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NEMS
International Energy Module

Model Documentation Report

World Oil Market
Petroleum Products Supply and
Oxgenates Supply Components

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ABBREVIATIONS & ACRONYMS

EMF	Energy Modeling Forum
GDP	Gross Domestic Product
IEO	International Energy Outlook
NEMS	National Energy Modeling System
OECD	Organization for Economic Cooperation and Development
OGSM	Oil & Gas Supply Module
OMS	Oil Market Simulation model
OPEC	Organization of Petroleum Exporting Countries
OS	Oxygenates Supply
PADD	Petroleum Administration for Defense District
PMM	Petroleum Market Module
PPS	Petroleum Product Supply
ROW	Rest-of-World
SPR	Strategic Petroleum Reserve
WOM	World Oil Market
WOP	World Oil Price
WORLD	World Oil Refining Logistics and Demand Model

PREFACE

The Energy Information Administration (EIA) has developed the National Energy Modeling System (NEMS) to enhance its energy forecasting capabilities and to provide the Department of Energy with a comprehensive framework for analyzing alternative energy futures. NEMS is designed with a multi-level modular structure that represents specific energy supply activities, conversion processes, and demand sectors as a series of self-contained units which are linked by an integrating mechanism. The NEMS International Energy Module (IEM) computes world oil prices and the resulting patterns of international trade in crude oil and refined products. This report is a reference document for energy analysts, model users, and the public that is intended to meet EIA's legal obligation to provide adequate documentation for all statistical and forecast reports *(Public Law 93-275, section 57(b)(1)*. Its purpose is to describe the structure of the IEM. Actual operation of the model is not discussed here.

The report contains four sections summarizing the overall structure of the IEM and its interface with other NEMS modules, mathematical specifications of behavioral relationships, and data sources and estimation methods. Following a general description of the function and rationale of its key components, system and equation level information sufficient to permit independent evaluation of the model's technical details is presented. The major sections of this report are:

- **Model Overview --** This section identifies the analytical issues IEM is intended to address, the general types of activities and relationships it embodies, and its interactions with other NEMS modules.

- **Structure of IEM Components --** This section describes in greater detail the modeling approach adopted for each IEM component, citing theoretical or empirical evidence supporting those choices. The structure of each component is displayed with flow diagrams and fundamental assumptions about behavior or technology are highlighted.

- **Mathematical Specifications --** Model equations for transforming data, representing behavioral or technological relationships, and defining market equilibrium are presented.

- **Variables, Data, and Parameters --** List of model inputs and outputs with definitions, sources, units of measure. Discussion of data sources and procedures for estimating model coefficients. Cross-reference tables orienting users to the model's computer code are also presented.

These sections of the report are followed by appendices that include an IEM model abstract and an annotated copy of the IEM computer code.

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1. MODEL OVERVIEW

A. IEM Design Objectives

The understanding of world oil market issues, especially the forecasting of mid to long term world oil prices, has always been a primary EIA focus. To enhance the capabilities of the NEMS to address international issues and their interaction with U.S. markets, the International Energy Module (IEM) was incorporated into the system. Components of the NEMS IEM accomplish the following:

- Calculate the average world oil price and provide supply curves for five grades of crude oil for import to the United States.

- Calculate the change in the world oil price in response to shifts in U.S. import demands.

- Provide crude oil and petroleum product supply curves with a representation of foreign supply levels and associated costs for U.S. petroleum imports. Calculate shifts in import supply curves as world oil market conditions vary.[1]

- Provide supply curves for U.S. imports of oxygenates (Methyl tertiary butyl ether [MTBE] and methanol).

Three separate components of the IEM have been developed to carry out these functions. The World Oil Market (WOM) component forecasts international crude oil market conditions, including demand, price and supply availability, and the effects of U.S. petroleum market on the world market. The Petroleum Product Supply (PPS) component generates supply curves for petroleum products imported into the United States. These supply curves reflect conditions in the international market, including refinery capacity, transportation costs, and the effects of U.S. demand on world markets. Finally, the Oxygenates Supply (OS) component produces supply curves for U.S. imports of MTBE and methanol.

B. Scope of IEM

The non-U.S. coverage of oil markets is relatively limited with no representation of refined product markets. The IEM supplements these petroleum-only results in terms of both model inputs and outputs by using results from the NEMS Petroleum Market Module (PMM) and generating import supply curves for crude oil and refined products that are disaggregated by grade and

[1] In international trade economics, what is called an "import supply curve" in this report is generally referred to as the rest-of-the-world excess supply curve.

location. The integrated NEMS formulation therefore links the demand for crude oil by refiners with end-use demands for refined products, which are in turn influenced by various measures of economic activity levels. Table 1-1 summarizes the regionality and level of detail of individual IEM components.

The world oil price (WOP) calculated in the WOM submodule is used to adjust exogenously-determined Petroleum Administration for Defense District-level (PADD) import supply curves for crude oil, refined petroleum products, and gasoline blending components (oxygenates). Figure 1-1 presents a map of the United States segregated into PADDs. World crude trade is mapped into five classes that reflect their product yield characteristics in the refinery environment. One class contains the light, low sulfur crude oils that have a relatively high yield of light products (gasoline, distillate, and jet fuel). The second class consists of medium sulfur heavy oils. The remaining classes have high sulfur content and three weight classes - light, heavy, and very heavy. A total of 12 refined product categories are covered, including gasoline blending components (MTBE and methanol) and two grades of distillate and residual fuels based on sulfur content.

While the IEM is intended to be executed as a module of the NEMS system, and utilizing its complete capabilities and features requires a NEMS interface, it is also possible to execute the WOM component of IEM on a stand-alone basis. The WOM forecasts world oil price on the basis of a market clearing given an exogenously specified OPEC output path. In addition to simultaneously forecasting prices and quantities, the WOM submodule can also be used to determine the regional production and consumption levels (and implicit trade patterns) corresponding to a user-specified world oil price path. Sensitivity analyses can be conducted to examine the response of the world oil market to changes in oil price, OPEC production capacity and demand.

To summarize, the model searches for a world oil price compatible with supply-demand equilibrium in each region. Non-OPEC world demand and supply are determined by a set of price-quantity relationships, and in equilibrium the difference between world demand and non-OPEC world supply equals OPEC production. OPEC production is determined by an exogenously specified output path. Output of a price run includes forecasts of the world oil price, OPEC production, world petroleum production and consumption, net imports by region, OPEC revenue, and spare OPEC capacity.

C. Relation to Other NEMS Components

The IEM both uses information from and provides information to other NEMS components. It primarily uses information about U.S. supply and demand balances and provides information about market conditions in the rest of the world. It should be noted, however, that the present focus of the IEM is exclusively on the international oil market. Currently, any interactions between the U.S. and foreign regions in fuels other than oil (for example, coal trade) are modeled in the particular NEMS module that deals with that fuel. Sources of crude oil demand and supply relationships in the IEM are shown in Table 1-2.

For U.S. crude oil supply and demand, the WOM uses forecasts generated by the NEMS Petroleum Market Module (based on supply curves provided by the Oil & Gas Supply Module and demand curves from the end-use demand modules). For other non-OPEC regions, regional oil demand in a given year is determined as a function of the prevailing average world oil price, the current level of regional economic activity, and its own lagged value. Non-OPEC regional oil supply is specified as a function of the world oil price and regional supply in the previous period. The time path of OPEC production is set exogenously.[2] In addition to these behavioral relationships, regional oil demand and supply values that are determined exogenously include: (1) OPEC demand levels, (2) U.S. Strategic Petroleum Reserve fill rates or drawdown, and (3) worldwide commercial stock build or withdrawal.

The WOM subcomponent calculates world crude oil prices based on initial estimates of U.S. crude oil supply and demand volumes provided from the PMM. The resulting WOP determines the position of crude oil, refined product, and oxygenates supply curves, which are sent to the PMM to summarize the availability of imports and petroleum product prices for each year of a NEMS forecast. These supply curves are then brought into the PMM to determine the U.S. petroleum supply/demand balance that reflects a least-cost mix of domestic and foreign supplies. The resulting U.S. crude oil supply and demand quantities are then sent back to the WOM component to recalculate the WOP, which is again used to adjust crude oil and petroleum product supply curves. This iterative process continues until the WOP is stable over successive iterations, implying that the crude oil market is equilibrated both in the U.S. and, given U.S. supplies and demands, the world as a whole. Table 1-3 summarizes IEM inputs from and outputs to other NEMS modules.

[2] OPEC behavior can alternatively be represented using a price reaction function relating percentage price changes to capacity utilization rates, with stable prices when target utilization rates are achieved. Although this formulation was previously consistent with observed outcomes, its explanatory power has been greatly diminished by changes in market relationships associated with and following the Gulf War. Therefore, a straight market-clearing approach with exogenously specified OPEC output paths is now preferred.

Table 1-1. Scope of IEM Components

IEM Component	Regionality	Coverage
WOM/Pricing	U.S U.S. Territories Canada Mexico Japan Australia/New Zealand OECD Europe Other South & Cental America Pacific Rim Other Developing Countries Former Soviet Union Eastern Europe China OPEC	Petroleum
WOM/U.S. Imports	PADDs	Crude oil Low Sulfur Light Med. Sulfur Heavy High Sulfur Light High Sulfur Heavy High Sulfur, Very Heavy
PPS	PADDs	Refined Products Reformulated Gasoline Gasoline Distillate Low Sulfur Distillate Low Sulfur Residual Fuel High Sulfur Residual Fuel Jet Fuel Liquefied Petroleum Gases Petrochemical Feedstocks Other Refined Products*
OS	PADDs	Oxygenates Methanol MTBE

* Includes refinery gas, naphtha, petroleum coke, and other miscellaneous products.

Table 1-2. Sources of Crude Oil Demand and Supply

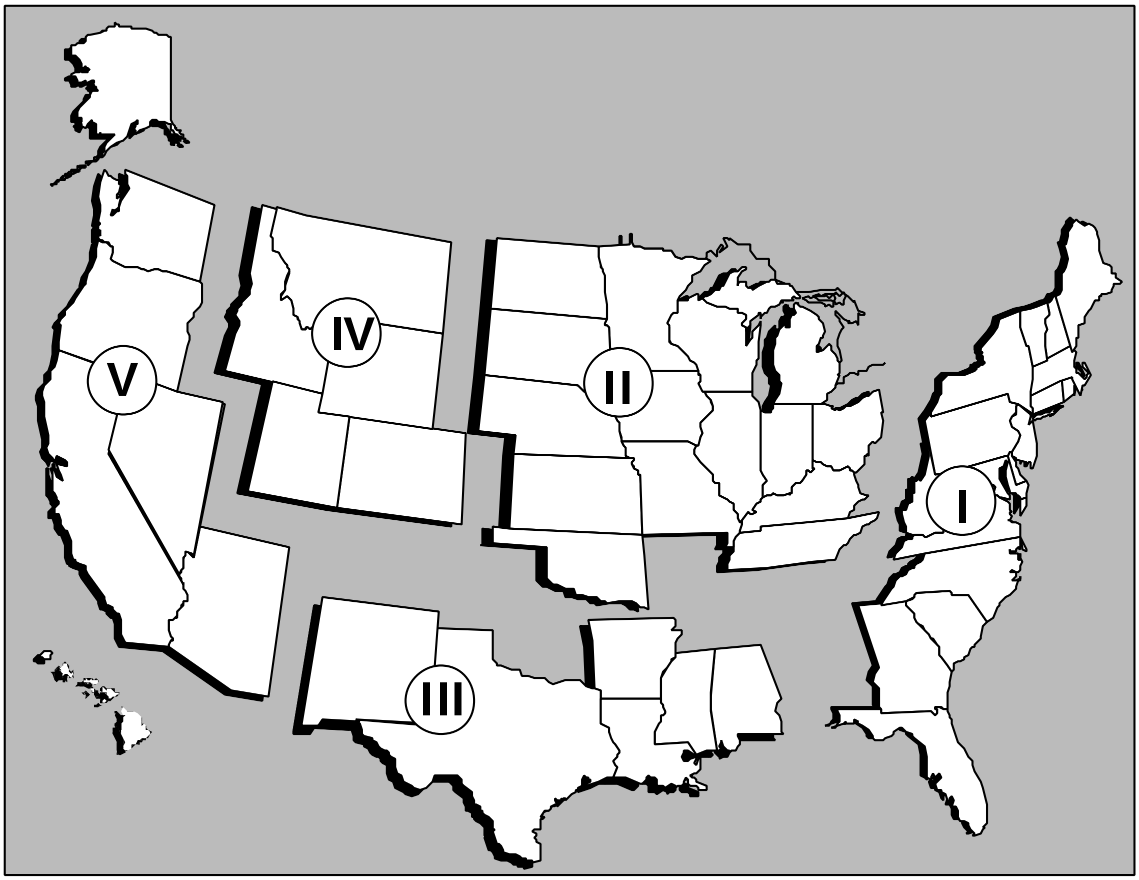
	Crude Oil Demand	Crude Oil Supply
U.S.	NEMS PMM	NEMS PMM
Other Non-OPEC	Endogenous	Endogenous
OPEC	Exogenous	Exogenous

Table 1-3. Intermodule Input and Output Flows for the International Energy Module

Model Inputs	From Module	Regions
Controlling information: iteration count, time horizon, etc.	System	N/A
U.S. Petroleum supply and demand	PMM	U.S.

Model Outputs	To Module	Regions
World oil price	System	N/A
Import supply curves for crude oil by grade	PMM	PADD
Import supply curves for refined products	PMM	PADD
Import supply curves for gasoline blending components (oxygenates)	PMM	PADD

Figure 1-1. Petroleum Allocation for Defense Districts Map



2. STRUCTURE OF IEM COMPONENTS

2.1 World Oil Market

A. Background

The purpose of the World Oil Market component of IEM is to compute the prices and available quantities of crude oil for import to the U.S. under alternative worldwide energy market conditions over the 1990-2020 time period. Alternative scenarios could include policy and regulatory initiatives (such as foreign adoption of U.S. clean air standards), resource conditions (such as the declining quality of crude oil in world trade or the location of new refinery capacity), and economic growth paths (such as low, mid, and high cases).

Prior to the NEMS, *Annual Energy Outlook* forecasts have not typically contained any formal feedback mechanism between world oil price estimates and U.S. petroleum consumption and imports. World oil price trajectories have been treated simply as unalterable assumptions in each scenario. Now world oil prices are endogenously determined as a function of NEMS-determined oil supply and demand, introducing formal feedback effects to world and U.S. economic growth.

B. General WOM Modeling Approach

The World Oil Market (WOM) submodule adopts the basic methodology of an earlier EIA oil market forecasting tool, the Oil Market Simulation (OMS) model. However, the WOM submodule is able to achieve more detailed coverage of U.S. supply and demand patterns provided through linkages with the NEMS Petroleum Market Module (PMM). The OMS model used a recursive simulation approach in which period t+1 values of endogenous variables such as oil demand and supply levels are influenced by their values in period t. Implementing this approach involves three key components of global crude oil markets: demand, non-OPEC oil supply, and OPEC production. Here the behavior and decision rules of economic agents in the oil market which determine these factors is discussed.

Crude Oil Demand:

U.S. crude oil demand is provided to the WOM submodule by the PMM, and is therefore exogenous to the WOM. The demand for crude oil in each non-U.S. region is endogenously determined within the WOM submodule by three factors: real income, world oil price, and demand for crude oil in the previous period. Traditional economic theory and empirical findings have shown that both income and price play an important role in determining oil consumption; income has a positive impact on demand and price has a negative impact. Price changes influence demand both directly and indirectly through their impact on levels of economic activity. The demand for oil in a previous year is called lagged demand, and is used to capture the demand adjustment process reflected in varying short-run and long-run price elasticities. Short-run demand is considered less elastic than long-run demand because the demand for petroleum products is derived from the demand for the services of energy-using capital or other end-use durables, such as automobiles, aircraft, and electric appliances. Delays in altering this energy-using capital stock limit the extent to which consumers are able to change their levels of energy consumption in the short-run. Therefore, the inclusion of lagged variables in the oil demand equation assumes that consumption will slowly adjust over time in response to a one-time change in prices, *ceteris paribus*, until a new level of demand is reached which is consistent with the new structure of relative prices.

Non-OPEC Oil Supply:

U.S. crude oil production is also provided to the WOM submodule by the PMM. The supply of oil from other non-OPEC regions is determined by two factors: world oil price and non-OPEC production lagged one period. Crude oil production within each region is divided into conventional and unconventional sources, with distinct supply functions and parameter values for each type of production. Conventional and unconventional supplies are both positively related to world oil prices, subject to an upper bound set by production capacity. The incorporation of lagged production in the supply equations reflects that the supply of oil at any particular time is, in part, determined by supply during the previous period. As with oil demand, short-run supply responses to a change in oil prices is limited by the time required to invest in the new equipment required to expand production capacity (e.g., drilling rigs) and the delays inherent in adding reserves, developing wells, and extracting oil. Therefore, oil supply is more price-elastic in the long-run than in the short-run. Other things being equal, oil producers will adjust over time in response to a discrete change in prices until a new optimal level of supply is reached. Lagged supply can also be thought of as a proxy for information about oil reserves and production capacity.

OPEC Production:

Output and pricing behavior of OPEC in the IEM are exogenously specified by a time path of OPEC production based on expert judgement and/or "offline" analysis. Assumed growth rates of OPEC production may vary from year to year over the forecast period, but the level of OPEC output within any given year is independent of the WOP. (Of course, the converse does not hold since the equilibrium WOP will depend on the specified level of OPEC output.

World Oil Market Interactions:

The WOM submodule of IEM solves for the equilibrium world oil price (WOP) which equates world petroleum demand with the sum of non-OPEC supply and OPEC production. Changes in prices bring the world oil market into balance though three primary channels:

- The direct effect on regional demand due to world prices, where higher prices imply lower consumption and vice-versa.

- The direct effect on non-OPEC production, where a higher price stimulates increased output, all else held constant.

- The indirect effect of price on consumption as it alters real income growth (the feedback effect), with higher oil prices reducing real income which, in turn, implies lower consumption since the consumption/income effect is positive, although generally inelastic.

