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The University of Oklahoma, Ph.D., 1973
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THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

MANERGY: AN ENERGY MANAGEMENT MODEL OF THE UNITED STATES FOR THE PREDICTION OF ENERGY DEMAND, RESOURCE CONSUMPTION, ENVIRONMENTAL EFFECTS, THE ASSESSMENT OF NEW TECHNOLOGY, AND ENERGY RESOURCE ALTERNATIVES

A DISSERTATION

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in partial fulfillment of the requirements for the

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BY

WILLIAM WOODROW TALLEY II

Norman, Oklahoma

1973

MANERGY: AN ENERGY MANAGEMENT MODEL OF THE UNITED STATES FOR THE PREDICTION OF ENERGY DEMAND, RESOURCE CONSUMPTION, ENVIRONMENTAL EFFECTS, THE ASSESSMENT OF NEW TECHNOLOGY, AND ENERGY RESOURCE ALTERNATIVES

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ABSTRACT

A computerized, systems-analysis model of the United States energy system has been developed and presented in code form. The model was designed for use as a management tool for assessing the consequences of resource and fuel alternatives, environmental controls, and technological advances. The assessment guidelines are presented as resource consumptions, environmental impacts, and balance of payment deficits to the year 2100.

The model's capabilities and its inherent flexibility have been demonstrated for a baseline case and several alternatives. The base case was based on current energy use patterns, diversified resource development, projected fuel splits, population and gross national product projections, and reasonable advances in technology. The alternatives included

1. nuclear powered crude petroleum refineries, which use high-temperature gas-cooled reactors for process heat;
2. different natural gas substitutes including various combinations of liquefied natural gas imports, substitute natural gas from coal, petroleum syngas, and gas pipeline imports;

3. different crude petroleum substitutes including various combinations of crude oil imports, syncrude from coal, and tar sands and oil shale production;
4. the current trend in population growth rate to two children per family;
5. clean transportation fuels such as hydrogen, electricity, and methanol; and
6. water resource conservation by alternative systems for waste heat removal.

The model has sufficient flexibility to include the results of the many existing and future studies on energy supply and demand. It quantifies the impacts of energy policy decisions into acceptable indices. As such, it has the capability to provide energy management guidelines necessary to make decisions on research and development priorities, legislation and regulations.

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William W. Talley II

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CHAPTER I

INTRODUCTION

The United States of America is faced with an 'energy crisis' which is being amplified by the current tug-of-war between energy suppliers and the environmental extremists. In order to prevent energy chaos, more rationale must be developed for guiding energy policy decisions. A tool must be made available which can provide the energy management guidelines for making decisions today on the research and development priorities, legislation and regulations which will materially affect the energy consumption and its distribution among energy sources to the year 2100. This tool should be used to construct an orderly plan, i.e., a national policy, for energy utilization which clearly recognizes the ecological trade-offs available. The tool required is a computerized model of the United States energy system which performs a complete systems analysis using a systematic procedure for quantifying the impact of any energy policy decision on the public welfare. Such a model should allow:

1. The incorporation of any or all of the many studies and projections on supply-demand which are constantly in preparation by industry and government (5, 50).

2. The substitution of current experience and trends in energy-utilization patterns in place of postulates.
3. The inclusion of the dynamic response of the energy supply system to changes in demand brought about by construction delays, anti-pollution regulations, cost of technology to preserve the environment, increases in the cost of energy, availability of alternate or yet-to-be-developed primary fuel sources, energy policy decisions, etc.

The model must be able to handle almost any combination of circumstances brought about by shifts in energy demand patterns. Most important of all, it must give a quantitative yield of basic information relative to the effects of the complex interactions within the energy system.

The development of a computerized U.S. energy system model that meets the above requirements and the demonstration of its flexibility is the purpose of this dissertation.

CHAPTER II

REVIEW OF PREVIOUS WORK

Recent studies conducted on energy requirements, energy utilization technology, conversion technology, and resource availability are used as the data base for this computer-based, systems-analysis model of the United States energy system. These previous studies have attempted to analyze the United States energy requirements. A summary of the forecasts made prior to 1970 has been prepared (9). More recent studies include the McKetta report (40), the Federal Power Commission's "1970 National Power Survey" (22), and the Department of the Interior's "United States Energy--A Summary Review" (87). These studies forecasted the energy requirements and potential supplies of various sectors of the energy system to 1990 to 2000 based on assumed fixed growth rates of energy usage. The FPC's report deals primarily with electrical power requirements, electrical supply systems and electrical generation fuel supplies.

Comprehensive studies have been made by the National Petroleum Council on energy requirements to the year 1985 with some projections to the year 2000 (43, 44, 45, 46). However,

these studies in general were based on a higher birth rate than is presently anticipated and in most cases the projections were made using fixed fuel use growth rates. Mr. Gerald Gambs (23) summarized the results of these studies and assessed probable economic and environmental constraints and effects through 1985. The Chase Manhattan Bank (92) has projected the United States energy requirements and resource availability to 1985 for the major energy consuming sectors using fixed annual growth rate predictions. Both of these studies are short range forecasts.

Resources for the Future (36) projected requirements to the year 2000 on the basis of a detailed analysis of the needs of individual households, commercial and industrial requirements and the transportation sector. The applicable technologies and fuel mix for a given application were based on forecast trends.

The concepts developed by Resources for the Future were extended by Associated Universities (6). They (AUI) made projections for 1969, 1977, 1985, 1990, 2000 and 2020 based on a population growth rate which now appears to be too high. Furthermore, their model (limited to hand calculations) is inadequate with respect to such parameters as fuel splits, energy conversion efficiencies, domestic oil and gas production, coal conversion, imports, current nuclear reactor development, oil shale, tar sands, nuclear fusion, geothermal, solar and tidal resources.

Intertechnology Corporation (35) conducted a study on the detailed costing, modeling and determination of influence coefficients of technologies on the cost of energy, primarily electricity. The status and probable trends of the present energy economy were presented with the economics of alternatives for energy conversion.

The U.S. Department of the Interior (78) has projected the basic materials demand and production technology to the year 2000. Also, Morrison and Readling (77), using a log-linear relationship between energy resource demand and population with various economic indicators, made projections of energy demands to the year 2000. The form of this log-linear relationship was determined by regression analysis of data from the 1947 to 1965 period.

Several linear programming models have been constructed. The Atomic Energy Commission (70) used this approach for a cost benefit analysis between fossil and nuclear electrical generating station alternatives with a specified base load electrical demand. Hoffman (31) constructed a linear programming model which can perform optimizations with respect to dollar costs, environmental effects, or resource consumption at a future fixed time point with specified sector energy demands.

The basic concepts for the computerized energy system model developed in this work represent an extension of the AUI work and incorporates inputs from the more comprehensive studies cited earlier (Figure II-1).

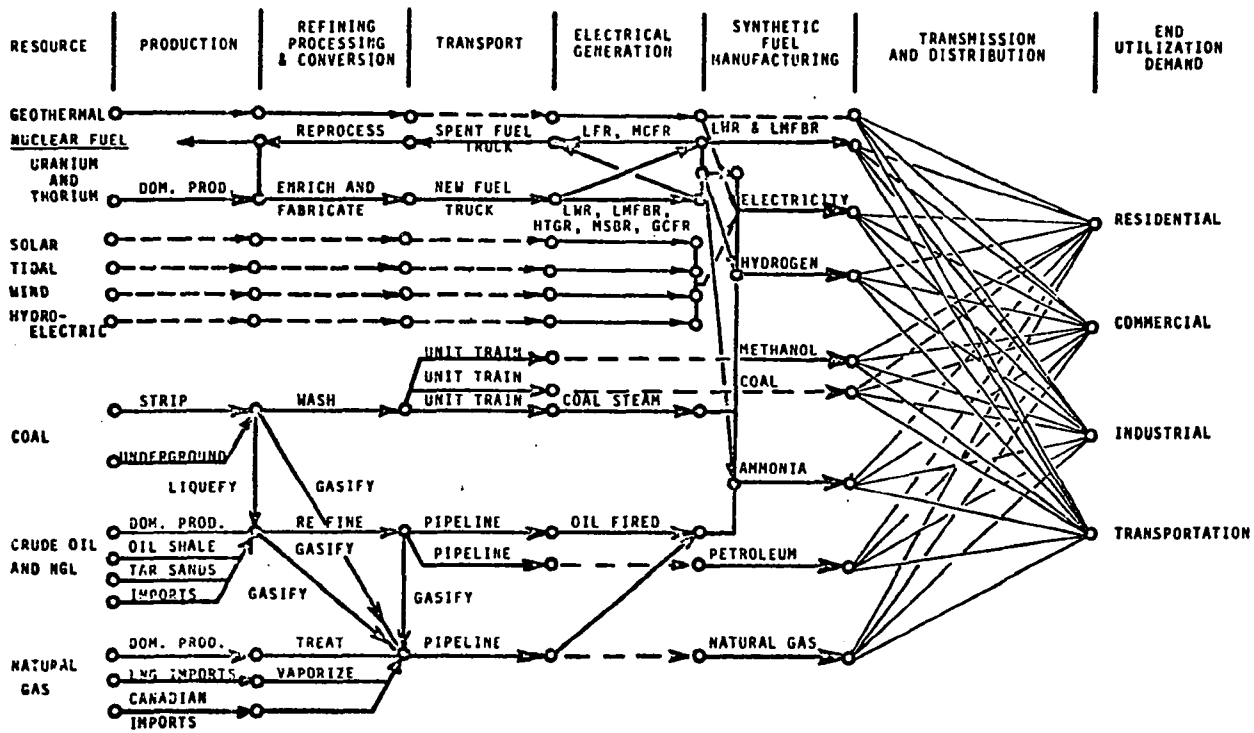


Figure II-1. The United States Energy System--Energy Supply and Demand Model (Adapted from Reference 6).

CHAPTER III

THE UNITED STATES ENERGY SYSTEM MODEL

The MANERGY model of the United States energy system is constructed such that it will predict the energy demand, the resource consumption, the environmental effects, and the balance of payment requirements for available energy resource and demand and technology alternatives. Consequently, the model provides a systematic procedure for assessing the full implications of energy utilization technology and resource alternatives.

The MANERGY model applies economic constraints to resources and demands only through the projected fuel supply-demand fractions. No other economic constraints are employed.

Example cases demonstrating the model's capabilities and flexibility are presented in Chapters IV through X. These cases are presented for illustrative purposes only since all possible alternatives were not included. The assumptions required for the formulation of each case are, of course, subject to interpretation. For these illustrative cases the United States coal production, world petroleum production, and world naturel gas production were assumed adequate to meet the U.S. demands. These may not be valid assumptions in every case. For example, the projected cumulative coal demand may exceed current estimated United States coal reserves before the year 2100.

The MANERGY model and Forester's "World Dynamics" model are complimentary. Where as Forrester's model has ultimate stability with essentially no fine detail, the MANERGY model possesses almost infinite detail with stability imposed by the

user. The detail of the MANERGY model provides the necessary tools for assessing the full implications of energy utilization technology and resource alternatives.

The model is programmed for an IBM 360 computer in Fortran IV. A complete program listing is provided in Appendix B.

General Description

Figure II-1 illustrates the interdependence of the principal options available in the United States energy system model, and a generalized flow chart of the MANERGY model is presented in Figure III-1.

The energy requirements of the nation are separated into end utilization energy demands, transmission and distribution energy requirements, synthetic fuel manufacturing energy demands, electrical generation requirements, transportation losses, refining, processing and conversion energy requirements, production losses and alternative resources. The demands on energy resources are classified according to resource fuel type:

1. Geothermal and geopressure
2. Nuclear (Fuels--Uranium and Thorium)
    a. Gas Cooled Fast Breeder Reactor (GCFR)
    b. High Temperature Gas Cooled Reactor (HTGR)
    c. Laser Fusion Reactor (LFR)
    d. Liquid Metal Fast Breeder Reactor (LMFBR)**
    e. Light Water Reactor (LWR)**
    f. Molten Salt Breeder Reactor (MSBR)
    g. Magnetically Contained Fusion Reactor (MCFR)

    **portable power sources
3. Solar
4. Tidal
5. Wind
6. Hydroelectric
7. Coal
8. Crude Petroleum and Natural Gas Liquids
    a. gasoline
    b. kerosene (jet fuel)

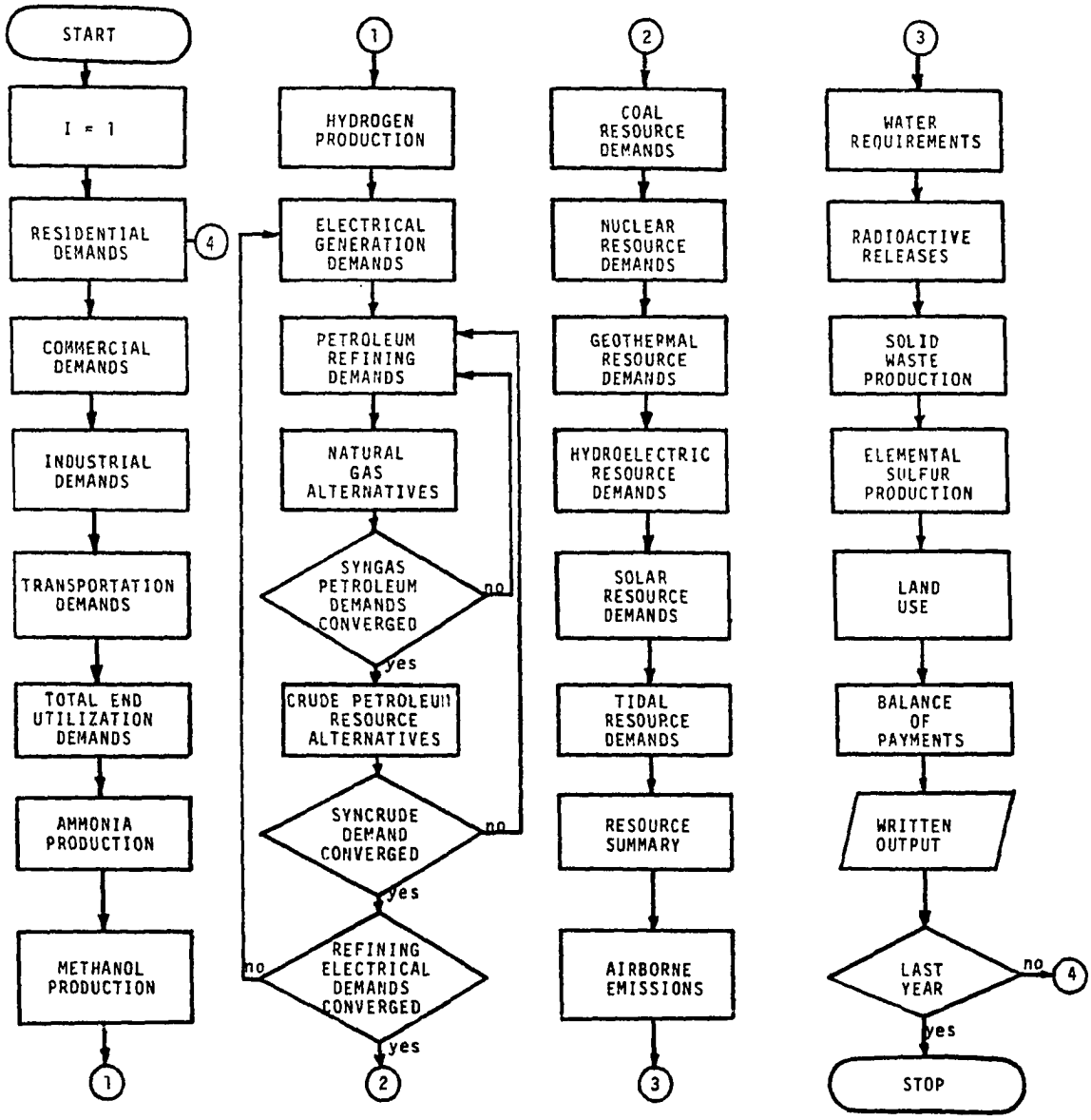


Figure III-1. A Simplified Flow Chart of the MANERGY Model.

c. distillate oil
d. residual oil

9. Natural Gas

10. Intermediate Fuels

a. electricity
b. methanol
c. ammonia
d. hydrogen

As shown in Figure II-1 and III-1, the end utilization demands are generated from the four demand categories: residential, commercial, transportation, and industrial.

The residential energy demand is generated from six different use categories: space heating, air conditioning, water heating, cooking, refrigeration and miscellaneous. For each of the demand categories the efficiency of fuel utilization for each fuel alternative is assigned with allowances being made for projected increases in efficiencies brought about by improved insulation or utilization technology.

The annual residential energy requirements for each of the six categories to the year 2100 are derived from U.S. population and household-size projections and are expressed as Btu's per household.

The commercial energy demand is generated from six different use categories: space heating, air conditioning, water heating, cooking, refrigeration and miscellaneous. For each of the demand categories the efficiency of fuel utilization for each fuel alternative is assigned with allowances being made for projected increase in efficiencies brought about by improved insulation or utilization technology.

The annual commercial energy requirements for each of the six categories to the year 2100 are derived from U.S. population and gross national product projections.

The transportation energy demand is generated from six different categories of transportation: airplanes, automobiles, buses, railroads, ships (or barges) and trucks.

The annual energy requirements for each of the six demand categories to the year 2100 are based on projected passenger miles and projected cargo ton miles. These projections are derived from U.S. population and gross national product projections and are expressed as Btu's per passenger mile (a combination of passengers per vehicle and Btu's per vehicle mile) and Btu's per cargo ton mile. For each of the demand categories the efficiency of fuel utilization for each fuel alternative is assigned with allowances being made for projected increases in efficiencies brought about by improved conversion and propulsion technology. The LMFBR and the LWR reactors are the only nuclear reactors that are suitable, per se, for propulsion. All other reactor types are used only for electrical power generation or the production of hydrogen and ammonia. The conventional forms of transportation for both passengers and freight and all prime fuel sources are included so that viable propulsion system alternatives can be considered.

The industrial energy demand is generated from the sixteen major energy consuming categories of industry:

alumina, primary aluminum, secondary aluminum, cement, caustic soda and chlorine, primary copper, refined copper, primary magnesium, secondary magnesium, primary zinc and secondary zinc, pig iron, steels, petrochemicals and other raw materials and miscellaneous.

For each of the demand categories the efficiency of fuel utilization for each fuel alternative is assigned with allowances being made for projected increases in efficiencies brought about by improved processes and technology.

The annual energy requirements for each category to the year 2100 are derived from gross national product and literature projections of U.S. requirements and estimated energy consumption in Btu's per unit weight of product.

The end utilization demands, shown in Figure III-1, are corrected for transmission and distribution energy requirements. The sum of the transmission and distribution losses and the end utilization demands constitute the input or demand for each fuel type.

The demands for synthetic fuels are next corrected for the energy consumed in the manufacture of the fuels from a more basic resource. Since natural gas and petroleum are already in short supply, while coal and nuclear sources are still plentiful, one of the most viable synthetic fuel assumptions is that all methanol will be made from coal, all hydrogen by electrolysis of water and all ammonia from air and electrolytic hydrogen. These energy requirements for synthetic fuels

provide the basis for determining the electrical generation requirements and losses in transportation of base resources.

The electrical generation demand is next separated according to classes of power plants (nuclear, coal, gas, etc.) and is then corrected for the corresponding power plant efficiencies.

The losses in transporting each basic resource fuel from its point of origin to its subsequent use by means of pipelines, trucks or unit trains are next calculated according to distances traversed.

The refining, processing and conversion requirements are iterated with the transportation losses to compensate for feedback between resource conversion and transportation losses. The base fuel demands are now increased by the energy required for the process losses which occur during the refining and processing of the base fuel, i.e., crude oil refining, coal washing, nuclear fuel fabrication and reprocessing, etc. At this point the energy requirements have been transformed into the following base resource demands:

1. Geothermal
2. Uranium
3. Thorium
4. Solar
5. Tidal
6. Wind
7. Hydroelectric
8. Coal
9. Crude Petroleum and Natural Gas Liquids
10. Natural Gas

The resource conversion demands are determined as follows. The resource demands are balanced with projected

net domestic production. The short fall is divided among alternative resource supplies (liquefied natural gas, tar sands, oil shale, and oil and gas imports) and resource conversions (syngas and syncrude from coal and syngas from petroleum). The amount of energy required to supply the syngas or syncrude is determined taking into account conversion process efficiencies.

The net domestic production of base energy resources is determined by reducing the gross production by production losses and lease fuel use. Production losses and lease fuel use are determined from compilations by the Bureau of Mines.

The demands on base energy resources are balanced with projected net domestic production. If the natural gas requirements cannot be met by domestic production, the effect of LNG imports, Canadian imports, syngas from coal gasification and from naptha, distillate oil, residual oil or crude oil gasification are included. If domestic crude petroleum production cannot meet the requirements for the energy demand plus the demand for petroleum to be used in making syngas, then the effects of oil imports, recovery and conversion of oil shale and tar sands, and liquefaction of coal are included.

The impact of basic energy resources and of technology alternatives on the environment are determined for each individual step in the energy utilization scheme: production, transmission, conversion, storage and end utilization. At each step, airborne pollution indices are assigned for carbon

dioxide, carbon monoxide, sulfur dioxide, nitrogen oxides, hydrocarbons, aldehydes, particulates, tritium, krypton-85 and ionizing radiation. Thermal pollution and cooling water requirements are obtained for once-through, forced or natural convection cooling towers, spray ponds, cooling ponds, or dry air cooling alternatives. The amount of solid waste, including radioactive materials and the land-use requirements are also taken into account.

The effect of end use fuel alternatives on a balance of payments deficit is determined based on projected import prices and suppliers.

The United States energy system model's output (Appendix C) consists of:

1. Matrices of base energy demand in trillions of Btu's versus the twenty-one energy sources for each residential, commercial, industrial and transportation demand category.
2. A matrix of energy demand in trillions of Btu's versus the twenty-one energy sources for the total end utilization demand, electrical generation, petroleum refining, synthetic gas production, synthetic crude production, synthetic fuels manufacture.
3. Matrices of air pollution generated (CO_2, CO, SO_2, NO_x, particulates, hydrocarbons and aldehydes) versus each of the end utilization energy demand categories, electrical generation, petroleum refining, synthetic gas and crude oil production and synthetic gas manufacturing.

4. Cooling water requirements in terms of evaporation and once-through consumption.
5. Solid waste production.
6. Land use.
7. Radioactive material production and releases.
8. Sulfur production.
9. Coal resource balance in terms of requirements for end utilization energy demands, electrical generation, syncrude production, syngas production, methanol production, petroleum refining.
10. Petroleum resource balance in terms of tar sand, oil shale, syncrude requirements, domestic crude production and crude oil imports.
11. Natural gas resource balance in terms of domestic natural gas production, Canadian pipeline imports, liquefied natural gas imports and synthetic gas production.
12. Nuclear resource balance in terms of Kilograms of Separative Work (KGSW) required, power required for separative work, thorium production and uranium production.

Features of the model which demonstrate its complete flexibility include:

1. The incorporation of future studies and projections on supply-demand which are constantly in preparation by industry and government.
2. Substitution of current experience and trends in energy-utilization patterns in place of postulates.

3. Time constants or dynamic response of the energy supply system to changes in demand brought about by construction delays, anti-pollution regulations, availability of alternate or yet-to-be-developed primary fuel sources, energy policy decisions, etc.

In short, the model can handle almost any combination of circumstances brought about by shifts in energy demand patterns, whether they be elastic or inelastic. Thus, it provides energy management guidelines for making decisions today on research and development priorities, legislation and regulations which will materially affect the energy consumption and its distribution among energy sources by the year 2100. Most important of all, it gives a quantitative yield of basic information relative to the effects of the complex interactions within the energy system.

End Utilization Demands

The end utilization demands include residential, commercial, industrial and transportation. The future demands are derived from projections of the population, number of households and gross national product.

U.S. Population

The United States population has been projected to the year 2020 by the Bureau of Census for various assumed birth rates (76). The President's Commission on Population Growth and the American Future has also projected the U.S.

population to 2070 based on birth rates of two children per family and three children per family (15). These data and the projection of these data to the year 2100 are shown in Figure III-2. The average of the U.S. Bureau of Census Series D (assumed fertility of 2450 children per 1000 women) and Series E (assumed fertility of 2100 children per 1000 women) projections, Figure III-2 was used as the most probable U.S. population projection.

Number of Households

To obtain a projection of the number of households in the United States, the U.S. population projection was divided by the projected persons per household. A historical plot of the persons per household versus date was constructed with the projection based on the number of persons per household being asymptotic to 2 persons per household at infinite time, Figure III-3. The projected number of households is determined by

$$HHLD(I) = PUSP(I)/PPH(I) \qquad \text{(III-1)}$$

where

HHLD(I) = number of households in year I

PUSP(I) = projected U.S. population in year I

PPH(I) = persons per household in year I

I = year (1970, 1980, 1990, ..., 2100)

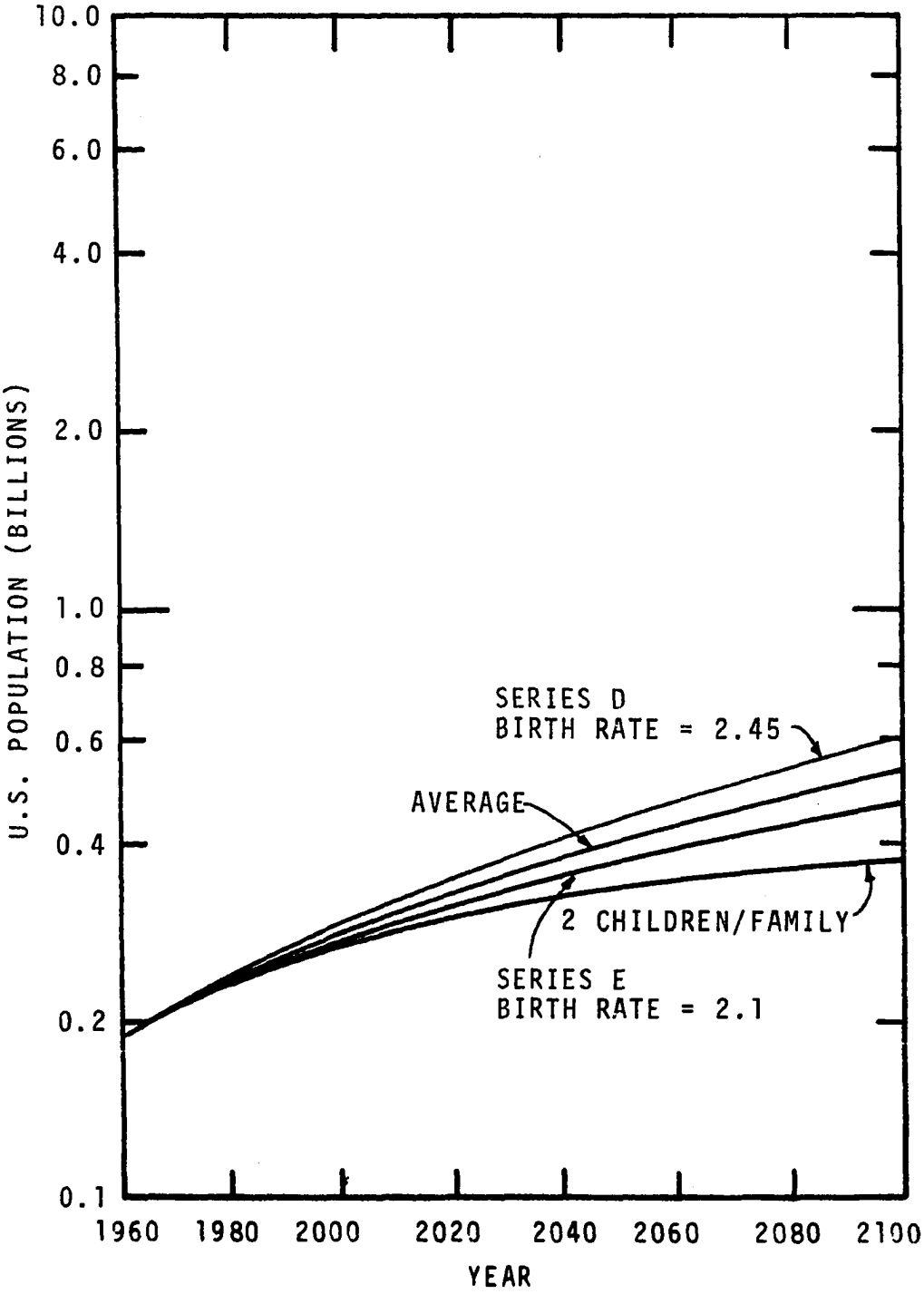


Figure III-2. Projected U.S. Population (15, 76).

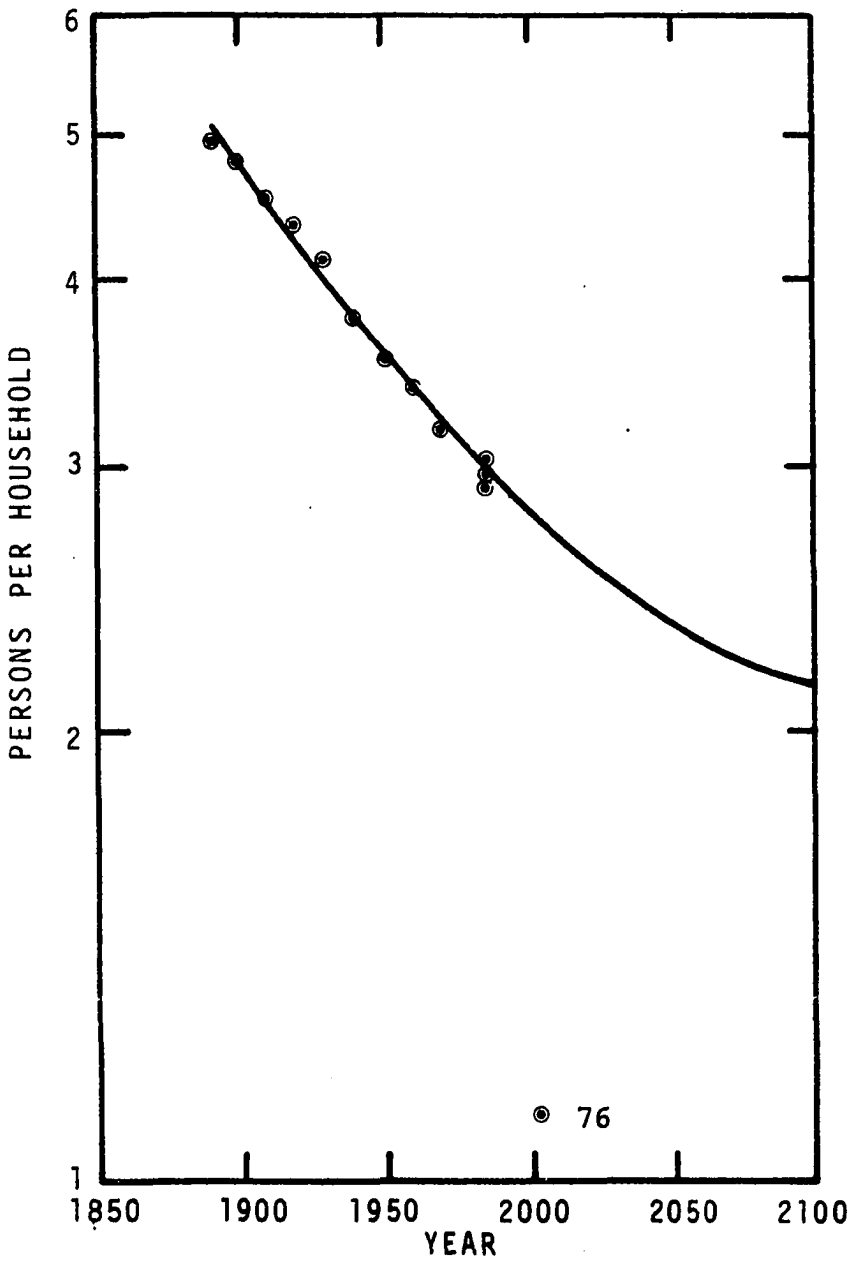


Figure III-3. Persons Per Household Projection.

The projected number of households using the average U.S. population projection from Figure III-2 and the persons per household from Figure III-3 is shown in Figure III-4.

Gross National Product

The gross national product was projected using the correlation between the gross national product in constant 1958 U.S. dollars and the population of the United States, Figure III-5. The gross national product was determined from the assumed population projection by using Figure III-5 to obtain the gross national product corresponding to the projected U.S. population in year, I. The projected gross national product as a function of time for the average population projection in Figure III-2 is shown in Figure III-6.

Residential Projection

The residential end utilization energy requirements, Figure III-1, were projected using the number of households in the United States projection, Figure III-4. The residential energy demand is generated from six different use categories: space heating, air conditioning, water heating, cooling, refrigeration and miscellaneous usage. In general, the energy demand for each category of residential use for fuel J in year I is generated by

$$REUD(J) = RSEU(I) \times HHLD(I) \times UDREU(J) \times REUHF(I,J) \times \frac{REUEF(1970,J)}{REUEF(I,J)} \qquad \text{(III-2)}$$

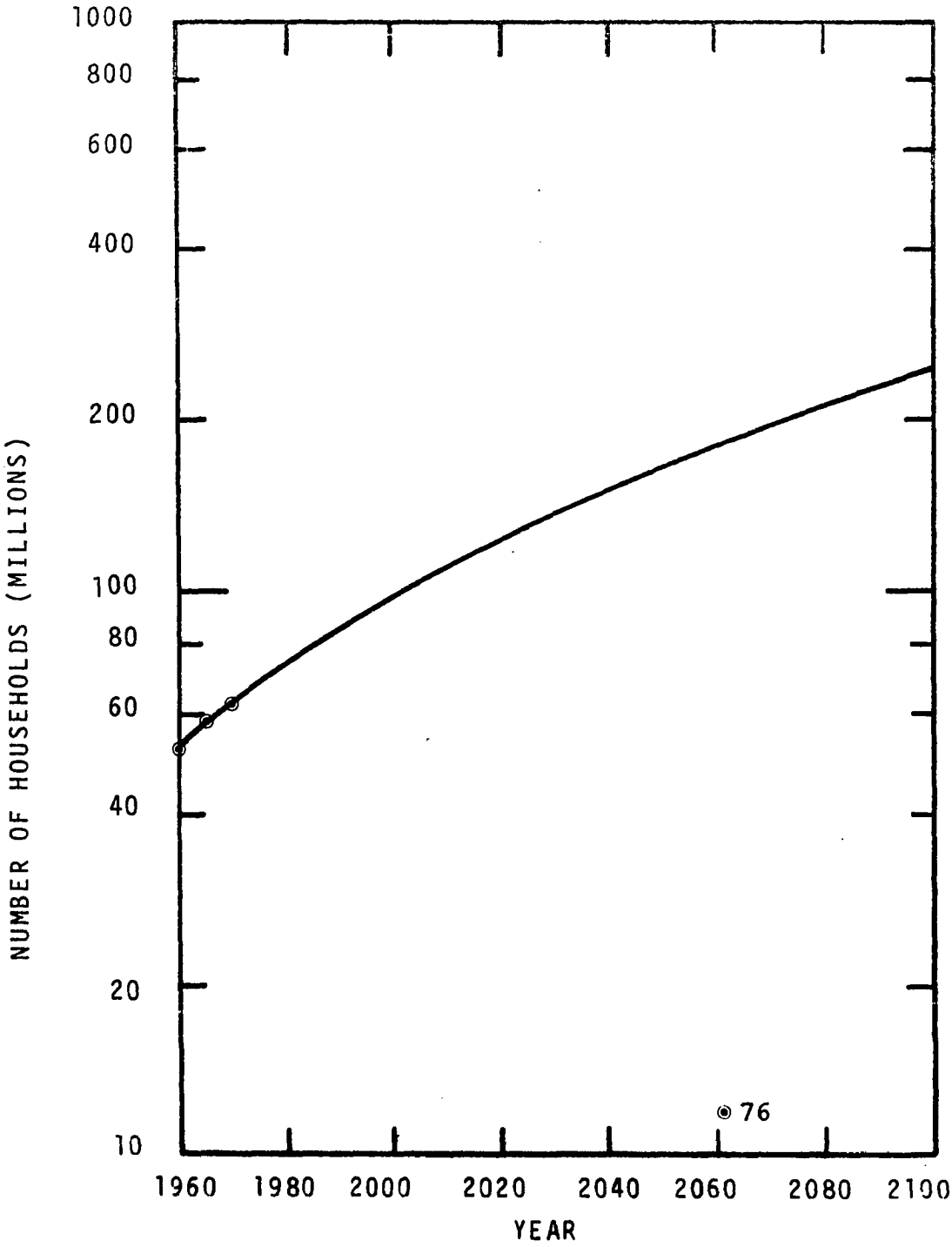


Figure III-4. Projected Number of Households in the United States.

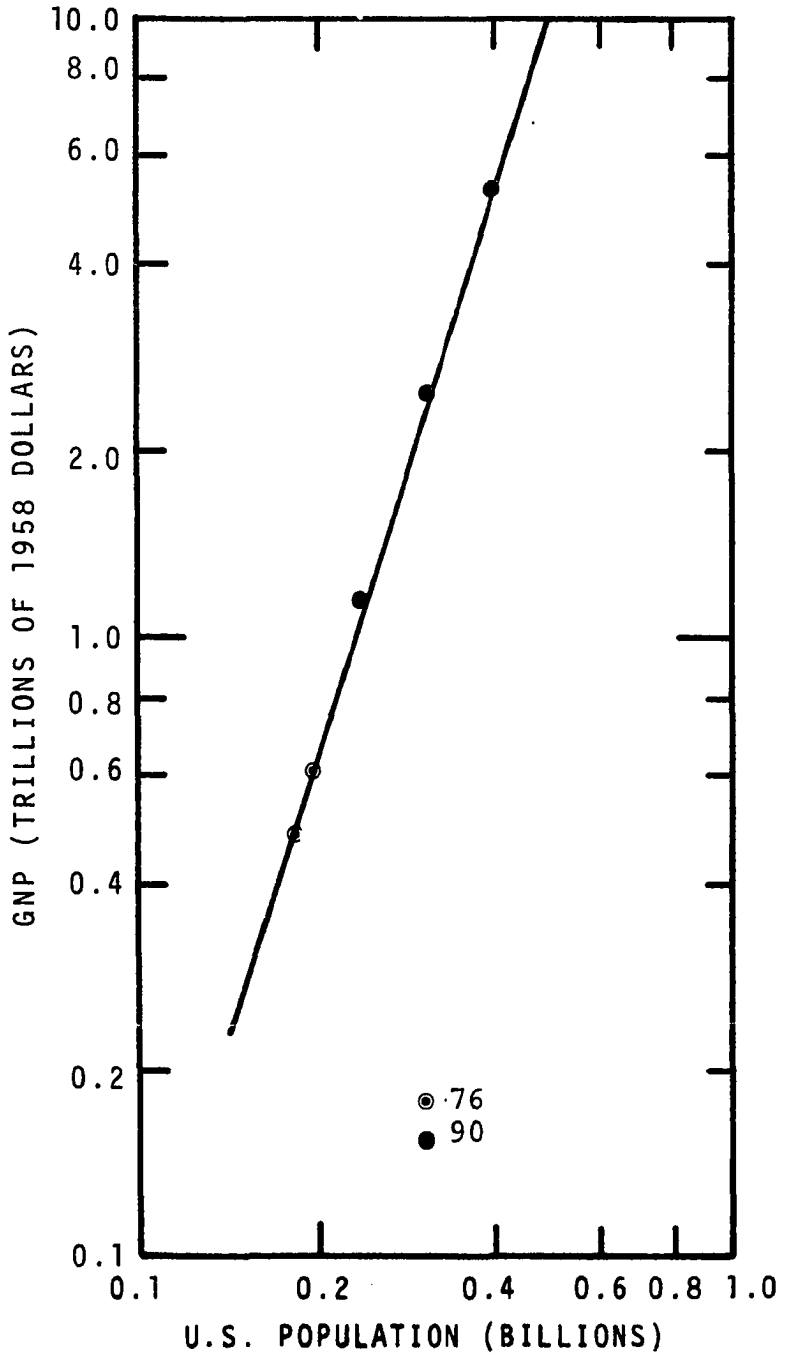


Figure III-5. Gross National Product and U.S. Population.

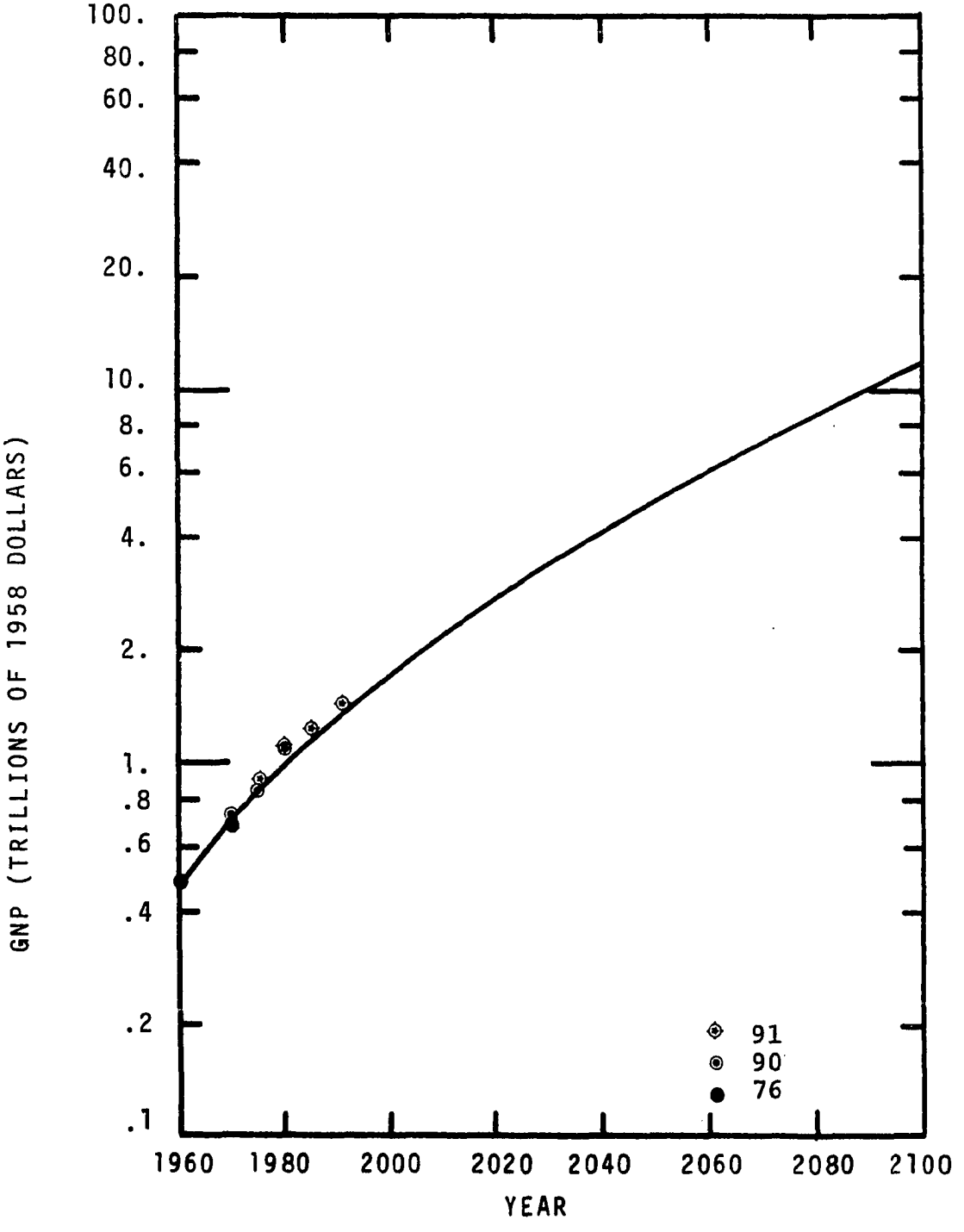


Figure III-6. Gross National Product Projection.

where

REUD(J) = U.S. residential end use demand for fuel J in year I

RSEU(I) = fraction of households with this end use in year I

HHLD(I) = number of households in year I

UDREU(J) = unit demand of residential end use for fuel J

REUHF(I,J) = fraction of households with end use supplied by fuel J in year I

REUEF(I,J) = efficiency of end use for fuel J in year I

The projection of the energy demand for each of the six categories is treated in detail in Appendix A.

For each residential use category the airborne emissions due to direct consumption of energy resources are also calculated (see Airborne Emissions, page 78).

Commercial Projection

The commercial end utilization energy requirements, Figure III-1, were projected using the gross national product projection, Figure III-6. The commercial energy demand was generated from six different use categories: space heating, air conditioning, water heating, cooking, refrigeration and miscellaneous usage. In general, the energy demand for each category of commercial use for fuel J in year I is given by

$$CEUD(J) = CEUB \times GNPR70(I) \times CEUDF(I,J) \times \frac{CEUEF(1970,J)}{CEUEF(I,J)} \qquad \text{(III-3)}$$

where

CEUD(J) = U.S. commercial end use demand for fuel J in year I

CEUB = commercial end use demand in 1970

GNPR70(I) = GNP(I)/GNP(1970) (III-4)

GNP(I) = gross national product in year I

CEUDF(I,J) = commercial end use demand fraction for fuel J in year I

CEUEF(I,J) = commercial end use efficiency for fuel J in year I

The projection of the energy demand for each of the six categories is treated in detail in Appendix A. For each commercial use category the airborne emission due to direct consumption of energy resources were also calculated (see Airborne Emissions, page 82).

Industrial Projection

The industrial energy demand was generated from the sixteen major energy consuming categories of industry: alumina, primary aluminum, secondary aluminum, cement, caustic soda and chlorine, primary copper, refined copper, primary magnesium, secondary magnesium, primary zinc, secondary zinc, pig iron, steel, chemicals, petrochemicals, chemical feed stocks and other raw materials, and miscellaneous usage. Some industrial requirements such as petroleum refineries, electrical utilities, and uranium enrichment plants are treated in later sections. These industries are not end uses of

energy per se, but their energy demand is dependent on the end utilization demands, electrical power requirements, types of electrical generation plants, etc., and cannot be projected on a population, households, or gross national product basis. In general, the energy demand for each category of industrial use for fuel J in year I is given by projecting the demand for that commodity.

$$IEUP(I) = IEUP(\text{reference year}) \times \frac{GNP(I)}{GNP(\text{reference year})} \qquad \text{(III-5)}$$

where

IEUP(I) = domestic industrial commodity production in year I

GNP(I) = gross national product in year I

IEUP (reference year) = domestic industrial commodity production in the reference year from the literature

and using the commodity projection to predict the end use demand for that material.

$$IEUD(J) = IEUP(I) \times IEUFD(I,J) \times IEUUD(I) \qquad \text{(III-6)}$$

where

IEUD(J) = U.S. industrial end use energy demand for fuel J in year I to produce this commodity

IEUP(I) = domestic industrial commodity production in year I

IEUFD(I,J) = industrial end use energy demand fraction for fuel J in year I

IEUUD(I) = energy required/unit weight of material in year I

The projection of the energy demand for each of the sixteen industrial categories is treated in detail in Appendix A. For each industrial use category, the airborne emissions due to direct consumption of energy resources and the airborne emissions due to commodity production were also calculated (see Airborne Emissions, page 84).

Transportation Projection

The transportation energy demand, Figure III-1, was generated from six different categories of transportation: airplanes, automobiles, buses, railroads, ships (or barges), and trucks. In general, the energy demand for each category of transportation for fuel J in year I is given by

$$TEUD(J) = TEUBI(I) \times TEUDF(I,J) \qquad \text{(III-7)}$$

where

TEUD(J) = U.S. transportation end use energy demand for fuel J in year I

TEUBI(I) = projected end use transportation energy requirements in the year I

TEUDF(I,J) = transportation end use energy demand fraction for fuel J in year I

The projection of the energy demand for each of the six categories of transportation is treated in detail in Appendix A. For each transportation demand category the airborne emissions due to direct consumption of energy resources were also calculated (see Airborne Emissions, page 88).

Transmission and Distribution Energy Loss Correction

The end utilization demands, shown in Figure III-1, were corrected for transmission and distribution energy losses. The natural gas losses were determined from pipeline compressor natural gas demands. The natural gas pipelines and local distribution systems require 3.66 percent of the natural gas entering the pipeline to drive the pipeline compressors (13, 82). (As will be seen later another 10 percent of the natural gas is consumed in the production step.) Therefore the amount of natural gas required to meet the end utilization, electrical generation, petroleum refining and synthetic fuel demands after correction for transmission losses is

$$\begin{aligned}\text{Corrected Gas Demand} = (1.0 + 0.0366)&(\text{end utilization gas demand} \\ &+ \text{electrical generation gas demand} \\ &+ \text{petroleum refining gas demand} \\ &+ \text{synthetic fuel gas demands})\end{aligned} \qquad \text{(III-8)}$$

The electrical power transmission and distribution losses are approximately 9.1 percent (91). Therefore the amount of electrical power which must be generated to satisfy the end utilization, the uranium enrichment, synthetic fuel, and petroleum refining demands is:

$$\begin{aligned}\text{Electricity to be Generated} = (1.0 + 0.091)&(\text{end utilization electrical} \\ &\text{demand} + \text{synthetic fuel electrical} \\ &\text{demand} + \text{uranium enrichment} \\ &\text{electrical demand} + \text{petroleum refining} \\ &\text{electrical demand})\end{aligned} \qquad \text{(III-9)}$$

The transmission and distribution power losses for hydrogen are assumed to be approximately equal to the natural gas transmission and distribution losses (38, 39).

The transmission and distribution losses for all other fuels are either negligible or are accounted for as an end utilization demand.

Synthetic Fuel Manufacturing Energy Demands

The actual demands for synthetic fuels--ammonia, methanol, and hydrogen--were converted into more basic resource demands by correcting for the energy consumed in the manufacture of the synthetic fuels from a more basic resource. Since natural gas and petroleum are already in short supply, while coal and nuclear sources are still plentiful, the most viable synthetic fuel manufacturing assumption is that all methanol will be made from coal, all hydrogen by electrolysis of water and all ammonia from air and electrolytic hydrogen.

Ammonia

Ammonia used as a synthetic fuel was assumed to be manufactured by the catalytic synthesis of nitrogen and electrolytic hydrogen

$$N_2 + 3H_2 \rightarrow 2NH_3 \qquad \text{(III-10)}$$

such as described by Faith, Keyes and Clark (21) with an overall yield of 85 percent. The nitrogen is supplied by an air liquefaction plant which requires approximately four megawatts

of electrical power to produce the 830 tons of nitrogen required to make 1000 tons of ammonia (7). The 177 tons of hydrogen required to make 1000 tons of ammonia (7) is assumed to have been produced in an electrolytic hydrogen plant. Using these assumptions, the production of ammonia used as a synthetic fuel creates the following energy demand factors (7, 21, 32).

