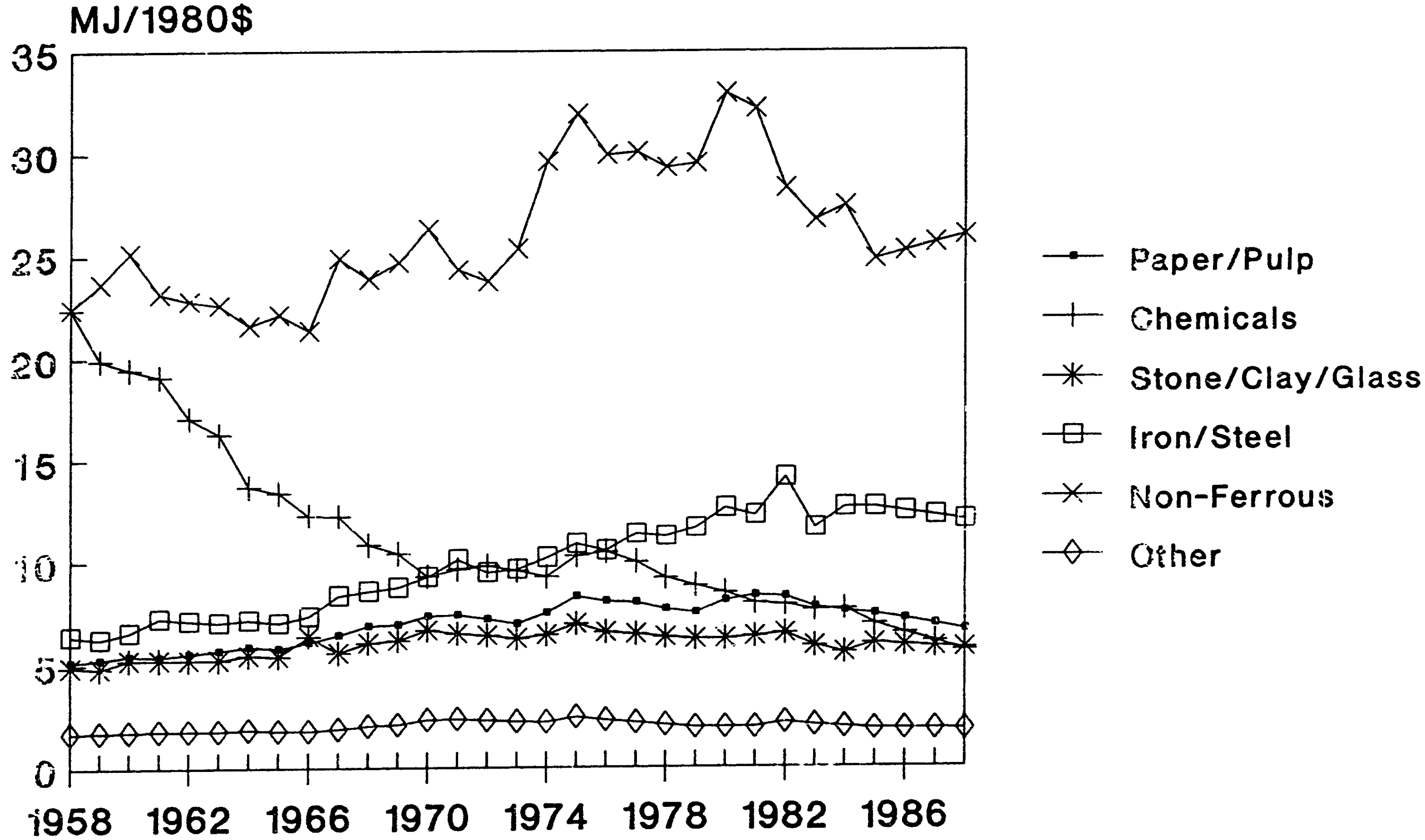
U.S. Manufacturing
Electricity Intensity by Industry



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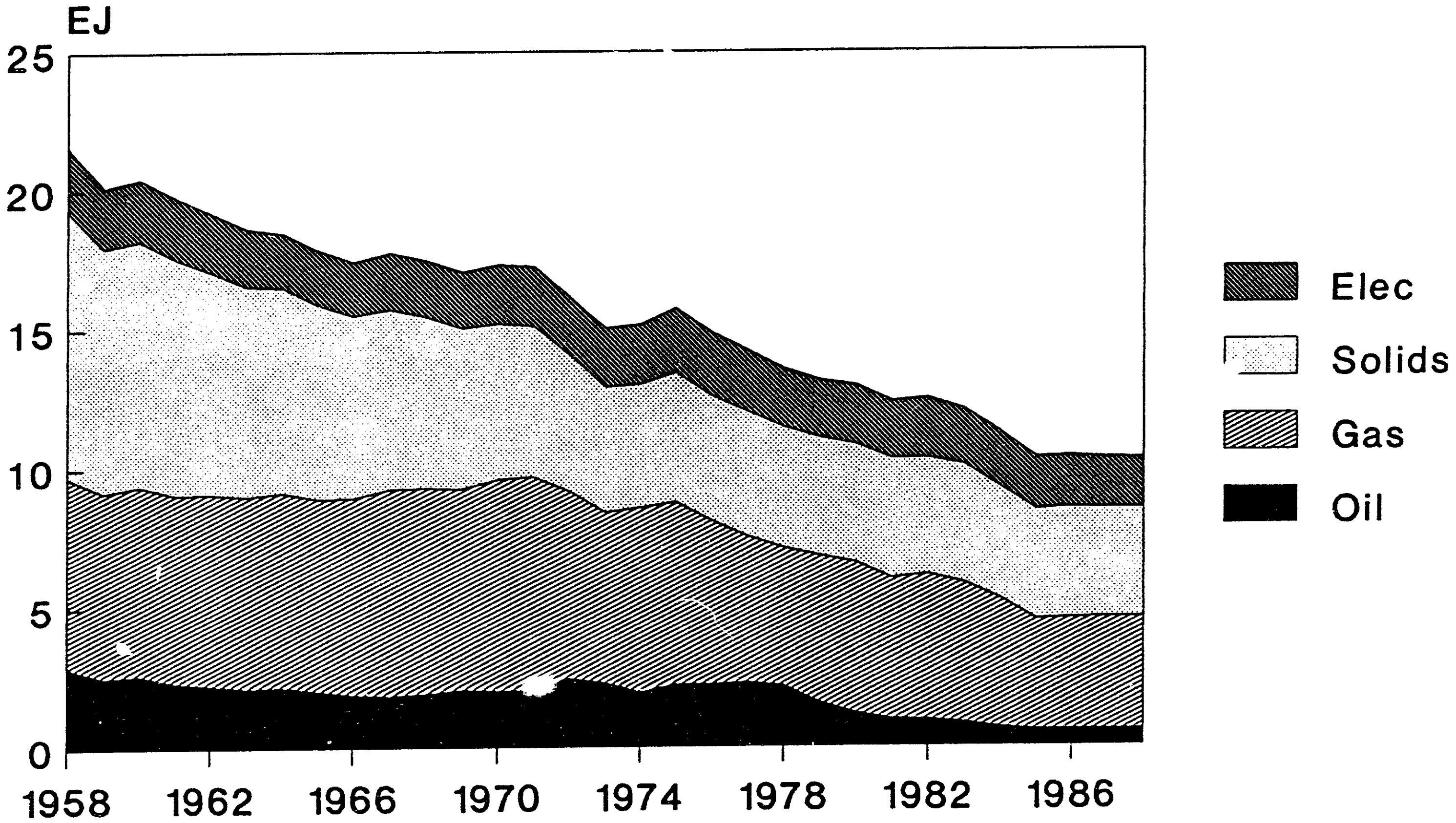
U.S. Manufacturing
Energy Use w/ 1973 Output and Structure
Actual Energy Intensities



