THE U.S. OIL AND GAS SYSTEM REPRESENTATION IN THE EEMIS DATA STRUCTURE

J. D'ACIERNO, A. HERMLEE, M. BELLER,
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NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS
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Abstract

The object of this report is to demonstrate the physical aspects of the United States oil and natural gas industries which are incorporated in the design of the data structure of the Energy Emergency Management Information System (EEMIS) for the U.S. Department of Energy (DOE). The overall data structure guidelines were to provide information needed to address energy emergencies and to carry out U.S. Department of Energy missions. Therefore, the data structure is designed to convey current and historical information relating to stocks and flows of energy commodities in the U.S.

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I. INTRODUCTION

This report presents an abstract of the physical aspects of the oil and natural gas energy systems needed to design an energy data structure for the Energy Emergency Management Information System (EEMIS). This data structure forms the basis of an information system that is responsive to decision and policy makers in an energy emergency. It is designed to incorporate all aspects of the petroleum and natural gas energy systems in a consistent fashion to provide up-to-date data on energy shortages, and information on the impacts of various policies taken during a shortage. Energy shortages can result from a sudden decrease in petroleum or natural gas production, a sudden decrease in imports, transportation outages, or unanticipated heavy regional demand. Emergency actions that can be taken in response to these shortages include fuel allocations, emergency conservation plans, natural gas curtailments, refinery yield orders, or gasoline rationing. Energy shortages and emergency actions taken in response to these shortages can all be analyzed at the state, regional, and national levels within the framework of the data structure.

The emphasis in choosing the data elements was on providing:

- Information needed to address energy emergencies.
- Information of interest in carrying out Department of Energy missions.

Therefore, the data are designed to convey information, on as current a basis as is practical, relating to stocks and flows of energy supplies and products. This information is critical to evaluating the anticipated magnitudes of energy problems. Additionally, because energy emergencies generally involve reallocations of supplies and products, source and destination data are required, thus emphasizing the importance of the transportation network. And finally, for situations where even monthly data collection is insufficient, facility ownership and location information are incorporated in the structure to permit immediate contact to take place, so that information can be exchanged rapidly during an emergency.

The energy data structure provides current monthly estimates and short-term forecasts of supply and demand conditions to establish indicators that signal an impending energy shortage. The crude oil, oil product, and natural gas transportation systems are represented in sufficient detail to allow for allocation of supplies in a shortage. In the event of an emergency in which there is a shortage of one fuel, there is a tendency to substitute alternate fuels causing possible shortages in these fuels. These substitution strategies and the capability for interfuel substitution are represented in the EEMIS demand structure.

A general description of the structure defining aggregation and timing aspects of the data and some general data definitions are contained in Section II. Sections III to VII describe the ability of data elements in the petroleum, natural gas, demand, import/export, and transportation sector structures to represent physical aspects of the oil and gas energy systems. The reasons for choosing the data elements and explanations for what is and what is not modeled are given in these sections. Finally, a list of all data elements in the structure at the facility, state, regional, and national levels of aggregation is contained in the Appendix.

II. GENERAL DESCRIPTION OF DATA STRUCTURE

The data structure described in this report is designed to support the EEMIS program by providing timely and detailed data in an orderly flow for use during energy emergencies. The energy emergencies presented in Table II-1 can arise directly from a sudden decrease in petroleum imports or from a sudden drop in oil and gas production, or they can be caused by a loss in capability to transport oil and natural gas. In order to provide sufficient information to manage emergencies arising from these shortages, an orderly data structure with sufficient detail and timeliness with respect to supply, production, distribution, transportation, and consumption aspects of the physical energy system is necessary.

Table II-1
Potential Causes of Fuel Shortages

Sudden decrease in petroleum imports due to:

- Embargo
- Natural disaster
- Destruction of production or distribution facilities
- Import quotas
- Rapid price escalation

Sudden decrease in gaseous fuel supplies in the U.S. due to:

- Natural disaster
- Destruction of facilities
- Work stoppages
- Imports loss

Sudden decrease in petroleum production in the U.S. due to:

- Natural disaster
- Destruction of production or distribution facilities
- Work stoppages

Regional transportation outages due to:

- Cold weather
 - Destruction of facilities
 - Work stoppages
 - Natural disaster
-

Data required to respond to energy emergencies must contain detailed information on all aspects of the energy system for current, historical, and forecasted data as presented in Table II-2. The information system for fuel supplies must contain production, storage, and import levels in terms of their availability to the production and distribution system. Data on production and distribution must include major supplies, their sources, and the quantity and price of fuel supplied to geographic regions and demand sectors. Fuel supply can be a production, storage, or import quantity, depending on the particular activity within the overall energy system. Logistical data are necessary on the availability of the fuel supply. These data include drawdown capability, location, status of the transportation system, fuel type, and price.

Table II-2
General Data Requirements for Management of Energy
Emergencies Due to Shortages of Natural Gas, Crude Oil, and
Petroleum Products

Data Element	Details Pertinent to Data Element
Fuel supply	<ul style="list-style-type: none"> • Production, storage, and import levels • Availability (drawdown capability, location, access to transportation system, fuel type, price)
Production and distribution system	<ul style="list-style-type: none"> • Major suppliers and distributors • Fuel supply (quantity, fuel type, price, demand region, and demand sector)
Consumption	<ul style="list-style-type: none"> • Geographic region and demand sector • Fuel consumed (quantity and fuel type) • Major suppliers (location, quantity, fuel type, method of transport) • Alternate fuel capability (flexibility) • Storage level (quantity in storage, fuel type, capacity)
Transportation system status	<ul style="list-style-type: none"> • Capability and limitations (access to nodes in production, distribution, and consumption system; limiting factors - logistical-type data) • Operating levels (utilization) • Alternate capabilities and limitations (flexibility)

Aggregation Aspects of Data

There are many activities in the petroleum and natural gas industries that together make up the physical aspects of the energy system. Each activity in the EEMIS data structure, such as oil refining or oil product storage at bulk terminals, is represented by a unique "facility" that is defined in a uniform manner for all activities in the oil and gas industries. This is the lowest level of detail specified for the structure. Since, for example, there are about 300 oil refineries and about 800 crude oil bulk terminals in the U.S., these data are manageable. Consider, however, the problem of defining crude oil or natural gas production facilities (oil or gas wells). There are approximately 500,000 oil wells and 150,000 gas wells in the U.S. This presents a formidable data collection, storage, and management task. To circumvent this problem, energy production facilities will be defined as representing energy production regions by company at the state or substate level. Since good data are available on this basis, it makes the data handling systems more manageable.

Single unit facilities for bulk storage terminals and oil refineries must be described in great detail because the loss of one could cause a significant perturbation to the energy system. For example, the loss of a major oil refinery can cause an enormous oil products supply shortfall in a region. The analysis of effects and alternative actions requires extremely fine detail on the abilities of other refineries to take up the slack, transportation alternatives, and quantity, quality, and location of crude oil stocks. However, the loss of a few oil or gas wells out of tens of thousands has a relatively minor effect which may hardly be felt in the system.

Facility level data can be aggregated to the state, regional, and national levels fairly simply. The state is chosen as the smallest political entity used in the system because it is a well-defined unit, has considerable political power, and generally is the smallest unit exercising any independent energy policy. Energy inquiries to the federal government generally emanate from the state energy office or governor, who exercises major influence on energy activities in his state. Additionally, a great deal of energy data are generated and collected at the state level, and are thus compatible with the choice of this level of aggregation.

After the state level, the next higher aggregation level is regional. The regional level need not be defined a priori, because almost any regional definition is consistent with the state level of aggregation. The nine census regions, ten DOE regions, or five PAD regions all contain collections of entire states within their individual regions, permitting aggregation of state data to accommodate their definitions. Conversely, data reported at the regional level

can be checked against aggregated state data for consistency. The only incompatible regions are the Bureau of Mines Refinery Districts, which cut across states. However, since data from this source are generally normalized by PAD regions, and the Refinery District designations are rarely used today, they have a negligible contribution for EEMIS.

In summary, the use of facility level data permits a micro level analysis when required for energy emergencies, and offers great advantages in simplifying aggregation to any specified level--state, regional, or national--for use in macro level analysis for EEMIS or other purposes.

Data Element Definitions

Data elements were selected to represent the physical aspects of the oil and natural gas energy systems in sufficient detail to meet requirements specified in the EEMIS Program Plan. Data elements for each facility in the EEMIS data structure fall within three general categories: inputs, outputs, and storage. The data elements related to inputs and outputs are similar and include the fuel type, quantity, source, destination, route, price, short-term projections, and transportation links associated with the flow of energy to or from each facility. Detailed storage data include both the quantity of fuel in storage and the capacity of each facility. These data elements are represented in the generic facility illustrated in Table II-3. Source and destination data elements, which tie various facilities together, and transportation linkages, which tie each facility into the transportation network, are key factors in the EEMIS structure. These linkages are not available in other EIA information systems, but are essential for combining individual data elements into an overall data structure that represents actual as well as alternate patterns of supply and demand. Such a structure is required for allocating supplies and assessing the true impact of shortages in the event of an emergency.

Timing Aspects of Data

In general, EIA data are collected on a monthly basis; as a practical matter, they are reported monthly but are rarely available sooner than two to three months after receipt. This is a serious drawback to any practical effort for analytical capability in an emergency. However, the data structure is designed primarily for monthly data for the following reasons:

1. Monthly data are normally collected, and offer historical data for time series analysis.
2. For EEMIS to function, it is a minimally acceptable criterion. Of course, weekly data would be much better, but are impractical in a system so complex. Where weekly data are absolutely needed in an emergency, telecommunications will be necessary.

The administrative problem of timely collection of monthly data will exist within the EIA Program offices, and it must be assumed that some accommodation will be reached to permit raw data to be accessed by the EEMIS data base as quickly as is practical. It should be noted that in an analysis, even one data element may prove to be a key component, and if it is lacking from the system the availability of, say, ninety-nine other elements in the same time sequence will not compensate for the deficiency. Thus, timing and completeness are necessary. In conclusion, it is felt that monthly data do not overwhelm the system, but offer a reasonable compromise in terms of collection practicality and system resolution.

Table II-3
Generic Facility

- A. Facility characteristics
 - 1. Location
 - 2. Company ID
 - 3. Capacity
 - B. Inputs
 - 1. Quantity by fuel type, source, and route
 - 2. Price by fuel type and source
 - 3. Transportation links available
 - 4. Short-term projections
 - C. Storage
 - 1. Quantity by fuel type
 - 2. Capacity
 - D. Outputs
 - 1. Quantity by fuel type, destination, and route
 - 2. Price by fuel type and destination
 - 3. Transportation links available
 - 4. Short-term projections
-

III. PETROLEUM SECTOR DESCRIPTION

The EEMIS Petroleum System is a representation of the physical aspects of the U.S. petroleum system and, as such, it accommodates energy data for the different activities which together make up this complex system. There are many actions that can be taken for management of petroleum energy in the U.S., and these measures involve virtually every energy activity in the physical energy system. For example, some federal emergency actions that can be

instituted on the basis of EEMIS data are to: implement emergency conservation plans, allocate or redirect crude oil and controlled petroleum products, issue refinery yield orders, implement gasoline rationing, draw down Strategic Petroleum Reserves, impose price controls, and collect oil import fees. The Petroleum Sector Structure was designed to provide information that is required to implement these emergency actions, and to provide a comprehensive medium to assess the overall oil energy situation that is needed prior to and during emergency action.

The major activities in the physical petroleum system are included in the EEMIS Petroleum System flow diagram shown in Figure III-1. Arrows in this figure show the flow of oil to represent interactions between these activities. Resource and extraction, which make up total supply for the overall system, consist of domestic production and imports of crude oil, and imports of oil products. Crude oil is transported to oil refineries where it is converted into many types of oil products. Together with oil product imports, these domestic refinery products are transported and distributed to final end users, who constitute demand. Crude oil bulk terminals and oil product bulk terminals may handle these materials to facilitate the transportation and distribution activities. These are major storage facilities which normally handle oil on a day-to-day basis. The Strategic Petroleum Reserve is a major storage reserve facility that functions to reduce U.S. vulnerability to supply shortages.

The activities in the physical system that are represented as facilities in the EEMIS Petroleum Sector are: domestic crude oil production, crude oil bulk terminals, the Strategic Petroleum Reserve, oil refineries, and oil product bulk terminals. Imports and exports are included in the petroleum sector where they are either a source or destination of flows for these facilities. The transportation of crude oil and oil products is described by routes for flows among these facilities, and by links that tie each facility into the transportation network. Comprehensive descriptions of demand, imports, and exports, and the transportation network are included in the Demand Sector Description (Section V), the Import/Export Sector Description (Section VI), and the Transportation Network Description (Section VII).

Crude Oil Types. In the oil industry, crude petroleum is always identified by state or country of origin since its composition varies depending on the resource location. There are two physical properties which have the strongest influence on the value of crude oil and on the types of product that a particular refinery can produce from crude oil feedstocks. These properties are API gravity and sulfur content. Pour point is another important property which is used as a rough indication of some of the constituents of crude oil.

In order to allocate crude oil to refineries one must identify the types of crude oil that the refinery can process, and to communicate with refiners one must use the language of the oil industry. Thus, stocks and flows of crude oil will be monitored by state or country of origin, API gravity, sulfur content, and pour point. The U.S. refining industry also characterizes foreign crude imports using standard classifications. EEMIS will incorporate this system to aid in identifying the type of crude oil that can be allocated to particular refineries. The world crude oil export streams* will be adopted as EEMIS crude oil types for foreign crude oil.

*Physical Aspects of the U.S. Oil and Gas Systems, Table V-2, BNL 51076, 1979.

