MASTER

DISAGGREGATING REGIONAL ENERGY
SUPPLY/DEMAND AND FLOW DATA TO
173 BEAs IN SUPPORT OF
EXPORT-COAL ANALYSIS

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EXPORT COAL ANALYSIS

Prepared for:

U.S. Department of Transportation
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and

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PREFACE

This report documents the procedures and results of a study sponsored jointly by the U.S. Department of Transportation and the U.S. Department of Energy. The contract was administered through DOE's Oak Ridge Office. Technical management of the contract was the responsibility of DOT's Office of Policy and International Affairs.

The study was conducted to provide BEA-level production/consumption data for energy materials for 1985 and 1990 in support of an analysis of transportation requirements for export coal. Base data for energy forecasts at the regional level were obtained from the Department of Energy, Energy Information Administration. The forecasts selected for this study are described in DOE/EIA's 1980 Annual Report to Congress, and are:

- *1985 Series B, Medium Oil Import Price (\$37.00/Barrel)

- *1990 Series B, Medium Oil Import Price (\$41.00/Barrel)

Each forecast period is extensively described by approximately forty-three statistical tables prepared by EIA and made available to TERA for this study.

This report provides sufficient information to enable the transportation analyst to appreciate the procedures employed by TERA to produce the BEA-level energy production/consumption data. The report presents the results of the procedures, abstracts of data tabulations, and various assumptions used for the preparation of the BEA-level data.

The end-product of this effort was the BEA to BEA energy commodity flow data by mode which serve as direct input to DOT's transportation network model being used for a detailed analysis of export coal transportation. The selection of mode by TERA's method in the overall study effort is preliminary. TERA's modal selection rules, in most cases, are rudimentary and do not allow for intermodal transport. However, the

results obtained using this methodology constitute a useful starting point for DOT's network model which determines final modal choice on the basis of cost, capacity and other considerations. A description of DOT's transportation network model is contained in "National Energy Transportation Study, A Preliminary Report to the President." That report, published in July 1980, was also sponsored jointly by DOT and DOE.

EXECUTIVE SUMMARY

Purpose and Scope

In July 1978, TERA, Inc. was awarded a contract by the U.S. Department of Energy, Office of Policy and Evaluation, to take energy scenarios provided by the Government and to disaggregate from the regional level the annual energy production and consumption data for several fuel types for each scenario into 173 Bureau of Economic Analysis' Economic areas --so called BEA areas (Reference 1). This work was part of a larger effort sponsored by a joint task force of the Department of Transportation (DOT) and Department of Energy (DOE) to identify potential bottlenecks in the U.S. energy transportation system in the period 1985 to 1990. The final report "National Energy Transportation Study" was published in July 1980 (Reference 6).

In March 1981, TERA was asked by DOE to perform a similar disaggregation analysis, this one directed at the potential transportation problems caused by expanding coal exports. In this study, TERA was to be given energy forecasts for 1985 and 1990 for use in disaggregating coal and petroleum supplies and demands as well as origin/destination (O/D) flows using Interagency Coal Exports (ICE) Task Force estimates of coal export levels in 1985 and 1990.

Given these O/D flows, the Department of Transportation network model was to be used to identify potential bottlenecks due to coal exports. The energy commodities which were to be included in this study were coal, crude oil and refined oil products.

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For each MEFS forecast, the disaggregation model breaks down the MEFS regional forecast into a more highly detailed forecast using BEA regions. This disaggregation is accomplished by analyzing historical production factors and economic variables which cause local variations in energy production and demand growth rates for subregions within the larger MEFS regions. These economic factors are used to forecast "shares" of production and demand for each of the subregions which, when applied to the DOE/MEFS forecast for the larger DOE regions, enable TERA's model to compute forecasts of production and demand for each BEA region.

In addition, since production and demand are not equal for each BEA region, energy must be transported between these regions to achieve a supply/demand balance. The TERA model computes a solution for such "origin-destination flows" using a cost-minimizing linear programming model of the energy transportation system. This solution is totally consistent with the higher level interregional flow data contained in the MEFS solution, which means, for example, the sum of all BEA production for those BEAs in one MEFS region is equal to the MEFS regional total used as input.

Finally, the TERA model allocates the origin-destination flows to particular transportation modes. These assignments are made on the basis of historical modal shares as well as other known or estimated transportation constraints for each mode.

The results of the TERA disaggregation model are further processed by DOT. For this purpose, DOT's network model is used in conjunction with an extensive data base of supplies and demands for other commodities which compete with oil and coal for transportation facilities in the forecast period. The DOT model allocates these commodities (both energy and non-energy) to the various transportation links and modes and estimates the expected bottlenecks in the forecast period.

The modal shares for energy commodities developed by this analysis are used to pre-load the DOT transportation network model. These modal shares are then modified by subsequent network model iterations.

Results

Two cases were run for this study: 1985 and 1990 Series B, Oil Import Prices (\$37.00 and \$41.00 per barrel, respectively) as defined by DOE/EIA's 1980 Annual Report to Congress. In both instances, MEFS results were modified by ICE Task Force estimates for the coal export sector. These modifications were successfully made and disaggregation runs performed.

Two report-writers were developed to produce BEA-level flow data tables for the disaggregated MEFS-ICE scenario results. These tables were analyzed for reasonableness and consistency and were found to have both. The BEA-level flow data was also written upon magnetic tape to be used for input to the DOT transportation network model. The preparation of these data tapes was the prime objective of this study.

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CHAPTER I. INTRODUCTION

Background

Purpose and Scope of Project

In July 1978, TERA, Inc. was awarded a contract by the U.S. Department of Energy, Office of Policy and Evaluation, to take energy scenarios provided by the Government and to disaggregate from the regional level the annual energy production and consumption data for several fuel types for each scenario into 173 Bureau of Economic Analysis' Economic areas--so called BEA areas (Reference 1). This work was part of a larger effort sponsored by a joint task force of the Department of Transportation (DOT) and Department of Energy (DOE) to identify potential bottlenecks in the U.S. energy transportation system in the period 1985 to 1990. The final report "National Energy Transportation Study" was published July 1980 (Reference 6).

In March 1981, TERA was asked by DOE to perform a similar disaggregation analysis, this one directed at the potential transportation problems caused by expanding coal exports. In this study TERA was to be given energy forecasts for 1985 and 1990 for use in disaggregating coal and petroleum supplies and demands, as well as O/D flows using Interagency Coal Export (ICE) Task Force estimates of coal export levels in 1985 and 1990.

Given these origin-destination flows as starting points, the Department of Transportation network model would then be

used to estimate total energy and non-energy commodity transportation demand for each mode to identify locations where transportation bottlenecks could appear.

The energy commodities which were to be included in this study were coal (nine types), crude oil and refined oil products (pipeable and non-pipeable).*

Nine types of coal defined by the MEFS were to be considered on the basis of their respective thermal values and sulfur content.

Four transportation modes were to be considered. These included pipeline, rail, truck, and barge.

TERA was designated to apply the foregoing methodology to the 1985 and 1990 energy forecasts defined by DOE scenarios of national supply and demand (Medium World Oil Prices) in order to produce detailed supply, demand, and origin-destination flow forecasts. See Reference 2 for discussion on forecasts.

This report is a description of TERA's development and application of a computerized methodology for accomplishing this project.

Outline of Report

After this introductory chapter, the principles behind the methodology TERA has used in the coal export analysis project are described in Chapter II. This methodology is divided into several sections: disaggregation, origin-destination flows and modal shares.

*See Reference 1.

In Chapter III the computer implementation of the methodology is detailed. This includes the basic system developed and gives in detail a description of the program and data sets which make up that system.

Chapter IV presents some results of the analysis with emphasis on the tabulations produced for DOE and validation of these results.

In this report a number of technical words and abbreviations used in the areas of energy and computer applications are included. For this reason an extensive glossary of the key words and abbreviations has been included in the appendix to facilitate a full understanding of the report.

Overview of Methodology

Figure I-1 presents the general structure of the system used in this study. Regional energy flows for each scenario are produced by the DOE/MEFS model and modified by assumptions contained in the Interagency Coal Export (ICE) Task Force (References 3, 4, 5). The DOE/MEFS, more precisely known as the Midterm Energy Forecasting System, is an outgrowth of the Project Independence Evaluation System (PIES). The ICE task force was created to identify the coal export potential of the United States and forecast these movements.

MEFS data, along with the incorporation of ICE information, produces a simultaneous forecast of supply, demand, and interregional flows for all energy commodities produced and/or consumed in the United States. These commodities include

FIGURE I-1
GENERAL STRUCTURE OF THE ANALYSIS

crude oil, refined products, natural gas, synthetic gas, coal, electricity, nuclear fuel, and even solid waste for conversion to oil, gas, and electricity.

The MEFS forecast is based on a complicated regional breakdown which is different for each energy type. Thus, there are natural gas, coal and oil producing regions as well as oil refinery regions and energy demand regions. Note, however, natural gas was not included in this analysis. Figures I-2 through I-6 show the regional identification contained in the MEFS and ICE data. Table I-1 shows in detail the correspondence between the MEFS coal region codes and coal producing states.

The MEFS forecast is used as an input by TERA's disaggregation model. Whereas the MEFS model computes values for all energy commodities simultaneously, the TERA model operates on each energy commodity one at a time. The TERA model disaggregates nine types of coal:*

- high BTU, high sulfur
- high BTU, medium sulfur
- high BTU, low sulfur
- medium BTU, high sulfur
- medium BTU, medium sulfur
- medium BTU, low sulfur
- low BTU, low sulfur
- lignite
- premium grade*

*Later these coals are combined into two new types: steam and metallurgical for purposes of the export coal analysis. See Chapter IV.

FIGURE I-2: MEFS NATURAL GAS SUPPLY REGIONS

FIGURE I-3: MEFS COAL PRODUCTION REGIONS

FIGURE I-4: MEFS CRUDE OIL PRODUCING REGIONS

FIGURE I-5: MEFS REFINING REGIONS

FIGURE I-6: MEFS ENERGY DEMAND REGIONS

TABLE I-1
MEFS COAL SUPPLY REGIONS

Code	Name and Composition	
C1	Northern Appalachia	Pennsylvania Ohio Maryland W. Virginia, North
C2	Central Appalachia	W. Virginia, South Virginia Kentucky, East Tennessee
C3	Southern Appalachia	Alabama
C4	Midwest	Kentucky, West Illinois Indiana
C5	Central West	Iowa Missouri Kansas Arkansas Oklahoma
C6	Gulf	Texas
C7	E. No. Gt. Plains	North Dakota South Dakota Montana, East
C8	W. No. Gt. Plains	Montana, West Wyoming Colorado, North
C9	Rocky Mountains	Colorado, South Utah
CA	Southwest	Arizona New Mexico
CB	Northwest	Washington
CC	Alaska	Alaska

Three types of oil are also included in the TERA model:

- crude oil
- pipeable refined products
- non-pipeable refined products

The regional breakdown, or level of disaggregation, for the TERA model is the Bureau of Economic Analysis (BEA) region. This is the 173 regional breakdown which BEA used until 1978. Figure I-7 shows the BEA regions.

For each forecast, the TERA model disaggregates the MEFS regional forecast into a more highly detailed forecast using BEA regions. This disaggregation is accomplished by analyzing historical production factors and economic variables which cause local variation in energy production and demand growth rates for subregions within the larger MEFS regions. These economic factors are used to forecast "shares" of production and demand for each of the subregions which, when applied to the DOE/MEFS/ICE forecasts for the larger DOE regions, enable TERA's model to compute forecasts of production and demand for each BEA region.

In addition, since production and demand are not equal for each BEA region, energy must be transported between these regions to achieve a supply/demand balance. The TERA model computes a solution for such "origin-destination flows" using a cost-minimizing linear programming model of the energy transportation system. This solution also satisfies a set of MEFS interregional flow constraints, i.e., the sum of flows

between BEA regions in different MEFS regions as predicted by TERA's model must equal the flow between those regions computed by MEFS and provided by ICE. Thus, the disaggregated solution is totally consistent with MEFS and ICE.

Finally, the TERA disaggregation model allocates the origin-destination flows to particular transportation modes. Thus, coal and oil can be assigned to truck, rail, or barge. Oil can be assigned to pipeline as well. These assignments are made on the basis of historical modal shares.

In the case of oil and coal, the results of the TERA model are further processed by DOT. DOT's transportation network model is used in conjunction with an extensive data base of supplies and demands for other commodities which are expected to compete with oil and coal for transportation facilities in the forecast period. This model allocates these commodities (both energy and non-energy) to the various transportation links and modes and estimates the expected bottlenecks in the forecast period.

The results of the DOT modeling framework are then analyzed in light of current and emerging issues in U.S. coal transportation.

CHAPTER II
METHODOLOGY

CHAPTER II. METHODOLOGY

Coal Methodology Description

Conceptual Framework

As with each of the other energy commodities, the objective in the case of coal is to disaggregate national and regional energy supply and demand (production and consumption) projections to 173 Bureau of Economic Analysis economic areas (BEAs), and to allocate the flows of energy commodities by mode from supply to demand BEAs. The projected BEA-to-BEA flows by mode are then input to a Department of Transportation network model which predicts and analyzes potential constraints in the transportation network.

The methodology used by TERA to disaggregate and allocate the DOE-provided scenarios for coal consists of five basic elements:

- The disaggregation of regional coal supply projections to 173 BEAs;
- The disaggregation of regional coal demand projections to 173 BEAs;
- The disaggregation of export demand to nine (9) ports on the East, Gulf, West Coasts and Great Lakes.
- The allocation of regional coal flow projections from supply BEAs to demand BEAs; and
- The determination of a predicted modal split for each of the projected BEA-to-BEA flows.

In general, the disaggregation of both supply and demand projections is based upon historical data (production and consumption), existing conditions (coal reserve base, utility and industrial user locations), as well as projected future conditions

(BEA population and manufacturing sector value-added growth projections, utility and industrial growth or expansion projections). A complete description of this data base is contained in Appendix B of this report. The allocation of BEA-to-BEA coal flows is done through the use of a linear programming model which minimizes the total cost of coal transportation between BEAs. The modal splits with consideration given to known or anticipated changes in these patterns.¹

Disaggregation Model Structure

The relationship of these five basic elements to each other and to the inputs and outputs of the model is shown in Figure II-1, which presents a conceptual overview of the coal disaggregation and allocation methodology. In the following pages each of the components of this model is discussed.

Scenario Inputs. The scenario inputs are the DOE-supplied MEFS regional projections of coal supply and demand along with the incorporation of ICE Task Force data and MEFS interregional flow projections. The scenario input is "variable data" since it changes for each scenario under consideration. However, in terms of each scenario run of the model, the scenario input is given (i.e., constant) and provides regional constraints to the disaggregation of supply, demand, and flows by BEA.

¹For example, Great Lakes shippers are currently expanding their fleets and improving their facilities with an intention of capturing a significant portion of the anticipated increased flows of Western coal to the industrial East and Midwest. In the past, the railroads have captured nearly 100 percent of such movements.

FIGURE II-1

OVERVIEW OF TERA MODEL'S COAL METHODOLOGY

NOTE: Model does not assign intermodel flows when more than one mode is involved.

Disaggregation of Coal Supply. The disaggregation of the MEFS scenario regional coal supply (production) projections (see Table II-1) is the first of the basic model elements. The procedure which is used to disaggregate projected regional coal production consists of four steps:

- (1) Determine a preliminary projected coal production by county using a statistically estimated equation stating future production to be a function of known reserves, past production and coal characteristics in that county. Using given data for reserves and production in the base year, compute preliminary projected production for the forecast year.

- (2) Sum these preliminary production projections over all counties in each MEFS region and divide this total into the preliminary projected production for each county in the region. This step results in a "production share" for each county.

- (3) Apply this county-specific "production share" to the MEFS regional scenario production forecast to obtain "normalized" county production forecasts for each county in each MEFS region.

- (4) Sum the county production forecasts over all counties in each BEA, to generate the BEA production forecast.