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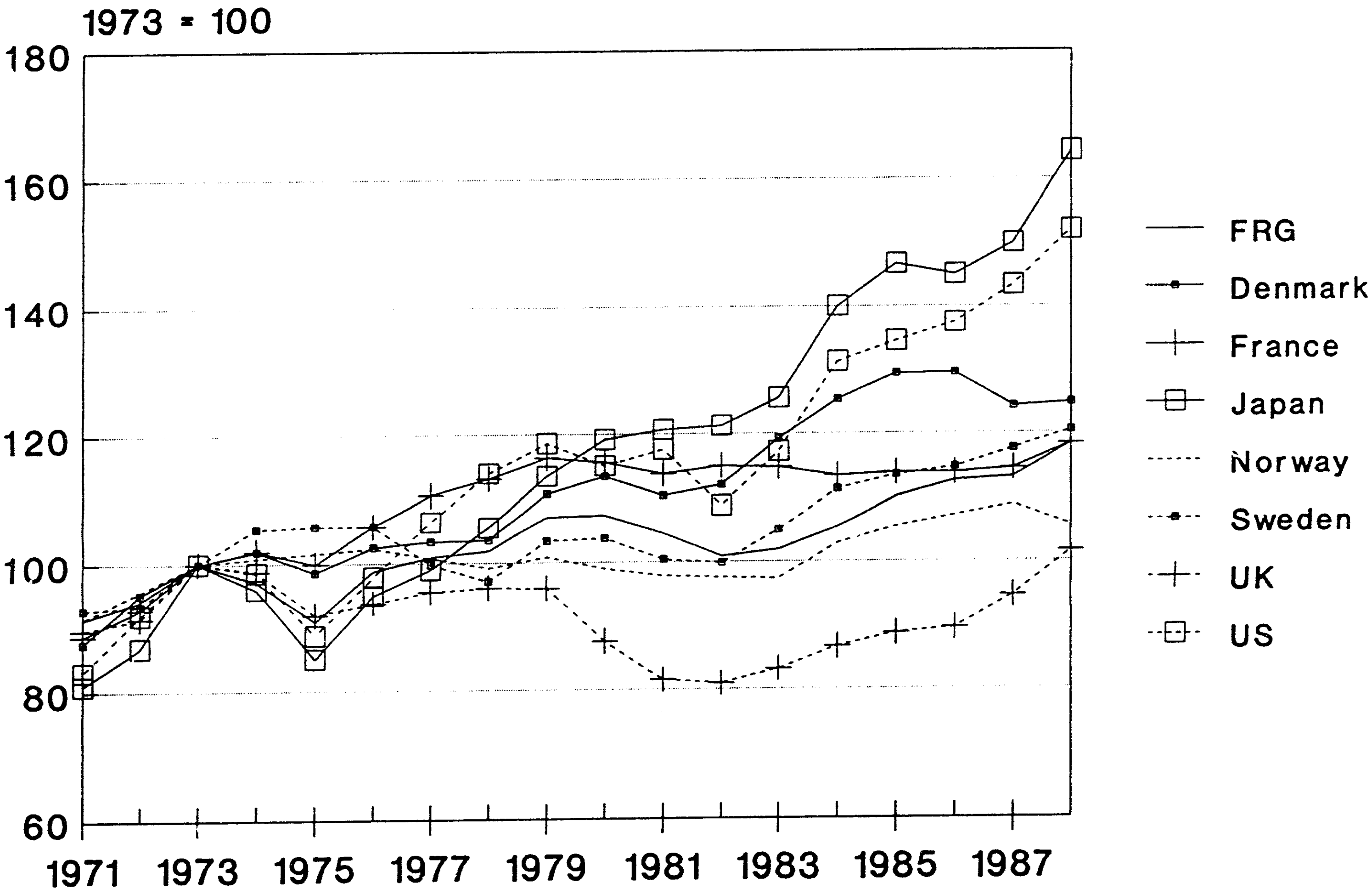
Manufacturing Value Added



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Now, these calculations are at a high level of aggregation. I'm sure that there are things that are left out of the calculations, but the calculations suggest to me that we ought to be looking really carefully at this issue of structural change. What are the fundamental processes, and where are the trends headed?

I guess I should point out that it's not clear to me how structural change shall be dealt with in the NEMS model. The documentation has the production in the major industries, I believe, as being exogenous to the model. Certainly, if one's focus is on energy demand per unit of activity, that's a reasonable thing to focus on, but on the other hand, given that the industrial energy demand is so dominated by the production and the basic materials, one would really like to see somewhere in the modeling system a module that deals with the role of basic materials in the economy.

I think a rule of thumb, which strikes one who is looking at energy use trends in different sectors of the economy, is that energy is often the tail that is wagging the dog. We are energy analysts, and so, we like to think that energy is important and that it's at the top of people's minds.

But, in fact, often to understand energy trends one has to understand just about everything else. It makes our jobs interesting, but complicated.

This slide shows energy intensities measured for each industry group. These are in terms of delivered energy, where, you know, the trends look the same in terms of primary energy. You can take your pick, or even if we use a price-weighted index of energy use, the shape of the curves is the same.

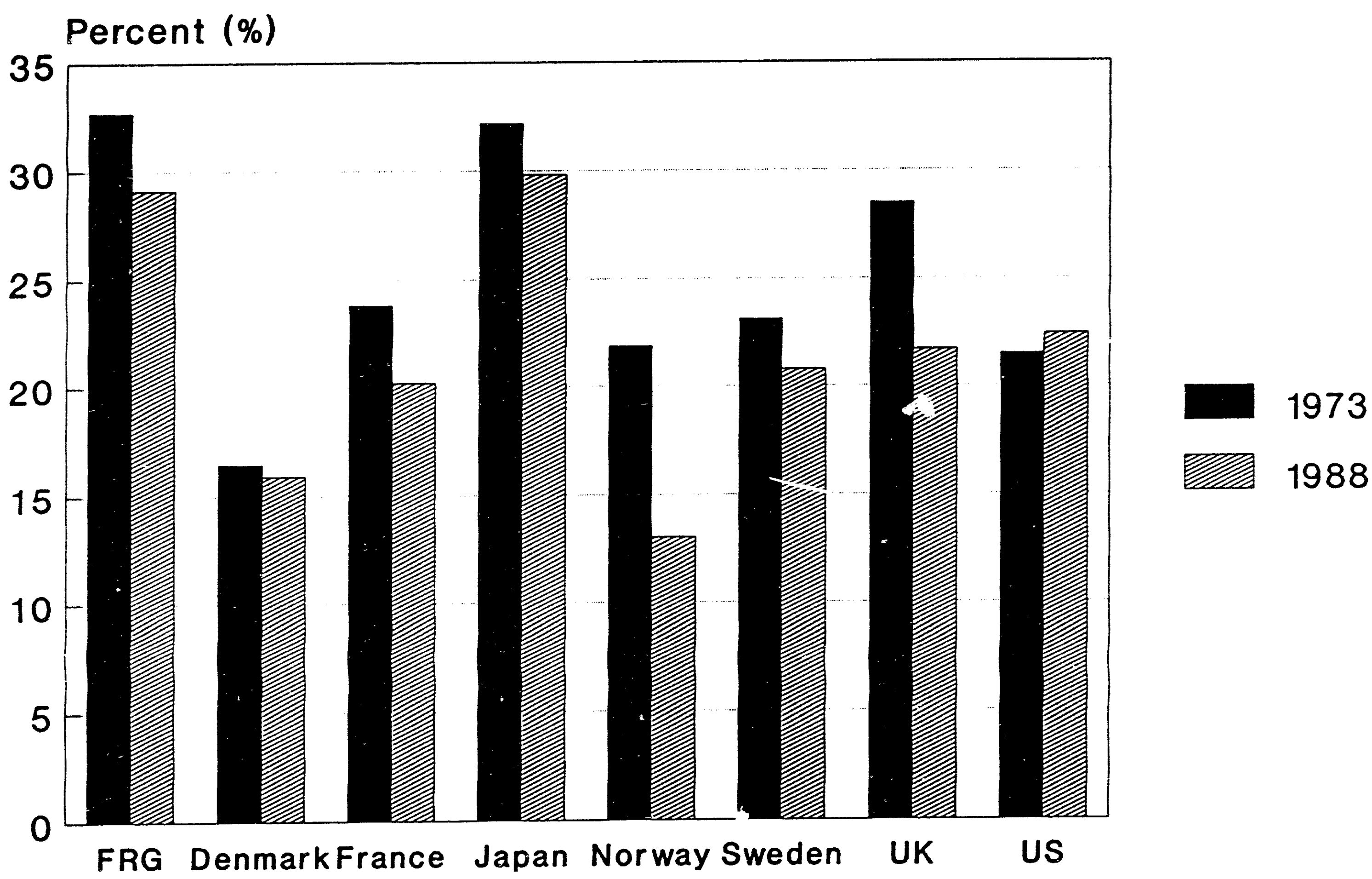
The shapes of all of these curves are downward lines, and the X axis stretches from 1958 to 1988. I should point out that I don't actually have data points in '86 and '87. Those are interpolations. What I have is the 1985 MECS and the 1988 MECS, and I'm not sure entirely that the 1985 and the 1988 MECS are entirely consistent. My understanding is that the coverage in the 1988 MECS was expanded so that the numbers are a little larger than they were in the '85 MECS. At least that was true when these numbers were put together, I believe.