EEMIS - PETROLEUM SYSTEM

Figure III-1

Oil Product Types. The petroleum data structure is tied together with many different types of oil products to illustrate fuel substitution capabilities and to represent the true supply and demand picture for oil. The criterion for determining the types of oil products that should be monitored for EEMIS is that the product type must be a common fuel that is used in relatively large amounts. Therefore, non-fuel oil products (e.g., lubricating oils, petroleum coke, asphalt, and road oil) are not included. This reduces the list of products to gasolines, jet fuels, distillate fuel oils, residual fuel oils, and light products. Each of these groups of oil products contains two or more specific types of products in the data structure.

Motor gasoline is the largest volume petroleum product, representing 39% of total oil product demand in 1977. Most new American automobiles must use unleaded gasoline to meet EPA guidelines. In 1978 more than one-third of all motor gasoline was made in this grade, and this fraction is expected to increase as new cars represent a larger portion of the national automobile fleet. Total refinery production is highly dependent upon the relative amounts of leaded and unleaded fuels that must be made. Since no other grades of motor gasoline are specified for usage in automobiles, leaded and unleaded gasoline fuel types will suffice for energy management purposes.

Aviation gasoline is made in relatively small amounts, constituting only 0.2% of total refinery output in 1978. It is used for propeller-driven airplanes with spark ignition engines, which, although representing a small segment of the transportation sector, are often needed for such essential services as crop dusting. Therefore, this gasoline fuel type will also be monitored for EEMIS.

Jet fuels are vital to the commercial and military air transportation sectors. Kerosene-type jet fuel, used by commercial jet aircraft, made up about 5% of total refinery output in 1978. Naphtha-type jet fuel constituted only about 1% of output, but this type of jet fuel is vital for military usage. Both fuels are monitored as fuel types in the data structure.

Distillate fuel oils are an important group of oil products that accounted for about 19% of refinery output and 18% of petroleum demand in 1977-1978. There are two types of distillate fuel oils: heating fuel oil, which includes No. 1, No. 2, and No. 4 fuel oils; and diesel fuels. Heating fuel oil is the largest fuel type in the group (44% of total distillate fuel oil sales in 1977 were for heating oils*) and is essential for residential heating purposes, especially in the Northeastern States. In addition, heating fuel oil (No. 2 and No. 4 oil) is used as a fuel for industrial boilers, railroads, electric power plants, and water vessels. The primary fuel for truck and railroad transportation is diesel fuel, which accounts for about 27% of the total amount of distillate fuel oil use in the U.S. About 81% of diesel fuel is for highway usage and the remainder is used off the road. Heating, diesel, and No. 4 fuel oils are the three products within the distillate fuel oil group in the data structure.

*Physical Aspects of the U.S. Oil and Gas Systems, Table V-2, BNL 51076, 1979.

Residual fuel oils are the next largest group of oil products consumed in the U.S. Demand for this group, 16.7% of total oil product demand in 1977, is approximately the same as demand for distillates. Residual fuel oils represent the largest group of oil products used by the industrial and electric utility sectors in the U.S. Electric utilities consumed 51% of residual fuel in 1977,* the industrial sector consumed about 15%. The most common types of residual fuel oil are No. 5 and No. 6, which cannot be burned efficiently without preheating. No. 6 must be used in burners equipped with preheaters permitting a high-viscosity fuel, and both fuel types require preheating of combustion chambers for proper combustion characteristics. Another small group of residual fuel oils are heavy diesel oil and Navy Special Oil. Ships and railroads, which are fueled by this group as well as by No. 5 and No. 6 residual fuel oils, consumed about 12% of total residual fuel oil sold in the U.S. in 1977. The product group, residual fuel oil, therefore includes two types of products in the data structure: No. 5 and No. 6 fuel oils, and other residual fuel oils.

Another group of oil products is called light products in the EEMIS data structure. This group includes propane, 1.7% of refinery production in 1978; ethane and ethylene, 0.1%; other liquefied gases (butanes and butane-propane mixtures), 0.4%; and petrochemical feedstocks (excluding all other products in the group), 3.7%. All these products can be used as feedstocks for the petrochemical industry. Propane is also important to the residential, commercial, industrial, and electric utility demand sectors. Ethane and butanes can be burned as fuels but are more expensive than propane. The light products fuel type, petrochemical feedstocks, includes products (other than those above) used as a raw material for the chemical industry. This type is made up of naphthas, gas oils, aromatics, and other intermediate products made at the refinery that are used for this purpose. These petrochemical feedstocks are not true light products according to conventions of oil industry** but are included in the EEMIS light products group for convenience.

There are three additional oil product types which must be accounted for in the data structure but do not fall within the four product groups mentioned. These products are unfinished oils, kerosene, and others. The product group, other, will be used for these three types in the petroleum energy hierarchy. Unfinished oils are defined to be all oils requiring further processing at the refinery, i.e., any operation except mechanical blending. Kerosene is a petroleum distillate which is similar to No. 1 fuel oil but is tailored with special properties for use as a fuel in space heaters, cook stoves, and water heaters. Kerosene includes all grades of kerosene called range oil. The product type, other, is a catchall for plant condensate, natural gasoline, methanol, and other finished products such as ramjet fuel and petroleum rocket fuels.

*Data from U.S. EIA, Sales of Fuel Oil and Kerosene, Annual Report, November 1978.

**See Physical Aspects of the U.S. Oil and Gas Systems, BNL-51076, p. 45, 1979, for a description of light products.

Domestic Crude Oil Production Facility

Domestic production is the primary source of crude oil, accounting for 59% of the total U.S. supply in 1978, while imports accounted for the remaining 41%. A comprehensive monitoring scheme for domestic production, storage, and shipment of crude oil is an essential starting point for monitoring petroleum supplies.

The number of operating wells in the U.S., about 500,000, is too large to permit monitoring supplies at the wellhead, since the monthly reporting system would be overly burdensome. However, a geographic region must be used as a basis for crude oil production data because the quantity and quality of crude oil produced are highly dependent on geographic location. Crude oil producing regions are therefore defined as a means of structuring production data to accurately represent the physical process of crude oil extraction. The smallest geographic region required for efficient data gathering purposes is the state boundary, for small and minor oil producing states, and large substate regions for the major oil producing states. The exact boundaries that should be selected for substate regions (within major producing states) is dependent upon actual substate production data. A crude oil producing region and the corporations in control of production within the region are two data elements required to characterize one unique petroleum production unit called a crude oil production facility. This is the most disaggregated crude oil production facility in the data structure.

Monitoring production on a controlling company basis for state and substate regions may be difficult in view of the large number of oil producing companies (over 2,000 in the state of Texas alone); however, monitoring by company is necessary so that EEMIS users can identify and contact the parties in control of production, if necessary. A rank order of the producing companies (by volume produced) will facilitate monitoring by company, because a relatively small number of producers supply the bulk of the oil. For example, 60 to 100 companies account for about 80% of the petroleum produced in Texas. In the case of a natural disaster that destroys crude oil production capabilities over a large area, the major producing oil companies in the affected region(s) can be identified from historic rank order data and contacted first to quickly evaluate the impact of the disaster.

Three classes of activities occur within a given crude oil production facility: production, storage, and shipment. Production for a crude oil facility is the amount of crude oil extracted by all oil wells operated by the company within the crude region. Production capacity information is required so that the EEMIS user can determine the added amount of production that can be achieved from each company or region without damaging the resource base. Reserves data have little short-term effect on production activities and are not required information for EEMIS. Short-term projections of production should remain relatively constant during normal situations, but these projections should be most helpful when a crisis situation must be evaluated. Forecasts of domestic production will be based on production projection figures for each region.

Storage of crude petroleum at the lease by producing companies, normally three to seven days' production, amounts to a significant portion of national crude oil stocks. Stock levels play an important role in ascribing a time measurement to a crisis when it becomes necessary to draw from storage to maintain shipments.

The output from a crude oil producing facility is the amount of petroleum actually supplied to bulk terminals and refineries. This data element is the first true domestic crude oil supply that actually enters the energy system. The destination for each output quantity of crude oil provides the linkage between a crude oil production facility and a refinery or bulk terminal. When data are structured in this manner the user can conceptualize the flow of crude oil from the production facility to storage and conversion facilities. When production is lost or curtailed, the user can derive from historic destination data the impact of the production loss. In many cases the producing company may not know the true destination for shipments. As a result the extent to which the flow of crude oil can be tracked is always limited.

Shipments of crude oil from leases usually travel by pipeline or tank truck. A description of every link between the production facility and the transportation network is required in order to tie the facility into the transportation network. This description includes transport company name, mode of transportation, capacity data, and other information described in the transportation network data structure, Section VII. The route for shipments from a production facility to refining and storage terminal facilities is a list of transportation links. The link and route data in the transportation network can be used to derive alternate flow patterns for redirecting the flow of crude oil supplies, if necessary.

The aggregation of crude oil production data to higher levels can give added perspective concerning this segment of crude oil supply. Facility (sub-state) level data can be aggregated to the state level so that data elements constitute state level crude oil production facilities. The data can also be collected at the state level instead of aggregating up from the facility level. This can be done at higher levels of aggregation to obtain regional level (a group of states) or national level (all the states) crude oil production facilities. The same data that are collected for the facility (lowest) level apply at the aggregated levels, but have slightly different meaning. For example, destination for shipments from a regional crude oil production facility is a refinery region or crude oil bulk terminal region rather than a specific refining or bulk terminal facility.

Aggregated crude oil production facility output data can be used as a measure of the supply of domestic crude. For example, with state level production facilities the EEMIS user will know the extent to which refineries in a state in the Midwest are dependent on Texas crude production, and the supply outlook can be determined from production and output for Texas at any time. In addition, the actual crude flow from the Texas crude production facility to the particular state refinery facility might be a better measure of supply. Finally, the EEMIS user can determine the total crude supply from the national level production facility.

Price data are required for both production and outputs from domestic crude oil production facilities. The wellhead price is the value given to the crude by the producing company when it is extracted. Prices for crude oil outputs are always associated with a destination, and transportation costs are not included in output price data.

Crude Oil Bulk Terminal

Domestic and foreign crude oil supplies often pass through a crude oil bulk terminal which can store large amounts of petroleum and channel the crude oil to refineries. The bulk terminal is therefore an essential point for gathering information concerning source and destination for much of the domestic and all of the imported crude oil, in order to track the flow of petroleum from the resource regions to refineries. In addition, the crude oil in bulk terminal storage is a substantial portion of total crude supplies.

The large amounts of crude oil stored at terminals must be known in sufficient detail to support crude oil allocation programs which are administered through EEMIS. The bulk terminal must provide enough information to identify and locate specific types of crude oil that a refinery may need. Information used to determine alternate means for transporting crude oil most efficiently from a bulk terminal to a refinery is also required. For cases when imported crude oil in transit must be redirected, it is necessary to know the capability of each terminal to receive shipments. Sufficient detail on characteristics, inputs, storage, and outputs must be provided to aid in these and other EEMIS user requirements.

The data element characteristic required for identifying a unique crude oil terminal is its geographic location. This level of detail is needed to precisely locate stocks of crude oil and to locate the facilities where tankers carrying imported and domestic crude oil can dock. The controlling company must be known for each terminal so that EEMIS users can contact the terminal, if necessary.

Data elements which are required to track the physical flow of crude oil are inputs and outputs for each terminal. Sources and destinations are needed for the overall structure in the petroleum section so that the terminal facility can be linked to domestic crude oil producing facilities, foreign countries, and refineries. In the event of another oil embargo, source data for imports would be used to identify bulk terminals affected, and destination data for outputs from the terminals would be used to identify refineries that are dependent on the embargoed oil. If a particular terminal becomes incapacitated, the impact on the normal flow pattern for crude oil can be evaluated quickly from destination data, so that the affected refineries can be identified. The normal and alternate transportation links, which are necessary for a terminal to access the transportation network, are also required so that the effects of transportation outages can be remedied expediently. Limitations on the number and size of tankers that can access a terminal are included in

links. These limitations are a very important factor in the redirection of crude oil supplies. The price for inputs and outputs of crude oil can be used to track the price of petroleum as it flows through the energy system. In addition, the relationship between price and country of origin, in the case of imports, will be helpful for forecasting the effects of a rapid price escalation on total supply.

The amount and type of crude oil in storage at each terminal are required information for the administration of crude oil allocation programs, particularly the type of crude oil that is available at a given time since each refinery can process only a blend of crude oil that falls within certain physical property limitations. These factors must be considered in order to effectively allocate crude oil to refineries. The amount of crude oil in storage at terminals for current, historical, and future months, must also be monitored in order to determine current and forecasted crude oil supply. Historical data are needed so that users can perform analysis for a frame of reference; the relative level of stocks is particularly helpful for alerting EEMIS users of potential shortages.

Aggregation of inputs, outputs, and storage level for bulk terminals is a helpful way to represent the crude oil supply situation. Input source data at the state level indicate the producing states and foreign countries that supply oil to terminals in each state. Output destinations at the state and regional levels are state and regional refinery facilities. Therefore, the user can determine trends for the flow of crude oil in the U.S. at aggregated levels; for example, one can determine which states receive shipments from bulk terminals in a particular state. National level data, which give a concise summary of the total supply of crude oil to bulk terminals, the storage level for all terminals in the country, and the amount going to oil refineries, are useful for determining the supply of crude at any time and for forecasting total refinery output based on crude oil that is sent to refineries.

Strategic Petroleum Reserve

The objectives of the Strategic Petroleum Reserve (SPR) Plan and EEMIS are essentially the same: to diminish U.S. vulnerability to the effects of a decrease in petroleum supplies. Because of this common goal, EEMIS would not be complete without incorporating the SPR into the data structure.