Since data relating to coal production is not collected or aggregated by BEA at the present time, TERA developed a disaggregating methodology which takes regional projections down to the county level, and then aggregated the county projection back up to the BEA level. Counties were chosen as the basic unit in

TABLE II-1

MEFS 1985 COAL PRODUCTION BY REGION

SERIES B - ARC80 BASE CASE
 PRICE PATH : MEDIUM
 OIL IMPORT PRICE: 37.00
 RUN DATE: 11.07

COAL REGIONAL PRODUCTION SUMMARY IN MILLION SHORT TONS PER YEAR (BY COAL TYPE)

COAL TYPES	SUPPLY REGIONS*												TOTAL
	C1	C2	C3	C4	C5	C6	C7	C8	C9	CA	CB	CC	
PREMIUM (27 HHBTU/TON)	23.89	133.50	5.42		.56				4.34				167.73
BITUMINOUS (23.00 HHBTU/TON)	195.94	103.40	15.61	25.37	2.22			16.15	11.60				370.29
LOW SULFUR	.14	20.30	2.56		.02			16.15	6.50				45.67
MEDIUM SULFUR	125.43	67.59	13.05	10.66	.56				5.10				222.39
HIGH SULFUR	70.37	15.51		14.71	1.65								102.24
MID-BITUMINOUS (21.00 HHBTU/TON)	18.88			139.73	11.63			24.52	6.30	59.90	.15		261.13
LOW SULFUR				.08				9.98	5.54	43.45	.15		59.20
MEDIUM SULFUR	.15			8.53				14.54	.76	16.46			30.44
HIGH SULFUR	18.74			131.12	11.63								161.49
SUB-BITUMINOUS (18.33 HHBTU/TON)								139.62			6.08		145.69
LOW SULFUR								92.17					92.17
MEDIUM SULFUR								47.45			6.08		53.52
LIGNITE (13.00 HHBTU/TON)						56.75	29.74						86.48
LOW SULFUR							5.37						5.37
MEDIUM SULFUR						56.75	24.37						81.11

• SUPPLY REGIONS

C1	NORTHERN APPLACHIAN
C2	CENTRAL APPLACHIAN
C3	SOUTHERN APPLACHIAN
C4	MIDWEST
C5	CENTRAL WEST
C6	GULF
C7	N.E. GREAT PLAINS
C8	N.W. GREAT PLAINS
C9	ROCKIES
CA	SOUTHWEST
CB	NORTHWEST
CC	ALASKA

SULFUR CONTENTS

LOW	LESS THAN .67 LBS./HHBTU (PREMIUM IS LOW SULFUR)
MEDIUM	.67 TO 1.68 LBS./HHBTU
HIGH	MORE THAN 1.68 LBS./HHBTU

this procedure for several reasons. First, reasonably accurate data for coal production and coal reserves by county are readily available. Second and most importantly, while data of similar accuracy exists for other geographic units (e.g., states, Bureau of Mine Districts), the geographic correspondence between these other units and BEAs or MEFS Coal Regions is more difficult to achieve. Counties are the greatest common denominator of the BEAs and MEFS regions and thus represent the one building block which allows complete correspondence between BEAs and the larger geographic units. In no case is any one county in more than one BEA nor in more than one MEFS region.

Past coal production in any county is assumed to be a function of three factors: (1) county coal reserves, (2) coal sulfur content, and (3) BTU content of coal. Quite obviously, the size of the reserve base is a major determinant of all future production. However, it must be noted that future production is not solely a function of reserves. In some cases the capital costs of opening and operating a new mine may make it uneconomical or even prohibitive. In other cases, the quality of the coal in a county or region may be so poor that future production may not be economically feasible. In either case, future production may be more likely (i.e., greater) from an existing mine or another region even though that existing mine or region may have a much smaller known reserve base. Thus, a future production function

must give some weight to coal characteristics as well as reserves. By using regression analysis, such a function can be determined for each coal type in each coal region.

The equation estimated by TERA for coal production is:

$$\log P = a_0 + a_1 \log R + a_2 \log S + a_3 \log H \quad (2-1)$$

where P is annual production in millions of short tons, R is reserves in millions of short tons, S is sulfur content in percent, and H is heat content in BTU's per pound. In this equation one would expect that a_1 and a_3 would be positive and a_2 would be negative. That is, production would be positively correlated with reserves and heat content and negatively correlated with sulfur content.

The results of the estimation are presented below:

$$R^2 = 0.377$$

$$F(4,192) = 37.93$$

<u>Coefficient</u>	<u>Value</u>	<u>T-stat</u>
a_0	-30.0641	3.67
a_1	0.6336	10.21
a_2	- 0.4865	1.87
a_3	3.5663	4.15

Each of the three explanatory variables is significant and of the correct sign. The T-stats and F statistics for the equation are statistically significant. The R^2 of 0.377 is somewhat low. This value indicates that 37.7 percent of the variance is explained by the simple model used here. Other perhaps more subtle or local factors would have to be included to explain the remainder of the variance.

With this function estimated, preliminary forecasts of county production for the forecast years can be made. These preliminary production projections are summed by region and each county's share of the MEFS region's possible production for each county is computed. This production share for each county in a region can now be applied to any MEFS scenario regional projection to obtain the predicted county production in each region. Once these county production projections are obtained, they can readily be summed by BEAs to obtain projected production by BEA.

The steps in the production disaggregation process can be represented mathematically as:

$$PC_i = f(R_i, S_i, H_i) \quad (2-2)$$

$$PSC_i = \frac{PC_i}{\sum_{i \in I} PC_i} \quad (2-3)$$

$$PPC_i = PSC_i \cdot SP_r \quad (2-4)$$

$$PPB_j = \sum_{i \in CB} PPC_i \quad (2-5)$$

where:

- PC_i = Preliminary future production in county i
- R_i = Known reserves in county i
- S_i = Sulfur content of the coal produced in county i
- H_i = BTU content of the coal produced in county i
- PSC_i = Production share for county i
- PPC_i = Projected production in county i
- SP_r = Scenario regional production in MEFS region r

- PPB_j = Projected production in BEA j
- I = The set of all counties contained in MEFS region r
- B = The set of all counties contained in BEA j

It should be noted that in these operations, the various types of coal are kept separate and thus for each coal-producing BEA, more than one type of coal may be produced. It is assumed, however, that within each county only one coal type is produced. In actuality, there may be some counties which have, historically, produced more than one type of coal. But since most reserve data characterizes the "average" type of coal in a county, whenever production occurs, it is assumed to be of the same "average" type. Coal types considered in the study are more fully described in later sections.

Disaggregation of Coal Demand. The procedure which is used to disaggregate projected regional coal demand (consumption) consists of five general steps with the second and third steps each requiring several sub-steps. The five general steps can be described as:

- (1) Disaggregate past county coal consumption by coal type by sector (utility vs. non-utility).
- (2) Disaggregate projected coal export demand.
- (3) Project coal consumption by county in the non-utility sector using non-utility coal consumption by type as a function of past consumption.
- (4) Project coal consumption by county in the utility sector using a definite set of relationships between coal-fired generation capacity and coal consumption.
- (5) Sum the county coal consumption projections for both sectors by type and by BEA to obtain total BEA coal consumption by type.

Data on coal consumption by state has historically been collected by the U.S. Bureau of Mines. Data related to coal consumption is also collected at the county and subcounty level by the Environmental Protection Agency (EPA) as part of the National Emissions Data System (NEDS), more commonly known as the Point Source File. (See Appendix B)

The consumption figures in the NEDS file are identified by a county code so that these figures can be readily aggregated to counties, states, BEAs, or larger MEFS regions. The file also includes user codes which enable an identification of the end-use sector, i.e., utility or non-utility.

Non-Utility Coal Demand

The procedure used in projecting coal consumption in the non-utility sector is more easily understood as a series of sub-steps. These steps include:

- (a) Determine each county's share of each state's non-utility coal consumption for the base year for all types of coal based on the NEDS file.
- (b) Determine a normalized county non-utility coal consumption for the base year 1975 based on DOE/BOM state level data and the county shares developed in (a).
- (c) Determine each county's share of each MEFS region's non-utility coal consumption (see Table II-2) by summing over counties in each MEFS region and dividing the total into each county's normalized consumption determined in (b).
- (d) Apply this share to the MEFS regional non-utility coal consumption projection for the forecast period to obtain a projected county non-utility coal consumption by type.
- (e) Sum the county projections by coal type by BEA to obtain a projected BEA consumption of non-utility coal by type.

TABLE II-2

MEFS 1985 COAL DEMAND BY REGION

SERIES D - ARCO BASE CASE
 PRICE PATH : MEDIUM
 OIL IMPORT PRICE: 37.00
 RUN DATE: 11.07

COAL REGIONAL DEMAND SUMMARY IN MILLION SHORT TONS PER YEAR

COAL TYPE	DEMAND REGIONS										SYNTHETICS	TOTAL
	NW-ENG.	NY/HJ	MID-ATL	S.-ATL	HIDWEST	S.-WEST	CENTRAL	N-CNTRL	WEST	N.-WEST		
UTILITY												
LO-SULFUR	.0	3.6	9.9	33.3	38.1	1.3	2.2	.0	4.2	.0		92.6
MED-SULFUR	.8	15.0	71.4	71.2	60.6	.7	1.2	.0	5.4	.0		236.2
HI-SULFUR	6.5	9.7	13.7	54.5	54.8		20.1	.0	.0	.0		159.2
SUB-BIT LO-S	.0	.0	.0		13.0	52.2	17.2	28.1	12.3	.0		122.0
SUB-BIT MED-S	.0	.1	.0		23.6	5.0	.3	7.8	2.2	.0		32.7
LIGNITE LO-S					.3			5.1				5.4
LIGNITE MED-S					4.7	55.3		14.4				74.5
TOTAL	7.3	29.3	95.0	159.3	195.1	114.6	40.6	55.4	24.1	.0		712.4
1978	1.0	9.7	79.4	123.7	155.0	25.9	36.7	30.4	11.2	3.4		476.3
RES., COM., IND.												
MET COAL*	.0	2.7	25.5	7.7	29.3	.7	.3	3.1	1.7	.0		71.0
NON-MET	.7	4.3	12.1	19.3	40.2	33.6	13.3	7.4	6.4	6.2		143.6
TOTAL	.7	7.1	37.6	26.9	69.5	34.4	13.6	10.6	8.1	6.2		214.6
TOTAL	8.0	35.3	132.6	186.0	264.6	148.9	54.2	66.0	32.2	6.2	12.1	926.1
1978 TOTAL	1.1	15.5	120.0	144.1	210.3	29.0	41.1	37.9	14.3	5.0		619.3
GROWTH RATE	33.2	12.5	1.4	3.7	3.3	26.3	4.3	8.3	12.2	3.1		6.3

*MET COAL INCLUDES 70% PREMIUM BIT COAL AND 30% OTHER BITUMINOUS LOW SULFUR COAL.

**SYNTHETICS COAL DEMAND INCLUDES COAL USED IN PRODUCING SYNGAS, SYNCRUDE AND ELECTRICITY.

Consumption projections in the non-utility sector rely primarily on the data contained in the EPA Point Source files. Future consumption of non-utility coal is assumed to occur in the same counties that it has in the past. No data currently exists as to what non-utility industries will convert from other fuels to coal in the future, so that no new non-utility coal-consuming counties can be predicted. Coal conversion assumptions are, however, contained in the MEFS regional scenario projections. The effect of the methodology is to allocate coal in the regional projections (including the conversion assumptions) to those counties (and BEAs) in the region which currently consume non-utility coal.

Non-utility demand for metallurgical grade coal (MT) is handled slightly differently. MEFS defines metallurgical coal as being 70% premium BTU coal (13,000 BTU/lb or greater) and 30% other bituminous low sulfur. Since the MEFS demand for this type of coal is confined to the iron and steel industry (principally in the production of coke), consumption of MT coal in the non-utility sector is confined to those states in which Bureau of Mines reports have shown consumption of coal at coking plants. In those states, county shares are the same for MT as for the other coal types.

Mathematically these procedures for each coal type can be expressed as:

$$CSC_i = CC_i / \sum_{i \in I_j} CC_i \quad (2-6)$$

$$NCC_i = CSC_i \cdot CB_j \quad (2-7)$$

$$SC_i = NCC_i / \sum_{i \in R_k} NCC_i \quad (2-8)$$

$$CC_{i,n} = MEFSC_{k,n} \cdot SC_i \quad (2-9)$$

$$BEAC_{m,n} = \sum_{i \in B_m} CC_{i,n} \quad (2-10)$$

where:

- CSC_i = County i base year consumption share of state consumption from EPA file
- CC_i = Base year consumption in county i in EPA file
- I_j = Set of all counties in state j
- NCC_i = Normalized consumption in county i in base year
- CB_j = Consumption in state j (BOM) in base year
- SC_i = County i 's share of normalized consumption in MEFS region k
- R_k = Set of all counties in MEFS region k
- $CC_{i,n}$ = Consumption forecast for county i , coal type n
- $MEFSC_{k,n}$ = MEFS consumption forecast for MEFS region k coal type n
- $BEAC_{m,n}$ = Consumption forecast for BEA m , coal type n
- B_m = Set of all counties in BEA m

Utility Demand

The procedure to project coal consumption by BEA in the utility sector can also be understood through a series of sub-steps:

- (a) Determine the projected coal-fired electricity generation capacity for each county.
- (b) Determine the county share of this regional coal-fired generation capacity and assume that this share will also equal the future county share of utility coal consumption.

- (c) Apply this share to the regional utility coal consumption projections by type (see Table II-2) to obtain a projected county utility coal consumption by type.
- (d) Sum the county projections by coal type by BEA to obtain a projected BEA consumption by coal type for the utility sector.

The steps involved in the disaggregation of the utility sector coal consumption are basically self-explanatory. Future coal-fired generation capacity is determined through the use of Federal Energy Regulatory Commission (FERC) data which specifies the rated capacity and location for all coal-fired generation units, both in operation and currently planned. County coal consumption by utilities is assumed to be directly proportional to the county coal-fired capacity within that region. Since utilities will generally burn several types of coal during the year, the calculated share of regional generation capacity and, therefore, utility coal consumption, is assumed to apply to all types of coal that are used by utilities in that region.

The steps involved in the disaggregation of utility coal consumption can be expressed mathematically as:

$$CCAPS_i = CCAP_i / \sum_{i \in R_k} CCAP_i \quad (2-11)$$

$$PUC_i = MEFSUC_k \cdot CCAPS_i \quad (2-12)$$

$$BUC_j = \sum_{i \in B_j} PUC_i \quad (2-13)$$

where:

- $CCAPS_i$ = Share of coal fired electricity generation capacity for county i in MEFS region
- $CCAP_i$ = Coal fired electricity generation capacity of county i
- R_k = Set of all counties in MEFS region k
- PUC_i = Projected utility consumption of coal in county i
- $MEFSUC_k$ = MEFS scenario forecast utility coal consumption in MEFS region k
- BUC_j = Utility consumption in BEA j
- B_j = Set of all counties in BEA j

As was the case with coal production (supply), the integrity of coal types is preserved in the disaggregation of coal demand.

Disaggregation of Coal Exports. TERA's model disaggregates coal exports from all coal producing regions to BEA region containing the ports of export. This procedure is determined by following the steps described below:

- (1) Determine the coal regional production summary for each supply region by coal type.
- (2) Apply forecasted coal tonnage by export region to obtain domestic origin-destination.
- (3) Calculate the share each port will capture in its export region based upon existing capacity or minimum allowable throughput.
- (4) Incorporate disaggregated coal movements for each coal type into the MEFS model.

The MEFS model provides the coal regional production summary required in the first step for the 1985 and 1990 medium price path scenario examined. The data provides coal production in each of the supply regions and establishes the total supply parameters for the disaggregation.

The second step involves the use of data developed by the Interagency Coal Export (ICE) Task Force which is shown in Tables II-3 and II-4. Forecasts have been made that delineate steam and metallurgical coal exports by export region and the origin of this coal.