Btu Hydrogen/Btu Ammonia = 1.1420

Btu electricity/Btu ammonia = 0.0010279

Therefore the ammonia manufacturing hydrogen requirements are:

$$AMH2D = 1.1420 \times AMD \qquad \text{(III-11)}$$

where

AMH2D = hydrogen required for ammonia production in trillion Btu/year

AMD = ammonia demand in trillion Btu/year

and the electrical power requirements are:

$$AMELD = 0.0010279 \times AMD \qquad \text{(III-12)}$$

where

AMELD = electrical power required for ammonia production in trillion Btu/year

AMD = ammonia demand in trillion Btu/year

Hydrogen

Hydrogen used as a substitute fuel will most probably be produced by the electrolysis of water. The electrical demand created by electrolytic hydrogen requirements was added to the end utilization demand for electrical energy as shown in Figure III-1. The hydrogen demand is generated from an end utilization demand and/or the production of ammonia, another synthetic fuel.

The manufacturing efficiency of electrolytic hydrogen is projected to increase as shown in Figure III-7. Therefore, the electrical power required to supply electrolytic hydrogen in year I is given by

$$HED = H2D/HEEFF(I) \qquad \text{(III-13)}$$

where

HED = electrical demand created by the manufacture of electrolytic hydrogen in the year I in trillion Btu/year

H2D = electrolytic hydrogen demand in trillion Btu/year

HEEFF(I) = projected efficiency of hydrogen electrolysis Btu hydrogen/Btu electrical in the year I

Methanol

It was assumed that all methanol will be made from coal. Using 1970 technology, methanol can be produced with an overall manufacturing efficiency of 0.517 Btu methanol/Btu coal (32). However, advanced technology could increase the methanol production efficiency to 0.66 Btu methanol/Btu

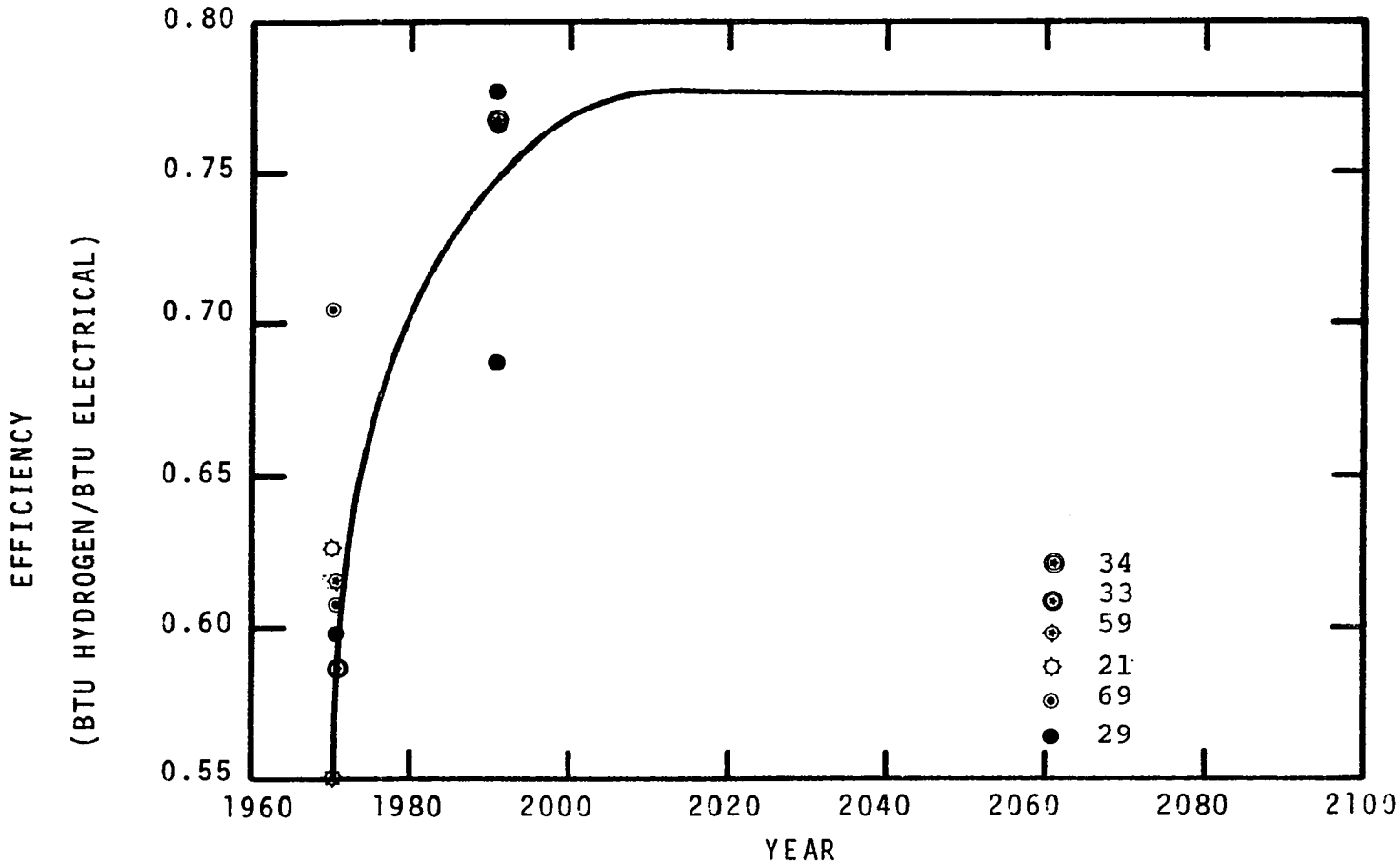


Figure III-7. Manufacturing Efficiency for Electrolytic Hydrogen Projection.

coal (61). The coal demand for methanol production is added to the end utilization demand for coal as shown in Figure III-1. The coal required to manufacture methanol in the year I is given by

$$CEMD = MED/MEFF(I) \qquad \text{(III-14)}$$

where

CEMD = coal demand created by the manufacture of methanol in year I in trillion Btu/year

MED = methanol demand in trillion Btu/year in year I

MEFF(I) = projected methanol manufacturing efficiency, Btu methanol/Btu coal, in the year I

Electrical Generation

Electrical generation energy requirements represent approximately 20 to 30 percent of the annual energy consumption in the United States. Many studies have been made on future electrical generation capacity fraction by plant types (6, 22, 46, 70, 71, 72, 76). The results of these studies are synthesized in Figure III-8. The base case incorporates, as a best estimate, the development of a fusion reactor with commercial plants available by 2020.

The electrical generation plants considered include coal fired, gas fired, petroleum fired, geothermal, hydroelectric and nuclear. The nuclear plants are split into fission types and fusion types.

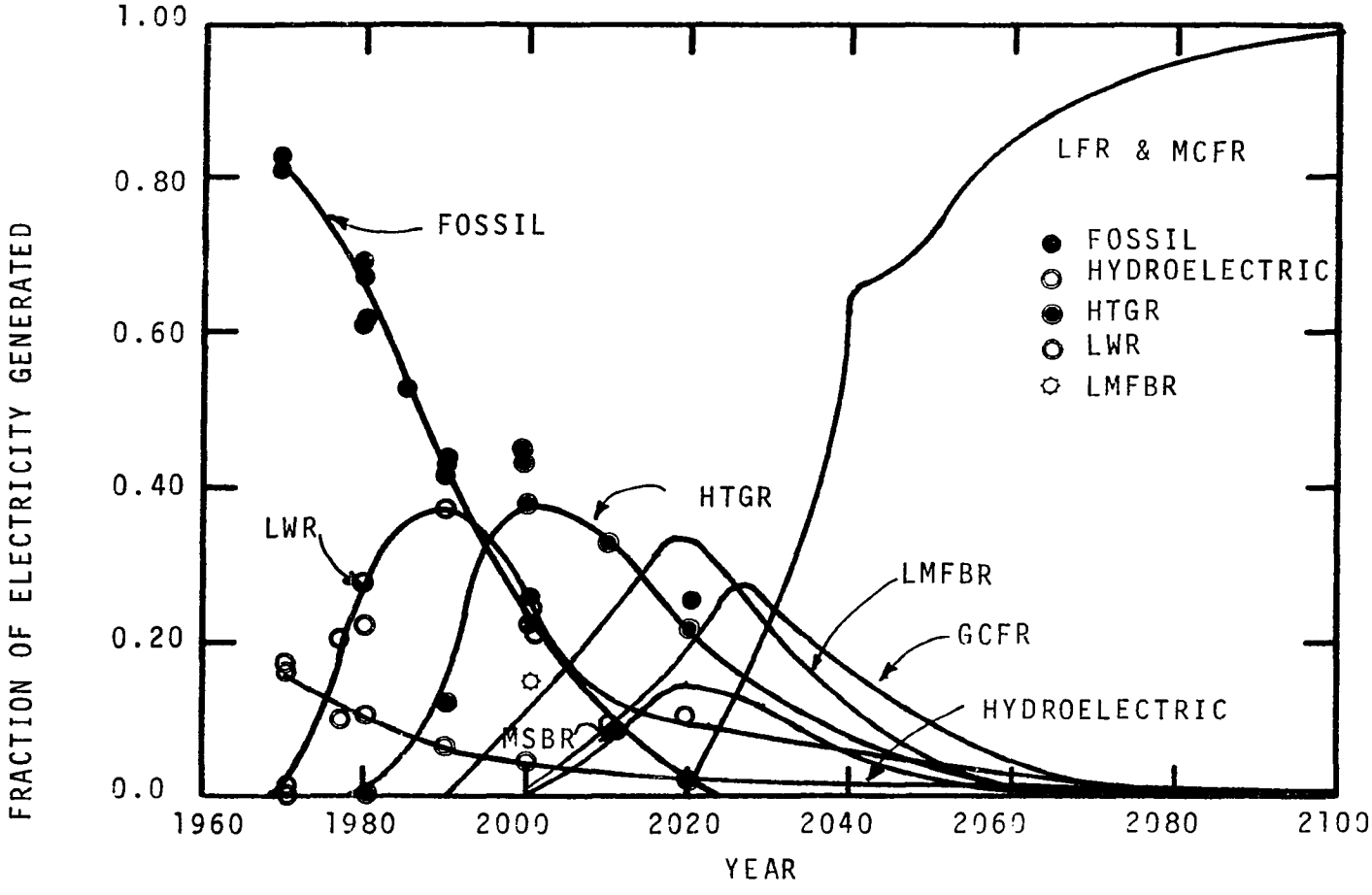


Figure III-8. Projected Fraction of Electrical Generation by Plant Type (6, 22, 46, 70, 71, 72, 76).

Coal Fired

Coal fired electrical generating plants are based on the coal-steam system with incorporation of 1970 technology by 2000 and complete magnetohydrodynamics topping (MHD) by 2040 (Figure III-11).

Gas Fired

Gas fired electrical generating plants are based on the gas-steam system with incorporating the Brayton topping cycle at various stages of improvement by 2010, 2020, and 2030 and MHD by 2040 (Figure III-11).

Petroleum Fired

Oil fired electrical generating plants are based on the oil-steam system with incorporation of the MHD topping cycle by 2040 (Figure III-11).

Geothermal

Geothermal electrical generation plants are based on the hot vapor and hot water cycles with resources development to 2000 as shown in Figure III-15 and geothermal generation increasing to a plateau of approximately 12 to 15 x 10^{15} Btu/year to 2100.

Hydroelectric

Hydroelectric generation is based on pumped storage and projected future hydroelectric sites (22) as shown in Figure III-16.

Nuclear Fission

The nuclear fission reactors incorporated in the model include gas-cooled breeder reactors (GCFR), high temperature gas-cooled reactors (HTGR), liquid metal fast breeder reactors (LMFBR), light water reactors (LWR), and molten salt breeder reactors (MSBR). One of the limitations on the incorporation of breeder reactors is the availability of plutonium.

Gas-Cooled Breeder Reactors (GCFR): Gas cooled breeder reactors use a plutonium based fuel cycle with the shortest doubling time of all breeder reactors. (The doubling time is the amount of time it takes to breed enough plutonium from Uranium-238 to fuel an identical reactor.) The GCFR uses helium as a coolant and can either use a helium-steam cycle or a Brayton (gas turbine) cycle. The use of a Brayton cycle permits dry cooling towers for waste heat removal.

High-Temperature Gas-Cooled Reactor (HTGR): The HTGR uses a helium gas coolant and either steam or Brayton cycle. The HTGR can use either a thorium based or plutonium based fuel cycle. For more information on HTGR's, see Appendix D.

Liquid Metal Fast Breeder Reactors (LMFBR): LMFBR's use a plutonium based fuel cycle with a liquid metal such as sodium as the primary and secondary coolant. They use the steam cycle for electrical power generation.

Light Water Reactors (LWR): The LWR category includes Pressurized Water Reactors (PWR) and Boiling Water Reactors (BWR). LWR's may use either enriched uranium or a plutonium

based fuel cycle and a steam cycle for electrical power generation.

Molten Salt Breeder Reactors (MSBR): The MSBR is unique in that its fuel is mixed with the primary coolant in the form of a molten salt. The MSBR has a thorium based fuel cycle and uses a steam cycle for electrical power generation.

Nuclear Fusion

The nuclear fusion reactors incorporated in the model include the Laser Fusion Reactor (LFR) and the Magnetically Contained Fusion Reactor (MCFR).

Laser Fusion Reactor (LFR): The LFR uses a laser beam to compress a deuterium-tritium pellet sufficiently for the fusion reaction to occur. The tritium is bred from lithium and the deuterium is supplied from sea water. The LFR utilized a steam cycle for electric power generation.

Magnetically Contained Fusion Reactor (MCFR): The MCFR concept uses a magnetic field to contain and compress the plasma gas sufficiently for the fusion reaction to occur. The deuterium-tritium fuel cycle is also used in the MCFR. Electrical generation may be either by electrogas dynamics (EGD), MHD, or steam cycle.

Heat Removal System Effects

Various methods are available for the removal of waste heat: reservoirs, rivers, oceans, cooling towers, cooling ponds, spray ponds, dry cooling, etc. Each of these

methods of waste heat removal require power from the generation plant to pump the cooling water, run the cooling tower fans, etc., or decrease the thermodynamic efficiency. The percentage of power required for a given type of waste heat removal system above that required if cooling water only passed through the condenser and then back to its source, i.e., once through cooling, is called degradation factor (Table III-2).

Fuel Demand for Electrical Generation

As shown in Figure III-1, the end utilization, synthetic fuel, uranium enrichment, and petroleum refining electrical power demands after correction for transmission and distribution losses were used in conjunction with the projected electrical generation by plant type, Figure III-8; the projected fraction of fossil fuel electrical generation demand for each fossil fuel type, Figure III-9; the projected split between distillate oil and residual oil for oil-fired electric power plants, Figure III-10; the projected electrical generation plant efficiency, Figure III-11 and Table III-1; and the degradation factor for cooling water alternatives, Table III-2 to obtain the fuel demand for electrical generation for fuel J in year I.

$$\begin{aligned} ELGD(J) = {} & [EDC \times EGFD(I,J)/EGEF(I,J)] \\ & \times \{FROT(I) + 1.045 \times FRNC(I) + 1.0175 \\ & \times [FRFC(I) + FRSP(I)] + 1.075 \times FRDC(I) \\ & + FRCP(I)\} \end{aligned} \qquad \text{(III-15)}$$

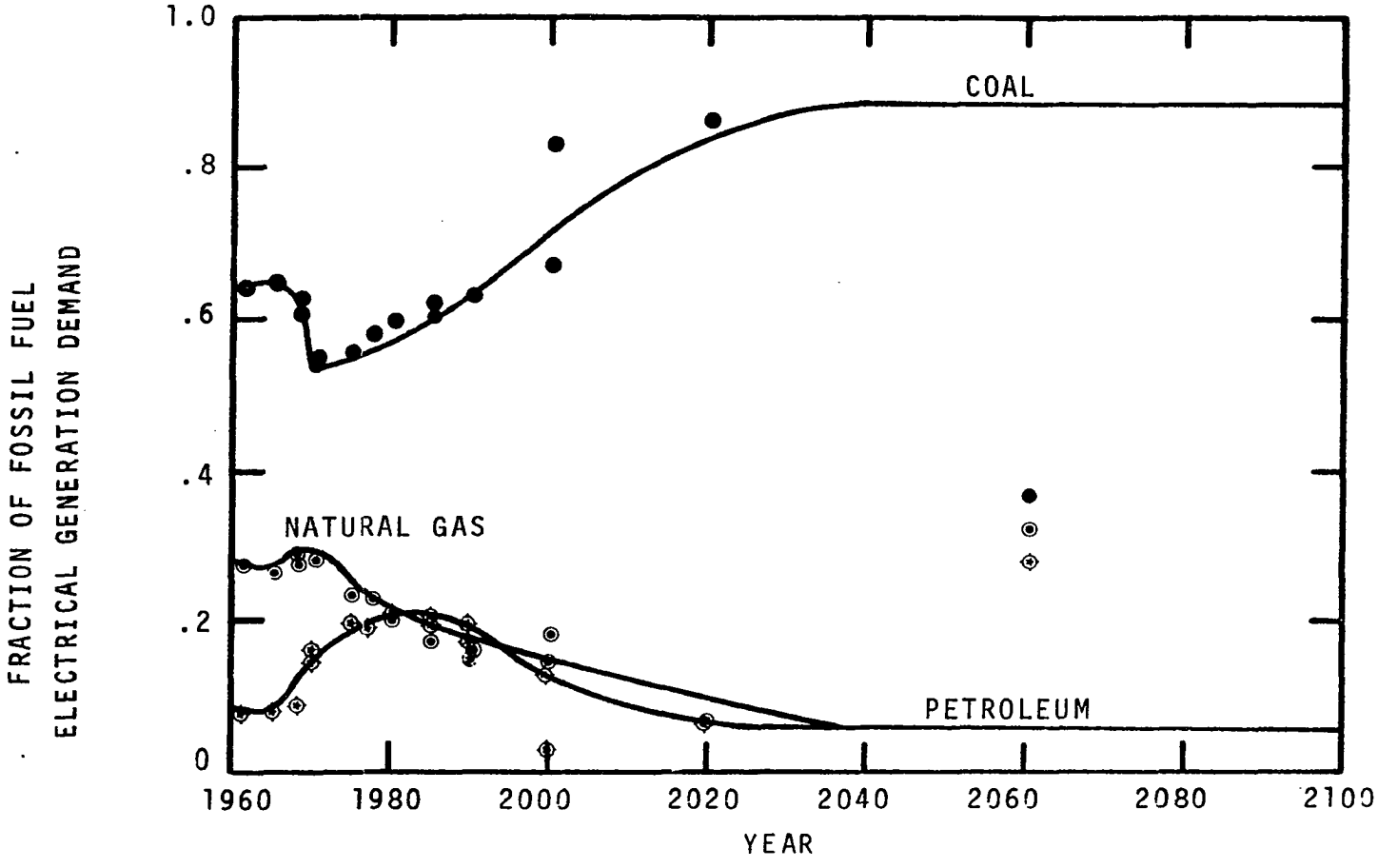


Figure III-9. Projected Fraction of Fossil Fuel Electrical Generation Demand for Each Fossil Fuel Type (6, 22, 76, 78).

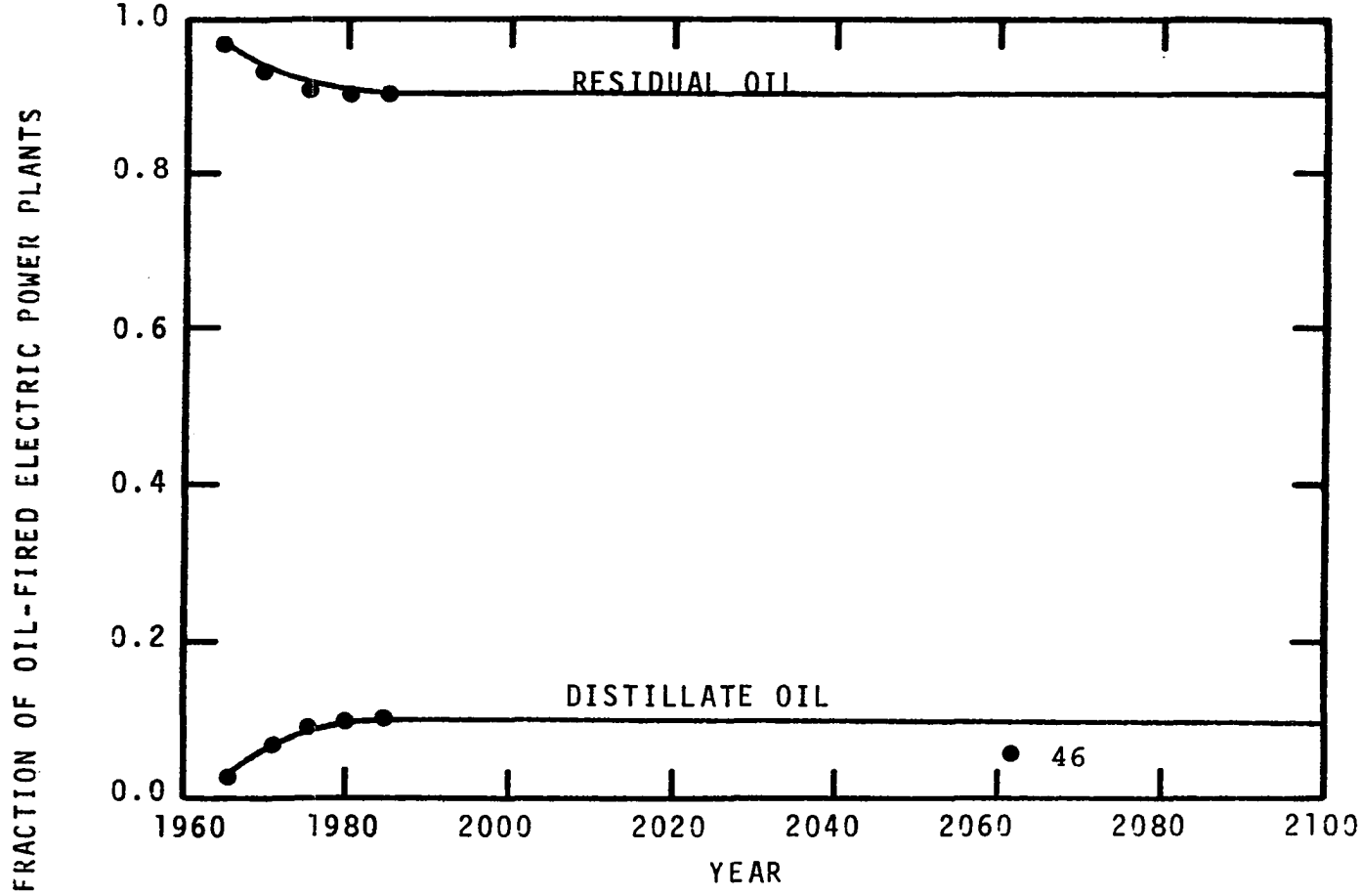


Figure III-10. Projected Split Between Distillate Oil and Residual Oil for Oil Fired Electric Power Plants.

TABLE III-1

ELECTRICAL GENERATION EFFICIENCY
(22, 46, 70, 71, 72, 76)

Plant Type	Year	Efficiency (Btu electricity/Btu fuel)
coal	--	(see Figure III-11)
geothermal	1970+	0.143
hydrogen	1970+	0.3
natural gas	--	(see Figure III-11)
GCFR	2010+	0.398
HTGR	1970+	0.407
LFR	2020+	0.50
LMFBR	1980+	0.371
LMFBR	2010	0.392
LMFBR	2020+	0.40
LMFBR	2040+	0.42
LWR	1970+	0.325
MSBR	1970+	0.44
MCFR	2020+	0.50
gasoline	1970+	0.30
jet fuel	1970+	0.30
distillate oil	--	(see Figure III-11)
residual oil	--	(see Figure III-11)
methanol	1970	(same as natural gas; see Figure III-11)
solar	--	0.3
tidal	--	0.2
wind	--	0.2
hydroelectric	--	0.76

TABLE III-2

ELECTRICAL POWER GENERATION COOLING WATER DEGRADATION FACTOR

Type of Cooling Used	Fractional Decrease in Net Power Generated Relative to Once-Through Cooling Net Power
Once-Through	0.0
Forced Convection Cooling Tower	0.0175
Spray ponds	0.0175
Cooling ponds	0
Natural Convection Cooling Tower	0.045
Dry cooling	0.075

where

ELGD(J) = electrical generation energy demand for fuel J in year I

EDC = transmission loss corrected electrical demand from Equation III-9

EGFD(I,J) = projected fraction of generation for plants of fuel type J in year I

EGEF(I,J) = projected electrical generation efficiency for fuel J in year I from Figure III-11 and Table III-1

FROT(I) = fraction of electrical generation plants using once through cooling in year I

FRNC(I) = fraction of electrical generation plants using natural convection cooling towers in year I

FRFC(I) = fraction of electrical generation plants using forced convection cooling towers in year I

FRSP(I) = fraction of electrical generation plants using spray ponds in year I

FRDC(I) = fraction of electrical generation plants using dry cooling in year I

FRCP(I) = fraction of electrical generation plants using cooling ponds in year I

The electrical generation energy requirements are added to the corrected synthetic fuel and end utilization demands.

Refining, Processing and Conversion

The refining, processing and conversion requirements are iterated with the transportation losses to compensate for feedback between resource conversion and transportation losses. The base fuel demands are now increased by the energy required

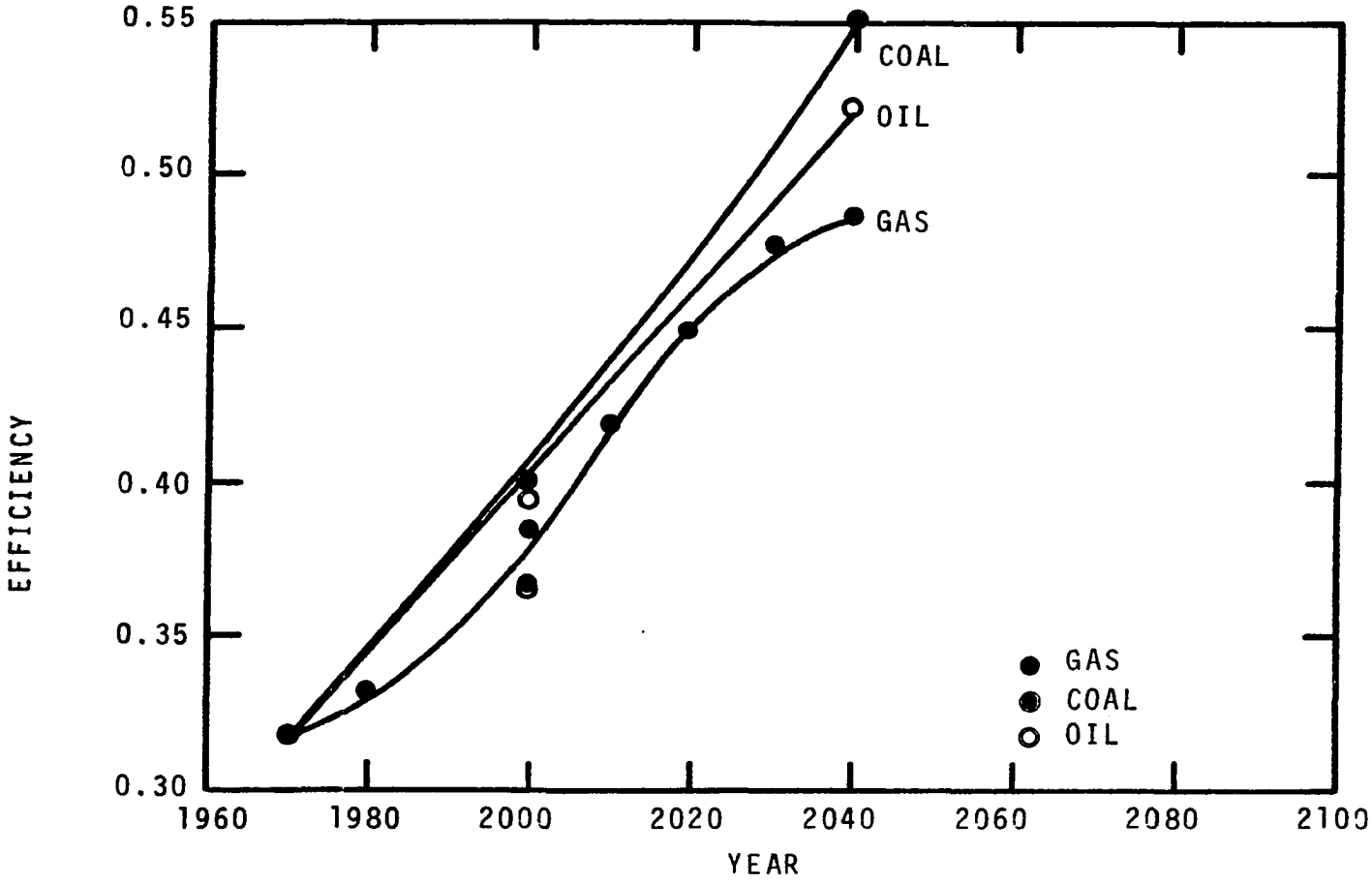


Figure III-11. The Projected Electrical Generation Efficiency for Fossil Fuels (22, 44, 45, 46).

for the process losses which occur during the refining and processing of the base fuel, i.e., petroleum refining, uranium enrichment, etc., and the conversion to other fuels, i.e., petroleum gasification and coal gasification and liquefaction as shown in Figure III-1.

Petroleum Refining

The transportation corrected petroleum demands, Figure III-1, were used to determine the energy requirements for petroleum refining. Petroleum refineries were used to refine crude petroleum and the syncrudes produced from coal, oil shale and tar sands. Due to new refinery technology, the petroleum refining efficiency is projected to increase, resulting in lower unit energy requirements, Figure III-12. The 1970 petroleum refining fuel fractions, Table III-3, were assumed to remain constant. All fuel oil used as refinery fuel was assumed to be residual fuel oil and supplied from an off-site source. Since some of the petroleum is consumed within the refinery for fuel, i.e., refinery gas, liquefied petroleum gas (LPG) and petroleum coke, the amount of crude supplied to the refinery must be corrected for internal refinery fuel consumption.

$$CTS = CTSR(I) \times PETD \qquad \text{(III-16)}$$

where

CTS = crude petroleum supplied to the refinery

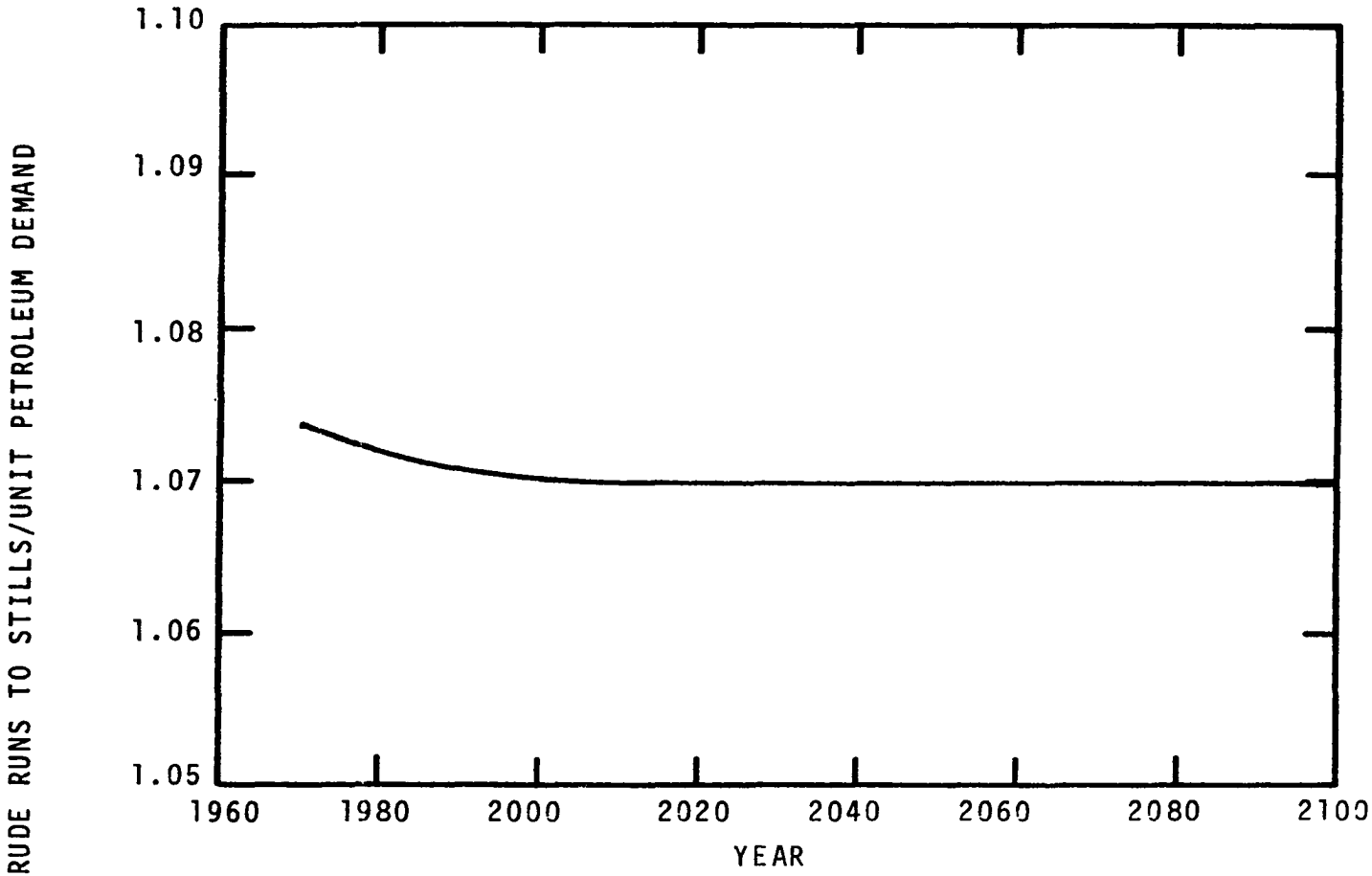


Figure III-12. Projected Ratio of Btu's Crude Supplied to a Petroleum Refinery per Btu of Refined Product.

TABLE III-3

PETROLEUM REFINING FUEL FRACTIONS
(46, 81)

Fuel	Source	Fraction
coal	external	0.004
natural gas	external	0.382
electricity	external	0.025
residual oil	external	0.112
LPG	internal	0.006
refinery gas	internal	0.358
petroleum coke	internal	0.113

CTSR(I) = the ratio of Btu crude supplied/Btu refined product in year I, Figure III-12

PETD = total refined petroleum demand including refinery fuel oil consumption

The energy required for petroleum refining for fuel J in year I is given by

$$PRD(J) = PRFF(I,J) \times \frac{PRUD(I)}{5,800,000} \times CTS \qquad \text{(III-17)}$$

where

PRD(J) = petroleum refining energy demand for fuel J in year I

PRFF(I,J) = projected petroleum refining energy demand fraction for fuel J in year I

PRUD(I) = projected petroleum refining energy requirements (Btu/Btu crude charged) in year I, Figure III-13

CTS = crude petroleum supplied to the refinery

The energy requirements for petroleum refining are added to the previously calculated demands by fuel type as shown in Figure III-1.

Uranium Enrichment

The uranium enrichment energy requirements were determined from the Kilograms of Separative Work (KGSW) required for one year of nuclear reactor operation. The current capabilities of the United States Atomic Energy Commission enriching facilities are listed in Table III-4.

The capacities and production rates of uranium enrichment plants are normally expressed in terms of separative

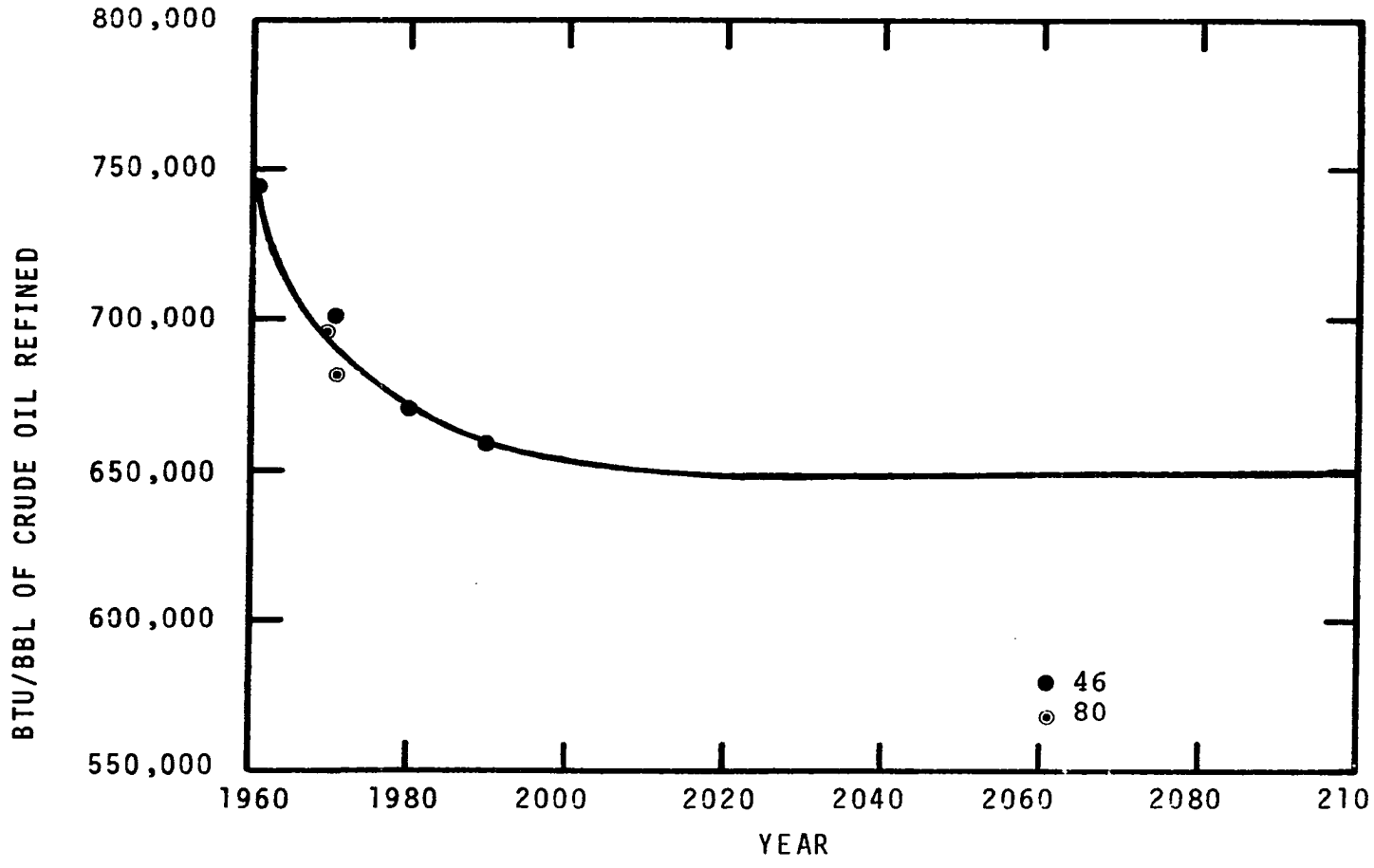


Figure III-13. Projected Petroleum Refinery Unit Energy Requirements.

TABLE III-4

URANIUM ENRICHMENT CAPACITY (75)

	Improvement (10^6 kgsw/year)	Total (10^6 kgsw/year)
1972	--	17.2
Cascade improvement	4.8	22.0
Cascade power upgrading	4.5	26.5

TABLE III-5

NUCLEAR POWER PLANT URANIUM ENRICHING REQUIREMENTS

Power Plant	Year Introduced	Fuel Cycle	Net Separative Work (kgsw/10^6 Btu-thermal)	
High-temperature gas-cooled reactor	1980+	high enriched uranium carbide in ThC with recycling of bred U-233	0.00149	(72, 73)
Light water reactor	1970	non-recycle	0.01435	(70, 73)
	1980	Pu-recycle	0.001109	(70,73)
	1990+	Pu-recycle	0.001016	(70, 73)

work units (76). The separative work unit is not a quantity of material, but is a measure of the effort expended in the plant to separate a quantity of uranium of a given assay into two components with higher and lower uranium-235 content. Separative work is normally expressed in kilograms to give it the same dimensions as the material, i.e., kilograms of uranium. The separative work is proportional to the total amount of uranium hexafluoride pumped within the diffusion enriching plant. Therefore the separative work is determined by the product flow rate and the inlet feed, the product and the tail's U-235 content. The kilograms of separative work (KGSW) required for nuclear reactor type J in year I are given by

$$SWREQ(J) = KGSW(I,J) \times RD(J) \times 10^6 \qquad \text{(III-18)}$$

where

SWREQ(J) = kilograms of separative work required by reactor type J in year I

KGSW(I,J) = unit separative work requirements, kilograms separative work/million Btu (thermal) in year I for reactor type J, Table III-5.

RD(J) = total nuclear reactor demand for reactor J in trillion Btu/year

The total separative work requirements are the sum of the individual reactor requirements, Equation III-18, and the estimated government requirements, 990,000 kgsw/year (75).

$$SWREQT = \sum_J SWREQ(J) + 990{,}000 \qquad \text{(III-19)}$$

where

SWREQT = separative work requirements for year I

SWREQ(J) = separative work requirements for reactor type J in year I

Using the results of Equation III-19, the electrical power required for separative work is given by

$$PRSW = SWREQT \times UEDSW(I)/10^6 \text{ trillion Btu/year} \quad \text{(III-20)}$$

where

PRSW = electrical power required for separative work in trillion Btu/year

SWREQT = from Equation III-19

UEDSW(I) = projected energy demand per kilogram of separative work in year I, Figure III-14

The power required for separative work was added to the electrical energy demand and iterated across the electrical generation requirements to account for nuclear generating capacity feedback as shown in Figure III-1.

Petroleum Gasification

The natural gas resource demands, Figure II-1, were balanced with the projected net domestic production. The short fall is then divided among alternative natural gas resource supplies (liquefied natural gas, Canadian pipeline imports, synthetic natural gas from coal and synthetic natural gas from petroleum).

In order to meet increasing gas demand and for peak shaving purposes, synthetic natural gas will be manufactured

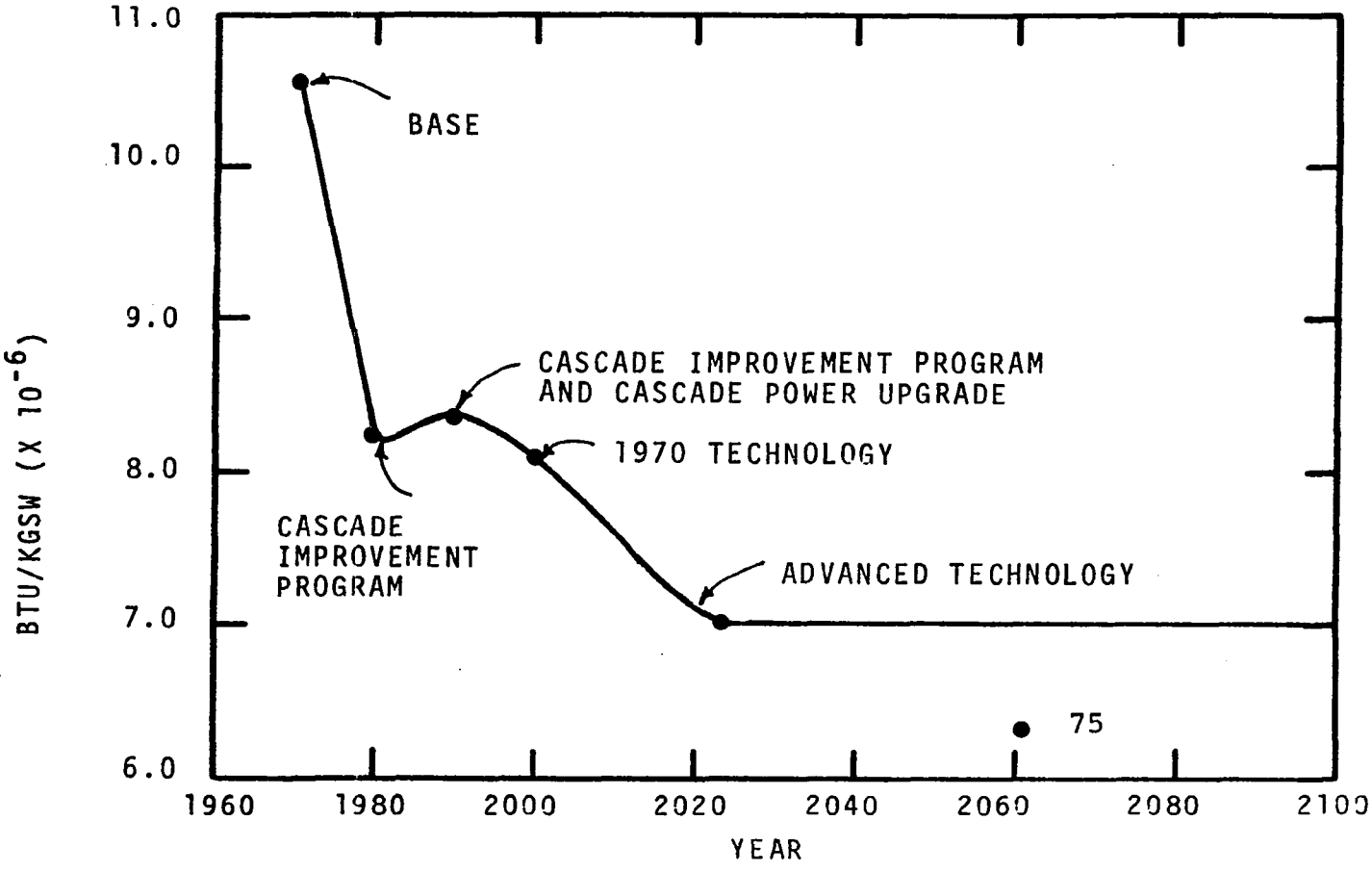


Figure III-14. Projected Uranium Enriching Energy Requirement per Kilogram of Separative Work.

from petroleum products (naptha, light oil, medium and heavy oil, crude petroleum and methanol). The amount of synthetic natural gas, SNG, supplied by the gasification of petroleum products and coal gasification is given by

$$SGASR = SGASF(I) \times GASREQ \qquad \text{(III-21)}$$

where

SGASR = amount of syngas required in year I

SGASF(I) = fraction of excess gas requirements to be supplied in year I

GASREQ = natural gas requirements in excess of domestic supply for year I

The SNG production fuel requirements are determined by

$$SGFR(J) = \frac{SGASFF(I,J)}{SGEF(J)} \times SGASR \qquad \text{(III-22)}$$

where

SGFR(J) = SNG production fuel demand for fuel J in year I

SGASFF(I,J) = SNG production fuel fraction for fuel J in year I

SGEF(J) = energy efficiency of SNG production for fuel J, Table III-6

SGASR = amount of SNG required to meet natural gas demands exceeding net domestic production from Equation III-21

The airborne emissions due to petroleum gasification are determined in the Airborne Emissions section, page 98.

TABLE III-6

PETROLEUM SYNGAS PRODUCTION EFFICIENCY

Fuel	Conversion Efficiency (Btu gas/Btu fuel)
naptha	0.91 (30)
kerosine & light oil	0.90 (63)
medium & heavy oil	0.90 (8)
crude oil	0.84 (66)
methanol	0.935 (56)

Coal Gasification and Liquefaction

Synthetic natural gas and synthetic crude petroleum can be produced by the gasification and/or liquefaction of coal. The reference combined coal gasification and coal liquefaction process is characterized by the Coal-Oil-Gas (COG) process (10). The characteristics of the reference coal liquefaction process (38, 39) and the coal gasification process (2, 30, 38, 39, 57) are averages of typical pilot operations. Table III-7 gives the general characteristics of the three processes including overall efficiencies, product fractions, airborne emission factors, and elemental sulfur and solid waste fractions.

The coal resource demand for syngas from coal is determined by Equation III-21 and Equation III-22 using Table III-7 for overall efficiencies.

The syncrude is produced either in a coal liquefaction plant or a combined coal liquefaction and gasification plant. The syncrude requirements are given by

$$SC = SCF(I) \times PETREQ \qquad \text{(III-23)}$$

where

SC = syncrude requirements in trillion Btu/year in year I

SCF(I) = fraction of petroleum demand exceeding domestic supply to be supplied by syncrude from coal in year I

PETREQ = petroleum demand exceeding domestic supply for year I, Equation III-47

TABLE III-7

CHARACTERISTICS OF COAL GASIFICATION AND/OR LIQUEFACTION PLANTS

(2, 10, 30, 38, 39, 57)

Characteristic	Gasification	Liquefaction	Gasification and Liquefaction
Overall efficiency (Btu product/Btu coal)	0.633	0.85	0.738
Product Fraction			
refined coal	--	--	0.073
syncrude	--	1.0	0.323
syngas	1.0	--	0.604
Airborne Emissions (lb/10^6 Btu-product)			
CO_2	80.5	62.5	72.0
CO	--	--	--
SO_2	--	--	--
NO_x	--	--	--
particulate	--	--	--
hydrocarbon	3.92	--	--
aldehydes	0.65	--	0.142
Sulfur (lb/10^6 Btu-product)	5.23		3.30
Solid Waste (lb/10^6 Btu)	7.84		3.82

The fraction of syncrude supplied by coal liquefaction plants is

$$SCCL = FCL(I) \times SC \qquad \text{(III-24)}$$

where

SCCL = syncrude to be supplied by coal liquefaction plants in year I

FCL(I) = fraction of syncrude plants that are only coal liquefaction plants in year I

SC = syncrude requirements in trillion Btu/year in year I, Equation III-23

The fraction of syncrude supplied by combined coal gasification and coal liquefaction plants is

$$SCCLG = FCLG(I) \times SC \qquad \text{(III-25)}$$

where

SCCLG = syncrude to be supplied by combined coal liquefaction and gasification plants in year I

FCLG(I) = fraction of syncrude plants that are combined coal liquefaction and gasification plants in year I

SC = syncrude requirements in trillion Btu/year in year I

The combined coal conversion plants also produce synthetic natural gas and refined coal

$$CLG = SCCLG \times \frac{0.323}{0.604} \qquad \text{(III-26)}$$

$$CLC = SCCLG \times \frac{0.073}{0.604} \qquad \text{(III-27)}$$

where

CLG = syngas produced due to crude oil manufactured in a combined coal conversion plant in year I

SCCLG = syncrude produced in combined coal conversion plants in year I, Equation III-25

CLC = refined coal produced due to crude oil manufactured in a combined coal conversion plant in year I

$\frac{0.323}{0.604}$ = ratio of syngas to syncrude production, Table III-7

$\frac{0.073}{0.604}$ = ratio of refined coal to syncrude production, Table III-7

The synthetic natural gas and refined coal produced due to syncrude production provide a feedback reducing the syngas and coal requirements. The coal required for syncrude production is given by using Equation III-24 and III-25.

$$SCFR(I) = SCCL/0.85 + SCCLG/(0.604x0.738) \quad (III-28)$$

where

SCFR(I) = coal required for syncrude production in year I

and 0.85 and 0.738 are the efficiencies of coal conversion to syncrude given in Table III-7.