There are nine separate SPR sites which are scheduled to have a total storage capacity of 750 MM barrels of crude oil by 1985. SPR sites are large in comparison to the oil terminals monitored in EEMIS. Each SPR site stores crude oil in four or more caverns and each cavern is capable of storing between 5 MM and 32 MM barrels. Because of the vast size of the SPR sites it is very important that they be monitored individually in EEMIS, and that all factors related to drawdown capability be covered in the data requirements. Therefore, facility level SPR data will be on the basis of each SPR site.

All nine of the SPR sites are similar in overall design. Each site is located near a port terminal where imported crude oil is received. Crude oil is blended into SPR types and stored in underground caverns which are first filled with brine. The brine is displaced when oil is pumped into the cavern, and must be discarded by ocean dumping, injection into wells, or delivery to a brine chemical company. To withdraw crude oil, water must be pumped into the cavern to displace an equal volume of oil. A large fresh water source is needed for this purpose. Separate brine, water, and crude oil pipeline networks are required to fill and withdraw oil from the caverns. Special pumps are sized to deliver specified amounts of oil, brine, and water so that desired fill and withdrawal rates can be ultimately achieved.

It is not necessary for EEMIS to incorporate detailed data for pumping and pipeline distribution equipment at each SPR site. Instead, the overall capability for filling, storage, and withdrawal of oil is required in the data structure. The capabilities for each site will ultimately be different, and at least until 1985 will change from month to month as construction of components of site systems is completed; monthly capacity data will therefore be needed for the SPR.

Data for the SPR sites are structured in the same way as the crude oil bulk terminal, since these two facilities have many similarities. Imported crude oil flows into the SPR at a very fast rate. During the first 11 months of the program the flow rate averaged about 6.1 MMbbl/month. Thus, inputs to the reserve constitute a large amount of petroleum and must be represented within the energy system. Source information is required to determine the countries which supply the reserve, because the reliability of crude oil imports is highly dependent on the country of origin.

The amount of petroleum stored at each SPR site is an essential data element that is used for assessing drawdown strategy. The type of crude oil in storage in the SPR is identified by the SPR-type designation. Only one of the five SPR crude types can be stored in a given cavern. Therefore, information about drawdown capability is required for each SPR type stored at the site. This reflects the overall capability of the pumping equipment and pipeline distribution networks for the caverns. Drawdown rate for an underground cavern is a function of the quantity in storage, and the data are therefore represented as a function (rather than an independent value) to accurately represent the physical system.

In the event of an emergency that would require drawdown of the SPR, linkages for SPR oil to the existing commercial transportation network could be a limiting factor in the drawdown or reserves. Therefore, a description of every available transportation link is necessary for evaluation of drawdown strategy. In the event of an emergency that requires SPR drawdown, destinations and routes for shipments would be required to track the flow of SPR to specific refineries. Short-term projections of shipments can be used to forecast supplies during SPR drawdown.

Oil Refineries

Oil refineries in the United States processed 14.7 MMbbl/day of crude oil to produce 89.4% (16.8 MMbbl/day) of the total domestic demand for oil products during 1978. Petroleum products accounted for 48.4% of total gross energy consumption in the U.S. in 1978. Therefore, about 43% of total gross energy consumption in the U.S. is directly dependent upon the operations of oil refineries. Since refineries are the primary suppliers of this large portion of total energy, the data structure must include refinery operations to represent the complete U.S. energy system.

There were 289 refineries operating in the U.S. as of January 1, 1979, and every refinery is unique. Each refinery normally processes petroleum within a fixed range of physical properties (API gravity, sulfur content, etc.) and the product output at any time is dependent upon feedstocks, fixed equipment, and blending stock levels, as well as operating personnel and other refinery specific conditions. EEMIS must observe each individual refinery in order to plan and support actions such as refinery yield orders, oil product allocation, and supply forecasts.

There are many major refineries in the 100 to 500 Mbbl/day crude capacity range (the average size is 62.5 Mbbl/day), and often one of these big refineries is the major supplier for one or more geographic regions. If production at one or more of these refineries were suddenly curtailed as a result of a natural disaster, sabotage, or work stoppages, a comprehensive analysis of the operations for each affected refinery would be required for a complete understanding of the ensuing impact on the nation or specific regions. In addition, the operations of other refineries which could supply the affected regions must be evaluated to determine how to best distribute the impact of the lost refining capacity.

Geographic location is the data element characteristic that identifies each refinery. The controlling corporate entity for each refinery must be known so that responsible people can be contacted, if necessary. A detailed listing of fixed equipment such as distillation and vacuum towers, catalytic cracking units, etc. would have no meaning for EEMIS users because the operation of equipment is dependent on day-to-day conditions at the refinery which cannot be monitored. Intermediate product stock levels, maintenance operations, availability of process steam and other utilities, and operating personnel are some of the factors that affect the operation of equipment. In lieu of a detailed equipment list, the rated capacity of major processing equipment at the refinery is a data requirement that can be related to production limitations. For example, crude distillation capacity is the maximum amount of crude oil that can be processed by the refinery, and it therefore limits the total amount of output. Catalytic cracking units dictate to a large extent the maximum amount of gasoline that can be produced.

Planning for a refinery yield order program requires knowledge of individual refinery flexibility to insure that refinery yield orders be kept within physical limitations. The production level (yield) for each product made at a given refinery is primarily dependent upon the capabilities of fixed equipment, the properties and quantity of crude petroleum that can be used as a feedstock, and the levels of intermediate products stored at the refinery at any given time. An important data requirement which is a general indication of overall refinery limitations is the maximum and minimum amount of each product that can be made from a given feedstock, and the remaining product mix that can be supplied by the refinery. This data requirement is a matrix (Figure III-2) that summarizes the processing flexibility for a refinery. Actual refinery flexibility at any given time can vary significantly from this matrix due to (1) variation of feedstock properties from the "norm" which is assumed to be available, (2) equipment downtime due to scheduled maintenance and other reasons, and (3) manpower limitations. Therefore this refinery flexibility matrix is at best an approximation of the capabilities of the fixed equipment to produce an output mixture for a given feedstock.

Three data element groups are required to obtain a complete understanding of operations for a refinery for energy management purposes: inputs (refinery receipts), storage, and outputs (refinery shipments) of crude petroleum and oil

	Motor Gasoline	Aviation Gasoline	Kerosine-Type Jet Fuel	Naphtha-Type Jet Fuel	Distillate Fuel Oil	Residual Fuel Oil (less than 0.5%)	Residual Fuel Oil (greater than 0.5%)	Light Products	Other Products
Motor Gasoline									
Aviation Gasoline									
Kerosine-Type Jet Fuel									
Naphtha-Type Jet Fuel									
Distillate Fuel Oil									
Residual Fuel Oil (less than 0.5%)									
Residual Fuel Oil (greater than 0.5%)									
Light Product									
Other Products									

Figure III-2

Refinery Flexibility Matrix

Matrix for determining product mix flexibility for oil refineries. Refiner would enter in the diagonal column of heavy black boxes the minimum or maximum values of the product and the resulting output of all other products would be entered across each row. Two forms would be used each year to cover for minimum and maximum values on separate forms. The refiner would assume the refinery is operating at 100% of crude oil capacity for the normal average crude mixture.

products. These three groups of refinery data provide the minimum information necessary for a complete understanding of refinery operations. For example, the amount of crude oil that a given refinery processes is equal to total receipts of crude oil minus any change in the level of crude oil in storage. The quantity of oil products that are actually produced can be similarly derived from shipment and storage data.

Production from a given refinery is dependent upon the quantity and type of crude oil used as feedstock. Therefore it is extremely important to monitor refinery receipts of crude oil in addition to storage levels by crude oil type. The information required to forecast refinery output includes input and storage levels of the different types of crude oil. These data elements are also necessary for allocating crude oil among oil refineries. Short-term projections of inputs can also be used to forecast refinery outputs.

The supplier for crude oil received by the refinery can be either a domestic crude oil production facility, a foreign country, or a crude oil bulk terminal. Source data specifying the supplier for each quantity of crude oil received by the refinery contribute to the overall EEMIS data structure by linking a refinery with these other facilities. By structuring crude oil supply data in this way, crude oil supply patterns for U.S. refineries can be identified, and the impact of a sudden decrease in petroleum imports or domestic production can be quickly determined by EEMIS users. In addition, source data for crude inputs are useful for planning crude allocation schemes.

Refineries in the U.S. normally store enough crude oil, on average, to maintain production for one week. Thus, stocks at refineries constitute a substantial quantity of available crude oil supply. In order to forecast refinery outputs, one must know current and historical input and stock levels of the different types of crude oil. Storage data are therefore an important EEMIS requirement.

There is normally 30 to over 60 days' supply of production kept in storage at the refinery. The actual level depends on the product. Current and historical monthly stock levels for oil products are required data so that EEMIS users can be alerted to potential shortages of oil products based on storage level at the refinery.

Refinery output is a rough indicator of total supply of oil products in the U.S. (about 10% is imported). The destination for output from a refinery can be wholesale and retail distributors and end users. Refinery output data specifying type of destination and geographic region for output are required in order to systematically derive domestic demand for oil products (see Section V). The refinery must specify the demand sector (e.g., residential, commercial, industrial, electrical utilities, and transportation) and geographic demand region (state) for each quantity of oil product shipped.

The Economic Regulatory Administration's gasoline allocation system determines how much motor gasoline is available each month at service stations. Individual refineries do the actual allocating to wholesale and retail distributors (jobbers) and retailers, where the refinery markets directly. The system uses a base period as a reference in determining allocation fractions for state authorities (to meet emergency needs or to ease hardship cases) and for priority customers. The current base period is defined as the sales volume of the same month from November 1977 through October 1978. A refiner must set aside 3% of his available gasoline supply each month as the "state setaside." Customers with No. 1 priority - farm customers and the Department of Defense - must be supplied 100% of their current needs. No. 2 priority is for emergency users, such as fire, police, ambulance, sanitary agencies, passenger transportation, and truckers, and these users must be supplied 100% of their base period volumes. Distributors and retailers have the lowest priority, and they must share the remaining volumes subject to allocation. EEMIS data required for gasoline reallocation and rationing are: (1) the monitoring of individual refineries, (2) current monthly output data, (3) historical monthly output data, and (4) destination data for refinery output.

By associating a demand sector and geographic region (to derive demand) for each quantity of oil product shipped from a refinery, the data become structured, and, as a result, output data are more meaningful than total supply data. This methodology provides the link between supply and demand that is essential to assess a wide variety of shortages that may occur. For example, the impact (on demand) of crude oil shortages due to a sudden decrease in domestic production or to an oil embargo can be determined from the refinery crude oil supply link for inputs, and oil product destination link for outputs. Destination data for refinery outputs are also useful in planning oil product allocation, gasoline rationing, and other actions which focus on refinery shipment to the demand sectors.

Refinery price data for crude oil inputs and oil product outputs are required to determine the pricing structure of the oil refining industry. Value added to petroleum by the refiner can be determined easily by using these data.

A list of transportation links comprising the route taken by crude oil from a domestic production region, foreign country, or crude oil bulk terminal to the oil refinery is required to determine the impact of a transportation outage. For the state and regional level oil refinery facilities, route data can be used to determine the effect of a regional transportation outage on different refinery states or regions. For example, if a section of the Mississippi River becomes blocked with ice, the impact on crude oil supply to all refineries in Illinois would be known. Transportation links available for inputs to Illinois refineries include all Mississippi River terminal facilities as well as major pipelines that may or may not be used at any time. By integrating available pipeline transportation links into the transportation network, the user can determine how much of the lost supply can be made up by using pipelines to bring the oil to Illinois.

Routes for outputs from refineries to demand facilities can be used in an analogous fashion to determine the effect of transportation outages on refinery outputs. For example, in the case of the frozen Mississippi, the user could quickly determine the impact this would have on shipments from Illinois refineries by river to other state destinations. Alternate transportation links available between Illinois and the normal state destinations could be searched out to determine how much of the lost supply could be regained by switching the transport modes from barge and tanker to pipeline.

Oil Product Bulk Terminal

There are two primary supplier facilities for oil products in the U.S. energy system: oil refineries and oil product bulk terminals. A comprehensive representation of oil product distribution in the data structure necessitates the monitoring of both these facilities. Oil product terminals are a primary storage facility for oil products made at both U.S. and foreign refineries. In some areas, especially where there are no refineries, a bulk terminal is the only primary source for supply. Product imports must pass through bulk terminals; therefore, imports are monitored most accurately by collecting data from terminals.

Only a fraction of oil products is sold directly to end users from oil refineries; the largest portion of refinery shipments is usually sent to either wholesalers or retail distributors. In order to accurately represent oil distribution in the data structure, and to derive the real demand for oil products, information concerning the ultimate destination for oil products must be captured. The ideal solution to this data problem would be to collect data from every facility that handles oil products. However, gathering monthly data from the large number of retail distributors, estimated to be between twenty and thirty thousand, is an impossible task. On the other hand, it is possible to gather monthly data from bulk terminals in a timely manner; the Joint Petroleum Reporting System is a mandatory monthly EIA data system which currently monitors storage levels of finished petroleum products at bulk terminals (at the state level). In order to eliminate small retail distributors and to monitor imports of oil products, the Energy Information Administration (EIA) defines a bulk terminal as "a facility which is primarily used for storage and for marketing of gasoline, kerosene, distillate, and residual fuel oils and which (1) has total bulk storage capacity of 50,000 barrels or more, or (2) receives its petroleum products by tanker, barge, or pipeline."* The same definition, amended to include all oil product types, can be used to describe an oil product bulk terminal facility in the EEMIS data structure.

Data element characteristics for the facility level bulk terminal are the location and the name of the controlling company. Geographic location is used to define a unique facility. The controlling company is responsible for operations at the terminal, and EEMIS users would contact the company when necessary.