The parameters in the non-OPEC oil demand and supply equations are estimated on the basis of forecasts from other larger models. This approach is adopted because the OMS is designed to forecast future activities in the world oil market. Models providing various inputs to the OMS model include the Short-Term Integrated Forecasting System (STIFS), the World Energy Projection System (WEPS), and the Wharton Econometric Forecasting Associates, Inc (WEFA Group) Macro Model. Details about the derivation of WOM parameter values are discussed in Section 4 of this report.

Crude Oil Import Supply Curves:

The equilibrium world oil price is input directly into the NEMS System module and indirectly to the NEMS PMM in the form of crude oil import supply curves, distinguished by PADD and crude oil quality as outlined in Table 2-1. Because foreign regions are represented in the IEM only as aggregate estimates of petroleum supply and demand (making no distinction as to crude oil, natural gas liquids, refined products, etc.), foreign sources of crude oil to the U.S. are represented in the form of import supply curves. A library of crude oil import supply curves are derived external to NEMS using the WORLD model (see Section 2.2B) as a function of the world oil price, the location and quality of the available world trade crude, world-scale transportation rates and bunker fuel costs, and scenario-specific assumptions. After the WOM has converged, through iterations with related components of NEMS, on a forecasted average world oil price, crude oil import supply curves will be provided to NEMS based on the information in the externally-derived library. The NEMS will be constrained to import a mix of crude oil qualities such that the average acquisition cost to domestic refiners will equal the forecasted world oil price.

Table 2-1. Crude Oil Categories for IEM Import Supply Curves.

Group	Code	Sulfur Content	API Gravity
Low Sulfur Light	S	0-0.2	25-66
		0.2-0.5	32-66
Medium Sulfur Heavy	MH	0.2-1.1	21-32
High Sulfur Light	HL	0.5-1.1	32-56
		1.1-1.3	30-56
		1.3-1.99	35-56
High Sulfur Heavy	HH	1.3-1.99	21-35
High Sulfur Very Heavy	HV	> 0.7	< 21

C. Flow Diagram of WOM Structure

Figure 2-1 shows the general structure of the WOM submodule, including its links with the PPS and OS submodules of IEM. Based on external assumptions and a trial price, crude oil supplies and demands for non-OPEC regions are calculated. U.S. supply and demand is provided from the NEMS PMM (using import supply relationships that are consistent with the trial price), while balances for the rest-of-world (ROW) regions are endogenously estimated using the relationships from Section 3 below.[3] Regional oil production and consumption levels are aggregated to obtain non-OPEC world totals, and any excess of demand over supply is assumed to be met by OPEC production. This "call on OPEC production" is then compared to the exogenously specified level of OPEC output for that period. If required OPEC output is greater than specified OPEC output, there is excess world demand for oil and the current trial price should be raised in the next iteration to dampen demand and stimulate non-OPEC oil production. The new price P'_t is used to adjust the exogenously-derived import supply curves for crude oil and refined products, which in turn induce

[3] Non-OPEC world regions represented in the IEM are the U.S., Canada, Mexico, Japan, Australia/New Zealand, OECD Europe, Other South & Central America, Pacific Rim, Other Developing Countries, Former Soviet Union, Eastern Europe, and China.

revisions in U.S. petroleum supply and demand balances. Together with revised ROW crude oil supplies and demands, these adjustments alter the residual demand for OPEC oil. If required OPEC output is under the specified level, the trial price should be lowered to stimulate oil demand and reduce non-OPEC production. This process continues until the demand for OPEC output equals the specified level, indicating that both world and U.S. crude oil markets are in equilibrium at that price.

D. Key WOM Assumptions

The WOM submodule of IEM is based on an approach to modeling international oil markets that is dependent on two key assumptions: 1) oil is the marginal fuel, and 2) OPEC produces such marginal supply at prices that inhibit any significant market penetration of new technologies. Under these assumptions, world oil prices are computed as a function of OPEC production decisions, availability of non-OPEC oil supplies, and worldwide economic growth. Under the assumption that oil is the marginal fuel, competition between oil and other fuels can be ignored since potential volumes of fuel switching are assumed to be too small to influence prices. The second assumption means the price of oil will not rise high enough to induce the market penetration of new technologies that would reduce the demand for oil sufficiently to put downward pressure on its price.[4] Other assumptions which facilitate the analysis include:

- The current oil price, Gross Domestic Product (GDP) growth rates, and last year's supplies and demands are the only determinants of non-OPEC supply and demand.[5]

- A set of reference supplies and demands (usually specified at a constant real price throughout the forecast period).

- Price-taking behavior by all countries and regions except for OPEC.

E. Basis of WOM Modeling Choices

Two distinct approaches are generally used to model the world oil market: recursive simulation and optimization. Both approaches assume that OPEC has significant influence on the world oil price; however, each method assumes a different basis for OPEC behavior. The rationale behind

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[4] Over time conventional oil is expected to gradually decline as the world's marginal fuel. Therefore, accounting for competition among fuels and allowing for the greater possible penetration of new technologies for coal, nuclear power, natural gas and other alternatives will become increasingly important.

[5] This assumption does not apply to the U.S. in the IEM. In order to ensure consistency between World Oil Market results and other components of NEMS, U.S. crude oil supply and demand is taken from the NEMS Petroleum Market Module, which in turn draws inputs from the NEMS Oil & Gas Supply Module.

recursive simulation is the perception that there is only limited understanding of past and future energy market behavior. In optimization, OPEC is assumed to set prices in order to maximize the discounted present value of its stream of profits throughout the forecast period. Such an approach implies perfect foresight about future energy markets. That is, OPEC's output decisions are not myopically based only on their influence on current prices and revenue, but instead depend on perfect information about supplies and demands over the entire forecast horizon.[6]

A survey of current models indicates that recursive simulation is favored over optimization. Four advantages of using the recursive simulation approach are frequently cited: 1) it often does well in explaining past data, 2) it evolves from today's actual oil price, 3) forecasts change only gradually in response to parameter changes, and 4) lags can easily be incorporated into the responsiveness of supply and demand. The primary advantage of the optimization approach is that there can be a clearly defined objective for OPEC (e.g., profit maximization) rather than the somewhat *ad hoc* objectives (e.g., target capacity utilization) used in the recursive simulation approach, but this is more than offset by the requirement to assume perfect foresight.

2.2 Petroleum Product Supply

A. Background

The purpose of the PPS component within the IEM is to represent the availability of foreign petroleum product supplies to U.S. markets, so that a least cost mix of domestic and imported supplies can be derived within the PMM. The PPS relies on petroleum product import supply curves obtained from the World Oil Refining, Logistics, and Demand (WORLD) Linear Programming (LP) model, a detailed international refining and transportation model depicting refinery operations, product trade, and capital expansions and retirements. Since imbedding WORLD directly into the NEMS structure is currently not feasible due to its size and complexity, a set of import supply curves generated from solutions to WORLD are used to summarize global petroleum supply conditions.[7]

Only a few international energy models provide forecasts by petroleum product type. However, these models do not simulate the petroleum refining and transportation sectors. By not modeling the refining and transportation sectors of the petroleum industry, these models cannot quantify the impacts on product prices or other factors of interest for policy analyses. They cannot assess the impact, for example, of future refinery construction, significant changes in transportation costs due

[6] It is important to note that there are as many optimal *ex ante* OPEC revenue streams as there are expectations of future energy market conditions. Any given optimization is driven by a set of foresight assumptions that are highly uncertain.

[7] The possibility of directly incorporating a streamlined or "reduced form" version of WORLD into the IEM has been briefly examined with only limited success.

to requirements for new types of vessels, or new environmental regulations that affect refinery operations or the mix of products consumed.

B. General PPS Modeling Approach

A representation of foreign product supply levels and associated costs are incorporated in the PPS component of the IEM. This representation takes the form of petroleum product supply curves which are obtained from output generated by the WORLD LP model, and subsequently adjusted within the PPS to reflect changes in the world oil price (WOP).[8] These import supply curves consist of a series of three stepped line segments, each defining a single price over a range of supply (Figure 2-2 provides representations of the 1993 import supply curves for motor gasoline and jet fuel to PADD1). PADD-specific import supply curves are generated for each of ten refined products for each year of a NEMS forecast.

The WORLD LP Model:

WORLD is a 6,800 row by 37,500 column LP model which simulates the operation, technology, and economics of the international petroleum industry. The WORLD model includes numerous cost, technology, demand and logistics components, including detailed refining matrices, and is well-suited for examining the impacts on domestic refiners of environmental regulations, such as reformulated fuel specifications and other policy initiatives. It provides detailed simulations for each year of a NEMS forecast with features such as:

- Crude Oils - provides detail on over 120 world crude oils, by nation and crude type, including SPR crudes;

- Refining Technology - simulates and provides a detailed representation of over 50 refinery processes, including advanced technologies for reformulated gasoline, oxygenates and military fuels;

- Capital Investment - contains factors which represent the cost of capital for refineries in each region;

- Product Formulation and Demand - 30 product types are represented, and allows product blending and quality specifications to be represented;

- Transportation - provides comprehensive inter-regional transportation detail of crudes, petroleum products, and intermediates;

- Regional Effects - numerous levels of detail are provided, including individual country,

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[8] Again, because foreign regions are represented in the IEM only as aggregate estimates of petroleum supply and demand (making no distinction as to crude oil, natural gas liquids or refined products, for example), it becomes necessary to represent the foreign sources of refined petroleum products to the U.S. in the form of import supply curves.

crude supply regions (EIA supply regions), refining regions (PADDs) and demand regions (Census Divisions), as well as detail on refinery types.

WORLD is solved by using the above data on crude shipping, processing, investment, blending and product shipping to satisfy specific product demands in a manner which minimizes worldwide refining and transportation costs while simultaneously meeting all system constraints, including shipping limits, capacity and operational limits, product blending specifications, and regional product demands.

Derivation of Import Supply Curves:

The primary output from WORLD to the IEM are the price-quantity arrays used to construct petroleum product import supply curves for each PADD and forecast year of the NEMS. The following steps summarize how the product import supply curves are generated by WORLD for the PPS:

1. Determine maximum refined product imports into the United States by assuming that no additional domestic refinery capacity is built. This is accomplished using the WORLD model for a given year and world oil price case (high, base, or low).

2. The WORLD model simulation in Step 1 represents one piecewise-linear step of an import supply curve for each PADD/refined product combination. Two additional steps of the import supply curves are obtained by reducing U.S. refined product demands in amounts equivalent to one-third of a PADD's import for each refined product and using the WORLD model for each reduced-demand case.

3. The quantities reflected in the import supply curves are the differences between a PADD's import levels in successive simulations of the model. The prices are the marginal prices (shadow costs) from the linear programming solution.

Supply Curve Adjustment:

The fundamental operation conducted within the PPS component is the adjustment of the product import supply curves received from the WORLD model to reflect changes in the estimated world oil price. For a given year of a NEMS forecast, the various components of the IEM iterate with the domestic PMM in NEMS to find a WOP consistent with supply-demand balance in the domestic petroleum markets. The supply curve adjustment process consists of adding or subtracting any change in the WOP to the import product prices after model iteration. The process shifts the import product supply curves up or down by the amount of change in the WOP after each model iteration, but does not alter the shape of the supply curves. Input for this calculation (the WOP) is obtained from the WOM component of the IEM.

The PPS component passes the adjusted product supply curves to the domestic PMM which contains an initial estimate of the quantities of petroleum product and crude imports. The supply levels and costs (the supply curves) of imported products determined within the PPS are then compared to the equivalent U.S. product information in the PMM. That is, the set of product import supply curves, after being adjusted to reflect changes in the WOP, are passed to the PMM and a new U.S. supply and demand balance is achieved in response to the new prices. This iterative process continues until a least cost mix of domestic and foreign supplies is determined.

C. Flow Diagram of PPS Model Structure

Figure 2-3 presents a flow diagram of the PPS Component of the IEM. As can be seen, the WOM component of the IEM provides the world oil price to the PPS which adjusts the import supply curves received from WORLD. This data is then passed to the PMM component of the NEMS which computes a supply/demand balance based on the new set of prices.

D. Key PPS Assumptions

Because of its size and complexity, the WORLD model is currently precluded from being incorporated directly into the NEMS computing environment. Because the petroleum product import supply curves used within the PPS are obtained exogenously, the IEM is not a completely closed system. Incorporating the product import supply curves exogenously implies that the U.S. supply and demand assumptions in the WORLD model will never perfectly correspond to the supply and demand estimates in the IEM and NEMS as a whole. However, such discrepancies have always been found to be insignificant in the mid-term assuming business-as-usual world oil market conditions (that is, conditions under which there are no major disruptions in worldwide petroleum supplies over the forecast period).

E. Basis of PPS Modeling Choices

Models of petroleum product supply that incorporate refinery operation and transportation costs are generally linear programming (LP) models. LPs are the model of choice in the petroleum industry because they allow refiners and distributors to optimize operations given certain production and transportation constraints. In addition, petroleum refining and transportation LPs are the best source of information on marginal costs for individual refined products. Other alternatives involve testing numerous refinery configurations to determine optimal operations before marginal costs can be calculated. The sum of individual petroleum companies' marginal costs becomes the industry supply curve, under the assumption of perfect competition.

LPs yield some measurement of the coproduction phenomenon, one of the most difficult concepts to model in the petroleum industry. In a refinery operation, more than one output is produced at a time. If gasoline is the primary product sought from a refinery run, there will also be coproduction of distillate, jet fuel, and other refined products. Similarly, the production of distillate results in the coproduction of gasoline, jet fuel, and so forth. Isolating marginal costs for any particular fuel in this system of interdependency is difficult without the use of LPs. On the other hand, the disadvantages of LPs include the large quantities of data required to support the model and the amount of computer time needed to solve it.

The key building blocks of the PPS submodule are the supply curves exogenously derived by the WORLD LP model. WORLD is an international refining and transportation LP model, which depicts the economics of worldwide refining and the international trade of crude oils and refined products. In the past, two EIA models have been used to address these issues. However, the refinery formulations of these models failed to adequately simulate the petroleum refining and transportation sectors, and did not appropriately consider environmental regulations or contain adequate structure for assessing potential expansion or retirement of existing worldwide refinery capacity. Consequently, they could not assess the impact, for example, of future refinery construction, significant changes in transportation costs due to requirements for new types of vessels, or new environmental regulations that affect refinery operations or the mix of products consumed.

WORLD can be used to calculate product supply curves under alternative assumptions about the world oil price, changes in refinery operations, and changes in transportation. It allows for additions and retirement of refineries, and changes in their operation and structure. Because of its enhanced capabilities, the WORLD model is now used to generate import supply curves for use in the NEMS. By passing these curves to the domestic PMM component of the NEMS, the PPS modeling choice now allows for an interactive, endogenous determination of the optimal level of U.S. petroleum product imports to be made within the NEMS. Because of its large size and complexity, the WORLD model cannot be directly incorporated into the NEMS.

Due to computer run-time considerations, crude oil, refined product and oxygenate imports into the U.S. are formulated as a set of piece-wise linear import supply curves. It is generally acknowledged that representations of foreign refinery operations would be a superior formulation over the import supply curves. With foreign refinery models in the NEMS, it would be possible to assess such issues as where incremental refinery capacity might be built in the mid to longer term given the stricter environmental specifications of fuels. There has been some experimental efforts to incorporate a reduced-form version of the WORLD model in the NEMS. However, results from these efforts have so far shown only limited potential.

2.3 Oxygenates Supply

A. Background

The purpose of the OS component is to represent the costs of oxygenated fuels available for import into the U.S. The Clean Air Act Amendments of 1990 (CAA90) impose new environmental requirements on some energy sectors. One section of the law requires an increase in the oxygen content of gasoline to reduce carbon monoxide emissions, which can be accomplished by blending with oxygenates. Effective November 1992, gasoline sold in many areas of the United States during the winter must contain a minimum level (2.7 percent by weight) of oxygen. In 1995, "reformulated gasoline" requirements become effective year-round in nine urban areas. Reformulated gasoline is designed to reduce smog formation and requires a minimum oxygen level (2.0 percent by weight) in addition to other component specifications. These new requirements will increase U.S. demand for oxygenates, but the quantity of future demand is uncertain.Several alcohols and ethers can serve as oxygenates, but the ones most commonly used are ethanol and methyl tertiary butyl ether (MTBE). Methanol is also classified as an oxygenate, but it is not expected to be used directly for gasoline blending. However, it is important as a feedstock for the production of MTBE.

It should also be noted that while its environmental properties are an important determinant in the demand for MTBE, MTBE is primarily used as an additive to boost octane content, in unleaded gasolines. In this context, while U.S. lead reduction levels are largely complete, efforts in Western Europe are ongoing, and are just beginning in many other countries of the world. Consequently, the growing demand for oxygenates in the U.S., coupled with the lead reduction programs in other countries, will increase the worldwide demand for MTBE. It is unlikely that domestic production of MTBE will be sufficient to meet the growing U.S. demand, so imports will become an increasingly important source of supply.

B. General OS Modeling Approach

The OS component of the IEM provides import supply curves for methanol and MTBE. These supply curves represent the prices associated with given quantities of methanol and MTBE that are available for import to the United States from foreign sources. The curves are developed and obtained from the WORLD LP model. Within WORLD the curves are developed from data on pricing practices for current production capacity and assumptions about pricing for new production capacity that is under construction or expected to be constructed in the future. Figure 2-4 presents an example of methanol import supply curves to PADD1 over alternative time periods.

These supply curves are used in the OS component in the same manner as described for the petroleum product supply curves in the preceding section. First, the oxygenate supply curves received from the WORLD model are adjusted to reflect changes in the WOP. These supply curves are then passed to the PMM component, where a new supply and demand balance is achieved. (The WOP is obtained from the WOM component within the IEM). Second, the new quantities of U.S. MTBE and methanol from the PMM component imply a new WOP. The OS component again adjusts the set of oxygenate supply curves based on the new WOP calculated within the WOM. This interaction between the OS, WOM and the PMM is continued until a least cost mix of domestic and foreign oxygenates is obtained. That is, convergence is established when the import quantities (or prices) calculated in the current iteration are identical to the quantities from the prior iteration.