The reason I say that is because, if you look at the chart, we see linear trends in energy intensities for the most part until 1985, and then stabilization. I think the stabilization might be an artifact of the construction of numbers, I'm not quite sure.

What we see here, though, is stable energy intensity trends, a stable decline in energy intensities in the key industries during periods of high energy prices, low energy prices, rising energy prices, and falling energy prices.

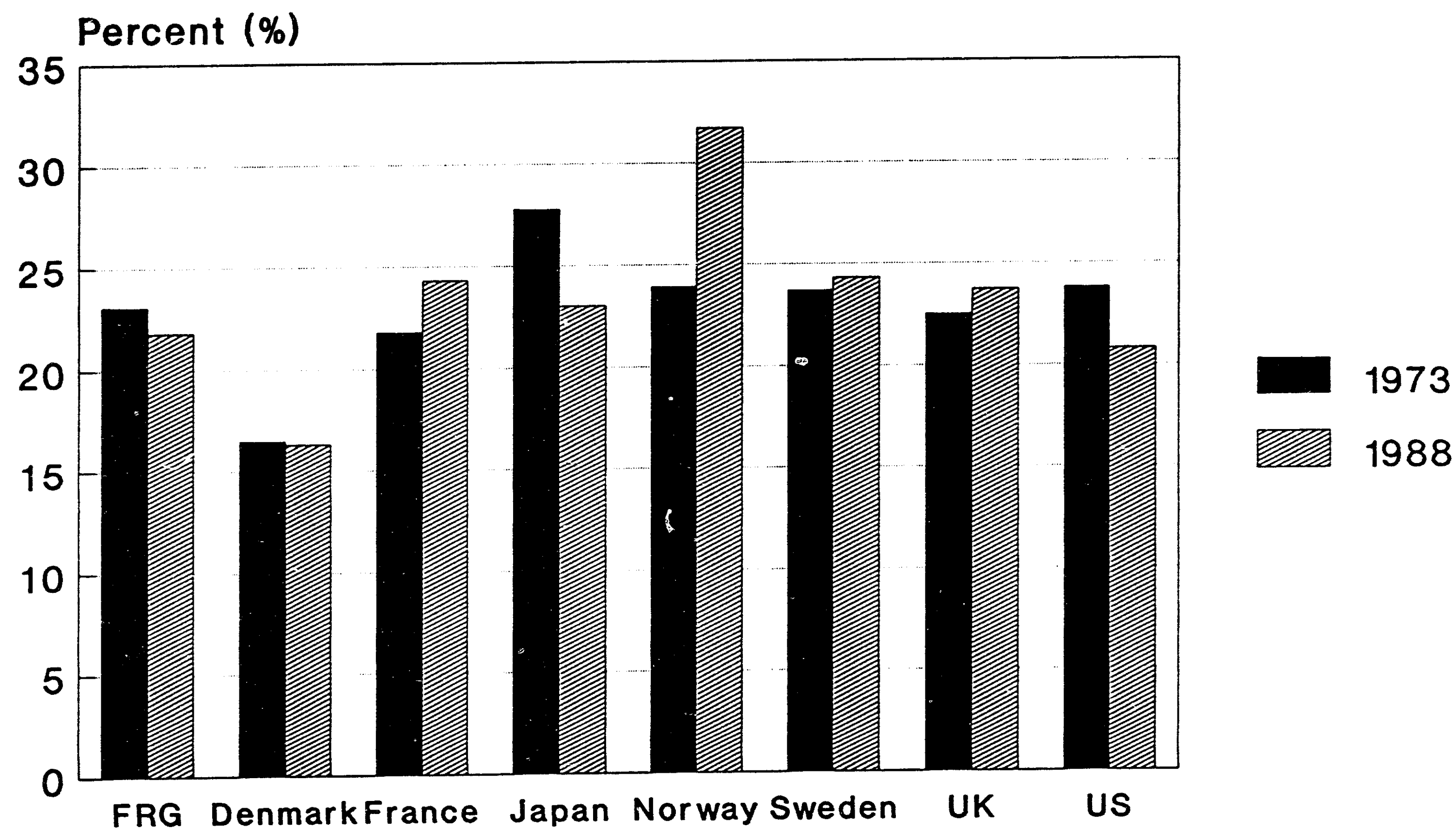
Now, of course, energy prices play a role in shaping these trends, but it's clear when you look at the trends that there are also fundamental long-term processes going on. When we build a new plant, the technology in the new plant is just out and out better than the technology of the old plant. It turns out that one of the ways that it's better is that it has