The determination of the actual port of export is estimated based upon the projected coal handling capacity of each port in the 1985-1990 period. Thus, the forecasted coal export by export region is further disaggregated to specific port area that can be reliably represented by a BEA number. Table II-5 provides the data used in the development of each port's potential market share. Due to the lack of data on the capacity of Toledo, the minimum allowable throughput information was felt to provide a realistic division of coal exports on the Great Lakes.

The final step involves combining the information developed to provide flows by coal type from DOE producing region to the port of export. Tables II-6 and II-7 represent the coal that is exported from each port in the 1985 and 1990 medium price scenarios.

TABLE II-3
PROJECTED U.S. STEAM COAL EXPORTS 1985-1990
(MILLIONS OF TONS)
(Low Steam Coal Case)

Coal Type	Coastal Export Regions			DOE Coal Supply Regions											
	Regions	Millions of Tons		C1	C2	C3	C4	C5	C6	C7	C8	C9	CA	CB	CC
		1985	1990												
Bituminous Low Sulfur (HL)	South Atlantic	10.02	17.00		X	X									
	Gulf	1.18	2.00		X	X									
	Pacific	5.90	10.00								X	X	X		
Bituminous High Sulfur (HH)	North Atlantic	2.96	5.00	X	X										
	Gulf (Mobile)	1.77	1.00		X		X								
	Gulf (New Orleans)	0.59	3.00		X		X								
	Great Lake/ Lake Erie	5.90	10.00	X	X		X								
Mid-Bituminous Low Sulfur	Gulf	2.34	4.00								X				
	Pacific	2.34	4.00								X				
		33.00	56.00												

SOURCE: ICE Task Force (Reference 4)

NOTE: X's indicate coal supply regions for each coal type.

TABLE II-4
PROJECTED U.S. METALLURGICAL COAL EXPORTS 1985-1990

Coastal Export Regions			DOE Coal Supply Regions											
Region	Tons 1985	1990	C1	C2	C3	C4	C5	C6	C7	C8	C9	CA	CB	CC
North Atlantic	0	0												
South Atlantic	33.65	39.00	X	X										
Gulf (Mobile)	8.60	10.00		X	X									
Great Lakes/ Lake Erie	7.75	9.00	X	X										
	50.00	58.00												

32

*Met. coal has 70% premium BTU coal plus 30% bituminous low sulfur coal.

SOURCE: ICE Task Force. (Reference 4).

TABLE II-5
COAL EXPORT PORT STATISTICS

Port Range	Port Name	Port Code	BEA	Capacity) (Millions of Tons)	Minimum Allowable Thruput*
North Atlantic	Philadelphia	PQ	15	9.0	0.1
	Baltimore	PR	17	23.1	9.1
South Atlantic	Hampton Roads	PS	22	59.8	33.6
Gulf	Mobile	PT	137	10.5	1.3
	New Orleans	PU	138	7.0	1.4**
	Myrtle Grove			3.0	
	Baton Rouge			2.0	
Pacific	Los Angeles/ Long Beach	PV	165	10.5	0.1
	Seattle	PW	155	12.5	0
Great Lakes	Cleveland	PX	68	19.0	12.0
	Toledo	PY	70	20.0	4.0

*Actual 1979 export coal tonnage, except for Cleveland and Toledo for which 1978 export Met. coal tonnage to Canada is shown.

**Total for BEA 138.

SOURCE: ICE Task Force (Reference 5).

TABLE II-6
EXPORT OF COAL BY PORT AND COAL PRODUCTION REGION-1985
(MILLIONS OF TONS)

	MT Coal			
	PS	PX	PY	PT
C1	3.647	0.840	—	—
C2	30.003	6.910	—	8.107
C3	—	—	—	0.493

	HL Coal				
	PS	PT	PU	PV	PW
C2	9.018	.499	.563	-	-
C3	1.002	.055	.063	-	-
C8	-	-	-	1.935	2.272
C9	-	-	-	1.693*	-
CA	-	-	-	-	-

	HH Coal					
	PQ	PR	PT	PU	PX	PY
C1	0.679	1.746	-	-	3.096	1.032
C2	0.150	0.385	0.569	0.642	0.682	0.227
C4	-	-	0.540	0.609	0.647	0.216

	ML Coal			
	PT	PU	PV	PW
C8	1.100	1.240	1.076	1.264

*NOTE: C9 does not serve Seattle.

TABLE II-7
EXPORT OF COAL BY PORT AND COAL PRODUCTION REGION-1990
(MILLIONS OF TONS)

MT Coal				
	PS	PX	PY	PT
C1	6.630	1.148	0.383	-
C2	32.370	5.602	1.867	9.600
C3	-	-	-	0.400

HL Coal					
	PS	PT	PU	PV	PW
C2	13.600	0.752	0.848	-	-
C3	3.400	0.188	0.212	-	-
C8	-	-	-	0.200	5.400
C9	-	-	-	3.900*	-
CA	-	-	-	0.500*	-

HH Coal						
	PQ	PR	PT	PU	PX	PY
C1	1.344	3.456	—	—	5.175	0.225
C2	0.060	0.140	0.300	0.100	2.100	1.725
C4	—	—	2.700	0.900	0.075	0.700

ML Coal				
	PT	PU	PV	PW
C8	1.880	2.120	1.840	2.160

*NOTE: C9 and CA do not serve Seattle.

Allocation of Coal Flows

The disaggregation of the regional production and consumption projections to the BEA level will produce the supply and demand vectors needed for the development of a 173 X 173 matrix, detailing the projected BEA-to-BEA flows. This matrix is generated by a linear programming model using a system known as MPS3 which obtains a minimum cost solution in the allocation of coal from coal-producing to coal-consuming BEAs.

The objective function of the LP is to minimize the costs of transportation of coal subject to the following constraints:

- (1) The sum of movements from all supply BEAs i to a demand BEA j must be equal to the demand in BEA j ;
- (2) The sum of all movements to demand BEAs j from a supply BEA i is equal to the supply in BEA i ;
- (3) The sum of all movements between BEAs i in MEFS region I and BEAs J in MEFS region J must equal the MEFS inter-regional flow $F_{I,J}$.

Mathematically, these constraints can be represented as:

$$\sum_i X_{i,j} = D_j \quad (2-14)$$

$$\sum_j X_{i,j} = S_i \quad (2-15)$$

$$\sum_{\substack{i \in I \\ j \in J}} X_{i,j} = F_{I,J} \quad (2-16)$$

where:

i = Supply BEA

j = Demand BEA

$X_{i,j}$ = Movement of coal from BEA i to BEA j
 I = Set of all BEAs in MEFS supply region I
 J = Set of all BEAs in MEFS demand region J
 $F_{I,J}$ = Movement of coal from MEFS region I to J

Because of round-off errors in the disaggregation model, it is not always true that total supply equals total demand and MEFS interregional flows always balance with supply and demand. For this reason, an additional term is added to the coal flows model which allows small deviations from the computed BEA supplies and demands to occur, thus allowing the model's equations to be solved. The same is true for the interregional flow constraints. These deviations are severely penalized in the LP objective function in order to keep them to their minimum possible levels. Typical values of these losses and gains are on the order of hundreds of tons compared to total supply and demand of hundreds of millions of tons. The revised model can be expressed as:

Find flows $X_{i,j}$ and total cost Z such that

$$Z = \text{Min.} \left\{ \sum_{i,j} C_{i,j} \cdot X_{i,j} + 10^{12} \sum_i (L_i + G_i) + 10^9 \sum_{(I,J)} (L_{IJ} + G_{IJ}) \right\} \quad (2-17)$$

where:

$$\sum_i X_{i,j} + G_j = D_j \quad (2-18)$$

$$\sum_j X_{i,j} - L_i = S_i \quad (2-19)$$

$$\sum_{\substack{i \in I \\ j \in J}} X_{i,j} - L_{I,J} + G_{I,J} = F_{I,J} \quad (2-20)$$

$$X_{i,j} \geq 0 \quad (2-21)$$

The transportation costs $C_{i,j}$ are input to the LP as a set of cost equations for inter-BEA movements of coal. The equations were derived by TERA using data published by the Interstate Commerce Commission (ICC) on rail rates between geographic regions for different types of movements (i.e., unit trains, multiple cars, trainloads, or single car). The rail cost equations developed by TERA are approximations of reality in terms of average tariffs and average mix of types of movement. A more rigorous delineation of the possible range of transportation costs among the 173 BEAs was beyond the needs of this project since the DOT network model considers transportation costs by mode in greater detail.

The following rail cost equations in 1978 dollars were used in the LP model:

- (1) For all movements from all BEAs ≤ 115 or from BEAs 134-138, to all other BEAs except 20-55 or 134-138, the transportation cost per ton (TCT) in dollars is:
TCT = 3.61 + .0034 X Distance.
- (2) For all movements from all BEAs ≤ 115 or from BEAs 134-138, to BEAs 20-55 or to 134-138: TCT = .84 + .0064 X Distance.
- (3) For all movements from all BEAs > 115 except 134-138, to all BEAs ≤ 115 or to 134-138: TCT = 2.82 + .0078 X Distance.

- (4) For all movements from all BEAs > 115 except 134-138, to all BEAs ≤ 115 except 134-138: $TCT = .699 + .0078 \times \text{Distance}$.

The derivation of these equations is more fully documented in Appendix D.

The output of the LP is a matrix of flows of coal by coal type between supply and demand BEAs.

Prediction of Modal Splits for the Allocated Flows

In order to provide the proper inputs to the network model used by the Department of Transportation to identify probable or possible constraints in the transportation network, one further step must be taken in the methodology. Each of the projected BEA-to-BEA coal flows must be allocated to modes. Intermodal transfers are not part of the algorithm. The modal shares derived by TERA are approximations principally based on historical data. They have been requested as a reasonable approximation to be used as the initial iteration of DOT's network model. This approximation is refined by DOT in subsequent iterations, thus solving for a final modal split.

TERA's methodology for predicting the approximate modal splits can be summarized as being composed of four basic steps:

- (1) For each identified BEA-BEA flow, the originating BEA is assigned to a single Bureau of Mines District and each destination BEA assigned to a single state.
- (2) Using this "BOM-State" pair as a proxy for the BEA-BEA pair, a historical split is determined as reported by the Bureau of Mines Bituminous Coal and Lignite Distribution Annual - 1976, Table 2.

- (3) This historical split is then examined as an indicator of a future split in terms of:
 - (a) potential for additional water competition if a water link is possible,
 - (b) potential for truck competition if the distance is short and the annual volume is small, and
 - (c) compatibility with regional split projections determined by TERA for DOE in previous studies.
- (4) As a result of the analysis in step (3), the historical split is adjusted and a new projected modal split for each BEA-to-BEA flow predicted.

This completes TERA's methodology for coal in the disaggregation model. Chapter III will present detailed descriptions of the actual programs and data sets used in this analysis.

Crude Oil and Refined Products Methodology

The overall method employed is similar to that used for coal. Regional production and consumption projections are first disaggregated to 173 BEAs. Next, BEA level production is allocated to BEA level consumption in a manner consistent with the MEFS interregional supply-demand balance. Finally, the BEA level flows thus obtained are assigned to modes of transport. Crude oil, non-pipeable products, and petroleum products capable of being transported by pipeline are each evaluated independently.

Crude Oil

The methodology developed is made up of the following four components: disaggregation of production, disaggregation of demand, allocation of supplies to demands, and modal splits. Each component is described separately in this section.

Disaggregation of Crude Oil Production. Figure II-2 shows the elements and the approach used to disaggregate crude oil production and imports to BEAs.

Inputs to the disaggregation are arrayed on the left of the figure and numbered 1 through 5. Inputs 2 and 5 are taken from the MEFS. Input element 2 is the interregional flows to be disaggregated. It is found in the transportation vectors produced by the MEFS, giving the amount of oil in thousands of barrels per day to be shipped from an oil region by type of oil. The sum of all oil shipped out of an oil region is equal to the region's production (element 7) (see Table II-8). Because the output of TERA's method was desired in tons per year, the regional flows (element 2) were converted to tons per year (element 6) using data on specific gravity by oil type (element 1) (see Table II-9). The data on specific gravity are part of the assumptions underlying the MEFS.

The information used to disaggregate regional production forecasts into BEA production forecasts is found in published data on proven reserves in 43 regions delineated by the American

TABLE II-8

MEFS 1985 CRUDE PRODUCTION BY REGION AND TYPE

SERIES H - ARC80 BASE CASE
 PRICE PATH : MEDIUM
 OIL IMPORT PRICE: 37.00
 RUN DATE: 11.07

DOMESTIC CRUDE REGIONAL PRODUCTION IN THOUSAND BARRELS PER CALENDAR DAY

NPC REGION	NEW DISCOVERIES	PRESENT RESERVES	INDICATED RESERVES	ENHANCED OIL RECOVERY	TOTAL
1S SOUTH ALASKA	19.2	59.5	60.1		138.8
1N NORTH SLOPE	52.0	1427.0			1479.0
2 PACIFIC COAST	354.1	323.0	74.2	439.0	1190.3
3 W. ROCKY MTHS.	122.5	47.5	2.0		172.0
4 E. ROCKY MTHS.	246.3	198.0	136.6	33.0	613.9
5 W.TEX.&E.N.MEX.	276.9	856.0	259.0	63.0	1454.9
6 W. GULF BASIN	379.2	760.8	295.9	83.2	1519.1
7 MIDCONTINENT	180.5	262.4	89.0	1.0	532.9
8-9-10 MI.BAS,INT,AP	59.0	100.7	67.5	5.0	232.2
11 ATLANTIC COAST	1.4	3.8			5.2
TOTAL ON-SHORE	1671.1	4038.7	985.1	624.2	7337.1
2A PACIFIC OCEAN	3.0	139.5	24.0		166.5
6A GULF OF MEXICO	128.7	292.3	104.7		525.7
11A ATLANTIC OCEAN	1.5				1.5
TOTAL OFF-SHORE	133.2	431.8	128.7		693.7
TOTAL CRUDE PRODUCTION	1804.3	4470.5	1113.8	624.2	7932.8
OTHER*					1392.7
TOTAL OIL PRODUCTION	1804.3	4470.5	1113.8	624.2	9425.5

*INCLUDES GAS LIQUIDS, BUTANE, SYNCRUDE AND SHALE

OLD OIL IS PRODUCTION FROM RESERVES PROVED PRIOR TO 1/1/78. NEW PRODUCTION IS FROM RESERVES ADDED AFTER 1/1/78.

TABLE II-9
SPECIFIC GRAVITIES OF OILS

Type	Specific Gravity (Bbls/Ton)
Crude	6.00 - 7.00 (6.50 Avg.)
Residual Oil	5.81
Distillate Fuel Oil	6.71
Gasoline	7.60
Jet Fuel	7.02
Kerosene	6.87

Source: EIA MEFS Model.

FIGURE II-2
CRUDE OIL PRODUCTION METHODOLOGY

Petroleum Institute (API)² and on past production at 173 BEAs developed by Oak Ridge National Laboratory.³

In order to be compatible with Oil regions as defined in the MEFS, data on reserves and production were broken down into counties. BEA level production in 1974⁴ was divided evenly among all the counties in the BEA (element 11) and summed to production regions (element 12). A proportion of regional production was computed for each county in the region (element 13). For each county which was assigned production in element 11, an equal share of reserves was given API reserve region (element 8). The reason for limiting reserves to those counties with past production is that some of the reserve regions are entire states or even more than one state in size. Therefore, the allocation of reserves to counties was made conservatively to avoid projecting future production in unlikely areas. The county level reserves are then summed over each MEFS oil region (element 9) and a relative proportion is computed for each county in the oil region (element 10). Although the uniform allocation of production and reserves to counties is arbitrary, when aggregated to oil regions this method permits oil region totals to be disaggregated in a manner which reflects the relative concentrations of reserves

²API, American Gas Association, Canadian Petroleum Association, Reserves of Crude Oil, Natural Gas Liquids and Natural Gas in the United States and Canada as of December 31, 1977, vol. 32, June 1978.