*Instructions for the Preparation of the Monthly Bulk Terminal Stocks of Finished Petroleum Products Report (FEA-P321-M-0).

The oil product distribution system, which functions to deliver many different petroleum products from refineries to end users, is a complex system of refineries, wholesalers, retail distributors, and foreign countries which constitute supply, and end users which constitute demand. The EEMIS data structure represents this complex system by structuring data for the important facilities in the physical system: oil refineries, bulk terminals, and the import/export sector, which represent supply; and the demand sector. The physical flow of oil products to and from oil product bulk terminals is represented by input and output data elements in the data structure, and these elements are an important part of the oil distribution system.

Oil product bulk terminals are tied into the overall data structure by means of source and destination data for inputs and outputs. Source data are required to identify the refinery or foreign country supplying oil products to the bulk terminal. A crude oil embargo or a domestic crude oil shortfall resulting in a sudden decrease in refinery production can thereby be linked directly to the appropriate bulk terminals that are supplied by the affected refineries. Destination data for bulk terminal shipments are required so that demand for oil products can be determined. The state and the demand sector, which identify a demand facility (Section V), are therefore required information for each quantity of products that are shipped. Output destinations link the terminal with a demand facility, so that the direct impact of a disruption of supply to the terminal can be determined. This allows EEMIS users to measure the impact of a crude oil shortage or a decrease in refinery production on the amount of supplies that will be available to meet demand.

Often the limiting factor in receiving and sending shipments of oil products at a bulk terminal is the capacity of the tanker loading platform, pipeline, or tank truck loading platform. For example, in a situation where a bulk terminal is required to ship large amounts of product to another terminal which has lost its normal supply, the tanker loading platform may be capable of handling only the terminal's normal day-to-day operations. The data element, "transportation links available," describes the links between the terminal and the commercial transportation network so that users can consider this limiting transportation factor. Thus, transportation limitations at the terminal can be incorporated into plans for product allocations.

Bulk terminals store a large amount of oil products, and the amount in storage at the terminal is an indication of the supply situation at any given time. Storage quantity for each product type is a required element that will alert users when particular products are approaching low levels. In this way users are informed of impending product shortages. By choosing the level of aggregation the user can evaluate the overall supply at facility, state, regional, and national levels. Comparison of current and historical monthly data will be the basis for forecasting supply.

IV. NATURAL GAS SECTOR DESCRIPTION

The EEMIS natural gas sector structure follows the flow of natural gas through the energy system from supply to treatment at gas processing plants, transportation, storage, and distribution to various end-use demand sectors (see Figure IV-1). The two most likely measures to be taken in a gas supply shortfall, exclusive of voluntary conservation, are curtailments to low-priority users and allocation of available supplies. Data required to implement these measures are specified in the transmission and distribution facility of the natural gas sector structure, as well as in various other facilities of the structure.

Six facilities have been defined in the structure as representative of the natural gas industry:

- Natural Gas Production
- Gas Processing Plant
- LNG Terminal
- Underground Storage
- Supplemental Fuel Storage
- Transmission and Distribution

In addition, demands for natural gas and the gas transportation network are represented in the demand sector and transportation network structures, respectively.

Natural Gas Production

Domestic production of natural gas accounts for 95% of the gas supply in the United States, and LNG and pipeline imports account for the remainder. Production data from gas and oil wells are required for each company at a state or substate level to determine how supply interruptions resulting from natural disasters or the destruction of facilities will affect supplies to the pipeline companies. Separate production data for gas and oil wells are specified in the structure because natural gas produced from oil wells is largely dependent on the quantity of oil produced, whereas gas produced from gas wells is completely determined by the production capacity of the well and the market for gas.

Production data in EEMIS will be collected by company at the state or substate level rather than for each of the 145,000 gas wells and 500,000 oil wells in the U.S., which would be infeasible on a monthly basis. Production data from the major producing states will be collected at a substate level (e.g., Texas Railroad Districts), and at the state level from other regions. If an emergency situation causes a shutdown or sudden decrease in regional gas production, the EEMIS user will require data on the quantity of gas cutoff, the pipeline companies affected, and whether excess gas from other producing

EEMIS - NATURAL GAS SYSTEM

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Figure IV-1

regions can be diverted to those pipelines unable to meet their firm contractual obligations. Production data at the state or substate level by company are sufficient to meet these user requirements. Production data for all producing companies will be aggregated to the state, regional, and national levels to provide current and projected production data to meet user requirements. Aggregated source/destination data provides state and regional energy offices with source information for their natural gas supplies.

Under Title III of the Natural Gas Policy Act (NGPA),* the President may authorize any interstate pipeline or local distribution company to contract for the purchase of emergency gas supplies from any producer of natural gas at a fair and equitable price, during a natural gas supply emergency. This provision requires information on current production by company, the flow of gas from gathering lines to gas processing plants, and the wellhead price of the gas. These data requirements are defined as follows in the natural gas production facility of the EEMIS gas structure.

Characteristics of a natural gas production facility are geographic region and producing company. There are approximately 1300 producers with annual sales of 100 MMscf or more and over 2400 producers with smaller sales. Production data specified in the structure are quantity by well type (gas well or oil well), wellhead price, daily production capacity, and short-term production projections. The wellhead price of natural gas is subject to phased decontrol as defined in the NGPA.** Short-term production projections, normally at a relatively constant level throughout the year, are required in the event of a shutoff or sudden decrease in production due to a natural disaster or the destruction of facilities. These projections will provide information on when production can be expected to return to normal.

Output data defined for a production facility are quantity of gas produced by destination, wellhead price by destination, transportation links available, and short-term shipment projections. These output data are necessary in a natural gas emergency in which supplies from producers are directed to pipeline companies that require additional natural gas to meet demands of high-priority users. Most producing wells normally operate at or near their optimum rate of production, and any significant increase in production can affect ultimate recovery of resources from the well. In a short-term supply emergency, producers of natural gas can best assist in reducing the shortage by diverting their supplies to meet requirements of high-priority users, rather than by increasing production.

*NGPA, Title III - Additional Authorities and Requirements, Subtitle A - Emergency Authority.

**See Physical Aspects of the U.S. Oil and Gas Systems, BNL 51076, 1979, for details of wellhead price deregulation.

Gas Processing Plant

In the event that a natural gas processing plant is shut down because of a natural disaster or destruction of facilities, "wet" gas inputs to the plant will be redirected to another processing plant, if possible. If not, the wet gas can be rerouted to bypass the processing plant and go directly into the interstate or intrastate pipeline system. This option entails losing the natural gas liquids, and would only be chosen if no other option existed. Shortages of natural gas liquids may develop, requiring reallocation of these products to refineries, chemical plants, and bulk terminals to minimize shortages.

In 1977, 88% of the marketed production of natural gas was processed to extract condensable hydrocarbons and other impurities before delivery to the pipelines. The other 12% was delivered directly to end-use consumers without processing either because it contained a low yield of liquids that did not warrant processing, or because the gas was produced from an isolated field where production was not sufficient to justify construction of a gas processing plant.

The data requirements in the EEMIS sector structure for gas processing plants specify quantity and source data for wet gas input to a plant. This information, along with data from the transportation network, allows the EEMIS user to redirect flows from an inoperative plant to others that are operating below capacity. A sudden decrease or complete shutdown in regional gas production will require reallocations from other producing regions to minimize the impact on high-priority users. These reallocations may take place among the pipeline companies, or may require diverting gas in the gathering lines before it reaches the processing plant. If this occurs, capacity and flow data into processing plants will be required.

The natural gas sector structure specifies inputs, outputs, capacities, and storage levels at each processing plant, but internal flows in a plant are not specified. Internal flow and type of equipment in a plant provide information on the ability of a facility to process gases of varying composition, and extract varying amounts of liquids from the wet gas. The cryogenic process, for example, is capable of a higher recovery rate for ethane and propane than the more conventional oil-absorption process. This information may be desirable for long-term planning, but is not necessary for allocating supplies over the short term since investments in major capital equipment can not be made in this time frame.

The storage of natural gas liquids at processing plants is monitored to provide data on available supplies of ethane, LPG's, and heavier hydrocarbons to refineries and bulk terminals in the petroleum sector. Storage of natural gas liquids at gas processing plants is linked to refineries and bulk terminals via the transportation network structure in which transportation mode (pipelines, tank trucks) and route information are specified.

The quantity of output of natural gas and other products (ethane, LPG's, pentanes, finished products) from a processing plant is specified by product type and destination. Natural gas output from a processing plant enters either the interstate or intrastate pipeline system. Pipeline company name and the quantity received are monitored by pipeline for each processing plant. If a processing plant were shut down or its output suddenly reduced, this information would be used in redirecting additional supplies to the affected pipeline companies.

Short-term receipt projections of wet gas from a producing region, shipment projections of dry gas to the pipelines, and shipment projections of natural gas liquids to refineries and bulk terminals are monitored by destination in the structure. This information will be used by the system to forecast possible shortages and to reallocate supplies to meet these shortages.

LNG Terminal

Receiving terminals for liquefied natural gas import natural gas from overseas or other U.S. terminals in specially designed insulated tankers, store the LNG in large insulated tanks, and revaporize the liquefied gas for base-load distribution into the pipelines. On the basis of LNG projects either planned or under construction, imports could be as high as 1.6 trillion ft³/yr by 1985, or 10% of the total supply of natural gas in the United States.

The LNG terminal facility incorporated into the natural gas sector structure is designed to monitor exporting* as well as importing terminals. In the facility level structure each terminal will be a separate entity in the structure. At the state, regional, and national levels of aggregation, input, output, and storage data will be totaled for all terminals in the geographic region specified. National level aggregates will provide data on total LNG imports to the U.S., while facility level data will provide input, output, and sendout capacity data for each terminal.

Characteristics of an LNG terminal specified in the structure are location and ownership. It is relatively common for a base-load LNG import terminal to be jointly owned by two or more companies, e.g., the Cove Point, Maryland, terminal, which began operations in March of 1978 and has a sendout capacity of one billion ft³/day, was jointly financed by Columbia LNG Corporation (a subsidiary of Columbia Gas System) and the Consolidated System LNG Company (a subsidiary of Consolidated Natural Gas Company).

*There is currently one major exporting terminal in the United States which is located in Kenai, Alaska, and exports LNG to Japan. It has a liquefaction capacity of 185 MMcf/day. A second terminal to be located in Cook Inlet, Alaska, will supply LNG to one of several proposed LNG receiving terminals in California.

Inputs to LNG receiving terminals are monitored by source of supply (foreign country and company) and delivered price. Input quantities are required by source in the event supplies are cut off due to an embargo or internal strife in a foreign country. One terminal may have contracts with several sources to bring supplies up to terminal capacity. The LNG terminal proposed in California, for example, is planning to import 900 MMscf/day from Indonesia and the Cook Inlet area of South Alaska. Storage data monitored in the structure are quantity in storage, storage capacity, and sendout capacity. Although base-load LNG plants normally operate at a relatively constant sendout rate throughout the year, they may not be sending gas into the pipeline at full capacity because of constraints on supply or insufficient demand. In the event of a natural gas supply shortage of at least several months' duration, an importing terminal not operating at full capacity may help alleviate a temporary shortage by delivering additional quantities of gas into the pipeline if they can be negotiated on an interim basis.

Outputs from LNG receiving terminals are monitored in the structure by destination (interstate or intrastate pipeline company) and price. These data are needed to assess regional impacts of a cutoff in supply due to an embargo or internal disorder in a foreign country. Pipeline companies purchasing gas from the terminal are identified in the structure along with the quantity and price of their purchases. The EEMIS user can then refer to the transmission and distribution facility in the gas structure to gain further insight into the problem. Transportation links between foreign countries and LNG receiving terminals provide data on routes that tankers normally follow in transporting liquefied gas to the U.S., as well as alternate routes that are available if normal routes cannot be followed. Transportation links between the terminal and the gas pipeline network provide data on alternate modes of transport that are available, such as tank trucks, if sendout lines from a terminal are shut down.

Underground Storage

Underground natural gas storage reservoirs are critical to the natural gas energy system, supplying up to one-third of total gaseous fuel supplies during periods of peak demand. These reservoirs are normally operated by a transmission or distribution company, or an independent operator. Thirty-two jurisdictional transmission companies operate 210 of the 386 storage reservoirs. Gas reservoirs typically contain gas from several gas companies, requiring data on gas ownership as well as on operating company. A distribution company located in a region not containing underground reservoirs, for example, may require storage to balance its load curve. It will typically store gas in a facility operated by its pipeline supplier or another operator to meet the seasonal demands of its customers. Natural gas distribution companies serving the New York City Metropolitan area, for example, store gas in underground reservoirs to meet the winter heating demands of their customers. These reservoirs are located in Pennsylvania, and comprise 10% of storage capacity in the U.S.

Title III of the NGPA gives the President authority to declare a national gas supply emergency if a shortage endangering supplies for high-priority use exists or is imminent. During an emergency, the President, under certain conditions, has the authority to order supply allocations to interstate pipelines and local distributors. Reallocating supplies requires information on the location and availability of natural gas. Approximately 2 trillion ft³ or 10% of annual natural gas consumption is stored as working gas in underground reservoirs, and is available for use during an emergency. Data on quantity of working gas in storage by reservoir, peak-day sendout, and transportation links to the pipeline network are required if underground gas storage is to be used as a source of supply during a gas emergency.

In the facility level structure, each underground storage reservoir is defined as a separate facility in the structure. In the state, regional, and national level structures, reservoirs are aggregated up to the appropriate level of detail. Facility level data are required for allocating gas in an energy shortage, whereas state, regional, and national level data are required to determine current and forecasted supplies to a region.