Manufacturing Share of GDP



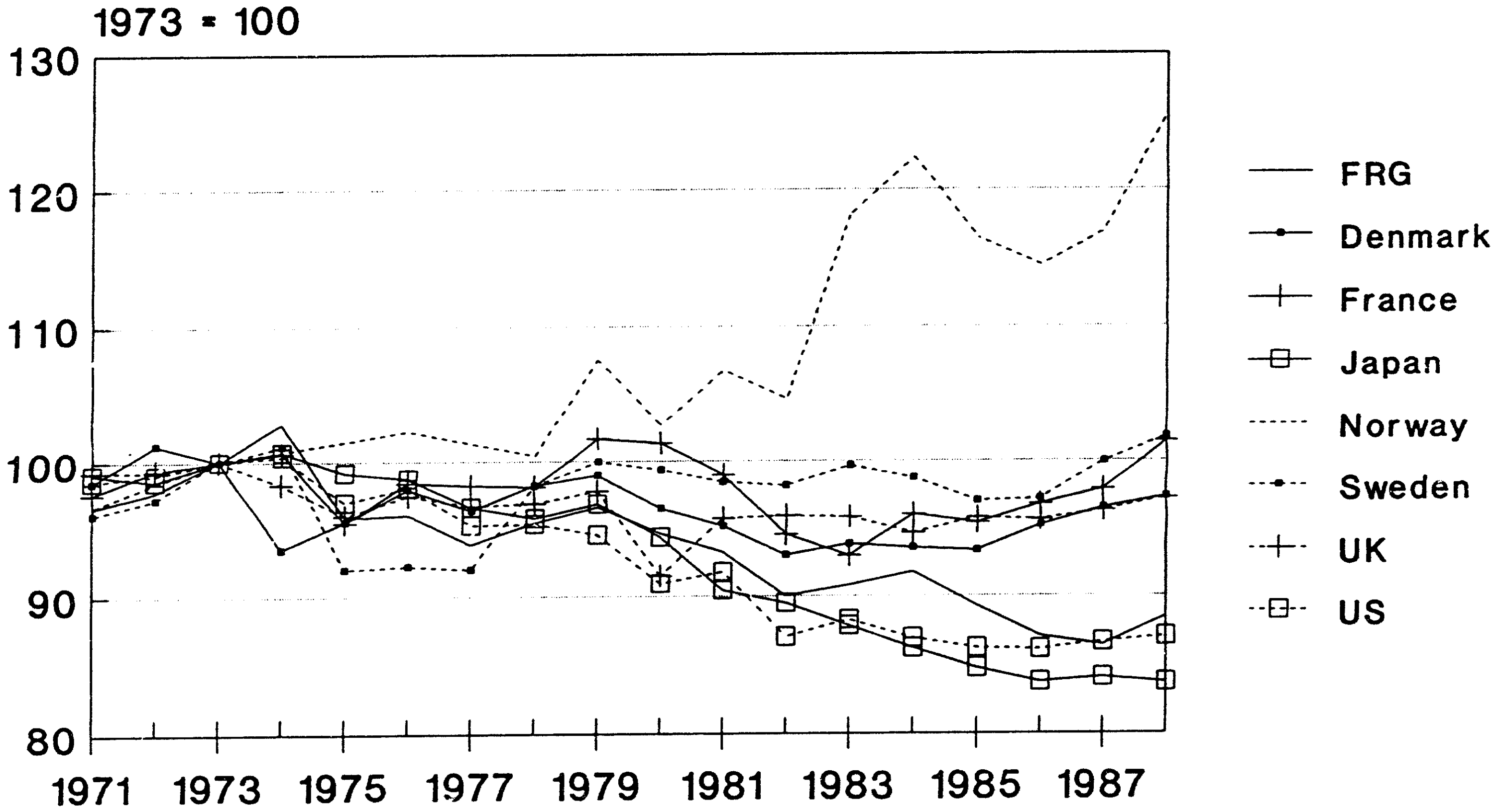
mfr%

Raw Materials Share of Manufacturing Value Added



"Raw Materials" = Paper/pulp; Chemicals; Stone/Clay/Glass; Iron/Steel; Nonferrous metals (raw%)

Manufacturing Energy Use
1973 Output and Energy Intensities
Actual Industry Structure



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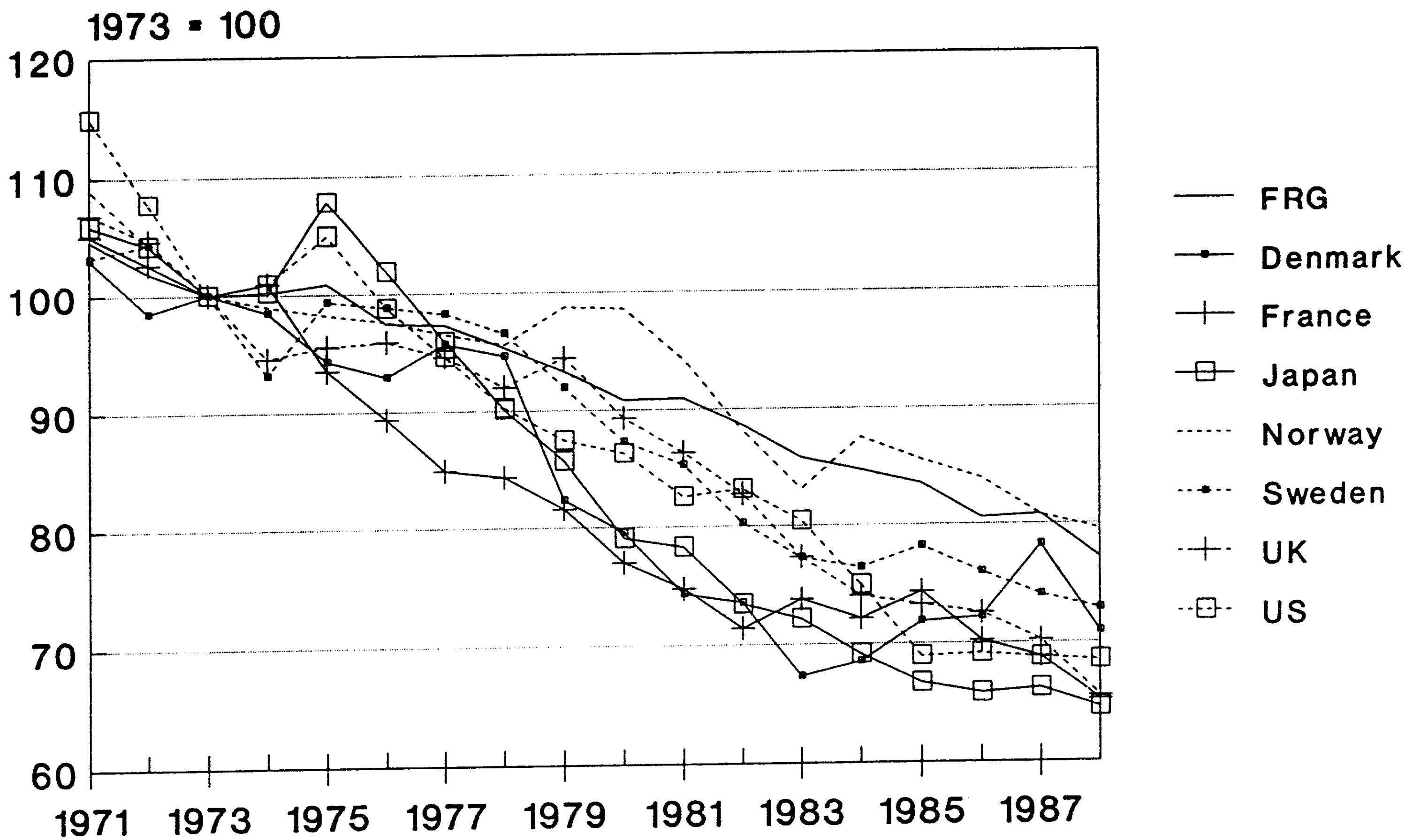
Manufacturing Energy Intensity Adjusted for Structural Change



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lower energy intensities.

What this means is that, typically, one sees dramatic energy savings over time occurring simply because of autonomous technological change, even in the absence of price changes.

This is electricity intensity. This graph is a little more difficult to interpret, I suppose. One sees electrification going on, and this doesn't measure electricity and efficiency, because this accounts both for increased penetration of electric-intensive technologies and then, of course, the changes in the efficiency of those technologies.

One sees electrification in non-ferrous metals. In all probability, that means the shift towards primary aluminum production. One sees clear evidence of electrification in iron and steel, that's the shift to electric arc furnaces, and a dramatic reduction in electricity intensity in chemicals. On the whole these trends actually rather wash out. There's not an aggregate, not a strong trend one way or the other in energy intensity in U.S. manufacturing.

This graph is another hypothetical graph. I say, "What happens if the level of output is fixed at 1973 levels in each industry, but the energy intensities follow their historical paths?" So, this is an index number, too, in a way. It's a way of synthesizing what the impacts of changing energy intensities are and energy is.

Again, we see the flat line. At one point, I did a statistical analysis testing to see if one could find a difference in float between the pre- and post-'73 eras. The answer was that there really isn't a significant trend break. That's true for delivered energy, it's true for primary energy, and it's true for a price-weighted energy intensity index.