³P.L. Rice & D.P. Vogt, Energy Availabilities for State and Local Development: A Methodology and Data Overview, ORNL/TM-589, June 1977.

⁴Data used was taken from National Energy Transportation Study data base. Though more recent data may be available at this time, updating of the entire NETS data base was not called for in this work.

and production in different and overlapping subareas according to the best available information.

Among the outputs of the MEFS are oil production values for MEFS regions specified as to the vintage of the oil (element 5 in Figure II-2). The vintage of the oil refers to its initial development date. Oil fields developed before 1974 produce "old oil." This distinction is part of the two tier crude oil pricing system. For each oil region, a proportion of production between old oil and new oil was computed (element 14). Using the total production of oil by region (element 7) less the oil to be allocated directly to BEAs (element 15), the proportion that is new oil is divided among the counties in the same proportion as proven reserves (element 16) while the old oil is divided among the counties in the region in the same proportion as 1974 production (element 17). County production levels thus obtained are summed to the BEAs (element 18).

Some oil supplies may be allocated directly to BEA's due to their special nature (element 15). Imported oil is allocated to coastal areas based on which coast (East, Gulf or West) was specified in the MEFS output files (element 2). Four additional offshore BEAs were created to designate offshore import areas: BEA 174 is Canada; BEA 175 is East Coast; BEA 176 is Gulf Coast; and BEA 177 is West Coast. In each case, flows were computed from these pseudo-BEA's to ports or other border points. For example, in 1985 all of Canadian imports were received in BEA 94, the confluence of the Interprovincial and the Lakehead pipelines. Imports on the East

Coast are assigned to the ports of Boston, New York, Philadelphia, Baltimore, etc., according to the fraction of crude and oil products received in these ports in 1978. A similar allocation is made for Gulf and West Coast ports. Table II-10 shows the allocation fractions used for each port. Additional direct allocations shown in element 15 are the following:

- All of Alaskan crude oil production is allocated to BEA 172, the state of Alaska;
- Projected crude oil production offshore in the Atlantic Ocean is assumed to come from the Baltimore Canyon areas and to be shipped via pipeline and barge to refineries in BEAs 14 and 15 on the East Coast. These BEAs are specified as the origin BEAs for this oil;
- Oil produced offshore in the Gulf of Mexico is allocated to the Coastal BEAs 138, 139, and 140 in fixed proportions of .856, .139, and .005, respectively, based on historical patterns;⁵
- Oil produced offshore in the Pacific Ocean is allocated to BEA 165 where all of California offshore production has been brought ashore in the past;⁶
- Shale oil was allocated to existing and projected shale oil plants:⁷ the first 47 thousand barrels per day (MBD) to an existing plant in BEA 149, the next 125 MBD to proposed plants in BEA 151 scheduled for completion by 1985, and any additional volumes to proposed plants of no scheduled completion time in BEA 149;

⁵ Data on historical proportions obtained from the U.S. Geological Survey, the State of Louisiana Office of Conservation, and the DOE, Energy Data Reports.

⁶ State of California, State Lands Commission.

⁷ U.S. Bureau of Mines, Projects to Expand Energy Sources in the Western States, IC8772, 1978.

TABLE 11-10
IMPORTS OF CRUDE BY PORT BEA, 1985-1990

Refinery Region 1 - New England

<u>Port Code</u>	<u>BEA</u>	<u>1978 Fraction</u>	<u>1985 K-tons</u>	<u>1990 K-tons</u>
P5	001	.184	19,347	18,887
P7	002	.004	421	411
P0	014	.241	25,341	24,738
PQ	015	.571	60,039	58,613
R1 Total		<u>1.000</u>	<u>105,148</u>	<u>102,649</u>

Refinery Region 2 - Midwest

<u>Port Code</u>	<u>BEA</u>	<u>1978 Fraction</u>	<u>1985 K-tons</u>	<u>1990 K-tons</u>
PR	138	1.000	39,377	70,282
R2 Total		<u>1.000</u>	<u>39,377</u>	<u>70,282</u>

Refinery Region 3 - Gulf Coast

<u>Port Code</u>	<u>BEA</u>	<u>1978 Fraction</u>	<u>1985 K-tons</u>	<u>1990 K-tons</u>
PA	137	.057	3,675	2,053
PC	138	.085	5,481	3,061
PD	139	.042	2,708	1,512
PE	140	.272	17,539	9,795
PF	141	.406	26,179	14,620
PG	143	.138	8,898	4,970
R3 Total		<u>1.000</u>	<u>64,480</u>	<u>36,011</u>

TABLE II-10
IMPORTS OF CRUDE BY PORT BEA, 1985-1990 (CONT'D)

Refinery Region 6 - Atlantic Coast

<u>Port Code</u>	<u>BEA</u>	<u>1978 Fraction</u>	<u>1985 K-tons</u>	<u>1990 K-tons</u>
PR	17	.091	2,130	3,176
PT	22	.520	12,171	18,148
PU	24	.084	1,966	2,932
PW	33	.090	2,106	3,141
PX	34	.012	281	419
PY	35	.064	1,498	2,234
P1	37	.006	140	209
P2	38	.051	1,194	1,780
P6	39	.082	1,919	2,861
R6 Total		1.000	23,405	34,900

- Synthetic crude was assigned to BEAs with projected syn-crude plants:⁸ if the source of the coal for the syn-crude is Coal Region 8, the syn-crude is assigned to BEA 94; for Coal Region 4, the BEA is 114; and for Coal Regions 1 and 2, the BEA is 70.

Disaggregation of Crude Oil Consumption. Figure II-3 shows the elements and methodology used to disaggregate crude oil consumption to BEAs. Crude oil is "consumed" at refineries in the production of refined petroleum products. Projected crude oil receipts at refining regions are allocated to counties in proportion to current and anticipated refining capacity in the county.

The same output file from the MEFS used above for designating crude oil production at Oil Regions is used to designate receipts at Refining Regions (element 2). Using the same set of specific gravities by crude type (element 1), the total receipts are converted to tons per year (element 4) and summed for the entire MEFS Refining Region (element 5).

Refining capacity is projected by county for all counties in the United States based on existing refining capacity⁹ and planned additions to refining capacity¹⁰ (element 3). County level refining capacity is summed for all counties in a Refining Region (element 6) and relative proportions computed (element 7). Total

⁸Ibid., and . . . Projects to Expand Energy Sources in the Eastern States, IC8765, 1978.

⁹U.S. Department of Energy, Energy Data Reports: Petroleum Refineries, Annual, 1977

¹⁰U.S. Bureau of Mines, op. cit., IC8765 and IC8772.

FIGURE II-3

METHODOLOGY TO DISAGGREGATE REFINERY RECEIPTS OF CRUDE OIL

crude oil in each Refining Region (element 5) (see Table II-11) is then allocated to counties in proportion to refining capacity (element 8). County level receipts of crude oil are summed finally to BEAs (element 9).

Allocations of Crude Oil Origins to Destinations. Figure II-4 shows the elements and the methodology used to allocate crude oil shipments from BEAs to refinery receipts to BEAs in order to derive inter-BEA origin-destination flows of crude oil. The allocation of supplies to demands is accomplished through an LP program which minimizes the total ton-miles of oil shipped between BEAs. The objective function to be minimized is the linear function:

$$Z = \text{MIN} \sum_{i,j} C_{i,j} X_{i,j} + N \{ \sum L_i + \sum G_i \} + M \{ L_{I,J} + G_{I,J} \} \quad (2-21)$$

subject to:

$$L_i + \sum X_{i,j} = S_i \quad (2-22)$$

$$G_i + \sum X_{i,j} = D_j \quad (2-23)$$

where:

$C_{i,j}$ = The "cost" in terms of miles between supply BEA i and demand BEA j ;

$X_{i,j}$ = The flow of crude oil between supply BEA i and demand BEA j ;

N = A very large "cost" set equal to 10^9 ;

M = A very large "cost" set equal to 10^{12} ;

L_i and G_i are losses and gains in the constraint equations.

TABLE II-11

MEFS 1985 CRUDE DISTRIBUTION BY PRODUCTION REGION AND REFINERY DISTRICT

SERIES B - ARCO BASE CASE
 PRICE PATH : MEDIUM
 OIL IMPORT PRICE: 37.00
 RUN DATE: 11-07

CRUDE REGIONAL DISTRIBUTION SUMMARY IN THOUSAND BARRELS PER CALENDAR DAY

NPC REGION	SA	PAD1A	PAD1B	PAD2A	PAD2B	PAD3	PAD4	PAD5	TOTAL
DOMESTIC CRUDES:									
1S SOUTH ALASKA		25.0	25.0			125.0		1442.8	1617.8
1N NORTH SLOPE	1479.0								
2 PACIFIC COAST						236.8		953.5	1190.3
3 W. ROCKY MTHS.					34.6		138.2		172.8
4 E. ROCKY MTHS.				613.9					613.9
5 W.TEX.-E.N.MEX.				133.5	1321.4				1454.9
6 W. GULF BASIN				180.6		1338.5			1519.1
7 MIDCONTINENT				532.9					532.9
8-9-10 MI.BAS,INT,AP				232.2					232.2
11 ATLANTIC COAST			5.2						5.2
TOTAL ON-SHORE		25.0	30.2	1693.1	1356.0	1700.3	138.2	2396.3	7339.1
2A PACIFIC OCEAN								166.5	166.5
6A GULF OF MEXICO				525.7					525.7
11A ATLANTIC OCEAN		1.5							1.5
TOTAL OFF-SHORE		1.5		525.7				166.5	693.7
SHALE						5.0			5.0
SYNCRUDE									
TOTAL DOMESTIC CRUDE		26.5	30.2	2218.8	1356.0	1705.3	138.2	2562.8	8037.8
IMPORTED CRUDE	1812.5		416.8	701.2		1148.3	283.7		4422.6
TRANSHIPMENTS VIA NO. TIER PIPELINE									
TOTAL CRUDE	1897.0		447.0	2920.0	1356.0	2353.6	422.0	2562.8	12462.3

NOTE: ALASKA NORTH SLOPE CRUDE IS DELIVERED FIRST TO SOUTH ALASKA WHERE IT IS COMBINED WITH SOUTH ALASKAN CRUDE FOR DISTRIBUTION

TABLE II-11 (Continued)

MEFS 1985 CRUDE DISTRIBUTION BY PRODUCTION REGION AND REFINERY DISTRICT

SERIES B - ARC80 BASE CASE
 PRICE PATH : MEDIUM
 OIL IMPORT PRICE: 37.00
 RUN DATE: 11-07

CRUDE REGIONAL DISTRIBUTION SUMMARY IN THOUSAND BARRELS PER CALENDAR DAY (CONTINUED)

NPC REGION	PAD1A	PAD1B	PAD2A	PAD2B	PAD3	PAD4	PAD5	TOTAL
CO-PRODUCTS:								
1S SOUTH ALASKA								
1N NORTH SLOPE								
2 PACIFIC COAST							23.6	23.6
3 W. ROCKY MNS.				27.0	22.9			49.9
4 E. ROCKY MNS.				64.8				64.8
5 W.TEX.&E.N.MEX.				116.5	78.1			194.6
6 W. GULF BASIN					547.4			547.4
7 MIDCONTINENT				115.1	99.0			214.2
8-9-10 MI.BAS,INT,AP			53.5					53.5
11 ATLANTIC COAST		2.0						2.0
TOTAL ON-SHORE		2.0	53.5	323.4	747.4		23.6	1149.9
2A PACIFIC OCEAN							1.5	1.5
6A GULF OF MEXICO					236.2			236.2
11A ATLANTIC OCEAN	.1							.1
TOTAL OFF-SHORE	.1				236.2		1.5	237.8
TOTAL DOMESTIC CO-PRODUCTS	.1	2.0	53.5	323.4	983.6		25.1	1397.7

CO-PRODUCTS TOTAL INCLUDES 813.61 MB/CD BUTANE AND 569.11 MB/CD GAS LIQUIDS.

FIGURE II-4

ALLOCATION OF SUPPLIES TO DEMAND REGIONS FOR CRUDE OIL

S_i and D_j are supply at BEA i and demand at BEA j , respectively.

The losses and gains are dummy variables inserted to insure equality. The value of these variables will usually be driven to zero in the solution of the LP by the high cost given to them. If the sum of supplies at BEAs is not equal to the sum of demands at BEAs then L and G will equal the difference. This difference arises due to rounding errors in the disaggregation algorithm.

$L_{I,J}$ and $G_{I,J}$ are losses and gains in the constraint equation:

$$G_{I,J} - L_{I,J} + \sum_{\substack{i \in I \\ j \in J}} X_{i,j} = F_{I,J} \quad (2-24)$$

$F_{I,J}$ is the crude oil flow between MEFS oil Region I and refinery Region J (see Table II-11). The losses ($L_{I,J}$) and gains ($G_{I,J}$) for interregional flows similarly insure equality at every stage of the LP solution. These two are driven to zero in the "cost" minimization function by the high cost assigned to them. In the final solution these variables will be different from zero to the extent of rounding errors making the MEFS interregional supply-demand balance not equal.

Every BEA having one or more counties within a MEFS oil or refining region is assigned to that region giving the LP considerable flexibility in assigning inter-BEA flows to BEAs overlapping MEFS regions. Equations (2-22), (2-23), and (2-24)

constitute the constraint equations or conditions the solution must adhere to. Needless to say, the non-negativity constraint of $X_{i,j} \geq 0$ must also be met.

In Figure II-4 data inputs in elements 1 through 6 specify S_i , D_j and $F_{I,j}$ in the above equations. A matrix of BEA supply-demand constraints is set up for equations (2-22) and (2-23) (element 7). A reference table giving all BEAs overlapping a MEFS oil region or refining region, together with tables specifying the MEFS oil and refining regions having flows of crude oil and the amount of such flows, are combined to form a matrix of values for equation (2-24) (element 9). All that remains is to specify the "costs" in terms of miles for the inter-BEA flows. A table of coordinates for each BEA (element 2) plus an assignment of the external BEAs to coastal BEAs (element 3) are used to compute distances in element 8. Elements 7, 8, and 9 constitute the formal inputs to the linear program (element 10) which computes the inter-BEA flows (element 11).

Allocation of Flows to Modes of Transport. In Figure II-4 element 12 shows a modal allocation rule. The application of this rule results in the completed file of BEA by BEA flows of crude oil by mode of transport (element 13).

Since the selection of mode at this stage in the overall NETS effort is preliminary, the modal selection rule is rudimentary. The great majority of crude oil is shipped entirely by pipeline from origin to destination. Three broad regions of the

country were delineated for which pipeline interconnections are possible for all BEAs in the region having at least one pipeline passing through it. A matrix of dummy variables (1 or 0) was constructed for each BEA to designate the BEA as having a pipeline in it belonging to one or more of the three broadly interconnecting pipeline systems in the United States. If a BEA-to-BEA flow exists between BEAs connected in this way by pipeline or if a flow is from a BEA to itself for a BEA having a pipeline in it, then the flow is assumed to be shipped via pipeline.

Water transport is the second most significant form of transportation of crude oil. BEAs connected by a contiguous inland or coastal waterway are grouped together for possible water shipment between them. If pipeline shipment is not possible and water shipment is, then it is selected for all cases except where the movement is less than 50 miles in which case the mode is assumed to be truck. All inland waterway connections are by barge. Coastal water connections may be either by barge or by tanker. If the flow is greater than 400,000 tons per year or the distance greater than 500 miles, then the mode chosen is tanker. If it is less for both then it is barge. If none of the above apply (no pipe, no water and too far for truck) then railroad is chosen. These modal selection rules roughly replicate reality. They do not allow for intermodal transport nor fully simulate local circumstances. No account is taken of gathering pipelines, trucks or rail cars since only interregional movements are analyzed. However, the results obtained using this methodology constitute a useful starting point for the DOT network model which determines final modal choice on the basis of cost, capacity and other considerations.