Nuclear Fuel Cycles

Each nuclear reactor type and even each individual nuclear reactor has its own fuel cycle. A typical nuclear fuel cycle consists of the following steps: mining, milling, chemical preparation, conversion, gaseous diffusion cascade enrichment, conversion, fuel pellet manufacturing, fuel element fabrication, reactor burn-up, chemical reprocessing and

conversion. Each step in the fuel cycle has a recovery efficiency associated with it. The overall efficiency, the initial core loading, and the equilibrium fuel cycle are used to determine the U_3O_8 and the ThO_2 requirements for each reactor type, Table III-8.

The U_3O_8 requirements for reactor type J in year I are given by

$$TU3O8(J) = U3O8UD(I,J) \times XXBED(J) \qquad \text{(III-29)}$$

where

TU3O (J) = metric tons of U_3O_8 required for reactor type J in year I

U3O8UD(I,J) = tonnes of U_3O_8 required per million Btu thermal power produced by reactor type J in year I

XXBED(J) = total thermal power production for reactor type J in year I

The ThO_2 requirements for reactor type J in year I are given by

$$TTHO2(J) = THO2UD(I,J) \times XXBED(J) \qquad \text{(III-30)}$$

where

TTHO2(J) = metric tons of ThO_2 required for reactor type J in year I

THO2UD(I,J) = tonnes of ThO_2 required per million Btu thermal power produced by reactor type J in year I, Table III-8

XXBED(J) = total thermal power production for reactor type J in year I

Using Equations III-29 and III-30, the total ThO_2 and U_3O_8 requirements for year I are given by

TABLE III-8

NUCLEAR POWER PLANT CHARACTERISTICS

Reactor Design	Year Introduced	Thermal Effic. %	Fuel Cycle	Net U_3O_8 *	Net ThO_2 **
GCFR (70)[+]	2000	0.395	Pu in Th	--	--
GCFR (70)	2020	0.398	Pu in Th	--	--
HTGR (72)	1978	0.407	UC-ThC U-233 recycle	1.63	0.351
LFR (65)	2020	0.50	D-T pellets	--	--
LMFBR (73)	1990	0.40	Pu oxide	--	--
LMFBR (73)	2000	0.42	Pu oxide	--	--
LMFBR (73)	2010	0.371	Pu carbide	--	--
LMFBR (73)	2020	0.392	Pu carbide	--	--
LWR (70)	1970	0.325	Enriched U.	2.85	--
LWR (70)	1980	0.325	Pu in nat. U.	2.25	--
LWR (70)	1990	0.325	Pu in nat. U.	1.54	--
MCFR (65)	2020	0.50	D-T	--	--
MSBR (55)	2000	0.44	Pu in Th	--	0.417

*Units: 10^{-6} tonnes/10^6 Btu thermal at 0.25 percent tails.

**Units: tonnes/10^6 Btu thermal.

[+]Numbers refer to references in Bibliography.

$$TTHO2 = \sum_{J} TTHO2(J) \qquad \text{(III-31)}$$

and

$$TTU3O8 = \sum_{J} TU3O8(J) \qquad \text{(III-32)}$$

respectively.

Resource Production and Availability

The projected energy demands on each of the energy resource bases--geothermal, uranium, thorium, hydroelectric, coal, petroleum, natural gas, tidal, wind and solar--must be balanced with its projected production or utilization capacity. If a short fall occurs, then an alternate resource or synthetic fuel must be used. Estimated ultimate United States energy reserves, Table III-9, are based on the fuel heating values used in References 7, 43, 83 and 84.

Geothermal

Possible geothermal energy resources are classified as either hot rock, hot fluid or hot vapor systems. Areas where the energy contained in rock and contained fluids is thermodynamically and economically available for utilization are most generally found along the edges of continental plates and occur in association with volcanism and recent mountain building. Geothermal energy can be used for process steam, space heating and most importantly for electrical power generation. The projected development of geothermal energy for electrical power generation is shown in Figure III-15. Present technology hot vapor geothermal power plants operate at approximately 14.3 percent efficiency (67).

TABLE III-9

ULTIMATE U.S. ENERGY RECOVERABLE RESERVES
(INCLUDING ALASKA)

Resource	Ultimate Reserve 10^{15} Btu		Reference
coal (50% recovery)	10,296.		(7)
crude petroleum	1493.5		(7)
natural gas liquids	180.6		(7)
natural gas	1465.		(7)
oil shale (@ 60%)	6786.0	(coal 1)	(7, 68)
tar sands (@ 35%)	32. - 51.		(7)
geothermal	70. - 130.		(86)

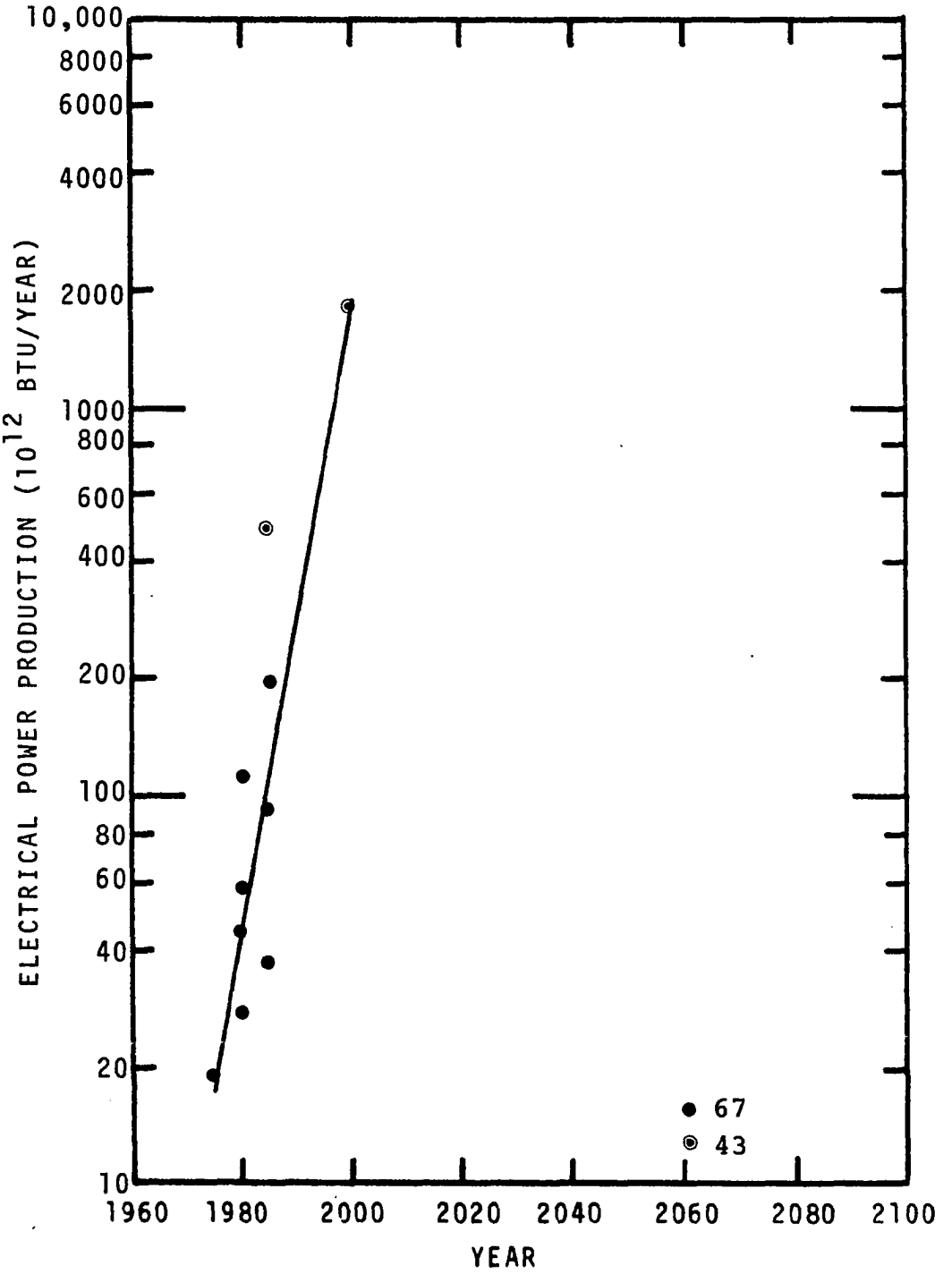


Figure III-15. Projected Annual Geothermal Electrical Power Production.

Hydroelectric

United States hydroelectric power will be essentially fully developed by the year 2000 as shown in Figure III-16. The efficiency of hydroelectric power production is assumed to be 76 percent (22).

Nuclear Fuels

Nuclear fuel resources include uranium, thorium, lithium, deuterium and tritium. Potential conventional uranium resources in the United States are estimated to be 650,000 tons of U_3O_8 produceable at $10.00 or less per pound (25, 74) with a total uranium resource base of approximately 1,600,000 tons (68). If by-product uranium is included, the $10.00 resource is 1,900,000 tons of U_3O_8 and total resource base is 7,600,000 tons of U_3O_8 recoverable at $20.00 or less per pound of U_3O_8 (68). The energy model assumes that the U_3O_8 price will rise so that enough U_3O_8 can be economically produced to meet the U_3O_8 demand.

Potential United States thorium resources are estimated to be approximately 250,000 tons of ThO_2 (83, 84). The energy model assumes that the ThO_2 price will rise so that enough ThO_2 can be economically produced to meet the ThO_2 demand.

Coal

Based on a recovery factor of 50 percent and using an economic cutoff on bed thickness of 28 inches for bituminous

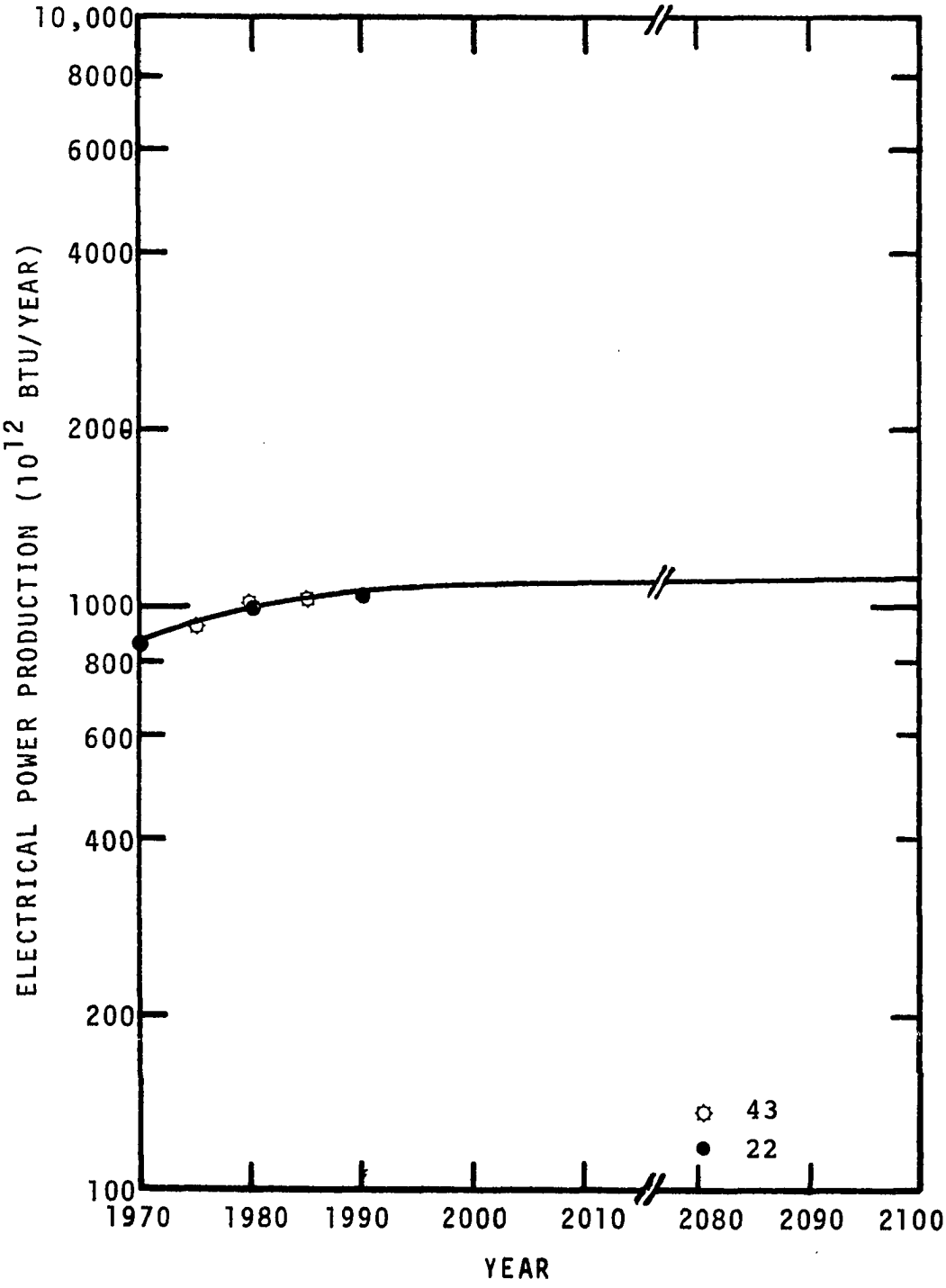


Figure III-16. Projected Annual Hydroelectric Electrical Power Production.

coal and 5 feet for subbituminous coal and lignite, approximately 390 billion short tons, 10,296 x 10^{15} Btu, of coal are recoverable within 1000 feet of the surface (68, 87). Coal has the most complicated energy demand of all resources. Coal can be used directly as an end utilization fuel, it can be used to generate electricity, refine petroleum, make synthetic fuels, and it can be converted into synthetic natural gas and synthetic crude petroleum. The sum of all of these coal demands is the annual coal production requirements. It is assumed that the price of coal will rise so that all of the coal fuel demands can be filled.

Solar, Tidal and Wind

Three of the more exotic energy resources--solar, tidal, and wind--are included in the model. They may be used for any of the end utilization demands or at any step in the model's energy scheme as shown in Figure III-1.

Most likely tidal power will only be used for electrical power generation with the maximum United States potential capacity of 100 gigawatts (64). Wind may be used directly as in wind driven pumps, mills, etc., or may be used to generate electricity (64). Solar energy may be used to generate electricity, or it may be used directly to fulfill space heating, water heating, etc., end utilization demands.

Natural Gas

The natural gas energy demands are filled by domestic

natural gas production, synthetic natural gas from petroleum and coal, Canadian pipeline imports and liquefied natural gas imports.

Domestic natural gas production: The domestic natural gas production was projected using the general equation developed by Elliott and Turner (20)

$$CDNGP(I) = \frac{UDNGR}{1 + \exp[b(I+c) - \exp[a(I+K)]]} \qquad \text{(III-33)}$$

where

CDNGP(I) = cumulated domestic natural gas production in year I in trillion Btu

UDNGR = ultimate recoverable domestic natural gas reserves, Table III-7

a,b,c,k = constants determined by regression analysis of cummulative and annual production data

Using the ultimate domestic natural gas reserves of DeGolyer and McNaughton (17) and Elliott (19): 1,465,000 trillion Btu, adjusted cumulated production (1, 17, 37, 53) and non-linear regression analysis the constants for Equation III-33 are

$$a = -0.07234$$

$$b = -1984.1$$

$$c = -0.006899$$

$$k = -1540.5$$

The annual production of domestic natural gas is given by

$$ADNGP(I) = CDNGP(I) - CDNGP(I-1) \qquad \text{(III-34)}$$

where

ADNGP(I) = annual domestic natural gas production in year I

CDNGP(I) = cumulated domestic natural gas production in year I

The projected domestic natural gas production is shown in Figure III-17. Domestic natural gas production must be corrected for extraction losses and plant fuel use. The extraction losses and plant fuel use (excluding transmission losses) reduce the domestic natural gas production to 0.90374 of the gross natural gas production (82).

$$DNGP(I) = 0.90374 \times ADNGP(I) \quad \text{trillion Btu/year} \qquad \text{(III-35)}$$

where

DNGP(I) = corrected domestic natural gas production in year I

The corrected gas demand, CORGD, from Equation III-8, the net domestic natural gas production, DNGP(I), from Equation III-35, and the by-product syngas from coal liquefaction, CLG, from Equation III-26 were used to determine the amount of natural gas, GASREQ, which must be supplied by synthetic natural gas, Canadian pipeline imports and liquefied natural gas

$$GASREQ = CORGD - [DNGP(I) + CLG] \qquad \text{(III-36)}$$

Canadian pipeline gas: The amount of natural gas imports from Canada in gas pipelines, CGPLI, is

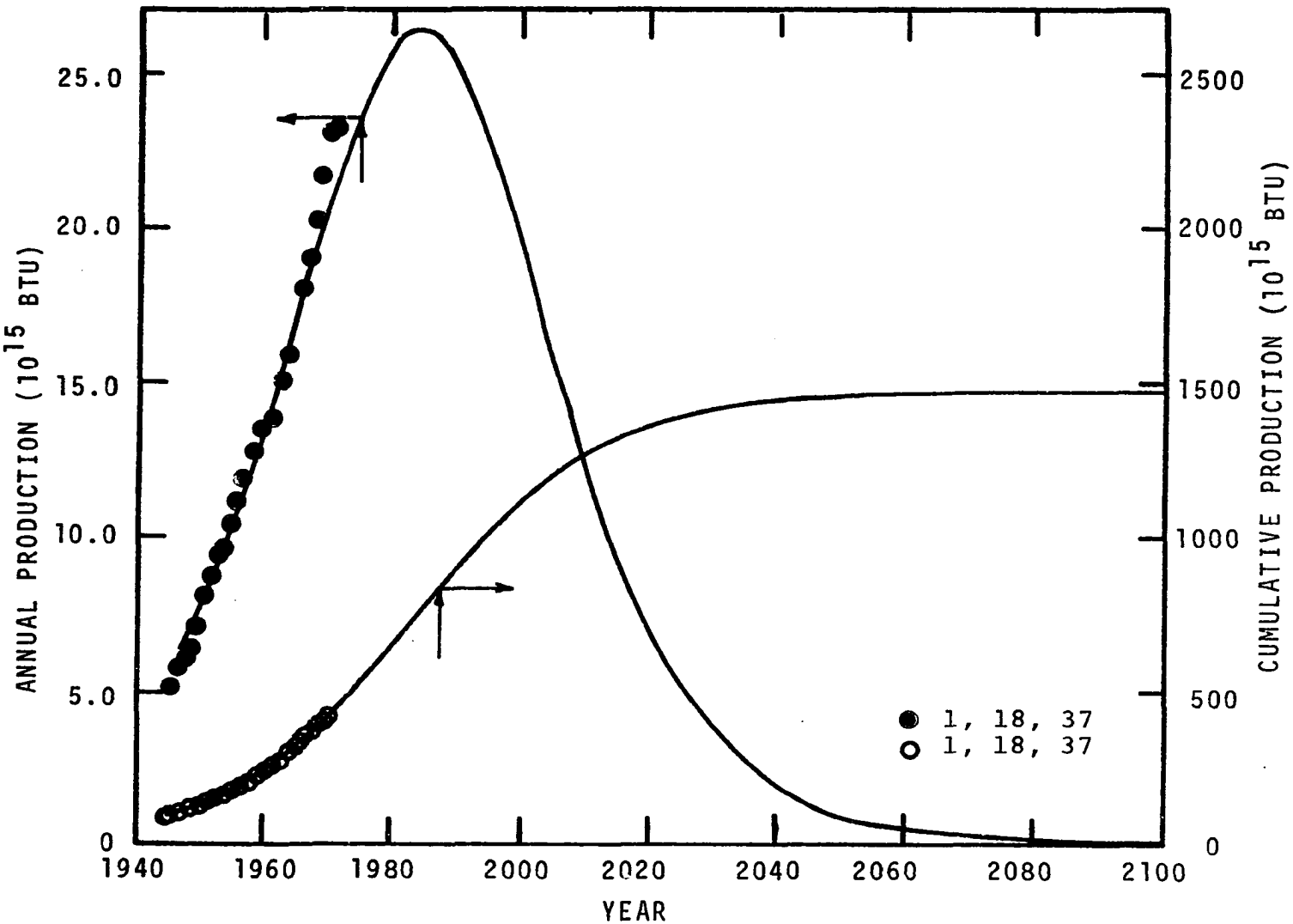


Figure III-17. Projected Domestic Natural Gas Production.

$$CGPLI = CGPLIF(I) \times GASREQ \qquad \text{(III-37)}$$

where

CGPLIF(I) = projection fraction of gas demand exceeding net domestic production supplied by Canadian pipeline imports in year I

Liquefied natural gas: The amount of liquefied natural gas imports in year I, LNGI, is given by

$$LNGI = LNGF(I) \times GASREQ \qquad \text{(III-38)}$$

where

LNGF(I) = projected fraction of gas demand exceeding domestic production supplied by LNG imports in year I

Synthetic natural gas: The amount of synthetic natural gas manufactured in year I is given by Equation III-21. The energy demand for syngas manufacturing is converted to a petroleum and/or coal resource demand using Equation III-22.

The following constraints are applied to the natural gas resource demands:

$$CGPLIF(I) + LNGF(I) + SGASF(I) = 1.0 \qquad \text{(III-39)}$$

and

$$SGASR + LNGI + CGPLI + DNGP(I) + CLG = CORGD \qquad \text{(III-40)}$$

Crude Petroleum and Natural Gas Liquids

The petroleum energy demands are filled by domestic production of crude petroleum and natural gas liquids, oil

shale, tar sands, syncrude from coal, and crude oil imports.

Domestic production of crude petroleum and natural gas liquids: Domestic natural gas liquids production is given by Equation III-33, the domestic natural gas production constants, and the ultimately recoverable natural gas liquids reserve. The ultimately recoverable natural gas liquids reserve is 180,600 trillion Btu (17, 19). Therefore,

$$CDNGLP(I) = \frac{180,600}{1 + \exp[b(I+c) - \exp[a(I+k)]]} \qquad \text{(III-41)}$$

where

CDNGLP(I) = cumulated domestic natural gas liquid production in year I in trillion Btu

a = -0.07234

b = -1984.1

c = -0.006899

k = -1540.5

Using the results of Equation III-41, the annual natural gas liquids production is given by

$$ADNGLP(I) = CDNGLP(I) - CDNGLP(I-1) \qquad \text{(III-42)}$$

The cumulated and annual natural gas liquids production is shown in Figure III-18.

The cumulated domestic crude petroleum production is given by

$$CDCPP(I) = \frac{UDCPR}{1 + \exp[e(I+f) - \exp[d(I+g)]]} \qquad \text{(III-43)}$$

where

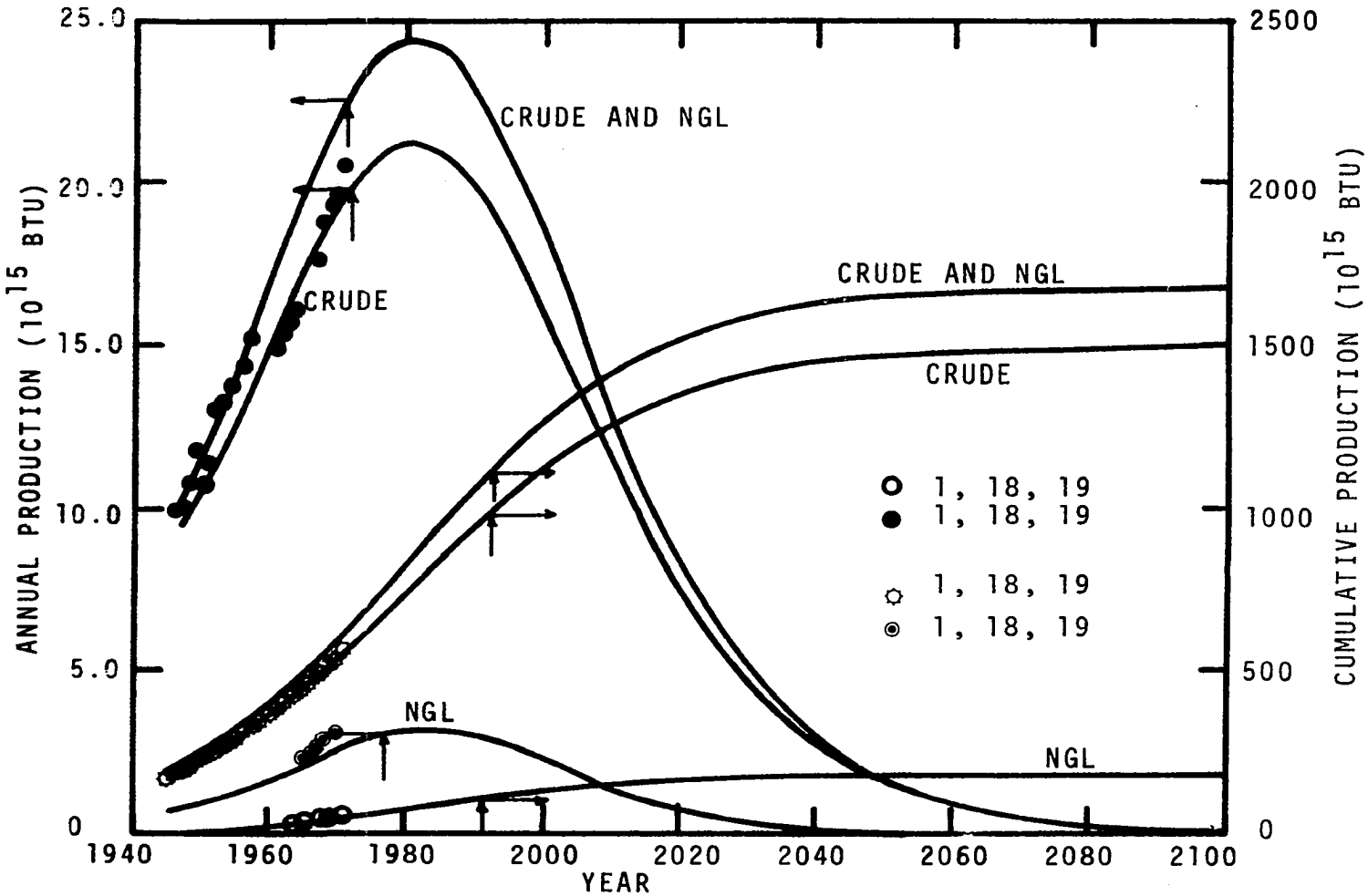


Figure III-18. Projected Cumulated and Annual Crude Petroleum and Natural Gas Liquids Production.

CDCPP(I) = cumulated domestic crude petroleum production in year I

UDCPR = ultimate domestic crude petroleum reserves, Table III-9

d,e,f,g = constants determined from cumulative and annual production data

Using the ultimate domestic crude petroleum reserve of De Golyer and McNaughton (17) and Elliott (19) (1493.5 trillion Btu), the cumulated production (1, 18, 19), and non-linear regression analysis, the constants for Equation III-43 are

$$d = -0.054$$

$$e = -2005$$

$$f = +0.002$$

$$g = -1835.2$$

Using the results of Equation III-43, the annual domestic crude petroleum production is given by

$$ADCPP(I) = CDCPP(I) - CDCPP(I-1) \qquad \text{(III-44)}$$

The cumulated and annual domestic crude petroleum from Equations III-43 and III-44 were added to the cumulated and annual natural gas liquids production, Equations III-41 and III-42, to obtain the projected total petroleum energy production in year I, Figure III-18.

$$CTPP(I) = CDCPP(I) + CDNGLP(I) \qquad \text{(III-45)}$$

where

CTPP(I) = cumulated total petroleum production in year I in trillion Btu

$$DCP(I) = ADCPP(I) + ADNGLP(I) \qquad \text{(III-46)}$$

where

DCP(I) = annual total petroleum production in year I in trillion Btu/year

The crude petroleum demand, CTS, from Equation III-16, and the domestic crude production, DCP(I), from Equation III-46, are used to determine the amount of crude oil, PETREQ, which must be supplied by tar sands, oil shale, oil imports and syncrude production.

$$PETREQ = CTS - DCP(I) \qquad \text{(III-47)}$$

Oil Shale: The amount of oil shale production required in year I, OS, is given by

$$OS = OSF \times PETREQ \qquad \text{(III-48)}$$

where

OSF = fraction of crude petroleum demand exceeding domestic supply to be supplied by oil shale reserves

The environmental effects of oil shale production are also determined (see the environmental effects section).

Tar sands: The amount of tar sands production required in year I, TS, is given by

$$TS = TSF \times PETREQ \qquad \text{(III-49)}$$

where

TSF = fraction of crude petroleum demand exceeding domestic supply to be supplied by tar sands reserves

The environmental effects of tar sands production are also determined (see the environmental effects section).

Crude oil imports: The amount of oil imports required in the year I, OI, is given by

$$OI = OIF \times PETREQ \qquad \text{(III-50)}$$

where

OIF = projected fraction of crude petroleum demand exceeding domestic supply to be supplied by oil imports

Synthetic crude oil: The amount of synthetic crude oil required in the year I is given by Equation III-23. The coal resource demands created by coal liquefaction is given by Equation III-28.

The following constraints are applied to crude oil resource demands:

$$SCF + OSF + TSF + OIF = 1.0 \qquad \text{(III-51)}$$

$$DCP(I) + OS + TS + OI + SC = CTS \qquad \text{(III-52)}$$

Environmental Impacts

The impact of basic energy resources and of technology alternatives on the environment is determined for each individual step in the energy utilization scheme: production,

transmission, conversion, storage and end utilization. At each step, airborne pollution indices are assigned for carbon dioxide, carbon monoxide, sulfur dioxide, nitrogen oxides, hydrocarbons, aldehydes and particulates. The amount of solid waste and elemental sulfur produced and the land-use requirements are also determined. Thermal pollution and cooling water requirements are obtained for once-through, forced or natural convection cooling towers, spray ponds, cooling ponds, or dry air cooling alternatives. The amount of tritium and krypton-85 released to the environment is determined as is the amount of radioactive solid waste produced. Also the total annual population exposure to ionizing radiation is determined.

Airborne Emissions

The airborne emissions in tons/year for each index is determined for each step in the energy utilization scheme, Figure III-1. The airborne emissions which occur at the end utilization step are separated into residential, commercial, industrial and transportation emission sources.

Residential: The airborne emissions are determined, for each of the six residential source categories: space heating, water heating, air conditioning, cooking, refrigeration and miscellaneous. In general, the airborne emissions for each category of residential use for emission index, K, and year, I, in tons per year is given by

$$APREU(K) = 500 \times \sum_{J} [PIR(K,J) \times REUD(J) \times SCON(I,J,K)] \qquad \text{(III-53)}$$

where

APREU(K) = airborne emissions of index K in year I due to this residential end use

PIR(K,J) = residential airborne emission factor for index K and fuel J, Table III-10

REUD(J) = residential end use demand for fuel J in year I, Equation III-2

SCON(I,J,K) = sulfur content of fuel J in year I in percent, Table III-11

K = 1, 2,...7 for CO_2, CO, SO_2, NO_x, particulates, hydrocarbons and aldehydes respectively

Then the total residential airborne emission for index K in year I is:

$$APRT(K) = APRSH(K) + APRWH(K) + APRAC(K) + APRC(K) + APRR(K) + APRM(K) \qquad \text{(III-54)}$$

where

APRT(K) = total airborne emission of index K in tons/year due to residential energy consumption

APRSH(K) = airborne emission of index K in year I due to residential space heating

APRWH(K) = airborne emission of index K in year I due to residential water heating

APRAC(K) = airborne emission of index K in year I due to residential air conditioning

APRC(K) = airborne emission of index K in year I due to residential cooking

APRR(K) = airborne emission of index K in year I due to residential refrigeration

TABLE III-10

RESIDENTIAL AIRBORNE EMISSION FACTORS (89)
($lb/10^6$ Btu)

Fuel Type	CO_2	CO	SO_2*	NO_x	Particulate	Hydrocarbon	Aldehyde
Electricity	--	--	--	--	--	--	--
Natural gas	120	0.02	0.0006	0.05	0.019	0.008	0.01
Distillate Oil	170	0.036	1.024S	0.086	0.072	0.0216	0.0144
Residual Oil	170	0.036	1.024S	0.086	0.072	0.0216	0.0144

*S = percent sulfur in fuel.

TABLE III-11

SULFUR CONTENT OF NON-TRANSPORTATION FUELS (46)

Fuel	Year	Percent Sulfur
1 (coal)	1970	2.8
1 (coal)	1980+	0.83
14 (distillate oil)	1970	0.6
14 (distillate oil)	1980+	0.6
15 (residual oil)	1970	2.253
15 (residual oil)	1980+	0.75

APRM(K) = airborne emission of index K in year I due to residential miscellaneous

Commercial: The airborne emissions are determined for each of the six commercial source categories: space heating, water heating, air conditioning, cooking, refrigeration and miscellaneous. In general, the airborne emission for each category of commercial use for emission index K, fuel type J, and year I, in tons per year is given by

$$APCEU(K) = 500 \times \sum_{J} [PIC(K,J) \times CEUD(J) \times SCON(I,J,K)] \quad \text{(III-55)}$$

where

APCEU(K) = airborne emission of index K in year I due to commercial end use

PIC(K,J) = commercial airborne emissions factor for index K and fuel J, Table III-12

CEUD(J) = commercial end use demand for fuel J in year I, Equation III-3

SCON(I,J,K) = sulfur content of fuel J in year I in percent, Table III-11

Then the total commercial airborne emission for index K in year I is:

$$APCT(K) = APCSH(K) + APCWH(K) + APCAC(K) + APCC(K) + APCR(K) + APCM(K) \quad \text{(III-56)}$$

where

APCT(K) = total airborne emission of index K in tons/year due to commercial energy consumption

APCSH(K) = airborne emission of index K in year I due to commercial space heating

TABLE III-12

COMMERCIAL AIRBORNE EMISSION FACTORS (89)

Fuel Type	CO_2	CO	SO_2*	NO_x	Particulate	Hydrocarbon	Aldehyde
coal	224.	0.378	1.4394S	0.227	0.1515	0.1136	0.000189
electricity	--	--	--	--	--	--	--
natural gas	122	0.020	0.0006	0.10	0.019	0.008	0.01
distillate oil	170	0.00144	1.024S	0.288	0.108	0.0216	0.0444
residual oil	170	0.00134	1.049S	0.267	0.1536	0.02	0.00668

*S = percent sulfur in fuel.

APCWH(K) = airborne emission of index K in year I due to commercial water heating

APCAC(K) = airborne emission of index K in year I due to commercial air conditioning

APCC(K) = airborne emission of index K in year I due to commercial cooking

APCR(K) = airborne emission of index K in year I due to commercial refrigeration

APCM(K) = airborne emission of index K in year I due to commercial miscellaneous

Industrial: The airborne emissions are determined for each of the sixteen industrial souce categories: alumina, primary aluminum, secondary aluminum, cement, caustic soda and chlorine, primary copper, refined copper, primary magnesium, secondary magnesium, primary zinc, secondary zinc, pig iron, steel, petrochemicals and other raw materials and miscellaneous usage.

In general the airborne emissions for each category of industrial use for emission index K, fuel type J, and year I in tons per year is given by:

$$APIEU(K) = 500 \times \sum_{J} [PII(K,J) \times IEUD(J) \times SCON(I,J,K)] \qquad \text{(III-57)}$$

where

APIEU(K) = airborne emission of index K in year I due to industrial energy end use

PII(K,J) = industrial airborne emission factor for index K and fuel J, Table III-13

IEUD(J) = industrial end use demand for fuel J in year I, Equation III-6

TABLE III-13

INDUSTRIAL AIRBORNE EMISSION FACTORS (89)
($lb/10^6$ Btu)

Fuel Type	CO_2	CO	SO_2*	NO_x	Particulate	Hydrocarbon	Aldehyde
coal	224.	0.0758	1.4394S	0.5682	1.7235	0.0379	0.00189
natural gas	122	0.0004	0.0006	0.12	0.018	0.04	0.003
distillate oil	170	0.00144	1.024S	0.288	0.108	0.0216	0.0144
residual oil	170	0.00134	1.049S	0.267	0.1536	0.02	0.00668

*S = percent sulfur in fuel.

SCON(I,J,K) = sulfur content of fuel J in year I in percent, Table III-11

Using Equation III-57 and adding the airborne emissions due to the production process yields the airborne emissions for emission index K in year I:

$$APIEUT(K) = APIEU(K) + 500 \times APIEU(N,K) \times IEUP(I) \quad \text{(III-58)}$$

where

APIEUT(K) = airborne emission of index K in tons/year due to industrial material production and energy end use

APIEU(K) = from Equation III-57

APIEU(N,K) = industrial production air emission index for emission index K. If N = 1 then uncontrolled emissions; if N = 2 then controlled emissions, Table III-14

IEUP(I) = industrial production of this commodity, Equation III-5

The total industrial airborne emission for index K in year I is:

$$\begin{aligned} APIT(K) = {} & APALT(K) + APALPT(K) + APALST(K) + APCET(K) \\ & + APCHT(K) + APCUPT(K) + APCURT(K) + APMGPT(K) \\ & + APMGST(K) + APZNPT(K) + APZNST(K) + APPIT(K) \\ & + APIMET(K) + APIMFT(K) + APIRMT(K) + APSTT(K) \end{aligned} \quad \text{(III-59)}$$

where

APALT(K) = airborne emission of index K in year I due to alumina production

APALPT(K) = airborne emission of index K in year I due to primary aluminum production

TABLE III-14

INDUSTRIAL PRODUCTION AIRBORNE EMISSION FACTORS (89)

(lb/ton product)*

Product	CO_2	CO	SO_2	NO_x	Particulate	Hydrocarbon	Aldehyde
alumina	--	--	--	--	10./10.	--	--
aluminum--primary	--	--	--	--	80./80.	--	--
aluminum--secondary	--	--	--	--	4.3/1.3	--	--
cement**	--	--	--	--	54./4.	--	--
chlorine	--	--	--	--	--	--	--
copper--primary	--	--	312./31.2	--	34./3.	--	--
copper--refined	--	--	--	--	65./3.25	--	--
magnesium--pri.	--	--	--	--	4./.4	--	--
magnesium--sec.	--	--	--	--	4./.4	--	--
pig iron	2750/2750	44/44	3./3.	--	192./4.	--	--
steel--BOF	--	--	3./3.	--	46./.92	--	--
steel-electric	--	18/18	.2/.2	--	11./.22	--	--
steel-open hearth	--	--	--	.1/.1	22./.44	--	--

*uncontrolled emission/controlled emission.

**16/376 lb-bbl product.

APALST(K) = airborne emission of index K in year I due to secondary aluminum production

APCET(K) = airborne emission of index K in year I due to cement production

APCHT(K) = airborne emission of index K in year I due to chlorine production

APCUPT(K) = airborne emission of index K in year I due to primary copper production

APCURT(K) = airborne emission of index K in year I due to refined copper production

APMGPT(K) = airborne emission of index K in year I due to primary magnesium production

APMGST(K) = airborne emission of index K in year I due to secondary magnesium production

APZNPT(K) = airborne emission of index K in year I due to primary zinc production

APZNST(K) = airborne emission of index K in year I due to secondary zinc production

APPIT(K) = airborne emission of index K in year I due to pig iron production

APIMET(K) = airborne emission of index K in year I due to industrial miscellaneous electrical usage

APIMFT(K) = airborne emission of index K in year I due to industrial miscellaneous fossil fuel use

APIRMT(K) = airborne emission of index K in year I due to industrial raw material use

APSIT(K) = airborne emission of index K in year I due to steel production

Transportation: The airborne emissions are determined for each of the six transportation source categories: airplane, automobile, bus, railroad, ship and truck. In general, the airborne emission for each category of transportation use

for emission index K and year I in tons/year is given by:

$$APTEU(K) = 500 \times \sum_{J} [PIT(I,K,J) \times TEUD(J) \times TSCON(I,J,K)] \quad \text{(III-60)}$$

where

APTEU(K) = airborne emission of index K in year I due to transportation end use

PIT(I,K,J) = transportation airborne emission factor for index K, fuel J, and year I, Table III-15

TEUD(J) = transportation end use demand for fuel J in year I, Equation III-7

TSCON(I,J,K) = sulfur content of transportation fuel J in year I in percent, Table III-16

The total transportation airborne emission for index K in year I is:

$$APTT(K) = APAP(K) + APAU(K) + APRRR(K) + APS(K) + APT(K) + APB(K) \quad \text{(III-61)}$$

where

APTT(K) = total airborne emission of index K in tons/year due to transportation energy consumption

APAP(K) = airborne emission of index K in year I due to airplane transportation

APAU(K) = airborne emission of index K in year I due to automobile transportation

APRRR(K) = airborne emission of index K in year I due to railroad transportation

APS(K) = airborne emission of index K in year I due to ship (or barge) transportation

APT(K) = airborne emission of index K in year I due to truck transportation

APB(K) = airborne emission of index K in year I due to bus transportation

TABLE III-15

TRANSPORTATION AIRBORNE EMISSION FACTORS (6, 58, 89)

(lb/million Btu)

Demand Type	Fuel Type	CO_2	CO	SO_2	NO_x	Particulates	Hydrocarbons	Aldehydes
Airplane	Hydrogen	--	--	--	0.0276	--	--	--
	Gasoline	149.	1.070	0.082	0.206	0.324	0.7	0.021
	Jet fuel	149.	1.070	0.082	0.206	0.329	0.7	0.021
	Methanol	149.	0.135	--	0.0064	--	0.0277	--
Automobile (1970)	Gasoline	149.	17.08	0.04	1.46	0.071	2.992	0.021
Automobile	Hydrogen	--	--	--	0.0276	--	--	--
	Gasoline	149.	0.78	0.04	0.092	0.071	0.094	0.021
	Methanol	149.	0.135	--	0.0064	--	0.0277	--
	Electricity	--	--	--	--	--	--	--
Bus	Hydrogen	--	--	--	0.0276	--	--	--
	Gasoline	149.	0.78	0.04	0.092	0.071	0.094	0.021
	Distillate oil	170.	0.77	0.194	1.32	0.094	0.590	0.022
	Methanol	149.	0.135	--	0.0064	--	0.0277	--
Railroad	Hydrogen	--	--	--	0.0276	--	--	--
	Distillate oil	170.	0.77	0.194	1.32	0.094	0.590	0.022
	Methanol	149.	0.135	--	0.0064	--	0.0277	--
Ships	Hydrogen	--	--	--	0.0276	--	--	--
	Distillate oil	170.	0.77	0.194	1.32	0.094	0.590	0.022

TABLE III-15--Continued

Demand Type	Fuel Type	CO_2	CO	SO_2	NO_x	Particulates	Hydrocarbons	Aldehydes
Ships	Residual oil	170.	0.00134	1.049S*	0.267	0.1536	0.020	0.00668
	Methanol	149.	0.135	--	0.0064	--	0.0277	--
Truck	Hydrogen	--	--	--	0.0276	--	--	--
	Gasoline	149.	0.78	0.04	0.092	0.071	0.094	0.021
	Distillate oil	170.	0.77	0.194	1.32	0.094	0.590	0.022
	Methanol	149.	0.135	--	0.0064	--	0.0277	--

*S = percent sulfur in fuel.

TABLE III-16

SULFUR CONTENT OF TRANSPORTATION FUELS (46)

Fuel	Year	Percent Sulfur
Coal	1970	2.8
Coal	1980+	0.83
Distillate oil	1970	1.0
Distillate oil	1980+	1.0
Residual oil	1970	2.253
Residual oil	1980+	0.75

Total end utilization: Using Equations III-54, III-56, III-59 and III-61, the total airborne emissions for end utilization use of energy resources for emission index K in year I is:

$$TAPEU(K) = APRT(K) + APCT(K) + APIT(K) + APTT(K) \quad \text{(III-62)}$$

Electrical generation: The airborne emissions from electrical generation plants are given by:

$$APEGT(K,J) = 500 \times [PIEG(I,K,J) \times ELGD(J) \times SCON(I,J,K)] \quad \text{(III-63)}$$

and

$$APEGT(K) = \sum_{J} APEG(K,J) \quad \text{(III-64)}$$

where

APEG(K,J) = airborne emission for index K in year I for fuel J due to electrical power generation

APEGT(K) = total airborne emission for emission index K in year I due to electrical power generation

PIEG(I,K,J) = electrical generation airborne emission factor for fuel J in year I for index K, Table III-17

ELGD(J) = electrical generation thermal power requirements for fuel J in year I, Equation III-15

SCON(I,J,K) = sulfur content of fuel J in year I, Table III-11

Synthetic fuels: The airborne emissions due to synthetic fuel manufacturing are given by:

$$APMETH(K) = 500 \times PIMETH(K) \times MED \text{ tons/year} \quad \text{(III-65)}$$

TABLE III-17

ELECTRICAL GENERATION AIRBORNE EMISSION FACTORS (89)*

Fuel	CO_2	CO	SO_2**	NO_x	Particulate	Hydrocarbon	Aldehyde
coal, 1970	224	0.0379	1.4394S	0.6818	0.9848	0.0136	0.00189
coal, 1980+	224	0.0379	1.2S	0.07	0.020	0.0136	0.00189
natural gas, 1970	122	0.004	0.0006	0.370	0.0150	0.04	0.003
natural gas, 1980+	122	0.004	0.0006	0.20	0.015	0.040	0.0030
distillate oil, 1970	170	0.000267	1.0488S	0.701	0.053	0.0134	0.0067
distillate oil, 1980+	170	0.000267	0.8S	0.30	0.054	0.0134	0.0067
residual oil, 1970	170	0.000267	1.0488S	0.701	0.053	0.0134	0.0067
residual oil, 1980+	170	0.000267	0.80S	0.30	0.054	0.0134	0.0067

*Units: lb/million Btu.

**S = percent sulfur in fuel.

where

APMETH(K) = total airborne emission of index K in year I due to methanol production

PIMETH(K) = airborne emission factor for index K in year I, Table III-18

MED = methanol demand in trillion Btu/year in year I

Methanol production is the only contributor to airborne pollution. It is assumed that the airborne emissions from electrolytic hydrogen and ammonia facilities are negligible.

Petroleum refining: The airborne emissions from petroleum refineries are given by:

$$APPR(K,J) = PIPR(K,J) \times PRD(J) \times 500 \times PSCON(I,J,K) \quad \text{(III-66)}$$

$$APPRT(K) = APPR(K,J) + PIPRS(K) \times CTS \quad \text{(III-67)}$$

where

APPR(K,J) = airborne emission of index K for fuel J due to petroleum refining energy consumption in year I

APPRT(K) = total airborne emission of index K in year I due to petroleum refining

PIPR(K,J) = petroleum refining emission factor for fuel J and index K, Table III-19

PRD(J) = energy demand of refineries for fuel J in year I, Equation III-17

PSCON(I,J,K) = sulfur content of petroleum refinery fuels for fuel J in year I

PIPRS(K) = airborne emissions due to petroleum refining operations, Table III-19

TABLE III-18

METHANOL PRODUCTION AIRBORNE EMISSION FACTORS*

Factor	$lb/10^6$ Btu
CO_2	87.2
CO	--
SO_2	--
NO_x	--
Particulate	--
Hydrocarbon	4.95
Aldehyde	--

*Extrapolated from coal gasification emissions, Table III-7, using overall process efficiency ratios.

TABLE III-19

PETROLEUM REFINING AIRBORNE EMISSION FACTORS (6, 89)

Fuel	CO_2	CO	SO_2	NO_x	Particulate	Hydrocarbons	Aldehyde
Coal	224	0.0758	1.4394S*	0.5682	1.7235	0.0379	0.000189
Natural gas	122	0.00040	0.00060	0.120	0.018	0.040	0.003
LPG	122	0.00040	0.00060	0.120	0.018	0.040	0.003
Refinery gas	122	0.00040	0.00060	0.120	0.018	0.040	0.003
Petroleum coke	224	0.0758	1.4394S	0.5682	1.7235	0.0379	0.000189
Residual oil	170	0.00134	1.049S	0.267	0.1531	0.020	0.00668
Refining	--	0.634	0.0212	0.0025	0.0028	0.0242	0.0011

*S = percent sulfur in fuel.

CTS = crude to stills, Equation III-16

Syngas and syncrude: The airborne emissions due to synthetic natural gas production from petroleum and coal are given by

$$APSG(K,J) = 500 \times PISG(K,J) \times SGASR \times SGASFF(I,J) \quad \text{(III-68)}$$

and

$$APSGT(K) = APSG(K,J) \quad \text{(III-69)}$$

where

APSG(K,J) = airborne emissions of index K for fuel J due to SNG production in year I

APSGT(K) = total airborne emissions of index K due to SNG production in year I

PISG(K,J) = SNG production airborne emissions factor for index K and fuel J, Table III-7 and III-20

SGASR = SNG requirements in year I, from Equation III-21

SGASFF(I,J) = SNG fuel fraction for fuel J in year I

The airborne emissions due to synthetic crude petroleum production from coal are given by

$$APSCT(K) = 500 \times [PISCL(K) \times SCCL + PISCLG(K) \times SCCLG] \quad \text{(III-70)}$$

where

APSC(K) = airborne emission of index K in year I due to syncrude production

PISCL(K) = syncrude airborne emission factor for coal liquefaction plant for emission index K and fuel J, Table III-7

TABLE III-20

PETROLEUM GASIFICATION AIRBORNE EMISSION FACTORS

Fuel Type	CO_2	CO	SO_2	NO_x	Particulate	Hydrocarbons	Aldehydes
Naptha	58.6	--	--	--	--	--	--
Light oil	59.3	--	--	--	--	--	--
Heavy oil and crude oil	63.5	--	--	--	--	--	--

PISCLG(K) = syncrude airborne emission factor for a combined coal gasification and liquefaction plant for emission index K and fuel J, Table III-7

SCCL = syncrude produced in a coal liquefaction plant in year I

SCCLG = syncrude produced in a combined coal conversion plant in year I

Therefore, by using the results of Equations III-62, III-64, III-65, III-67, III-69 and III-70, the total airborne emissions due to energy resource production, transmission, conversion, storage and end utilization is given by

$$TAP(K) = TAPEU(K) + APEGT(K) + APMETH(K) + APPRT(K) + APSGT(K) + APSCT(K) \text{ tons/year} \quad \text{(III-71)}$$

Elemental Sulfur Production

The amount of elemental sulfur produced due to coal gasification and liquefaction, SULP, is given by

$$SULP = [SPCL \times (SCCLG + SCCL) + SPCG \times SGASR \times SGASFF(I,1)] \quad \text{(III-72)}$$

where

SPCL = sulfur production coefficient for coal liquefaction from Table III-21

SCCLG = syncrude to be supplied by combined coal gasification and liquefaction plants in year I from Equation III-25

SCCL = syncrude to be supplied by coal liquefaction plants in year I from Equation III-24

SPCG = sulfur production coefficient for coal gasification from Table III-21

TABLE III-21

ELEMENTAL SULFUR PRODUCTION COEFFICIENT
(10, 30, 38, 39, 57)

Resource	Coefficient (tons/million Btu product)
coal gasification	0.00392
coal liquefaction	0.00165

SGASR = amount of syngas required in year I from Equation III-21

SGASFF(I,1) = SNG production fuel fraction for coal in year I

Solid Waste Production

The amount of solid waste produced due to energy resource utilization is determined for oil shale, tar sands, and syncrude and syngas from coal using the solid waste production coefficients from Table III-22 and the resource demands for year I.