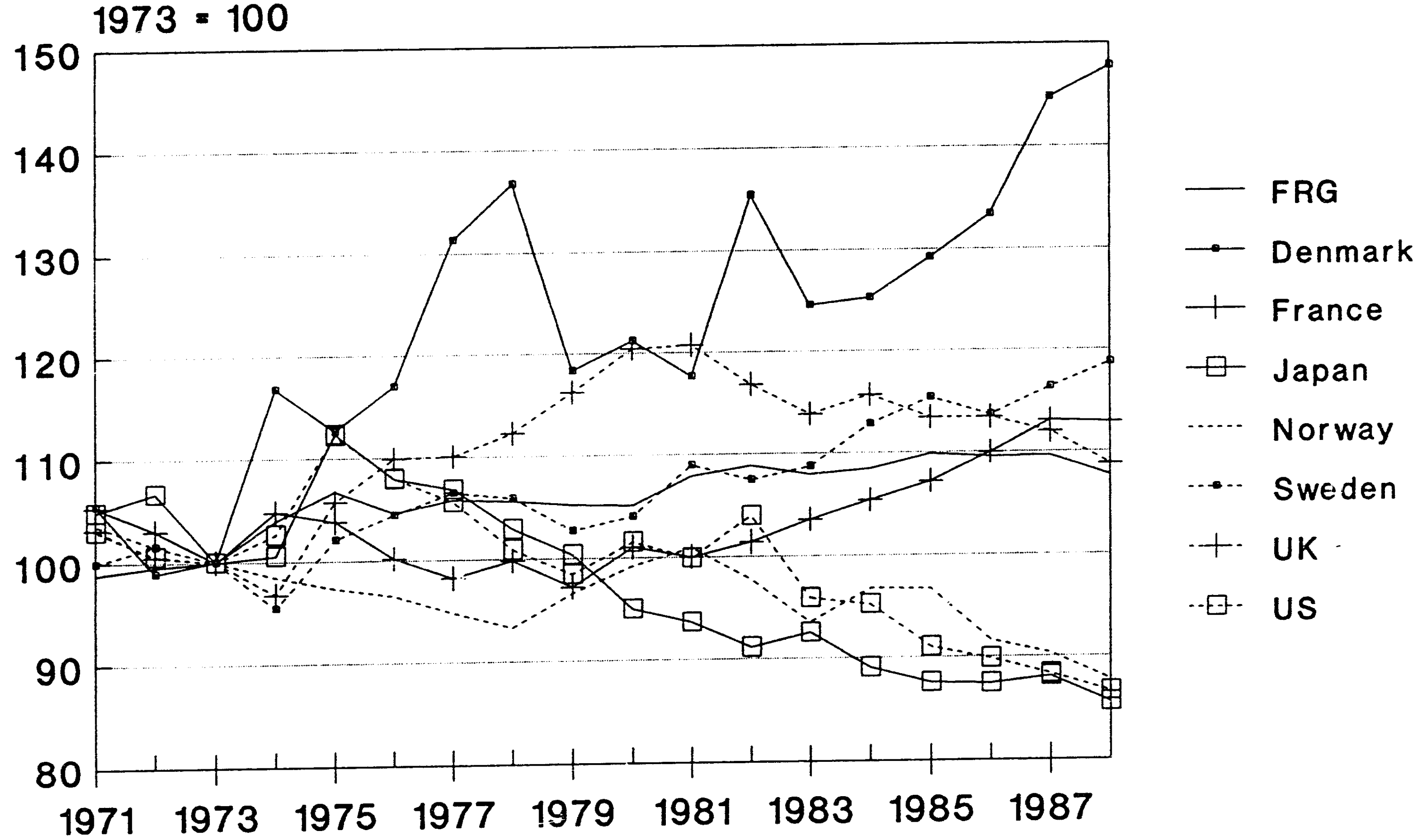
Here we see a dramatic improvement, or a dramatic reduction in solids intensity in the '50s and '60s. We see the shift away from oil happening later on, and we see, if we blew up the top part of the picture, electricity intensity not changing a lot when it's measured in this way.

As I mentioned, a big part of our work, my group's work, is on international trends. I will spare you the details of our international work except for this one picture. What we have here is an index of energy intensity adjusted for structural change in four countries: the U.S., Germany, Japan and Norway. Then we have the dotted line on top, which is the producer price index for energy in the U.S.

What we see here is that these linear energy intensity trends seem to hold up in all four countries. The slope of the line is about the same. In a way, that's surprising, because the economic conditions in these countries are radically different.

Norway, starting in the '50s, had a policy of making low price electricity available to energy-intensive industries. Some aluminum smelters and what not are paying about half a cent per kilowatt hour for aluminum, and the prices haven't changed very much in Norway. The prices are low in Norway, and, yet, even in a relatively low priced nation

Manufacturing Electricity Intensity Adjusted for Structural Change



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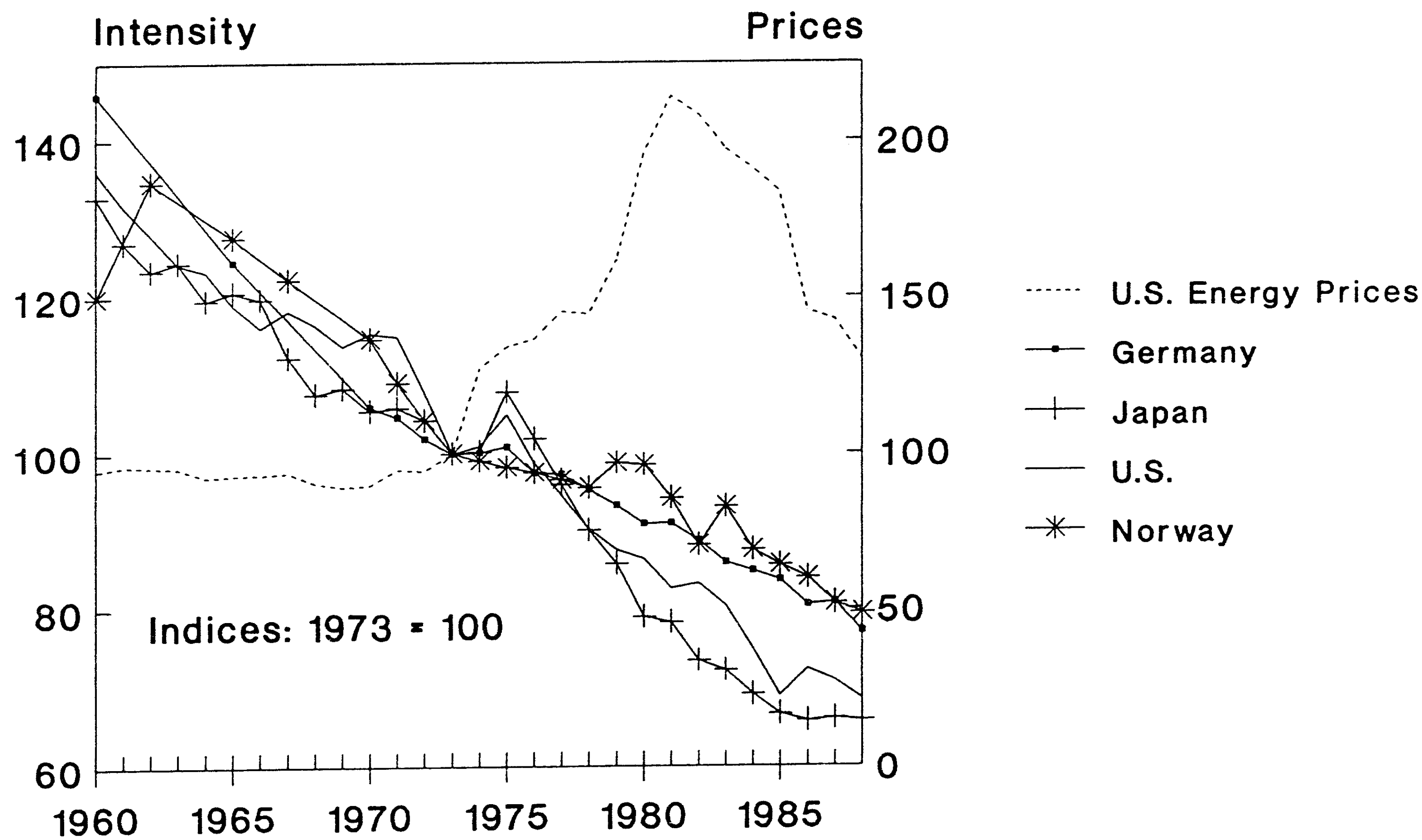
Manufacturing Energy Intensity
Constant 1973 Industry Structure