Characteristics of an underground storage reservoir defined in the structure are location, operating company, and drawdown rate as a function of gas in storage. The withdrawal rate of gas in an underground reservoir is dependent upon pressure in the reservoir, which varies directly with the quantity of gas in storage. Drawdown rate is an essential factor in determining the availability of gas supplies from an underground storage facility. Inputs and outputs to an underground storage facility specified in the structure are injections of gas by source, withdrawals by destination, and the company owning gas in storage. The company that owns gas in a storage field must be identified if regional supplies are to be assessed. If an interstate pipeline purchases natural gas and injects it into a storage field it owns and operates, then storage field operator, source of supply, and gas ownership will all be identified with the same pipeline company. In other instances, a pipeline company delivers gas owned by a distribution company to an independently operated storage field, in which case storage field operator, source of supply, and gas ownership will each be identified with a different company.

The gas sector structure specifies the quantity of working gas in storage by owning company, price charged for storage, working gas capacity, and cushion gas capacity for each underground storage facility. Working gas in storage by November of each year at the facility, state, regional, and national levels is an indicator of natural gas supplies for the coming winter. Working gas in storage during the winter months is an indicator of supplies available for the remainder of the heating season. Cushion gas is normally not withdrawn, but in the event of a gas emergency a fraction of the cushion gas may, in some instances, be withdrawn at a reduced drawdown rate.

Supplemental Fuel Storage

Supplemental fuel storage facilities include LNG, propane, and SNG peak-shaving plants located on site which supply transmission and distribution companies with gaseous fuel supplies during periods of peak demand. Although

supplemental fuel storage is generally owned and operated by a single transmission or distribution company, it is incorporated in the structure as a separate facility in order to track inputs and outputs, and also to maintain a uniform design across various sectors in the structure. If a transmission or distribution company owns more than one LNG, propane, or SNG plant, each plant will be designated as a separate entity in the facility level structure. Supplemental fuel storage facilities at the state or regional level of aggregation include all facilities physically located in that state or region, regardless of ownership. Thus, LNG, propane, or SNG plants, owned by an interstate pipeline that is not identified with a particular state or region, will be incorporated into the state or regional supplemental fuel storage facility in which they are physically located.

Characteristics of the supplemental fuel storage facility specified in the structure are location, type of facility (LNG, propane, or SNG), and ownership. Location of a facility is required to aggregate supplemental fuel supplies to the state and regional levels and to monitor these supplies in the event of a regional gas shortfall.

Inputs of natural gas to LNG plants, propane to propane plants, and naphtha or LP gas to SNG plants are monitored by source. Propane and SNG plants receive their supplies from refineries and bulk terminals in the petroleum sector. Thus, energy emergencies in the petroleum sector can directly affect supplies to natural gas transmission and distribution companies, in addition to the effects of fuel switching due to supply shortages in the petroleum sector. These cross-sectoral impacts resulting from an energy emergency are accounted for in the EEMIS sector structures by source/destination data elements associated with each facility. Data on the quantity of LNG, propane, and naphtha or LP gas in storage and peak-day sendout are basic information required by a utility in determining its ability to meet forecasted demand. Although supplemental fuels make up a relatively small fraction of total annual supplies of natural gas, they are essential to many utilities in meeting their firm requirements for natural gas. Output from supplemental fuel storage facilities to transmission and distribution companies represents actual deliveries into the pipeline for a given time period, and may vary from zero during the summer months to peak-day sendout levels during the heating season.

Transmission and Distribution

Natural gas transmission systems transport gas from producing to consuming regions, while distribution systems distribute gas to end-use customers. The intrastate pipelines primarily operate in the producing states and transport about one-third of all gas consumed, while interstate lines account for the remainder. Pipeline companies transporting natural gas differ from crude oil and oil product pipelines in that gas pipeline companies normally take ownership of the natural gas at the wellhead or gas processing plant outlet, whereas petroleum pipeline companies generally transport crude oil and oil products

that are owned by an oil producer. As a result, gas pipeline companies play a central role in the natural gas energy system and are represented in the EEMIS gas structure as separate facilities.

At the facility level each of the 83 interstate pipeline companies and approximately 1400 intrastate pipeline and distribution companies is represented by a separate facility. Since an intrastate pipeline or distribution company's service region is limited by state boundaries, it is fairly straightforward to characterize these companies at the state, regional, or national level of aggregation: all intrastate pipeline companies and distributors in a state or region will be represented by one facility. At the national level, all intrastate pipelines and distributors in the U.S. will be represented by one facility. Interstate pipeline companies transporting gas across state lines, however, cannot be represented at the state or regional level in the same manner as local distributors, since an interstate pipeline may be transporting gas from, say, Texas to Virginia. At the state or regional level of aggregation, the structure specifies separate data for each interstate pipeline company. This structure provides state energy offices and other regional energy agencies with current and forecasted data on supplies of natural gas to their state or region. At the national level, all interstate pipelines in the U.S. will be represented by one facility.

In the event of a natural gas shortage due to a supply shortfall or a sudden increase in demand due to cold weather, transmission and distribution companies will reallocate natural gas from a region of adequate supply to those requiring additional supplies to meet demand. Gas companies routinely reallocate supplies in this manner, both as a part of their everyday operations and in the event of a major interruption in supply.

Under the NGPA the President also has the authority to reallocate supplies if a natural gas supply emergency is declared. Title III - Additional Authorities and Requirements, Subtitle A - Emergency Authority, of the NGPA, gives the President authority to declare a natural gas supply emergency if a gas shortage endangering high-priority use exists or is imminent. High-priority use is defined as use by a residence or commercial establishment requiring less than 50,000 ft³/day, and any use which would endanger life, health, or maintenance of physical property if curtailed. The President's declaration of emergency will terminate after 120 days or earlier, unless extended because of continued emergency conditions. The emergency authority is similar to that conferred upon the President by the Emergency Natural Gas Act of 1977, which was in effect during the unusually cold 1976-1977 winter. During an emergency, the President may authorize certain emergency sales of gas. If these emergency sales are not sufficient to protect high-priority users, he may allocate supplies to interstate pipeline and local distributors that are served by interstate pipelines, or request additional supplies to meet requirements for high-priority use.

This program requires supply/demand information from transmission and distribution companies for a wide range of data defined in the natural gas structure. Characteristics of a transmission or distribution facility represented in the structure are company name and states or region serviced. The

areas served by each company are specified for state or regional energy office use to identify suppliers in the event of a regional shortage. Inputs to transmission and distribution facilities are the quantity and price by source. These data are needed by states to reallocate intrastate supplies and determine future supplies. Transmission and distribution companies receive their gaseous fuel supplies directly from a producer or gas processing plant, another transmission company, underground or supplemental fuel storage, pipeline imports, or an LNG terminal. The price paid for gas by a transmission company (wellhead price) and distribution company (city-gate price) is specified in the structure for each source. These price data are needed to assure that just and reasonable prices are charged by interstate pipelines in making emergency allocations under Title III of the NGPA.

Reallocation of supplies requires a thorough familiarity with the interstate gas pipeline network. The EEMIS transportation network structure defines data elements for each link in the pipeline network in terms of location, capacity, and current flow through the line. In the case of more than one pipeline linked to a distributor, the data element "transportation links available" indicates alternate routes for use during periods of high demand when existing supply routes are inadequate. The transportation network defines capacity and current flow for these alternate routes.

Figure IV-2 is a simplified configuration of a typical pipeline system in which two gas pipelines are supplying distributor A. Pipelines A and B receive their supplies from two producers, with pipeline A storing its excess supply underground to meet peak seasonal demand. Distributor B receives its gas supply from pipeline C, and supplements its pipeline supply with gas from a peak-shaving LNG plant to meet peak seasonal demand. Pipeline C receives its supply entirely from pipeline B rather than from a producer contract. This simplified pipeline configuration illustrates the complexity of the natural gas pipeline system in the U.S., and the need to quantify source/destination flows of natural gas in order to reallocate supplies during a natural gas emergency.

Quantity of gas in storage by transmission or distribution company is monitored for underground storage, LNG, propane, and SNG storage facilities. These supplies are used to supplement pipeline gas during the heating season, and are required in assessing the ability of a state or region to meet its seasonal demand for natural gas. Data on individual storage facilities are provided in the underground storage and supplemental fuel storage segments of the structure, whereas data provided here are aggregated by fuel type for a given transmission or distribution company over all storage facilities.

Outputs from transmission and distribution facilities include quantity by destination and type of service (firm or interruptible). Destinations represented in the structure are demand facilities, other transmission companies, underground storage, LNG storage, and pipeline exports to foreign countries. Gas curtailments for each transmission and distribution company are monitored by demand facility and type of service. Data on current deliveries and curtailments by demand sector (residential, commercial, industrial, electric

Figure IV-2

Natural Gas Pipeline Configuration

utility) and type of service are used by each transmission or distribution company in developing plans, according to the FERC Curtailment Priorities,* for future curtailments in the event of a supply shortfall.

Quantities of alternate fuels used and the fuel switching capabilities of all end-use customers are specified in the structure for each transmission and distribution company. The capability of end-use customers for switching to alternate fuels is an important consideration for a gas company in developing its curtailment plan, and would be an important factor in reallocating gas during an emergency. An industrial plant which has the capability to burn alternate fuels is a low priority customer, according to the FERC Curtailment Plan. It may have its gas supply curtailed before a plant which does not have the capability to use alternate fuels and requires natural gas to maintain production. Delivered price to end-use customers, as specified in the struc-

*See Physical Aspects of the U.S. Oil and Gas Systems, BNL 51076, 1979, for details of FERC Curtailment Priorities.

ture, is used in computing the additional cost consumers must pay for emergency gas supplies, and the impact these higher prices have on the local economy. Short-term forecasts as well as current monthly data are monitored for all quantities associated with transmission and distribution facilities, except for capacity and price data. Short-term supply/demand forecasts are used to predict whether seasonal curtailments will be necessary. If curtailments to high-priority users are forecast, reallocation or emergency gas purchases can be planned.

V. DEMAND SECTOR DESCRIPTION

The approach used in the EEMIS data structure to characterize demand in the energy system is to describe the usage of all fuels within common geographic regions and by selected large end users. These two representations of demand are specified by a demand facility and large end-use consumer facility in the structure.

Demand Facility

A demand facility is structured in geographic units by demand sector to capture the patterns of interfuel substitution that exist in the energy system. This structure is appropriate for the design of an energy management information system that must monitor the oil and gas energy system in the U.S. The breakdown of fuels by sector and region gives a complete overview of the energy system so that users can determine the total impact of regional shortages and can develop allocation plans to remedy the situation. In the event of a shortage of one fuel such as natural gas, there is a tendency to switch to alternate fuels, causing possible shortages in these fuels. This aspect of the energy system is represented in the data structure. For example, residential and industrial usage of natural gas and/or No. 2 fuel oil is indicated for each demand region so that the user can examine tradeoff options as they exist. A side benefit of using geographic regions is the ability to map in weather patterns and forecasts to foresee shortages of weather-dependent fuels.

It is impossible to gather timely data from every user of oil to determine true demand. EEMIS is a supply-driven energy information system, and therefore the data structure represents demand information which originates from primary suppliers for oil rather than from the real end users. As a result, demand is the flow of supplies to end users, or in the case of some petroleum products, to distributors. Secondary storage, the amount of oil products that is in storage tanks at jobbers, retail oil distributors, and gasoline stations, is not accounted for in the data structure because: (1) timely sales and storage data cannot be gathered for the large number of gasoline stations in the U.S. (approximately 186,000) and retail distributors (about 20,000 to 30,000), and (2) the level of storage at these establishments, usually a week's

supply or less, is not sufficient for a system that uses a one-month time frame. Surveys of sales and storage for these establishments on a regional basis would be helpful as a supplement to regional demand data. This type survey is sometimes conducted by state governments during periods of high demand.

Measurement of demand for natural gas differs from that for oil in that distributors of natural gas meter the flow of gas to each end user. These distributors are represented in the natural gas sector structure as individual facilities. Distributors report natural gas sales by demand sector and state to provide the data required for the EEMIS structure.

The smallest geographic representation of a demand facility is the state. Substate regions would result in a large reporting burden for the oil and gas industries and increase the level of inaccuracy because of reporting inconsistency and time lag. Primary suppliers - oil refineries and bulk terminals, natural gas pipelines and distributors - will report volume and price by demand sector and state for oil and natural gas shipments. By summing flows into a region, the system will derive total sectoral demand by fuel type.

A schematic representation of the flow of oil products from primary suppliers to demand is given for two states in Figure V-1. Primary suppliers in this figure are represented as rectangles, and demand sectors as circles. The flow of supply quantities from suppliers to demand is shown with arrows. Each arrow can represent quantities of one or more oil product types. Total demand for a state is the sum of the flow quantities from primary suppliers to demand sectors in the state. The quantity of products supplied to wholesale and retail fuel oil distributors in a state from the refinery and the bulk terminal would be the total demand for the residential and commercial sector. An assumption that is used to derive residential and commercial demand is that secondary suppliers do not supply industry or electric utility sectors. Surveys could be made of these secondary suppliers to determine their true market so that EEMIS can measure demand more accurately.

Demand for automobile transportation in State 2 is the sum of the output quantities to this demand sector from the refinery and bulk terminal. Demand for all other sectors can be derived in this manner. This methodology for deriving demand data does have a degree of inaccuracy. The amount of products supplied to the residential and commercial sector in State 2 from oil distributors in State 1 is assumed to be equal to the amount supplied from distributors in State 2 to State 1. This may not be true, and without incorporating survey information into the data structure, the amount of error realized by this assumption is unknown.