C. Flow Diagram of PPS OS Model Structure

Figure 2-5 presents a flow diagram of the OS component of the IEM. As can be seen the WOM component provides the world oil price to the OS which adjusts the oxygenate import supply curves received from the WORLD LP. These adjusted curves are then passed to the PMM, and through iteration with the WOM, the PMM calculates new input prices and achieves a new U.S. supply-demand balance.

D. Key OS Assumptions

The transportation demand module within NEMS forecasts total demand for high oxygen gasoline. The PMM will determine the quantity of oxygenates needed to satisfy that gasoline demand. The two oxygenates modeled within the OS component, MTBE and methanol, are treated as being competitive, and the PMM determines the demand for each separately.

Because of the expansion potential for the U.S. ethanol industry and the lack of commercial markets for other oxygenates, it is assumed that ethanol, ethyl tertiary butyl ether (ETBE), tertiary amyl methyl ether (TAME), and tertiary butyl alcohol (TBA) will all be supplied from domestic sources. The demand for these oxygenates is not expected to exceed domestic supply capabilities and foreign supplies are not expected to be widely available or less expensive than domestic supplies. Therefore, the IEM does not provide import supply curves for these oxygenates.

E. Basis of OS Modeling Choices

The basis for modeling the OS component corresponds exactly to those for the PPS component. That is, WORLD can be used to calculate oxygenate supply curves under alternative assumptions about the world oil price, changes in refinery operations, changes in transportation costs and requirements, and environmental regulations. It allows for additions and retirement of refineries, and changes in their operation and structure. Because of its highly detailed nature, oxygenate import supply curves are now generated by the WORLD model for use in the NEMS. By passing these curves to the domestic PMM component of the NEMS, the OS modeling choice allows for an interactive, endogenous determination of the optimal level of U.S. petroleum product imports to be made within the NEMS.

Figure 2-1. Flow Chart for IEM Module: Market Clearing with Exogenous OPEC Supply

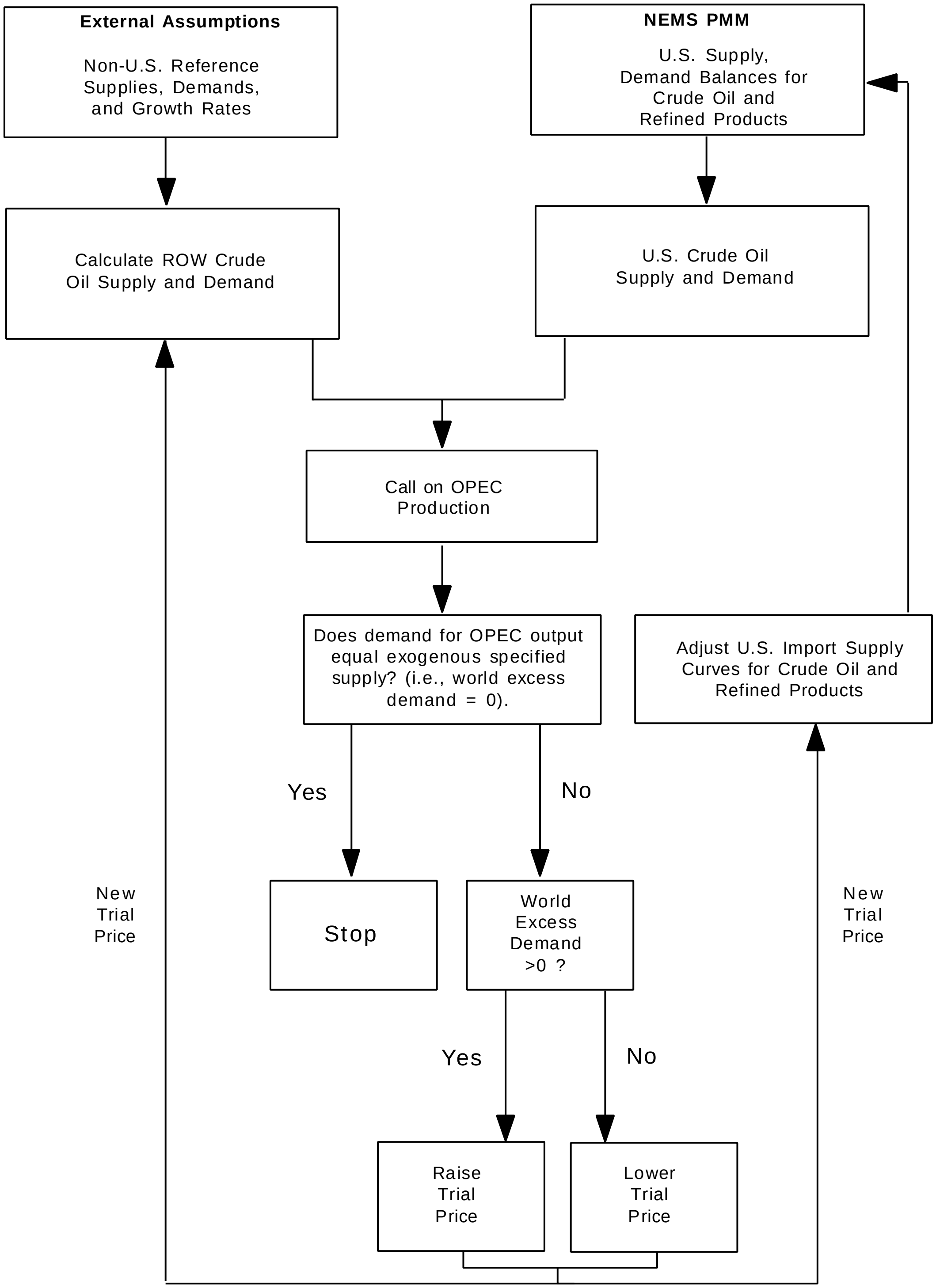


Figure 2-2. 1993 Motor Gasoline and Jet Fuel Import Supply Curves to PADD I

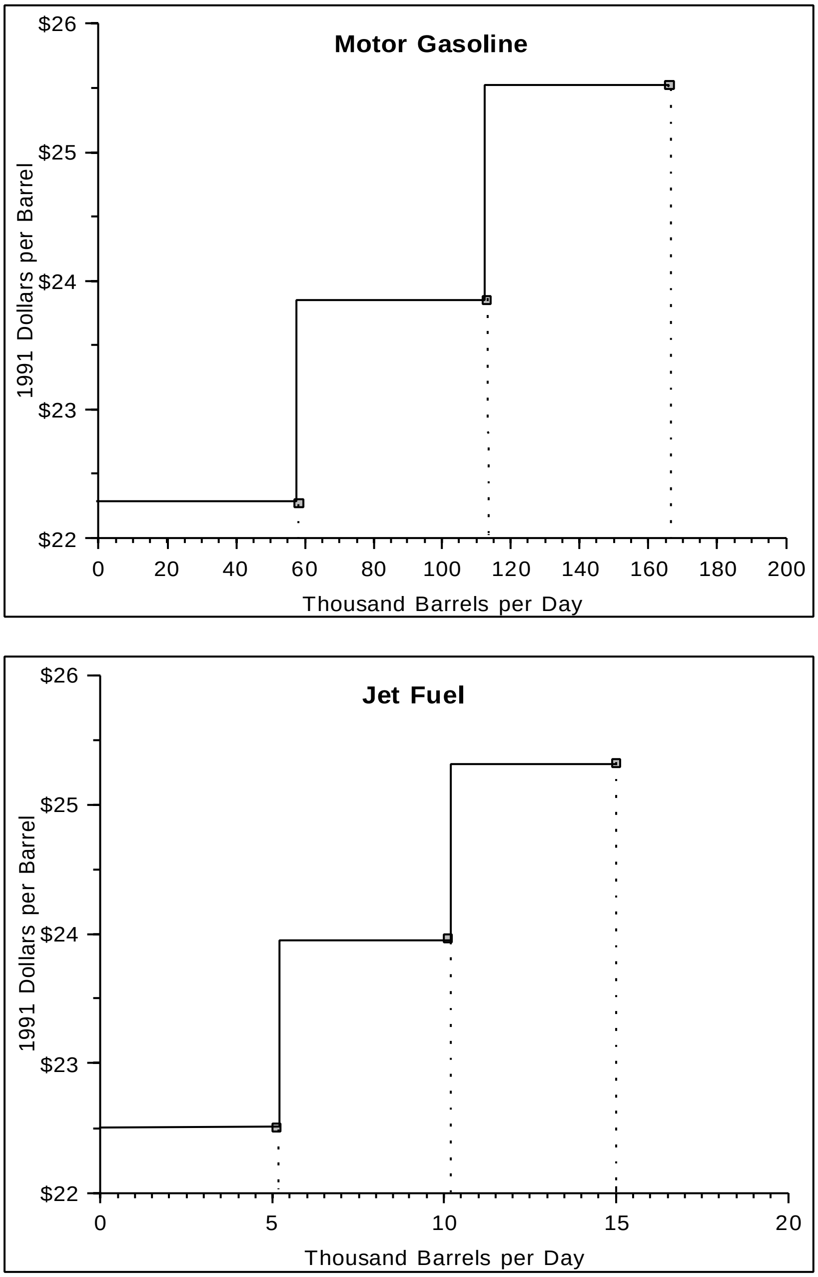


Figure 2-3. Flow Chart for Petroleum Product Supply Submodule

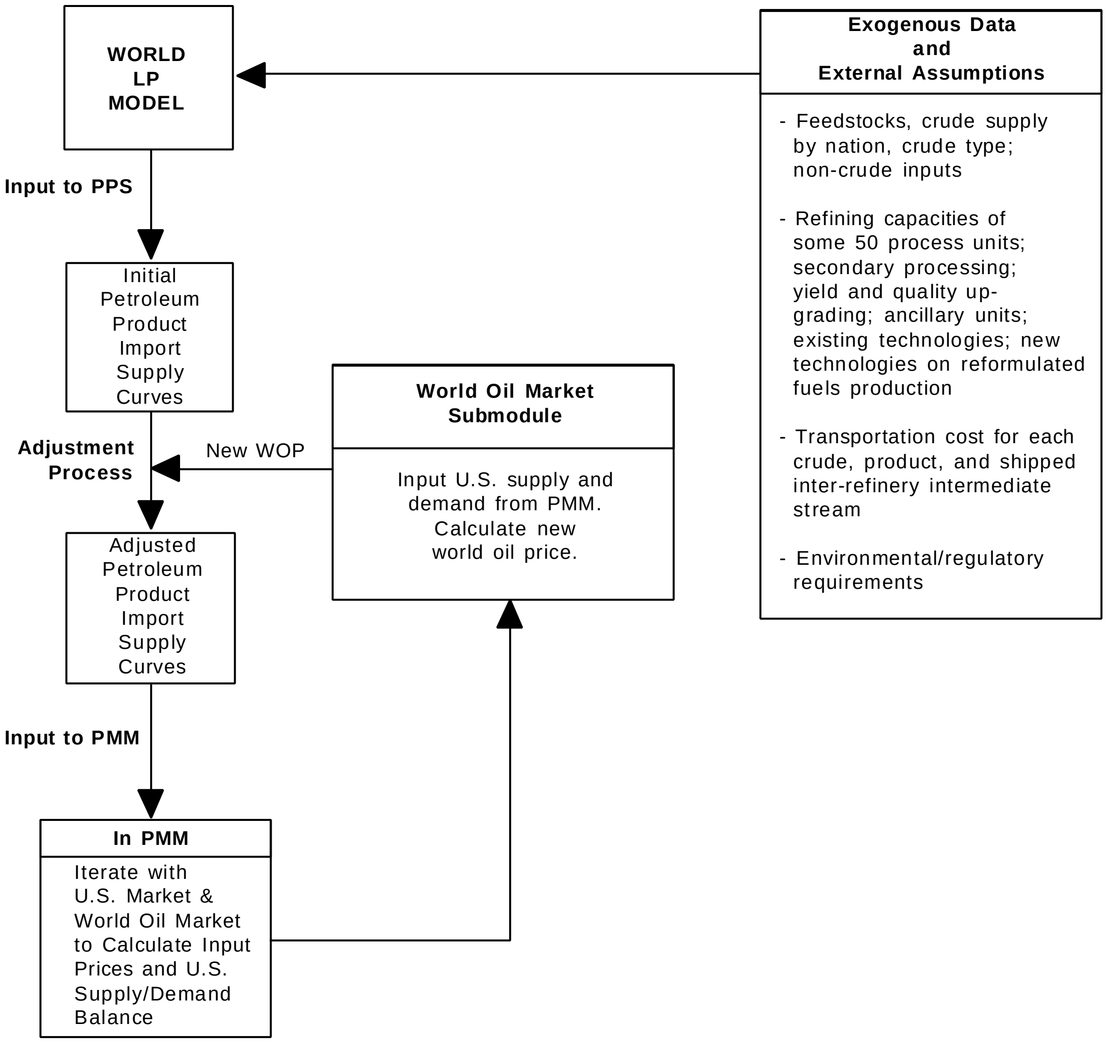


Figure 2-4. Methanol Import Supply Curves to PADD I, 1995, 2000, and 2005

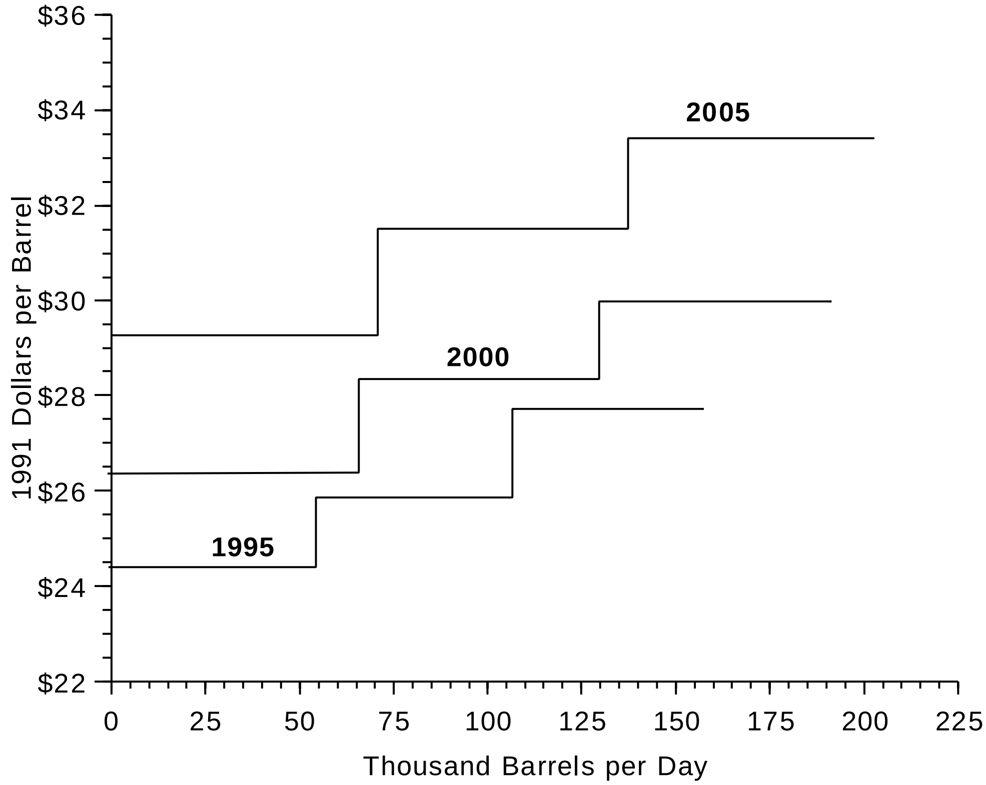
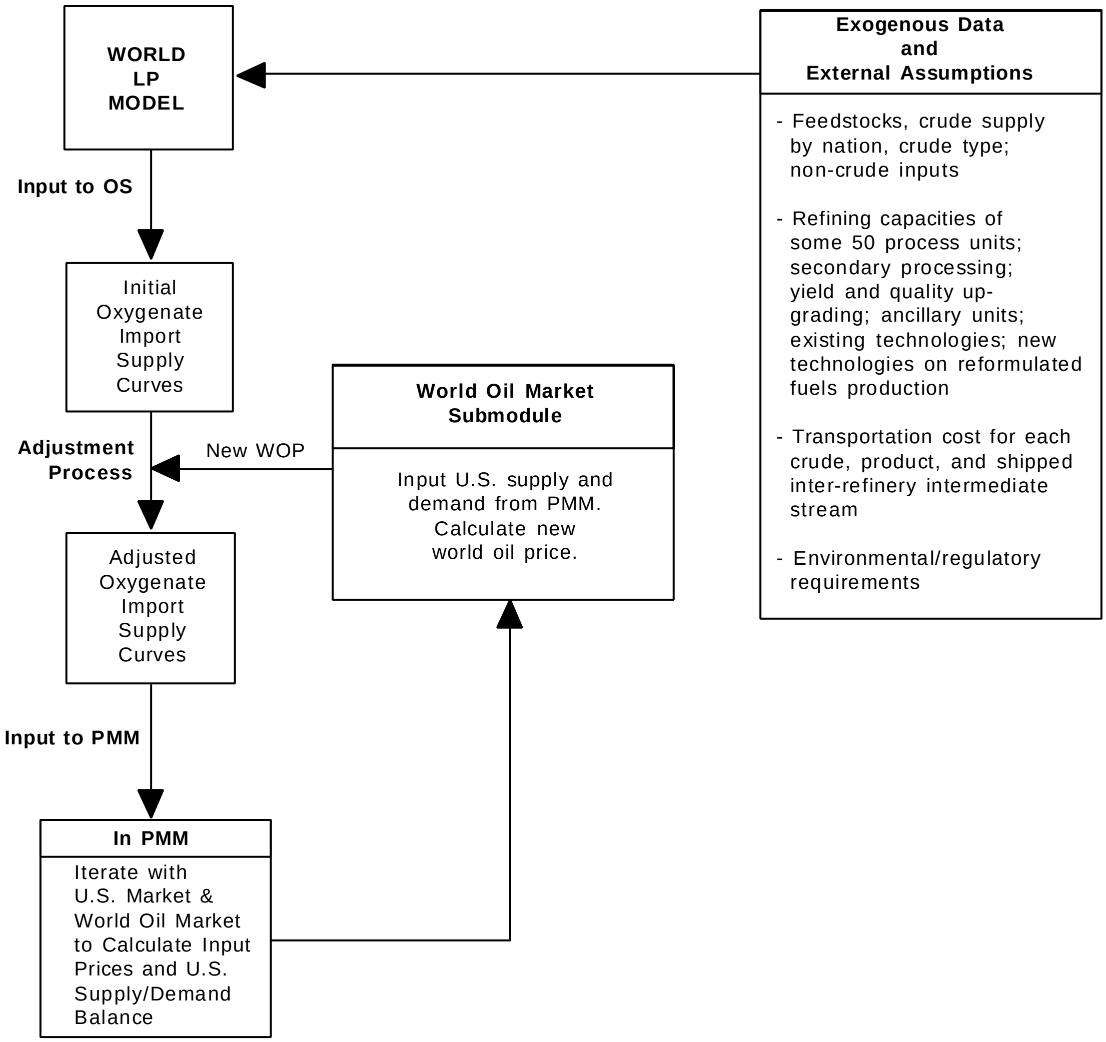