Oil shale:

$$OSSW = OSSWC \times OS \qquad \text{(III-73)}$$

where

OSSW = amount of solid waste created by oil shale production in year I in tons/year

OSSWC = oil shale solid waste coefficient from Table III-22

OS = amount of oil shale production in year I from Equation III-48

Tar sands:

$$TSSW = TSSWC \times TS \qquad \text{(III-74)}$$

where

TSSW = amount of solid waste created by tar sands production in year I in tons/year

TSSWC = tar sands solid waste coefficient from Table III-22

TS = amount of tar sands production in year I from Equation III-49

TABLE III-22

SOLID WASTE PRODUCTION COEFFICIENT

Resource	Coefficient tons/million Btu product
oil shale	0.4055 (43, 47)
tar sands	0.5862
syncrude	0.00191*
syngas	0.00191*

*From Table III-7.

Syncrude:

$$SCSW = SCSWC\ [SCCLG + SCCL] \qquad \text{(III-75)}$$

where

SCSW = amount of solid waste created by syncrude production in year I in tons/year

SCSWC = syncrude solid waste coefficient from Table III-22

SCCLG = amount of syncrude supplied by combined coal liquefaction and gasification plants in year I

SCCL = amount of syncrude supplied by coal liquefaction plants in year I

Syngas:

$$SGSW = SGSWC\ [SGASR \times SGASFF(I,1)] \qquad \text{(III-76)}$$

where

SGSW = amount of solid waste created by production of SNG from coal in year I

SGSWC = SNG solid waste coefficient from Table III-22

SGASR = amount of syngas required in year I from Equation III-21

SGASFF(I,1) = fraction of syngas supplied by coal gasification in year I

Total: Using the results of Equations III-73, III-74, III-75 and III-76, the total solid waste produced in year I is:

$$TSW = OSSW + TSSW + SCSW + SGSW \qquad \text{(III-77)}$$

Water Usage

One of the major factors in the utilization of energy resources is the availability of water resources. The water usage section of the model predicts the acre-feet of water required for once-through cooling of electrical power stations and electrolytic hydrogen plants. Once-through cooling is the term used to describe the waste heat removal system in which water is taken from a suitable source (ocean, river, large lake or reservoir), passed through the condenser and then returned to the source body of water (22). The water consumption in terms of evaporation, spray and wind drift for electrical power stations with various cooling alternatives is also calculated. The water requirements for oil shale production, tar sands production and coal conversion to SNG and syncrude are also determined.

Electrical generation: The water required for once-through cooling of electrical power stations is given by:

$$TCWU = \sum_{J} \{FROT(I) \times WUOT(J) \times ELGD(J) \times [1.0 - EGEF(I,J)]\} \qquad \text{(III-78)}$$

where

FROT(I) = fraction of electrical generation plants using once-through cooling in year I

WUOT(J) = water usage coefficient for once-through cooling for fuel J from Table III-23

ELGD(J) = electrical generation energy demand for fuel J in year I from Equation III-15

EGEF(I,J) = projected electrical generation efficiency for fuel J in year I from Figure III-11 and Table III-1

TABLE III-23

WATER USAGE COEFFICIENTS

Use	Coefficient*	Reference
Electrical generation		
fossil--once-thru (thru-condenser)	29520.0 (assume $\Delta T = 15°F$)	22, 51
fossil--once-thru (evaporation)	162.7	22, 51
nuclear--once-thru (thru condenser)	20470.2 (assume $\Delta T = 18°F$)	22, 51
nuclear--once-thru (evaporation)	187.2	22, 51
fossil--cooling pond (evap., spray & drift)	217.9	22, 51
fossil--cooling tower (evap., spray,& drift)	380.6	22, 51
nuclear--cooling pond (evap., spray & drift)	257.8	22, 51
nuclear--cooling tower (evap., spray & drift)	466.5	22, 51
Oil shale	81.8**	47
Tar sands	81.8**'***	14
Coal gasification	75.0**	10
Coal liquefaction	10.39**	10
Synthetic fuel--hydrogen		
feed water	58.8**	29
electrolytic cell cooling	73.2**	29

*Units: acre-feet/10^{12} Btu waste heat.

**acre-feet/10^{12} Btu product.

***Assumed same as oil shale.

The water consumed in electrical power stations due to evaporation, spray and drift in cooling towers, cooling ponds, spray ponds and once-through cooling is given by

$$TCWC = \sum_J \{[FROT(I) \times WCOT(J) + [FRNC(I) + FRFC(I)] \times WCCT(J) + [FRSP(I) + FRCP(I)] \times WCCP(J)\} \times ELGD(J) \times [1.0 - EGEF(I,J)] \quad \text{(III-79)}$$

where

FROT(I) = fraction of electrical generation plants using once-through cooling in year I

WCOT(J) = water usage coefficient for once-through cooling for fuel J from Table III-23

FRNC(I) = fraction of electrical generation plants using natural convection cooling towers in year I

FRFC(I) = fraction of electrical generation plants using forced convection cooling towers in year I

WCCT(J) = water usage coefficient for cooling towers for fuel J from Table III-23

FRSP(I) = fraction of electrical generation plants using spray ponds in year I

FRCP(I) = fraction of electrical generation plants using cooling ponds in year I

WCCP(J) = water usage coefficient for cooling ponds and spray ponds for fuel J from Table III-23

ELGD(J) = electrical generation energy demand for fuel J in year I, from Equation III-15

EGEF(I,J) = projected electrical generation efficiency for fuel J in year I from Figure III-11 and Table III-1

Oil shale recovery: Using Table III-23 and Equation III-48, the oil shale water consumption, WCOS, is given by:

$$WCOS = 81.8 \times OS \text{ acre-feet/year} \quad \text{(III-80)}$$

Tar sands recovery: Using Table III-23 and Equation III-49, the tar sands water consumption, WCTS, is given by:

$$WCTS = 81.8 \times TS \text{ acre-feet/year} \quad \text{(III-81)}$$

Syngas: Using Table III-23 and Equation III-21, the SNG production water consumption, WCCG, is given by:

$$WCCG = 75.0 \times SGASR \text{ acre-feet/year} \quad \text{(III-82)}$$

Syncrude: Using Table III-23 and Equations III-23 and III-26, the coal liquefaction water consumption, WCCL, is given by:

$$WCCL = 10.39 \, [SC + CLG] \text{ acre-feet/year} \quad \text{(III-83)}$$

Electrolytic hydrogen: Using Table III-23, the feed water requirements for an electrolytic hydrogen plant, WRHF, is given by:

$$WRHF = 58.8 \times H2D \text{ acre-feet/year} \quad \text{(III-84)}$$

where

H2D = electrolytic hydrogen demand in trillion Btu/year

and the cooling water requirements, WRHC, is given by

$$WRHC = 73.2 \times H2D \text{ acre-feet/year} \quad \text{(III-85)}$$

where

H2D = electrolytic hydrogen demand in trillion Btu/year

Total: Using the results of Equations III-78 through III-85, the total water requirements in year I for energy utilization, TCW, is given by:

$$TCW = TCWU + TCWC + WCOS + WCTS + WCCG + WCCL + WRHF + WRHC \text{ acre-feet/year} \quad \text{(III-86)}$$

Land Use

The amount of land required for energy supply in acres for year I is composed of the land requirements for strip-coal mining, oil shale production, tar sands production, electrical power transmission lines, electrical power plant siting, and waste heat removal systems. Land use coefficients, the amount of land required per unit Btu produced for each energy system section, are used together with the annual energy requirements to predict the land use.

Coal mining: Coal mining land use, LUCM, is given by

$$LUCM = LUCMC \times CSMF(I) \times [XXBED(I) - CLC] \quad \text{(III-87)}$$

where

LUCMC = coal mining land use coefficient from Table III-24

CSMF(I) = fraction of coal that is strip mined in year I

XXBED(I) = total coal resource demand in year I

CLC = refined coal produced due to crude oil manufactured in a combined coal conversion plant in year I from Equation III-27

TABLE III-24

LAND USE COEFFICIENT

Energy Utilization	Coefficient (acres/trillion Btu)
Coal mining--strip	13.44 (6)
Oil shale	2.33 (assume 30' thick deposit) (46)
Tar sands	0.0233 (assume 1/100 of oil shale)
Electric Power-Transmission	407. (6)
Electric Power Plant Siting	
coal	34.2 (6)
oil	8.56 (6)
gas	5.13 (6)
nuclear	10.00 (6)
solar	636.2 (65)
geothermal	133.8 (65)
hydroelectric	39,200 (22)
Cooling towers and spray ponds	0.298 (51)
Cooling ponds	22.0 (51)

Oil shale: Oil shale land use, OSLU, is given by

$$OSLU = OSLUC \times OS \text{ million acres} \qquad \text{(III-88)}$$

where

OSLUC = oil shale land use coefficient from Table III-24

OS = oil shale production in year I from Equation III-48

Tar sands: Tar sands land use, TSLU, is given by

$$TSLU = TSLUC \times TS \text{ million acres} \qquad \text{(III-89)}$$

where

TSLUC = tar sands land use coefficient from Table III-24

TS = tar sands production in year I from Equation III-49

Transmission lines: Electrical power transmission land use, ETLU, is given by

$$ETLU = ETLUC \times EDC \qquad \text{(III-90)}$$

where

ETLUC = electrical transmission land use coefficient from Table III-24

EDC = transmission loss corrected electrical demand from Equation III-19

Generating stations: Electrical power plant siting land use, EGLU, is given by

$$EGLU = \sum_{J} [LDUSC(J) \times ELGD(J) \times EGEF(I,J)] \qquad \text{(III-91)}$$

where

LDUSC(J) = electrical power plant siting land use coefficient for a plant of fuel type J from Table III-24

ELGD(J) = electrical generation energy demand for fuel J in year I from Equation III-15

EGEF(I,J) = projected electrical generation efficiency for fuel J in year I from Figure III-11 and Table III-1

Waste heat removal: The waste heat removal systems land use, LDUC, is given by

$$LDUC = \sum_{J} [LUCTC \times FRNC(I) + LUCPC \times FRCP(I) + LUSPC \times FRSP(I)] \times ELGD(J) \times [1.0 - EGEF(I,J)] \quad \text{(III-92)}$$

where

LUCTC = natural convection cooling tower land use coefficient from Table III-24

FRNC(I) = fraction of electrical generation plants using natural convection cooling towers in year I

LUCPC = cooling pond land use coefficient from Table III-24

FRCP(I) = fraction of electrical generation plants using cooling ponds in year I

LUSPC = spray pond land use coefficient from Table III-24

FRSP(I) = fraction of electrical generation plants using spray ponds in year I

ELGD(J) = electrical generation energy demand for fuel J in year I from Equation III-15

EGEF(I,J) = projected electrical generation efficiency for fuel J in year I from Figure III-11 and Table III-1

Radioactive Material Production and Releases

Nuclear reactors generate gaseous and solid radioactive material. Since nuclear reactors are not completely emission free, some radioactive material is released and possible population exposure to radiation may occur. The magnitude of these radioactive environmental impacts are determined by using the nuclear environmental coefficients, Table III-25, and the amount of power supplied by each type of nuclear reactor.

Tritium: The amount of tritium released by nuclear reactors in year I, TTR, is given by

$$TTR = 10^6 \times \sum_J [TRF(J) \times XXBED(J)] \text{ curies/year} \quad \text{(III-93)}$$

where

TRF(J) = tritium release coefficient from Table III-25 for reactor type J

XXBED(J) = amount of power generated by reactor type J in year I

Krypton-85: The amount of krypton-85 released by nuclear reactors in year I, TKR85, is given by

$$TKR85 = \sum_J [KR85F(J) \times XXBED(J)] \text{ curies/year} \quad \text{(III-94)}$$

where

KR85F(J) = krypton-85 release coefficient from Table III-25 for reactor type J

Long-lived solid waste: The amount of long-lived radioactive material generated by nuclear reactors in year I, TRLLC and TRLLW, are given by

TABLE III-25

NUCLEAR ENVIRONMENTAL COEFFICIENTS (6, 24, 46, 52, 55)

Reactor Type	Population Exposure (man-rem per 10^6 Btu-th)	Long-Lived Radio. Mate* (curies per 10^6 Btu-th)	Long-Lived Rad. Waste (cubic ft per 10^6 Btu-th)	Kr-85 (Ci per 10^6 Btu-th)	Tritium (Ci per 10^6 Btu-th)
GCFR	4.55×10^{-6}	--	--	0.00167	0.00045
HTGR	4.55×10^{-6}	3.04×10^{-6}	--	0.0082	0.00025
LFR	4.55×10^{-6}	--	--	--	--
LMFBR	4.55×10^{-6}	3.45×10^{-6}	0.16	0.00167	0.00045
LWR	4.55×10^{-6}	5.18×10^{-6}	0.18	0.0073	0.000265
MSBR	4.55×10^{-6}	--	--	0.0082	0.066
MCFR	4.55×10^{-6}	--	--	--	4.69

*Taken 10 years after generation due to reprocessing plant holdup time.

$$TRLLC = [RLLCF(J) \times XXBED(J)] \text{ curies/year} \quad \text{(III-95)}$$

$$TRLLW = [RLLWF(J) \times XXBED(J)] \text{ cubic feet/year} \quad \text{(III-96)}$$

where

RLLCF(J) = long-lived radioactive material coefficient from Table III-25 for reactor type J

RLLWF(J) = long-lived radioactive waste coefficient from Table III-25 for reactor type J

Population exposure: The total population exposure caused by nuclear reactors in year I, TPE, is given by

$$TPE = \sum_{J} [TPEF(J) \times XXBED(J)] \text{ man-rem/year} \quad \text{(III-97)}$$

where

TPEF(J) = population exposure coefficient for reactor type J from Table III-25

Balance of Payments Effects

One of the United States' major concerns is the effect on the U.S. balance of payments due to energy resource imports. Crude petroleum, liquefied natural gas and pipeline gas from Canada are considered in the energy balance of payments analysis. The balance of payments impact of each of these imports is estimated using a projected unit energy cost to the year 1980, Figure III-19, and then assuming a constant value thereafter for simplicity (46).

$$CCPI = OI \times OIC(I) \quad \text{(III-98)}$$

where

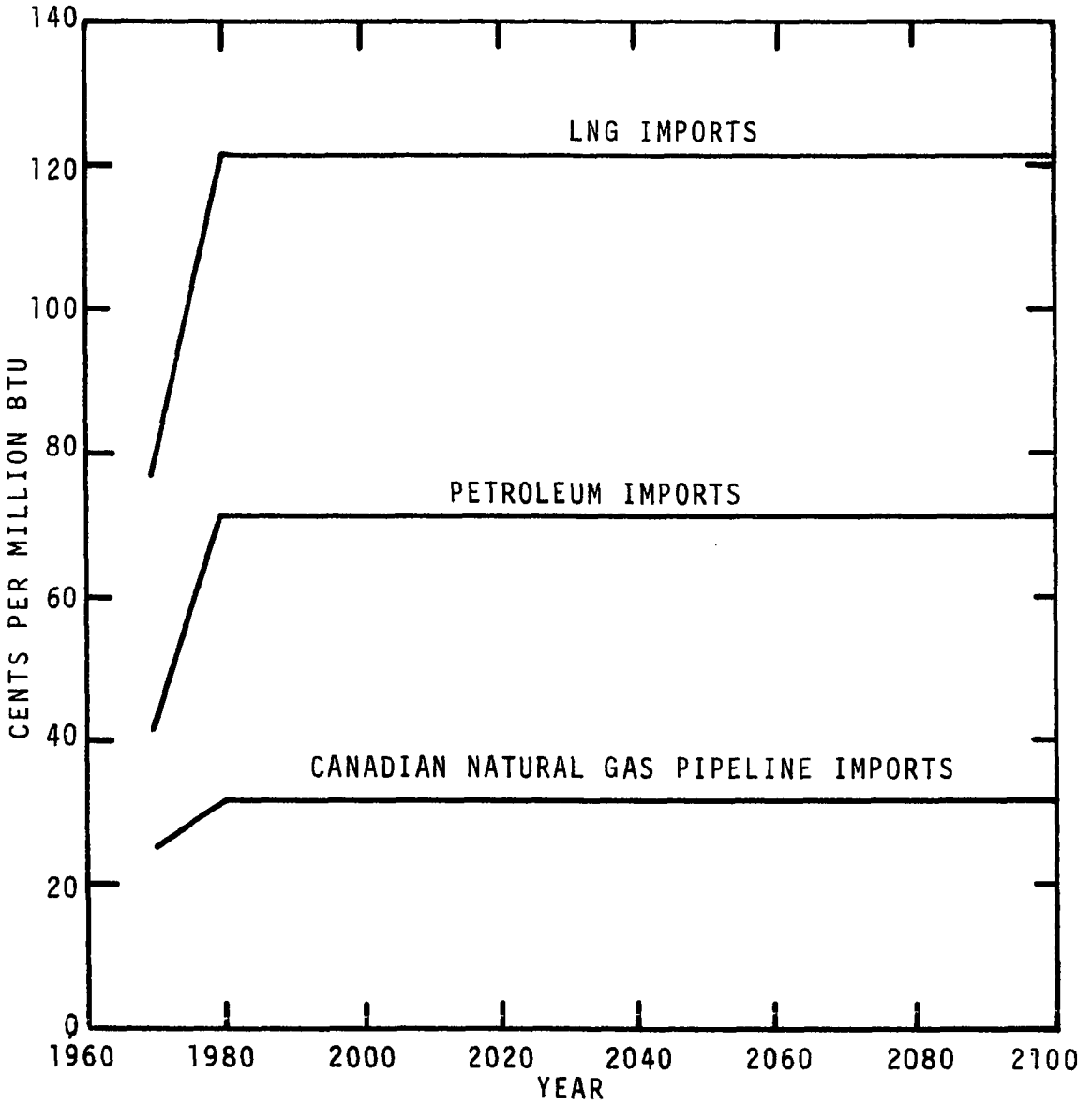


Figure III-19. Projected Import Energy Unit Costs in 1970 U.S. Dollars (46).

CCPI = cost of crude petroleum imports in year I in millions of 1970 U.S. dollars

OI = amount of oil imports in year I from Equation III-50

OIC(I) = projected cost per million Btu of imported crude petroleum in year I from Figure III-19

$$CLNGI = LNGI \times LNCC(I) \qquad \text{(III-99)}$$

where

CLNGI = cost of liquefied natural gas imports in year I in millions of 1970 U.S. dollars

LNGI = amount of liquefied natural gas imports in year I from Equation III-38

LNGC(I) = projected cost per million Btu of imported liquefied natural gas in year I from Figure III-19

and

$$CCGI = CGPLI \times CGC(I) \qquad \text{(III-100)}$$

where

CCGI = cost of Canadian pipeline gas imports in year I in millions of 1970 U.S. dollars

CGPLI = amount of Canadian pipeline gas imports in year I from Equation III-37

CGC(I) = projected cost per million Btu of Canadian pipeline gas imports in year I from Figure III-19

respectively.

Using the results of Equations III-98, III-99 and III-100, the total effect on the U.S. balance of payments in year I is given by

$$TBPOD = CCPI + CLNGI + CCGI \qquad \text{(III-101)}$$

where

TBPOD = total balance of payments deficit in year I due to the purchase of foreign energy resources

Examples of Model Implementation

In Chapters IV to X the base case and several examples of energy system alternatives will be examined and the results reported. This is not to treat all viable options but serves merely to demonstrate the use of the model for predicting both short term and long term effects. Thus a basis is provided for guiding and assessing the merit of energy policy decisions.

CHAPTER IV

BASE CASE ASSUMPTIONS AND RESULTS

The selection of all of the data, projected efficiencies, fuel supplies, etc., is critical to the validity of the base case. The base case supplies the bench marks from which evaluations of resource alternatives, fuel alternatives and new technology may be formed. The constraints on the base case consist of all of the data, projections and engineering judgments outlined in Chapter III and in Appendix A.

Assumptions

In addition to the constraints mentioned previously, the following assumptions are made based on the author's engineering judgment.

1. Coal will be produced by 50 percent strip mining and 50 percent underground mining.
2. Synthetic crude petroleum from coal will be produced 50 percent in coal liquefaction plants and 50 percent in combined coal conversion plants.
3. Coal liquefaction and gasification efficiencies and petroleum gasification efficiencies will be assigned according to Figure IV-1.

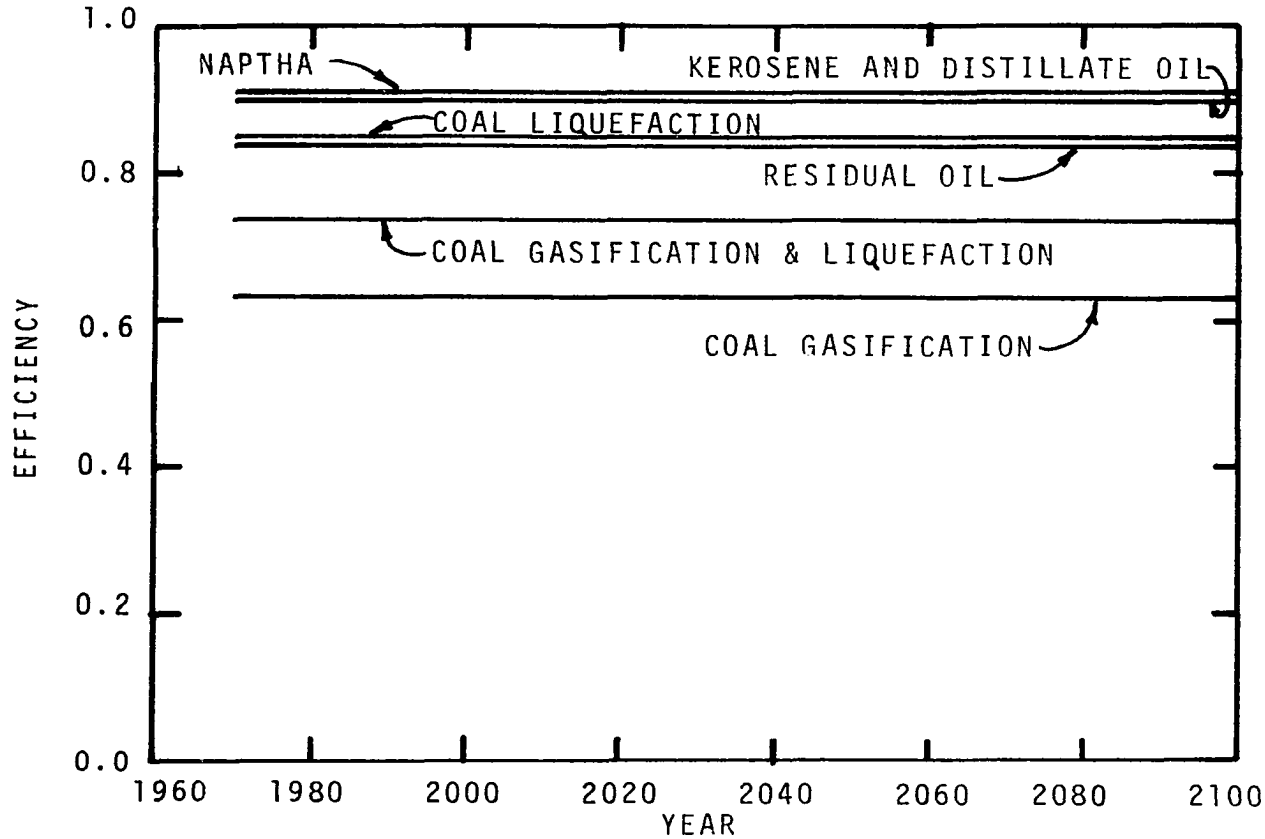


Figure IV-1. Projected Resource Conversion Efficiencies (See Tables III-6 and III-7).

4. The waste heat removal systems for electric power stations will continue to be constructed in the same proportion as existed in 1970 (Figure IV-2).
5. Canadian natural gas pipeline imports will supply a decreasing fraction of the gas demand exceeding domestic natural gas production with imports ceasing in 2040 (Figure IV-3).
6. Liquefied natural gas imports will supply the fraction gas demand exceeding domestic natural gas production shown in Figure IV-3.
7. Coal gasification and petroleum gasification will continue to be developed so that all imports of Canadian gas and LNG can be halted in 2040 (Figure IV-3).
8. Synthetic natural gas production will be initially dominated by petroleum gasification with coal gasification dominating after 2000 (Figure IV-4). Petroleum gasification plants built between 1970 and 1980 will be phased out between 2000 and 2010 based on a 20 to 30 year plant life.
9. The petroleum demand exceeding domestic crude production will initially be filled by crude oil imports. However, as coal liquefaction, oil shale and tar sands syncrude plants are constructed, the oil import fraction will decrease (Figure IV-5).

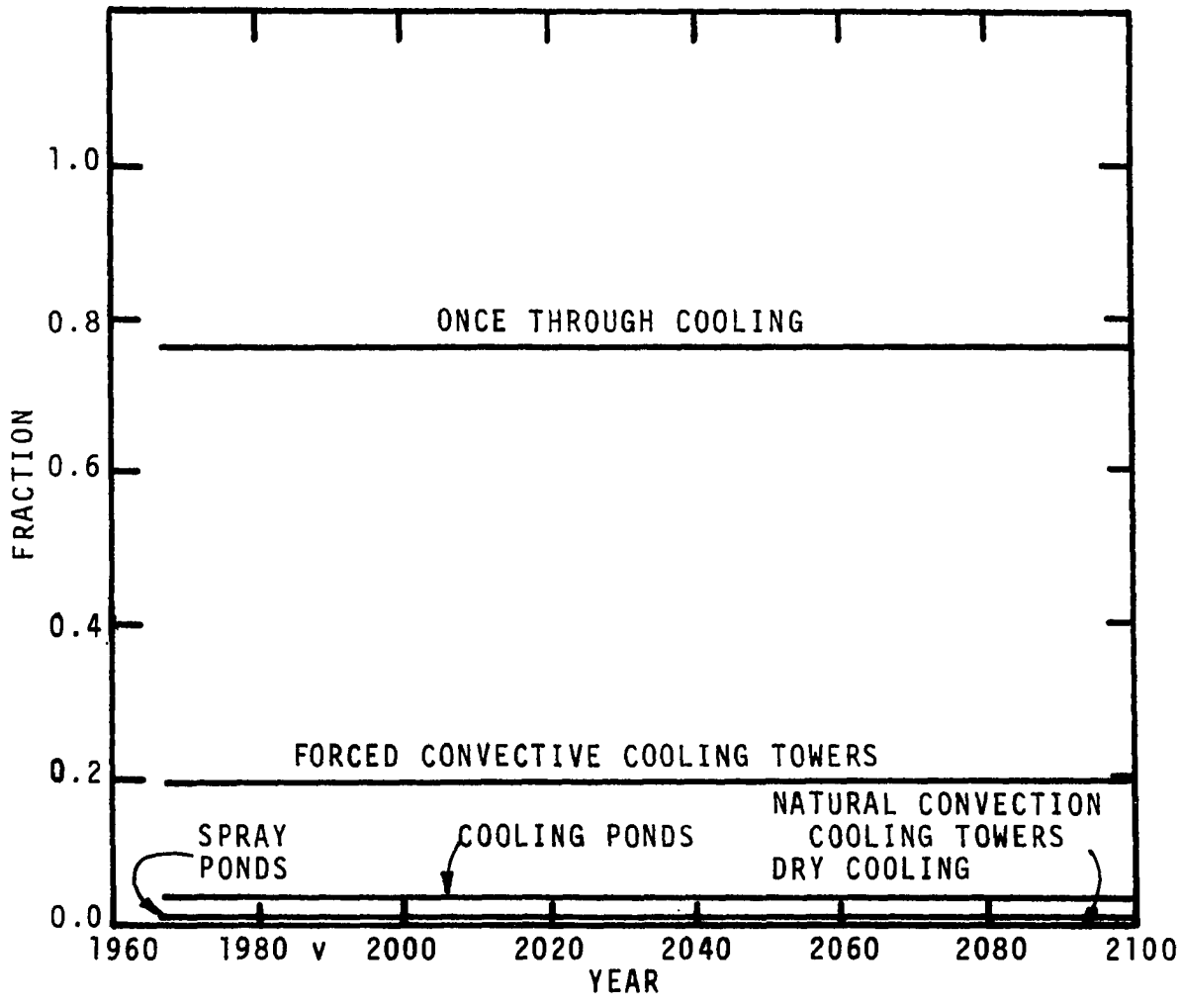


Figure IV-2. Projected Electrical Generation Station Waste Heat Removal System Fraction for Base Case (94).

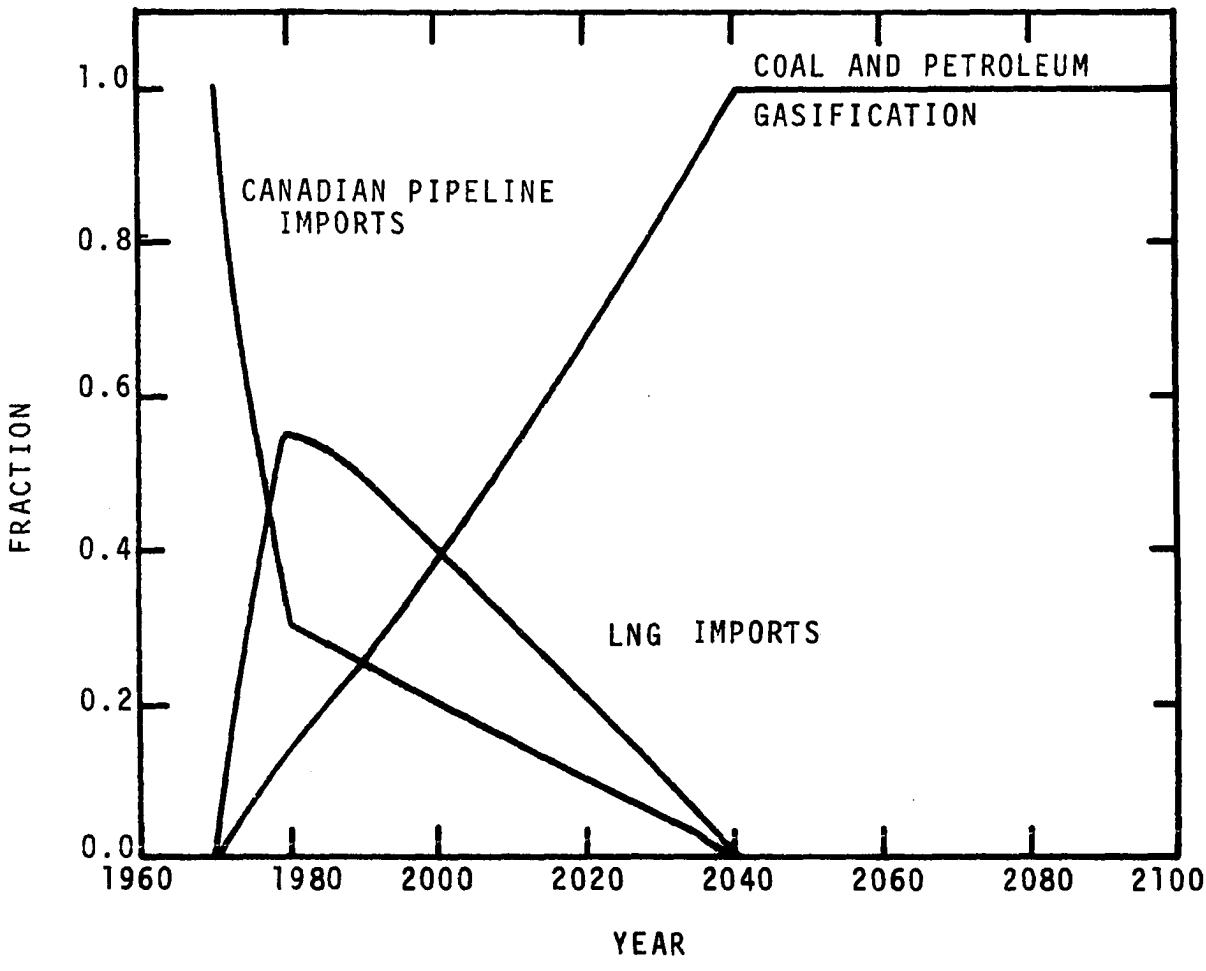


Figure IV-3. Projected Fraction of Natural Gas Demand Exceeding Domestic Production Supplied by Alternate Sources.

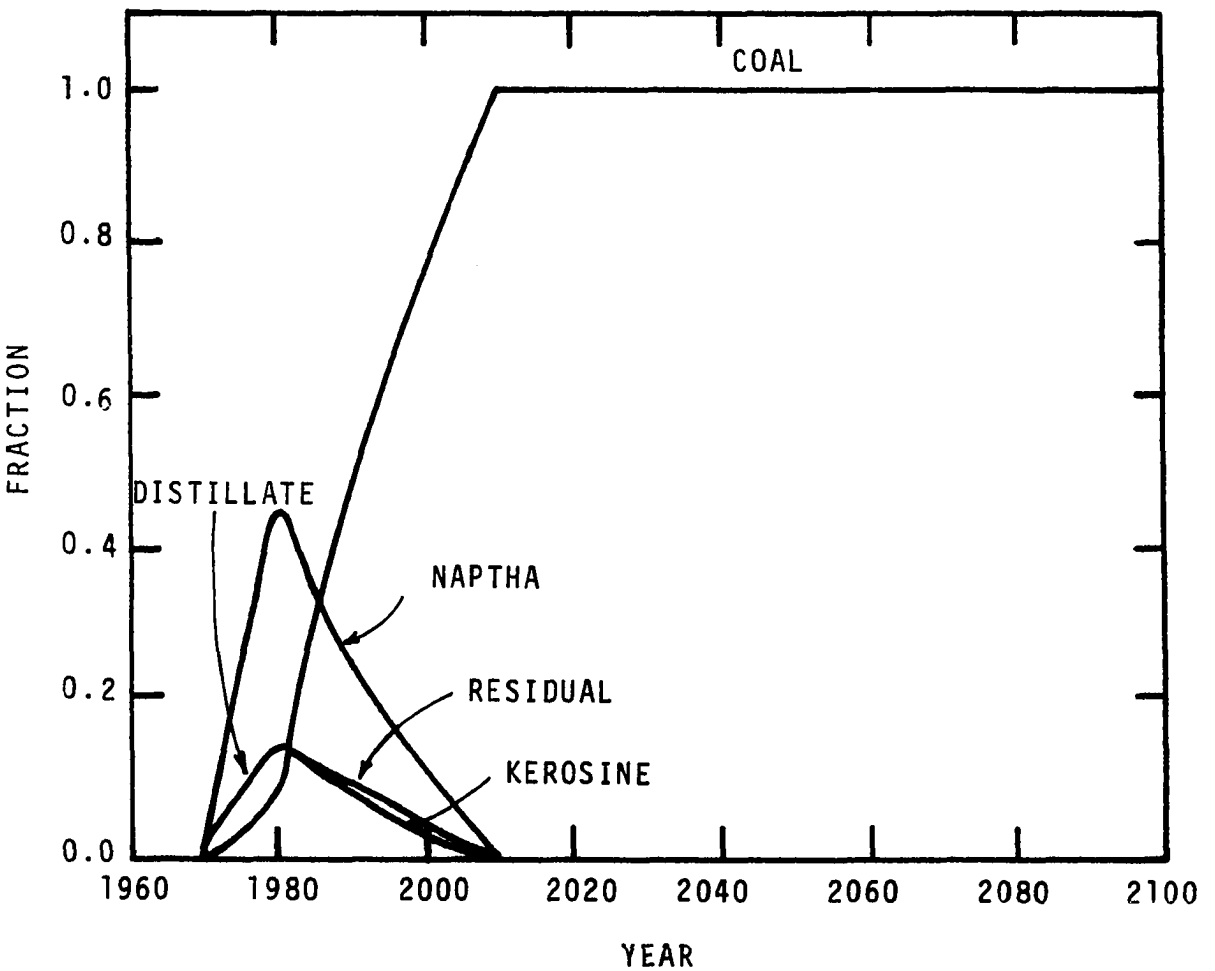


Figure IV-4. Projected Synthetic Natural Gas Fuel Fractions.

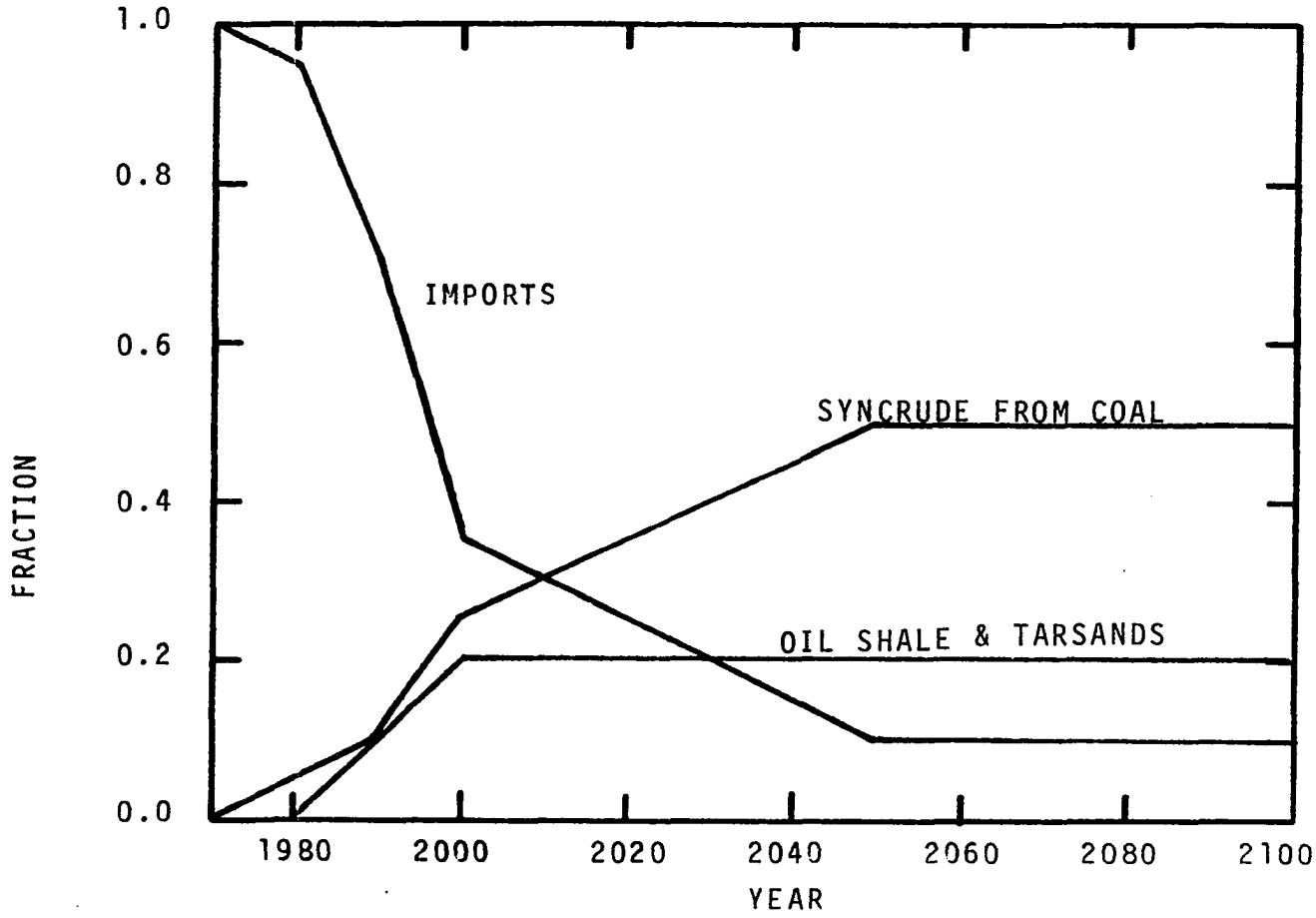


Figure IV-5. Projected Fraction of Petroleum Demand Exceeding Domestic Production Supplied by Alternate Sources.

Results

The general resource requirements, environmental impact projections, and balance of payments projection for the base case study are presented in this section. The detailed computer output of the MANERGY model for the years 1970 to 2100 is presented in Appendix C.

Resource Requirements

The total energy resource requirements are projected to increase by over a factor of 13 from approximately 70×10^{15} Btu/year in 1970 to 944×10^{15} Btu/year in 2100. The composite energy resource requirements, Figure IV-6, show that the major energy resources shift from petroleum and natural gas to coal, nuclear fission and fusion, oil shale and tar sands. These resource requirements supply the residential, commercial, industrial and transportation end utilizations, Figure IV-7. Comparison of the composite end utilization projections shows the relatively larger and larger percentage of energy consumed by the industrial and transportation sectors. Comparison of the total resource requirement with the end utilization demands, Figure IV-8, illustrates the tremendous amount of energy consumed in the production, transmission, refining, processing and conversion of energy resources.

Since the electrical generation section of Chapter III assumed the development of a fusion reactor and a significant share of the utility market to go to fusion commencing in

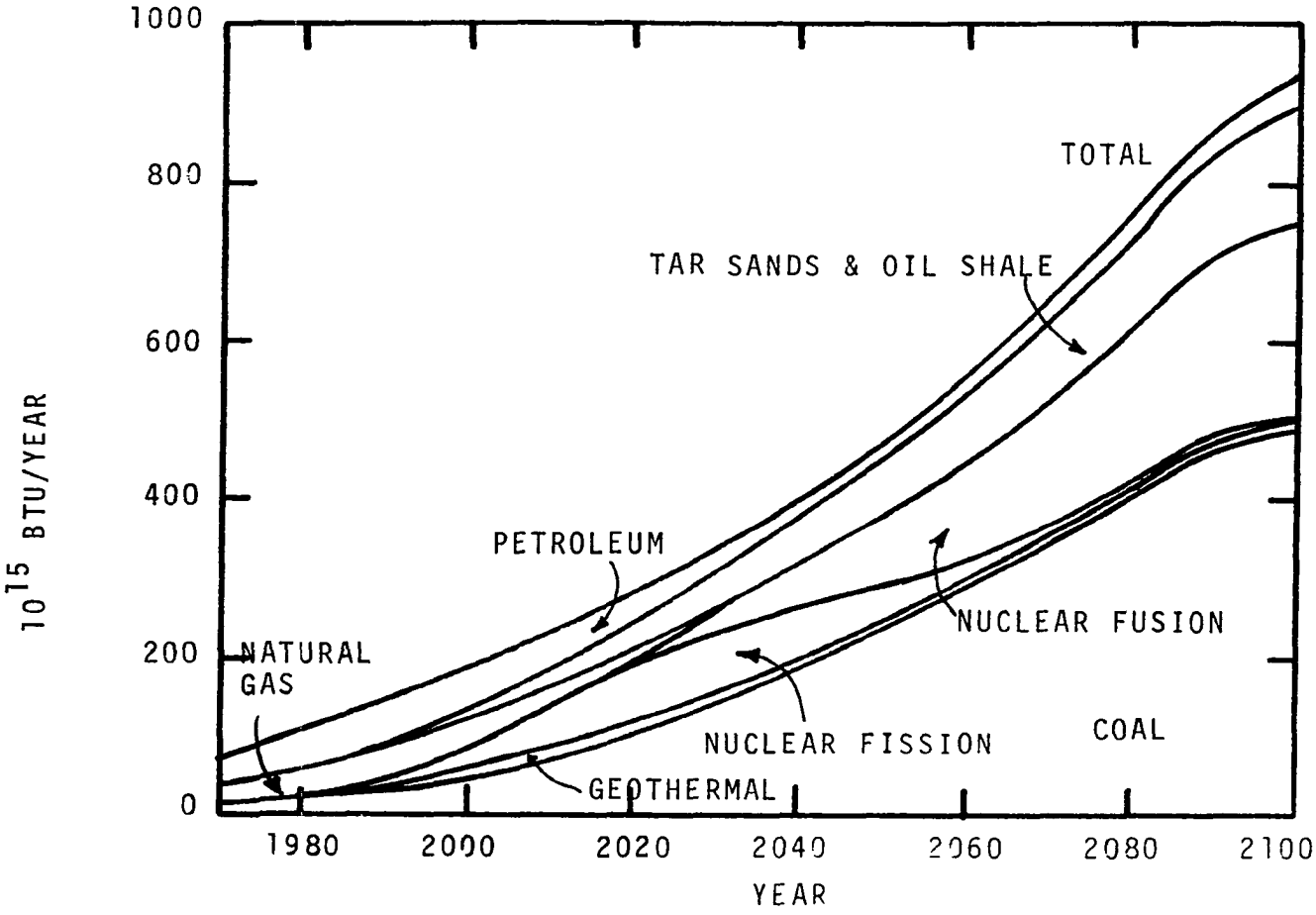


Figure IV-6. Composite Energy Resource Requirements--Base Case. NOTE: The base case projections indicate that the estimated U.S. coal reserves will probably be consumed by 2079.

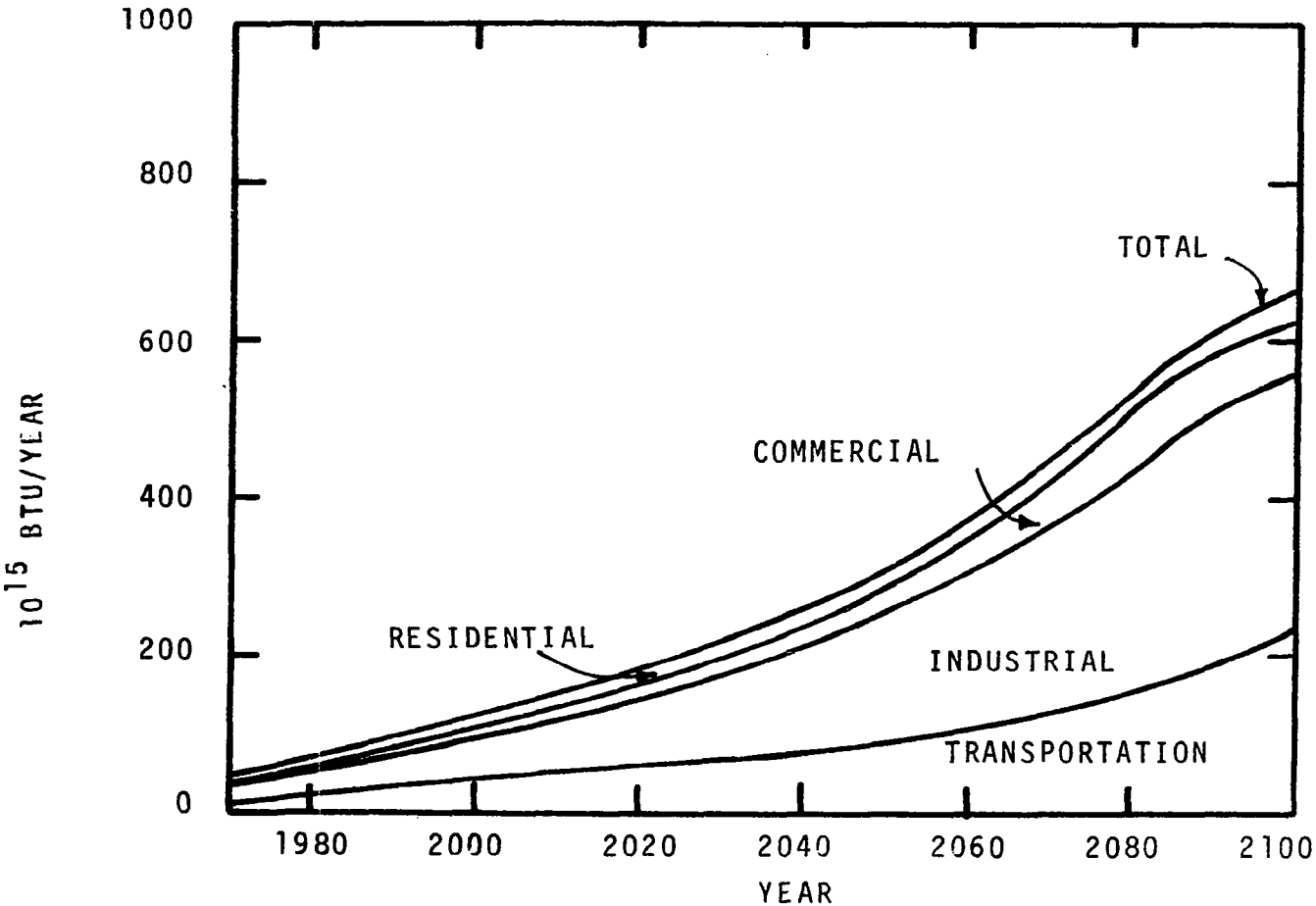


Figure IV-7. Composite End Utilization Energy Requirements--Base Case.