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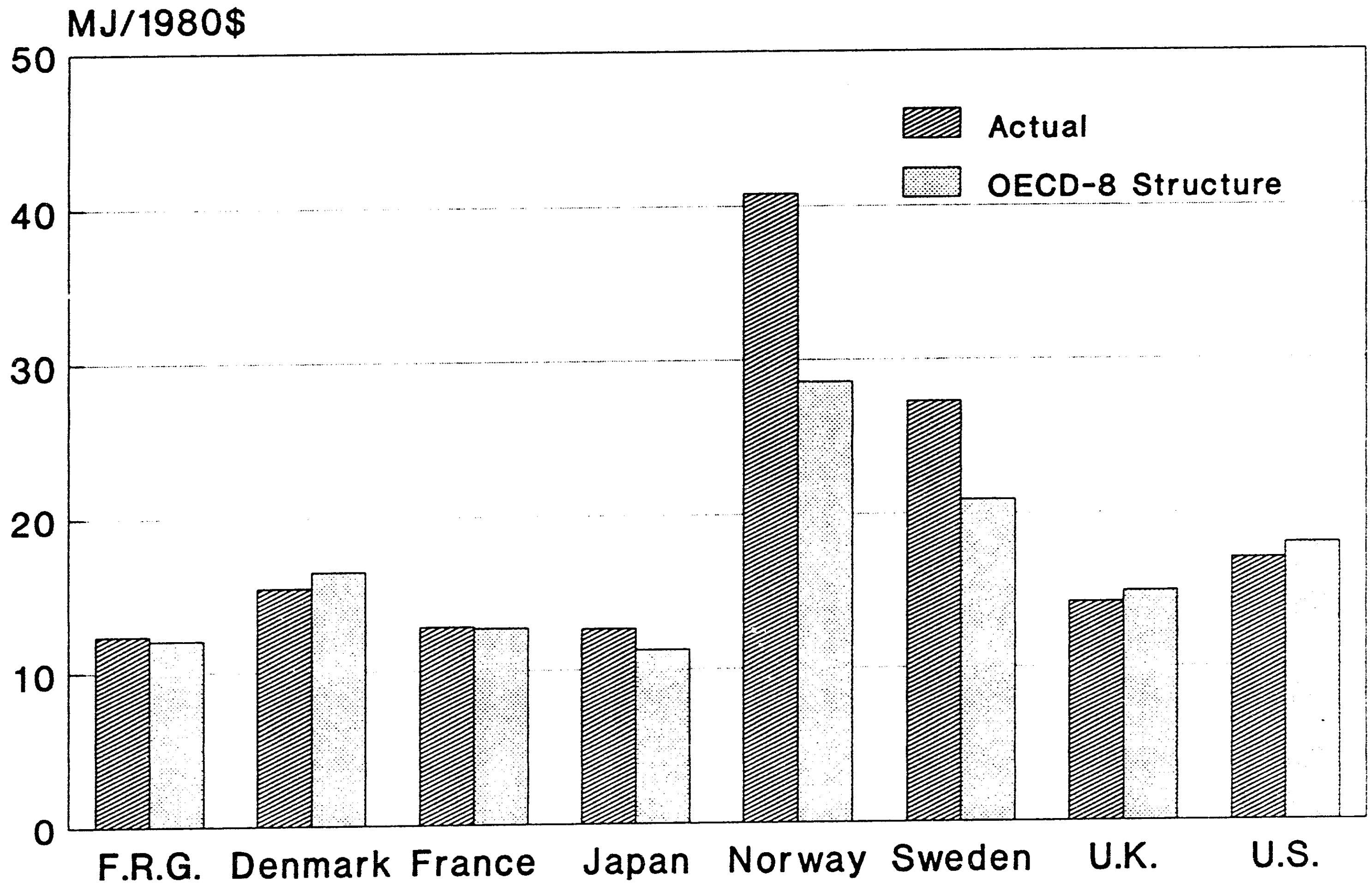
1988 Manufacturing Energy Intensity



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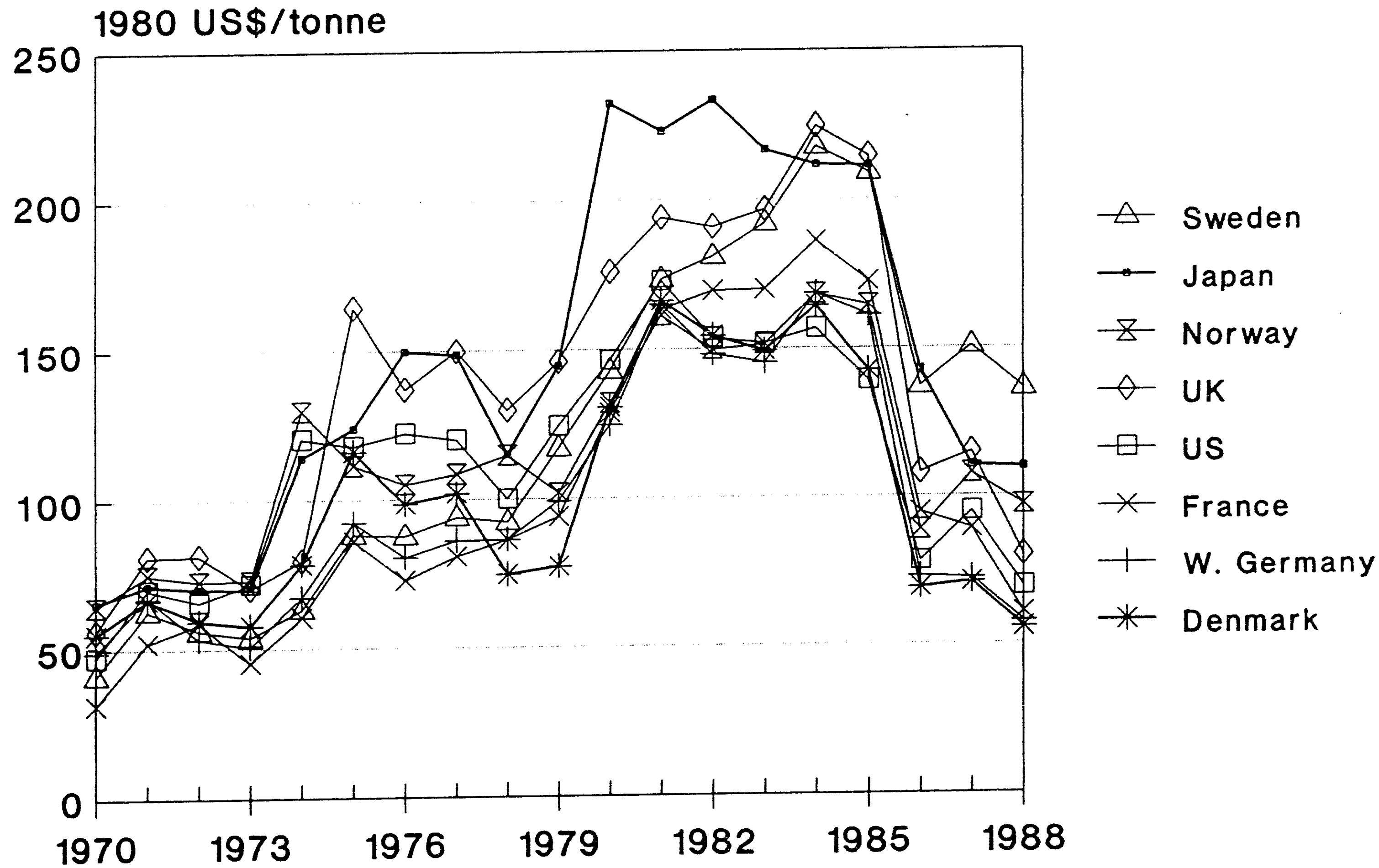
Industrial Heavy Fuel Oil Prices