Figure 2-5. Flow Chart for Oxygenates Supply Submodule



3. MATHEMATICAL SPECIFICATIONS

A. World Oil Market

Crude Oil Demand:

U.S. crude oil demand is calculated within the PMM, while crude oil demand for other world regions is estimated using the following functional forms[9]:

$$(1) \qquad D_{i,t} = RD_{i,t} \times \frac{(GDP_{i,t}/RDGP_{i,t})^{y_i}\,(D_{i,t-1}/RD_{i,t-1})^{a_i}\,(P_t/RP_t)^{b_i+f_i y_i}}{(GDP_{i,t-1}/RGDP_{i,t-1})^{a_i y_i}\,(P_{t-1}/RP_{t-1})^{a_i f_i y_i}}$$

where the prefix R denotes reference values and

i	=	U.S., U.S. Territories, Canada, Mexico, Japan, Australia/New Zealand, OECD Europe, Other South & Central America, Pacific Rim, Other Developing Countries, Former Soviet Union, Eastern Europe, China
D	=	oil demand
GDP	=	gross domestic product
P	=	oil price
t	=	forecast year
y	=	income elasticity
a	=	geometric Koyck-lag parameter
b	=	price elasticity
f	=	feedback elasticity

All parameters and variables except for the oil price P are region specific in all equations for non-OPEC oil demand and supply, although common parameter value assumptions may be adopted for all regions or a subset of regions. Note that the composite price coefficient b + fy reflects that the demand impact of price changes occurs through two channels. The coefficient b represents the usual substitution and income effects resulting in movement along a demand curve in traditional microeconomic theory. The coefficient f reflects the feedback effect arising because higher prices also reduce income, and multiplying this by the income elasticity to obtain the product fy captures the effect of income feedbacks on prices.[10]

[9] Crude oil demand by OPEC is exogenously determined.

[10] See Section 2.1B and "The Oil Market Simulation Model: Model Documentation Report" (System Sciences, Inc. for EIA, 1985) for further details on the model specification.

Non-OPEC Crude Oil Supply:

Total crude oil supply is divided into conventional and unconventional output, with distinct parameter values in the supply functions for each type of production. U.S. crude oil supply is calculated within the PMM (based on supply curves constructed within the Oil and Gas Supply Module), while crude supply for other regions is estimated using the following functional forms:

$$(2a) \qquad S^{c}_{i,t} = RS^{c}_{i,t} \times (S^{c}_{i,t-1}/RS^{c}_{i,t-1})^{d_i} \times (P_t/RP_t)^{e_i}$$

$$(2b) \qquad S^{u}_{i,t} = RS^{u}_{i,t} \times (S^{u}_{i,t-1}/RS^{u}_{i,t-1})^{g_i} \times (P_t/RP_t)^{h_i}$$

$$(2c) \qquad S_{i,t} = S^{c}_{i,t} + S^{u}_{i,t}$$

where R, P, and t are defined as before and

i	=	U.S., U.S. Territories, Canada, Mexico, Japan, Australia/New Zealand, OECD Europe, Other South & Central America, Pacific Rim, Other Developing Countries, Former Soviet Union, Eastern Europe, China
S^c	=	conventional oil supplies (includes crude oil, natural gas liquids, other liquids, and refinery processing gain)
S^u	=	unconventional oil supplies (includes enhanced oil recovery, synthetic crude oil, and extraction from tar sands and shale oil)
S	=	total non-OPEC liquids supply (excluding net Eurasian exports)
d	=	geometric Koyck-lag conventional supply parameter
g	=	geometric Koyck-lag unconventional supply parameter
e	=	price elasticity of conventional supply
h	=	price elasticity of unconventional supply

Oil Market Equilibrium:

Equilibrium in the world market for crude oil requires that world oil demand equal the sum of supplies from non-OPEC conventional sources, non-OPEC unconventional sources, and OPEC production:

$$(3) \qquad \textstyle\sum_i D_{i,t} + \Delta Stock_t = \sum_i S_{i,t} + OPEC_t + Disc_t$$

where D and S are defined as before and

$OPEC_t$ = OPEC production
ΔStock = change in oil inventories (> 0 implies stock build)
Disc = residual term

Crude Oil Import Supply Curve Adjustment:

Output from the WOM submodule is linked to the PMM via a set of crude oil import supply curves, which are externally derived from the WORLD LP model based on an assumed initial oil price. Crude oil import supply curves are distinguished by crude oil grade (see Table 2-1) and PADD location. In order to reflect changes in the WOP forecasted by the IEM, the price associated with each import supply quantity is adjusted by the difference between the current equilibrium price and its initial value:

$$(4) \qquad IMCRSC_{i,j,t} = (IMCRSC_{i,j,t} + Offset) \ / \ Deflator$$

where t is defined as before, and

IMCRSC = price component of the imported crude oil supply curve
i = crude oil grade
j = PADD
Offset = the difference between the NEMS forecasted price and the initial price derived by the WORLD model
Deflator = GDP price deflator used for adjusting IEM prices to some other year's real prices used by other modules within the NEMS.

B. Petroleum Product Supply

Petroleum Product Import Supply Curve Adjustment:

Within the PPS component of the IEM, petroleum product import supply curves are adjusted to reflect changes in the WOP during each iteration of the model until equilibrium supply-demand conditions are met. The adjustment process shifts import product supply curves up or down, but does not alter their shape (slope) after each iteration of the model. For example, if the WOP increases during model iteration to reflect new supply-demand conditions, this price increase is fully added to the product supply curves. This process is done for each of ten refined products for each of five PADDs, and for each year of the model forecast. Refined product import supply curves are adjusted in the following manner within the PPS:

$$(5) \qquad IMPPSC_{i,j,t} = (IMPPSC_{i,j,t} + Offset) \; / \; Deflator$$

where t is defined as before, and

IMPPSC	=	price component of the imported refined product supply curve
i	=	refined product type
j	=	PADD
Offset	=	the difference between the NEMS forecasted price and the initial price derived by the WORLD model
Deflator	=	GDP price deflator used for adjusting IEM prices to some other year's real prices used by other modules within the NEMS.

C. Oxygenates Supply

Methanol and MTBE Import Supply Curve Adjustment:

Within the OS component, methanol and MTBE import supply curves are adjusted to reflect changes in the forecasted WOP during each iteration of the IEM in the same manner as refined petroleum products are adjusted within the PPS. The adjustment process for oxygenates shifts these curves up (or down), but does not alter their shape. For example, if the current WOP increases, this price increase is fully added to the oxygenate supply curves. This process is done for methanol and MTBE for each of five PADDs, and for each year forecasted. The adjusted oxygenate import supply curves are calculated in the following manner within the OS:

$$(6) \qquad IMOXSC_{i,j,t} = (IMOXSC_{i,j,t} + Offset) \; / \; Deflator$$

where t is defined as before, and

IMOXSC	=	price component of the imported oxygenates supply curve
i	=	oxygenate type
j	=	PADD
Offset	=	the difference between the NEMS forecasted price and the initial price derived by the WORLD model
Deflator	=	GDP price deflator used for adjusting IEM prices to some other year's real prices used by other modules within the NEMS.

D. Solution Methodology

The WOM module projects annual world oil prices and associated worldwide petroleum supply/demand balances. The solution algorithm in the model solves for the price at which the demand for OPEC oil (total demand less non-OPEC supply) intersects either the exogenously specified OPEC production path or the price-reaction function. A standard iterating procedure, the Newton-Raphson algorithm, is used to search for a price P* at which total demand $D = f(P)$ less non-OPEC supply $S = g(P)$ equals the level of OPEC output X.[11] The level of OPEC output can be determined from either the exogenously specified production path or the inverse $X = h^{-1}(P)$ of the price reaction function.

The starting point for the algorithm is a set of reference quantities and prices. The reference price path is a projection that assumes prices remain constant in real terms throughout the forecast period. The reference quantities are derived using equations in the OMS model as a function of this assumed reference price path. These resulting reference values are projections of oil supply and demand that are consistent with historically observed quantities, world oil prices, GDP levels, and exchange rates. Each iteration gets closer to the solution, by adjusting the current estimate of the solution price up or down. It stops searching when the next adjustment to the price would be less than one-half cent.

Solution Method for Price Run:

The sequence of steps for obtaining an WOM price run solution is:

(a) User provides period t-1 historical values and reference paths of oil demand, supply, and GDP for each region.

(b) User provides OPEC demand and commercial and strategic inventory supplies.

(c) Based on a trial price, Equations (1) and (2c) are used to compute non-OPEC oil supplies and demands, with (2a) and (2b) substituted into (2c).

(d) The difference between (1) and (2c) equals world excess demand, which is the call on OPEC production.

(e) When an exogenous OPEC output path is specified, the demand for OPEC output from step (d) is compared to that level. If the call on OPEC output is greater (less) than OPEC supply, the trial price is raised (lowered) and steps (a)-(d) are repeated. If the call on OPEC output equals OPEC supply, the world oil market is in equilibrium at that price and the search process stops.

Solution Method for Production Run:

The sequence of steps for obtaining an OMS production run solution is:

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[11] Such solution techniques are discussed in *Mathematical Applications of Electronic Spreadsheets* by Deanne E. Arganbright (McGraw Hill, 1985). Here f, g, and h refer to functions and are unrelated to the parameters f and g in Section 3A.

(a) User provides annual world oil prices over forecast period.

(b) Assumed prices are substituted in Equations (1) and (2) to obtain annual regional non-OPEC production and demand.

(c) User provides OPEC demand and commercial and strategic inventory supplies.

(d) Regional demands are summed to obtain world demand.

(e) Regional production levels are summed to obtain non-OPEC world production.

(f) OPEC production is figured as the difference between world demand and non-OPEC world production, as implied by Equation (3).

4. VARIABLES, DATA, AND PARAMETERS

A. Variable and Parameter Lists

A complete listing of variables and parameters for each of the IEM submodules is provided in Tables 4-1 and 4-2, respectively.

B. WOM Data Sources and Estimation Methods

Estimation of Demand and Supply Functions:

In principle, the parameters of the foreign non-OPEC crude oil demand and supply functions represented by Equations (1), (2a), and (2b) could be estimated in a conventional fashion by applying regression analysis to a set of historically observed data. However, the values of these coefficients should also be consistent with the projections of macroeconomic activity, energy demand and supply, and domestic and international energy prices generated by other forecasting models. Therefore, the relevant oil demand and supply elasticities are derived using the results of simulations of such large-scale energy and macroeconomic models. The foreign-region coefficient estimates are calibrated to simulations of the World Energy Projection System (WEPS) and the WEFA Group macroeconomic model.[12] These data sources, including values of U.S. functions in stand-alone mode, are listed in Table 4-3.

C. PPS/OS Data Sources and Estimation Methods

Both the PPS and OS subcomponents of the IEM receive external input data from the WORLD LP model. The PPS receives price and quantity import data for ten refined products for each PADD, while the OS receive methanol and MTBE price and quantity import data for each PADD. These data are used to construct petroleum product and oxygenate import supply curves which are used by the PPM module of the NEMS to derive a supply/demand balance.

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[12] The OMS model, which is the predecessor of the WOM component of the IEM, was formerly operated on a stand-alone basis with U.S. oil demand and supply functions analogous to (1) and (2). The U.S. coefficient estimates of these functions were calibrated to simulations of the Short-term Integrated Forecasting System (STIFS), the Intermediate Future Forecasting System (IFFS), and the Data Resources, Inc. (DRI) macroeconomic model. Since the IEM now receives U.S. supply and demand data from the PMM, equations (1) and (2) no longer apply to the U.S. when the IEM is executed as a component of NEMS. However, the original specification can be retained if it is desired to run the IEM independently of other NEMS modules.

D. Cross-Reference Table

Table 4-4 provides for each equation in Section 3.0 of this report, the location of the corresponding equation in the FORTRAN code (Appendix B), by sub-routine name and line number.

Table 4-1. IEM Model Variables

World Oil Market Component

Variable	Definition	Type
P_t	World Oil Price	Endogenous
$D_{i,t}$	Demand for Oil	Endogenous
$RD_{i,t}$	Reference Demand for Oil	Exogenous
$RS_{i,t}$	Reference Oil Production	Exogenous
$GDP_{i,t}$	Gross National Product	U.S., Endogenous to NEMS (from Macroeconomic Module) Non-U.S., Exogenous
$S_{i,t}$	Total Oil Production	Endogenous
$S_{c,i,t}$	Conventional Oil Production	Endogenous
$S_{u,i,t}$	Unconventional Oil Production	Endogenous
$D_{O,t}$	Demand for OPEC Oil	Endogenous
POPEC	OPEC Oil Production	Endogenous
CU	OPEC Capacity Utilization	Endogenous
Z_t	Percent Change in P_t from P_{t-1}	Endogenous
$Q\_IMCR_{j,k,t}$	Crude Import Quantity Array	Exogenous
$P\_IMCR_{j,k,t}$	Crude Import Price Array	Exogenous
Offset	Difference between current WOP forecast (multiplied by a deflator) and initial oil price (in constant dollars)	Endogenous

Table 4-1. IEM Model Variables (continued)

Petroleum Product Supply & Oxygenate Supply Components

Variable	Definition	Type
P_t	World Oil Price	Endogenous
Offset	Difference between current WOP forecast (multiplied by a price deflator) and initial oil price (in constant dollars)	Endogenous
$IMRGSC_{j,t}$	Reformulated Gasoline Import Supply Curve (price and quantity array)	Exogenous
$IMGSSC_{j,t}$	Gasoline Import Supply Curve (price and quantity array)	Exogenous
$IMMDSC_{j,t}$	Distillate Import Supply Curve (price and quantity array)	Exogenous
$IMLDSC_{j,t}$	Low Sulfur Distillate Import Supply Curve (price and quantity array)	Exogenous
$IMLRSC_{j,t}$	Low Sulfur Residual Fuel Import Supply Curve (price and quantity array)	Exogenous
$IMHRSC_{j,t}$	High Sulfur Residual Fuel Import Supply Curve (price and quantity array)	Exogenous
$IMJFSC_{j,t}$	Jet Fuel Import Supply Curve (price and quantity array)	Exogenous
$IMLPSC_{j,t}$	LPG Import Supply Curve (price and quantity array)	Exogenous
$IMPFSC_{j,t}$	Petroleum Feedstock Import Supply Curve (price and quantity array)	Exogenous
$IMOTSC_{j,t}$	Other Refined Products Import Supply Curve (price and quantity array)	Exogenous

Table 4-1. IEM Model Variables (continued)

Variable	Definition	Type
$IMMESC_{j,t}$	Methanol Import Supply Curve (price and quantity array)	Exogenous
$IMMTSC_{j,t}$	MTBE Import Supply Curve (price and quantity array)	Exogenous

Units of measure:

Oil quantities = millions of barrels per day (MMB/D)
Oil prices = real dollars per barrel
Incomes = real dollars
Petroleum product import quantities = millions of barrels
Petroleum product import prices = real dollars per barrel

For all variables, the subscript t is a time index in annual increments (e.g., t-1 denotes last year), the subscript i distinguishes non-OPEC regions (U.S. [50 States], U.S. Territories, Canada, Mexico, Japan, Australia/New Zealand, OECD Europe, Other South & Central America, Pacific Rim, Other Developing Countries, Former Soviet Union, Eastern Europe, China), while the subscript j distinguishes PADDs, and the subscript k denotes products.

Table 4-2. WOM Model Parameters

For all parameters, the subscript t is a time index in annual increments (e.g., t-1 denotes last year) and the subscript i distinguishes non-OPEC regions (U.S. [50 States], U.S. Territories, Canada, Mexico, Japan, Australia/New Zealand, OECD Europe, Other South & Central America, Pacific Rim, Other Developing Countries, Former Soviet Union, Eastern Europe, China).

Parameter	Definition
Demand Functions:	
b_i	Price elasticity of oil demand
y_i	Income elasticity of oil demand
a_i	Koyck-lag demand parameter
f_i	Demand feedback elasticity
Supply Functions:	
e_i	Price elasticity for conventional oil supply
h_i	Price elasticity for unconventional oil supply
d_i	Koyck-lag parameter for conventional supply
g_i	Koyck-lag parameter for unconventional supply
i, j	Parameters of OPEC price reaction function

See "The Oil Market Simulation Model: Model Documentation Report" (System Sciences, Inc. for EIA, 1985) for details on parameter definitions and values.

Table 4-3. Data Sources for Estimated WOM Parameters

- Short-Term Integrated Forecasting System (STIFS)

  The STIFS short-term energy balance projections underlying Annual Energy Outlook forecasts are the source of implied short-term (one-year) elasticities of crude oil demand with respect to price, holding all other demand determinants constant.

- The National Energy Modeling System (NEMS)

  NEMS produces domestic energy balances for low, mid, and high world oil price scenarios and, for the mid-price trajectory, both high and low income runs to evaluate sensitivities to variation in income. The three price and two income scenarios provide domestic oil supply/demand and one-year price and income elasticities of demand.