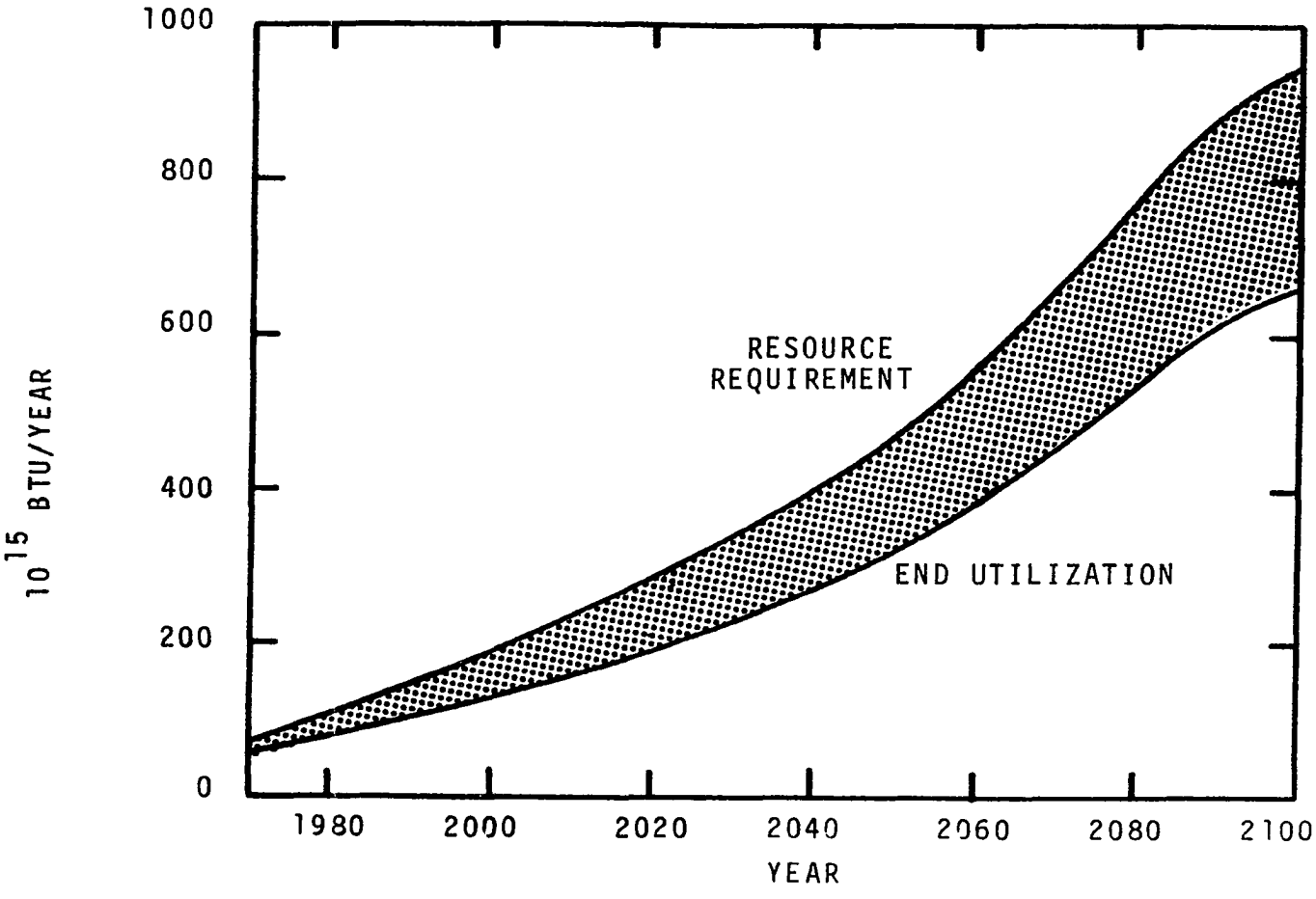


Figure IV-8. Total Annual Energy Production and Net End Utilization--Base Case.

2020, the nuclear energy production, Figure IV-9, shifts from fission to fusion after the year 2020. The demands on the nuclear fuel cycle required to meet the nuclear energy production requirements including the annual enriching plant capacity requirements in kilograms of separative work and the annual production requirements of uranium and thorium, Figures IV-10 and IV-11, respectively, follow the nuclear energy production trends in Figure IV-9.

The annual coal production, Figure IV-12, is composed of the sum of the end utilization coal requirement, coal requirements for electrical power generation, coal used for synthetic crude oil production, and coal used for synthetic natural gas production, Figures IV-13 through IV-15. These figures show the tremendous role that coal must play as the nation's future energy supplier of syncrude, syngas and electric power. Note that coal used for electric power is almost insignificant compared to syncrude and syngas requirements.

The annual crude petroleum demand, Figure IV-16, is filled by domestic crude production, synthetic crude oil from coal, crude oil imports, oil shale production and tar sands production, Figures IV-17 through IV-20, respectively. Note that all resources must be developed to meet the petroleum requirements.

Geothermal and hydroelectric annual energy production, Figures IV-21 and IV-22, respectively, are essentially

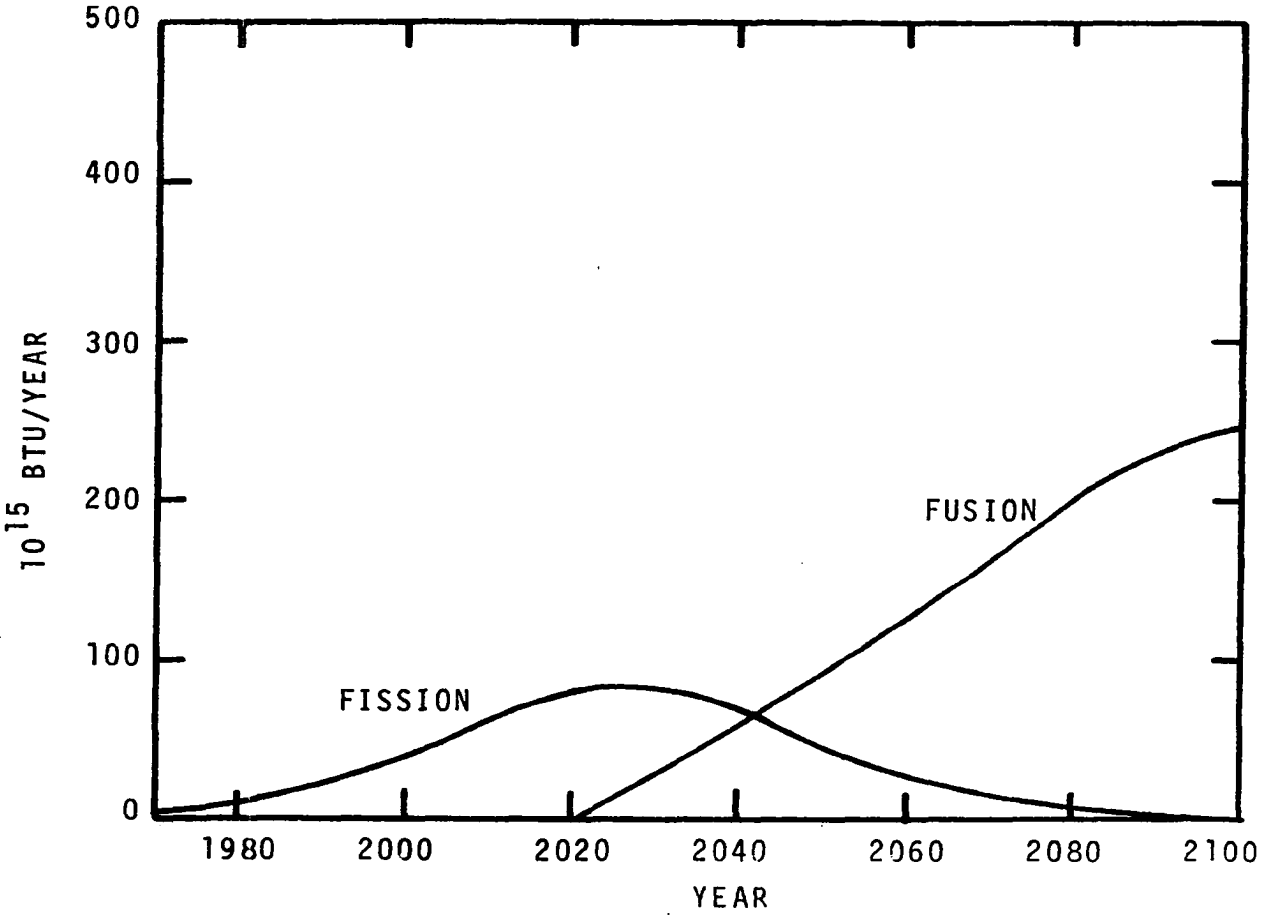


Figure IV-9. Nuclear Power Energy Production--Base Case.

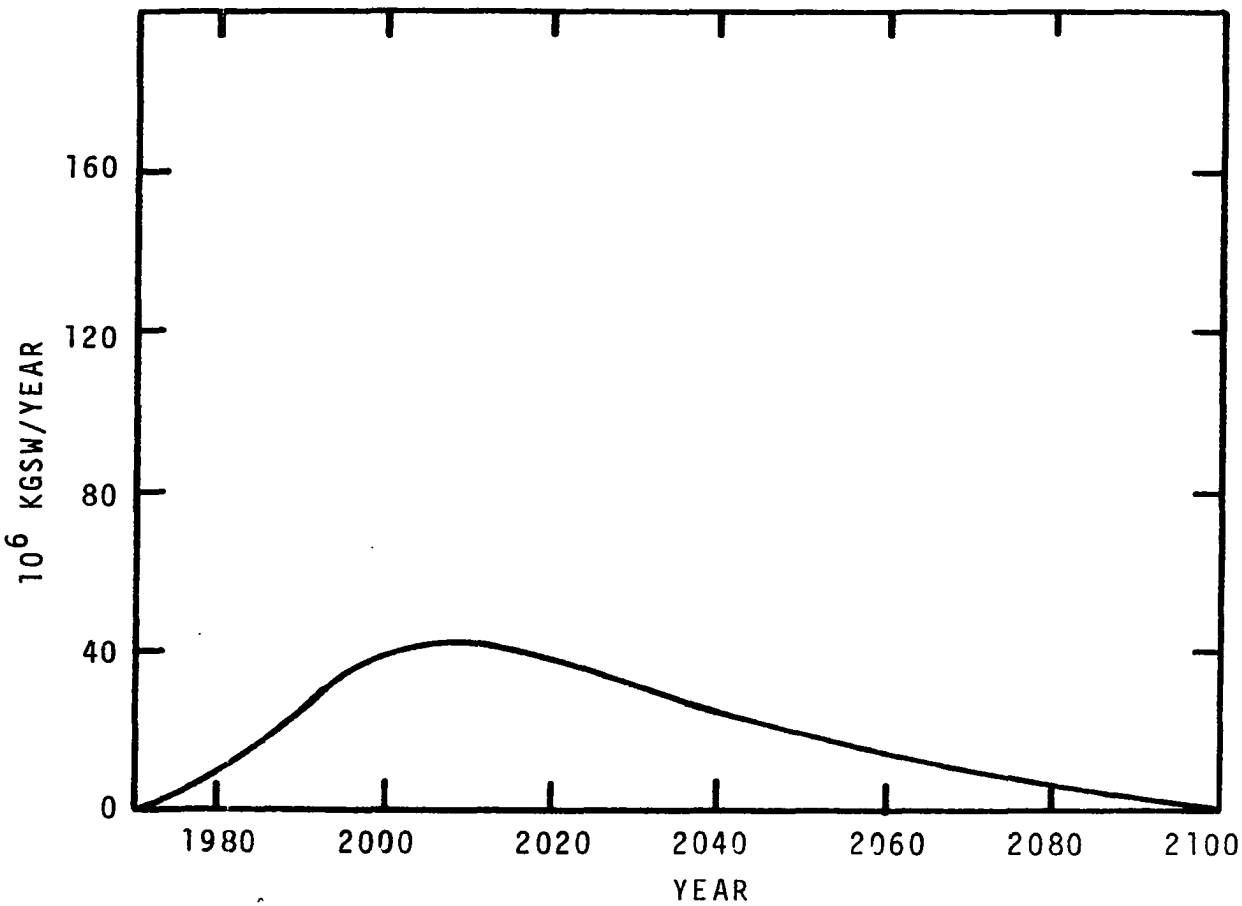


Figure IV-10. Annual Uranium Enrichment Requirements--Base Case.

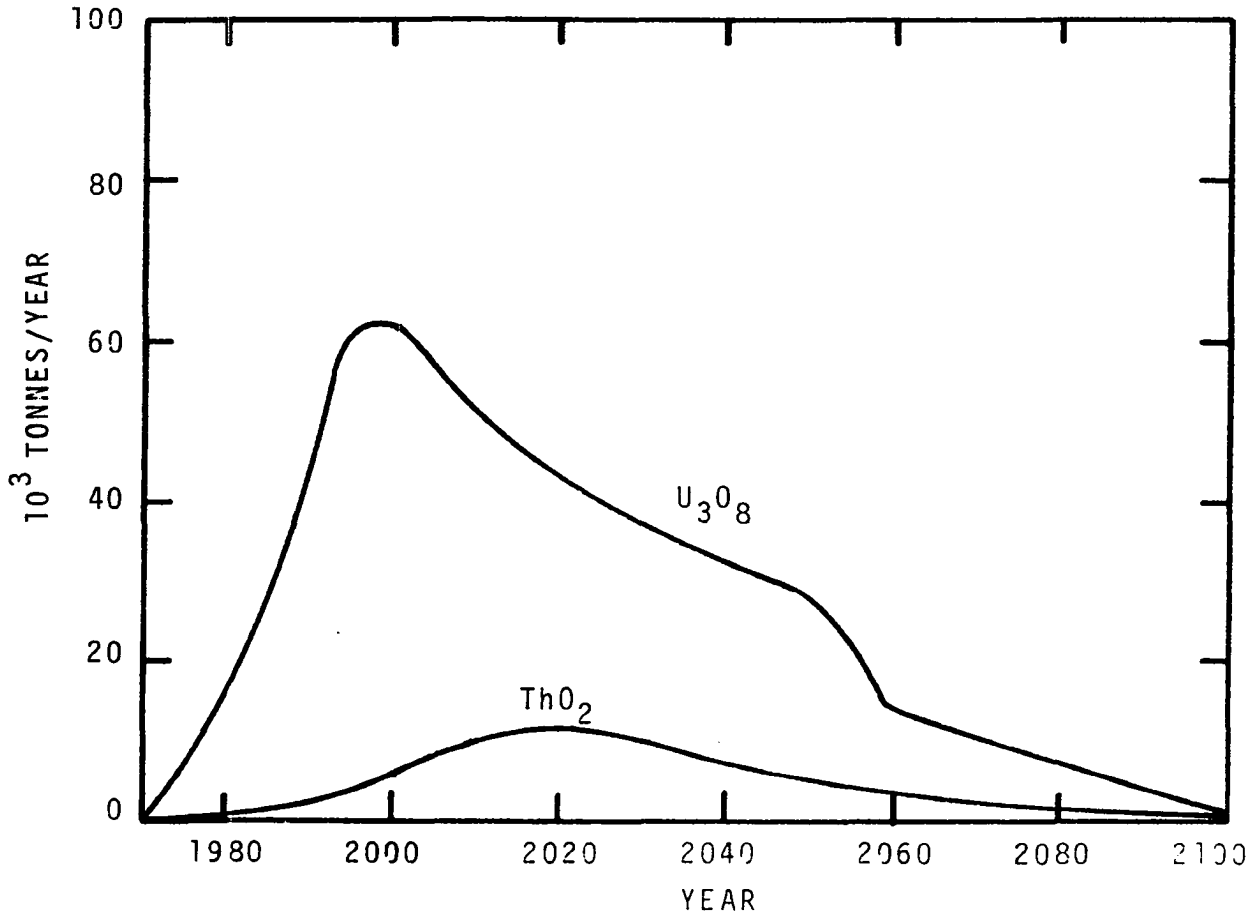


Figure IV-11. Annual Nuclear Resource Production Requirements--Base Case.

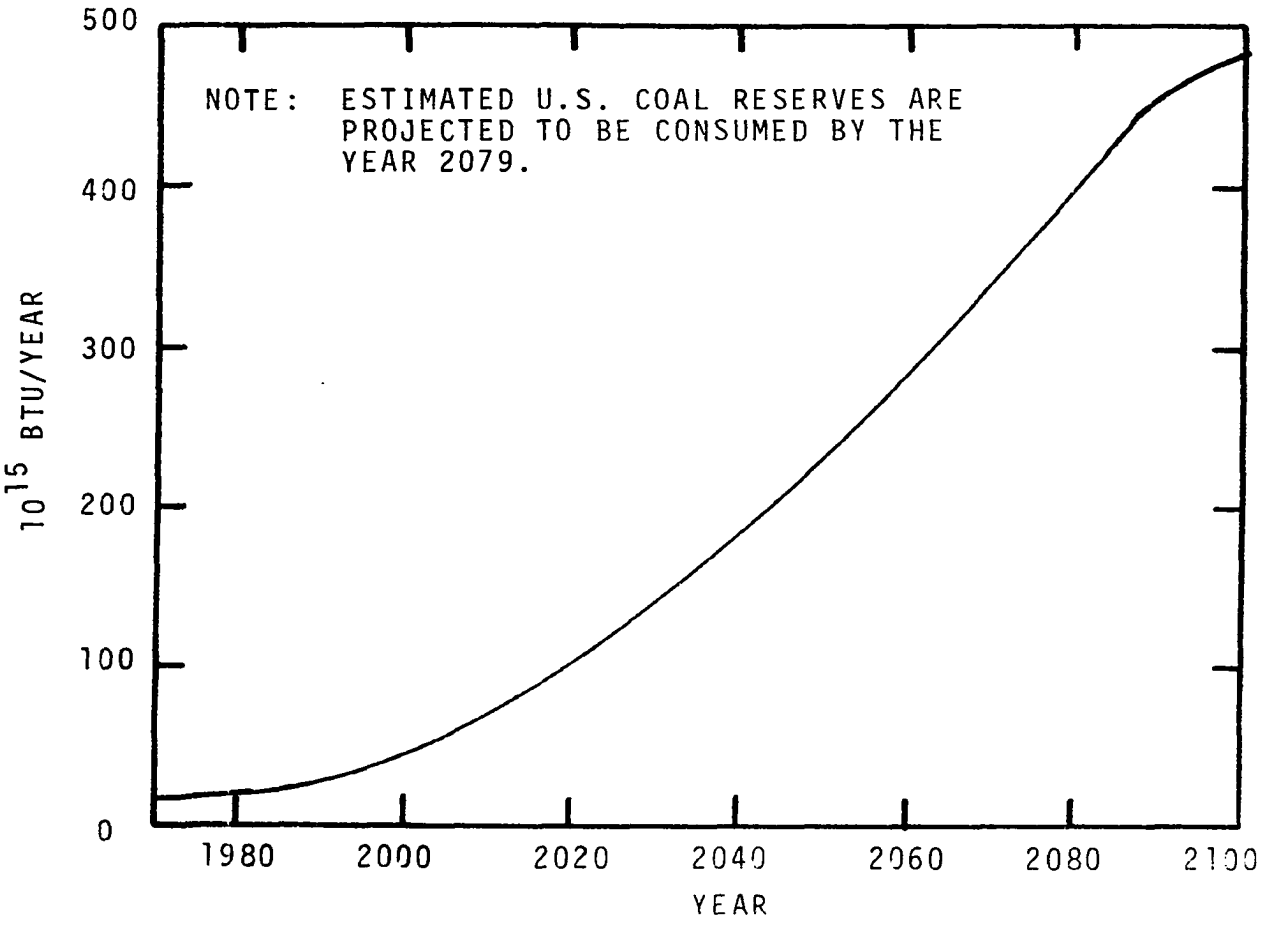


Figure IV-12. Annual Coal Production--Base Case.

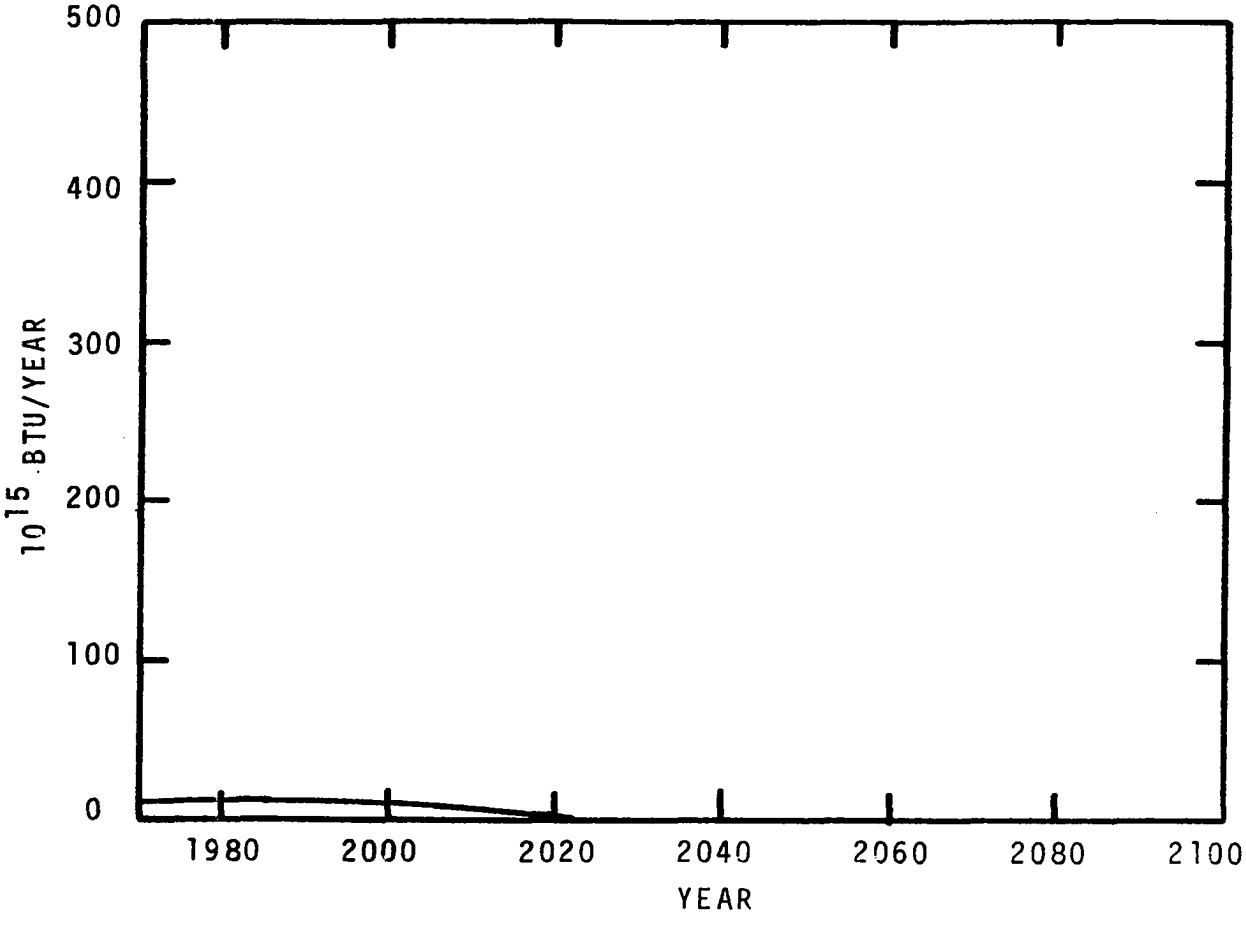


Figure IV-13. Annual Coal Requirements for Electrical Power Generation--Base Case.

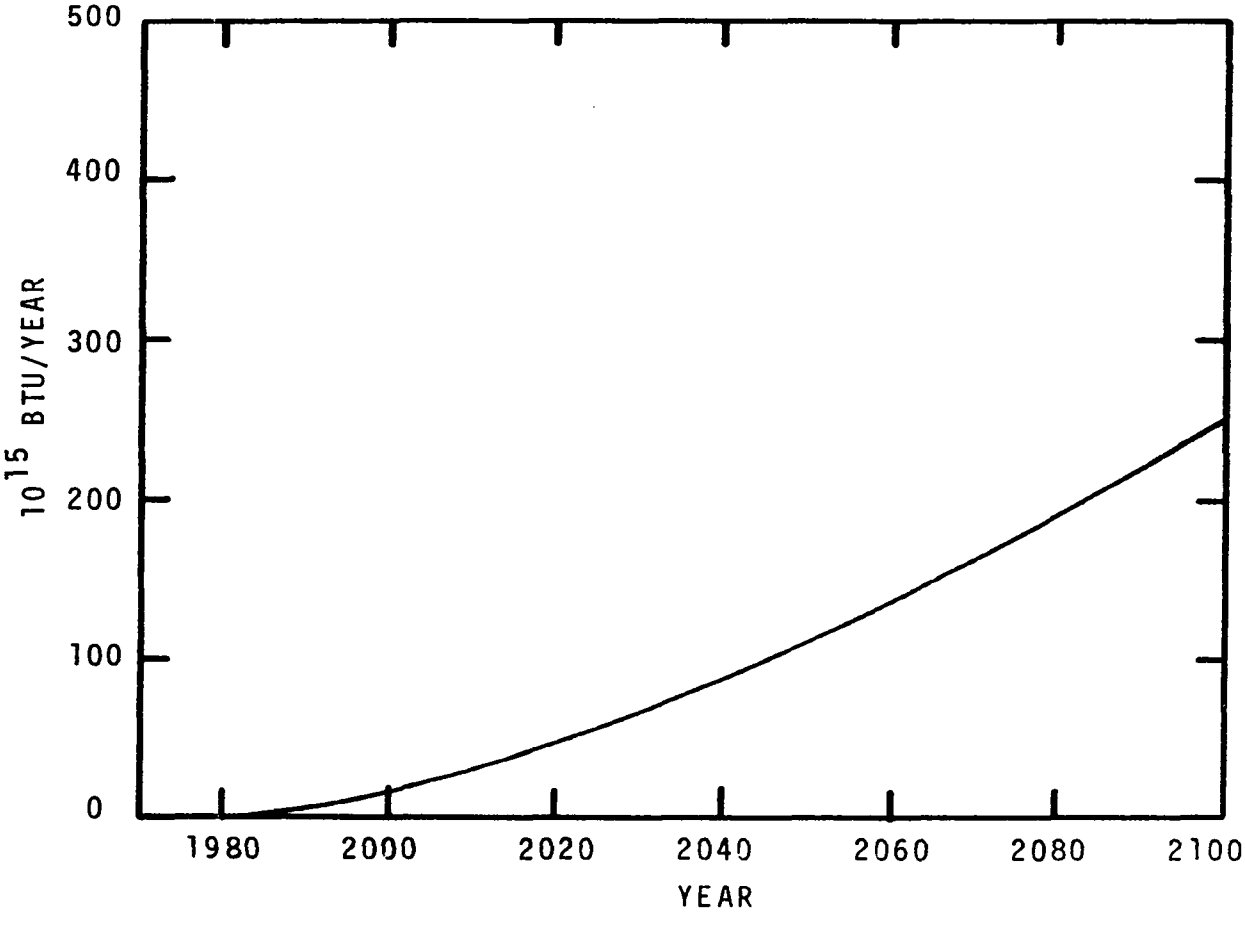


Figure IV-14. Annual Coal Requirements for Synthetic Crude Oil Production--Base Case.

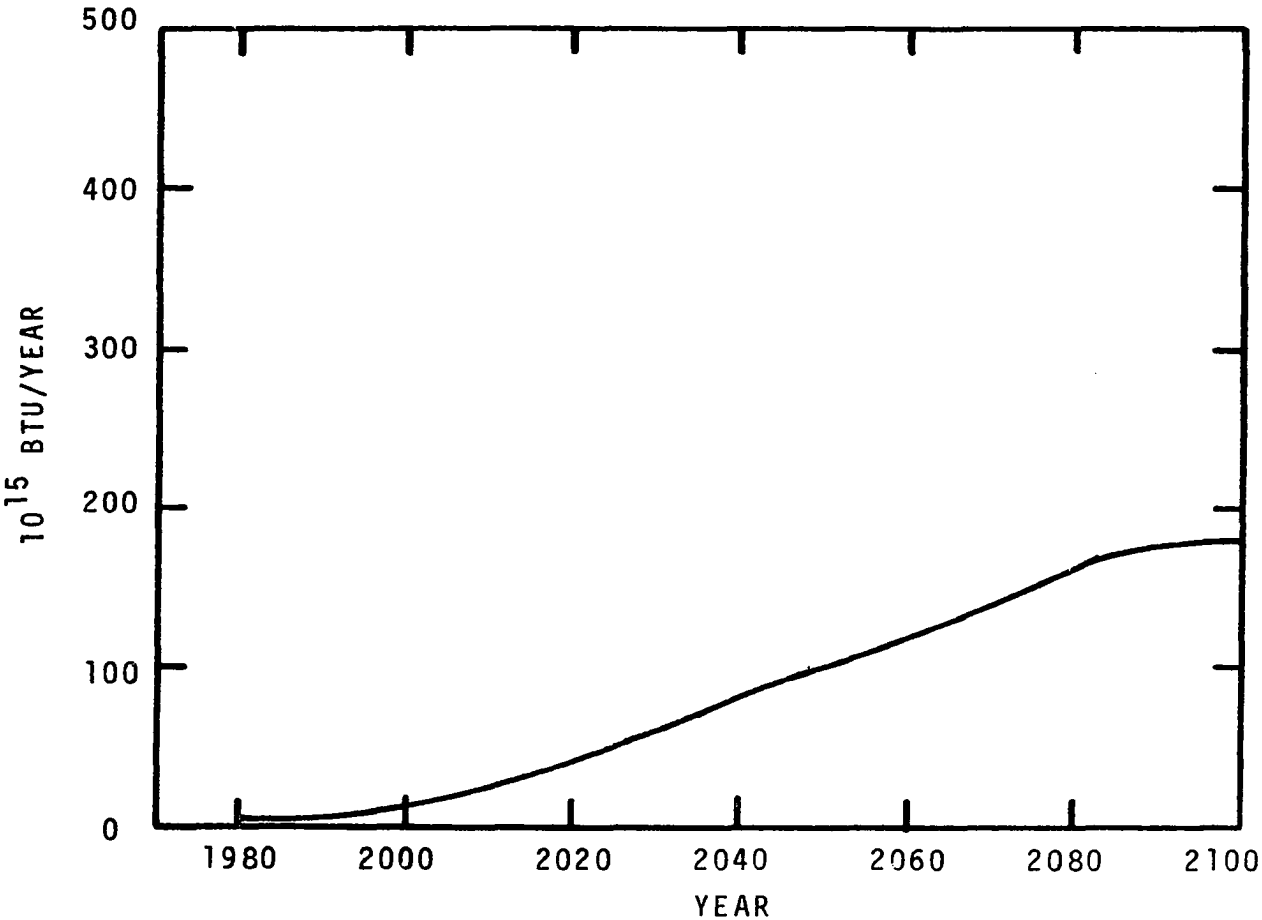


Figure IV-15. Annual Coal Requirements for Synthetic Natural Gas Production--Base Case.

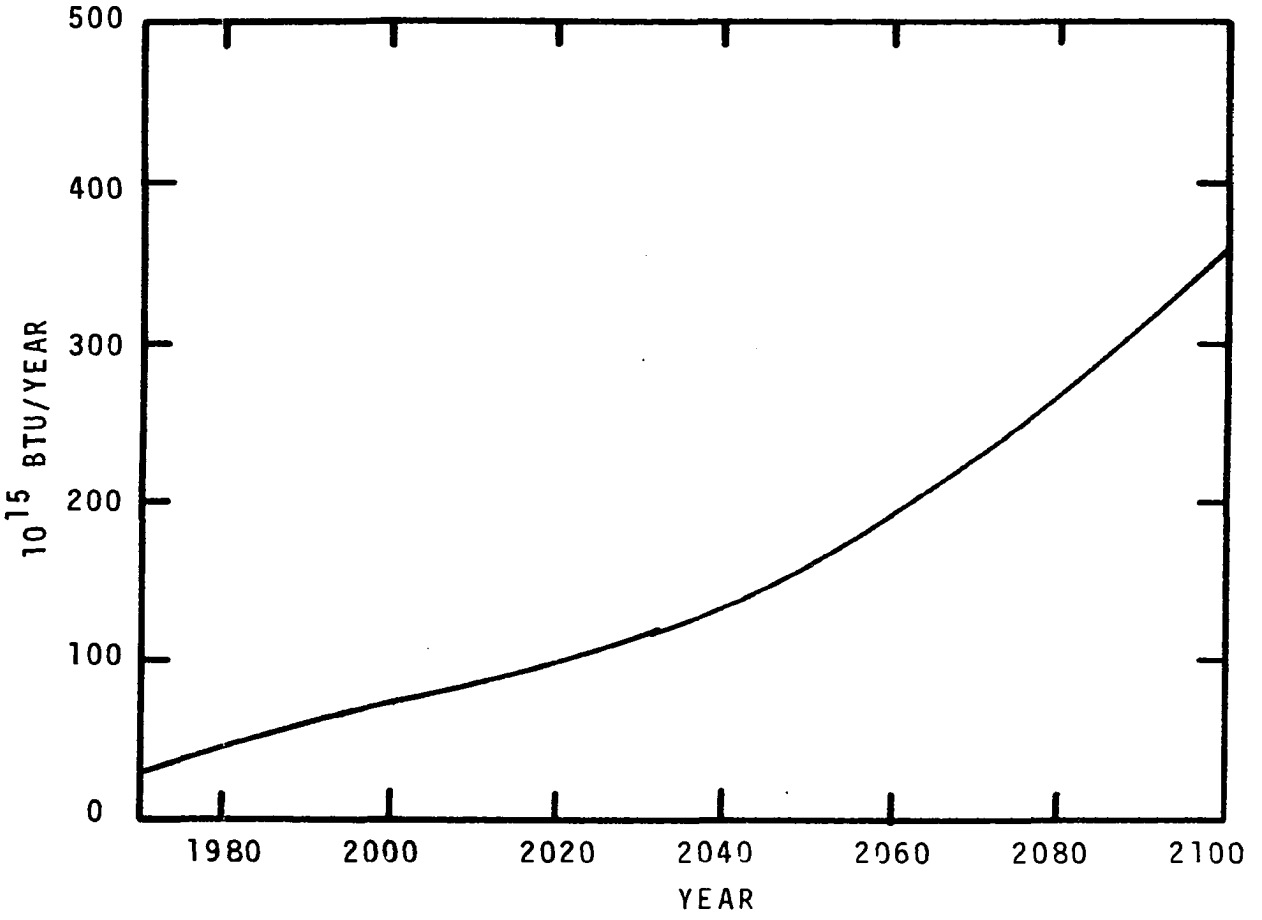


Figure IV-16. Annual Crude Petroleum Demand--Base Case.

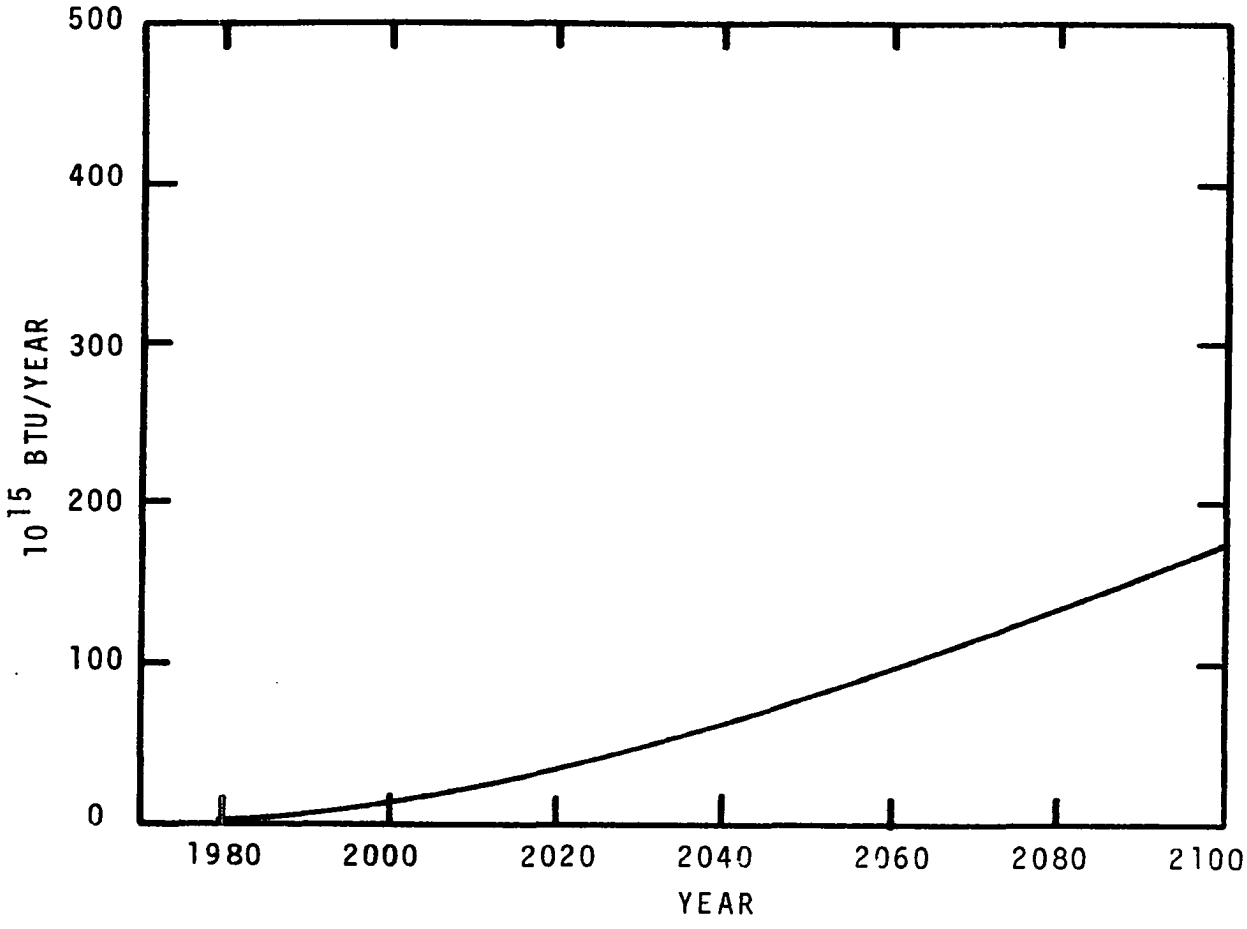


Figure IV-17. Annual Synthetic Crude Oil Demand--Base Case.

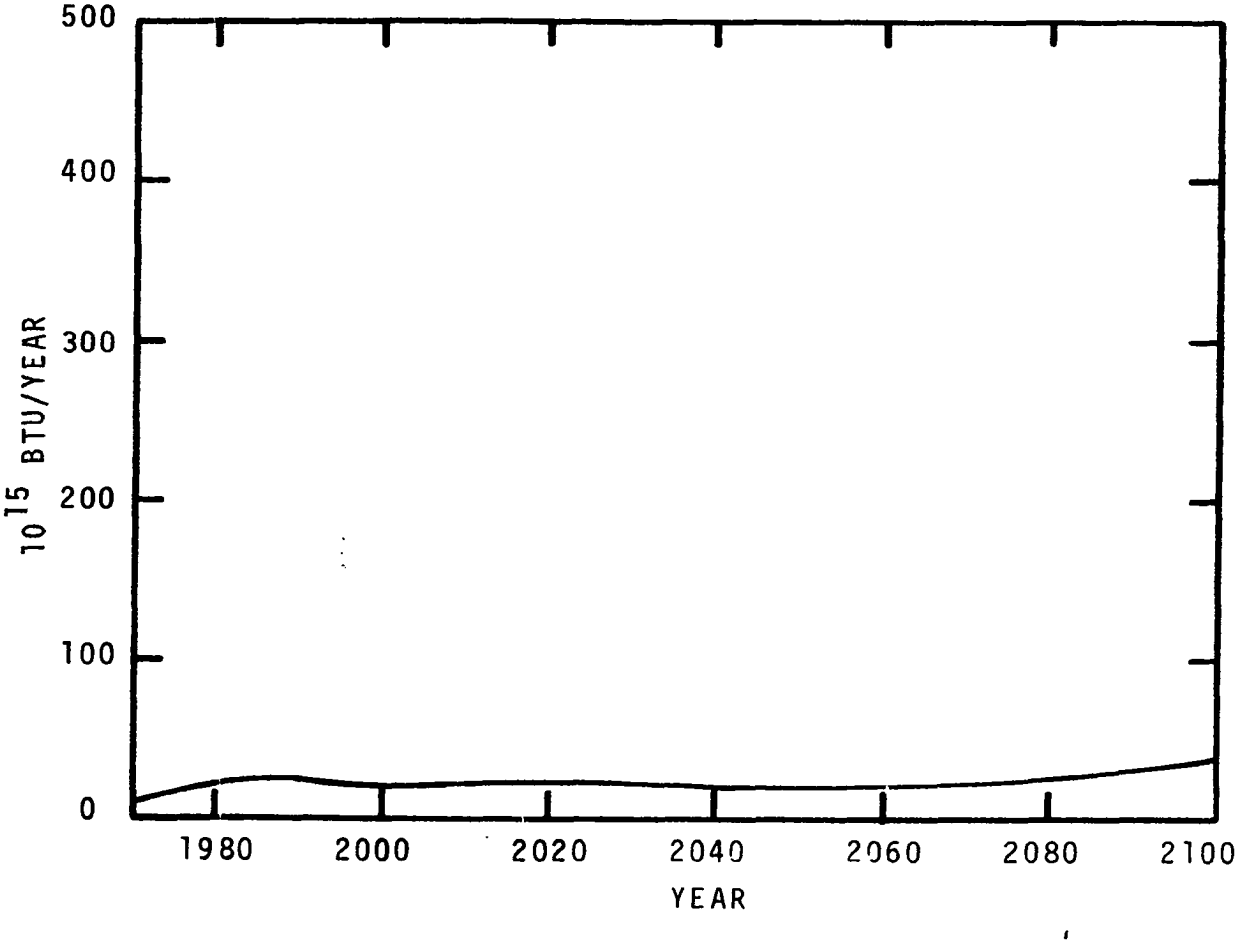


Figure IV-18. Annual Crude Oil Import Requirements--Base Case.

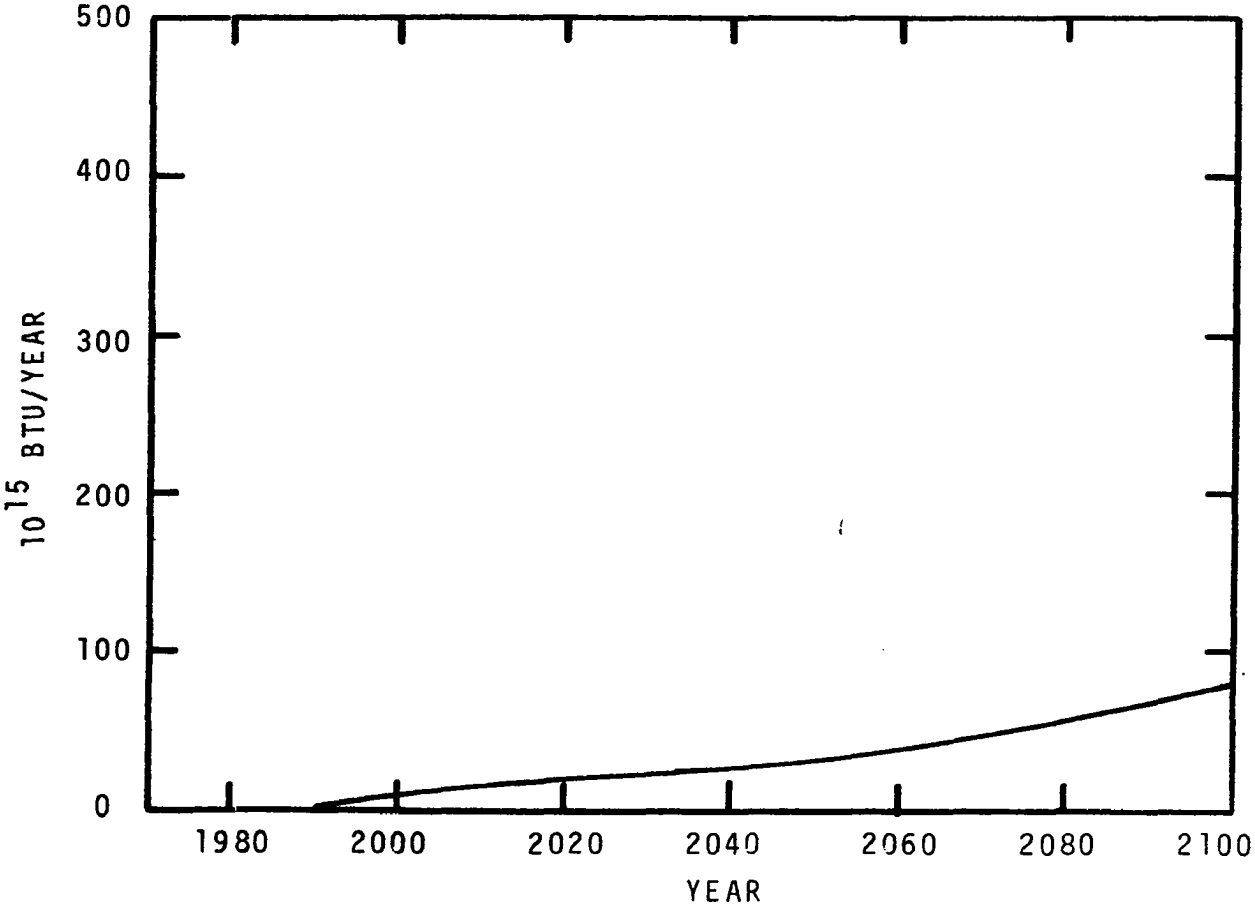


Figure IV-19. Annual Oil Shale Production--Base Case.

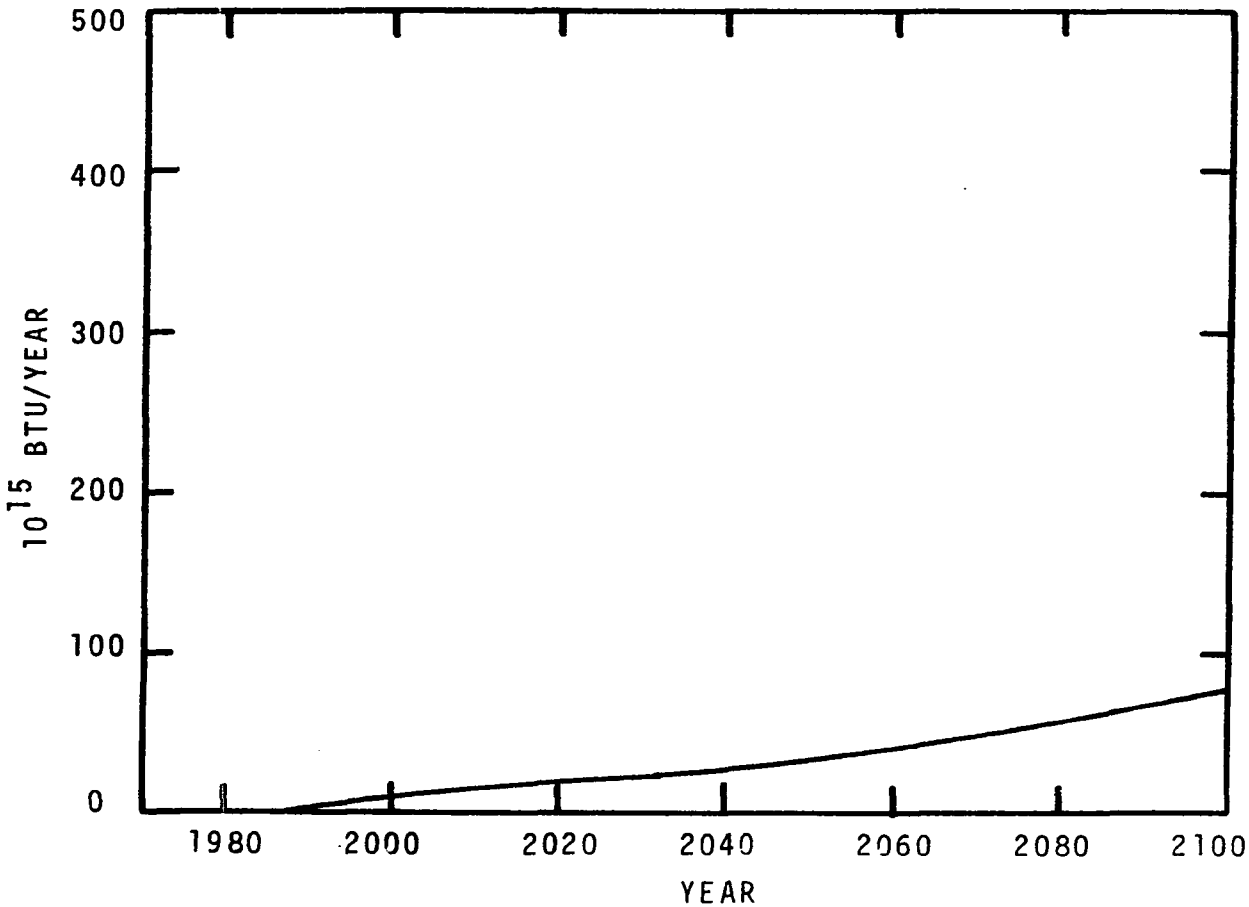


Figure IV-20. Annual Tar Sands Production--Base Case.

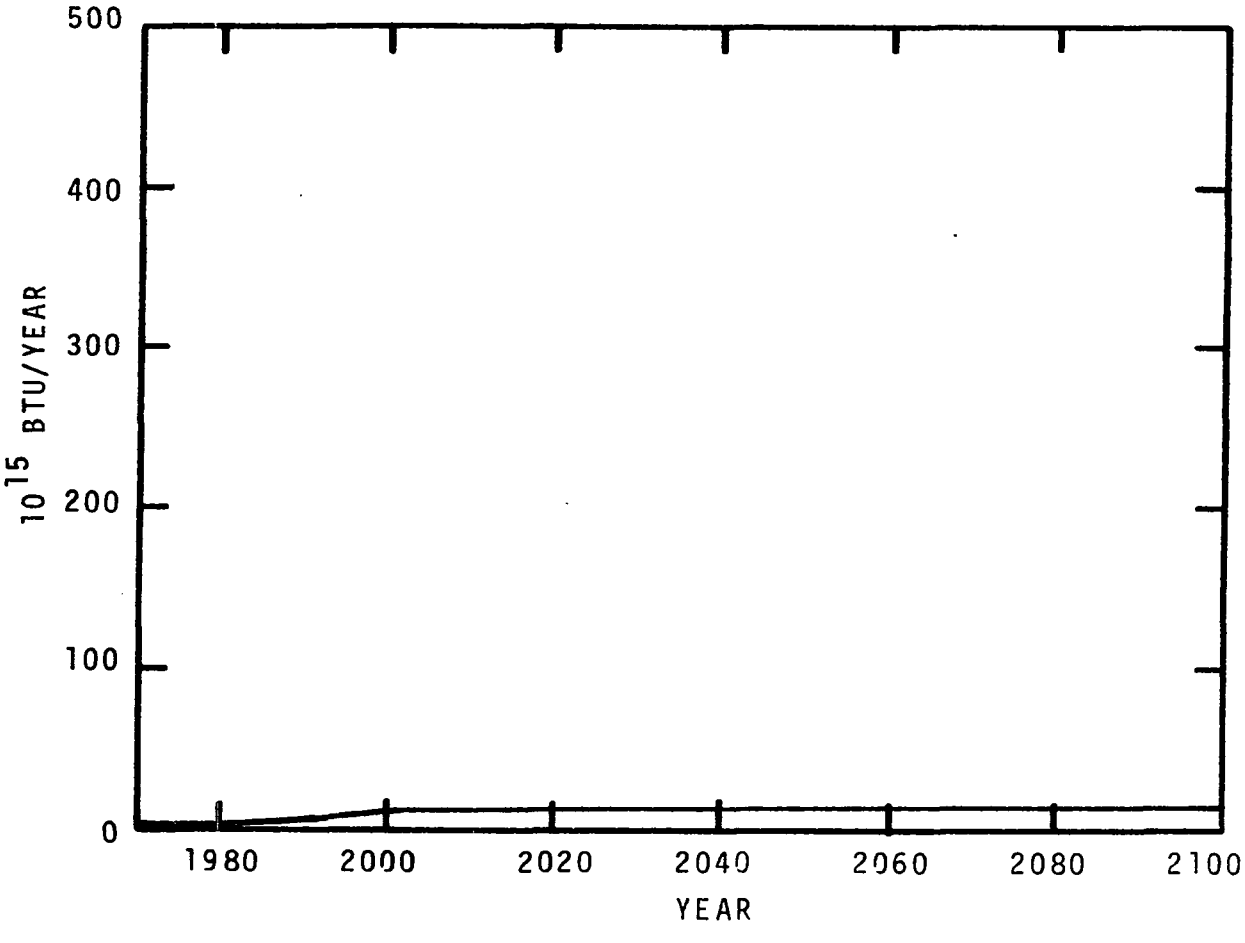


Figure IV-21. Annual Geothermal Energy Resource Production--Base Case.