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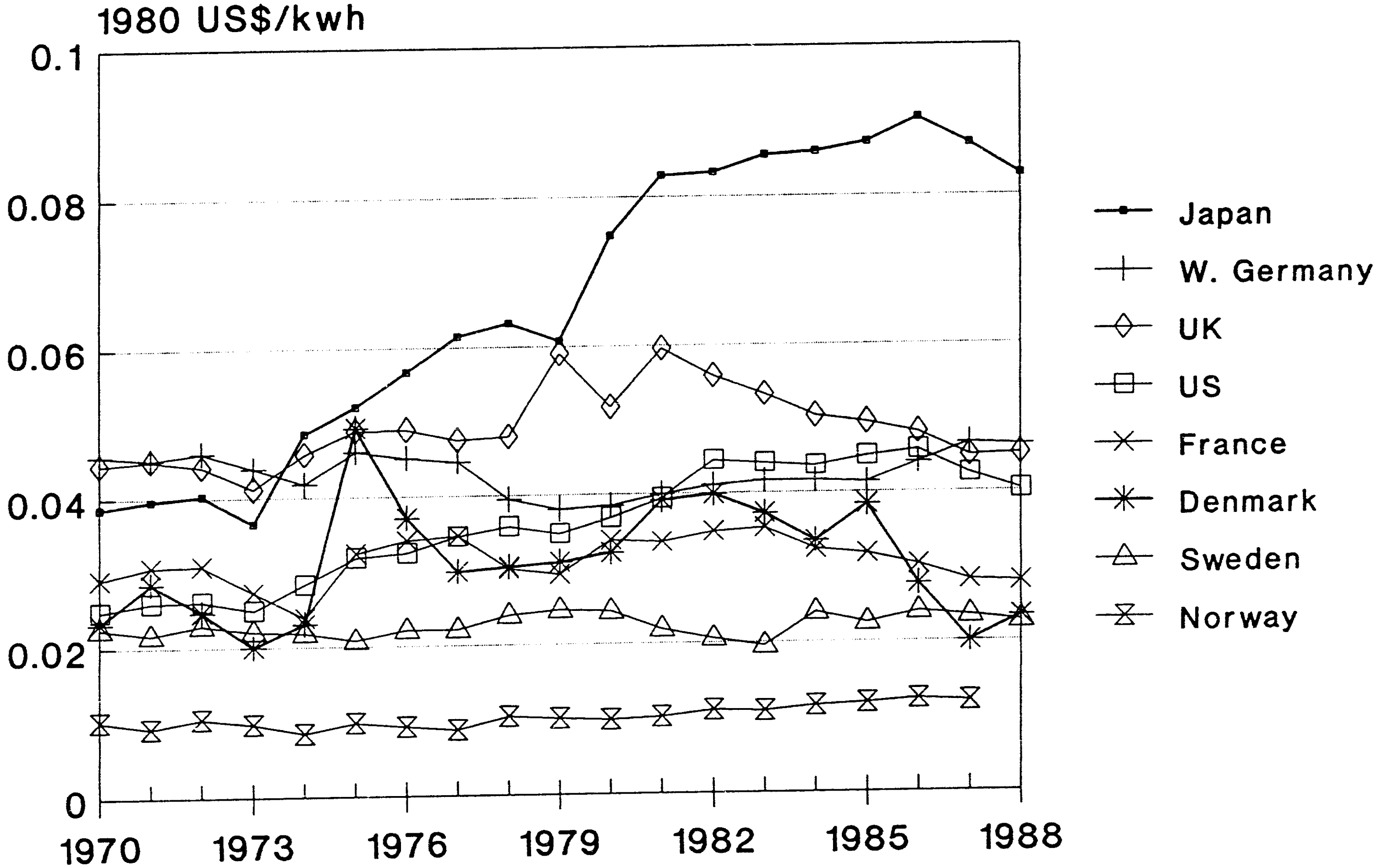
Industrial Electricity Prices



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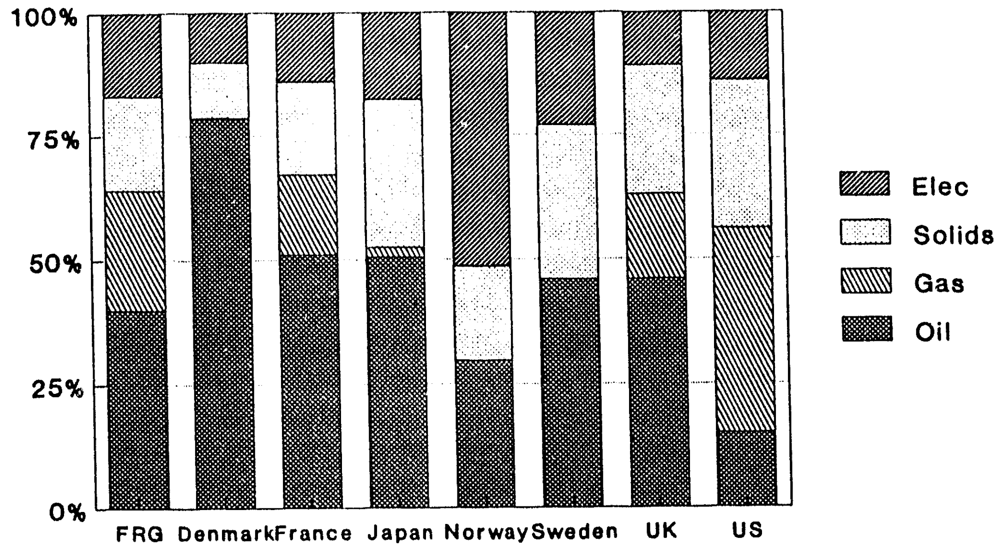
Manufacturing Fuel Shares 1973



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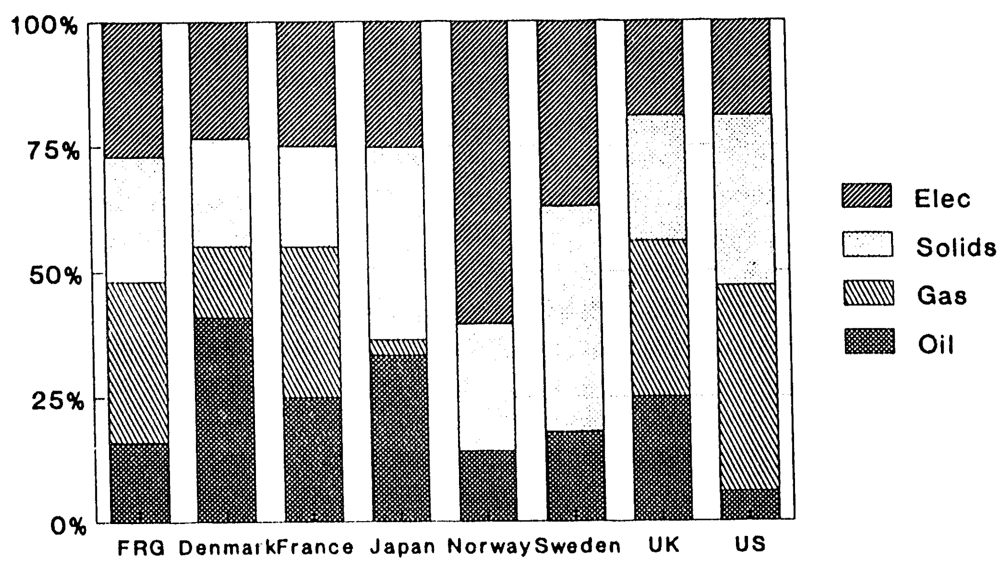
Manufacturing Fuel Shares 1988



fuel88

that's dominated by hydroelectricity, we still see this trend towards improved energy productivity.

I think that I will stop there. I have some packets that have my overheads, and then some other graphs based upon some work that we've done. I'll leave those at the back of the room for people to take.

Thanks.

MR. FLYNN: Thanks, Richard.

How's that for an objective set of comments? Frank Monforte pointed out that we didn't have emissions in there, which is quite right, and Tom Sparrow mentioned that we should be more ISTUM like, and Richard pointed out the need for better attention to some of the compositional effects. We certainly appreciate the comments and take them in the spirit that they are given, and they will guide our work efforts over the next few months.

We could respond to some of those comments, but I think people on the floor might want to have some of their own input, and we could take questions from the floor first and then get back to some of the other comments, if you'd like to proceed on that basis.

MR. SCHIPPER: My name is Mark Schipper. I work with EIA, and, specifically, I'm a math tech for the MECS, which is the Manufacturing Energy Consumption Survey.

We've addressed a lot of data issues. In the 1991 survey we have addressed a lot of technology issues, and also the end-use matrix, in terms of energy consumption.

We are underneath our redesigns in the 1994 MECS, and we would be interested in any comments on the end-use consumption matrix, and for the expansion of the technology MECS, because of a real need. The MECS started out as a consumption-based survey and it's now expanded into a more of a data collection for a modeling influence.

If you have any input, we can give you our card, and we can have that information instilled in the 1994 questionnaire.

MR. FLYNN: Thanks for reminding us of that. The people in the End-Use Survey Group have been very accommodating in terms of adding new questions wherever possible to their surveys, if they would help the modeling effort. So, any of you that are modelers should be providing your inputs to the Energy End-Use Group in EIA, and they will certainly be factoring that into their survey plans.

What is the agenda for getting new inputs on MECS, the next MECS?