Representing demand in this manner will permit rapid response and impact evaluation for different energy emergencies since specific facilities are identified as primary suppliers for a demand region. When a primary supply facility is put out of service by some form of destruction, the affected regions and sectors can be identified immediately. In the case of oil, other refineries

and bulk terminals which normally supply the affected regions (or did so in the past) can be identified quickly to determine alternate supplies available during an emergency. The same approach can be used for any disruption upstream of the primary supplier, e.g., an oil embargo, regional transportation outages, or destruction of crude oil or natural gas production facilities.

Characteristics which define a unique demand facility are the state and the demand sector. Input quantity represents the flow of oil and gas to the demand facility, and this data element is the derived demand figure in the EEMIS data structure.

The allocation of oil products and natural gas can be used to remedy shortages that develop in particular states or regions. Knowledge of the primary suppliers for states and regions, their historic demand patterns, and fuel switching capabilities is used as a basis for allocation. Source data for inputs to the demand facility provide the necessary link between supplier and demand. Capacity utilization for transportation of oil and gas can be determined from route information, so that the amount of additional fuel that can be transported along the normal route is known. Routes are also required so that alternate transportation schemes can be evaluated in the event of transportation outages.

Figure V-1
Schematic Diagram of the Relationship between Primary Suppliers and Demand for Oil Products in Two States

The extent of natural gas curtailments to firm customers is a determining factor in declaring a natural gas emergency. If a shortage of natural gas endangers the supply of gas for high-priority use, emergency purchases and allocations may be ordered to relieve the shortage. Historically, curtailments to interruptible customers have occurred only on the coldest winter days. It is becoming increasingly common for a utility to curtail deliveries to its interruptible customers for a major portion of the winter, with the customer depending upon an alternate fuel to meet its daily energy needs. This policy reduces a utility's options for meeting increased demand due to extremely cold weather or decreases in supplies. If a gas shortfall occurs during the heating season, a utility may be forced to curtail gas to firm industrial or large commercial customers with no alternate fuel capability, since lower-priority customers would have already been curtailed, causing the closing of manufacturing plants, schools, and other commercial establishments. Monitoring current and projected curtailments by local distributors can minimize these closings by providing government energy agencies, as well as the interstate gas pipeline companies, with the information and lead time that are needed for appropriate action to be taken.

Alternate fuel capabilities must also be considered in determining the most effective allocation program. For example, industry, in many instances, is capable of burning residual fuel oil in place of the natural gas that is used as primary fuel in boilers. Data elements specified in the demand structure that provide this information are alternate fuel usage and alternate fuel capabilities. These data are associated with each demand facility so that the fuel needs of other sectors that can be met by alternate fuels can be estimated.

Large End-Use Consumers

Large end-use consumers are defined to be those industrial and commercial facilities* whose annual requirements for oil, gas, coal, or electricity are above a specified level (100 million cubic feet in the case of natural gas). Data on fuel consumption by source of supply and transportation route will be collected at the company level in order to determine the impact of an energy supply interruption on major energy-consuming facilities. The capability of a facility for switching to alternate fuels is a key data requirement necessary in determining regional energy and economic impacts. Economic impacts as measured in terms of reduced industrial output, loss of service, and unemployment will heavily depend upon industry's ability to switch to alternate fuels. The increased demand for these alternate fuels is also monitored to avoid shortages.

If a natural gas distribution company, for example, has a supply interruption causing curtailments to a segment of its end-use customers, the EEMIS user will have immediate access to information on how this supply shortfall will affect major industrial and commercial facilities being served. By analyzing the alternate fuel capabilities of affected customers the user can determine which industries will be forced to shut down, and identify the industries that have the capability to switch to alternate fuels, such as oil or coal, in order to maintain production at previous levels.

*A large end-use consumer facility is defined as an individual plant.

In the case of oil, if a particular refinery is shut down or its output is suddenly reduced, the EEMIS user will have access to information on how this supply shortfall will affect major industrial and commercial facilities receiving their supplies either directly from the refinery or via a bulk terminal. Again, by analyzing alternate fuel capabilities of affected facilities, the impact on these industries can be determined and appropriate action taken. Data on alternate transportation links between refineries or bulk terminals and industrial plants allow the analyst to redirect the flow of oil products in order to distribute them across all sectors in an equitable manner.

VI. IMPORT/EXPORT SECTOR DESCRIPTION

The petroleum and natural gas sectors contain information concerning imports and exports of oil and gas wherever it is applicable to a particular facility. The import/export sector is designed to summarize these data, so that the EEMIS user can quickly determine the overall energy import and export situation. This is particularly important in the case of oil imports, since in 1978 the U.S. depended on imports for 41.0 and 10.6% of total supply of crude oil and petroleum products, respectively.

Foreign countries are subdivided into facilities in the data structure, and each facility is defined to be a company that either exports or imports oil or natural gas in one country. Total exports or imports for one country can be obtained by aggregating the transactions for all companies in the country. The EEMIS user therefore has access to the relative dependence of the U.S. energy system upon both a foreign country and a foreign or international company. In addition, the quantity and destination of U.S. exports are accessible.

Data elements for a foreign country facility are inputs, to cover exports from the U.S. to the facility, and outputs for U.S. imports from the facility. The actual amount of energy exchanged is the quantity data element for inputs and outputs. Destination is required to determine the specific refinery, bulk terminal, and transmission and distribution facility in the U.S. that receives the imports. Through aggregation of facility level data, the total imports to states, regions, or to the entire U.S. can be determined. This information can be used to show the dependence of facilities, states, and regions upon foreign countries for oil and natural gas supplies. When supplies to a facility are threatened, the impact on outputs from that facility can be determined from destination data. The EEMIS user can track the price of foreign supplies brought into the U.S. using price data broken down by company and country.

Transportation route information, output destinations, and quantity in transit can be used as a basis for the redirection of oil and natural gas shipments, if necessary. This information can also be used to determine the security of energy supplies in the U.S. Information on fuel in transit is useful for forecasting the supply of energy imports and predicting when the impact of a sudden decrease in supplies will be felt in the U.S.

VII. TRANSPORTATION NETWORK DESCRIPTION

The physical oil and gas systems are made up of many different activities that are often interrelated. Data elements associated with each activity are grouped into a facility that is termed a node in the transportation network. When oil or gas is transported between facilities, data elements describing this activity are represented as a link in the transportation network. The overall data structure is made up of many facility nodes and transportation links which provides a uniform structure for the oil and gas transportation system. Nodes and links can represent the energy transportation network at any level of detail or aggregation.

The basic unit for the energy transportation network is the transportation link. Each link is represented by a series of data elements that are necessary to describe the actual transportation process. The data elements are classified into three categories: characteristics, transportation of fuel, and fuel in transit.

Characteristics are required to define the link. The input and output nodes define the source and destination facilities involved in the movement. Mode of transportation indicates whether the movement is by tanker, barge, pipeline, truck, or railroad. For cases where certain details concerning a link are not available, it is termed a "megalink." The transportation company identifies the corporation that is in control of the operation. Other important logistical information included are the length of the path between the two nodes and the lag time for movement along the path. Finally, for many cases in the transportation system a link will transport only one fuel, either natural gas, crude petroleum, or oil products. This physical aspect is represented by a data field for the energy sector or category to which the link is limited.

Every link must initially be defined and mapped into the transportation network. For the oil and gas pipeline transportation system, the network would show a separate link for each company and each pipeline between two facilities such as an oil refinery and an oil product bulk terminal. This network is used as the framework on which the actual quantities of oil and gas movements are superimposed. Transportation data for each link are the capacity, the actual quantity that is moved, and transportation cost. Capacity data are helpful for users to determine the added amount of flow that may be possible. This is especially useful when one mode of transport between two facilities is not operational, since the amount of additional capacity available on a link can always be determined from the capacity and the actual quantity moved. When large volumes of crude oil or LNG are transported by tanker over long distances, the amount of these fuels that is in transit may be substantial. For example, a supertanker can hold more than 3 MMbbl of crude oil during a transit time of four to five weeks. The quantity of fuel in transit is therefore required in the data structure so that EEMIS users can redirect shipments of imported fuels.

There are many instances in the physical transportation system in which a mode of transportation and a transport company do not interface directly with a facility; for example, a major junction in a pipeline, the juncture of two separate pipeline companies, the delivery of crude oil by truck from a lease to a pipeline company, and the lightering of petroleum between two ships on the open seas. To represent these aspects of the physical system, a "pseudo" node, called a "transportation junction facility," is provided within the transportation network, which consists of input and output transportation links and other characteristics that define the node by location, type of fuel, and company ID.

The energy transportation network node and link data structure can represent the physical system at any level of aggregation. The facility level node and link representation of a pipeline network might look like Figure VII-1, a section of the facility level pipeline transportation network. In this figure A, B, C, and D are sources, such as the connections of crude oil production facilities to a pipeline gathering system; and E and F are destinations, such as the connection between the gathering system and two oil refineries.

Figure VII-1

Facility Level Node and Link Representation of a Pipeline Network

The solid nodes in this figure are the transportation junction facilities that signify major branches in the gathering pipeline system. If refineries E and F were in separate states from A, B, C, and D, this section of the facility level network could be aggregated to the state level (Figure VII-2). In Figure VII-2, G represents the state crude oil production facility that was aggregated from A, B, C, and D in Figure VII-1.

Figure VII-2

State Level Node and Link Representation of the
Pipeline Network in Figure VII-1

By aggregating the network, most of the details needed to show facility level transportation junctions are eliminated, and the result is a clear representation of the relationship between production in state B and refineries in states E and F.

Routes are represented as a list of transportation links between two facilities in the transportation network. Routes are required in the data structure for inputs and outputs at each facility in the oil and gas systems, since they describe the segments of the total transportation network that are involved in movements between two facilities. For example, crude oil transported from a foreign country to a refinery could travel by tanker up the Mississippi to a bulk terminal and be offloaded directly into a crude pipeline leading to the refinery. In Figure VII-3, the link and node data structure represent this route as a combination of transportation links; a route for oil products shipped by pipeline and barge is also shown. "Transportation links available" is a list of all links which tie a facility directly into the transportation network. This data element is required to define all means of access between a facility and the transportation network. This list can be used with the transportation network to determine the potential for products to be shipped by alternate routes when normal routes cannot be used.

The aggregated transportation networks may be used to illustrate the dependence of certain states and regions on specific types of transportation. For example, the state level network would indicate the dependence upon a particular mode of transportation for transporting crude oil from supply to demand regions. In addition, aggregations give a measure of the increased capacity that is possible for the transport schemes that are in use, as well as the capacity for alternate transportation schemes.

Figure VII-3

Node and Link Diagram of Routes Used in the Transportation of Petroleum

This is best illustrated by an example. The extent to which the Mississippi River is needed for transporting crude oil from bulk terminals in PAD 3 to refineries in PAD 2 is known from the regional transport network. In addition, the percent utilization of major pipelines between the two facilities and the additional capacity provided by the pipelines are also known. The type of information that is available from the aggregated transport network is necessary for allocating crude oil and oil products, and evaluating the impact of regional transportation outages.

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APPENDIX

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EEMIS PETROLEUM SECTOR STRUCTURE
Facility Level

I. Domestic Crude Oil Production Facility

A. Characteristics

1. Domestic crude region ID	}	defines unique facility
2. Company ID		

B. Production

1. Quantity (M) by crude type
2. Wellhead price (M) by crude type
3. Daily production capacity by crude type
4. Short-term production projections (M) by crude type

C. Storage

1. Quantity (MS) by crude type
2. Capacity

D. Output

1. Quantity (M) by crude type
2. Quantity (M) by crude type by destination (e.g., refinery, bulk terminal)
3. Quantity (M) by crude type by destination by route
4. Price (M) (charged by production facility--exclusive of transportation costs) by crude type by destination
5. Transportation links available
6. Short-term projections (M) by crude type by destination

Note: (M) stands for monthly totals, historical data for 5 years and projected data for 1 year.

(MS) stands for end-of-month snapshots, 5 year historical data.