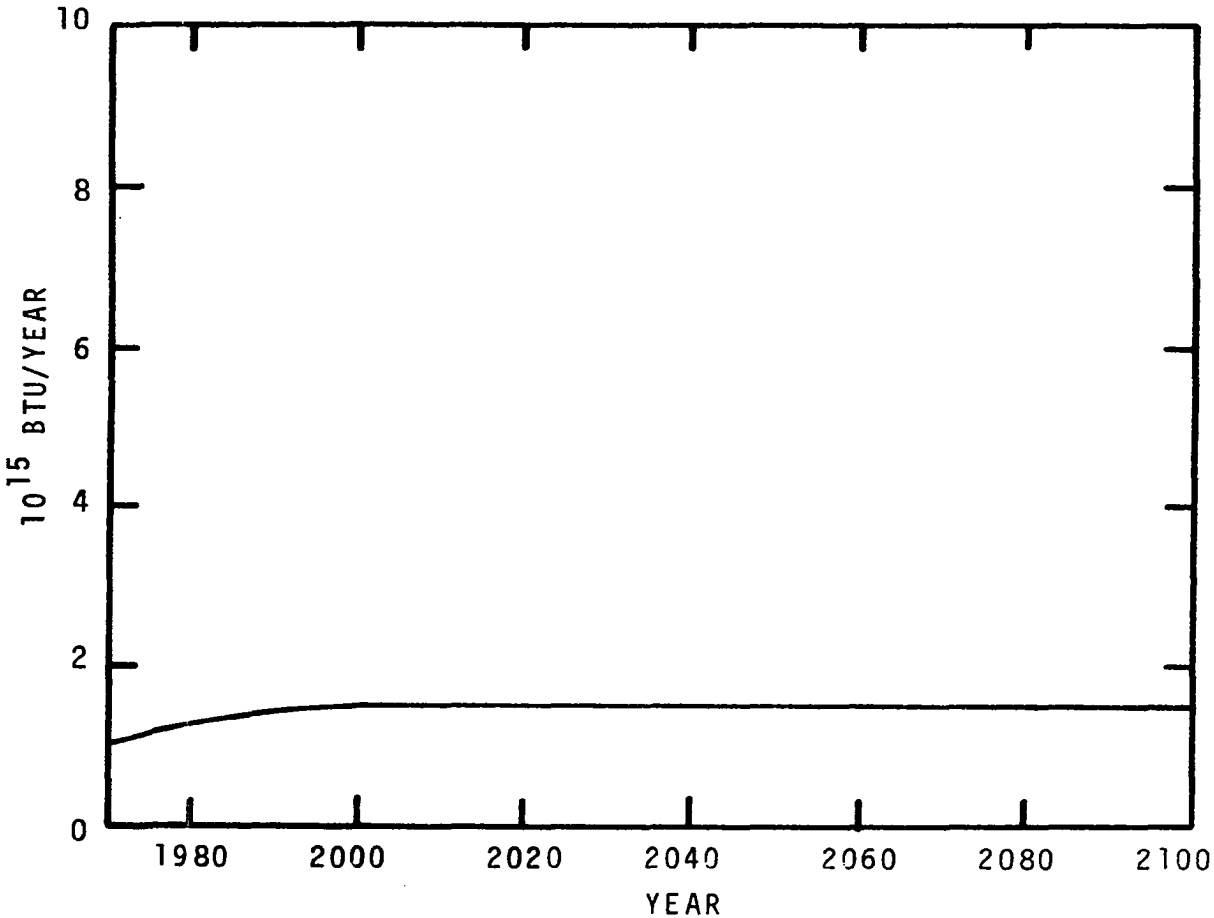


Figure IV-22. Annual Hydroelectric Resource Production--Base Case.

constant after the year 2000 due to rapid resource development of available resources in the next thirty years.

The difference between the annual natural gas production and demand, Figure IV-23, is due to transmission losses, lease losses and plant fuel use. The natural gas demand is filled by domestic natural gas production, liquefied natural gas imports, and synthetic natural gas from petroleum and coal, Figures IV-24 and IV-25.

Environmental Impact

The environmental impact projections for the base case include airborne emissions, radioactive releases, water and land usage and solid waste production.

Airborne emission, Figure IV-26, decrease initially due to the more stringent emission standards for automobiles and electrical generation stations. However, since the model assumes constant airborne emission controls after 1980, the air pollution continues to increase with energy demand until all of the gains made by emission controls are erased. It is doubtful whether the United States could tolerate the magnitude of emissions projected for 2040 and beyond.

Due to the domestic role of nuclear power in the energy supply projections, the annual population exposure to ionizing radiation, the projected radioactive releases from nuclear power plants--tritium, krypton-85 and long-lived waste from plant operations--increases dramatically following nuclear fission power production, Figures IV-27 through IV-29.

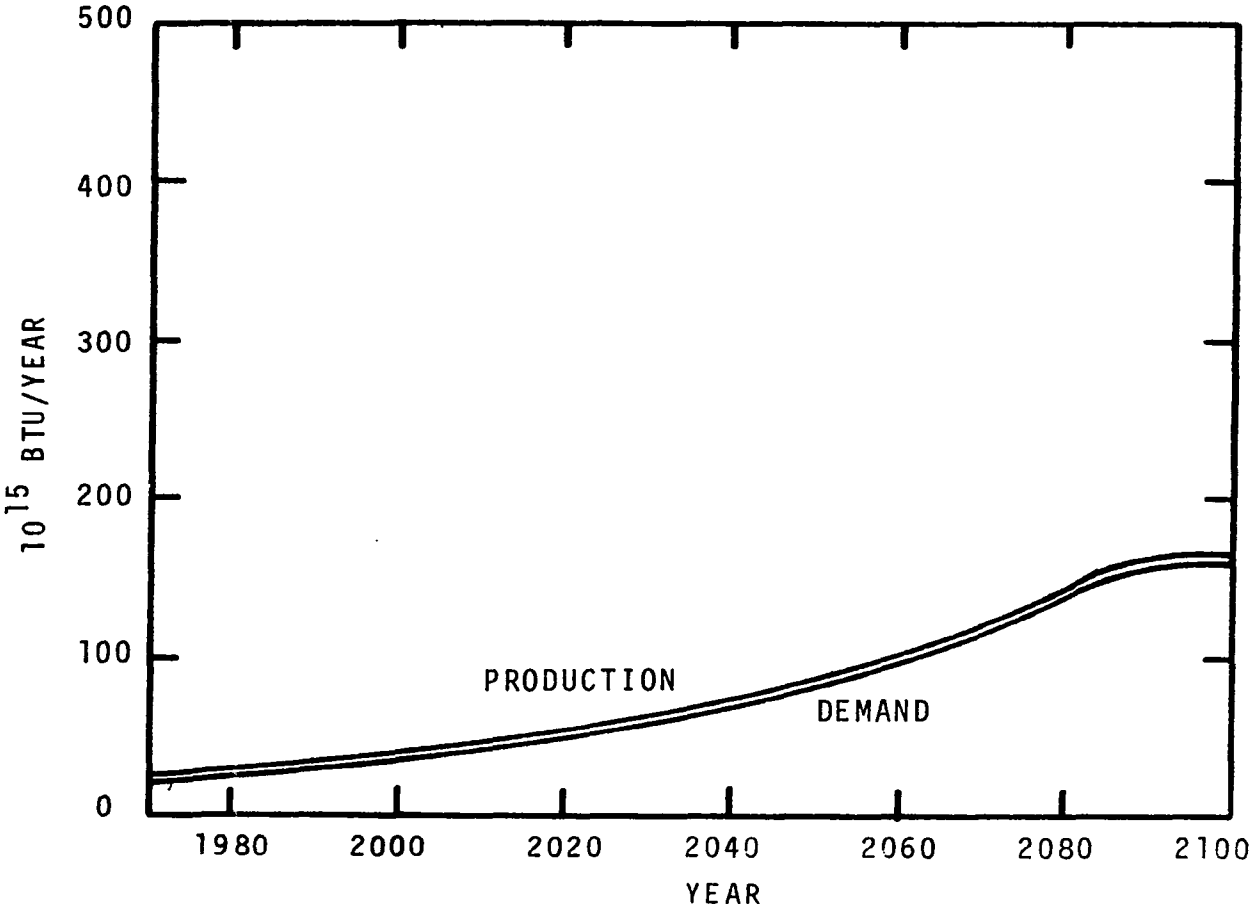


Figure IV-23. Natural Gas Production Requirements and Natural Gas Demand--Base Case.

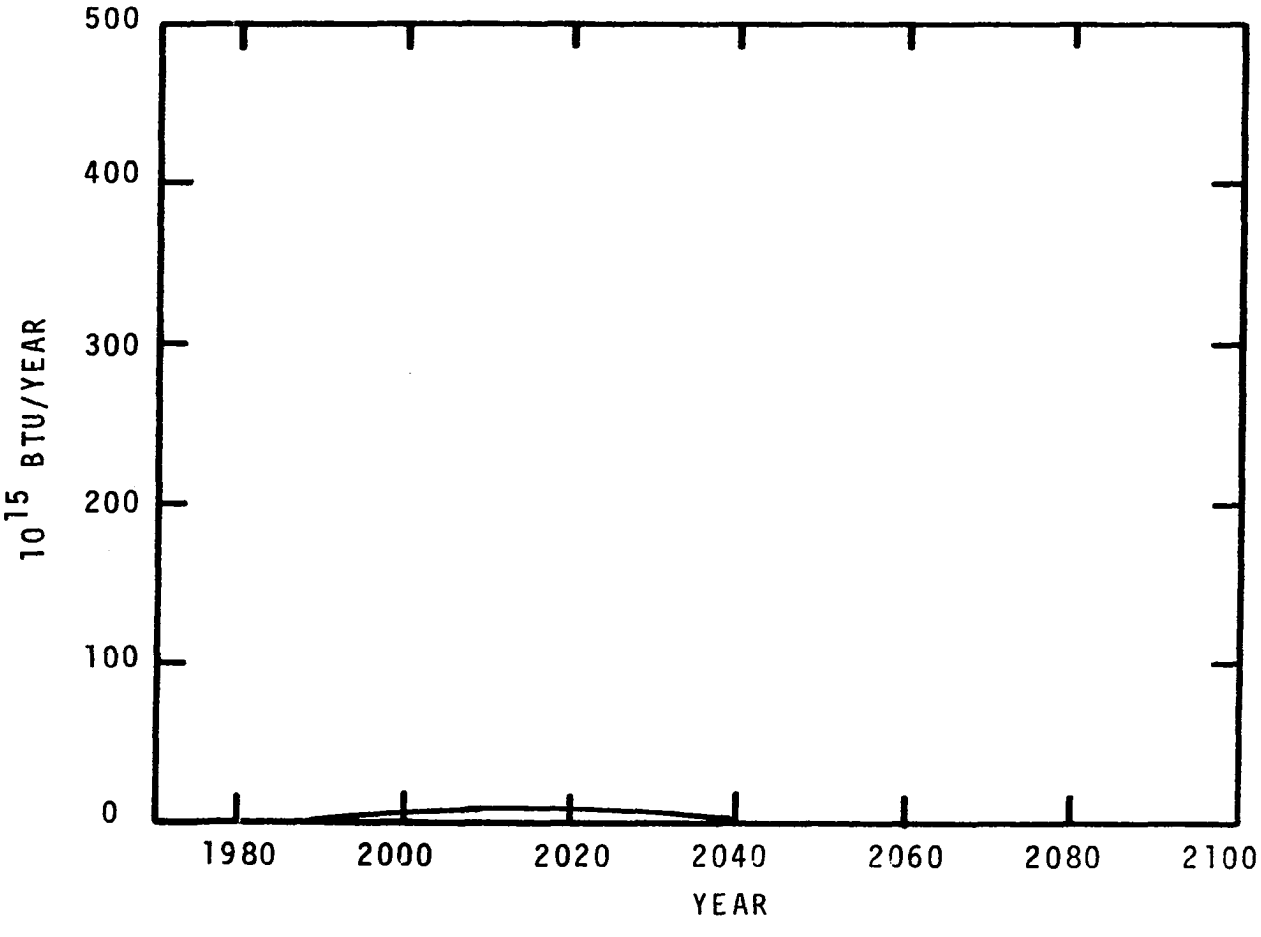


Figure IV-24. Annual Liquefied Natural Gas Imports--Base Case.

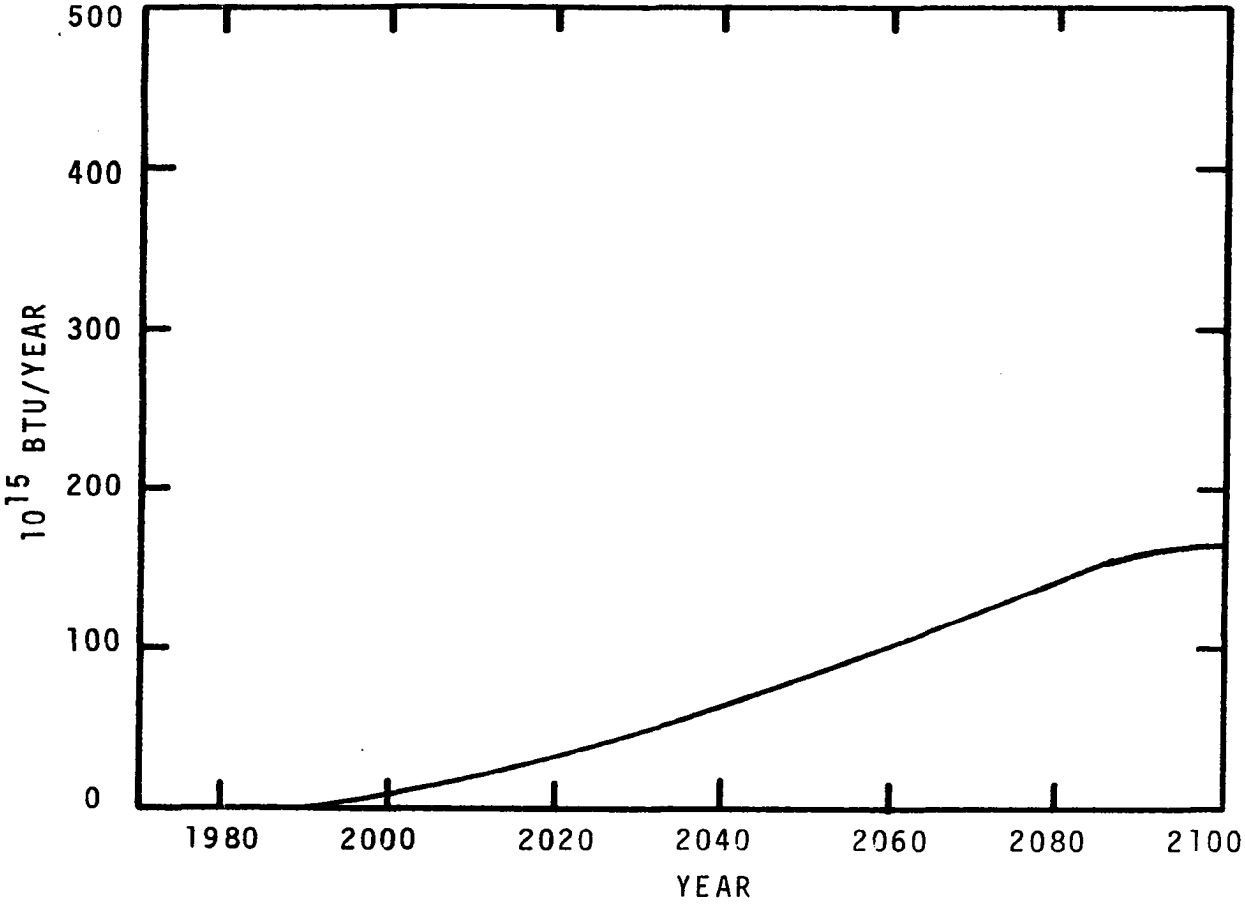


Figure IV-25. Synthetic Natural Gas Demand--Base Case.

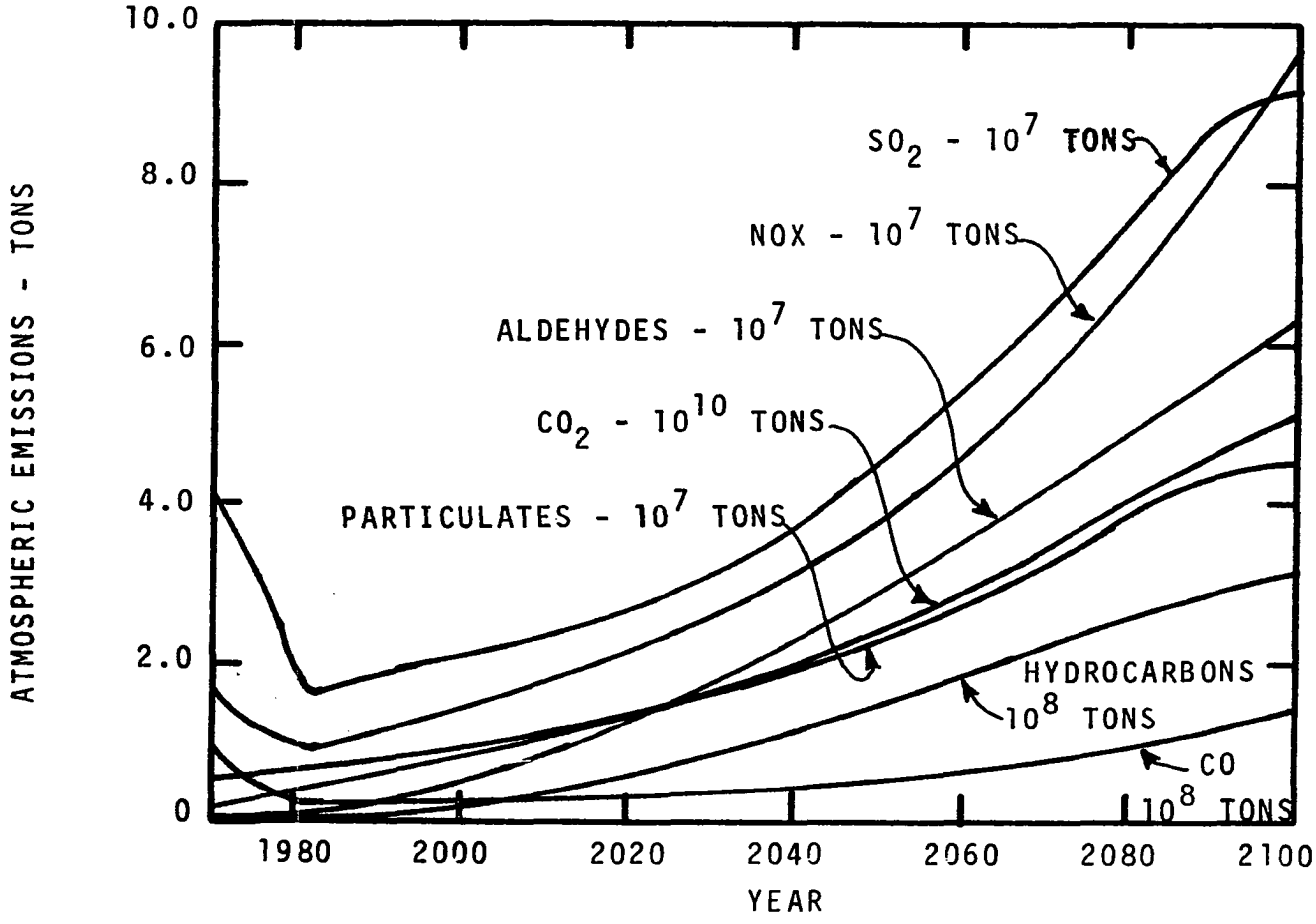


Figure IV-26. Annual Airborne Emissions--Base Case.

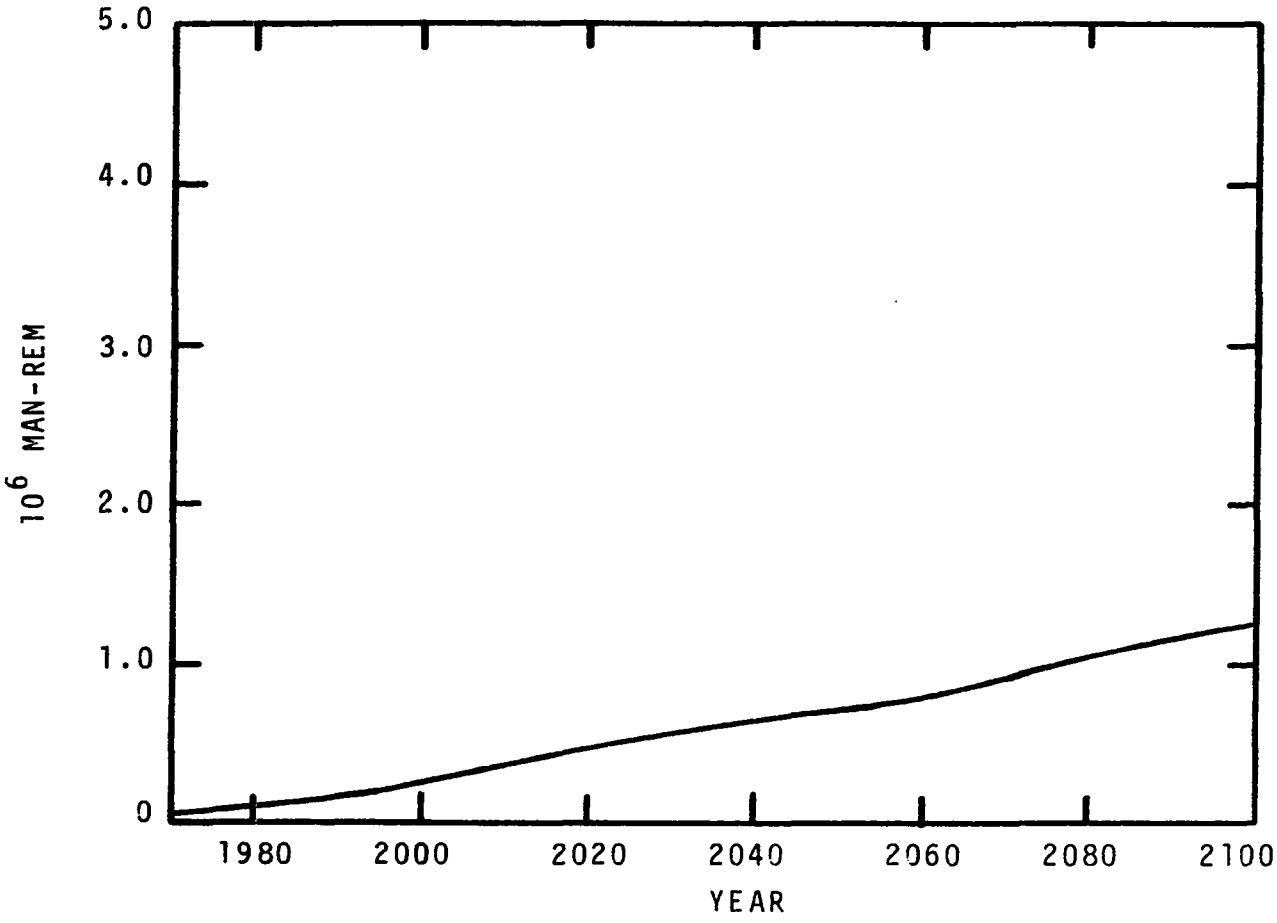


Figure IV-27. Annual Population Exposure to Ionizing Radiation--Base Case.

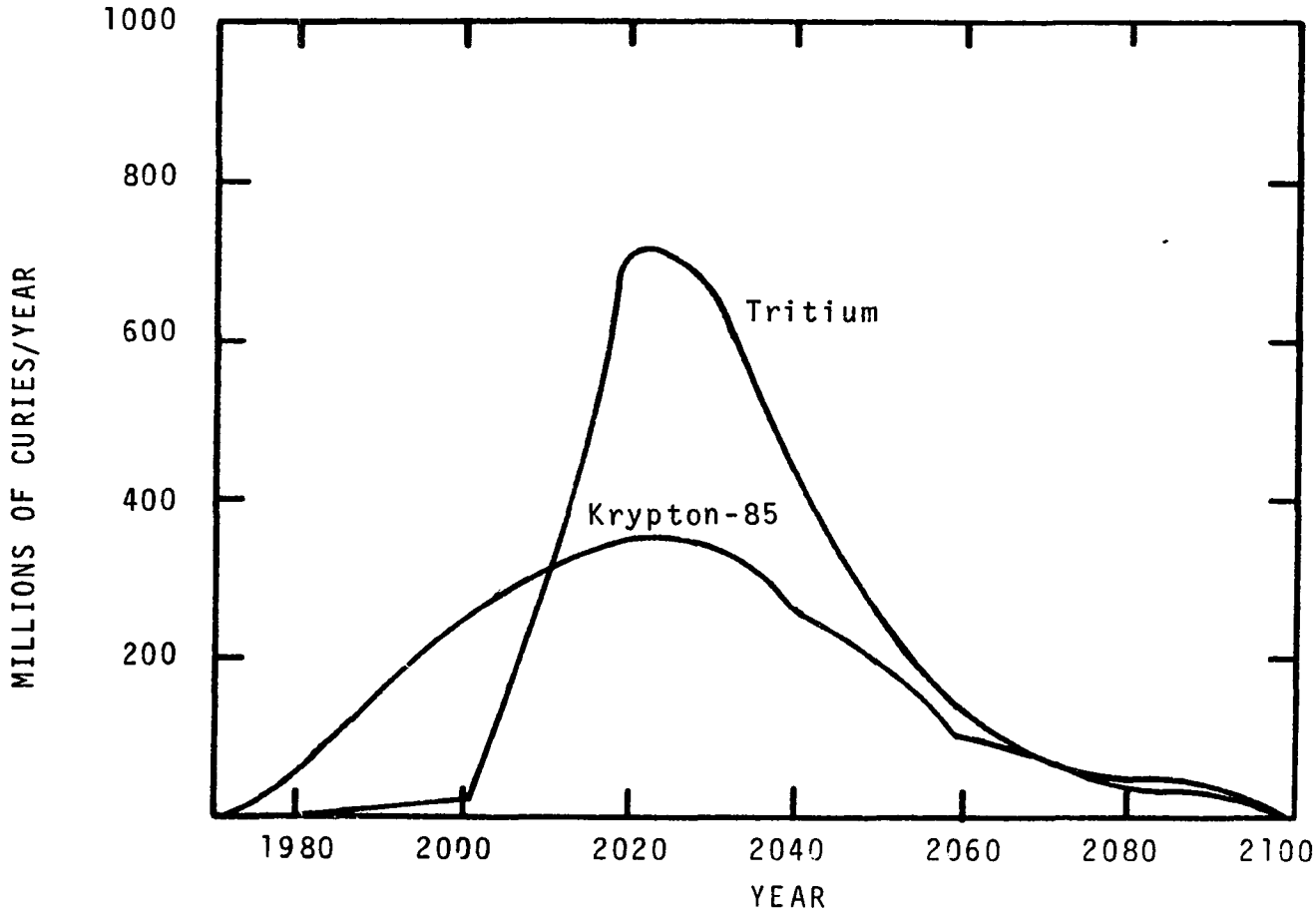


Figure IV-28. Annual Tritium and Krypton-85 Releases--Base Case.

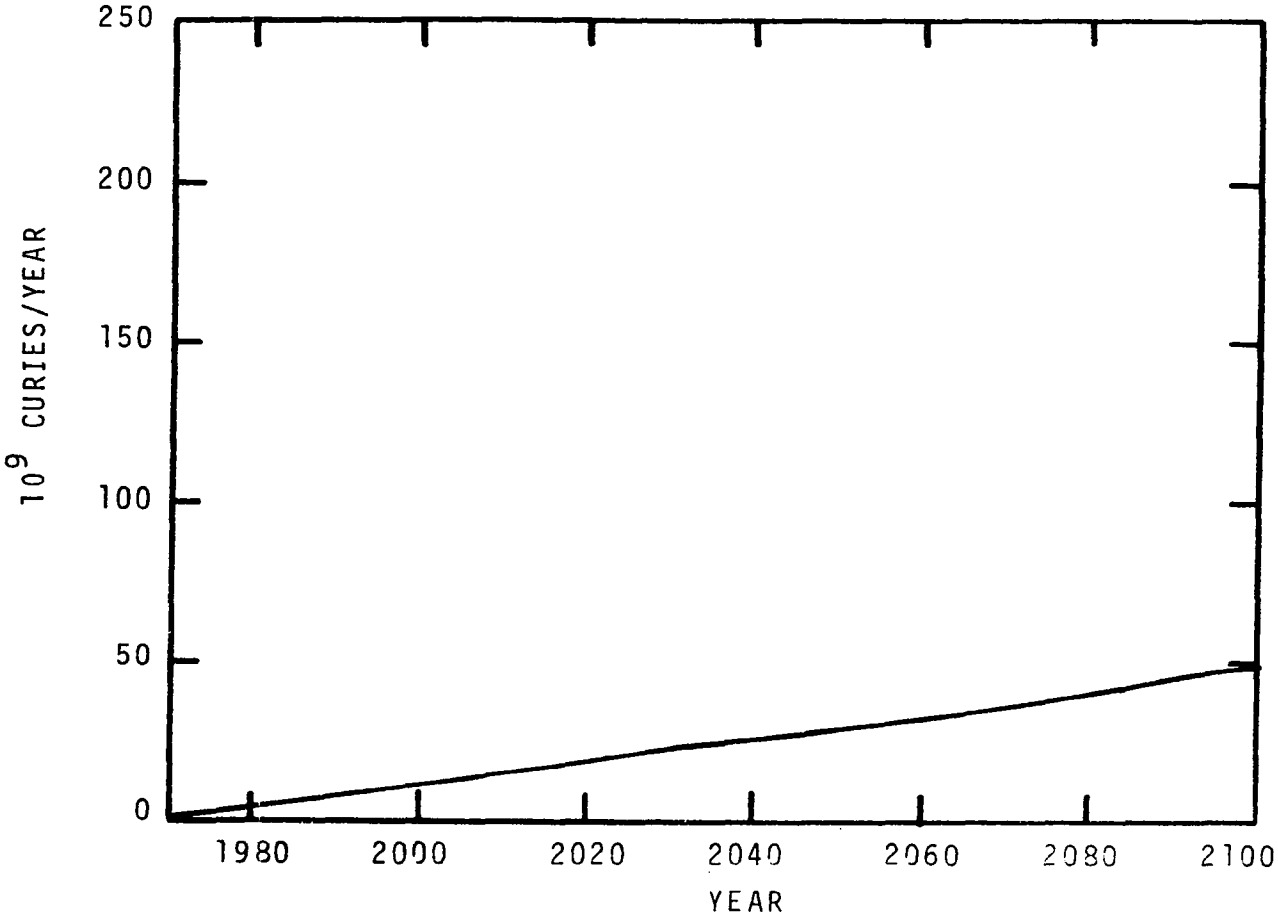


Figure IV-29. Annual Long-Lived Radioactive Solid Waste Production--Base Case.

The magnitude of solid waste and elemental sulfur production, Figures IV-30 and IV-31, follow the coal and oil demand curves. The annual water consumption and land usage for energy utilization are shown in Figures IV-32 and IV-33. The total land usage is essentially constant after 2000 due to the large hydroelectric and geothermal land requirements per unit energy produced.

Balance of Payments

The variation in the balance of payments deficit due to purchases of energy resources abroad, Figure IV-34, is due to the shift from crude petroleum imports to oil shale and syncrude in the year 2000 and the termination of LNG imports in 2040. Even with the stringent import limitations specified in the base case, the average balance of payments deficit due to energy purchases after 1990 is approximately 20 billion dollars per year.

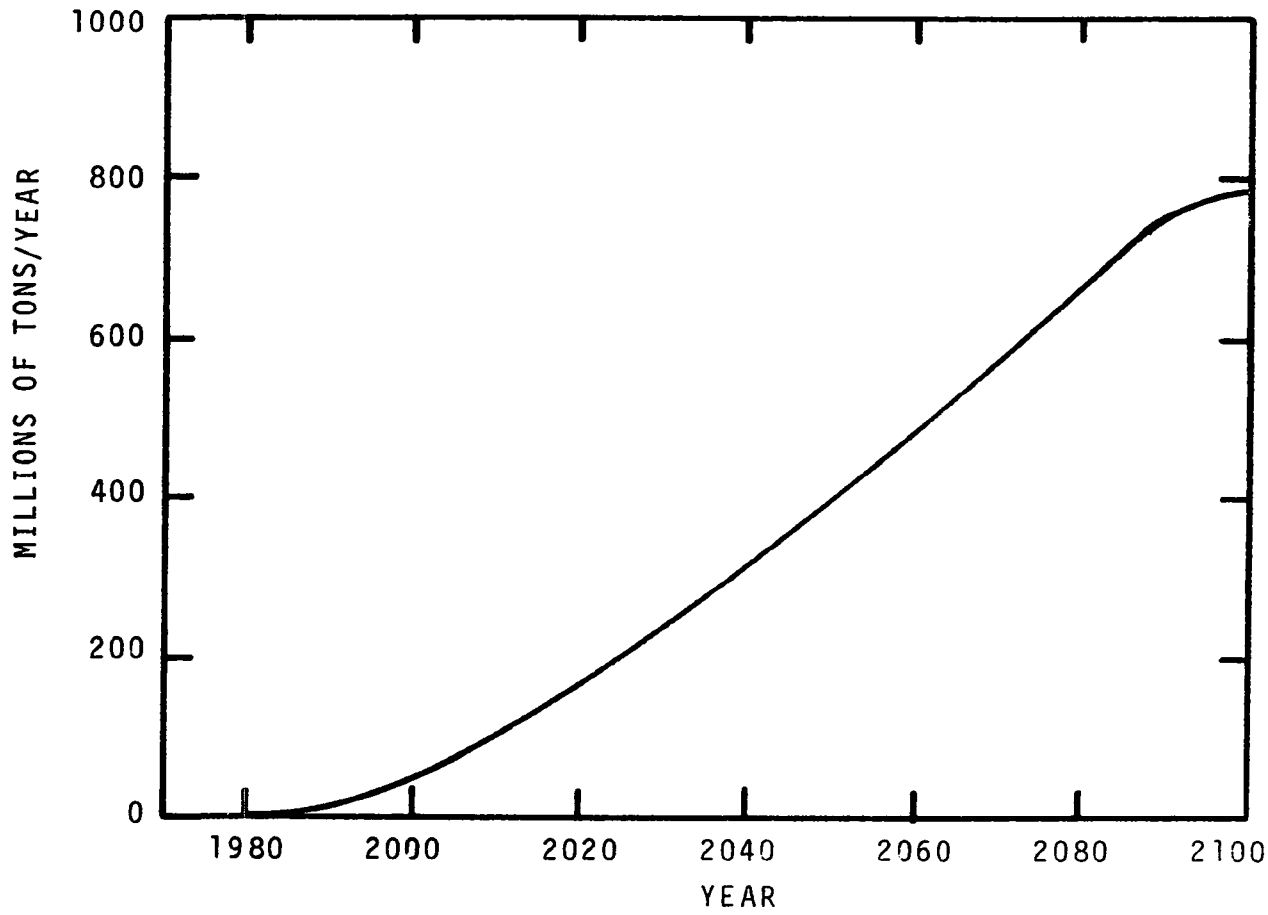


Figure IV-30. Annual Solid Waste Production--Base Case.

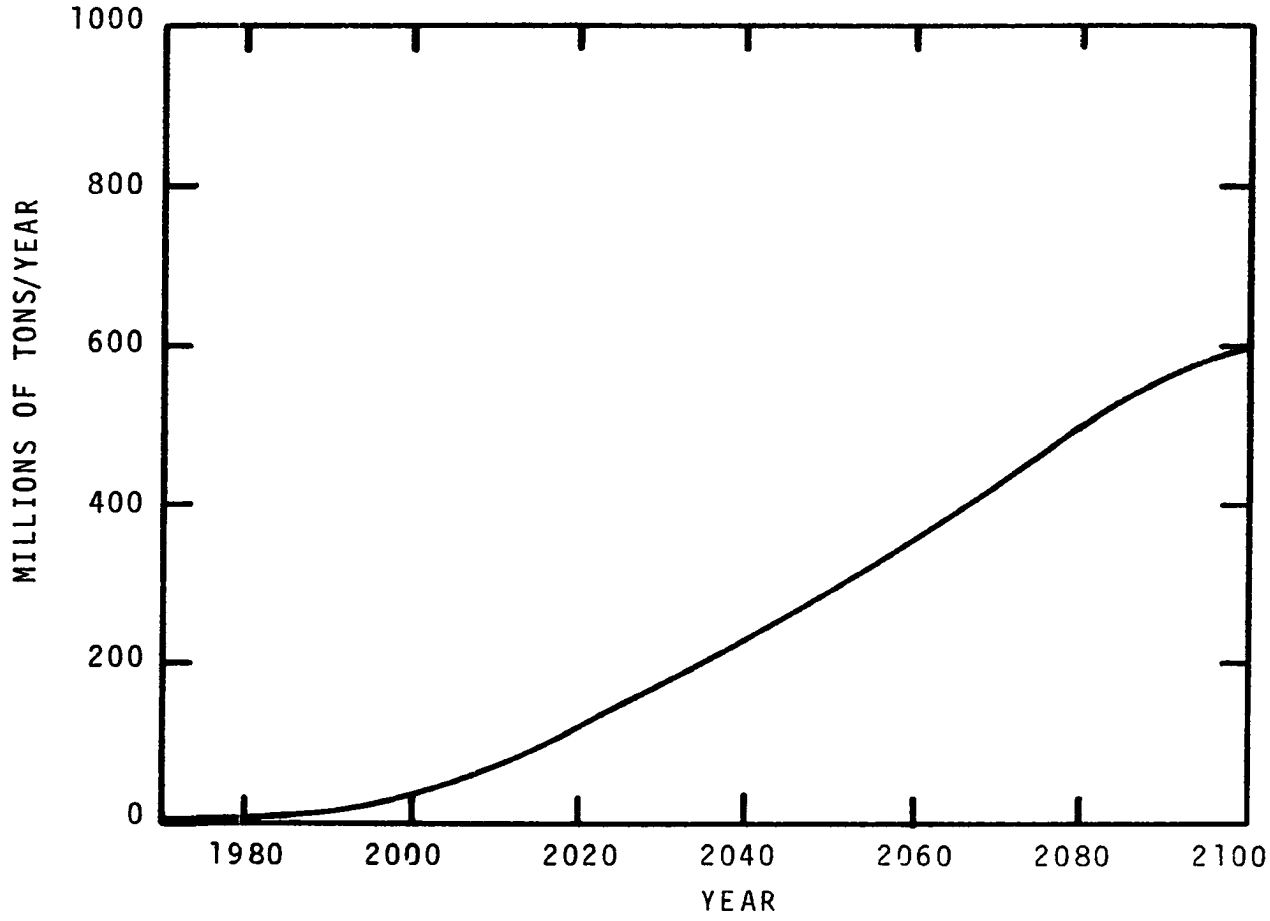


Figure IV-31. Annual Sulfur Production--Base Case.

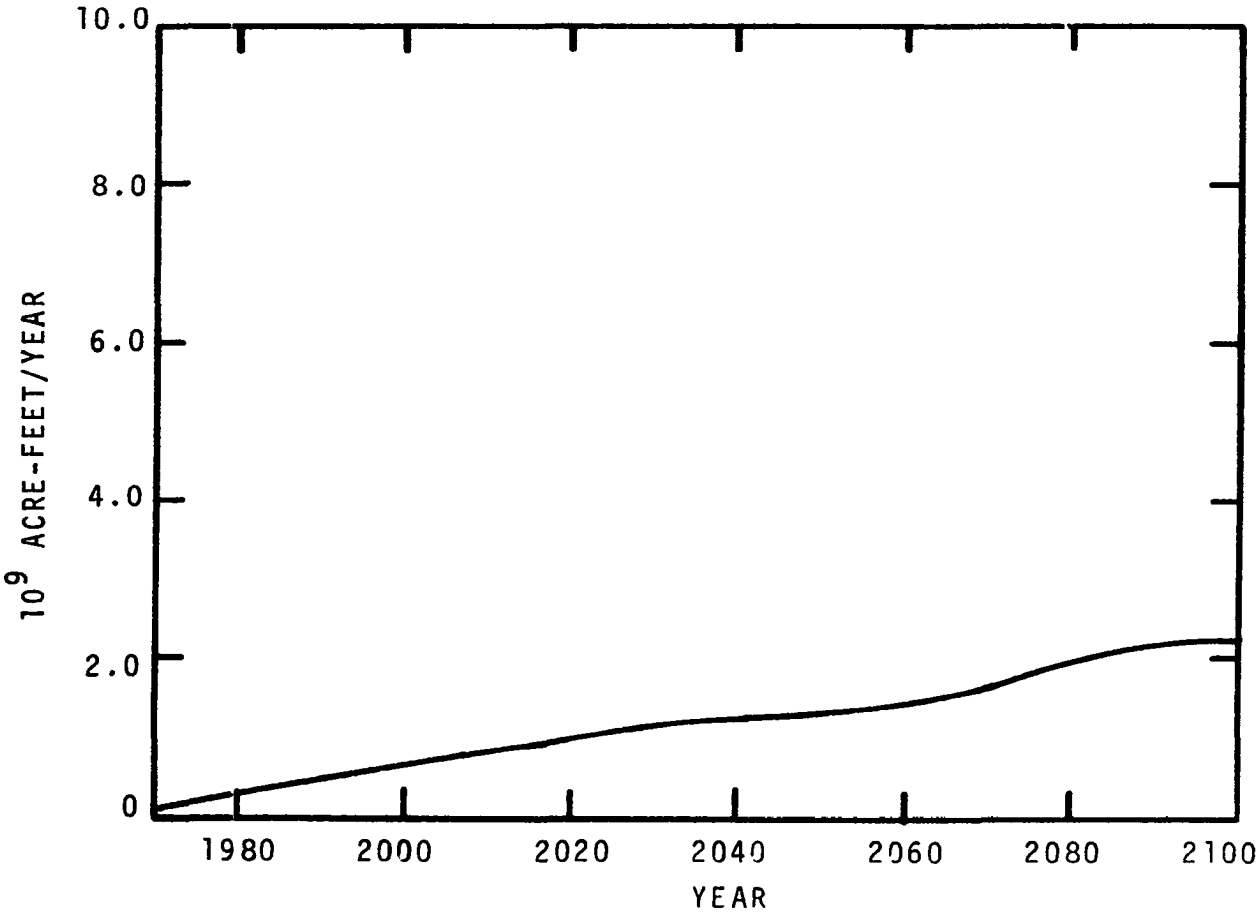


Figure IV-32. Annual Water Consumption--Base Case.

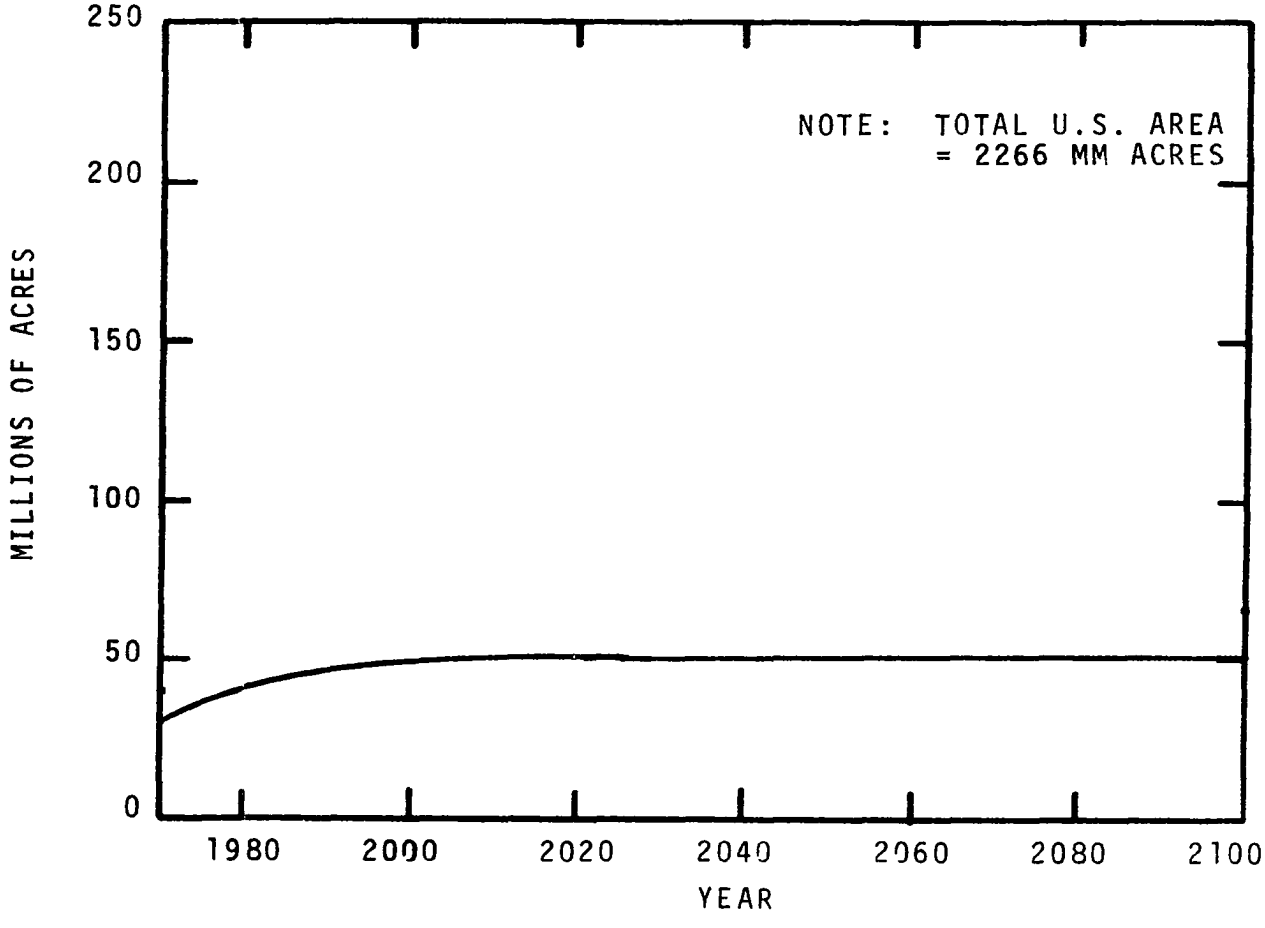


Figure IV-33. Land Usage for Energy Utilization--Base Case.

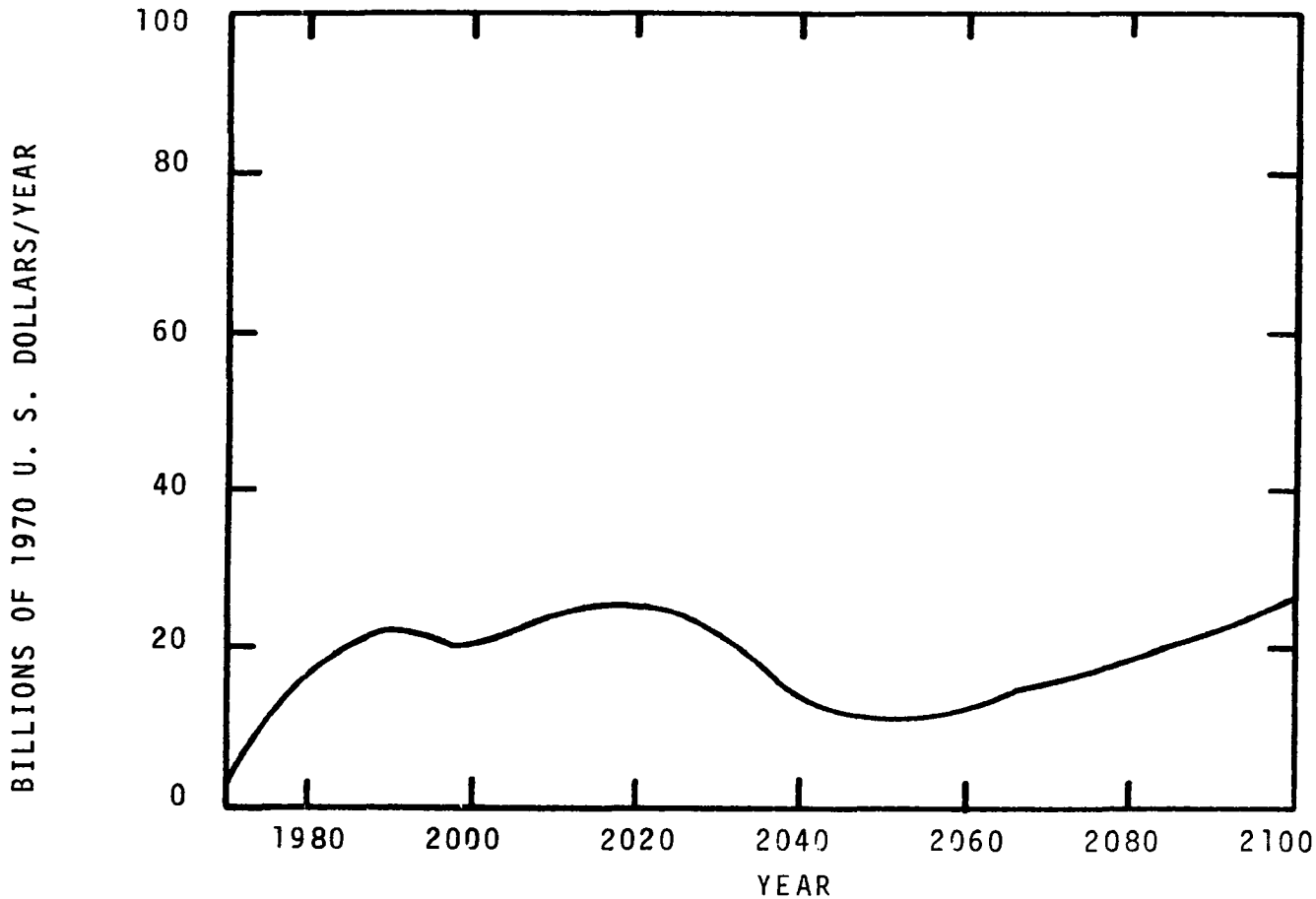


Figure IV-34. Balance of Payments Deficit--Base Case.