MR. SCHIPPER: We are currently underneath an internal redesign. We are working with the '91 data and the consumption, but the data are still not out, so there has yet to be any type of formal setup for putting in inputs from external sources.

MR. FLYNN: So, it looks wide open now.

MR. MONFORTE: I'd like to address that, being a modeler. There's are two things that would be great if MECS could provide them on the next pass.

I agree that probably the nicest thing that occurred in the 1991 MECS was the question where they asked customers to give their estimate of how much energy of each type goes to what end-use; how much is going to boilers; how much goes for motors; etc. That's a great question.

What would be nice is if we could expand the technology lists a little bit, maybe ask a question like, what fraction of your motor powers are energy efficient versus standard. Those kinds of things would be good questions.

The other thing is, in our business we are fortunate in that we get to go into utilities and do surveys and collect equipment detail and all that fun stuff, but it would certainly be nice at the national level if data that are being collected on the MECS become a little bit more available than just say tabular formats. It would be nice if we could get the data on a computer. We'd even pay for it.

MR. SCHIPPER: You mean microdata?

MR. MONFORTE: Yes, with full confidentiality and all that stuff would be fine.

MR. SCHIPPER: You can have access to it through the Center for Economic Studies at the Bureau of the Census.

MR. MONFORTE: The full MECS Survey? Okay. Well, I stand corrected. I had talked to someone at the EIA, and was pretty much told no.

MR. SCHIPPER: You are allowed to do the work on site, or have a Census agent do the work.

MR. ADLER: My name is Bob Adler. I work with Mark.

It brings up another point. The MECS connects economic data through the ASM, and as such, if there was a change in the coverage, as small as it was from 1985 to 1988 (about two percent), the ratios you are talking about still would not change.

As a matter of fact, the change in coverage was not so much of a survey change as it was a coverage adjustment.

When we did our work on the energy intensities, we also found that between 1985 and 1988 energy intensities remained relatively flat. I'm not sure what that's about either. We saw these comparatively dramatic changes between 1980 and 1985, so we verify what you have, but I don't think it's an artifact of the coverage adjustment.

Another question I'd like to ask is, in terms of frequency of the MECS, you said you'd like to go to an annual MECS. I'm not sure, in looking at this model, that it will start in 1994, I'm also not sure, looking at this model, where the MECS even fits in, in terms of the input, and where it could fit in if we went into the rate of increase.

MR. HONEYCUTT: Well, MECS is the basic data source that's used in the industrial model. That's supplemented, of course, with some engineering estimates, but MECS is, basically, the gospel.

MR. ADLER: Well, obviously, we don't cover agriculture, or -- construction --

DR. SPARROW: Could I comment? There's a huge database that needs liberation at the University Science Center. They've been collecting data for a long time on industrial energy audits, and they've collected it by four-digit data. I have been unable to get a hold of it.

You guys paid for it, it seems to me you ought to go talk to those people. Incidentally, they ask questions at the two-digit level and probably at the four-digit level, like what fraction of energy consumption is of the following type.

They have that database. I would urge that you get in touch with those guys and see if you can get a hold of that database, to at least increase the coverage.

The other one you ought to do is try and buy the Dunn & Bradstreet database.

MR. FLYNN: A question over here?

BERNARD GELB: The example Crawford Honeycutt used of cement gave me this question, that is, how does the model handle sudden shifts in import penetration? You've got the macro-model driving output, but by itself, it wouldn't catch the big surge of the cement imports at the two-digit level.

MR. HONEYCUTT: Well, you're right, but we are not using the two-digit level, at least not for that particular industry. We are using cement. But, the imports, again, would not be covered inside the DRI model. We'll have to come up with an estimate on that.

MR. FLYNN: Gale?

DR. BOYD: Gale Boyd, Argonne National Laboratory. This question is kind of focused at Tom's comment about the process of aggregation, and who is putting something on the air in about 60 sectors. I don't necessarily disagree with that, but I wanted to hear your feeling about how much of the process level disaggregation can essentially be captured by industry level disaggregation. In other words, you have sectors in here that equate to production. Maybe there are other sectors that don't, but it seems to me that you get essentially process or product level disaggregation by industry level disaggregation.

DR. SPARROW: Well, you can certainly do that, but that doesn't answer the basic question of how the technologies are competing for what end use.

If you go to 3312, for instance, in there are mini-mills and integrated mills, and with the electric arc competition in a mini-mill, there essentially is no competition. The electric arc competition in an integrated mill is with the blast furnace (BOF). So, what you really need is metal melding as a demand, and you need the alternatives which are competing for that metal melding demand.

I don't think disaggregation is going to solve that problem, unless you have a map, an overlay, which allows you to say, exactly at the four-digit or six-digit level or whatever, exactly what the technologies and the processes are that are competing with one another.

If you have that, you've got an end-use model anyway, so why not to go to an end-use model. Outside of the market basket effects problem, I don't see what good disaggregation does.

MR. FLYNN: To respond to an earlier observation from Tom about the ISTUM model, in the earlier stages of the NEMS development effort, we did look at the ISTUM model as one possible approach. The decision at that time was that because the model was so data intensive, somewhat outdated, and it was in APL at the time, there were a lot of negatives associated with it from the standpoint of bringing it into the integrating framework that we had.

So, we are aware that it is a model that has a lot of very good features, but it had some very substantial costs associated with it. We didn't think it would quite fit in.

MR. MONFORTE: I'd like to make one point. I want to hit something Tom Sparrow talked about, because we support end-use models. This is obviously a very biased opinion, but we have been knocked about the head several times about why end-use models under-forecast econometric models.

The bottom line is, they don't. They can over-forecast an econometric model. It all depends on the assumptions that you put within the model.

It is true that end-use models may, perhaps, give you smaller price elasticity effects, but, again, that's not really true, at least for the set of end-use models that we have. I think we have a better model of how stocking and vintaging, and all those things react to changes in prices.

In fact, I'm sitting back and looking at some of the stuff that Richard has done. I'm starting to come to a gut feel that with econometrics, in the past, the price effects are really capturing structural changes and industry MECS changes.

I think if you start breaking the econometric models down, and you start looking at end-use energy estimates at the four-digit level, you are going to get much smaller price effects than what you get at the aggregate level.

So, I needed to get that in there. I wanted to say that I would agree with everything that Tom Sparrow has said --

DR. SPARROW: Except that.

MR. MONFORTE: -- Except that, and there were five other things, but that's okay.

MR. HOWARTH: I'll follow up by giving a plug to Gale Boyd, who's in the audience and has proven that electricity prices or energy prices have no impact on energy efficiency in the steel sector. Perhaps, he would rebut that.

DR. BOYD: I wasn't going to say, after he gave that specific example in response to my question about disaggregation, I wasn't going to bring up that particular issue, but there does exist a study which will be published soon in the Energy Journal that looks at this issue of competition between electric arc and basic oxygen furnace. We found that there were no price effects, or the price effects were of the correct size and a magnitude so small that doubling electric price would slow the adoption of electric arc furnaces by eight days.

But, regarding the specific example you gave about the disaggregation issue, I would still argue that at some level you can look at that as either a fuel choice issue or prices don't matter. We found a trend in --

DR. SPARROW: You've got the wrong elasticity. Your problem is you don't understand why people melt. People don't melt because of electricity prices, they melt because of scrap prices. That's the basic factor.

You are quite right, electricity prices don't make a toot when it comes to adoption of that technology. What's really critical is the price of scrap, because that's what you are competing. You are competing iron/ore and coal against scrap. So, the real elasticity controlling that is the price elasticity with respect to scrap.

DR. BOYD: Does this mean an engineer and an economist are agreeing about something?

DR. SPARROW: Eight days. Let me look at it, Gale, because I have a hard time swallowing that all together. The question is, "What tariff, electricity price tariff, did you use?"

DR. BOYD: We did not have plant level pricing.

DR. SPARROW: Oh, well, Dr. Boyd.

MR. FLYNN: That seems to sum up the controversies that exist in industrial modeling.

We had a session here today that lived up to our expectations; we hope it lived up to your's. We certainly appreciate all the reviewers' time that went into preparing for this, and coming here, and giving us their insights. We thank the members of the audience for sticking with us and contributing their thoughts as well, and we now conclude the session.