- The World Energy Projection System (WEPS)

  The WEPS outputs for the *International Energy Outlook 1994* are also based on three price and tow income sensitivity cases. Mid- to long-term price/income sensitivities of demand were obtained for Canada, Mexico, Japan, Australia/New Zealand, OECD Europe, Other South & Central America, Pacific Rim, Other Developing Countries, Former Soviet Union, Eastern Europe, and China. Supply elasticities were also obtained for the same regions.

- The DRI and WEFA Group Domestic and International Macroeconomic Activity Models

  These models were used to estimate the effects of varying world oil price levels on total economic activity (i.e., energy-economy feedback effects).

Note: In addition to these sources, model users have the discretion to specify alternative elasticities.

Table 4-4. Cross-Reference Table

Line Number	Document Variable Name	Computer Variable Name	Dimension	Equation Number[13]	Subroutine Name
4190-4780	P_t	Price	(27)	1,2a,2b	OMS_sim
4190-4390	$D_{i,t}$	Demand	(7,27)	1	OMS_sim
4190-4390	$RD_{i,t}$	Ref_Dem	(8,27)	1	OMS_sim
4400-4780	$RS_{i,t}$	Ref_Sup	(6,27)	2a,2b	OMS_sim
4190-4390	$GDP_{i,t}$	GDP	(7,27)	1	OMS_sim
4400-4530	$S_{i,t}$	Supply	(5,27)	2c	OMS_sim
4400-4530	$S_{c,i,t}$	[14]	(5,27)	2a,2c	OMS_sim
4400-4530	$S_{u,i,t}$	Unc_Sup	(5,27)	2b,2c	OMS_sim
4540	POPEC	OPEC_Prod	(27)	3	OMS_Sim
4560-4590	CU	[15]	(27)	n.a.	OMS_sim
4690	$Stock_t$	Stk_Chg	(3,27)	3	OMS_sim
4690	$Disc_t$	Discrep	(27)	3	OMS_sim
5140-5170	$Q\_IMCRSC_{j,k,t}$	Q_ITIMCRSC	(27,5,5,3)	4	Crd_Sup_Crv
5190-5210	$P\_IMCRSC_{j,k,t}$	P_ITIMCRSC	(27,5,5,3)	4	Crd_Sup_Crv
5240-5990	Offset	Offset	(27)	4,5,6	Crd_Sup_Crv &
					Prd_Sup_Crv
5710	$IMRGSC_{j,t}$	ITIMRGSC	(27,5,3,2)	5	

[13] Equation numbers refer to the numbers assigned to each equation in Section 3.0 of this report. For example equation number 1 refers to the crude oil demand equation.

[14] Conventional supply is derived in the code as the difference between variable Supply and Unc_sup.

[15] Opec capacity utilization is derived as OPEC_Prod divided by OPEC_cap (OPEC capacity).

Table 4-4. Cross-Reference Table (continued)

Line Number	Document Variable Name	Computer Variable Name	Dimension	Equation Number	Subroutine Name
		Prd_Sup_Crv			
5730	$IMGSSC_{j,t}$	ITIMGSSC	(27,5,3,2)	5	Prd_Sup_Crv
5740	$IMMDSC_{j,t}$	ITIMMDSC	(27,5,3,2)	5	Prd_Sup_Crv
5750	$IMLDSC_{j,t}$	ITIMLDSC	(27,5,3,2)	5	Prd_Sup_Crv
5760	$IMLRSC_{j,t}$	ITIMLRSC	(27,5,3,2)	5	Prd_Sup_Crv
5770	$IMHRSC_{j,t}$	ITIMHRSC	(27,5,3,2)	5	Prd_Sup_Crv
5780	$IMJFSC_{j,t}$	ITIMJFSC	(27,5,3,2)	5	Prd_Sup_Crv
5790	$IMLPSC_{j,t}$	ITIMLPSC	(27,5,3,2)	5	Prd_Sup_crv
5800	$IMPFSC_{j,t}$	ITIMPFSC	(27,5,3,2)	5	Prd_Sup_Crv
5810	$IMOTSC_{j,t}$	ITIMOTSC	(27,5,3,2)	5	Prd_Sup_Crv
5820	$IMMESC_{j,t}$	ITIMMESC	(27,5,3,2)	6	Prd_Sup_Crv
5830	$IMMTSC_{j,t}$	ITIMMTSC	(27,5,3,2)	6	Prd_Sup_Crv

For all variables, the subscript t is a time index in annual increments (e.g., t-1 denotes last year), the subscript i distinguishes non-OPEC regions (U.S. [50 States], U.S. Territories, Canada, Mexico, Japan, Australia/New Zealand, OECD Europe, Other South & Central America, Pacific Rim, Other Developing Countries, Former Soviet Union, Eastern Europe, China), while the subscript j distinguishes PADDs, and the subscript k denotes products.

APPENDIX A

Model Abstract

---

a. Model Name: International Energy Module

b. Acronym: IEM

c. Description: Recursive model of world petroleum supply and demand by region derived from EIA's Oil Market Simulation (OMS) model with enhanced detail on U.S. market conditions from the NEMS Petroleum Market Module (PMM). Determines PADD-level import supply schedules by refined product type and crude oil grade consistent with estimated world oil price. IEM outputs include forecasted world oil price, non-OPEC oil production and oil consumption by region, and OPEC oil production and capacity utilization.

d. Purpose: As component of NEMS, forecast world oil price based on either an exogenously specified OPEC output path or OPEC pricing behavior and estimate U.S. import supplies of crude oil, refined petroleum products, and oxygenated gasoline blending components to allow estimation of U.S. oil supply and demand balances.

e. Model Update: Revisions to the model are ongoing.

Archive Tape ID: NEMS archive tape, 1999 Annual Energy Outlook.

f. Part of: NEMS

g. Model Interface:

Inputs: NEMS Petroleum Market Module (PMM), Short-Term Integrated Forecasting System (STIFS), Intermediate Future Forecasting System (IFFS), World Energy Projection System (WEPS), WEFA Group Int'l Macro Model.

Outputs: NEMS System Module and PMM.

h. Official Representative: Mr. G. Daniel Butler
Office of Integrated Analysis and Forecasting,
Energy Information Administration,

U.S. Department of Energy
Tel: (202) 586-9503

i. Documentation References: EIA, *Model Documentation Report: NEMS International Energy Module* (February 1999).

j. Archive Media: World Oil Market component of IEM is revised version of OMS model, recently archived in *International Energy Outlook 1993* and *Annual Energy Outlook 1993*.

k. System Described: The model describes world oil supply and demand on a regional basis annually from present time through 2020.

l. Coverage:

Forecast time period: Annual from 1990 to 2010

Demand Regions: United States (50 states and territories), Canada, Mexico, Japan, Australia & New Zealand, OECD Europe, Other Central & South America, Pacific Rim, Other Developing Countries, Former Soviet Union, Eastern Europe, China, OPEC

Supply Regions: United States (50 states and territories), Canada, Mexico, Japan, Australia & New Zealand, OECD Europe, Other Central & South America, Pacific Rim, Other Developing Countries, Former Soviet Union, Eastern Europe, China, OPEC

U.S. Detail: PADD-level import supply curves.

Product Types: 5 grades of crude oil, 10 refined products, and 2 oxygenates (methanol & MTBE)

m. Model Structure: The model includes three subcomponents: The World Oil Market (WOM); Petroleum Product Supply (PPS); and Oxygenates Supply (OS). The structure of the WOM component is based on the OMS model, with greater U.S. detail from NEMS PMM.

Modeling Technique: Recursive simulation (search for equilibrium oil price), linear programming (derive import supply curves), econometric (estimate parameters of OPEC price reaction curve and ROW crude demand/supply curves).

n. Input Data (Non-DOE): None

o. Input Data (DOE): U.S. crude oil supply and demand from PMM, reference demand and supply for ROW regions, initial (unadjusted) import supply curves from WORLD LP model.

Data Sources: *Annual Energy Review*, *Monthly Energy Review*, *International Energy Annual*, and *International Petroleum Statistics Report*, Energy Information Administration.

p. Computing Environment: EIA IBM RISC 6000 Series Mainframe.

q. Independent Expert Reviews: World Oil Market component of IEM is revised version of OMS model, which has undergone several independent reviews (e.g., *International Oil Supply and Demand*, Energy Modeling Forum, Stanford University, September 1991).

r. Status of Evaluation Efforts: On-going.

s.