Refined Products

Similar to coal and crude oil, the products part of the TERA NETS model is made up of the following four components: disaggregation of product supplies, disaggregation of product demands, allocation of supplies to demands and preliminary modal selection. Each component in the model is presented separately in this section.

Disaggregation of Production of Refined Products. Figure II-5 shows the elements and approach used to disaggregate total supplies at MEFS refining regions to BEAs. As with crude oil, the final values were desired as tons per year for two generalized product types: products capable of being shipped in a pipeline and products not so capable. The first product category includes all gasoline, jet fuels and middle distillates. The second category includes residual fuel oil only. Not included in the analysis are non-fuel petroleum products and liquified petroleum gases. MEFS regional flows from refining regions to demand and utility regions (element 2) are converted from thousands of barrels per day to millions of tons per year (element 4) using the specific gravity for each fuel type (element 1) assumed in the MEFS structure. Since the output data is in terms of interregional flows these must be summed for all products of each of the two general product types for each MEFS refining region (element 5) (see Table II-12).

The MEFS regional totals are disaggregated to BEAs in proportion to refining capacity in the BEA. A file of present and

TABLE II-12

MEFS 1985 REFINERY PRODUCTION BY REGION

 SERIES D - ARCO BASE CASE
 PRICE PATH : MEDIUM
 OIL IMPORT PRICE: 37.00
 RUN DATE: 11.07

REFINERY PRODUCTION SUMMARY IN THOUSANDS OF BARRELS PER CALENDAR DAY

MATERIAL	PAD1A	PAD1B	PAD2A	PAD2B	PAD3	PAD4	PAD5	DOMESTIC TOTAL	IMPORTS	SUPPLY TOTAL	RATIO TO TOTAL (DOMESTIC)
GASOLINE, ALL GRADES	959.4	206.0	1568.5	812.8	1208.9	217.8	938.3	5911.6	50.5	5962.1	.42
JET FUEL/ JET A	108.8	14.0	207.2	84.2	208.7	35.5	286.1	944.6	10.6	955.2	.07
LIQUID PET. GASSES	58.8	14.3	74.2	142.1	206.3	4.7	60.4	560.7	653.2	1213.9	.04
DISTILLATE, ALL GRADES	469.3	109.7	712.1	385.2	678.3	101.1	325.7	2801.1	55.1	2856.2	.20
RESIDUAL, ALL GRADES	221.3	56.8	54.5	15.8	341.4	15.3	476.6	1181.7	368.1	1549.8	.08
STILL GAS	54.7	12.9	102.5	47.6	97.6	13.7	103.8	432.7		432.7	.03
NAPHTHA	89.1	8.5	132.0	106.1	796.5	9.6	74.0	1215.7		1215.7	.09
OTHER REFINED PETROLEUM	38.7	45.1	260.1	99.6	224.8	40.5	389.9	1098.7	79.7	1019.0	.08
TOTAL	2000.1	467.3	3111.0	1693.3	3782.2	438.2	2654.7	14146.7	1057.7	15204.4	1.00
DOMESTIC CRUDE INPUT	26.5	39.2	2218.8	1356.0	1705.3	138.2	2562.8	8037.8		8037.8	
IMPORTED CRUDE INPUT	1972.5	416.8	701.2		1148.3	283.7			4422.6	4422.6	
TOTAL CRUDE INPUT	1899.3	447.0	2920.0	1356.0	2853.6	422.0	2562.8	8037.8	4422.6	12460.3	

FIGURE II-5

DISAGGREGATION OF PETROLEUM PRODUCT SUPPLIES

projected refining capacity by county was assembled from DOE and Bureau of Mines Data (element 3).¹¹ County proportions of regional refining capacity (element 6) are computed in element 7 and used to allocate domestically produced refined products to counties (element 9) for each of the two product types. These are then summed to BEA's (element 10). Imported products are allocated directly to coastal BEA's (element 8) based on MEFS assumptions and historical receipts at ports.¹² (See Tables II-13 and II-14.)

Disaggregation of Consumption of Refined Products. Figure II-6 shows a schematic of the logic flow for disaggregating four petroleum products to BEAs. The inputs to the disaggregation algorithm are numbered 1 through 9. The algorithm relies heavily on surrogate variables highly correlated to demand for specific products. It is also segmented into demands for four products by four sectors of the economy. The four products are:

- Gasolines
- Jet Fuel
- Distillate fuel oil, and
- Residual fuel oil

¹¹U.S. Department of Energy, Energy Data Reports, Petroleum Refineries, Annual, 1977 and U.S. Bureau of Mines, op. cit., 1C8772 and 1C8765.

¹²U.S. Army Corps of Engineers, Waterborne Commerce of the United States, Vicksburg, Miss., 1978.

TABLE II-13
IMPORTS OF PIPEABLE PRODUCTS BY PORT BEA, 1985-1990

Demand Region 1 - Northeast

<u>Port Code</u>	<u>BEA</u>	<u>1978 Fraction</u>	<u>1985 K-tons</u>	<u>1990 K-tons</u>
P5	001	.097	579	594
P7	002	.079	472	484
P8	004	.557	3,328	3,411
P9	005	.226	1,350	1,383
PO	014	.041	245	251
D1 Total		1.000	5,974	6,123

TABLE II-14
IMPORTS OF NON-PIPEABLE PRODUCTS BY PORT BEA, 1985-1990

Demand Region 1 - Northeast

<u>Port Code</u>	<u>BEA</u>	<u>1978 Fractions</u>	<u>1985 K-tons</u>	<u>1990 K-tons</u>
P5	001	.158	2,555	1,503
P7	002	.078	1,261	742
P8	004	.617	9,977	5,869
P9	005	.068	1,099	647
PO	014	.079	1,277	751
D1 Total		1.000	16,169	9,512

Demand Region 2 - New York-New Jersey

<u>Port Code</u>	<u>BEA</u>	<u>1978 Fractions</u>	<u>1985 K-tons</u>	<u>1990 K-tons</u>
PO	014	1.000	6,956	7,097
D2 Total		1.000	6,956	7,097

Demand Region 3 - Md. Atlantic

<u>Port Code</u>	<u>BEA</u>	<u>1978 Fractions</u>	<u>1985 K-tons</u>	<u>1990 K-tons</u>
PQ	015	.292	-	1,876
PR	017	.152	-	977
PS	018	.139	-	893
PT	022	.417	-	2,679
D3 Total		1.000	-	6,425

TABLE II-14
IMPORTS OF NON-PIPEABLE PRODUCTS BY PORT BEA, 1985-1990 (CONT'D)

Demand Region 4 - South Atlantic

<u>Port Code</u>	<u>BEA</u>	<u>1978 Fractions</u>	<u>1985 K-tons</u>	<u>1990 K-tons</u>
PU	024	.111	-	83
PV	031	.164	-	123
PW	033	.154	-	116
PX	034	.249	-	187
PY	035	.074	-	56
PZ	036	.129	-	97
P1	037	.114	-	86
P2	038	.002	-	1
PA	137	.003	-	2
D4 Total		1.000	-	751

The four sectors are:

- Utility
- Transportation
- Residential/Commercial and
- Industrial

The MEFS output files are examined to obtain regional totals of fuels by sector. The transportation sector shows shipments of fuels by type to utility regions (element 4). The other sectors are given in a demand vector giving fuel type, sector and amount used for each demand region (element 3). These are kept separate and converted to tons per year (element 12) using specific gravities assumed in the MEFS (element 2) and accumulated only for residential and commercial sectors (element 13). These are the totals to be disaggregated. The disaggregation of utility demands are handled somewhat differently than the other sectors. Disaggregation to each sector are described separately below.

(1) Utility. Utilities consume only distillate and residual fuel oils in the MEFS output files. These are used as boiler fuel for generating electricity. They were allocated to counties (element 20) in each utility region in proportion to the generating capacity of plants¹³ using these respective fuels (elements 1, 10 and 11).

¹³Federal Energy Regulatory Commission, Form 12 File, (Computer).

FIGURE II-6

DISAGGREGATION OF PETROLEUM PRODUCT DEMANDS

(2) Transportation. All fuel types are used in the transportation sector. The allocation of each is made on a two tier estimating procedure, the second tier of which relates county demands for a given fuel to demographic and economic data correlated to final demand. The first tier allocation procedure is the same for all remaining sectors. Historical data on demand for fuel by states by sector¹⁴ was used to allocate MEFS demand region totals to states. MEFS demand regions are made up of several states and are contiguous with state boundaries (elements 5, 14, and 15). The proportion by state of each fuel type used for transportation is applied to the regional totals to complete the first tier allocation (element 23).

The state total for each of the transportation fuels is allocated to counties in the following manner:

- gasoline is allocated based on proportion of projected county population¹⁵ (elements 6, 7, 16, 19, 24, 25, 30);
- jet fuel is allocated based on proportion of projected county commercial airline activity at airports¹⁶ (elements 9, 22 and 29);
- distillate fuel oil (diesel oil) is allocated based on county wholesale and retail trade projections¹⁷ (elements 6, 7, 16, 17, 18, 19, 24, 27 and 31).

¹⁴U.S. Bureau of Mines, Fuels and Energy Data; United States by States and Census Divisions, 1974, IC8739, 1977.

¹⁵U.S. Bureau of the Census, City County Data Book, 1972, and Water Resources Council, 1972 OBERS Projections (at BEAs).

¹⁶Federal Aviation Administration, Terminal Area Forecasts 1979-1990, FAA-AVP-78-6, 1978.

¹⁷U.S. Bureau of the Census, op. cit., and Water Resources Council, op. cit.

- Residual fuel oil (bunker and railroad fuel) is allocated to counties with ports in proportion to historical port tonnage¹⁸ in states with ports and in states without ports to counties with refineries in proportion to refining capacity.¹⁹ The latter is done on the reasoning that due to its high viscosity residual oil is not shipped very far except by water and a state without ports cannot ship by water.

(3) Residential/Commercial. Only distillate and residual fuel oils are demanded in these two sectors. The sectors are combined because they are combined in the Bureau of Mines state consumption data²⁰ used in the first tier disaggregation to states. State level totals (element 23) for distillate is disaggregated to counties (element 31) based on projected county population (element 25). This was done in view of the preponderance of residential demand for heating oil. On the other hand, very little residual fuel oil is used for space heating at residences so that such use is assumed to be correlated to commercial activity. Thus, state level totals for residual oil (element 23) were allocated to counties (element 33) based on projected county wholesale and retail trade²¹ (element 27). Only counties on the waterway or having a refinery were permitted an allocation of residual fuel oil due to the preponderance of water shipments of this fuel.

¹⁸U.S. Army Corps of Engineers, op. cit.

¹⁹U.S. Department of Energy, Energy Data Reports, Petroleum Refineries Annual 1977.

²⁰Op. cit.

²¹Op. cit.

(4) Industrial. Industrial demands for both distillate and residual fuel oil are disaggregated in the first tier to states in the same way as transportation and residential/commercial demand. At the second tier state demands for these two products (element 23) are allocated to counties (element 32) based on projected earnings in manufacturing²² (element 26). As above, only counties on a waterway or counties having a refinery are permitted an allocation of residual fuel oil.

Finally, county level demands for each fuel for each sector are summed to BEAs preserving only a distinction between pipeable and non-pipeable petroleum products (element 35).

Allocation of Petroleum Product Origins to Destinations. Figure II-7 shows the logic flow for the LP allocation of supplies to demands. The procedure is the same as explained for crude oil except that pipeable and non-pipeable products are handled separately. The program inputs are listed in elements 1 through 6. Preprocessors set up the LP matrices of constraints in elements 7, 8 and 9. Element 10 applies the LP algorithm and 12 shows the solution.

Allocation of Flows to Modes of Transport. The modal allocation rule differs for pipeable and non-pipeable products. As with

²²U.S. Bureau of the Census, op. cit.

FIGURE II-7

ALLOCATION OF PETROLEUM PRODUCTS

crude oil, the modal selection is preliminary with reference to the final NETS conclusions.

(1) Pipeable Products. The modal selection for pipeable products is similar to crude oil except that pipeline is not always chosen when available. If the flow moves less than 50 miles and is less than 500 thousand tons per year, then the mode is truck. If water transportation is available it is chosen. A matrix of BEAs connected by barge and a matrix of BEAs connected by tanker determine the water mode chosen. If none of the above conditions are met, then pipeline is chosen.

(2) Non-pipeable Products. By definition no pipeline transport is used. Water transportation is clearly the dominant form for transport of residual fuel oil due to its high viscosity. The disaggregation method permits residual fuel oil to be allocated only to counties on the water or having a refinery; allocation for utilities, however, is based on historical usage. Therefore, a high degree of water usage is expected for the interregional flows. Water transport is selected wherever available except for intra-BEA movements which are shipped via truck. The same matrices of barge and tanker BEAs are used to select the proper water mode. Any movement not local or not possible by water is assigned to railroad.

CHAPTER III

COMPUTER IMPLEMENTATION OF DISAGGREGATION METHODOLOGY

CHAPTER III

COMPUTER IMPLEMENTATION OF DISAGGREGATION METHODOLOGY

General Introduction to System

In the TERA implementation of the computerized disaggregation system, a general two-way division occurs for each of the two commodity classes (coal and oil). This division is between the preliminary data processing stage which is called the "specification" stage and the production processing stage which is referred to as the "operational model" or, simply, the "model."

The specification stage basically involves all manual and computer programming steps which have reduced a variety of raw data into a form which is directly usable by the model for new scenario runs. This stage includes the running of regression equations, estimation of statistical parameters, manipulation of other raw data to create files of subregional share factors, estimation of pipeline capacities, efficiencies, and costs, and so on. This is all the calculation which precedes the running of scenarios and which does not have to be repeated as each new scenario is run. In other words, it is very cost-effective to make additional scenario runs since the high front-end costs have already been committed.

The operational model, on the other hand, is the set of all programs and data sets which are needed in order to run each new scenario, with the exception of the input data which represents the actual scenario itself. The latter is the final piece which is needed to run the model and is different for each scenario.

The primary differences between the computer methodology for the three different energy types are found in the specification state. This is primarily due to the fact that the input data for each of the three energy types is different. On the other hand, the operational models for each energy type are similar to each other. In general, each of the three models follow the same basic pattern:

- retrieve MEFS solution file;*
- convert MEFS solution file into new format;
- adjust solution files using ICE Task Force assumptions (coal only);
- disaggregate MEFS solution file to BEAs;
- compute Origin-Destination (or network) flows; and
- compute modal shares for each flow.

A final step involves the consolidation of the results for these models onto magnetic tapes for delivery to DOE. These steps are described more fully in the following sections.

Coal

Specification Routine

The purpose of the coal specification routine is to compute county share factors for future production and consumption of coal. These share factors are then used by the coal disaggregation model to compute future county production and consumption and to aggregate these to the BEA region level.

In the coal specification routine developed by TERA, coal consumption shares are computed separately for non-utility and

*Note that these data are input directly from MEFS solution file in order to by-pass the problems associated with keypunching MEFS output report data into a data set, proofing it, etc.

utility uses. These and the production share methodology routines are discussed below.

(1) Production Shares

Figure III-1 shows the program and data flow for the production shares specification routine.

In this figure, oval boxes (COAL and COUNTY) represent basic input data sets, while hexagons (COLFIL, PFCOAL, and PFCOAL2) represent intermediate and final outputs. It should be noted that intermediate outputs are also inputs to the next level of programs.

Rectangles represent programs which operate on the input data sets to produce intermediate or final outputs. In this figure two names are given to each program. The first name is the name of the control program containing all Job Control Language (JCL) necessary to execute that step. The program is run from SUPERWYLBUR by submitting it to the batch processor.