CHAPTER V

HTGR REFINERY ALTERNATIVE

One of the major consumers of petroleum and natural gas energy is crude oil refineries. An excellent way to reduce fossil fuel consumption in petroleum refineries is to utilize a nuclear reactor as the primary energy source. A High-Temperature Gas-Cooled Reactor, HTGR, can supply the energy required for petroleum refining at a sufficiently high temperature (1350° to 1550°F) acceptable for petroleum refinery operations. The Liquid Metal Fast Breeder Reactor (LMFBR) and the Gas Cooled Fast Breeder Reactor (GCFR) are limited in reactor outlet temperatures by their canned UO_2 (or UC_2) fuel elements. The usage of cladded fuel elements reduces the maximum coolant temperature due to fuel pellet center melting, clad-pellet interactions and cladding strength limitations. Since the HTGR uses the microsphere fuel pellet in a graphite matrix core, these limitations are lifted permitting the HTGR to be used in high temperature process heat applications.

By using a HTGR as the primary source of energy for a crude oil refinery, the crude oil refining thermal

efficiency is increased, the crude oil throughput per unit product is reduced, net production rather than consumption of pipeline gas occurs, the available energy from current crude oil resources is increased, and the refinery's ecological impact on the environment is reduced. The HTGR supplies the process heat and electrical power necessary for complete refining of the crude oil and produces pure water using waste heat for desalination. A detailed description of a petroleum refinery using a High-Temperature Gas-Cooled Reactor as the primary energy source is presented in Appendix D.

Assumptions

The base case assumptions outlined in Chapter IV apply except that 25 percent of all crude oil is processed in HTGR refineries in 1990 and 50 percent by the year 2000.

Results

The annual petroleum refining fuel requirements for the base case (Figure V-1) indicate that the predominant energy source is pipeline gas. By shifting 25 and then 50 percent of the refinery processing demand to HTGR-powered refineries, the annual petroleum refining fuel requirements, Figure V-2, are shifted to nuclear fuels and the natural gas, oil, and coal requirements are dramatically reduced. The nuclear power energy production, Figure V-3, is increased slightly causing the nuclear fuel cycle requirements for both

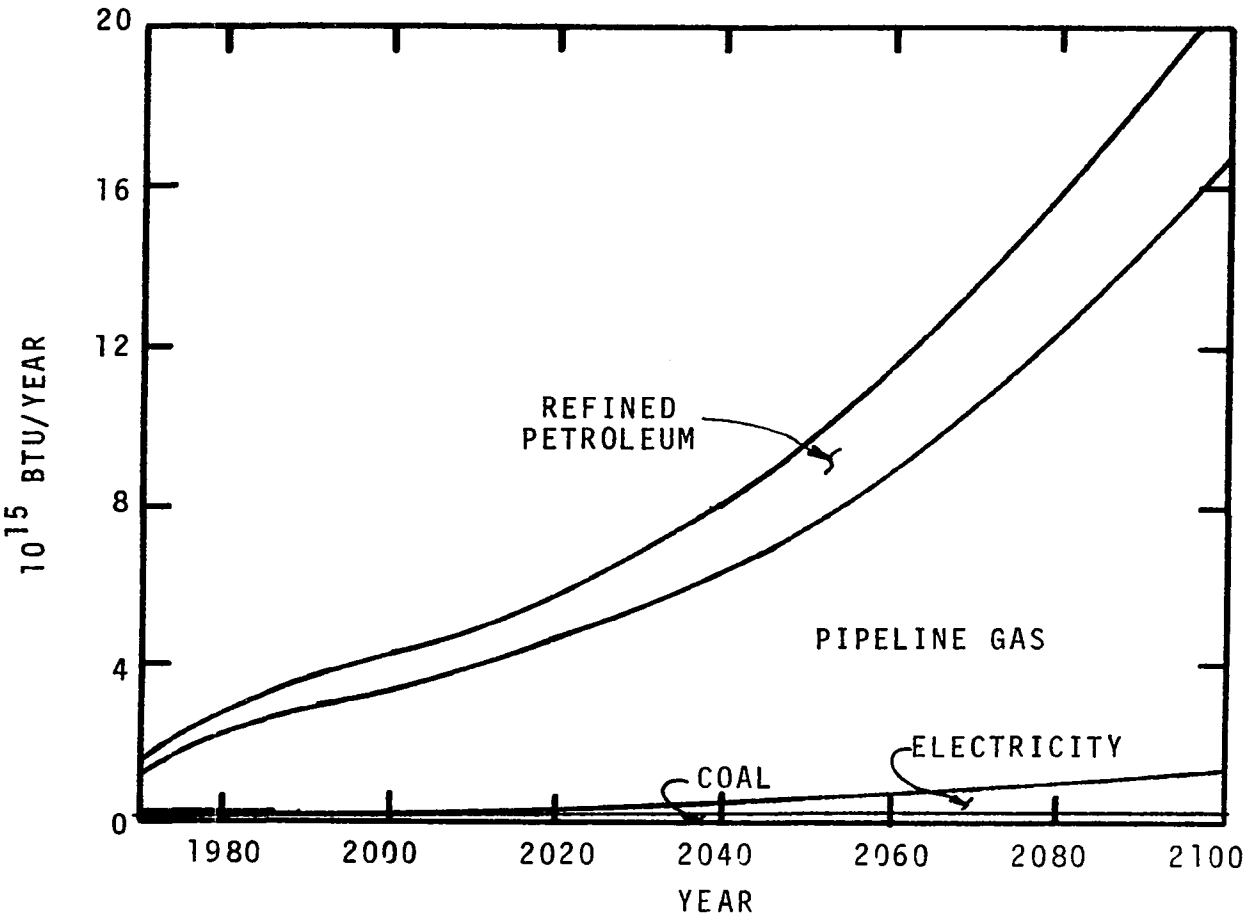


Figure V-1. Annual Composite Petroleum Refining Fuel Requirements--Base Case.

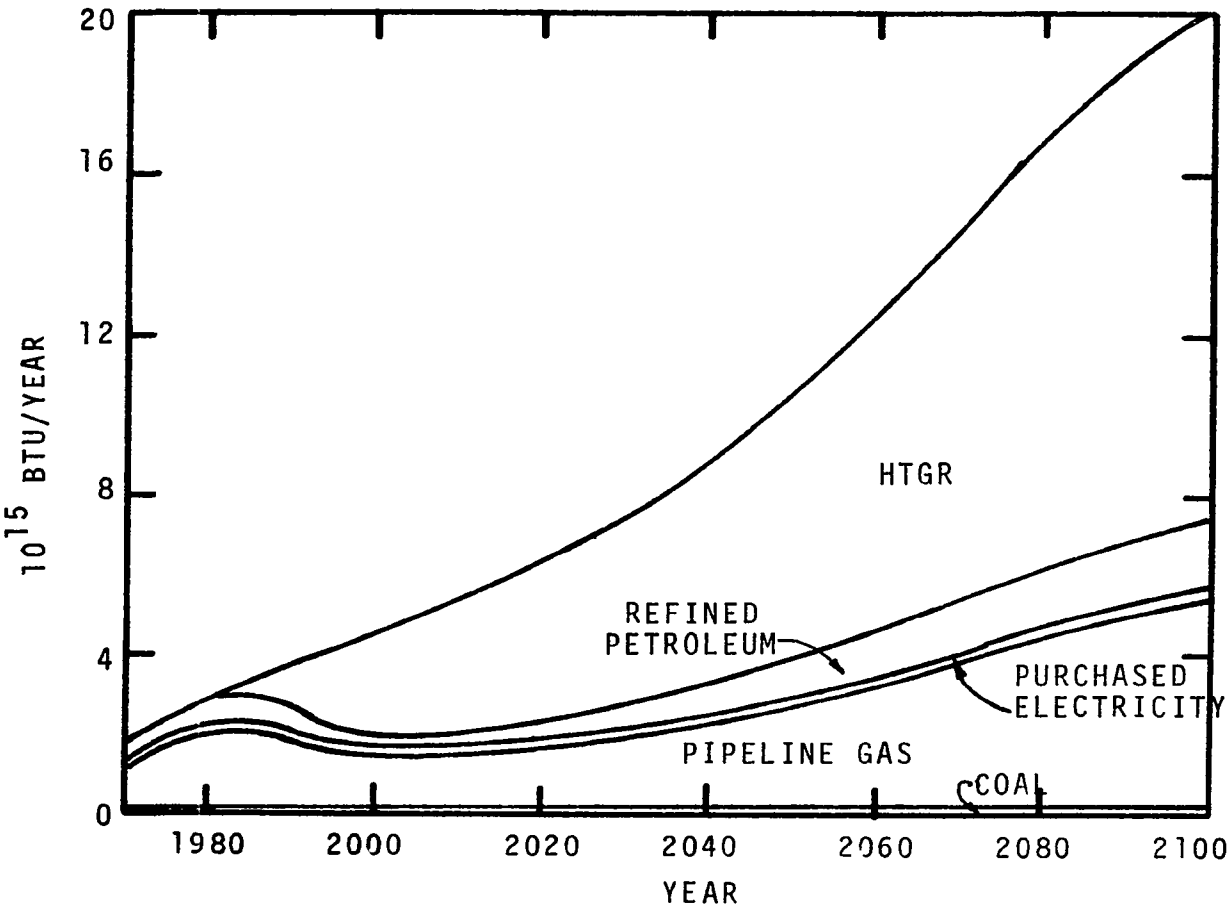


Figure V-2. Annual Composite Petroleum Refinery Fuel Requirements--HTGR Refinery Case.

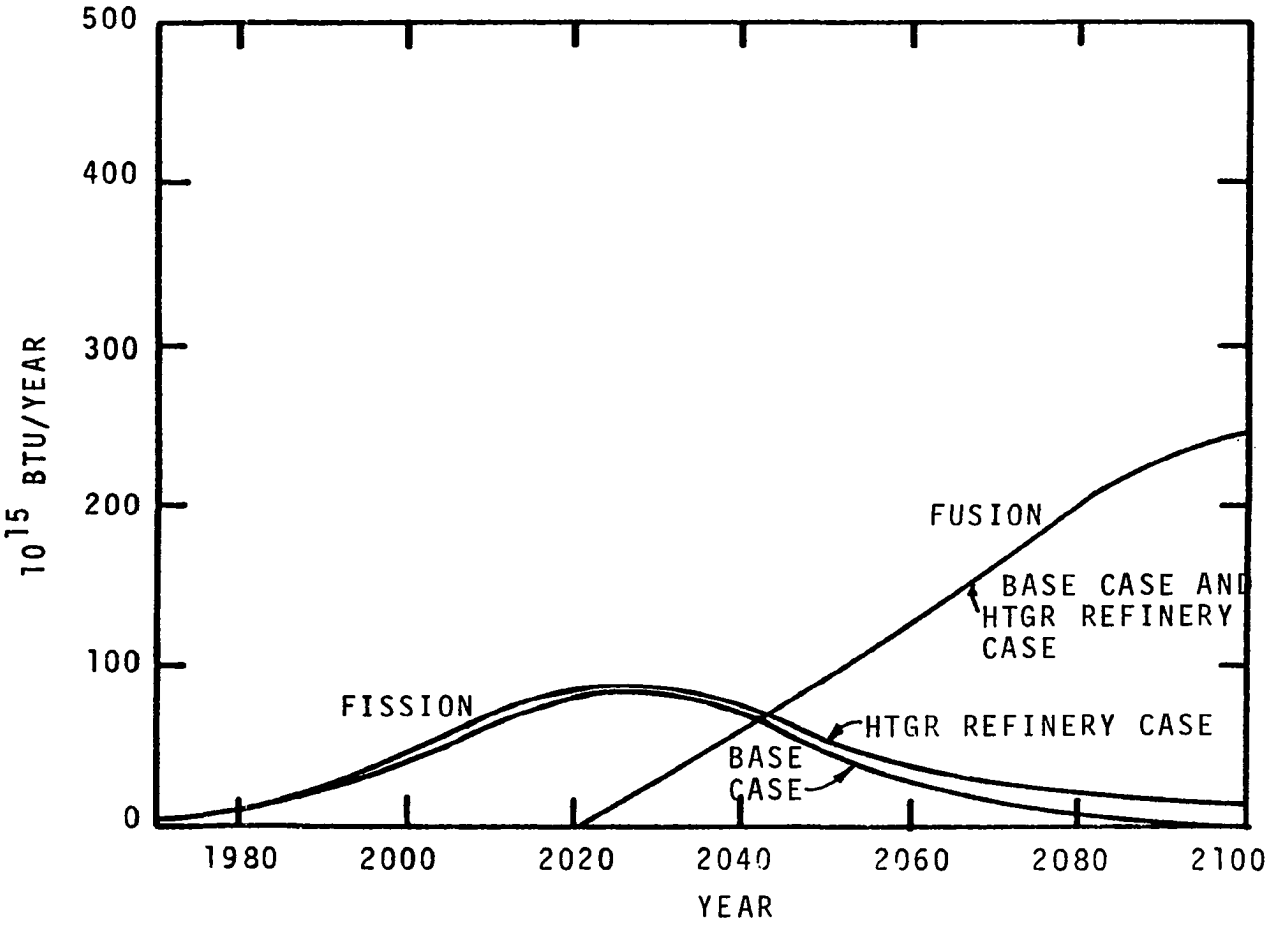


Figure V-3. Nuclear Power Energy Production--HTGR Refinery Case.

U_3O_8 and ThO_2 to increase (Figure V-4). The use of the HTGR refineries results in a decrease in the annual petroleum demand by approximately 3.4 percent (Figure V-5), and a decrease in the annual gas demand by approximately 7 percent (Figure V-6).

The only detrimental effects are the environmental impacts due to greater nuclear energy production. However, the population exposure to ionizing radiation, the tritium and krypton-85 releases, and the amount of long-lived radioactive waste increase only slightly (Figures V-7 through V-9).

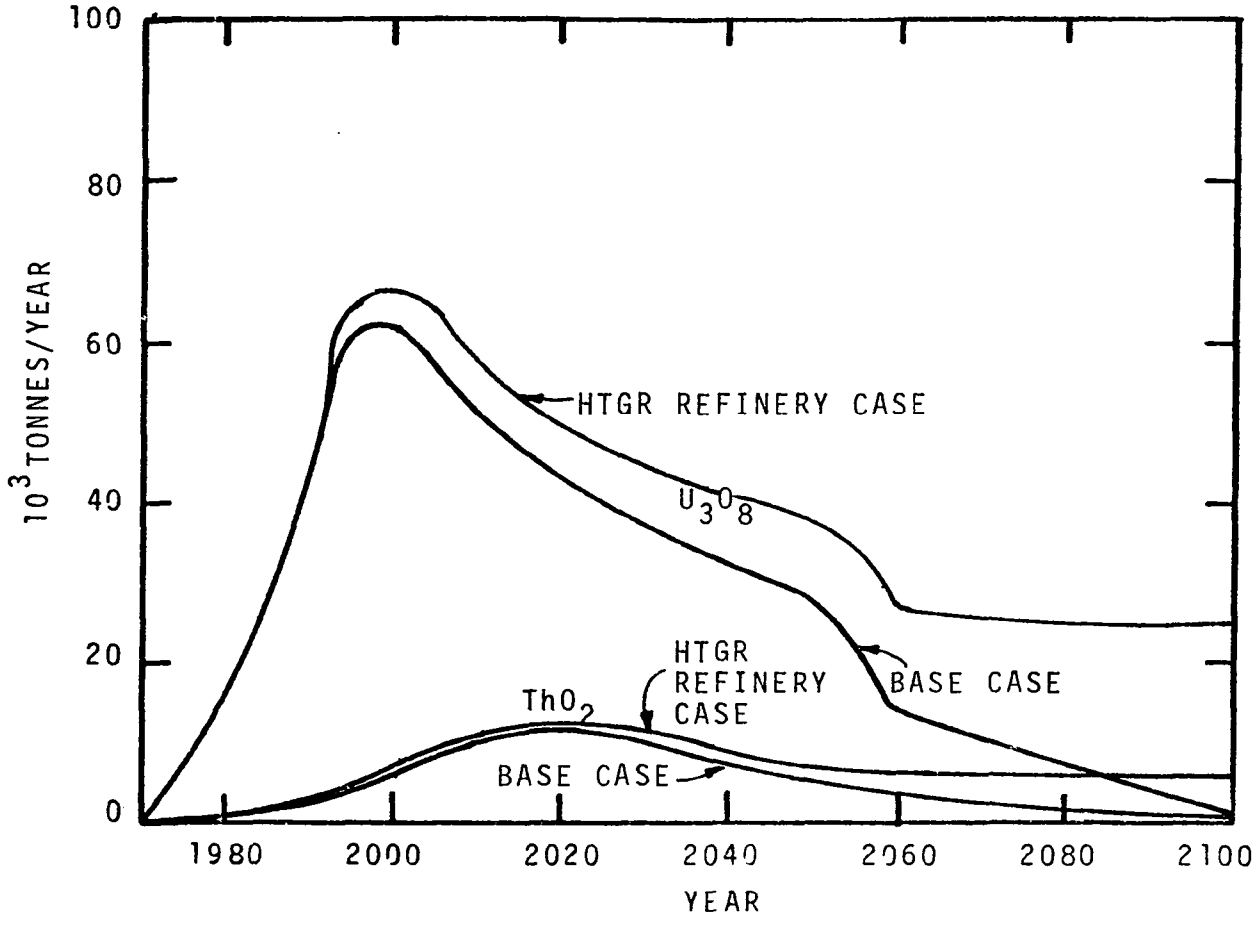


Figure V-4. Annual Nuclear Resource Production Requirements--HTGR Refinery Case.

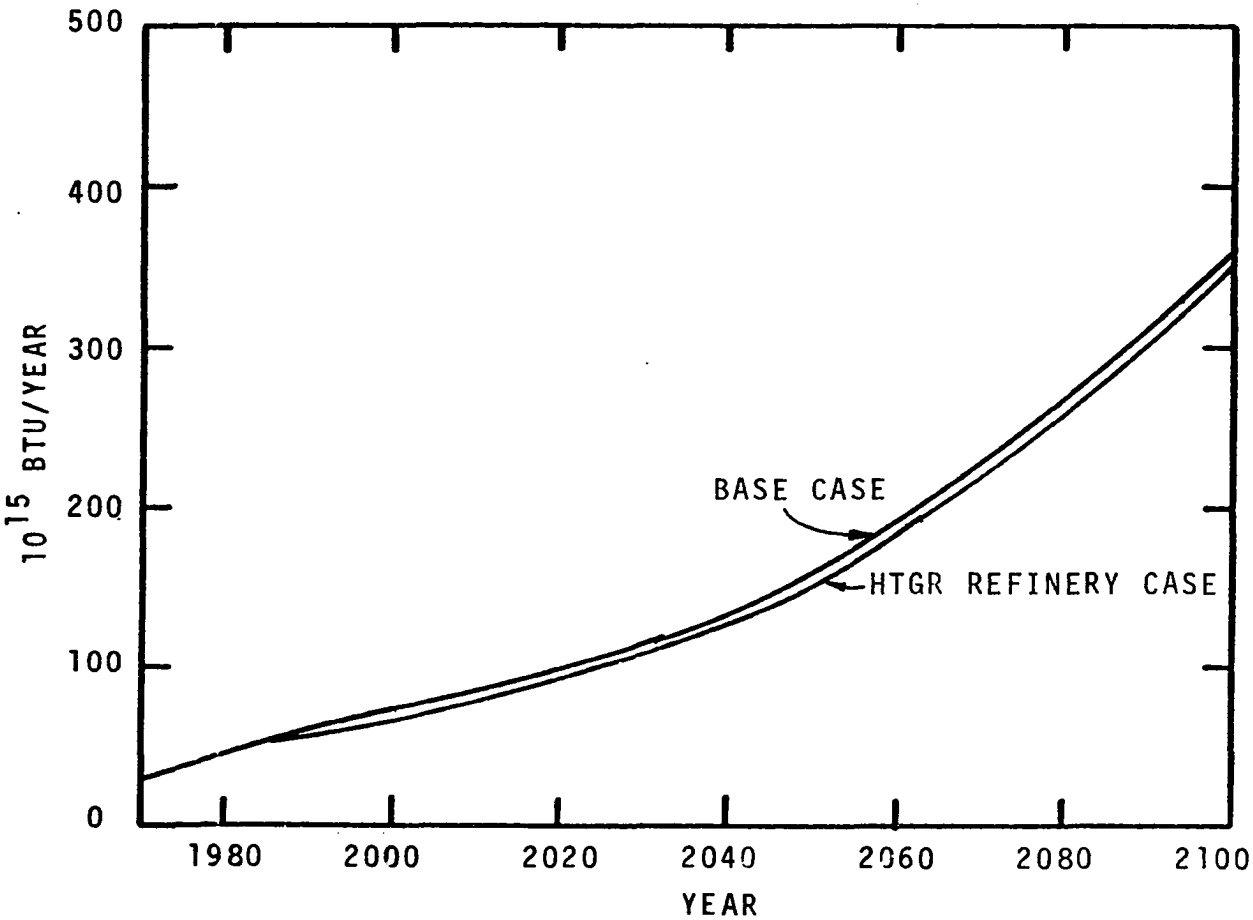


Figure V-5. Annual Crude Petroleum Demand--HTGR Refinery Case.

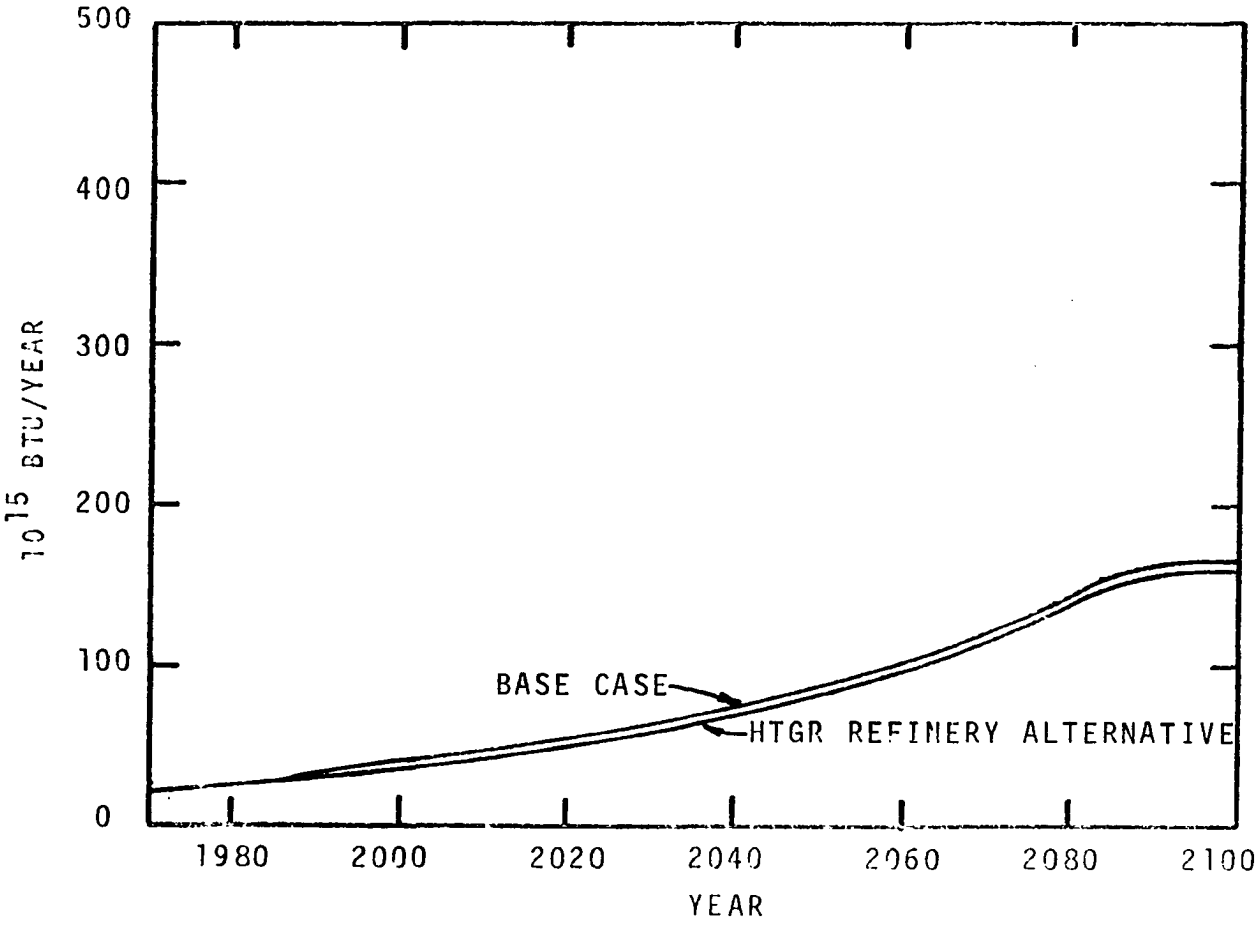


Figure V-6. Annual Natural Gas Demand--HTGR Refinery Case.

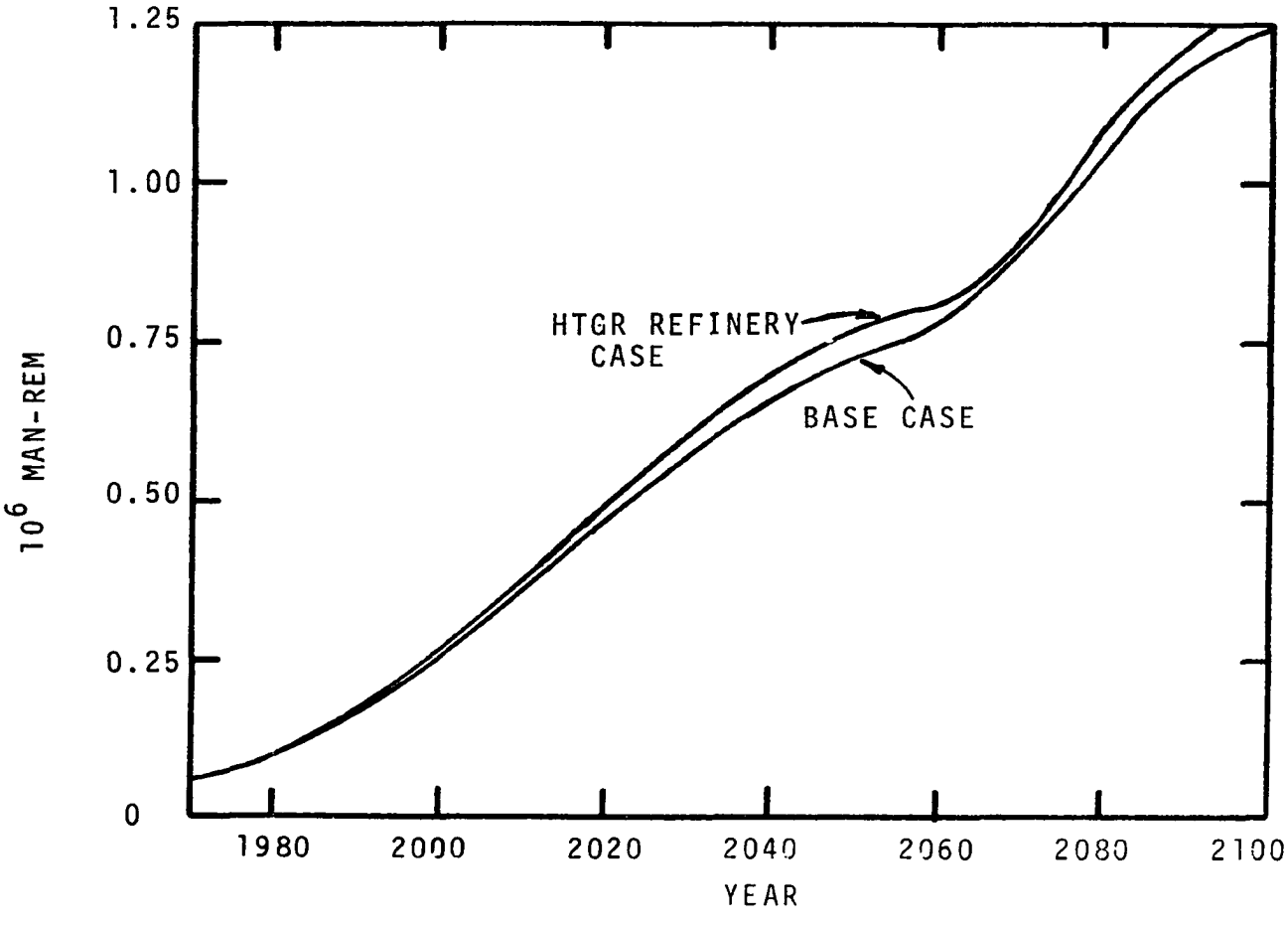


Figure V-7. Annual Population Exposure to Ionizing Radiation --HTGR Refinery Case.

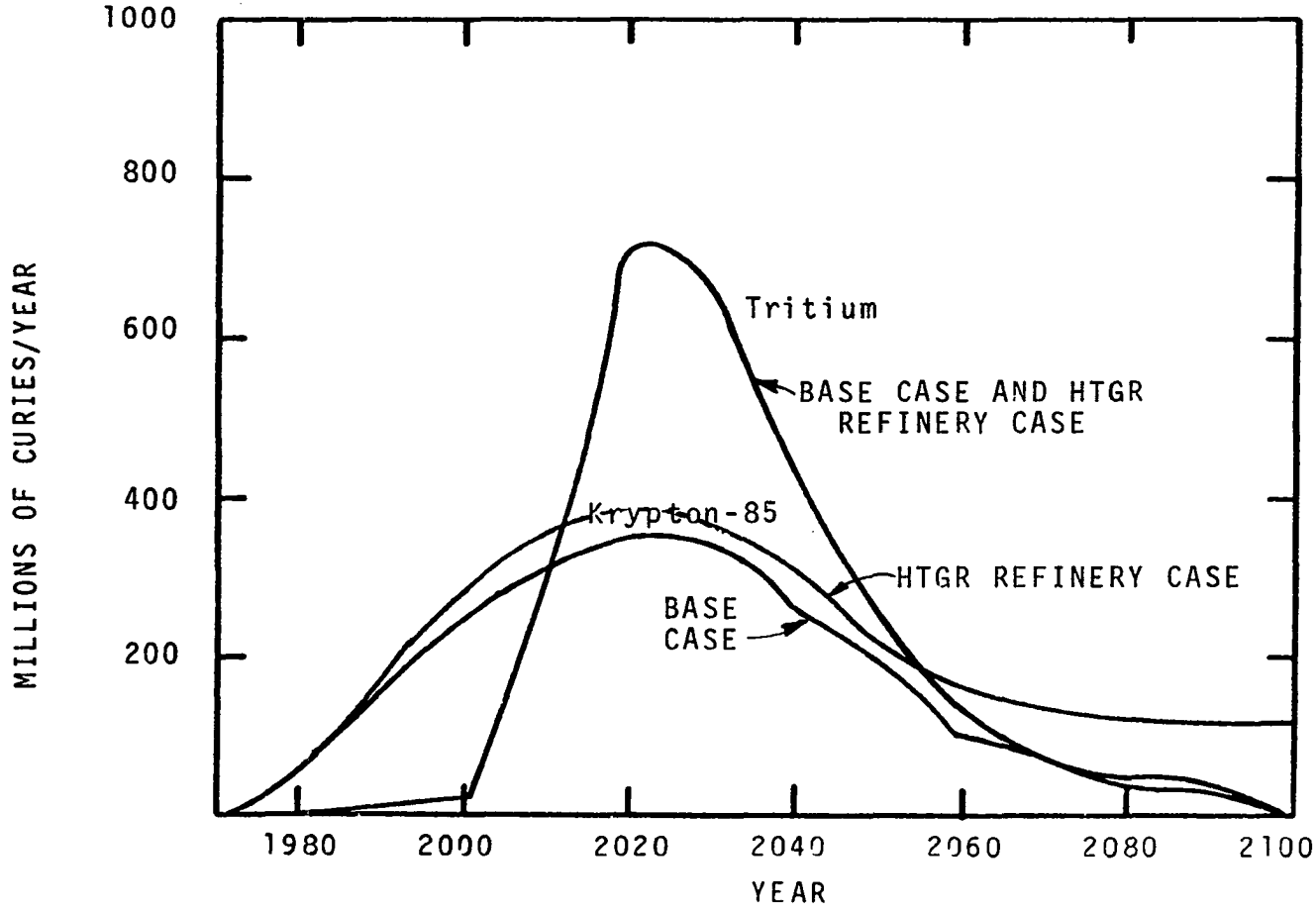


Figure V-8. Annual Tritium and Krypton-85 Releases--HTGR Refinery Case.

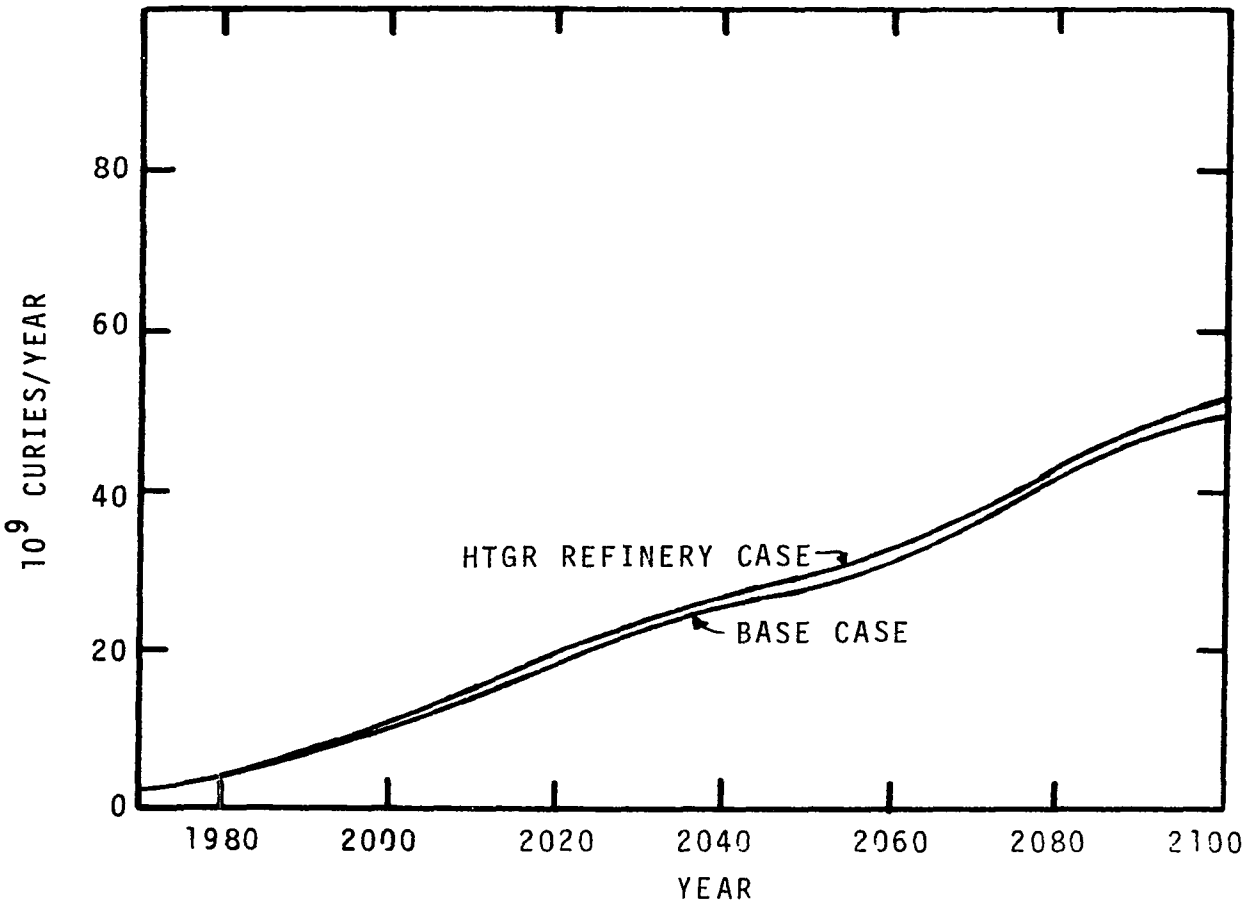


Figure V-9. Annual Long-Lived Radioactive Solid Waste Production--HTGR Refinery Case.

CHAPTER VI

NATURAL GAS SUPPLY ALTERNATIVES

A tremendous amount of publicity has been given to declining domestic natural gas production and reserves. Projected domestic production capacity begins to decline in the 1980's (Figure III-17), while the demand for natural gas surges even higher (Figure IV-23). Several alternative natural gas resources are available to meet the projected gas demand: coal gasification, crude petroleum and petroleum products gasification, Canadian pipeline imports and liquefied natural gas imports.

Two factors will probably control the selection of alternative natural gas supplies: the maximum permissible balance of payments deficit for energy resources and national security implications of foreign gas supplies.

The Manergy Model was used to determine effects on energy resources, balance of payments and the environment by an overall energy system analysis for several natural gas supply alternatives.

Assumptions

The following natural gas supply alternatives were assumed:

Case I: As of the year 1980, liquefied natural gas, LNG, imports account for 10 percent of the natural gas demand exceeding domestic natural gas production. Canadian pipeline gas fraction remains the same as for the base case, Figure IV-3.

Case II: As of the year 1980, LNG imports account for 25 percent of natural gas demand exceeding domestic natural gas production. Canadian pipeline gas fraction remains the same as for the base case, Figure IV-3.

Case III: As of the year 1980, LNG imports account for 50 percent of the natural gas demand exceeding domestic natural gas production. Canadian pipeline gas fraction remains the same as for the base case, Figure IV-3.

Case IV: This case assumes no coal gasification. The natural gas demand exceeding domestic production is filled by LNG imports with petroleum gasification and Canadian pipeline gas imports fraction the same as for the base case, Figures IV-3 and IV-4.

Results

Energy Resources

For the same end utilization demand, the total energy resource requirement (Figure VI-1) decreases with increasing LNG imports (Figure VI-2). This reduction in total energy

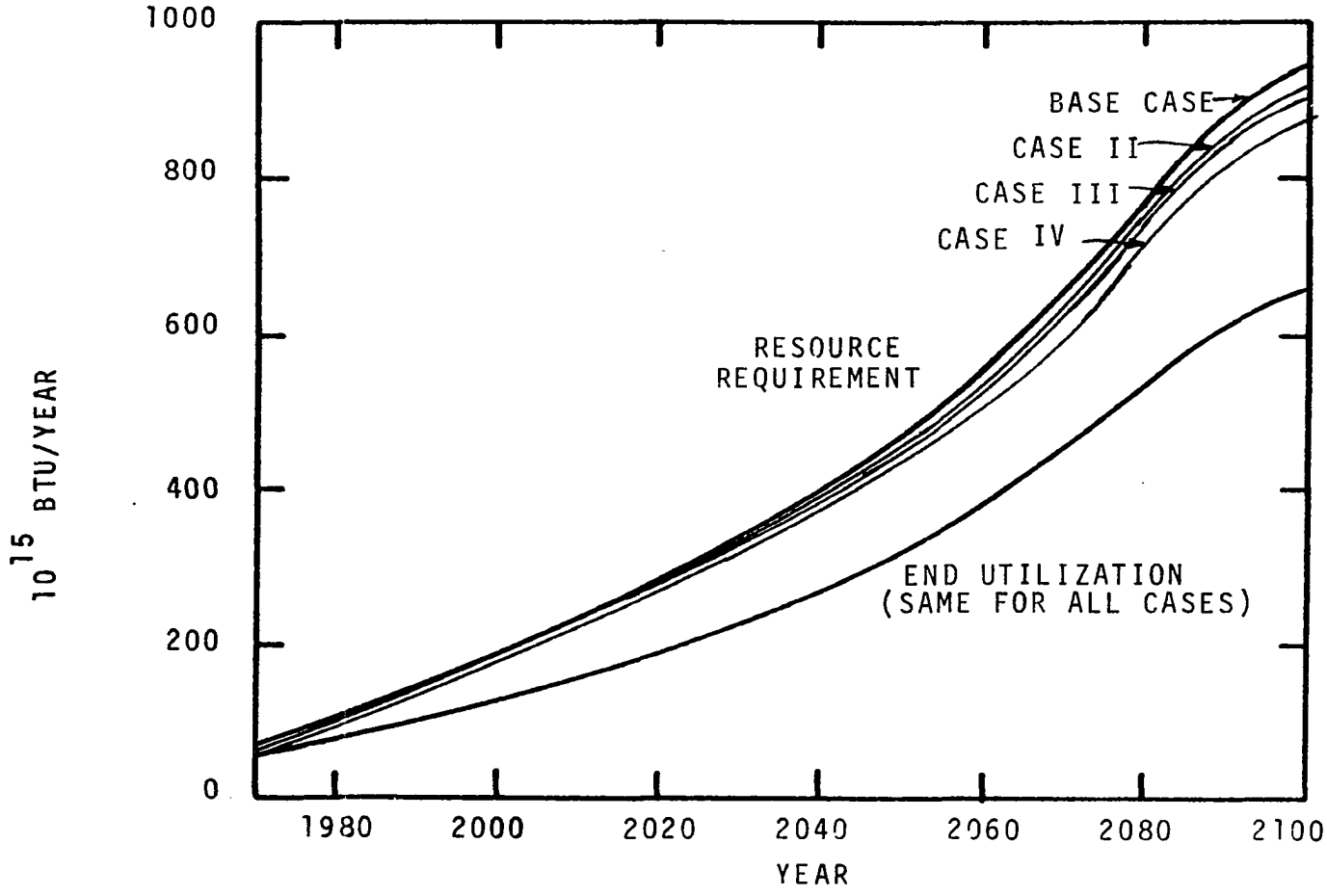


Figure VI-1. Total Annual Energy Production and Net End Utilization--Natural Gas Supply Alternative.

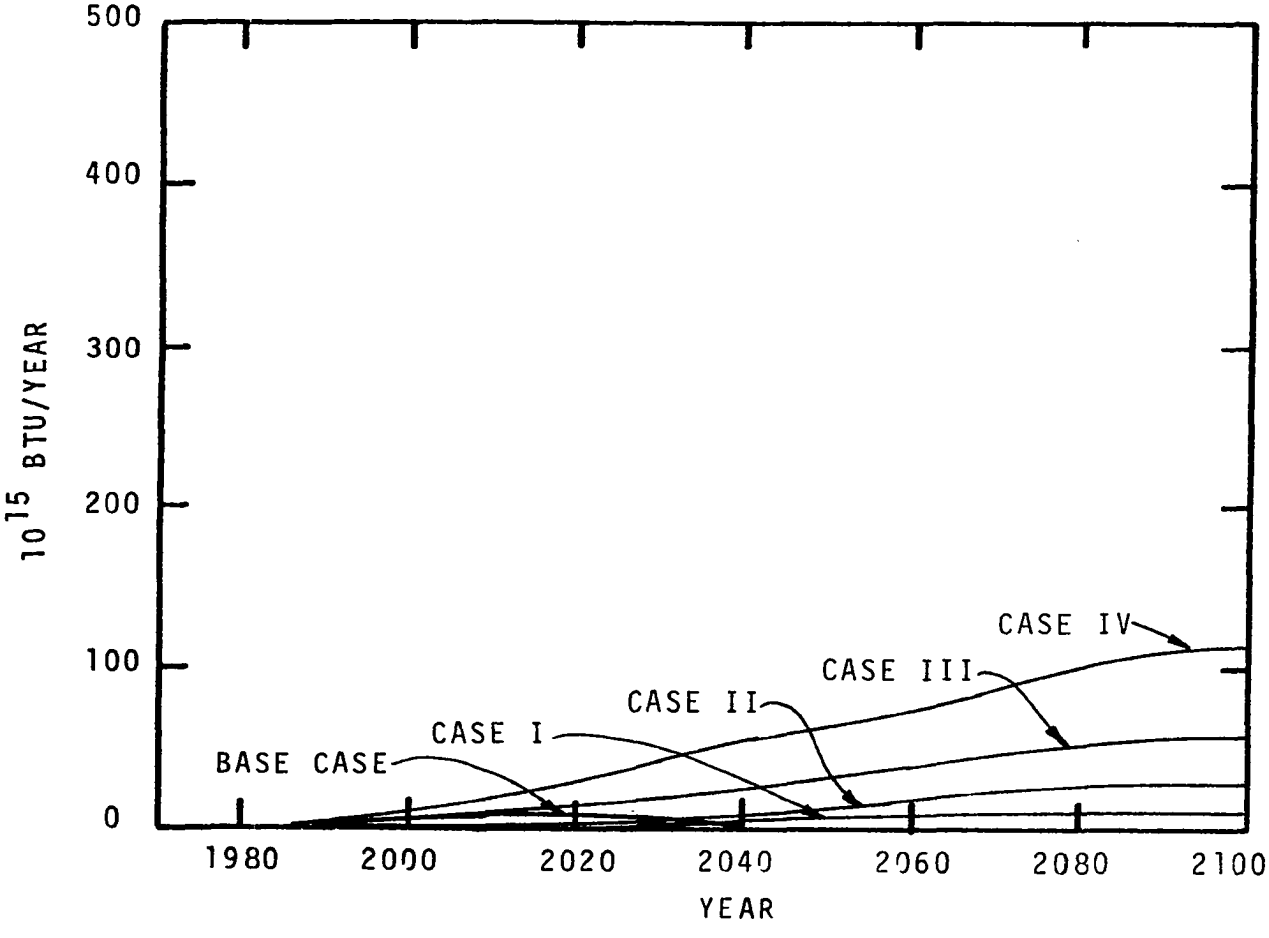


Figure VI-2. Annual Liquefied Natural Gas Imports--Natural Gas Supply Alternative.

requirements occurs because less coal gasification is required. This results in smaller system energy losses because the conversion of coal to synthetic natural gas is less efficient than LNG liquefaction and re-gasification. As expected, as the amount of LNG imports increases, the annual coal production requirements decrease because less syngas and therefore less syngas coal is required to meet the reduced synthetic natural gas demand (see Figures VI-3 through VI-5).

Environment

Since coal conversion to syngas decreases with increasing LNG imports, the annual production of solid waste and elemental sulfur decreases, Figures VI-6 and VI-7, respectively.

Balance of Payments

The determining factor for the fraction of LNG imports allowable will most likely be the balance of payments deficit. It is highly unlikely that the United States could support the 20 billion dollar per year deficit projected in the base case for 1990 and beyond (Figure IV-34), much less the much larger deficits of Cases I through IV (Figure VI-8).

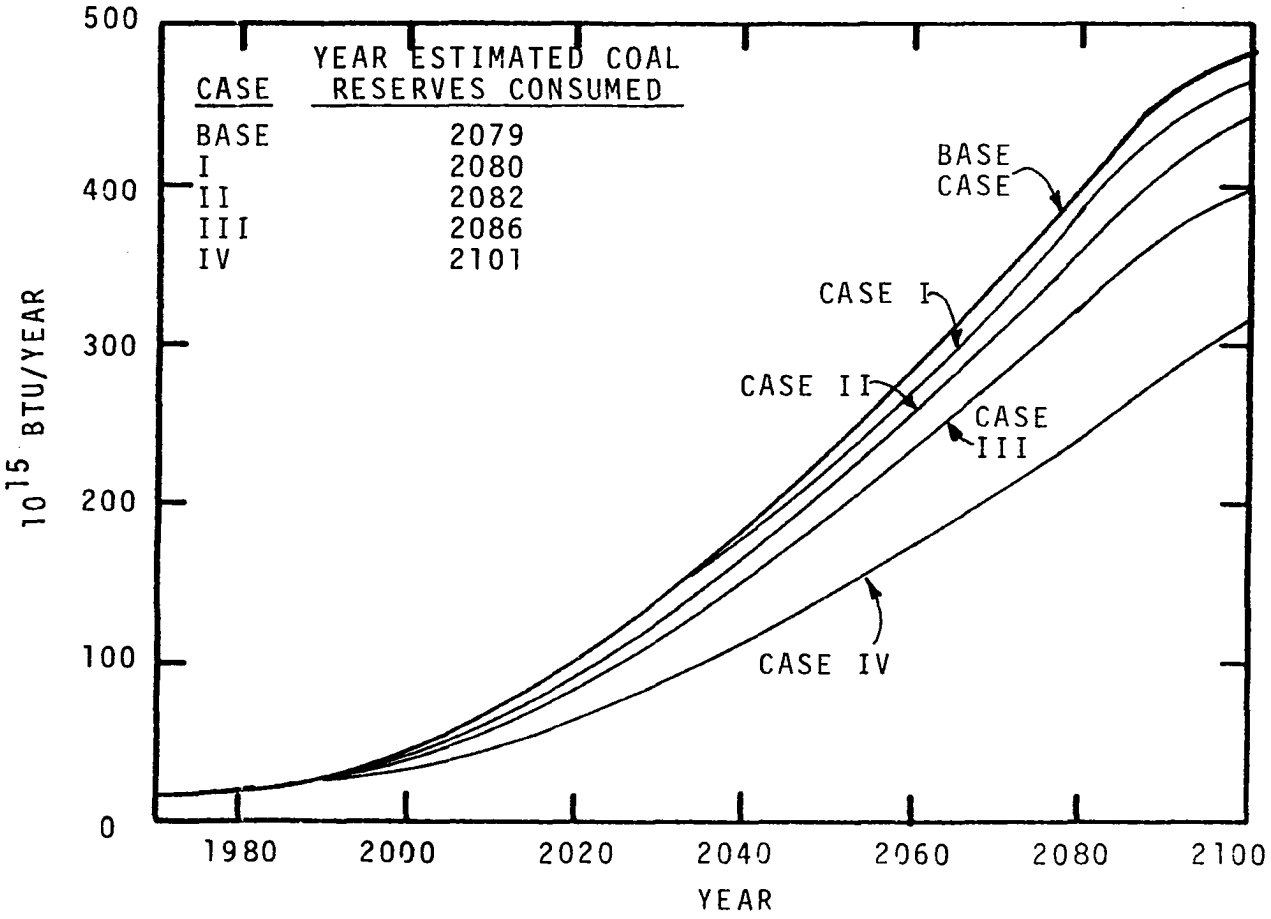


Figure VI-3. Annual Coal Production--Natural Gas Supply Alternative.