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APPENDIX B

IEM FORTRAN Computer Code

```
      SUBROUTINE WORLD
C
C  The following is a list of the variables used in the
C  International Energy Module of the NEMS.
C
C  Input Variables (The numbers in parentheses represent dimension,
C  unless noted otherwise.)
C
C    Year(32)            1989, 1990, ..., 2020
C
C    Ref_Price(32)       Reference case oil prices, 1989 - 2020
C
C    Start_Price(32)     Initial forecast prices in constant 1990
C                        dollars (taken from the Oil Market
C                        Simulation Model), 1989 - 2020
C
C    Price_Adj(7,32)     Price adjustments for U.S. Territories,
C                       Canada, Mexico, Japan, Australia/New Zealand,
C                       OECD Europe, Other South & Central America,
C                       Pacific Rim, Other Developing Countries,
C                       Former Soviet Union, Eastern Europe, China,
C                        1989 - 2020
C
C    OPEC_Cap2(32)       OPEC Production Capacity if OPEC_Behavior
C                       = 0; pre-determined OPEC production path
C                        if OPEC_Behavior = 1; 1989 - 2020
C
C    Ref_Dem(8,32)       Reference case oil demand for U.S.
C
C    Ref_Sup(6,32)       Reference case oil supply for U.S.,
C                        Territories, Canada, Mexico, Japan,
C                        Australia/New Zealand, OECD Europe,
C                       Other South & Central America, Pacific Rim,
C                        Other Developing Countries,
C                       Former Soviet Union, Eastern Europe, China,
C                        1989 - 2020
C
C    Stk_Chg(3,32)       Net stock withdrawal for U.S. (50
C                        States), U.S. (SPR), and Other Market
C                        Economies, 1989 - 2020
C
C    Discrep(32)         Difference between "Total Consumption"
C                        and "Total Supply," 1989-2020
C
C    Unc_Sup(5,32)       Unconventional oil supply for U.S.,
C                        Canada, Japan, OECD Europe, and Other
C                        Market Economies, 1989 - 2020
C
C    OPEC_Cap1(32)       OPEC Capacity 1, defined as report writer
C                        variables.  1989 - 2020
C
```

```
C    GDP(7,32)           Gross Domestic Product in 1987
C                        dollars, 1989-2020.
C
C    P_Elas_Dem(13)      Price demand elasticity for U.S.
C                        Territories, Canada, Mexico, Japan,
C                        Australia/New Zealand, OECD Europe,
C                       Other South & Central America, Pacific Rim,
C                        Other Developing Countries,
C                       Former Soviet Union, Eastern Europe, China
C
C    FB_Elas_Dem(13)     Feedback demand elasticity for U.S.
C                        Territories, Canada, Mexico, Japan,
C                        Australia/New Zealand, OECD Europe,
C                       Other South & Central America, Pacific Rim,
C                        Other Developing Countries,
C                       Former Soviet Union, Eastern Europe, China
C
C    P_Elas_Sup(13)      Supply price elasticity for U.S.
C                        Territories, Canada, Mexico, Japan,
C                        Australia/New Zealand, OECD Europe,
C                       Other South & Central America, Pacific Rim,
C                        Other Developing Countries,
C                       Former Soviet Union, Eastern Europe, China
C
C    I_Elas(13)          Income elasticity for U.S. Territories,
C                       Canada, Mexico, Japan, Australia/New Zealand,
C                       OECD Europe, Other South & Central America,
C                       Pacific Rim, Other Developing Countries,
C                       Former Soviet Union, Eastern Europe, China
C
C    Dem_Lag(13)         Demand lag for U.S. Territories,
C                       Canada, Mexico, Japan, Australia/New Zealand,
C                       OECD Europe, Other South & Central America,
C                       Pacific Rim, Other Developing Countries,
C                       Former Soviet Union, Eastern Europe, China
C
C    Sup_Lag(13)         Supply lag for U.S. Territories,
C                       Canada, Mexico, Japan, Australia/New Zealand,
C                       OECD Europe, Other South & Central America,
C                       Pacific Rim, Other Developing Countries,
C                       Former Soviet Union, Eastern Europe, China
C
C    Dem_Adj(32)         Income elasticity adjustment factor; used
C                       only for simulations where a sensitivity
C                        analysis of the economic parameters is
C                        being addressed; generally set to 1
C
C    Sup_Adj(32)         Price elasticity of supply adjustment
C                        factor; used only for simulations where
C                        a sensitivity analysis of the economic
C                       parameters is being addressed; generally
C                        to 1
C
C    GDP85(13)           Gross Domestic Product for 1985 in
C                        constant 1985 U.S. dollars for U.S.
C                        Territories, Canada, Mexico, Japan,
C                        Australia/New Zealand, OECD Europe,
C                       Other South & Central America, Pacific Rim,
C                        Other Developing Countries,
C                       Former Soviet Union, Eastern Europe, China
```

```
C
C    P_Elas_USup          Price elasticity for unconventional oil
C                          supply
C
C    Alpha               Price behavior factor for price reaction
C                        function (currently set to -0.332557634)
C
C    Beta                Price behavior factor for price reaction
C                        function (currently set to 0.0649573199)
C
C    Demand(13,X)         This is an array of oil demand for U.S.,
C    X = 1               U.S. Territories, Canada, Mexico, Japan,
C                         Australia/New Zealand, OECD Europe,
C                        Other South & Central America, Pacific Rim,
C                         Other Developing Countries,
C                        Former Soviet Union, Eastern Europe, China.
C                        The values for time period 1 are actual oil
C                         demand for 1989.
C
C    Supply(13,X)         This array contains oil supply for  U.S.,
C    X = 1               U.S. Territories, Canada, Mexico, Japan,
C                         Australia/New Zealand, OECD Europe,
C                        Other South & Central America, Pacific Rim,
C                         Other Developing Countries,
C                        Former Soviet Union, Eastern Europe, China.
C                        The values for time period 1 are actual oil
C                         demand for 1989.
C
C    Price(X)            The actual world oil price for 1989.
C    X = 1
C
C The following variables are used "universally" by the NEMS system
C to perform input/output operations:
C
C    Fname                File name (for purposes of i/o)
C
C    New                 Logical, New=FALSE => existing file;
C                                  New=TRUE => new file
C
C    Iunit1              FORTRAN unit number assigned using
C                         EXTERNAL FILE_MGR function.
C
C    FILE_MGR            Function for determining FORTRAN unit
C                        number to associate with a specific file.
C
C The following variables are used within the OMS_Sim,
C Crd_Sup_Crv, and/or Prd_Sup_Crv or are assigned as output in
C the Report_Variables section of the program.
C
C    I,J,K               Integer variables used as indices in
C                         looping and array structures.
C
C   First_Time(32)       Logical, true=> first iteration; false=>
C                         two or more iterations.
C
C    Price(32)           World Oil Price, 1989 - 2020.  Price(1)-
C                         -the 1989 actual world oil price--is set
C                         to 19.63.
C
C    Demand(7,32)        Oil demand for U.S., U.S. Territories,
```

```
C                       Canada, Mexico, Japan, Australia/New Zealand,
C                       OECD Europe, Other South & Central America,
C                       Pacific Rim, Other Developing Countries,
C                       Former Soviet Union, Eastern Europe, China,
C                        1989-2020.
C
C    Supply(5,32)        Oil supply from U.S., U.S. Territories
C                       Canada, Mexico, Japan, Australia/New Zealand,
C                       OECD Europe, Other South & Central America,
C                       Pacific Rim, Other Developing Countries,
C                       Former Soviet Union, Eastern Europe, China,
C                        1989-2020.
C
C    OPEC_Prod(32)       OPEC oil production, 1989 - 2020.  Set
C                       equal to Call_On_OPEC in OMS_Sim routine.
C
C    OPEC_Dem(32)       OPEC oil demand, 1989 - 2020.  Set equal
C                        to Ref_Dem for OPEC in OMS_Sim routine.
C
C    Balance(32)         Set equal to the variable "Discrep" (1989
C                        - 2020) in OMS_Sim routine.
C
C    OPEC_Behavior       0 = uses OPEC target capacity utilization
C                            pricing methodology employed in the
C                            Oil Market Simulation (OMS) model
C                        1 = uses market clearing methodology to a
C                            pre-determined OPEC output path
C
C    Old_Price           Initialized to 0 during first iteration
C                       and thereafter set to latest "New_Price"
C
C    New_Price           Initialized to "Start_Price" during first
C                       iteration for "current year" (CURIYR+1)
C                        and thereafter computed using the
C                       variables "Old_Price", "Function", and
C                        "Funct_Prime".  At the end of the
C                        iteration, "Price(t)" is set to
C                        "New_Price".
C
C    Sum_Demand          Oil demand aggregated over years and for
C                        the regions U.S., Canada, Japan, OECD
C                       Europe, Other Market Economies, and U.S.
C                        Territories.
C
C    Sum_Supply          Oil supply aggregated over years and for
C                        the regions U.S., Canada, Japan, OECD
C                        Europe, and Other Market Economies.
C
C    Call_On_OPEC        Unmet oil demand (OPEC Production).
C
C    Elas_Factor         Elasticity factor
C
C    Function            Price reaction function.
C
C    Funct_Prime        OPEC determined world oil price (P')
C
C    T                  Integer variable used as time index.  Set
C                        to CURIYR+1 in OMS_Sim.
C
C    Offset             Difference between International World Oil
```

```
C                        Price (multiplied by a price deflator) and
C                         Start_Price.  Used in the subroutines
C                         Crd_Sup_Crv and Prd_Sup_Crv.
C
C                ****END OF VARIABLE DESCRIPTIONS****
C
C   Main Routine For International Energy Module
C
      IMPLICIT NONE
      CALL OMS_Dat_In
      CALL OMS_Sim
      CALL Crd_Sup_Crv
      CALL Prd_Sup_Crv
      CALL World_Oil_Report
      RETURN
      END
CDBG  DEBUG SUBCHK
CDBG  END DEBUG
      SUBROUTINE OMS_Dat_In
      IMPLICIT NONE
      LOGICAL New
      CHARACTER*18 Fname
      INTEGER Iunit1
      INTEGER FILE_MGR
      EXTERNAL FILE_MGR
      INTEGER Year, I, J
      REAL Ref_Price, Price_Adj, OPEC_Cap2, Ref_Dem, Ref_Sup,
     .    Discrep, OPEC_Cap1,
     .    GDP, P_Elas_Dem, FB_Elas_Dem, P_Elas_Sup, I_Elas,
     .    Dem_Lag, Sup_Lag, Start_Price
      COMMON /OMSDATA/ Year(32), Ref_Price(32), Price_Adj(13, 32),
     .    OPEC_Cap2(32), Ref_Dem(14, 32), Ref_Sup(13, 32),
     .    Discrep(32), OPEC_Cap1(32),
     .    GDP(13, 32), P_Elas_Dem(13),
     .   FB_Elas_Dem(13), P_Elas_Sup(13), I_Elas(13), Dem_Lag(13),
     .    Sup_Lag(13), Start_Price(32)
C
C   Inputs International Reference Supply And Demand Values
C
      Fname='OMSREF'
      New=.FALSE.
      Iunit1=FILE_MGR('O',Fname,New)
      CALL Skip_Comments(Iunit1)
      READ (Iunit1, 100) (Year(I), I=1, 32)
  100 FORMAT (20X, 32I7)
      CALL Skip_Comments(Iunit1)
      READ (Iunit1, 200) (Ref_Price(I), I=1, 32)
  200 FORMAT (20X, 32F7.0)
      READ (Iunit1, 200) (Start_Price(I), I=1, 32)
      CALL Skip_Comments(Iunit1)
      DO 11 I=2, 13
      READ (Iunit1, 200) (Price_Adj(I, J), J=1, 32)
   11 CONTINUE
      CALL Skip_Comments(Iunit1)
      READ (Iunit1, 200) (OPEC_Cap2(I), I=1, 32)
      CALL Skip_Comments(Iunit1)
      DO 1 I=2, 14
      READ (Iunit1, 200) (Ref_Dem(I, J), J=1, 32)
    1 CONTINUE
      CALL Skip_Comments(Iunit1)
```

```
      DO 2 I=2, 13
      READ (Iunit1, 200) (Ref_Sup(I, J), J=1, 32)
    2 CONTINUE
      CALL Skip_Comments(Iunit1)
      READ (Iunit1, 200) (Discrep(I), I=1, 32)
      CALL Skip_Comments(Iunit1)
      READ (Iunit1, 200) (OPEC_Cap1(I), I=1, 32)
      Iunit1=FILE_MGR('C',Fname,New)
C
C   Inputs International Economic Parameters
C
      Fname='OMSECON'
      Iunit1=FILE_MGR('O',Fname,New)
      CALL Skip_Comments(Iunit1)
      DO 5 I=2, 13
      READ (Iunit1, 200) (GDP(I, J), J=1, 32)
    5 CONTINUE
      CALL Skip_Comments(Iunit1)
      DO 6 I=2, 13
     READ (Iunit1, 400) P_Elas_Dem(I), FB_Elas_Dem(I), P_Elas_Sup(I),
     .    I_Elas(I)
  400 FORMAT (20X, 4F10.0)
    6 CONTINUE
      CALL Skip_Comments(Iunit1)
      DO 7 I=2, 13
      READ (Iunit1, 500) Dem_Lag(I), Sup_Lag(I)
  500 FORMAT (20X, 2F10.0)
    7 CONTINUE
      Iunit1=FILE_MGR('C',Fname,New)
      RETURN
      END
CDBG  DEBUG SUBCHK
CDBG  END DEBUG
      SUBROUTINE Skip_Comments(File_Num)
C
C   Skips Commented Lines In All Input Files
C
      CHARACTER*1 Star, A
      INTEGER File_Num
      DATA Star/'*'/
      READ (File_Num, 100) A
  100 FORMAT (A1)
      DO WHILE (A.EQ.Star)
        READ (File_Num, 100) A
      END DO
      BACKSPACE File_Num
      RETURN
      END
CDBG  DEBUG SUBCHK
CDBG  END DEBUG
      SUBROUTINE OMS_Sim
C
C   Forecasts World Oil Price Using OPEC Price Reaction
C   Methodology Employed In The Oil Market Simulation (OMS)
C   Model
C
      IMPLICIT NONE
      INTEGER I, T, Year
      LOGICAL First_Time
      REAL Ref_Price, Price_Adj, OPEC_Cap2, Ref_Dem, Ref_Sup,
```

```
     .    Discrep, OPEC_Cap1,
     .    GDP, P_Elas_Dem, FB_Elas_Dem, P_Elas_Sup, I_Elas,
     .    Dem_Lag, Sup_Lag, Start_Price
      REAL GDP85, Transform, Price, Demand, Supply, OPEC_Prod,
     .   OPEC_Dem, Net_CPE, Balance, Old_Price, New_Price, Sum_Demand,
     .   Sum_Supply, Call_On_OPEC, Elas_Factor, Function, Funct_Prime
      DOUBLE PRECISION Alpha, Beta
      DIMENSION GDP85(13), Transform(13), First_Time(32)
      COMMON /FORECAST/ Price(32), Demand(13, 32), Supply(13, 32),
     .    OPEC_Prod(32), OPEC_Dem(32), Net_CPE(32), Balance(32)
      COMMON /OMSDATA/ Year(32), Ref_Price(32), Price_Adj(13, 32),
     .    OPEC_Cap2(32), Ref_Dem(14, 32), Ref_Sup(13, 32),
     .    Discrep(32), OPEC_Cap1(32),
     .    GDP(13, 32), P_Elas_Dem(13),
     .   FB_Elas_Dem(13), P_Elas_Sup(13), I_Elas(13), Dem_Lag(13),
     .    Sup_Lag(13), Start_Price(32)
      INCLUDE (PARAMETR)
      INCLUDE (INTOUT)
      INCLUDE (PMMOUT)
      INCLUDE (PMMRPT)
      INCLUDE (NCNTRL)
      DATA GDP85/3549., 15.06, 350.1, 171.96, 1352.3, 182.8, 2979.2,
     .    458.28, 307.42, 686.4, 1603.3, 540.9, 287.2/
      DATA Alpha, Beta/-0.332557634, 0.0649573199/
      DATA Transform/1., 0.97, 1.02, 0.97, 1.004, 1.002, 1.009,
     .    1.00675, 1.015, 1.006, 1., 1.028, 1.002/
      DATA First_Time/32*.TRUE./
      Demand(1, 1)=17.37
      Demand(2, 1)=0.212
      Demand(3, 1)=1.733
      Demand(4, 1)=1.66
      Demand(5, 1)=4.983
      Demand(6, 1)=0.79
      Demand(7, 1)=12.849
      Demand(8, 1)=2.994
      Demand(9, 1)=2.622
      Demand(10, 1)=3.679
      Demand(11, 1)=8.74
      Demand(12, 1)=1.76
      Demand(13, 1)=2.38
      Supply(1, 1)=9.88
      Supply(2, 1)=0.
      Supply(3, 1)=2.027
      Supply(4, 1)=2.932
      Supply(5, 1)=0.044
      Supply(6, 1)=0.624
      Supply(7, 1)=4.413
      Supply(8, 1)=2.343
      Supply(9, 1)=1.622
      Supply(10, 1)=3.159
      Supply(11, 1)=12.14
      Supply(12, 1)=0.381
      Supply(13, 1)=2.757
      Price(1)=20.58
      IF (.NOT.First_Time(CURIYR+1)) GO TO 1
      First_Time(CURIYR+1)=.FALSE.
      Old_Price=0.
      New_Price=IT_WOP(CURIYR,1)* 1.236      ! dsa code 5/2/95
      IT_WOP(CURIYR, 1)=New_Price/1.236
C The following is commented out so that the model will run standalone
```

```
C and so the first iterations' result will be more in line with the res
CDS      RETURN
    1 T=CURIYR+1
      Old_Price=New_Price
      Sum_Demand=0.
      Sum_Supply=0.
      Elas_Factor=0.
      DO 2 I=1, 13
      IF (I.EQ.1) Demand(1, T)=RFQPRDT(11, CURIYR)
      IF (I.GT.1)
     .    Demand(I, T)=(Ref_Dem(I, T)*(((GDP(I, T)/GDP85(I))**
     .     I_Elas(I))
     .     /((GDP(I, T-1)/GDP85(I))**
     .     (I_Elas(I)*Dem_Lag(I)))
     .   *((Demand(I, T-1)/Ref_Dem(I, T-1))**Dem_Lag(I))*((Old_Price
     .    /Ref_Price(T)*Price_Adj(I, T))**(P_Elas_Dem(I)
     .     -FB_Elas_Dem(I)*
     .    I_Elas(I))))*((Price(T-1)/Ref_Price(T-1)
     .    *Price_Adj(I, T-1))**(FB_Elas_Dem(I)*
     .     I_Elas(I)*Dem_Lag(I))))
     .     **(1./Transform(I))
      Sum_Demand=Sum_Demand+Demand(I, T)
      IF (I.EQ.1)
     .   Elas_Factor=Elas_Factor+(-0.091-0.04*0.77)*Demand(I, T)
      IF (I.NE.1)
     .   Elas_Factor=Elas_Factor+(P_Elas_Dem(I)-FB_Elas_Dem(I)*
     .     (I_Elas(I)))*Demand(I, T)
    2 CONTINUE
      DO 3 I=1, 13
      IF (I.EQ.1) Supply(1, T)=RFQTDCRD(15, CURIYR)
     .    +RFPQNGL(6, CURIYR, 6, 2)+RFETHD(CURIYR)+RFMETD(CURIYR)
     .     +RFQPRCG(6, CURIYR)
      IF (I.GT.1)
     .    Supply(I, T)=Ref_Sup(I, T)*(Supply(I, T-1)
     .   /Ref_Sup(I, T-1))**Sup_Lag(I)*(Old_Price/Ref_Price(T))**
     .     P_Elas_Sup(I)
      Sum_Supply=Sum_Supply+Supply(I, T)
      IF (I.EQ.1)
     .    Elas_Factor=Elas_Factor-0.05*Supply(I, T)
      IF (I.NE.1)
     .    Elas_Factor=Elas_Factor-P_Elas_Sup(I)*Supply(I, T)
    3 CONTINUE
     Call_On_OPEC=Sum_Demand+Ref_Dem(14, T)-Sum_Supply-Discrep(T)
      Elas_Factor=Elas_Factor/Old_Price
     Function=(1.+Alpha+Beta/(1.-Call_On_OPEC/OPEC_Cap2(T)))
     .     *Price(T-1)
      Funct_Prime=((Beta/OPEC_Cap2(T)*Elas_Factor)
     .    /(1.-Call_On_OPEC/OPEC_Cap2(T))**2)*Price(T-1)
     New_Price=Old_Price-((Old_Price-Function)/(1.-Funct_Prime))
      IF (New_Price.LT.0.9*Old_Price) New_Price=0.9*Old_Price
      IF (Start_Price(T).GT.0.) New_Price=Start_Price(T)
      Price(T)=New_Price
      IT_WOP(T-1, 1)=Price(T)/1.236
      OPEC_Prod(T)=Call_On_OPEC
      OPEC_Dem(T)=Ref_Dem(14, T)
      Net_CPE(T)=Supply(11, T)+Supply(12, T)+Supply(13, T)
     .    -Demand(11, T)-Demand(12, T)-Demand(13, T)
      Balance(T)=Discrep(T)
C On first iteration, cycle until the result stabilizes          !DS
      IF(CURITR.EQ.1.AND.Start_Price(T).LE.0.) THEN              !DS
```

```
        IF(ABS(Old_Price-New_Price).gt.0.001) then                  !DS
         write(6,*) ' old_price,new_price =',old_price,new_price   !DS
          goto 1                                                    !DS
        endif
      ENDIF                                                         !DS
      RETURN
      END
CDBG  DEBUG SUBCHK
CDBG  END DEBUG
      SUBROUTINE Crd_Sup_Crv
C
C   Generates PADD-Level Import Supply Curves (3-Steps) For
C   Five Grades Of Crude Oil
C
      IMPLICIT NONE
      INTEGER Year
      REAL Ref_Price, Price_Adj, OPEC_Cap2, Ref_Dem, Ref_Sup,
     .    Discrep, OPEC_Cap1,
     .    GDP, P_Elas_Dem, FB_Elas_Dem, P_Elas_Sup, I_Elas,
     .    Dem_Lag, Sup_Lag, Start_Price
      COMMON /OMSDATA/ Year(32), Ref_Price(32), Price_Adj(13, 32),
     .    OPEC_Cap2(32), Ref_Dem(14, 32), Ref_Sup(13, 32),
     .    Discrep(32), OPEC_Cap1(32),
     .    GDP(13, 32), P_Elas_Dem(13),
     .   FB_Elas_Dem(13), P_Elas_Sup(13), I_Elas(13), Dem_Lag(13),
     .    Sup_Lag(13), Start_Price(32)
      LOGICAL New
      CHARACTER*18 Fname
      INTEGER Iunit1
      INTEGER FILE_MGR
      EXTERNAL FILE_MGR
      INTEGER T, I, J, K
      REAL Offset
      INCLUDE (PARAMETR)
      INCLUDE (INTOUT)
      INCLUDE (NCNTRL)
      Fname='CRDCURV'
      New=.FALSE.
      Iunit1=FILE_MGR('O',Fname,New)
      DO 4 T=1, CURIYR
      DO 3 K=1, 3
      CALL Skip_Comments(Iunit1)
      DO 1 J=1, 5
      READ (Iunit1, 301) (Q_ITIMCRSC(CURIYR, I, J, K), I=1, 5)
  301 FORMAT (20X, 5F10.0)
    1 CONTINUE
      CALL Skip_Comments(Iunit1)
      DO 2 J=1, 5
      READ (Iunit1, 301) (P_ITIMCRSC(CURIYR, I, J, K), I=1, 5)
    2 CONTINUE
    3 CONTINUE
    4 CONTINUE
      Offset=1.236 * IT_WOP(CURIYR, 1) - ABS(Start_Price(CURIYR+1))
      DO 7 I=1, 5
      DO 6 J=1, 5
      DO 5 K=1, 3
      P_ITIMCRSC(CURIYR, I, J, K) = (P_ITIMCRSC(CURIYR, I, J, K)
     .  +Offset) / 1.236
    5 CONTINUE
    6 CONTINUE
```

```
    7 CONTINUE
      Iunit1=FILE_MGR('C',Fname,New)
      RETURN
      END
CDBG  DEBUG SUBCHK
CDBG  END DEBUG
      SUBROUTINE Prd_Sup_Crv
C
C   Generates PADD-Level Import Supply Curves (3-Steps) For Six
C   Refined Product Categories and Two Categories Of Oxygenates
C
      IMPLICIT NONE
      INTEGER Year
      REAL Ref_Price, Price_Adj, OPEC_Cap2, Ref_Dem, Ref_Sup,
     .    Discrep, OPEC_Cap1,
     .    GDP, P_Elas_Dem, FB_Elas_Dem, P_Elas_Sup, I_Elas,
     .    Dem_Lag, Sup_Lag, Start_Price
      COMMON /OMSDATA/ Year(32), Ref_Price(32), Price_Adj(13, 32),
     .    OPEC_Cap2(32), Ref_Dem(14, 32), Ref_Sup(13, 32),
     .    Discrep(32), OPEC_Cap1(32),
     .    GDP(13, 32), P_Elas_Dem(13),
     .   FB_Elas_Dem(13), P_Elas_Sup(13), I_Elas(13), Dem_Lag(13),
     .    Sup_Lag(13), Start_Price(32)
      LOGICAL New
      CHARACTER*18 Fname
      INTEGER Iunit1
      INTEGER FILE_MGR
      EXTERNAL FILE_MGR
      INTEGER I, J, K
      REAL Offset
      INCLUDE (PARAMETR)
      INCLUDE (INTOUT)
      INCLUDE (NCNTRL)
      Fname='PRDCURV'
      New=.FALSE.
      Iunit1=FILE_MGR('O',Fname,New)
      DO 2 I=1, CURIYR
        DO 1 K=1, 3
          CALL Skip_Comments(Iunit1)
          READ(Iunit1,301) (ITIMRGSC(CURIYR,J,K,1),J=1,5)
  301 FORMAT (20X,5F10.0)
          READ(Iunit1,301) (ITIMGSSC(CURIYR,J,K,1),J=1,5)
          READ(Iunit1,301) (ITIMDSSC(CURIYR,J,K,1),J=1,5)
          READ(Iunit1,301) (ITIMLDSC(CURIYR,J,K,1),J=1,5)
          READ(Iunit1,301) (ITIMLRSC(CURIYR,J,K,1),J=1,5)
          READ(Iunit1,301) (ITIMHRSC(CURIYR,J,K,1),J=1,5)
          READ(Iunit1,301) (ITIMJFSC(CURIYR,J,K,1),J=1,5)
          READ(Iunit1,301) (ITIMLPSC(CURIYR,J,K,1),J=1,5)
          READ(Iunit1,301) (ITIMPFSC(CURIYR,J,K,1),J=1,5)
          READ(Iunit1,301) (ITIMOTSC(CURIYR,J,K,1),J=1,5)
          READ(Iunit1,301) (ITIMMESC(CURIYR,J,K,1),J=1,5)
          READ(Iunit1,301) (ITIMMTSC(CURIYR,J,K,1),J=1,5)
          CALL Skip_Comments(Iunit1)
          READ(Iunit1,301) (ITIMRGSC(CURIYR,J,K,2),J=1,5)
          READ(Iunit1,301) (ITIMGSSC(CURIYR,J,K,2),J=1,5)
          READ(Iunit1,301) (ITIMDSSC(CURIYR,J,K,2),J=1,5)
          READ(Iunit1,301) (ITIMLDSC(CURIYR,J,K,2),J=1,5)
          READ(Iunit1,301) (ITIMLRSC(CURIYR,J,K,2),J=1,5)
          READ(Iunit1,301) (ITIMHRSC(CURIYR,J,K,2),J=1,5)
          READ(Iunit1,301) (ITIMJFSC(CURIYR,J,K,2),J=1,5)
```

```
         READ(Iunit1,301) (ITIMLPSC(CURIYR,J,K,2),J=1,5)
         READ(Iunit1,301) (ITIMPFSC(CURIYR,J,K,2),J=1,5)
         READ(Iunit1,301) (ITIMOTSC(CURIYR,J,K,2),J=1,5)
         READ(Iunit1,301) (ITIMMESC(CURIYR,J,K,2),J=1,5)
         READ(Iunit1,301) (ITIMMTSC(CURIYR,J,K,2),J=1,5)
    1   CONTINUE
    2 CONTINUE
      Offset=1.236 * IT_WOP(CURIYR, 1) - ABS(Start_Price(CURIYR+1))
      DO 4 I=1, 5
      DO 3 J=1, 3
      ITIMRGSC(CURIYR, I, J, 2) = (ITIMRGSC(CURIYR, I, J, 2)
     .    +Offset) / 1.236
      ITIMGSSC(CURIYR, I, J, 2) = (ITIMGSSC(CURIYR, I, J, 2)
     .    +Offset) / 1.236
      ITIMDSSC(CURIYR, I, J, 2) = (ITIMDSSC(CURIYR, I, J, 2)
     .    +Offset) / 1.236
      ITIMLDSC(CURIYR, I, J, 2) = (ITIMLDSC(CURIYR, I, J, 2)
     .    +Offset) / 1.236
      ITIMLRSC(CURIYR, I, J, 2) = (ITIMLRSC(CURIYR, I, J, 2)
     .    +Offset) / 1.236
      ITIMHRSC(CURIYR, I, J, 2) = (ITIMHRSC(CURIYR, I, J, 2)
     .    +Offset) / 1.236
      ITIMJFSC(CURIYR, I, J, 2) = (ITIMJFSC(CURIYR, I, J, 2)
     .    +Offset) / 1.236
      ITIMLPSC(CURIYR, I, J, 2) = (ITIMLPSC(CURIYR, I, J, 2)
     .    +Offset) / 1.236
      ITIMPFSC(CURIYR, I, J, 2) = (ITIMPFSC(CURIYR, I, J, 2)
     .    +Offset) / 1.236
      ITIMOTSC(CURIYR, I, J, 2) = (ITIMOTSC(CURIYR, I, J, 2)
     .    +Offset) / 1.236
      ITIMMESC(CURIYR, I, J, 2) = (ITIMMESC(CURIYR, I, J, 2)
     .    +Offset) / 1.236
      ITIMMTSC(CURIYR, I, J, 2) = (ITIMMTSC(CURIYR, I, J, 2)
     .    +Offset) / 1.236
    3 CONTINUE
    4 CONTINUE
      Iunit1=FILE_MGR('C',Fname,New)
      RETURN
      END
CDBG  DEBUG SUBCHK
CDBG  END DEBUG
      SUBROUTINE World_Oil_Report
      IMPLICIT NONE
      INTEGER I, Year
      REAL Ref_Price, Price_Adj, OPEC_Cap2, Ref_Dem, Ref_Sup,
     .    Discrep, OPEC_Cap1,
     .    GDP, P_Elas_Dem, FB_Elas_Dem, P_Elas_Sup, I_Elas,
     .    Dem_Lag, Sup_Lag, Start_Price
      REAL Price, Demand, Supply, OPEC_Prod, OPEC_Dem, Net_CPE,
     .    Balance
      COMMON /FORECAST/ Price(32), Demand(13, 32), Supply(13, 32),
     .   OPEC_Prod(32), OPEC_Dem(32), Net_CPE(32), Balance(32)
      COMMON /OMSDATA/ Year(32), Ref_Price(32), Price_Adj(13, 32),
     .    OPEC_Cap2(32), Ref_Dem(14, 32), Ref_Sup(13, 32),
     .    Discrep(32), OPEC_Cap1(32),
     .    GDP(13, 32), P_Elas_Dem(13),
     .   FB_Elas_Dem(13), P_Elas_Sup(13), I_Elas(13), Dem_Lag(13),
     .    Sup_Lag(13), Start_Price(32)
      INCLUDE (PARAMETR)
      INCLUDE (INTOUT)
```

```
      INCLUDE (NCNTRL)
      IF (CURIYR.LT.LASTYR) RETURN
      DO 1 I=1, LASTYR
      REPORT(I, 1)=IT_WOP(I, 1)*1.344
      REPORT(I, 2)=Supply(1, I+1)
      REPORT(I, 3)=Supply(3, I+1)
      REPORT(I, 4)=Supply(4, I+1)
      REPORT(I, 5)=Supply(7, I+1)
      REPORT(I, 6)=Supply(5, I+1)+Supply(6, I+1)
      REPORT(I, 7)=Supply(1, I+1)+Supply(3, I+1)+Supply(4, I+1)
     .    +Supply(5, I+1)+Supply(6, I+1)+Supply(7, I+1)
      REPORT(I, 8)=Supply(8, I+1)
      REPORT(I, 9)=Supply(9, I+1)
      REPORT(I, 10)=OPEC_Prod(I+1)
      REPORT(I, 11)=Supply(10, I+1)
      REPORT(I, 12)=Supply(8, I+1)+Supply(9, I+1)+OPEC_Prod(I+1)
     .    +Supply(10, I+1)
      REPORT(I, 13)=Supply(11, I+1)
      REPORT(I, 14)=Supply(12, I+1)
      REPORT(I, 15)=Supply(13, I+1)
      REPORT(I, 16)=Supply(11, I+1)+Supply(12, I+1)+Supply(13, I+1)
      REPORT(I, 17)=REPORT(I, 7)+REPORT(I, 12)+REPORT(I, 16)
      REPORT(I, 18)=Demand(1, I+1)
      REPORT(I, 19)=Demand(2, I+1)
      REPORT(I, 20)=Demand(3, I+1)
      REPORT(I, 21)=Demand(4, I+1)
      REPORT(I, 22)=Demand(5, I+1)
      REPORT(I, 23)=Demand(6, I+1)
      REPORT(I, 24)=Demand(7, I+1)
      REPORT(I, 25)=Demand(1, I+1)+Demand(2, I+1)+Demand(3, I+1)
     .    +Demand(4, I+1)+Demand(5, I+1)+Demand(6, I+1)+Demand(7, I+1)
      REPORT(I, 26)=Demand(8, I+1)
      REPORT(I, 27)=Demand(9, I+1)
      REPORT(I, 28)=OPEC_Dem(I+1)
      REPORT(I, 29)=Demand(10, I+1)
      REPORT(I, 30)=Demand(8, I+1)+Demand(9, I+1)+OPEC_Dem(I+1)
     .    +Demand(10, I+1)
      REPORT(I, 31)=Demand(11, I+1)
      REPORT(I, 32)=Demand(12, I+1)
      REPORT(I, 33)=Demand(13, I+1)
      REPORT(I, 34)=Demand(11, I+1)+Demand(12, I+1)+Demand(13, I+1)
      REPORT(I, 35)=REPORT(I, 25)+REPORT(I, 30)+REPORT(I, 34)
      REPORT(I, 36)=REPORT(I, 17)-REPORT(I, 10)
      REPORT(I, 37)=Net_CPE(I+1)
      REPORT(I, 38)=OPEC_Prod(I+1)/REPORT(I, 17)
    1 CONTINUE
      RETURN
      END
```