The second name in the rectangle is that of the program file itself. This may be a SAS or FORTRAN IV or MPS3 program. In Figure III-1 all programs are SAS. Thus, CJCL is the program run by the user to convert the basic COAL file into the first intermediate file called COLFIL. CJCL calls the SAS program named FCOAL to actually do the conversion. Next, TJCL is called by the user to convert COLFIL further into PFCOAL. TJCL uses the SAS program PFCOAL. Finally, the user calls PFC2JCL to

create the final production share file PFCOAL3. PFC2JCL operates with both PFCOAL and the county record file COUNTY using the SAS program PSSHARE to generate the PFCOAL3 file.

FIGURE III-1
COAL PRODUCTION SHARES SPECIFICATION ROUTINE

(2) Non-Utility Consumption Shares

In Figure III-2 the program and data flow for the non-utility demand sector is presented.

In this figure, the circle represents the EPA point source data tapes. These are processed into the PTFIL data file on the TERA NETS account by the PTJCL control program (which uses the

FIGURE III-2
NON-UTILITY CONSUMPTION SHARES

FPNT program to do the computations.) This data file is further refined by the FPTJCL program. Codes representing counties in the resulting file PTFILL are then changed to FIPS codes using the FIPJCL program and FIPEPA data set. The outcome of the processing is the PTGOOD file. Entries in this file show the county-by-county non-utility consumption of coal for each coal type. This data is normalized to Bureau of Mines non-utility coal consumption by state using the FXCOLJCL program. The resulting file PTGOODX is then operated on by SHRZZJCL to compute final consumption shares for each county in each state. These shares are stored in the file CSHAREZZ.

(3) Utility Consumption Shares

In Figure III-3 the utility consumption share program and data flow are presented. The input file F12FIL of utility capacity by fuel type is first used by SCJCL to extract coal fired capacity and to estimate this capacity for 1985 and 1990. This is stored in the intermediate data set COL85 (or COL90). This is further modified by COLJCL to produce COLFIX. The basic county record file COUNTY and COLFIX are used finally by CUSJCL to compute county consumption shares of each DOE region. The output file CUSHR85 (and CUSHR90) are then ready for use by the coal disaggregation routine.

FIGURE III-3
UTILITY COAL CONSUMPTION SHARE SPECIFICATION ROUTINE

Scenario Generator Routine

The purpose of this routine is to provide the disaggregation methodology with each MEFS forecast in a format appropriate to further processing. This is necessary because the MEFS solution is not, in itself, in such a useable form. Figure III-4 shows the program and data flow for this routine.

Using the TSO program called IPERUSE, portions of the MEFS solution file are extracted into two files: case.DATA and case.COEFF.DATA (Case is the generic name for the MEFS scenario selected). These files are used as inputs by the program CONVERT.PIES.COAL.CLIST, a SUPERWYLBUR macro-program which calls the FORTRAN-IV program CONVERT.PIES.COAL.CNTL. The output file generated by this program is called: case.PICOAL.DATA .

This file is then manually adjusted to integrate the ICE Task Force's coal export assumptions into the new scenario. The resulting data file is called ICE85M or ICE90M, depending on the year of the forecast.

FIGURE III-4
COAL SCENARIO GENERATOR ROUTINE

Coal Forecasting Routine

This routine, or set of routines, uses the results from the specification routines (which are constant from scenario to scenario for a given year) and the scenario generator as inputs to compute forecasts of coal production, distribution, and consumption by BEA for the forecast year.

Figure III-5 shows the program and data flow for this routine. First the production, non-utility consumption, and utility consumption shares data sets (PFCOAL3, CSHAREZZ, CUSHR85 (90)) are combined with the MEFS forecast as stored in case.PICOAL.DATA and

FIGURE III-5
COAL FORECASTING ROUTINE

operated on by DISAGG.COAL.CLIST to produce the BEA level supply/demand files (case.SUPDEM.ctype.DATA). In these files (nine in all) ctype refers to coal type. The nine coal types are HH, HM, HL, MH, MM, ML, LL, LG, and MT. In the first seven types the first letter refers to BTU content (High, Medium, or Low), the second to sulfur content (also High, Medium, Low). The eighth type is lignite, the ninth, premium grade coal.

Next, the NETS.COAL.FLOWS.MODEL operates on the supply/demand files and the ctype.TABLES.DATA file which contains BEA coordinates and geographical information translating DOE regions into BEAs. This produces the minimum cost origin-destination flow matrix from BEA to BEA which also satisfies the MEFS inter-regional flow constraints. This data is stored in nine files labelled: ICE85M.ctype.DATA (or ICE90M.ctype.DATA).

Finally, the coal modal split routine COL.MODSPLIT.CLIST operates on these flow data sets to produce the final flows by mode data sets in ICE85M.ctype.COAL.MODAL (e.g., ICE85M.HHCOAL.MODAL).

These data sets are now ready to be combined for transfer to output tapes for further use by DOE and DOT.

Crude Oil and Refined Petroleum Products

Specification Routine

In the case of crude oil and petroleum products the specification routine is highly intertwined with the disaggregation programs. While the coal methodology described above separates the specification of production and consumption shares (done once)

from the disaggregation of individual MEFS scenarios, the oil and products methodology computes these shares each time the disaggregation program is run. Thus the computation of these factors can be considered as a subroutine or subfunction of the disaggregation programs described below.

Figure III-6 shows how the NETS scenario generation works for the oil model.

NETS Oil Forecasting Routine

Figure III-7 shows the program and data flow for the NETS oil forecasting routine.

The first step in this routine involves combining the MEFS scenario as represented in the three data sets: case.PIES, case.VINT, and case.SECT with the basic data base of oil and products production, reserves, consumption, characteristics, etc., contained in the large rectangle at the upper right in the figure. This is accomplished by DISAGG.OIL.CLIST and produces for crude oil (CRUDE), non-pipeable products (NPRD) and pipeable products (PPRD) two data sets: SUPDEM and IRFLOWS. SUPDEM contains the disaggregated BEA level supply and demand values and IRFLOWS contains the MEFS interregional flows. The IRFLOWS files are manually adjusted to account for detailed BEA level imports according to historical Waterborne Commerce statistics.

These data are operated on by NETS.OIL.FLOWS.MODEL to produce minimum cost origin-destination flows which satisfy interregional flow constraints. These outputs are contained in the ICE85M.type.DATA and ICE90M.type.DATA files.

Finally, these data are used by the OIL.MODSPLIT.CLIST routine to produce flows by mode and to store them in the ICE85M.type.MODAL and ICE90M.type.MODAL files.

FIGURE III-7
OIL AND PRODUCTS FORECASTING ROUTINE

Output Files and Tapes

Coal, Crude Oil and Petroleum Products

All commodities other than natural gas are included in the DOT network model. Thus, the next step in TERA's procedures is to convert the coal, oil and products flows by mode files into a common format in a single file for each scenario (see Table IV-1, next chapter). This file is then written to a tape for transmittal to DOE. To check the accuracy of the tape data, the tape data is written back to a permanent file on TERA's NETS account and is printed offline for visual inspection.

In Figure III-8 the coal and oil output files are combined and recorded by the CACI2JCL routine using the FCACI2 FORTRAN program. The resulting file is called case.CACITAPE. This then written onto a tape using UPTAPE.CLIST. The data set on that tape is cataloged as : case.TAPE. This data set is rewritten to the file case.DISK where it is compared with case.CACITAPE for transmittal errors, etc. This is then printed for DOE.

The format for each record of the disk and tape files is identical. Each record has five fields separated by one or more blanks. These fields represent the commodity code, the origin BEA, the destination BEA, the mode code, and the annual flow in thousands of tons. See Chapter IV for more details about each code.

The tape is written in fixed, blocked records of 80 bytes each on an 800 BPI 9 track non-labeled tape. The format of each record is (I2, 9X, I3, 4X, I3, 4X, I1, 4X, I10).

FIGURE III-8
COAL AND OIL OUTPUT FILE ROUTINE

Note: "Case" is ICE85M or ICE90M.

CHAPTER IV

RESULTS

CHAPTER IV. RESULTS

In this section samples of results generated using TERA's disaggregation methodology are presented. These results demonstrate application of two separate report programs developed specifically for this study.

The first report writer produces a set of tables containing the detailed O/D flows by commodity and transportation mode for each case. The two cases run, of course, were the 1985 and 1990 snapshots for EIA's 1980 are medium world oil price scenario. Table IV-1 shows an excerpt from the detail table for 1990 inter-BEA flows. This table is ordered according to commodity and origin. Thus, all commodity 3 (pipeable petroleum products) O/D/M (origin to destination by mode) flows are grouped together at the beginning of the table and all O/D/M flows for commodity 3 and origin 15 are all grouped together within the commodity 3 group. Flows in this table are given in kilotons.

Tables IV-2 and IV-3 give the commodity code and mode code translations necessary to interpret the O/D/M tables generated in this study. Origin and destination BEA codes, of course, correspond to the 173 BEA region codes in use by the Department of Commerce, Bureau of Economic Analysis, prior to 1980.

Similar tabulations to Table IV-1 have been produced and delivered to DOT and DOE for intra-BEA flows and total BEA to BEA flows by commodity and origin, and by commodity and destination (e.g., see Table IV-4).

TABLE IV-1
EXCERPT FROM TABLE
ICE 1990 MEDIUM - INTERBEA FLOWS PAGE 1

SORT BY COMMODITY AND ORIGIN

CCMM CODE	ORIGIN BEA	DEST BEA	MODE CODE	ANNUAL K-TONS
3	1	3	6	593
3	2	1	6	143
3	2	14	6	13481
3	2	16	6	893
3	4	14	6	4371
3	5	1	6	597
3	5	3	6	669
3	5	4	6	117
3	6	15	6	702
3	7	6	3	3250
3	7	8	3	259
3	9	7	3	3737
3	9	25	6	561
3	10	5	6	1895
3	14	2	6	2064
3	14	4	6	13862
3	14	5	6	838
3	15	5	6	3625
3	15	8	6	3065
3	15	14	6	8884
3	15	18	6	7218
3	15	25	6	2698
3	15	44	6	2654
3	17	26	6	2130
3	17	45	6	2343
3	17	48	6	1388
3	22	44	6	6053
3	24	44	6	305
3	26	26	6	1816
3	26	27	6	197
3	26	34	3	3359
3	26	42	6	1041
3	27	27	6	385
3	28	27	6	308
3	40	15	6	1767
3	40	35	6	37
3	44	137	6	128
3	45	15	6	338
3	45	33	6	143
3	52	20	6	207
3	52	77	6	7268
3	52	88	6	513
3	53	77	6	1211
3	55	35	6	976
3	55	39	3	911
3	55	41	3	1020
3	55	43	3	997

TABLE IV-2
COMMODITY CODES

<u>Code</u>	<u>Commodity</u>
3	pipeable petroleum products (gasoline, jet fuel, distillate)
4	non-pipeable products (residual oil)
9	crude oil
21	premium coal
22	bituminous, medium sulfur coal
23	midbituminous, medium sulfur coal
24	bituminous, low sulfur coal
25	midbituminous, high sulfur coal
26	subbituminous, low to medium sulfur coal
27	bituminous, high sulfur coal
28	lignite
29	midbituminous, low sulfur coal
31	premium coal (export)
34	bituminous, low sulfur coal (export)
37	bituminous, high sulfur coal (export)
39	midbituminous, low sulfur coal (export)

Note: Coal type 31 is the same as type 21 in terms of BTU content and sulfur content. Same for 24 and 34; 27 and 37; 29 and 39.

TABLE IV-3

MODE CODES

<u>Code</u>	<u>Transportation Mode</u>
1	Railroad
2	Truck
3	Barge
4	Deepdraft
5	Crude Pipeline
6	Products Pipeline

TABLE IV-4
EXCERPT FROM TABLE
ICE 1990 MEDIUM - INTERBEA FLOWS PAGE 1

SORT BY COMMODITY AND DESTIN

COMM CODE	ORIGIN BEA	DEST BEA	MCDE CODE	ANNUAL K-TONS
3	2	1	6	143
3	5	1	6	597
3	175	1	4	593
3	14	2	6	2064
3	175	2	4	483
3	1	3	6	593
3	5	3	6	669
3	5	4	6	117
3	14	4	6	13862
3	175	4	4	3410
3	10	5	6	1895
3	14	5	6	838
3	15	5	6	2625
3	175	5	4	1383
3	7	6	3	3250
3	9	7	3	3737
3	7	8	3	259
3	15	8	6	3065
3	142	9	6	132
3	143	9	6	2226
3	141	10	6	1006
3	137	11	6	810
3	141	12	6	1659
3	124	13	6	863
3	125	13	6	439
3	141	13	6	197
3	2	14	6	13481
3	4	14	6	4371
3	15	14	6	8884
3	175	14	4	251
3	6	15	6	702
3	40	15	6	1767
3	45	15	6	338
3	120	15	6	1178
3	136	15	6	563
3	139	15	4	2097
3	2	16	6	893
3	129	16	6	11
3	140	16	3	2784
3	119	17	6	525
3	140	17	4	2064
3	145	17	6	2049
3	15	18	6	7218
3	119	19	6	895
3	52	20	6	307
3	64	20	6	128
3	68	20	6	668

Tables IV-5A and IV-5B present a summary of the tabulation for all BEA-to-BEA flows in 1985 and 1990. This summary shows total flows by commodity by mode and for all coal. The right-most column gives total flows by commodity for all modes. These figures can be compared against EIA's tabular outputs for coal production tonnages in order to validate the disaggregation method. This comparison is displayed in Tables IV-6A and IV-6B.

The second basic report generator developed for this study produces tabulations of O/D/M flows by state, by type of flow (inter- vs. intra-BEA), and by coal end-use (steam or met). Thirty-six tables are produced by this report writer. The first twelve are for inter-BEA flows, the next dozen for intra-BEA flows, and the final twelve are for all flows.

Within each group of twelve, the first four concern domestic flows, the next four exports, and the final four total (domestic plus exports). Finally, each group of four consists of steam coal flows by origin, metallurgical coal flows by origin, steam coal flows by destination, and metallurgical coal flows by destination.

Tables IV-7 through IV-14 show excerpts of the first eight tables for 1990. The remaining 28 tables are easily generalized from these eight. Things to note in these tables are:

- 1) Tonnages are listed both annually and daily.
- 2) Heat values (in billions of Btu's annually and millions of Btu's daily) are also given. These are calculated using EIA heat values for each coal type (see Table IV-15).
- 3) Subtotals by BEA and state are given.

TABLE IV-5A

BEA-BEA COMMODITY/MODE SUMMARY (ANNUAL K-TONS) - 1985 MEDIUM

COMM	RAIL	TRUCK	BARGE	DEEFDRAFT	CRUISE PIPE	PROD PIPE	TOTAL
3	0	61856	91463	40070	0	292486	499675
4	14745	16914	20679	44350	0	0	96688
9	0	32926	2034	70270	676206	0	781436
21	100529	2721	4949	0	0	0	103099
22	187524	16875	17890	0	0	0	<u>222279</u>
23	38421	637	1910	0	0	0	40368
24	42245	815	2540	0	0	0	45600
25	131981	10824	15375	0	0	0	158180
26	144942	756	0	0	0	0	145698
27	70784	10555	2831	0	0	0	84170
28	70124	11052	0	0	0	0	81176
29	55403	3709	17	0	0	0	59129
31	34493	501	0	0	0	0	34994
34	30165	478	1427	0	0	0	32070
37	10348	330	0	0	0	0	11178
39	4670	0	0	0	0	0	4670
COAL	922129	59253	46229	0	0	0	1027611

TABLE IV-5 B

BEA-BEA COMMODITY/MODE SUMMARY (ANNUAL K-TONS) - 1990 Medium

IM	RAIL	TRUCK	BARGE	DEEPDRAFT	CRUDE	PIPE	PROD	PIPE	TOTAL
3	0	45140	62751	27744	0	356228			491863
4	20930	28112	15203	30777	0	0			95022
5	0	4267	2183	184350	596392	0			787192
11	101555	8094	4883	0	0	0			114932
12	204492	10810	7018	0	0	0			222320
13	48186	715	125	0	0	0			49076
14	55944	841	554	0	0	0			57339
15	166608	14850	11543	0	0	0			193001
16	226361	3158	0	0	0	0			229519
17	120399	4101	5971	0	0	0			130471
18	191887	20780	3950	0	0	0			216617
19	67202	699	17	0	0	0			67918
21	36507	714	3359	0	0	0			40580
24	45619	768	0	0	0	0			46387
27	18783	65	112	0	0	0			18960
29	7983	0	0	0	0	0			7983
ALL	1291926	65595	37532	0	0	0			1395053

TABLE IV-6A
 VALIDATION OF DISAGGREGATION METHOD - 1985
 ANNUAL FLOWS IN K-TONS

<u>Commodity</u>	<u>EIA-ICE*</u>	<u>Table IV-5A</u>	<u>Difference</u>	<u>Explanation</u>
21	108,230	108,099	131	round-off-errors
22	222,390	222,279	111	round-off-errors
23	40,440	40,368	72	round-off-errors
24	45,670	45,600	70	round-off-errors
25	161,490	158,180	3,310	mine mouth coal gasi- fication
26	145,690	145,698	8	round-off-errors
27	86,325	84,170	2,155	mine mouth coal gasi- fication
28	86,480	81,176	5,304	mine mouth coal gasi- fication
29	59,200	59,129	71	round-off-errors
31	35,000	34,994	6	round-off-errors
34	32,100	32,070	30	round-off-errors
37	11,220	11,178	42	round-off-errors
39	4,680	4,670	10	round-off-errors

*ICE Task Force coal export assumptions were substituted for EIA's. EIA's were 59,500 for commodity 31 and 15,915 for commodity 37. Another 9,585 K-tons of export coal were reported in EIA's import summary table for steam coal, but could not be found in the solution files.