II. Crude Oil Bulk Terminal

A. Characteristics

1. Location--defines unique facility
2. Controlling company ID

B. Input

1. Quantity (M) by crude type
2. Quantity (M) by crude type by source (e.g., domestic crude oil production facility, or foreign country)
3. Quantity (M) by crude type by source by route
4. Delivered price (M) by crude type by source
5. Transportation links available
6. Short-term receipt projections (M) by crude type by source

C. Storage

1. Quantity (MS) by crude type
2. Capacity

D. Output

1. Quantity (M) by crude type
2. Quantity (M) by crude type by destination (e.g., refinery)
3. Quantity (M) by crude type by destination by route
4. Price (M) (charged by terminal) by crude type by destination
5. Transportation links available
6. Short-term shipment projections (M) by crude type by destination

III. Strategic Petroleum Reserve (SPR)

A. Characteristics

1. Location--defines unique facility
2. Company ID

B. Input

1. Quantity (M) by crude type
2. Quantity (M) by crude type by source (e.g., foreign country)
3. Quantity (M) by crude type by source by route
4. Delivered price (M) by crude type by source
5. Transportation links available
6. Short-term receipt projections (M) by crude type by source

C. Storage

1. Quantity (MS) by SPR type
2. Maximum drawdown rate by SPR type
3. Capacity by SPR type

D. Output

1. Quantity by SPR type
2. Quantity (M) by SPR type by destination (e.g., refinery)
3. Quantity (M) by SPR type by destination by route
4. Price (M) (charged by SPR Office) by SPR type by destination
5. Transportation links available
6. Short-term shipment projections (M) by SPR type by destination

IV. Oil Refinery

A. Characteristics

1. Location--defines unique facility
2. Controlling company ID
3. Distillation capacity
4. Other processing capacities (e.g., reforming, catalytic cracking)
5. Minimum and maximum values for each crude attribute (e.g., sulfur content, specific gravity)
6. Minimum production for each product type
7. Maximum production possible for each product type and total remaining capacity for other product types

B. Input

1. Quantity (M) by type for all petroleum groups
2. Quantity (M) by type by source (e.g., domestic facility, bulk terminal, foreign country)
3. Quantity (M) by type by source by route
4. Delivered price (M) by type by source
5. Transportation links available
6. Short-term receipt projections (M) by type by source

C. Storage

1. Quantity by type (MS)
2. Capacity by group

D. Output

1. Quantity (M) by type
2. Quantity (M) by type by destination (e.g., demand facility, foreign country)
3. Quantity (M) by type by destination by route
4. Price (M) (charged by refinery) by type by destination
5. Transportation links available
6. Short-term shipment projections (M) by type by destination

V. Oil Product Bulk Terminal

A. Characteristics

1. Location--defines unique facility
2. Controlling company ID

B. Input

1. Quantity (M) by product type
2. Quantity (M) by product type by source (e.g., refinery, bulk terminal, foreign country)
3. Quantity (M) by product type by source by route
4. Delivered price (M) by product type by source
5. Transportation links available
6. Short-term receipt projections (M) by product type by source

C. Storage

1. Quantity (MS) by product type
2. Capacity by group

D. Output

1. Quantity (M) by product type
2. Quantity (M) by product type by destination (e.g., demand facility, foreign country)
3. Quantity (M) by product type by destination by route
4. Price (M) (charged by terminal) by product type by destination
5. Transportation links available
6. Short-term shipment projections (M) by product type by destination

EEMIS PETROLEUM SECTOR STRUCTURE
State, Regional, and National Level

I. Domestic Crude Oil Production Facility

A. Characteristics

1. State or Region ID or national--defines unique facility
2. Listing of major company ID's

B. Production

1. Quantity (M) by crude type
2. Average wellhead price (M) by crude type
3. Daily production capacity by crude type
4. Short-term production projections (M) by crude type

C. Storage

1. Quantity (MS) by crude type
2. Capacity

D. Output

1. Quantity (M) by crude type
2. Quantity (M) by crude type by destination (e.g., State/Regional/National bulk terminal or refinery)
3. Quantity (M) by crude type by destination by route
4. Average price (M) by crude type by destination
5. Transportation links available
6. Short-term projections (M) for 1 and 2

II. Crude Oil bulk terminal

A. Characteristics

1. State or Region ID or national--defines unique facility

B. Input

1. Quantity (M) by crude type
2. Quantity (M) by crude type by source (e.g. State/Regional/National crude oil production, foreign country)
3. Quantity (M) by crude type by source by route
4. Average price (M) by crude type by source
5. Transportation links available
6. Short-term projections (M) for 1 and 2

C. Storage

1. Quantity (MS) by crude type
2. Capacity

D. Output

1. Quantity (M) by crude type
2. Quantity (M) by crude type by destination (e.g. State/Regional/National refinery)
3. Quantity (M) by crude type by destination by route
4. Average price (M) by crude type by destination
5. Transportation links available
6. Short-term projections (M) for 1 and 2

III. Strategic Petroleum Reserve (SPR)

A. Characteristics

1. State or Region ID or national--defines unique facility

B. Input

1. Quantity (M) by crude type
2. Quantity (M) by crude type by source
3. Quantity (M) by crude type by source by route
4. Average price (M) by crude type by source
5. Transportation links available
6. Short-term projections (M) for 1 and 2

C. Storage

1. Quantity (MS) by SPR type
2. Capacity by SPR type

D. Output

1. Quantity (M) by SPR type
2. Quantity (M) by SPR type by destination (e.g. State/Regional/National refinery)
3. Quantity (M) by SPR type by destination by route
4. Average price (M) by SPR type by destination
5. Transportation links available
6. Short-term projections (M) for 1 and 2

IV. Oil Refinery

A. Characteristics

1. State or Region ID or national--defines unique facility
2. Distillation capacity (for entire state or region)
3. Other processing capacities (for entire state or region)

B. Input

1. Quantity (M) by type
2. Quantity (M) by type by source (e.g. State/Regional/National crude oil production, foreign country)
3. Quantity (M) by type by source by route
4. Average price (M) by type by source
5. Transportation links available
6. Short-term projections (M) for 1 and 2

C. Storage

1. Quantity (MS) by type
2. Capacity by group

D. Output

1. Quantity (M) by type
2. Quantity (M) by type by destination (State/Regional/National demand facility or foreign country)
3. Quantity (M) by type by destination by route
4. Average price (M) by type by destination
5. Transportation links available
6. Short-term projections (M) for 1 and 2

V. Oil Product Bulk Terminal

A. Characteristics

1. State or Region ID or national--defines unique facility

B. Input

1. Quantity (M) by type
2. Quantity (M) by type by source (e.g. State/Regional/National refinery, foreign country)
3. Quantity (M) by type by source by route
4. Average price (M) by type by source
5. Transportation links available
6. Short-term projections (M) for 1 and 2

C. Storage

1. Quantity (MS) by type
2. Capacity by group

D. Output

1. Quantity (M) by type
2. Quantity (M) by type by destination (e.g. State/Regional/National demand facility)
3. Quantity by type by destination by route
4. Average price (M) by type by destination
5. Transportation links available
6. Short-term projections (M) for 1 and 2

EEMIS NATURAL GAS SECTOR STRUCTURE
Facility Level

I. Natural Gas Production

A. Characteristics

1. Natural gas production region ID	}	defines unique facility
2. Company ID		

B. Production

1. Quantity (M)
2. Quantity (M) by well type (gas well or oil well)
3. Wellhead price (M)
4. Daily production capacity
5. Short-term production projections (M)

C. Output

1. Quantity (M)
2. Quantity (M) by destination (processing plant)
3. Quantity (M) by destination by route
4. Quantity (M) by purchasing T&D facility
5. Price (M) (charged by producing facility) by destination
6. Price (M) (charged by producing facility) by purchasing T&D facility
7. Transportation links available (gathering lines).
8. Short-term shipment projections (M) by purchasing T&D facility

Note: (M) monthly totals, historical data for 5 years, projected data for 1 year.
(MS) end-of-month snapshots, 5 year historical data.

II. Gas Processing Plant

A. Characteristics

1. Location--defines unique facility
2. Controlling company ID
3. Capacity (thru-put) per unit time

B. Input (wet gas)

1. Quantity (M)
2. Quantity (M) by source (producing region) facility ID
3. Quantity (M) by source by route
4. Delivered price (M) by source
5. Transportation links available
6. Short-term receipt projections (M) by source

C. Storage of natural gas liquids (NGL)

1. Quantity (MS) by type
2. Capacity by group

D. Output

1. Quantity (M) by type
2. Quantity (M) by type by destination (T&D facility, refinery, bulk terminal)
3. Quantity (M) by type by destination by route (primary alternative)
4. Price (M) by type by destination
5. Transportation links available
6. Short-term shipment projections (M) by type by destination

III. LNG Terminal*

A. Characteristics

1. Location--defines unique facility
2. Controlling company ID

B. Input

1. Quantity (M) by type (LNG, natural gas)
2. Quantity (M) by type by source, (e.g., foreign country facility)
3. Quantity (M) by type by source by route
4. Delivered price (M) by type by source
5. Transportation links available
6. Short-term receipt projections (M) by type by source

C. Storage

1. Quantity (MS) by type in storage
2. Capacity by group
3. Sendout capacity (rate) by group

D. Output

1. Quantity (M) by type
2. Quantity (M) by type by destination (e.g., T&D facility)
3. Quantity (M) by type by destination by route
4. Price (M) by type by destination
5. Transportation links available
6. Short-term shipment projections (M) by type by destination

*Importing and exporting LNG terminals are accounted for in this structure.

Importing terminal: Import and store LNG, convert LNG to natural gas, and send out natural gas via pipeline

Exporting terminal: Receive natural gas from producing facility, convert natural gas to LNG and store, and export LNG via tanker.

IV. Underground Storage

A. Characteristics

1. Location--defines unique facility
2. Controlling company ID
3. Drawdown rate as a function of gas in storage

B. Inputs

1. Quantity (M)
2. Quantity (M) by source
3. Quantity (M) by source by route
4. Quantity (M) by owning company ID (T&D facility)
5. Transportation links available

C. Storage

1. Quantity of working gas (MS)
2. Quantity of working gas (MS) by owning company ID
3. Price (M) charged for storage
4. Price (M) charged for storage by owning company ID
5. Cushion gas (MS)
6. Total capacity

D. Outputs

1. Quantity (M)
2. Quantity (M) by destination
3. Quantity (M) by destination by route
4. Quantity (M) by owning company ID
5. Transportation links available

V. Supplemental Fuel Storage Facility

A. Characteristics

1. Location	}	defines unique facility
2. Storage type (LNG, propane, SNG)*		
3. Controlling company ID		

B. Inputs

1. Quantity (M) by type
2. Quantity (M) by type by source (T&D facility, refinery, bulk terminal)
3. Quantity (M) by type by source by route
4. Delivered price (M) by type by source
5. Transportation links available

C. Storage

1. Quantity (MS) by type
2. Capacity by group
3. Maximum drawdown rate by group

D. Output

1. Quantity (M) by type
2. Quantity (M) by type by destination (T&D facility)
3. Quantity (M) by type by destination by route
4. Price (M) by type by destination
5. Transportation links available

*Synthetic natural gas (SNG) is produced on site from naphtha.

VI. Transmission and Distribution (T&D) Facility

A. Characteristics

1. Company ID--defines unique facility
2. Nature of operation (interstate or intrastate)
3. States served

B. Inputs

1. Quantity (M)
2. Quantity (M) by source (processing plant, T&D facility, storage facility, foreign country, or LNG terminal)
3. Quantity (M) by source by route
4. Quantity (M) by selling production facility
5. Delivered price (M) by source
6. Delivered price (M) by selling production facility
7. Transportation links available
8. Short-term projections (M) for item numbers 1, 2, 3, and 4

C. Storage

1. Quantity (MS) by type (stored in other facilities)

D. Output

1. Quantity (M)
2. Quantity (M) delivered to enduse customers
3. Quantity (M) by destination (T&D facility, storage facility, foreign country, or demand facility)
4. Quantity (M) by destination by route
5. Quantity (M) delivered to end-use customers by type of service (firm or interruptible)
6. Quantity (M) of gas curtailments by demand facility
7. Quantity (M) of gas curtailments by type of service

8. Quantity (M) of alternate fuels used by alternate fuel type (e.g., No. 2 fuel oil, propane, bituminous coal) for all end-use customers
9. Existing capability (% gas displaced) for switching to alternate fuels by alternate fuel for all end-use customers
10. Delivered price (M) by destination
11. Delivered price (M) to end-use customers by type of service
12. Short-term projections (M) for item numbers 1 through 7

EEMIS NATURAL GAS SECTOR STRUCTURE
State, Regional, and National Level

I. Natural Gas Production

A. Characteristics

1. State or Region ID or national--defines unique facility
2. List of major producing company ID's

B. Production

1. Quantity (M)
2. Quantity (M) by well type (gas well or oil well)
3. Wellhead price (M)
4. Daily production capacity
5. Short-term production projections (M)

C. Output

1. Quantity (M)
2. Quantity (M) by destination (state/regional/national processing plant)
3. Quantity (M) by destination by route
4. Quantity (M) by purchasing T&D facility
5. Price (M) (charged by producing facility) by destination
6. Price (M) (charged by producing facility) by purchasing T&D facility
7. Transportation links available
8. Short-term shipment projections (M) by purchasing T&D facility

Note: (M) monthly totals, historical data for 5 years, projected data for 1 year
(MS) end-of-month snapshots, 5 year historical data.

II. Gas Processing Plant

A. Characteristics

1. State or Region ID or national--defines unique facility
2. Capacity

B. Input

1. Quantity (M)
2. Quantity (M) by source
3. Quantity (M) by source by route
4. Delivered price (M) by source
5. Transportation links available
6. Short-term receipt projections (M) by source

C. Storage of natural gas liquids (NGL)

1. Quantity (MS) by type
2. Capacity by group

D. Output

1. Quantity (M) by type
2. Quantity (M) by type by destination (state/regional/national T&D facility, refinery, bulk terminal)
3. Quantity (M) by type by destination by route
4. Price (M) by type by destination
5. Transportation links available
6. Short-term shipment projections (M) by type by destination

III. LNG Terminal*

A. Characteristics

1. State or region ID or national--defines unique facility

B. Input

1. Quantity (M) by type (LNG, natural gas)
2. Quantity (M) by type by source (e.g., state/regional/national foreign country)
3. Quantity (M) by type by source by route
4. Delivered price (M) by type by source
5. Transportation links available
6. Short-term receipt projections (M) by type by source

C. Storage

1. Quantity (MS) of LNG in storage
2. Capacity by group
3. Sendout capacity by group

D. Output

1. Quantity by type
2. Quantity (M) by type by destination (e.g., state/regional/national T&D facility)
3. Quantity (M) by type by destination by route
4. Price (M) by type by destination
5. Transportation links available
6. Short-term shipment projections (M) by type by destination

*Importing and exporting LNG terminals are accounted for in this structure.

Importing terminal: Import and store LNG, convert LNG to natural gas, and send out natural gas via pipeline.

Exporting terminal: Receive natural gas from producing facility, convert natural gas to LNG and store, and export LNG via tanker.