APPENDIX C

Sample Input Data for Petroleum Product Import Supply Curves

```
* Year: 1993

* Refined Product Import Quantities (Step 1)
Reformulated Mogas          8.8        5.1       12.9        5.1        5.1
Traditional Mogas          58.1        5.1        5.1        5.1       64.7
Diesel, Heating Oil        57.7        5.1        5.1        5.1        5.1
Low Sulfur No. 2           18.5        7.9       83.5        5.1       12.0
Low Sulfur Fuel Oil        63.9        5.1        5.1        5.1       56.6
High Sulfur Fuel Oil       23.6        6.9       82.8        5.1       35.1
Jet Fuel                    5.1       12.7        5.1       27.7        5.1
Liquefied Pet. Gases        5.1       37.2        5.1        5.1        5.1
Petchem. Feedstocks        12.9       48.0      110.6        7.5        5.1
Other Refined Prod.         5.1        5.6        6.4        5.1        5.1
Methanol                   48.8        6.4       38.8        5.1       36.8
M. T. B. E.                 5.1        5.1        5.1        5.1        5.1

* Refined Product Import Prices (Step 1)
Reformulated Mogas         24.57      23.61      23.30      23.36      22.38
Traditional Mogas          22.28      21.41      21.77      22.50      19.67
Diesel, Heating Oil        21.53      20.32      20.15      21.01      19.35
Low Sulfur No. 2           25.31      24.35      24.52      25.55      23.82
Low Sulfur Fuel Oil        14.35      13.80      14.16      10.97      13.68
High Sulfur Fuel Oil       12.17      11.46      11.26       7.44      10.61
Jet Fuel                   22.50      21.52      21.18      21.14      21.88
Liquefied Pet. Gases       13.11      12.11      11.98       9.57      12.58
Petchem. Feedstocks        17.87      17.48      17.41      18.24      15.69
Other Refined Prod.        15.93      15.42      15.57      12.12      13.30
Methanol                   22.46      25.86      23.06      22.96      21.59
M. T. B. E.                13.50      14.86      12.49      14.88      12.19

* Refined Product Import Quantities (Step 2)
Reformulated Mogas          8.3        5.0       12.2        5.0        5.0
Traditional Mogas          54.8        5.0        5.0        5.0       61.0
Diesel, Heating Oil        54.4        5.0        5.0        5.0        5.0
Low Sulfur No. 2           17.4        7.4       78.7        5.0       11.3
Low Sulfur Fuel Oil        60.2        5.0        5.0        5.0       53.3
High Sulfur Fuel Oil       22.3        6.5       78.1        5.0       33.1
Jet Fuel                    5.0       12.0        5.0       26.1        5.0
Liquefied Pet. Gases        5.0       35.0        5.0        5.0        5.0
Petchem. Feedstocks        12.1       45.3      104.3        7.1        5.0
Other Refined Prod.         5.0        5.3        6.1        5.0        5.0
Methanol                   46.0        6.0       36.6        5.0       34.7
M. T. B. E.                 5.0        5.0        5.0        5.0        5.0

* Refined Product Import Prices (Step 2)
Reformulated Mogas         26.26      25.26      24.71      24.61      23.66
Traditional Mogas          23.86      22.90      23.08      24.06      21.16
Diesel, Heating Oil        22.69      21.38      21.28      22.21      20.63
Low Sulfur No. 2           26.90      26.03      25.92      26.90      25.55
```

Low Sulfur Fuel Oil	15.43	14.54	14.89	11.53	14.42
High Sulfur Fuel Oil	13.03	12.26	12.15	10.64	11.30
Jet Fuel	23.96	22.65	22.82	22.43	23.06
Liquefied Pet. Gases	13.77	13.00	12.68	10.23	13.24
Petchem. Feedstocks	19.22	18.55	18.68	19.22	16.86
Other Refined Prod.	17.08	16.60	16.64	12.82	14.49
Methanol	23.97	24.76	24.32	24.32	23.07
M. T. B. E.	14.55	15.89	12.49	15.82	12.84

* Refined Product Import Quantities (Step 3)

Reformulated Mogas	8.0	4.9	11.8	4.9	4.9
Traditional Mogas	53.1	4.9	4.9	4.9	59.2
Diesel, Heating Oil	52.7	4.9	4.9	4.9	4.9
Low Sulfur No. 2	16.9	7.2	76.3	4.9	11.0
Low Sulfur Fuel Oil	58.4	4.9	4.9	4.9	51.7
High Sulfur Fuel Oil	21.6	6.3	75.7	4.9	32.1
Jet Fuel	4.9	11.6	4.9	25.3	4.9
Liquefied Pet. Gases	4.9	34.0	4.9	4.9	4.9
Petchem. Feedstocks	11.8	43.9	101.1	6.9	4.9
Other Refined Prod.	4.9	5.1	5.9	4.9	4.9
Methanol	44.6	5.8	35.5	4.9	33.7
M. T. B. E.	4.9	4.9	4.9	4.9	4.9

* Refined Product Import Prices (Step 3)

Reformulated Mogas	27.92	26.56	26.30	26.15	24.95
Traditional Mogas	25.53	24.27	24.50	25.56	22.32
Diesel, Heating Oil	23.97	22.81	22.56	23.78	21.96
Low Sulfur No. 2	28.67	27.87	27.41	28.44	26.99
Low Sulfur Fuel Oil	16.53	15.24	15.68	12.13	15.46
High Sulfur Fuel Oil	13.83	13.05	12.76	11.16	11.97
Jet Fuel	25.31	24.15	24.45	23.57	24.44
Liquefied Pet. Gases	14.53	13.82	13.52	10.78	13.88
Petchem. Feedstocks	20.21	19.52	19.99	20.36	17.87
Other Refined Prod.	18.09	17.61	17.45	13.68	15.32
Methanol	25.49	28.94	25.49	26.04	24.66
M. T. B. E.	15.24	16.98	11.89	16.78	13.44

```
* Year: 1995

* Refined Product Import Quantities (Step 1)
Reformulated Mogas        14.3       5.1      21.4       5.1       5.1
Traditional Mogas         59.5       5.1       5.1       5.1      54.6
Diesel, Heating Oil       61.6       5.1       5.1       5.1       5.1
Low Sulfur No. 2          30.8      13.1     139.2       5.1      20.1
Low Sulfur Fuel Oil       58.1       5.1       5.1       5.1      60.7
High Sulfur Fuel Oil      24.0      11.0      85.7       5.1      36.8
Jet Fuel                   5.1      21.1       5.1      26.5       5.1
Liquefied Pet. Gases       5.1      57.7       5.1       5.1       5.1
Petchem. Feedstocks        5.1      46.5     108.8       9.5       5.1
Other Refined Prod.        5.1       5.1       5.1       5.1       5.1
Methanol                  54.8      10.1      25.2       5.1      41.2
M. T. B. E.                5.1       5.1       5.1       5.1       5.1

* Refined Product Import Prices (Step 1)
Reformulated Mogas       26.35     25.68     24.70     25.11     23.87
Traditional Mogas        24.21     22.98     23.26     24.30     21.87
Diesel, Heating Oil      23.05     21.85     21.79     22.57     21.44
Low Sulfur No. 2         27.43     26.08     26.06     26.68     25.63
Low Sulfur Fuel Oil      16.28     15.55     15.78     12.51     15.38
High Sulfur Fuel Oil     14.03     13.25     13.34     10.63     12.30
Jet Fuel                 24.18     23.25     23.29     22.76     23.69
Liquefied Pet. Gases     14.59     14.01     13.73     11.22     14.31
Petchem. Feedstocks      19.91     19.44     19.13     19.83     17.62
Other Refined Prod.      17.91     17.19     17.40     13.71     16.14
Methanol                 24.39     27.26     24.71     24.55     23.66
M. T. B. E.              15.49     16.53     12.53     16.54     13.74

* Refined Product Import Quantities (Step 2)
Reformulated Mogas        13.5       5.0      20.1       5.0       5.0
Traditional Mogas         56.1       5.0       5.0       5.0      51.5
Diesel, Heating Oil       58.1       5.0       5.0       5.0       5.0
Low Sulfur No. 2          29.0      12.4     131.2       5.0      18.9
Low Sulfur Fuel Oil       54.8       5.0       5.0       5.0      57.2
High Sulfur Fuel Oil      22.6      10.3      80.8       5.0      34.7
Jet Fuel                   5.0      19.9       5.0      25.0       5.0
Liquefied Pet. Gases       5.0      54.4       5.0       5.0       5.0
Petchem. Feedstocks        5.0      43.9     102.6       9.0       5.0
Other Refined Prod.        5.0       5.0       5.0       5.0       5.0
Methanol                  51.6       9.6      23.8       5.0      38.9
M. T. B. E.                5.0       5.0       5.0       5.0       5.0

* Refined Product Import Prices (Step 2)
Reformulated Mogas       28.12     27.12     26.57     26.47     25.52
Traditional Mogas        25.72     24.76     24.94     25.92     23.02
Diesel, Heating Oil      24.55     23.24     23.14     24.07     22.49
Low Sulfur No. 2         28.76     27.89     27.78     28.76     27.41
Low Sulfur Fuel Oil      17.29     16.40     16.75     13.39     16.28
High Sulfur Fuel Oil     14.89     14.12     14.01     11.46     13.16
Jet Fuel                 25.82     24.51     24.68     24.29     24.92
Liquefied Pet. Gases     15.63     14.86     14.54     12.09     15.10
Petchem. Feedstocks      21.08     20.41     20.54     21.08     18.72
Other Refined Prod.      18.94     18.46     18.50     14.68     15.45
Methanol                 25.83     26.40     26.18     26.18     24.93
M. T. B. E.              16.41     17.75     13.67     17.68     14.70

* Refined Product Import Quantities (Step 3)
Reformulated Mogas        13.1       4.9      19.5       4.9       4.9
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Traditional Mogas	54.4	4.9	4.9	4.9	50.0
Diesel, Heating Oil	56.3	4.9	4.9	4.9	4.9
Low Sulfur No. 2	28.2	12.0	127.2	4.9	18.3
Low Sulfur Fuel Oil	53.1	4.9	4.9	4.9	55.5
High Sulfur Fuel Oil	22.0	10.0	78.3	4.9	33.6
Jet Fuel	4.9	19.3	4.9	24.3	4.9
Liquefied Pet. Gases	4.9	52.7	4.9	4.9	4.9
Petchem. Feedstocks	4.9	42.5	99.5	8.7	4.9
Other Refined Prod.	4.9	4.9	4.9	4.9	4.9
Methanol	50.1	9.3	23.0	4.9	37.7
M. T. B. E.	4.9	4.9	4.9	4.9	4.9

* Refined Product Import Prices (Step 3)

Reformulated Mogas	29.67	28.95	27.95	28.26	27.09
Traditional Mogas	27.20	26.11	26.51	27.49	24.13
Diesel, Heating Oil	25.75	24.53	24.20	25.68	23.73
Low Sulfur No. 2	30.35	29.92	29.73	30.33	29.12
Low Sulfur Fuel Oil	18.49	17.34	17.69	14.11	17.45
High Sulfur Fuel Oil	15.68	14.85	14.96	12.63	13.90
Jet Fuel	27.43	26.30	25.82	25.85	26.25
Liquefied Pet. Gases	16.51	15.83	15.28	12.66	16.14
Petchem. Feedstocks	22.47	21.43	21.80	22.43	19.86
Other Refined Prod.	20.31	19.58	19.61	15.68	16.24
Methanol	27.64	31.15	27.57	28.03	26.45
M. T. B. E.	17.42	18.93	16.02	18.67	15.77

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* Year: 2000

* Refined Product Import Quantities (Step 1)
Reformulated Mogas        14.3       5.1      21.4       5.1       5.1
Traditional Mogas         26.6       5.1       5.1      21.7       5.1
Diesel, Heating Oil       61.6       5.1       5.1      12.9       5.1
Low Sulfur No. 2          30.8      17.3     189.8      13.3      25.9
Low Sulfur Fuel Oil       71.4       5.1       5.1       5.1      53.0
High Sulfur Fuel Oil      23.1       5.1     102.0       5.1      40.4
Jet Fuel                  20.9      22.4      23.4      27.7       5.1
Liquefied Pet. Gases       5.1      59.8      36.4       5.1       5.1
Petchem. Feedstocks        5.1      46.9      93.6       5.1       5.1
Other Refined Prod.        5.1       5.1       5.1       5.1       5.1
Methanol                  67.0      27.3      72.6       6.3      67.6
M. T. B. E.                5.1       5.1       5.1       5.1       5.1

* Refined Product Import Prices (Step 1)
Reformulated Mogas       28.83     27.59     27.50     27.62     26.45
Traditional Mogas        26.55     25.80     25.76     26.42     24.01
Diesel, Heating Oil      25.36     24.31     24.27     24.75     23.83
Low Sulfur No. 2         29.38     28.81     28.47     29.30     28.01
Low Sulfur Fuel Oil      18.40     17.73     17.95     15.12     17.79
High Sulfur Fuel Oil     16.47     15.70     15.34     11.35     14.57
Jet Fuel                 26.96     25.30     25.66     25.44     25.79
Liquefied Pet. Gases     17.31     16.54     16.18     13.66     16.51
Petchem. Feedstocks      21.96     21.62     21.96     22.40     19.86
Other Refined Prod.      19.97     19.97     19.79     16.35     18.08
Methanol                 26.35     30.16     27.37     26.78     25.64
M. T. B. E.              17.73     19.19     14.44     19.22     16.16

* Refined Product Import Quantities (Step 2)
Reformulated Mogas        13.5       5.0      20.1       5.0       5.0
Traditional Mogas         25.1       5.0       5.0      20.5       5.0
Diesel, Heating Oil       58.1       5.0       5.0      12.2       5.0
Low Sulfur No. 2          29.0      16.3     179.0      12.5      24.4
Low Sulfur Fuel Oil       67.3       5.0       5.0       5.0      50.0
High Sulfur Fuel Oil      21.8       5.0      96.2       5.0      38.1
Jet Fuel                  19.7      21.1      22.1      26.1       5.0
Liquefied Pet. Gases       5.0      56.4      34.3       5.0       5.0
Petchem. Feedstocks        5.0      44.2      88.3       5.0       5.0
Other Refined Prod.        5.0       5.0       5.0       5.0       5.0
Methanol                  63.1      25.7      68.4       5.9      63.8
M. T. B. E.                5.0       5.0       5.0       5.0       5.0

* Refined Product Import Prices (Step 2)
Reformulated Mogas       30.64     29.64     29.09     28.99     28.04
Traditional Mogas        28.24     27.28     27.46     28.44     25.54
Diesel, Heating Oil      27.07     25.76     25.66     26.59     25.01
Low Sulfur No. 2         31.28     30.41     30.30     31.28     29.93
Low Sulfur Fuel Oil      19.81     18.92     19.27     15.91     18.80
High Sulfur Fuel Oil     17.41     16.64     16.53     13.85     15.68
Jet Fuel                 28.34     27.03     27.20     26.81     27.44
Liquefied Pet. Gases     18.15     17.38     17.06     14.61     17.62
Petchem. Feedstocks      23.60     22.93     23.06     23.60     21.24
Other Refined Prod.      21.46     20.98     21.02     17.20     17.69
Methanol                 28.35     28.58     28.70     28.70     27.45
M. T. B. E.              18.93     20.27     17.23     20.20     17.22

* Refined Product Import Quantities (Step 3)
Reformulated Mogas        13.1       4.9      19.5       4.9       4.9
```