TABLE IV-6B
VALIDATION OF DISAGGREGATION METHOD - 1990
ANNUAL FLOWS IN K-TONS

<u>Commodity</u>	<u>EIA-ICE*</u>	<u>Table IV-5</u>	<u>Difference</u>	<u>Explanation</u>
21	115,030	114,932	98	round-off-errors
22	222,410	222,320	90	round-off-errors
23	49,090	49,026	64	round-off-errors
24	57,420	57,339	81	round-off-errors
25	207,640	193,001	14,639	mine mouth coal gasification
26	242,900	229,519	13,381	mine mouth coal gasification
27	130,530	130,471	59	round-off-errors
28	240,940	216,617	24,323	mine mouth coal gasification
29	67,990	67,918	72	round-off-errors
31	40,600	40,580	20	round-off-errors
34	46,400	46,387	13	round-off-errors
37	19,000	18,960	40	round-off-errors
39	8,000	7,983	17	round-off-errors
TOTAL COAL	1,447,950	1,395,053	52,897	primarily mine mouth gasification

*ICE Task Force coal export assumptions were substituted for EIA's.
EIA's were 70,200 for commodity 31 and 37,800 for commodity 37.

TABLE IV-7

EXCERPT FROM TABLE 1 FOR 1990 MEDIUM CASE

BLE 1 - INTERBEA DOMESTIC STEAM COAL FLOWS BY ORIGIN PAGE 1

ICE TASK FORCE 1990 MEDIUM SCENARIO

TE: COLUMN SUMS MAY DIFFER FROM TOTALS DUE TO ROUNDING.

TE: BEAS MAY APPEAR IN MORE THAN ONE STATE DUE TO BEA/STATE OVERLAP.

ALABAMA

IGIN EA	DEST'N BEA	ANNUAL K-TONS	ANNUAL BBTUS	DAILY TONS	DAILY MMBTUS
45	37	735.	19848.	2014.	54379.
45	43	814.	21981.	2230.	60223.
45	50	319.	8621.	875.	23618.
45	115	296.	7999.	812.	21914.
45	130	4103.	99145.	11242.	271630.
45	131	949.	22583.	2600.	61871.
45	136	272.	7347.	745.	20128.
45	SUB	7489.	187524.	20518.	513764.
47	116	9.	214.	25.	587.
47	117	4.	95.	11.	261.
47	138	113.	2689.	310.	7368.
47	SUB	126.	2999.	345.	8216.
48	47	35.	950.	96.	2603.
48	115	1.	17.	2.	48.
48	130	181.	4303.	495.	11790.
48	138	13.	315.	36.	863.
48	SUB	230.	5586.	630.	15303.
ATE	TOTAL	7845.	196108.	21493.	537283.

ARKANSAS

IGIN EA	DEST'N BEA	ANNUAL K-TONS	ANNUAL BBTUS	DAILY TONS	DAILY MMBTUS
46	97	7.	178.	18.	487.
46	114	4.	95.	11.	261.
46	SUB	11.	273.	29.	748.
47	115	88.	2094.	241.	5738.

TABLE IV-8

EXCERPT FROM TABLE 2 FOR 1990 MEDIUM CASE

TABLE 2 - INTERBEA DOMESTIC METAL. COAL FLOWS BY ORIGIN
ICE TASK FORCE 1990 MEDIUM SCENARIO

PAGE 1

NOTE: COLUMN SUMS MAY DIFFER FROM TOTALS DUE TO ROUNDING.

NOTE: BEAS MAY APPEAR IN MORE THAN ONE STATE DUE TO BEA/STATE OVERLAP.

ALABAMA

ORIGIN BEA	DEST'N BEA	ANNUAL K-TONS	ANNUAL BBTUS	DAILY TONS	DAILY MMBTUS
45	37	605.	16332.	1657.	44744.
45	43	670.	18087.	1835.	49553.
45	50	263.	7093.	720.	19434.
45	115	244.	6581.	668.	18031.
45	130	383.	10335.	1049.	28316.
45	131	224.	5334.	614.	14615.
45	136	224.	6045.	613.	16562.
45	SUB	2612.	69808.	7156.	191254.
STATE TOTAL		2612.	69808.	7156.	191254.

ARKANSAS

ORIGIN BEA	DEST'N BEA	ANNUAL K-TONS	ANNUAL BBTUS	DAILY TONS	DAILY MMBTUS
46	97	5.	146.	15.	401.
46	SUB	5.	146.	15.	401.
134	56	37.	875.	101.	2398.
134	82	25.	590.	68.	1615.
134	SUB	62.	1465.	169.	4013.
STATE TOTAL		67.	1611.	183.	4414.

COLORADO

ORIGIN BEA	DEST'N BEA	ANNUAL K-TONS	ANNUAL BBTUS	DAILY TONS	DAILY MMBTUS
147	55	301.	7153.	824.	19612.

TABLE IV-9

EXCERPT FROM TABLE 3 FOR 1990 MEDIUM CASE

TABLE 3 - INTERBEA DOMESTIC STEAM COAL FLOWS BY DEST'N PAGE 1
 ICE TASK FORCE 1990 MEDIUM SCENARIO
 NOTE: COLUMN SUMS MAY DIFFER FROM TOTALS DUE TO ROUNDING.
 NOTE: BEAS MAY APPEAR IN MORE THAN ONE STATE DUE TO BEA/STATE OVERLAP.

ALABAMA

ORIGIN BEA	DEST'N BEA	ANNUAL K-TONS	ANNUAL BBTUS	DAILY TONS	DAILY MMBTUS
11	43	9.	212.	24.	579.
16	43	86.	2047.	236.	5608.
45	43	49.	1311.	133.	3592.
50	43	123.	2921.	336.	8004.
51	43	163.	3878.	446.	10625.
53	43	32.	765.	88.	2095.
77	43	182.	3961.	498.	10851.
93	43	4.	56.	12.	153.
114	43	1.	27.	3.	75.
SUB	43	649.	15178.	1777.	41582.
11	45	3931.	93559.	10770.	256326.
23	45	40.	946.	109.	2590.
50	45	2275.	54155.	6234.	148369.
51	45	2140.	57786.	5864.	158318.
53	45	730.	18559.	2136.	50846.
55	45	5036.	119868.	13799.	328405.
59	45	551.	12017.	1510.	32922.
113	45	4737.	103256.	12977.	282894.
114	45	195.	4244.	533.	11627.
125	45	141.	1833.	386.	5023.
144	45	476.	6185.	1303.	16944.
SUB	45	20302.	472406.	55621.	1294263.
48	47	734.	19815.	2011.	54287.
50	47	2063.	55697.	5652.	152596.
53	47	153.	3646.	420.	9989.
55	47	5681.	135204.	15564.	370422.
58	47	3458.	75391.	9475.	206550.
66	47	1211.	28816.	3317.	78948.
114	47	6.	131.	16.	358.
144	47	1291.	16780.	3536.	45972.
SUB	47	14597.	335479.	39991.	919122.
50	48	217.	5854.	554.	16039.

TABLE IV-10

EXCERPT FROM TABLE 4 FOR 1990 MEDIUM CASE

ABLE 4 - INTERBEA DOMESTIC METAL. COAL FLOWS BY DEST'N PAGE 1
 ICE TASK FORCE 1990 MEDIUM SCENARIO
 OTE: COLUMN SUMS MAY DIFFER FROM TOTALS DUE TO ROUNDING.
 OTE: BEAS MAY APPEAR IN MORE THAN ONE STATE DUE TO BEA/STATE OVERLAP.

ALABAMA

RIGIN BEA	DEST'N BEA	ANNUAL K-TONS	ANNUAL BBTUS	DAILY TONS	DAILY MMBTUS
45	43	79.	2137.	217.	5854.
53	43	40.	957.	110.	2621.
SUB	43	119.	3093.	327.	8474.
51	45	1773.	47373.	4859.	131159.
53	45	496.	11802.	1359.	32333.
SUB	45	2269.	59675.	6216.	163493.
48	47	604.	16307.	1655.	44677.
50	47	1698.	45838.	4651.	125582.
53	47	97.	2303.	265.	6310.
SUB	47	2398.	64448.	6571.	176569.
50	48	226.	6104.	619.	16724.
53	48	132.	3142.	362.	8607.
SUB	48	358.	9246.	981.	25331.
45	136	129.	3493.	354.	9569.
53	136	25.	591.	68.	1619.
SUB	136	154.	4084.	422.	11188.
52	137	551.	14864.	1508.	40725.
53	137	206.	4904.	565.	13435.
SUB	137	757.	19768.	2073.	54160.
TATE TOTAL		6056.	160313.	16591.	439215.

ARKANSAS

RIGIN BEA	DEST'N BEA	ANNUAL K-TONS	ANNUAL BBTUS	DAILY TONS	DAILY MMBTUS
145	117	2.	37.	4.	101.

TABLE IV-11
EXCERPT FROM TABLE 5 FOR 1990 MEDIUM CASE

ABLE 5 - INTERBEA EXPORT STEAM COAL FLOWS BY ORIGIN PAGE 1
ICE TASK FORCE 1990 MEDIUM SCENARIO
OTE: COLUMN SUMS MAY DIFFER FROM TOTALS DUE TO ROUNDING.
OTE: BEAS MAY APPEAR IN MORE THAN ONE STATE DUE TO BEA/STATE OVERLAP.

ALABAMA

RIGIN BEA	DEST'N BEA	ANNUAL K-TONS	ANNUAL BBTUS	DAILY TONS	DAILY MMBTUS
45	176	354.	8434.	971.	23107.
45	178	501.	11915.	1372.	32643.
45	SUB	855.	20349.	2342.	55751.
48	176	85.	2020.	232.	5533.
48	179	6.	151.	17.	414.
48	SUB	91.	2171.	250.	5947.
STATE TOTAL		946.	22520.	2592.	61698.

COLORADO

RIGIN BEA	DEST'N BEA	ANNUAL K-TONS	ANNUAL BBTUS	DAILY TONS	DAILY MMBTUS
150	177	174.	3786.	476.	10373.
150	178	177.	3868.	486.	10599.
150	179	200.	4360.	548.	11946.
150	181	202.	4412.	554.	12087.
150	SUB	754.	16427.	2064.	45005.
STATE TOTAL		754.	16427.	2064.	45005.

GEORGIA

RIGIN BEA	DEST'N BEA	ANNUAL K-TONS	ANNUAL BBTUS	DAILY TONS	DAILY MMBTUS
48	176	51.	1218.	140.	3337.
48	179	4.	91.	10.	250.
48	SUB	55.	1309.	151.	3587.
STATE TOTAL		55.	1309.	151.	3587.

IDAHO

RIGIN BEA	DEST'N BEA	ANNUAL K-TONS	ANNUAL BBTUS	DAILY TONS	DAILY MMBTUS
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TABLE IV-12

EXCERPT FROM TABLE 6 FOR 1990 MEDIUM CASE

TABLE 6 - INTERBEA EXPORT METAL. COAL FLOWS BY ORIGIN PAGE 1
 ICE TASK FORCE 1990 MEDIUM SCENARIO
 NOTE: COLUMN SUMS MAY DIFFER FROM TOTALS DUE TO ROUNDING.
 NOTE: BEAS MAY APPEAR IN MORE THAN ONE STATE DUE TO BEA/STATE OVERLAP.

ALABAMA

ORIGIN BEA	DEST'N BEA	ANNUAL K-TONS	ANNUAL BBTUS	DAILY TONS	DAILY MMBTUS
45	176	213.	5060.	583.	13864.
45	178	579.	14682.	1587.	40224.
45	SUB	792.	19742.	2170.	54089.
STATE TOTAL		792.	19742.	2170.	54089.

IDAHO

ORIGIN BEA	DEST'N BEA	ANNUAL K-TONS	ANNUAL BBTUS	DAILY TONS	DAILY MMBTUS
152	177	75.	1776.	204.	4866.
152	181	2025.	48186.	5547.	132017.
152	SUB	2099.	49962.	5751.	136883.
STATE TOTAL		2099.	49962.	5751.	136883.

KENTUCKY

ORIGIN BEA	DEST'N BEA	ANNUAL K-TONS	ANNUAL BBTUS	DAILY TONS	DAILY MMBTUS
50	176	1278.	34493.	3500.	94502.
50	SUB	1278.	34493.	3500.	94502.
52	175	1234.	33063.	3382.	90594.
52	176	3121.	77623.	8550.	212666.
52	178	1479.	39924.	4051.	109381.
52	179	70.	1664.	192.	4559.
52	SUB	5904.	152274.	16174.	417189.
53	175	615.	14637.	1685.	40101.

TABLE IV-13

EXCERPT FROM TABLE 7 FOR 1990 MEDIUM CASE

TABLE 7 - INTERBEA EXPORT STEAM COAL FLOWS BY DEST'N PAGE 3
 ICE TASK FORCE 1990 MEDIUM SCENARIO
 DTE: COLUMN SUMS MAY DIFFER FROM TOTALS DUE TO ROUNDING.
 DTE: BEAS MAY APPEAR IN MORE THAN ONE STATE DUE TO BEA/STATE OVERLAP.

HAMPTON ROADS

RIGIN BEA	DEST'N BEA	ANNUAL K-TONS	ANNUAL BBTUS	DAILY TONS	DAILY MMBTUS
13	176	54.	1279.	147.	3505.
15	176	1.	15.	2.	41.
45	176	354.	8434.	971.	23107.
48	176	1770.	42126.	4849.	115414.
52	176	15694.	373526.	42998.	1023359.
65	176	61.	1458.	168.	3994.
PORT TOTAL		17934.	426838.	49135.	1169418.

TABLE IV-14

EXCERPT FROM TABLE 8 FOR 1990 MEDIUM CASE

TABLE 8 - INTERBEA EXPORT METAL. COAL FLOWS BY DEST'N PAGE 3
 ICE TASK FORCE 1990 MEDIUM SCENARIO
 NOTE: COLUMN SUMS MAY DIFFER FROM TOTALS DUE TO ROUNDING.
 NOTE: BEAS MAY APPEAR IN MORE THAN ONE STATE DUE TO BEA/STATE OVERLAP.