IV. Underground Storage

A. Characteristics

1. State or region ID or national--defines unique facility
2. Maximum drawdown rate as a function of gas in storage

B. Input

1. Quantity (M)
2. Quantity (M) by source
3. Quantity (M) by source by route
4. Quantity (M) by owning state/regional/national T&D facility ID*
5. Transportation links available

C. Storage

1. Quantity of working gas (MS)
2. Quantity of working gas (MS) by owning state/regional/national T&D facility ID*
3. Price (M) charged for storage
4. Working gas capacity
5. Cushion gas (MS)
6. Total capacity

D. Outputs

1. Quantity (M)
2. Quantity (M) by destination
3. Quantity (M) by destination by route
4. Quantity (M) by state/regional/national T&D facility ID*
5. Transportation links available

*Refer to "Transmission and Distribution Facility" footnote for explanation of owning T&D facility ID at the state, regional, and national level.

V. Supplemental Fuel Storage Facility

A. Characteristics

1. State or region ID or national
 2. Storage type (LNG, propane, SNG)*
- } defines unique facility

B. Input

1. Quantity (M) by type
2. Quantity (M) by type by source (e.g., state/regional/national T&D facility, refinery, bulk terminal)
3. Quantity (M) by type by source by route
4. Delivered price (M) by type by source
5. Transportation links available

C. Storage

1. Quantity (MS) by type
2. Capacity by group
3. Maximum drawdown rate by group

D. Output

1. Quantity (M) by type
2. Quantity (M) by type by destination (e.g., state/regional/national T&D facility)
country)
3. Quantity (M) by type by destination by route
4. Price (M) by type by destination
5. Transportation links available

*Synthetic natural gas is produced on site from naphtha.

VI. Transmission and Distribution T&D Facility*

A. Characteristics

1. State or region ID	}	defines unique facility*
2. Company ID		
3. States served		

B. Inputs

1. Quantity (M)
2. Quantity (M) by source (state/regional/national processing plant, T&D facility, storage facility, foreign country, or LNG terminal)
3. Quantity (M) by source by route
4. Quantity (M) by selling production facility
5. Delivered price (M) by source
6. Delivered price (M) by selling production facility
7. Transportation links available
8. Short-term projections (M) for item numbers 1, 2, and 4

C. Storage

1. Quantity (MS) by type (stored in other facilities)

*At the national level:

One facility will represent all interstate T&D companies
One facility will represent all intrastate T&D companies

At the state or regional level:

A separate facility will represent each interstate T&D company
A separate facility will represent all intrastate T&D companies within each state or region.

D. Output

1. Quantity (M)
2. Quantity (M) delivered to end-use customers
3. Quantity (M) by destination (state/regional/national T&D facility, storage facility, foreign country, or demand facility)
4. Quantity (M) by destination by route
5. Quantity (M) delivered to end-use customers by type of service (firm or interruptible)
6. Quantity (M) of gas curtailments by demand facility
7. Quantity (M) of gas curtailments by type of service
8. Quantity (M) of alternate fuels used by alternate fuel type (e.g., No. 2 fuel oil, propane, bituminous coal) for all end-use customers
9. Existing capability (% gas displaced) for switching to alternate fuels by alternate fuel for all end-use customers
10. Delivered price (M) by destination
11. Delivered price (M) to end-use customers by type of service
12. Short-term projections (M) for item numbers 1 through 3, 5 through 7

EEMIS DEMAND SECTOR STRUCTURE
Facility Level

I. Demand Facility

A. Characteristics

1. State ID	}	defines unique facility
2. Demand sector (residential, commercial, industrial, transportation, electric utility, residential/commercial, military)		

B. Input

1. Quantity (M) by fuel type (e.g., natural gas, No. 2 fuel oil, bituminous coal)
2. Quantity (M) by fuel type by source
3. Quantity (M) by fuel type by source by route
4. Quantity (M) of natural gas by source by type of service (firm or interruptible)
5. Quantity (M) of gas curtailments
6. Quantity (M) of gas curtailment by type of service
7. Quantity (M) of alternate fuel usage by alternate fuel type by primary fuel type replaced
8. Price (M) by fuel type by source
9. Price (M) for natural gas by source by type of service
10. Transportation links available
11. Short-term projections (M) for item numbers 1 thru 6
12. Existing capability (% fuel displaced) for switching by primary fuel types by each alternate fuel type

Note: For the interim system the facility level demand facility is at the state level of aggregation.

II. Large End-Use Consumers

A. Characteristics

1. Location--defines unique facility
2. Controlling company ID
3. Demand sector (commercial, transportation, industrial, electric utility, military)
4. List of FERC priorities with associated percentages of gas usage
5. List of 2-digit SIC codes with associated percentages of total fuel usage

B. Input

1. Quantity (M) for all fuel sectors
2. Quantity (M) by fuel type (e.g., natural gas, No. 2 fuel oil, bituminous coal)
3. Quantity (M) by fuel type by source
4. Quantity (M) of natural gas by source by type of service (firm or interruptible)
5. Quantity (M) by fuel type by demand category (space heating and miscellaneous thermal, process steam, direct heat, or petrochemical feedstock)
6. Quantity (M) by fuel type by source by route
7. Quantity (M) of gas curtailments by type of service
8. Quantity (M) of alternate fuel usage by alternate fuel type by primary fuel type replaced
9. Delivered price (M) by fuel type by source
10. Delivered price (M) of natural gas by source by type of service
11. Transportation links available
12. Short-term projections (M) for item numbers 1 thru 8
13. Existing capability (% fuel displaced) for switching to alternate fuel types for each primary fuel type

C. Storage

1. Quantity (MS) by fuel type
2. Capacity by group

EEMIS DEMAND SECTOR STRUCTURE
State, Regional, and National Level

I. Demand Facility

A. Characteristics

1. State or region ID or national	}	defines unique facility
2. Demand sector (residential, commercial, industrial, transportation, electric utility, residential/commercial, military)		

B. Input

1. Quantity (M) by fuel type (e.g., natural gas, No. 2 fuel oil, bituminous coal)
2. Quantity (M) by fuel type by source
3. Quantity (M) by fuel type by source by route
4. Quantity (M) of natural gas by source by type of service (firm or interruptible)
5. Quantity (M) of gas curtailments
6. Quantity (M) of gas curtailment by type of service
7. Quantity (M) of alternate fuel usage with quantity of primary fuel type replaced by alternate fuel type by primary fuel type replaced
8. Price (M) by fuel type by source
9. Price (M) for natural gas by source by type of service
10. Transportation links available
11. Short-term projections (M) for item numbers 1 thru 6
12. Existing capability (% fuel displaced) for switching by primary fuel types by each alternate fuel type

II. Large End-Use Consumers

A. Characteristics

1. State or region ID or national
 2. Demand sector (commercial, transportation, industrial, electric utility, military)
 3. List of FERC priorities with associated percentages of gas usage
 4. List of 2-digit SIC codes with associated percentages of total fuel usage
- } defines unique facility

B. Input

1. Quantity (M) for all fuel sectors
2. Quantity (M) by fuel type (e.g., natural gas, No. 2 fuel oil, bituminous coal)
3. Quantity (M) by fuel type by source
4. Quantity (M) of natural gas by source by type of service (firm or interruptible)
5. Quantity (M) by fuel type by demand category (space heating and miscellaneous thermal, process steam, direct heat, or petrochemical feedstock)
6. Quantity (M) by fuel type by source by route
7. Quantity (M) of gas curtailments by type of service
8. Quantity (M) of alternate fuel usage with quantity of primary fuel type replaced by alternate fuel type by primary fuel type replaced
9. Delivered price (M) by fuel type by source
10. Delivered price (M) of natural gas by source by type of service
11. Transportation links available
12. Short-term projections (M) for item numbers 1 thru 8
13. Existing capability (% fuel displaced) for switching to alternate fuel types for each primary fuel type

C. Storage

1. Quantity (MS) by fuel type
2. Capacity by group

IMPORT/EXPORT SECTOR STRUCTURE
Facility Level

I. Foreign Country

A. Characteristics

1. Country ID	}	defines unique facility
2. Company ID		

B. Input:

1. Quantity (M) by type
2. Quantity (M) by type by source (production facility, bulk terminal, T&D facility)
3. Quantity (M) by type by source by route
4. Price (M) by type by source
5. Transportation links available
6. Short-term projections (M) for item numbers 1 thru 3
7. Quantity (MS) in transit by type by source by route

C. Output (to USA)

1. Quantity (M) by type
2. Quantity (M) by type by destination (refinery, bulk terminal, T&D facility)
3. Quantity (M) by type by destination by route
4. Price (M) by type by destination
5. Transportation links available
6. Short-term projection (M) for item numbers 1 thru 3.
7. Quantity (MS) in transit by type by destination by route

IMPORT/EXPORT SECTOR STRUCTURE
State, Regional, and National Level

I. Foreign Country

A. Characteristic

1. Country ID--defines unique facility

B. Input

1. Quantity (M) by type
2. Quantity (M) by type by source (e.g., State/Regional/National production facility, bulk terminal, T&D facility)
3. Quantity (M) by type by source by route
4. Price (M) by type by source
5. Transportation links available
6. Short-term projections (M) for item numbers 1 and 2
7. Quantity (MS) in transit by type by source by route

C. Output

1. Quantity (M) by type
2. Quantity (M) by type by destination (e.g. State/Regional/National refinery, bulk terminal, T&D facility)
3. Quantity (M) by type by destination by route
4. Price (M) by type by destination
5. Transportation links available
6. Short-term projections (M) for item numbers 1 and 2
7. Quantity (MS) in transit by type by destination by route

EEMIS TRANSPORTATION NETWORK STRUCTURE
Facility Level

I. Transportation Links

A. Characteristics

1. Company ID
2. Input facility ID
3. Output facility ID
4. Mode of transportation
5. Length
6. Lag time
7. Link type (megalink or detailed)
8. Energy sector or category

B. Transportation of fuel

1. Capacity
2. Quantity (M) by type
3. Transportation cost (M) by type

C. Fuel in Transit

1. Quantity (MS) by type

II. Transportation Junction Facility

A. Characteristics

1. Location
2. Company ID

B. Input

1. Transportation links available

C. Output

1. Transportation links available

EEMIS TRANSPORTATION NETWORK STRUCTURE
State, Regional, and National Level

I. Transportation Links

A. Characteristics

1. Input State/Regional/National facility ID
2. Output State/Regional/National facility ID
3. Mode of transportation
4. Energy sector and category

B. Transportation of fuel

1. Quantity (M) by type
2. Transportation cost (M) by type

EEMIS SUPPLEMENTARY FILE STRUCTURES

Domestic Crude Oil Production Region File

- A. Domestic crude oil production region ID
- B. Name
- C. List of county ID's
- D. List of latitude, longitude pairs
- E. Ordered list of company ID's

Natural Gas Production Region File

- A. Natural gas production region ID
- B. Name
- C. List of county ID's
- D. List of latitude, longitude pairs
- E. Ordered list of company ID's

Foreign Country File

- A. Foreign country ID
- B. Name

State File

- A. State ID
- B. Name
- C. List of latitude, longitude pairs
- D. Governor's office
 - 1. Name of Energy Advisor to Governor
 - 2. Phone number
 - 3. Office or building number
 - 4. Street address
 - 5. City
 - 6. Zip code
- E. Energy Office
 - 1. Name of department head
 - 2. Phone number
 - 3. Office or building number
 - 4. Street address
 - 5. City
 - 6. Zip code
- F. EEC Contact
 - 1. Name
 - 2. Phone number
 - 3. Office or building number
 - 4. Street address
 - 5. City
 - 6. Zip code

Region File

- A. Region ID
- B. Name
- C. List of state ID's
- D. List of latitude, longitude pairs
- E. List of regional energy commissions
 - 1. Name
 - 2. Name of director
 - 3. Phone number
 - 4. Office number
 - 5. Street address
 - 6. City
 - 7. State
 - 8. Zip code

Company File

A. Company ID

B. Name

C. National Office

1. Name of contact
2. Phone number
3. Office or building number
4. Street address
5. City
6. State
7. Zip code

D. Regional Offices

1. Names of contact
2. Phone numbers
3. Office or building number
4. Street address
5. City
6. State
7. Zip code

List of names and addresses
to contact for each region.
First listed is primary contact.

E. DOE Contacts

1. Name of contact
2. Phone number
3. Office or building number
4. Street address
5. City
6. State
7. Zip code

List of names and addresses
to contact for each region.
First listed is primary contact.

F. List of subsidiary company ID's and % ownership

G. List of owning company ID's and % ownership

PETROLEUM ENERGY HIERARCHY

SECTOR:

PETROLEUM

CATEGORY:

CRUDE OIL

OIL PRODUCT

GROUP: DOMESTIC

FOREIGN

STRATEGIC
PETROLEUM
RESERVE

GASOLINE

JET FUEL

DISTILLATE FUEL
OIL

RESIDUAL
FUEL OIL

LIGHT PRODUCTS

OTHER

TYPE: • East Texas
• North Slope

• Arabian
light
• Iranian
light

• Type I
• Type II
• Type III
• Type IV
• Type V

• Leaded
• Unleaded
• Aviation

• Naphtha type
• Kerosene type

• Heating
• Diesel
• No. 4 fuel oil

• No. 5 & No. 6
fuel oil
• Other

• Ethane/Ethylene
• Propane
• Other Liquified gases
• Petrochemical
feedstocks

• Unfinished
oils
• Kerosene
• Other

Crude oil, domestic

type code	name	state	% sulfur	spec. gravity	pour point	heat value
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Crude oil, foreign

type code	name	country	% sulfur	spec. gravity	pour point	heat value
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Crude oil, strategic petroleum reserve

type code	name	max % sulfur	min spec. gravity	max spec. gravity	max pour point	heat value
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Oil product: gasoline, jet fuel, light products,
others

type code	name	heat value	group name
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Oil product: residual fuel oil, distillate fuel oil

type code	name	min % sulfur	max % sulfur	heat value	group name
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DEMAND SECTOR HIERARCHY