Traditional Mogas	24.3	4.9	4.9	19.8	4.9
Diesel, Heating Oil	56.3	4.9	4.9	11.8	4.9
Low Sulfur No. 2	28.2	15.8	173.6	12.2	23.6
Low Sulfur Fuel Oil	65.3	4.9	4.9	4.9	48.4
High Sulfur Fuel Oil	21.1	4.9	93.3	4.9	37.0
Jet Fuel	19.1	20.5	21.4	25.3	4.9
Liquefied Pet. Gases	4.9	54.7	33.3	4.9	4.9
Petchem. Feedstocks	4.9	42.9	85.6	4.9	4.9
Other Refined Prod.	4.9	4.9	4.9	4.9	4.9
Methanol	61.2	25.0	66.3	5.7	61.8
M. T. B. E.	4.9	4.9	4.9	4.9	4.9

* Refined Product Import Prices (Step 3)

Reformulated Mogas	32.25	31.06	31.08	30.57	29.53
Traditional Mogas	29.72	28.62	29.31	30.09	27.36
Diesel, Heating Oil	28.44	27.22	26.96	28.20	26.64
Low Sulfur No. 2	33.17	32.29	32.15	32.91	31.62
Low Sulfur Fuel Oil	21.20	20.29	20.24	17.03	20.01
High Sulfur Fuel Oil	18.49	17.56	17.68	16.15	16.57
Jet Fuel	30.25	28.80	28.51	28.29	28.96
Liquefied Pet. Gases	19.02	18.56	17.99	15.48	18.61
Petchem. Feedstocks	24.89	24.59	24.24	25.18	22.62
Other Refined Prod.	22.50	22.35	22.51	20.40	18.69
Methanol	29.97	34.03	30.23	30.08	28.80
M. T. B. E.	20.14	21.52	16.56	21.22	18.20

Year: 2005

* Refined Product Import Quantities (Step 1)

Reformulated Mogas	14.3	5.1	21.4	5.1	5.1
Traditional Mogas	26.6	5.1	5.1	51.8	14.5
Diesel, Heating Oil	61.6	21.7	5.1	24.5	5.1
Low Sulfur No. 2	30.8	34.0	215.8	28.0	34.8
Low Sulfur Fuel Oil	89.6	5.1	5.1	5.1	64.2
High Sulfur Fuel Oil	34.3	5.8	111.7	5.1	46.9
Jet Fuel	21.4	45.6	46.9	54.4	5.1
Liquefied Pet. Gases	5.1	62.5	48.0	5.1	5.1
Petchem. Feedstocks	5.1	47.9	111.1	5.1	5.1
Other Refined Prod.	5.1	16.4	5.1	5.1	5.1
Methanol	71.0	37.7	75.1	5.1	70.5
M. T. B. E.	5.1	5.1	5.1	5.1	5.1

* Refined Product Import Prices (Step 1)

Reformulated Mogas	31.46	30.70	30.71	30.31	28.97
Traditional Mogas	29.67	29.03	29.00	30.06	26.77
Diesel, Heating Oil	28.06	26.84	27.13	28.26	26.55
Low Sulfur No. 2	32.73	31.56	31.16	32.44	31.34
Low Sulfur Fuel Oil	21.33	20.90	21.15	18.06	20.50
High Sulfur Fuel Oil	19.23	18.52	18.61	15.20	17.52
Jet Fuel	30.04	28.35	28.28	28.19	28.81
Liquefied Pet. Gases	20.04	19.06	19.20	16.75	19.31
Petchem. Feedstocks	24.99	24.51	24.85	25.27	23.14
Other Refined Prod.	23.21	22.75	22.81	19.24	19.60
Methanol	29.24	32.83	30.11	30.02	28.58
M. T. B. E.	20.57	22.28	17.60	22.00	19.08

* Refined Product Import Quantities (Step 2)

Reformulated Mogas	13.5	5.0	20.1	5.0	5.0
Traditional Mogas	25.1	5.0	5.0	48.8	13.6
Diesel, Heating Oil	58.1	20.5	5.0	23.1	5.0
Low Sulfur No. 2	29.0	32.0	203.4	26.4	32.8
Low Sulfur Fuel Oil	84.5	5.0	5.0	5.0	60.5
High Sulfur Fuel Oil	32.3	5.4	105.3	5.0	44.3
Jet Fuel	20.1	43.0	44.2	51.2	5.0
Liquefied Pet. Gases	5.0	58.9	45.2	5.0	5.0
Petchem. Feedstocks	5.0	45.1	104.7	5.0	5.0
Other Refined Prod.	5.0	15.5	5.0	5.0	5.0
Methanol	67.0	35.6	70.9	5.0	66.4
M. T. B. E.	5.0	5.0	5.0	5.0	5.0

* Refined Product Import Prices (Step 2)

Reformulated Mogas	33.82	32.82	32.27	32.17	31.22
Traditional Mogas	31.42	30.46	30.64	31.62	28.72
Diesel, Heating Oil	30.25	28.94	28.84	29.77	28.19
Low Sulfur No. 2	34.46	33.59	33.48	34.46	33.11
Low Sulfur Fuel Oil	22.99	22.10	22.45	19.09	21.98
High Sulfur Fuel Oil	20.59	19.82	19.71	15.75	18.86
Jet Fuel	31.52	30.21	30.38	29.99	30.62
Liquefied Pet. Gases	21.33	20.56	20.24	17.79	20.80
Petchem. Feedstocks	26.78	26.11	26.24	26.78	24.42
Other Refined Prod.	24.64	24.16	24.20	20.38	21.23
Methanol	31.53	33.30	31.88	31.88	30.63
M. T. B. E.	22.11	23.45	19.41	23.38	20.40

* Refined Product Import Quantities (Step 3)

Reformulated Mogas	13.1	4.9	19.5	4.9	4.9

Traditional Mogas	24.3	4.9	4.9	47.4	13.2
Diesel, Heating Oil	56.3	19.8	4.9	22.4	4.9
Low Sulfur No. 2	28.2	31.0	197.3	25.6	31.8
Low Sulfur Fuel Oil	81.9	4.9	4.9	4.9	58.7
High Sulfur Fuel Oil	31.4	5.3	102.1	4.9	42.9
Jet Fuel	19.5	41.7	42.9	49.7	4.9
Liquefied Pet. Gases	4.9	57.2	43.8	4.9	4.9
Petchem. Feedstocks	4.9	43.8	101.6	4.9	4.9
Other Refined Prod.	4.9	15.0	4.9	4.9	4.9
Methanol	65.0	34.5	68.7	4.9	64.4
M. T. B. E.	4.9	4.9	4.9	4.9	4.9

* Refined Product Import Prices (Step 3)

Reformulated Mogas	35.66	34.70	34.47	34.09	32.79
Traditional Mogas	32.89	32.23	32.49	33.69	30.43
Diesel, Heating Oil	32.35	30.45	30.41	31.62	29.67
Low Sulfur No. 2	36.47	35.91	35.65	36.17	35.30
Low Sulfur Fuel Oil	24.54	23.13	23.52	20.38	23.32
High Sulfur Fuel Oil	21.64	20.81	20.97	16.81	19.74
Jet Fuel	33.42	31.99	31.81	31.56	32.15
Liquefied Pet. Gases	22.85	21.56	21.40	18.88	21.97
Petchem. Feedstocks	28.69	27.53	27.76	28.38	25.97
Other Refined Prod.	25.91	25.85	25.34	21.59	24.21
Methanol	33.44	37.09	34.06	34.11	32.50
M. T. B. E.	23.25	25.12	21.44	24.92	21.86

* Year: 2010

* Refined Product Import Quantities (Step 1)

Reformulated Mogas	14.3	5.1	21.4	5.1	17.9
Traditional Mogas	35.7	5.1	5.1	72.8	13.5
Diesel, Heating Oil	93.1	21.0	5.1	31.5	5.1
Low Sulfur No. 2	46.9	49.2	232.1	30.8	35.0
Low Sulfur Fuel Oil	104.3	5.1	7.0	5.1	79.0
High Sulfur Fuel Oil	22.3	5.1	97.5	5.1	36.5
Jet Fuel	21.4	81.0	46.9	63.0	17.5
Liquefied Pet. Gases	5.1	63.6	65.9	5.1	5.1
Petchem. Feedstocks	5.1	48.7	111.8	5.1	5.1
Other Refined Prod.	5.1	30.8	5.1	5.1	5.1
Methanol	70.8	37.8	80.6	5.1	69.9
M. T. B. E.	5.1	5.1	5.1	5.1	5.1

* Refined Product Import Prices (Step 1)

Reformulated Mogas	34.38	33.87	33.14	32.86	32.02
Traditional Mogas	32.12	31.16	31.63	32.95	29.47
Diesel, Heating Oil	31.12	29.62	29.60	31.12	29.36
Low Sulfur No. 2	35.56	34.23	33.84	35.11	34.31
Low Sulfur Fuel Oil	24.36	23.28	23.69	20.58	23.68
High Sulfur Fuel Oil	21.83	21.21	21.58	18.48	20.75
Jet Fuel	32.47	31.23	31.00	30.59	31.76
Liquefied Pet. Gases	22.53	21.98	21.91	19.35	22.37
Petchem. Feedstocks	27.66	27.28	27.21	27.59	26.05
Other Refined Prod.	26.24	25.29	25.18	21.62	23.82
Methanol	32.46	35.30	32.67	32.72	31.16
M. T. B. E.	23.76	24.47	21.42	24.43	21.99

* Refined Product Import Quantities (Step 2)

Reformulated Mogas	13.5	5.0	20.1	5.0	16.8
Traditional Mogas	33.7	5.0	5.0	68.6	12.7
Diesel, Heating Oil	87.8	19.8	5.0	29.7	5.0
Low Sulfur No. 2	44.2	46.4	218.8	29.0	33.0
Low Sulfur Fuel Oil	98.3	5.0	6.6	5.0	74.5
High Sulfur Fuel Oil	21.0	5.0	91.9	5.0	34.4
Jet Fuel	20.1	76.4	44.2	59.4	16.5
Liquefied Pet. Gases	5.0	59.9	62.1	5.0	5.0
Petchem. Feedstocks	5.0	45.9	105.4	5.0	5.0
Other Refined Prod.	5.0	29.0	5.0	5.0	5.0
Methanol	66.7	35.6	76.0	5.0	65.9
M. T. B. E.	5.0	5.0	5.0	5.0	5.0

* Refined Product Import Prices (Step 2)

Reformulated Mogas	36.76	35.76	35.21	35.11	34.16
Traditional Mogas	34.36	33.40	33.58	34.56	31.66
Diesel, Heating Oil	33.19	31.88	31.78	32.71	31.13
Low Sulfur No. 2	37.40	36.53	36.42	37.40	36.05
Low Sulfur Fuel Oil	25.93	25.04	25.39	22.03	24.92
High Sulfur Fuel Oil	23.53	22.76	22.65	21.18	21.80
Jet Fuel	34.46	33.15	33.32	32.93	33.56
Liquefied Pet. Gases	24.27	23.50	23.18	20.73	23.74
Petchem. Feedstocks	29.72	29.05	29.18	29.72	27.36
Other Refined Prod.	27.58	27.10	27.14	23.32	24.30
Methanol	34.47	37.06	34.82	34.82	33.57
M. T. B. E.	25.05	26.39	22.93	26.32	23.34

* Refined Product Import Quantities (Step 3)

Reformulated Mogas	13.1	4.9	19.5	4.9	16.3

Traditional Mogas	32.6	4.9	4.9	66.6	12.3
Diesel, Heating Oil	85.1	19.2	4.9	28.8	4.9
Low Sulfur No. 2	42.9	45.0	212.2	28.2	32.0
Low Sulfur Fuel Oil	95.4	4.9	6.4	4.9	72.3
High Sulfur Fuel Oil	20.4	4.9	89.2	4.9	33.3
Jet Fuel	19.5	74.1	42.9	57.6	16.0
Liquefied Pet. Gases	4.9	58.1	60.2	4.9	4.9
Petchem. Feedstocks	4.9	44.5	102.2	4.9	4.9
Other Refined Prod.	4.9	28.2	4.9	4.9	4.9
Methanol	64.7	34.5	73.7	4.9	63.9
M. T. B. E.	4.9	4.9	4.9	4.9	4.9

* Refined Product Import Prices (Step 3)

Reformulated Mogas	38.78	38.09	37.39	37.46	35.74
Traditional Mogas	36.57	35.38	35.22	36.44	33.83
Diesel, Heating Oil	35.52	33.86	33.51	34.90	33.31
Low Sulfur No. 2	39.36	38.25	38.44	39.64	38.03
Low Sulfur Fuel Oil	27.39	26.26	26.60	23.37	26.27
High Sulfur Fuel Oil	24.67	24.12	24.11	20.53	22.99
Jet Fuel	36.93	35.04	35.11	34.73	35.76
Liquefied Pet. Gases	25.69	24.82	24.35	22.22	25.36
Petchem. Feedstocks	31.20	30.96	30.59	31.75	28.69
Other Refined Prod.	29.20	28.97	28.81	25.55	25.04
Methanol	36.53	40.06	36.65	36.89	35.41
M. T. B. E.	26.25	27.73	24.05	28.07	24.83