HAMPTON ROADS

ORIGIN BEA	DEST'N BEA	ANNUAL K-TONS	ANNUAL BBTUS	DAILY TONS	DAILY MMBTUS
13	176	32.	768.	88.	2103.
16	176	4640.	125280.	12712.	343233.
45	176	213.	5060.	583.	13864.
48	176	1062.	25276.	2910.	69248.
50	176	1287.	34749.	3526.	95203.
52	176	14178.	352663.	38843.	966199.
53	176	16607.	448389.	45499.	1228462.
65	176	37.	875.	101.	2396.
PORT TOTAL		38055.	993059.	104261.	2720707.

TABLE IV-15
HEAT VALUES BY COAL TYPE

<u>Coal Type</u>	<u>Heat Value (mmBtu/ton)</u>
Premium	27.00
Bituminous	23.80
Midbituminous	21.80
Subbituminous	18.33
Lignite	13.00

- 4) Many BEA's are split between two or more states.
- 5) Export coal table destinations are given as ports rather than states since the precise locations of export have been prespecified by the ICE task force.
- 6) For each such port a pseudo-BEA code between 174 and 182 has been used for destination codes.

Similar tables for crude oil and products were not required by the Government, but could be produced in a manner similar to that for coal.

APPENDIX A

GLOSSARY

alphanumeric: utilizing numerical and alphabetic characters.

batch processor: that subsystem of a computer which processes programs non-interactively; programs submitted by the user to the batch processor will be run without further input from the user.

BBL: barrel; 42 gallons.

BCF: billion cubic feet.

BEA: Bureau of Economic Analysis economic area.

bottleneck: the clogging of a channel with a flow near or equal to its capacity.

BTU: British Thermal Unit; there are about 1000 BTUs in a standard cubic foot of gas and about 6 million BTUs in a barrel of oil.

capacity: the maximum flow which can occur between two points in a given unit of time.

commodity: a material, substance, or energy which can be bought or sold.

cost minimization: the objective to minimize total costs of transportation in a network or transportation problem.

CPU: central processing unit; that part of a computer system where computations take place.

crude oil: any of a number of liquid hydrocarbons refined into gasoline, diesel fuel, residual fuel oil, etc.; for the purpose of this study also includes natural gas liquids, tar sands, shale oil, and butane used in refineries to produce refined petroleum products.

data set: an organized structured set of numerical or alphabetic data stored on a computer or computer device such as tape or disk.

demand: the amount of a commodity desired for consumption or further sale or storage.

disaggregate: to break down into smaller geographic units.

disk: a phonograph record-like device for storing large quantities of data in a place where it can quickly be accessed by the computer and its users.

distillate oil: a refined crude oil product which is used for diesel fuel, home heating, and firing of boilers.

DOE: Department of Energy (Federal).

DOT: Department of Transportation (Federal).

efficiency: unity less the fractional loss on a node or arc of a network model.

EIA: Energy Information Administration of the U.S. Department of Energy.

elasticity: a measure of sensitivity expressed as the percentage change in the variable of concern for every percent change in some other basic variable; for example, percentage change in demand per each percent change in price would measure the price elasticity of demand.

flow: the amount of a commodity transported from one place to another in a given unit of time.

forecast: a prediction of certain more detailed quantitative values based on the assumptions contained in a scenario.

horsepower: 555 foot lbs. of work per unit of time.

IBM: International Business Machines, a large producer of computers.

interactive: involving conversational programming between the computer and the user.

linear programming: a procedure for modeling certain problems which can be expressed mathematically in terms of linear (first power only) functions of variables; specifically, a linear objective and a set of linear equalities, and inequalities to be satisfied by the variables where the variables may take on any real numbers which satisfy the constraint set.

link: a network arc.

load factor: the average utilization of some transportation channel as a fraction of its capacity.

looping: building new pipe parallel to an existing pipeline in stages in order to increase the capacity of the entire line.

LP: a linear program or linear programming.

MEFS: Mid-term Energy Forecasting System.

MEMM: Mid-term Energy Market Model..

metallurgical grade coal: high BTU low sulfur premium coal used primarily to make coke for steelmaking purposes.

methodology: the system of procedures to be applied for the solution of a problem.

midterm: relating to a time horizon of approximately 5 to 20 years.

modal share: that fraction of a given O/D flow which is transported via the particular mode in question.

modal split: modal share.

MPS3: Mathematical Programming System 3, a linear programming code available on the DOE/EIA computer system.

NETS: National Energy Transportation Study.

network: a set of points (nodes) connected by directed line segments (arcs) used in mathematical representations of transportation problems.

node: the graphical representation of a point or area in a network model.

non-pipeable: not capable of being transported by pipeline

O/D flow: Origin-Destination flow.

Origin-Destination flow: a movement of some commodity from a source region (origin) to a consuming region (destination).

peruse: to read or examine closely; in particular, to scan data files for particular strings of data..

PIES: Project Independence Evaluation System.

pipeable: capable of being transported by pipeline.

production: the amount of a commodity actually produced from the available supply.

products: commodities; in particular, refined petroleum products.

program: a sequence of commands which tell a computer what calculations to perform on a given set of input data to produce a specified set of output results.

residual oil: a thick viscous product of crude oil which is used almost exclusively as fuel for boilers.

SAS: Statistical Analysis System; a statistical computer package available on the DOE/EIA computer system.

scenario: the set of assumptions which together provide a unified view of possible future conditions and which are used as inputs to a forecasting model which will produce results based on those assumptions.

sensitivity analysis: procedures for estimating how dependent the results of a forecast are to the assumptions underlying those results.

simultaneous: at the same time.

string: a group of alphanumeric symbols taken together as a linear unit.

subnetwork: a portion of a network which is itself a network.

SUPERWYLBUR: a system used on IBM computers for running batch programs, editing data sets and programs interactively, etc.

supply: the amount of a commodity available for sale, delivery, or production.

system: an interrelated set of elements (such as programs or computer hardware) forming a functionally unified whole.

tape: a storage device for computerized data; it has a longer time lag for access by the computer and its users than disk storage.

TERA: Transportation and Economic Research Associates, Inc.

time sharing: procedures whereby a computer is shared by many users at once in such a way as to seem to belong to each user alone.

TSO: Time Sharing Option; a system used on IBM computers for interactively running programs and processing data.

unit cost: average cost per unit of flow of any flow variable.

vintage: year of first discovery or production.

APPENDIX B
COAL DATA DESCRIPTION

COAL DATA DESCRIPTION

DATA SOURCES

Variable Data

The variable data to be used in TERA's disaggregation and allocation methodology consists of regional scenario projections provided by the Department of Energy. In the case of coal, these scenarios contain four necessary data elements: (1) coal production by type, by region; (2) coal consumption by sector, by type, by region; (3) interregional flows by type; and (4) export flows by type. Regional (and/or local) air quality constraints, macro-economic growth assumptions, and all other assumptions used in the generation of the scenario projections are explicitly assumed in MEFS.

Fixed Data

The fixed data used by TERA in the methodology was collected from various sources, all within the government. In general, it consisted of files, tapes, reports, and documents compiled and/or held by various departments. This data was then used to create the data bases used to derive the disaggregation, allocation, and modal split prediction methodologies. The fixed data used by TERA in the coal methodology fit into seven general categories: (1) geographic and general characteristics; (2) production data; (3) consumption data; (4) utility plant data; (5) coal transportation costs; (6) transportation modal shares; and (7) foreign distribution data.

(1). The geographic data (used for all energy commodities) consisted generally of two types: First, the identification of the geographic units themselves that were used in the study, and second, a determination of two primary economic indicators, population and value-added in the manufacturing sector. States and counties, designated by a five-digit FIPS (Federal Information Processing Standard) code, and the BEA designations were obtained from the U.S. Department of Commerce, Bureau of the Census. The geographic identification of scenario "regions" (i.e., MEFS Coal Region, MEFS Demand or Utility Regions) were obtained from various DOE publications. Geographic identification was based on counties since they were always contained within a specific BEA, one demand region, and one supply region. BEAs are not necessarily contained within one of the larger regions.

County population figures and value-added in the manufacturing sector statistics were also obtained from Bureau of the Census publications: the County and City Data Book - 1972, and the 1972 Census of Manufacturers, Volume III, Area Statistics.

The distance between the assigned centroids of each BEA was determined on the basis of a set of Cartesian coordinates for each centroid which were derived through the use of a modified Pythagorean Theorem which compensated for the curvature of the earth.

(2) Coal production data was also of two types. Coal production figures by county were obtained from the U.S. Bureau of

Mines (now partly in DOE) Coal-Bituminous and Lignite Annual - 1975.

An identification of the type of coal produced in each county was made based on data from the U.S. Bureau of Mines, the Reserve Base of U.S. Coals by Sulfur Content, supplemented by data contained in a study by the Congressional Research Service (CRS) entitled National Energy Transportation; Volume I - Current Systems and Movements. In the cases of counties for which the characteristics of the identified coal reserve base (and thus production) were not given, these characteristics were inferred from the characteristics of neighboring coal-producing or bearing counties and from state averages as determined in the above-mentioned CRS study.

(3) Coal consumption data are not presently collected below the state level by any of the administrative units of DOE. Such data is collected on a county and sub-county level by the Environmental Protection Agency (EPA) as part of its National Emissions Data System (NEDS). The NEDS file, also known as the Point Source File, presents information from almost 400,000 emission sources. Not all of these sources are energy consuming sources, but for those that are, annual emissions are estimated as a function of the amount and type of fuel consumed. The file further identifies the type of fuel user or "emitter" and thus enables a sectoral breakdown of fuel use. DOE does continue to publish coal consumption data by sector at the state level. This data is published annually and quarterly as part of the Bituminous Coal and Lignite Distribution Annual or Quarterly.

(4) The largest coal consuming sector is the utility sector. Data relating to this sector is extensively available through the DOE, more specifically through the Federal Energy Regulatory Commission (FERC). The utility data used by TERA is derived from the FERC file, known as F12E-2, which provides utility plant locations as well as existing and/or potential capacity.

(5) Transportation costs for moving coal were derived from the Interstate Commerce Commission's Investigation of Railroad Freight Rate Structures - Coal, ExParte No. 270 (Sub - No. 4), December 3, 1974.

Using the ICC data, 15 cost equations were determined for the gross origin-destination movement by applicable rate type.

Table B-1 presents a summary of these calculations.

These equations were then collapsed into four equations based on the following assumptions:¹

- that 85 percent of Western coal is predicted to be moved via unit trains or trainloads by 1985;
- that Eastern movements will generally be equally split between trainload and multiple-car movements;
- that Midwestern coal production can be assumed to be approximately one-third of the Eastern production and movements.

(6) Modal split data was primarily generated from the Bureau of Mines, Bituminous Coal and Lignite Distribution Annual - 1975 and supplemented by data previously generated by TERA.

¹These assumptions were culled from previous TERA work for the Department of Energy which drew heavily from Samir Desai and James Anderson's, Rail Transportation Requirements for Coal Movement in 1980.

TABLE B-1
COAL MOVEMENT RATE CALCULATIONS

Origin	Destination	Rate Type	Rate Equation ^a
Appalachia	East	trainload	$C=5.06 + .0016D$
		multi-car	$C=4.45 + .0004D$
	South East	trainload	$C=0.27 + .006D$
		multi-car	$C=1.40 + .0067D$
	West	trainload	$C=5.06 + .0016D$
		multi-car	$C=4.45 + .0004D$
Midwest	East	trainload	$C=1.08 + .0088D$
		multi-car	$C=1.58 + .0078D$
	South East	trainload	$C=0.27 + .006D$
		multi-car	$C=1.40 + .0067D$
	West	trainload	$C=1.08 + .0088D$
		multi-car	$C=1.58 + .0078D$
West	East & South East	trainload	$C=3.1 + .0074D$
	West	trainload	$C=0.6 + .0074D$
		multi-car	$C=1.26 + .01D$

^aC=rate (\$); D=distance (miles).

SOURCE: ICC, Investigation of Railroad Freight Rate Structures-Coal, ExParte No. 270, (Sub-No. 4), December 3, 1974.

(7) Foreign distribution data for the export of coal was primarily developed through data developed by the Interagency Coal Export Task Force's Supply/Demand subgroup.

GENERAL PURPOSE DATA BASE

Three general purpose data sets were used in the coal disaggregation and allocation methodology that were also used for the other energy commodities. These data sets were:

(1) Basic County Record (file name - COUNTY) which contains the following data elements:

- state name
- county name
- state and county FIPS code
- BEA code
- PIES demand region code
- PIES coal region code
- 1972 population
- 1972 manufacturing sector value added

This file provided the basic geographic reference for connecting the smallest geographic units to the larger regional and BEA units.

(2) Basic BEA Record (BEAR) which contains the following data elements:

- BEA number
- 1985 OBERS population projection
- 1985 OBERS manufacturing sector value-added projection
- 1990 OBERS population projection
- 1990 OBERS manufacturing sector value-added projection

(3) BEA Centroid Coordinate File (DIST) which contains the adjusted longitude and latitude for the assumed centroids of the 173 BEAs and which enables straight-line distance between adjoining BEAs to be calculated.

SPECIAL COAL DATA SETS

Three additional data sets were developed specifically for coal. These sets were:

(1) Basic County Coal Record (COAL) which contains the following elements:

- county FIPS code
- estimated reserve base
- 1975 production
- average sulfur content
- average BTU content
- coal type

Coal type was assigned to a county on the basis of the average sulfur and BTU content as determined by the Bureau of Mines, the Congressional Research Service and TERA. An attempt was made to closely correlate types used by TERA to the types used in the PIES framework. The nomenclature used in the TERA methodology consisted of a two-letter designation which, except in the cases of lignite and "metallurgical" coal are keyed to the sulfur and BTU content. These nine types and their characteristics are detailed in Table B-2.

(2) Preliminary Predicted County Production (PFCOAL) which contains the county code and coal type and the estimated county coal production that was obtained as a result of a regression analysis of the data contained in the Coal file.

(3) County Coal Factors (PFCOAL2) is the next progression from PFCOAL in that a data element is added which displays the county share of the regional coal production by type.

TABLE B-2
COAL TYPE SPECIFICATIONS

Name	General Characteristics	Specific Characteristics	
		BTU/lbs.	Sulfur (percentage by weight)
HM	High BTU-medium sulfur	BTU>12000	1<S<3
MM	Medium BTU-medium sulfur	11000<BTU <12000	1<S<3
HH	High BTU-high sulfur	BTU>12000	S>3
MH	Medium BTU-high sulfur	11000<BTU<12000	S>3
LL	Low BTU-low sulfur	9500<BTU<11000	S<1
HL	High BTU-low sulfur	BTU>12000	S<1
ML	Medium BTU-low sulfur	11000<BTU<12000	S<1
LG	all Lignite	BTU<9500	
MT	Premium or metallurgical grade bituminous coal	BTU>13000	S<1

(4) County Coal-Fired Utility Generation Capacity (COL85) which contains the predicted coal-fired electrical utility capacity by county for 1985. This file also contains unsited coal-fired capacity by state. An analogous file, COL90, was created to represent the predicted coal-fired capacity for 1990.

(5) Adjusted county Coal-Fired Utility Generation Capacity (COLFIX) which presents data similar to COL85 but which fully allocates the "unsited" capacity to counties.

(6) County Coal-Fired Utility Shares (CUSHR85 and CUSHR90) are based on the data in COLFIX in conjunction with the geographic reference file. They consist of county shares of the regional generation capacity. Separate files for 1985 and 1990 were created for the different scenarios.

(7) County Non-Utility Coal Consumption (PTGOOD) contains the results of the sorting of the EPA Point Source tapes and delineates county code, coal type and estimated 1976 coal consumption.

(8) County Non-Utility Coal Consumption Shares (CSHARE) are based on the PTGOOD consumption estimates and the geographic reference file.

(9) Scenario Inputs (PICOAL) contain the DOE-supplied scenario inputs which are to be disaggregated and allocated. These files contain the following elements:

- production by MEFS regions by coal type
- consumption by MEFS regions by coal type by sector (utility, non-utility, export)
- interregional flows by type

FIGURE I-7

BUREAU OF ECONOMIC ANALYSIS (BEA) REGIONS

APPENDIX C
REFERENCES

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