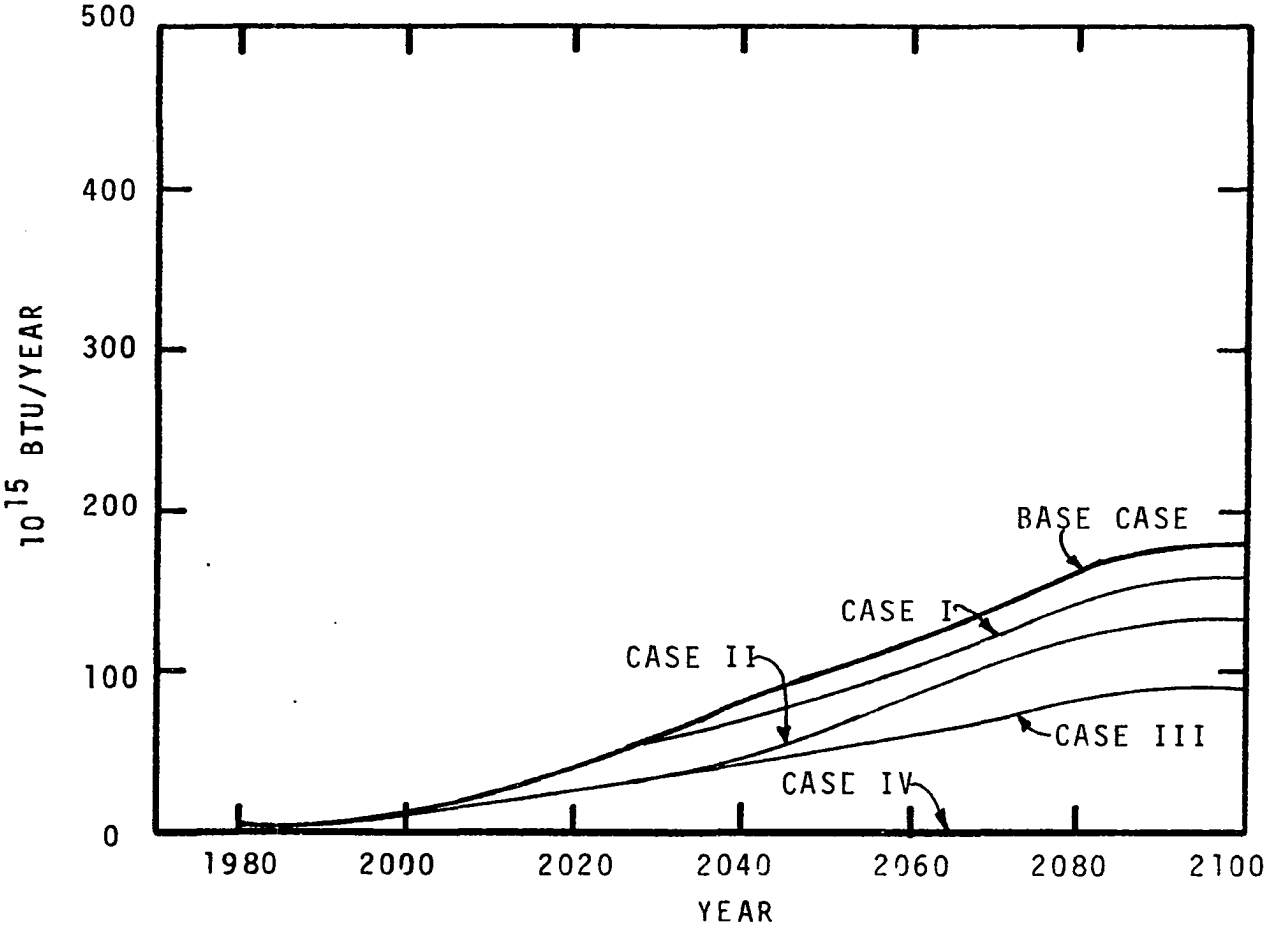


Figure VI-4. Annual Coal Requirements for Synthetic Natural Gas Production--Natural Gas Supply Alternative.

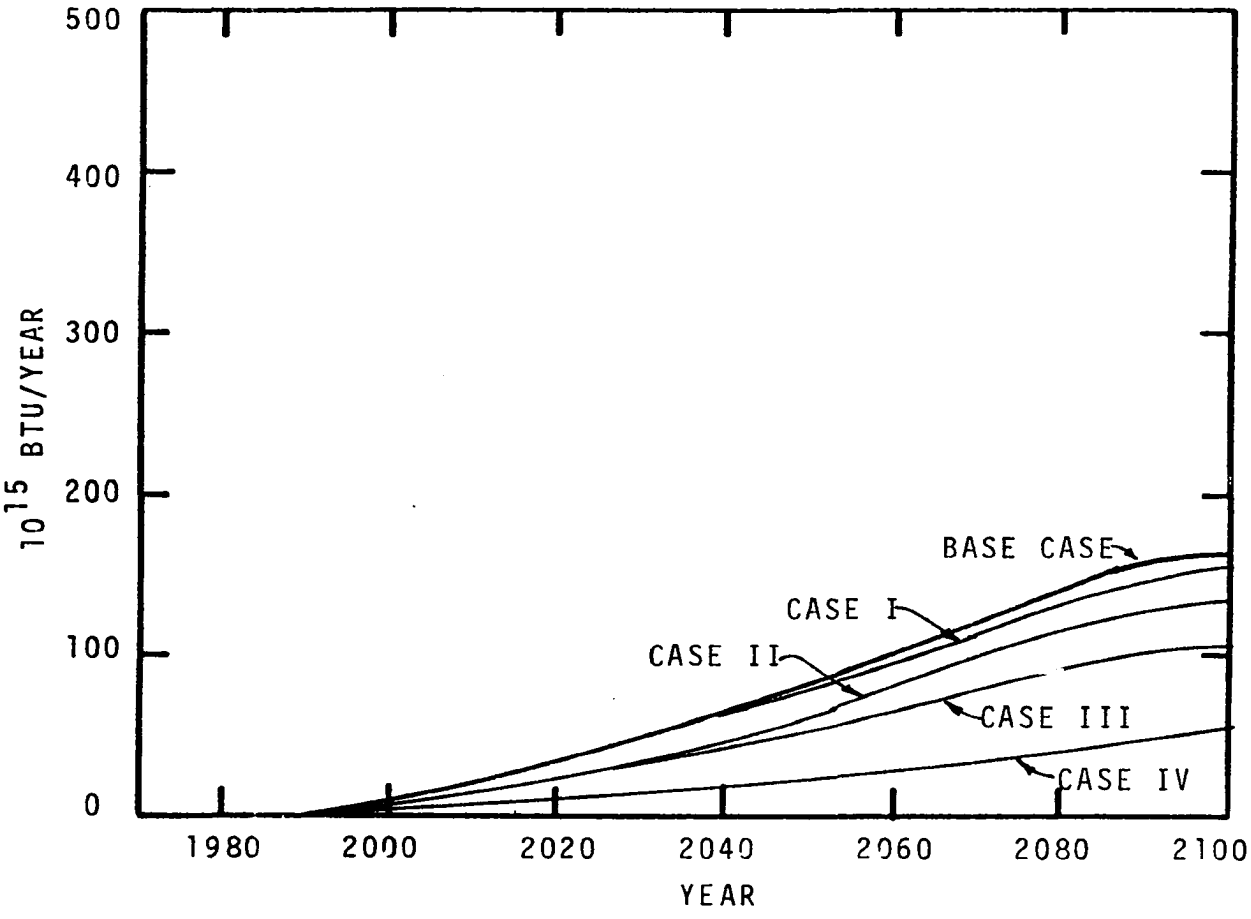


Figure VI-5. Synthetic Natural Gas Demand--Natural Gas Supply Alternative.

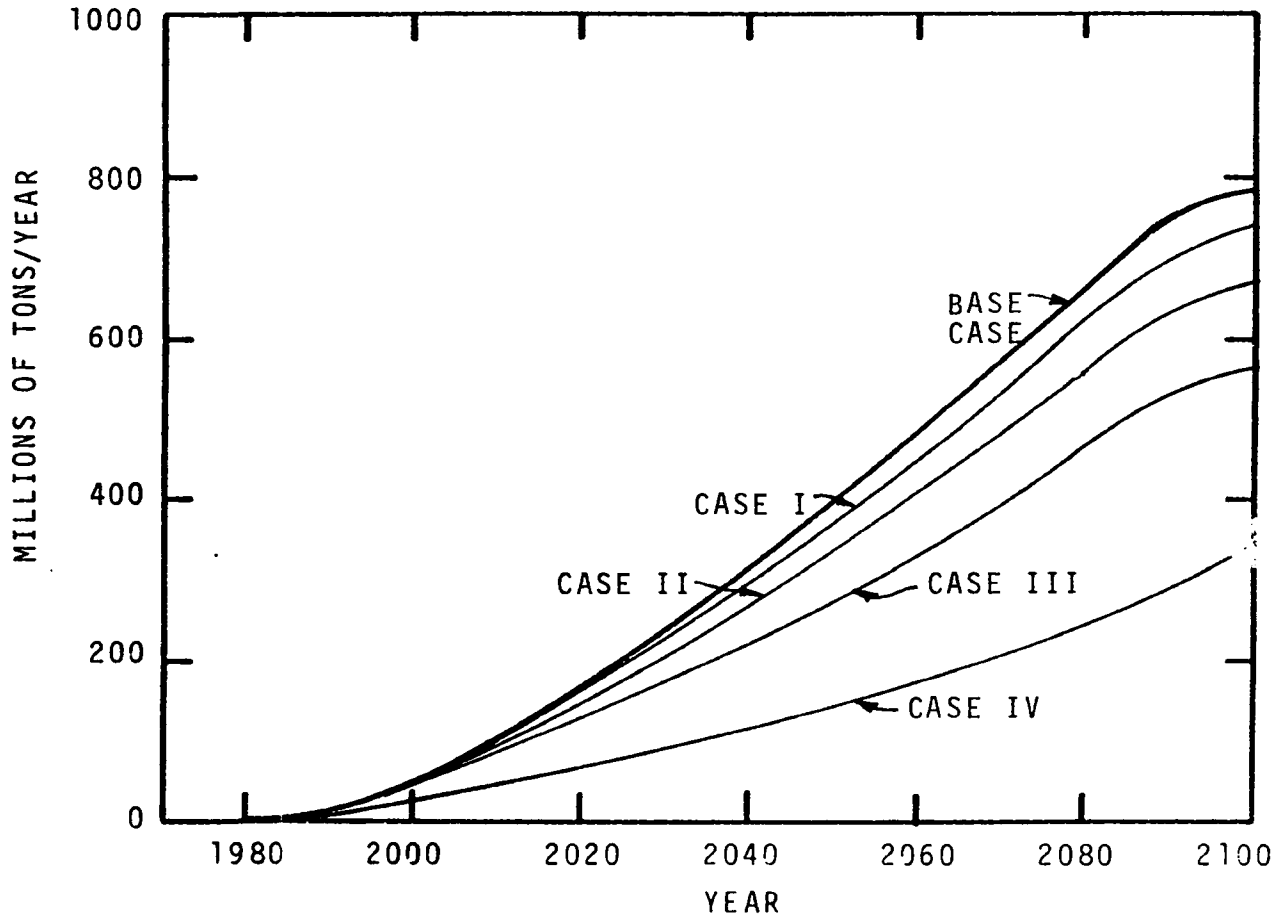


Figure VI-6. Annual Solid Waste Production--Natural Gas Supply Alternative.

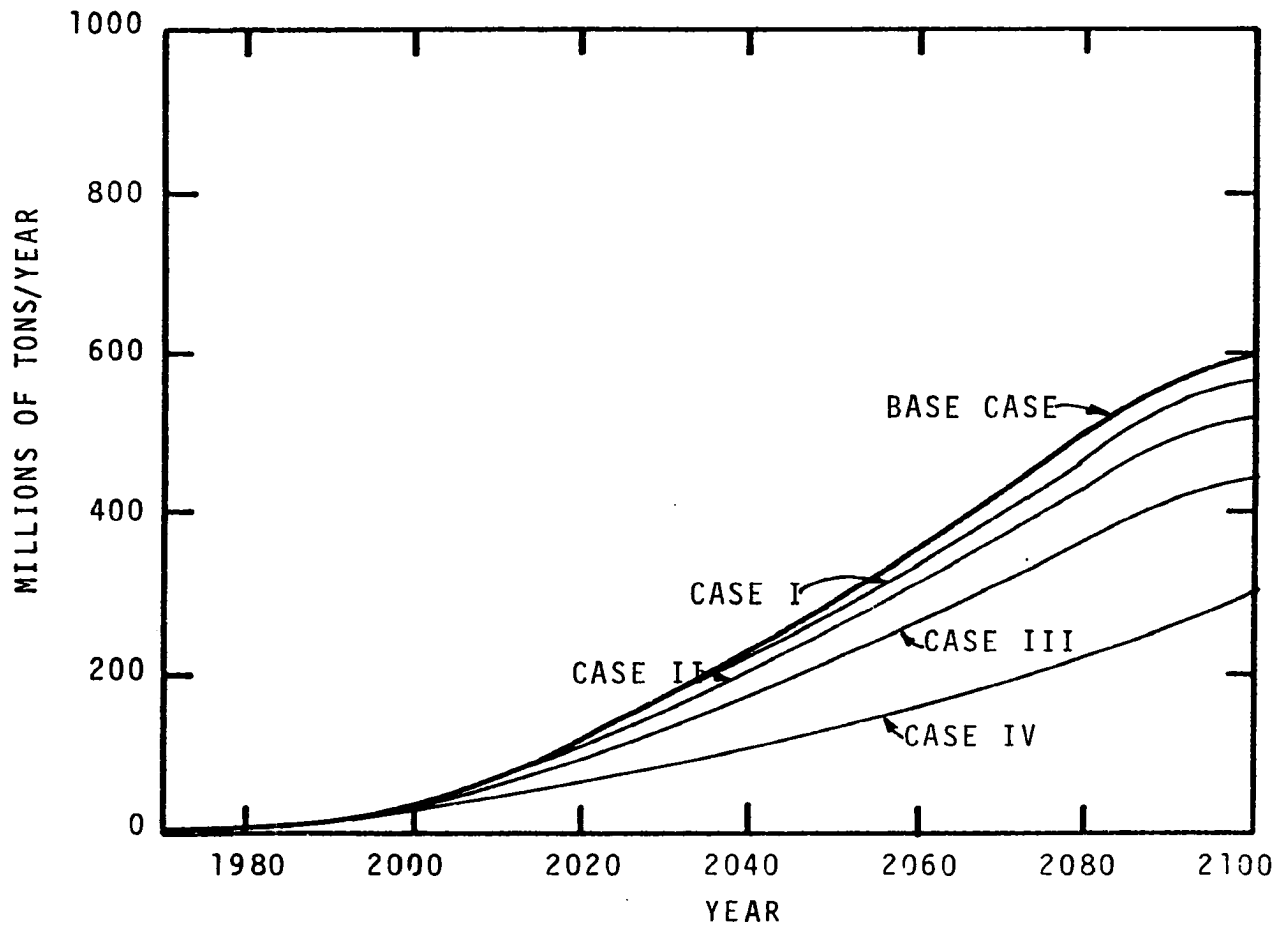


Figure VI-7. Annual Sulfur Production--Natural Gas Supply Alternative.

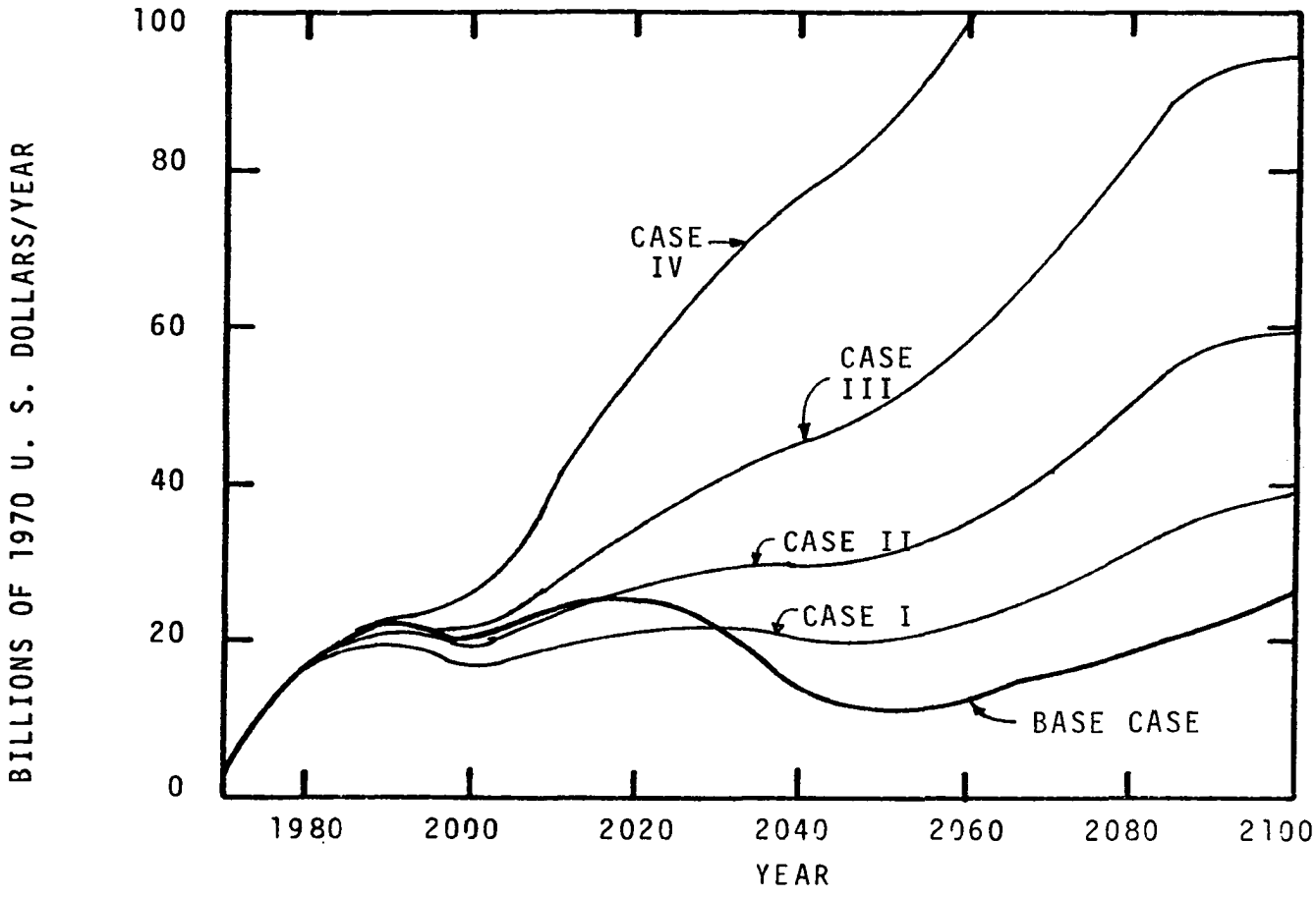


Figure VI-8. Balance of Payments Deficit--Natural Gas Supply Alternative.

CHAPTER VII

OIL SUPPLY ALTERNATIVES

After the 1980's, the United States is faced with declining petroleum production capacity, Figure III-18, and a surging demand for petroleum products, Figure IV-16. Several alternative crude oil resources are available to meet the projected petroleum demand: coal liquefaction, syncrude from tar sands and oil shale deposits, and petroleum imports. Two factors will probably control the selection of alternative crude oil supplies: the maximum permissible balance of payments deficit for energy resources and national security implications of foreign oil supplies.

The Manergy model was used to determine the effects on energy resources, balance of payments and the environment by an overall energy system analysis for the oil supply alternatives for the year 1990 and beyond:

Case I: No oil imports are allowed.

Case II: Oil imports are allowed to account for 50 percent of oil demand exceeding domestic crude petroleum production.

Case III: Oil imports are allowed to account for 100 percent of oil demand exceeding domestic production.

Assumptions

Alternative resources are used to meet the fraction of petroleum demand exceeding domestic production. The fraction of this demand which is supplied by alternative resources after the year 1990 for each case is listed in Table VII-1. Prior to 1990 the base case assumptions hold (Figure IV-5).

Results

As expected, as the fraction of the petroleum demand filled by crude oil imports increases, Figure VII-1, the annual coal production requirements decrease, Figure VII-2. The annual coal production requirements decrease because less syncrude and therefore less syncrude coal is required to meet the reduced synthetic crude oil demand (Figures VII-3 and VII-4, respectively). Partially offsetting the reduced syncrude coal demand are the increased synthetic natural gas coal requirements, Figure VII-5. The syngas coal requirements increase with increasing oil import fraction because less coproduct syngas is produced by coal liquefaction plants. As with coal production, the annual oil shale and tar sand production requirements decrease with increasing fraction of crude oil imports, and the amount of solid waste and sulfur produced decreases because less syncrude from coal liquefaction, tar sands and oil shale deposits are required to meet the reduced synthetic crude oil demand (see Figures VII-6 through VII-9).

TABLE VII-1

OIL SUPPLY ALTERNATIVES

PROJECTED FRACTION OF PETROLEUM DEMAND EXCEEDING DOMESTIC PRODUCTION

Case Title	Case I	Case II	Case III
Fraction--1990+	none	50%	100%
Oil imports	0.0	0.500	1.0
Oil shale	0.250	0.125	0.0
tar sands	0.250	0.125	0.0
syncrude	0.500	0.250	0.0

The determining factor for the permissible fraction of crude oil imports will most likely be the balance of payments deficit. It is highly unlikely that the United States could support the 20 billion dollar per year deficit projected in the base case for 1990 and beyond (Figure IV-34) much less the much larger deficits of Case II and Case III (Figure VII-10).

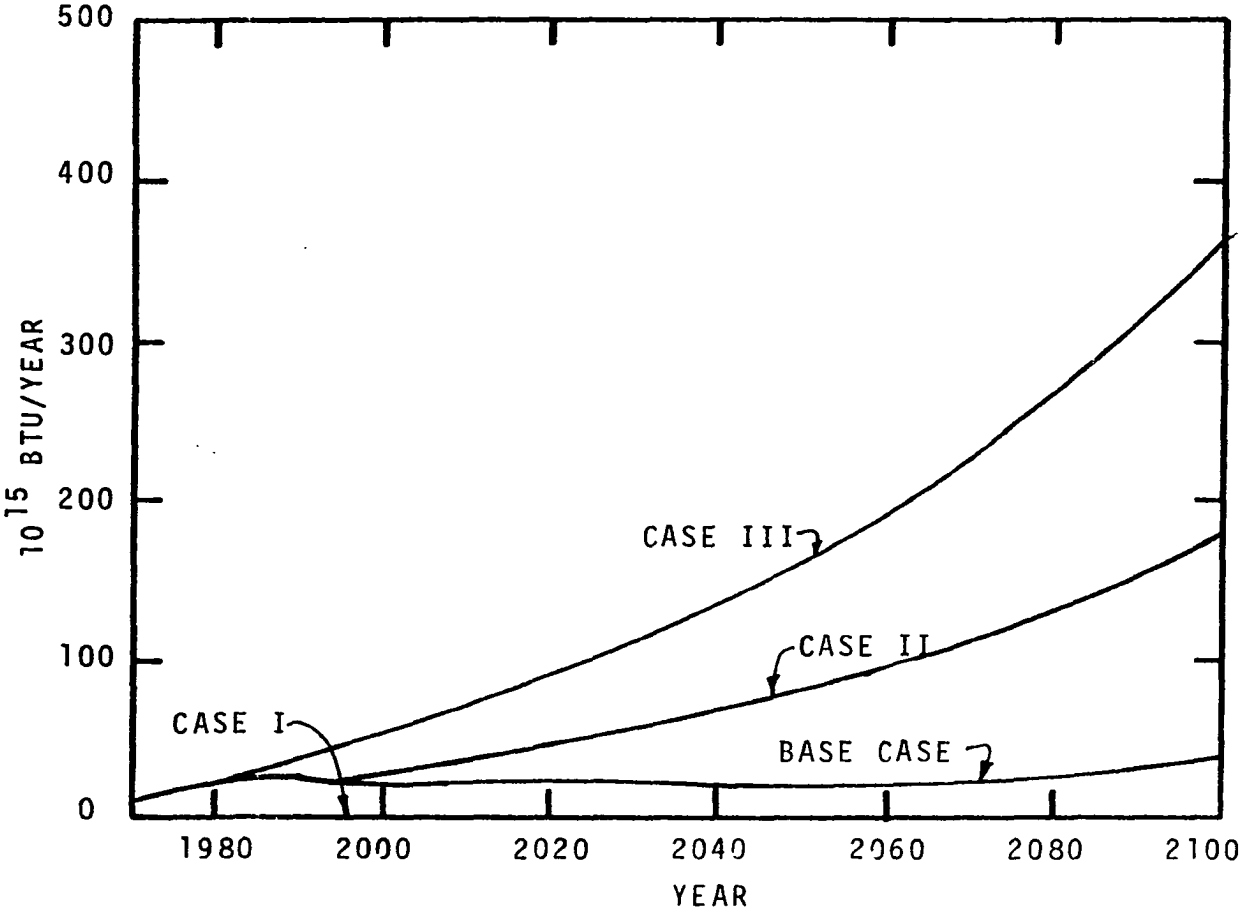


Figure VII-1. Annual Crude Oil Import Requirements--Oil Supply Alternatives.

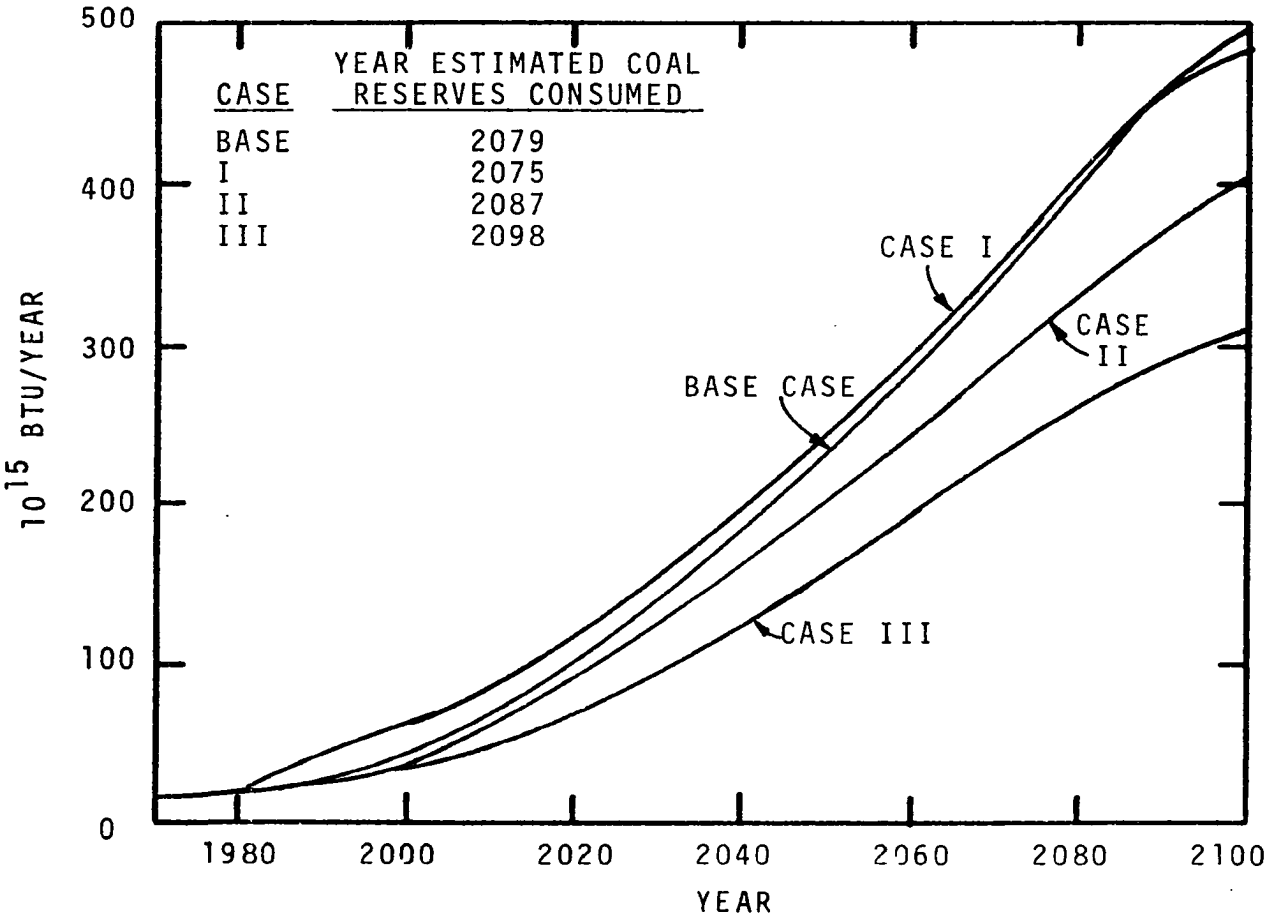


Figure VII-2. Annual Coal Production--Oil Supply Alternatives.

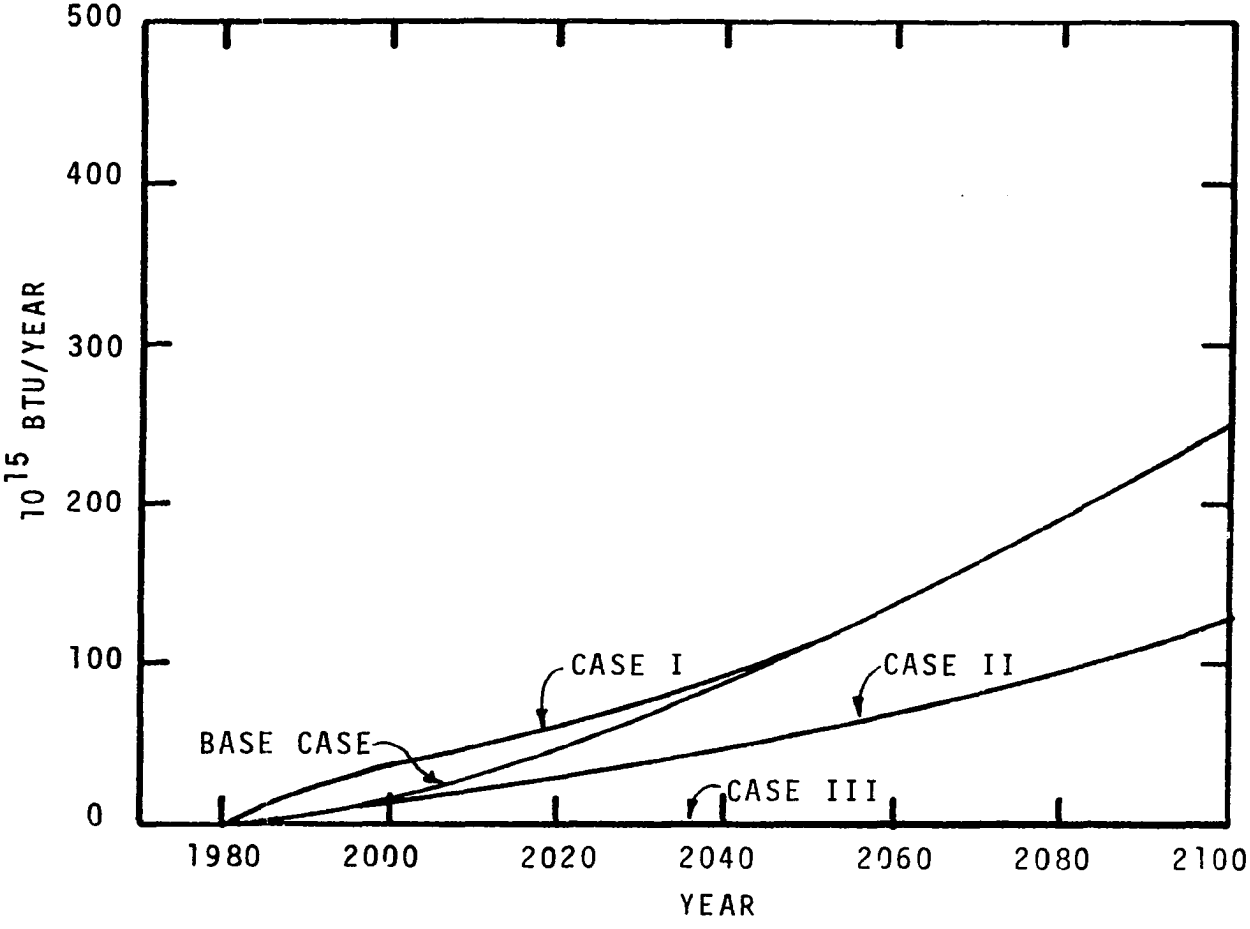


Figure VII-3. Annual Coal Requirements for Synthetic Crude Oil Production--Oil Supply Alternatives.

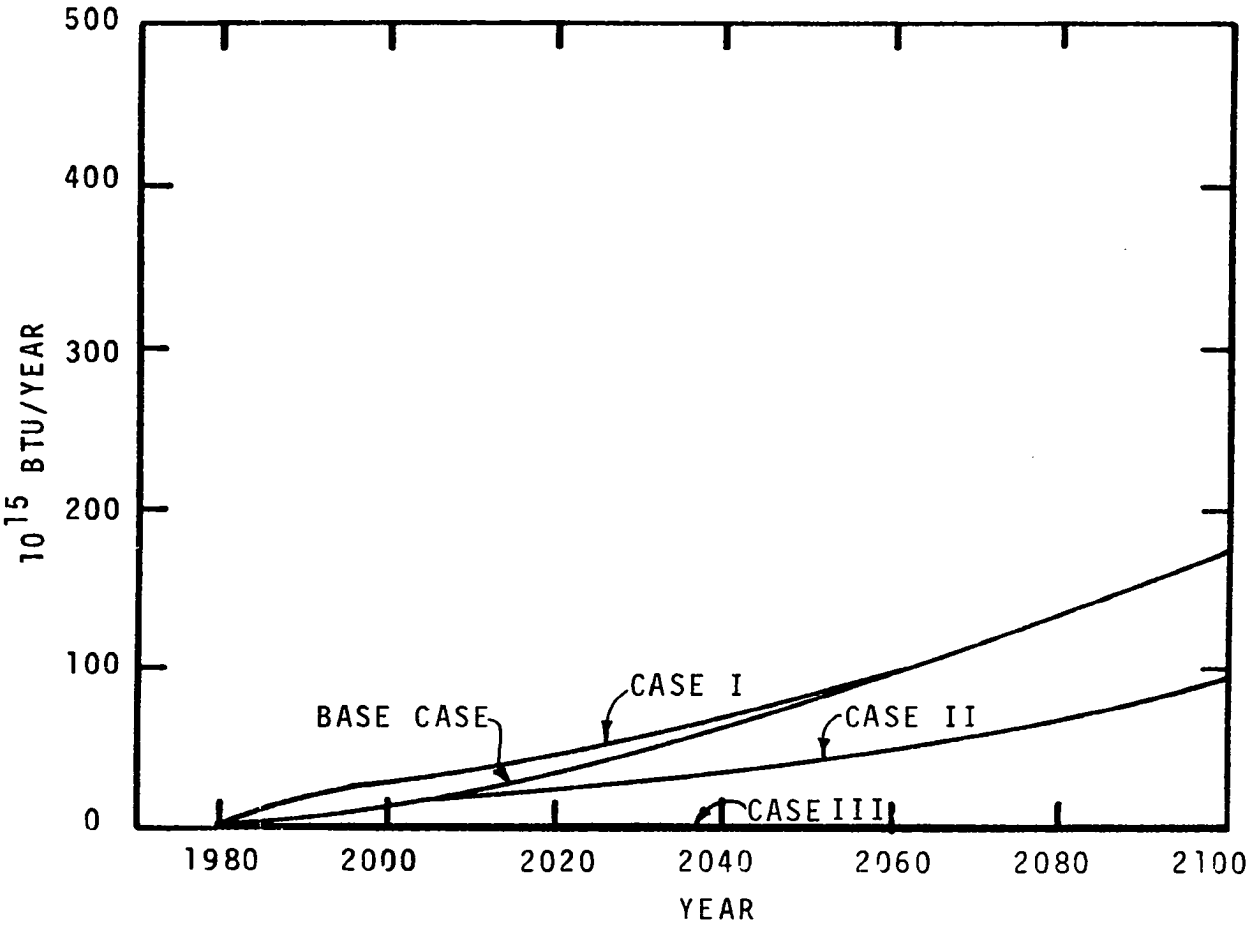


Figure VII-4. Annual Synthetic Crude Oil Demand--Oil Supply Alternatives.

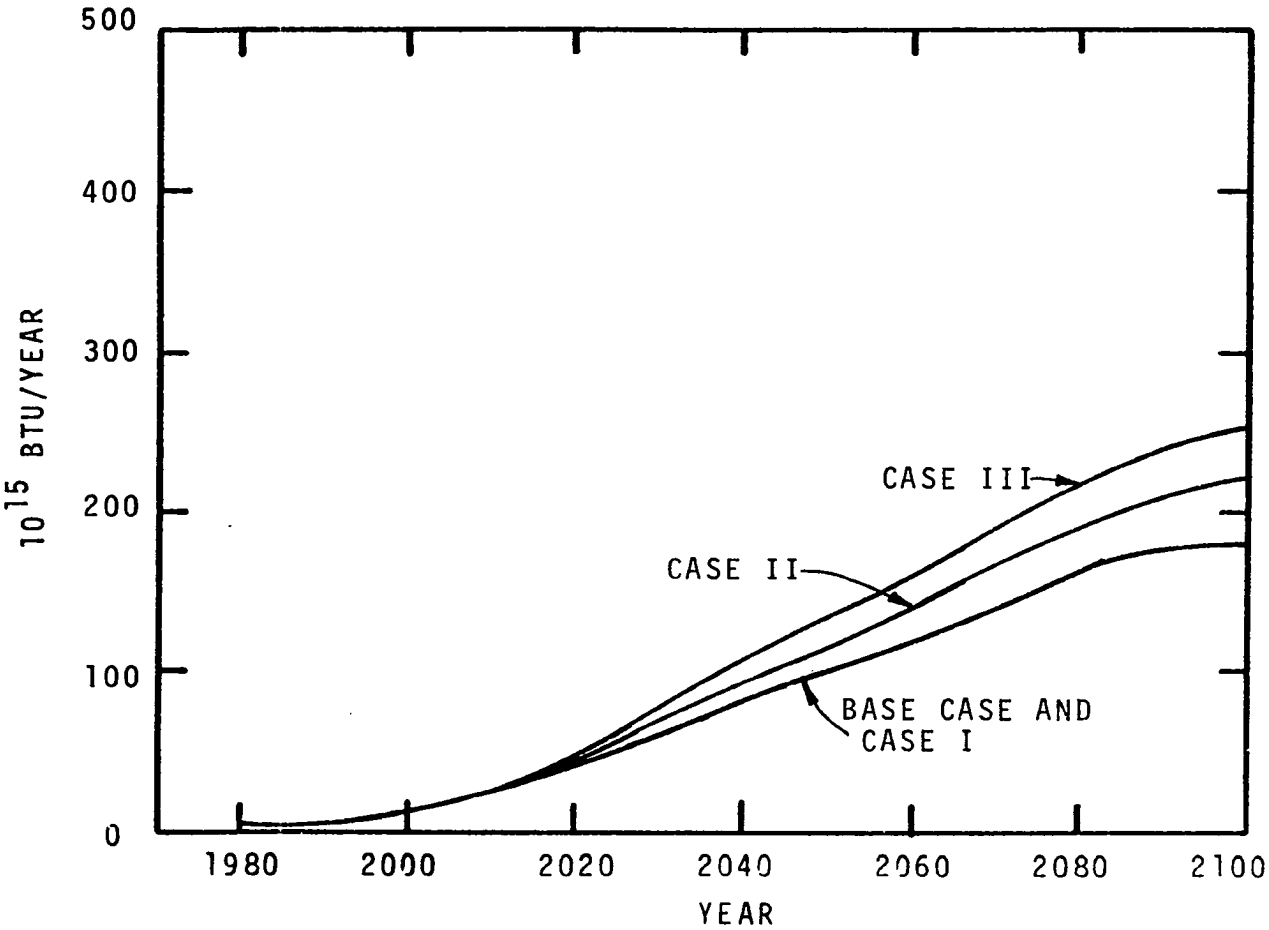


Figure VII-5. Annual Coal Requirements for Synthetic Natural Gas Production--Oil Supply Alternatives.

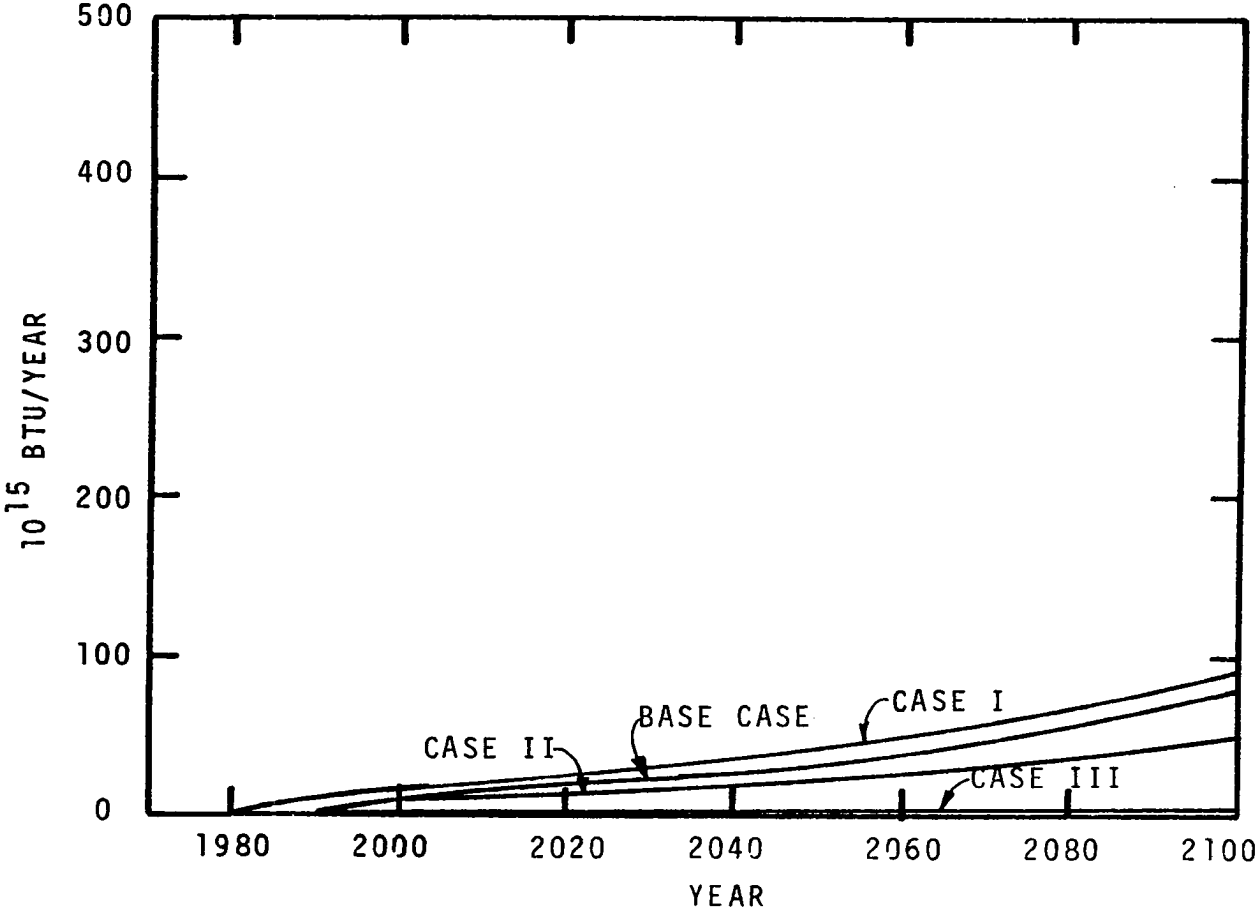


Figure VII-6. Annual Oil Shale Production--Oil Supply Alternatives.

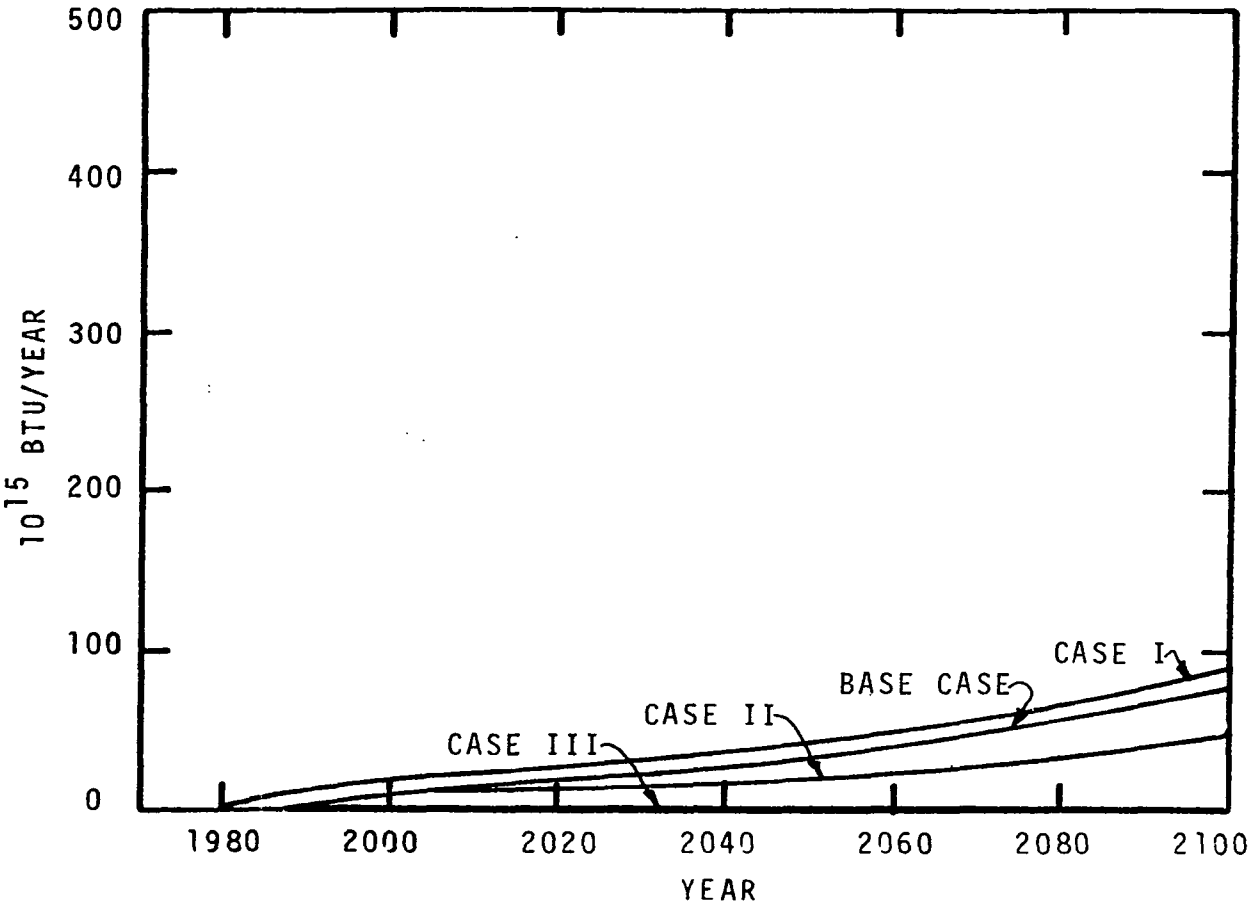


Figure VII-7. Annual Tar Sands Production--Oil Supply Alternatives.

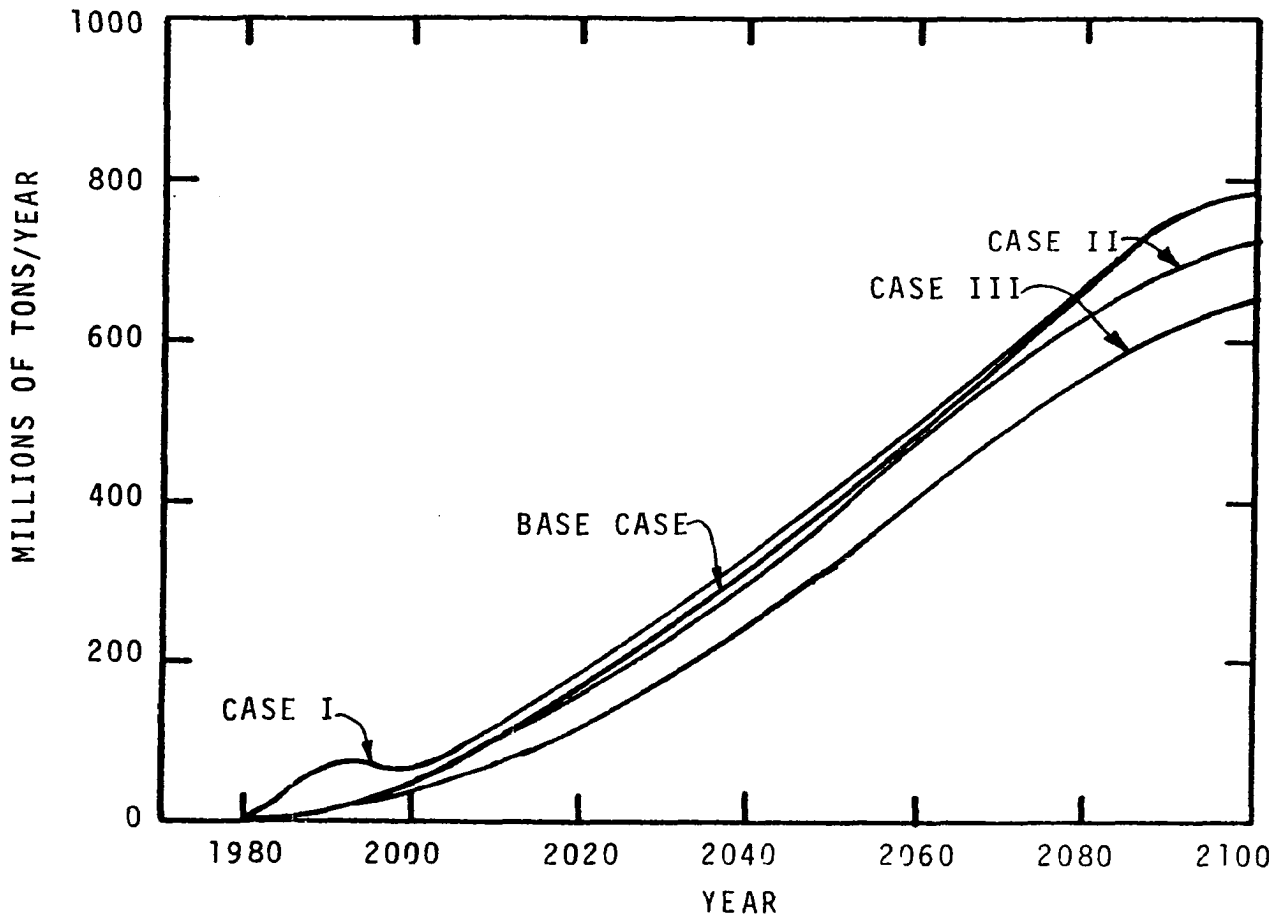


Figure VII-8. Annual Solid Waste Production--Oil Supply Alternatives.

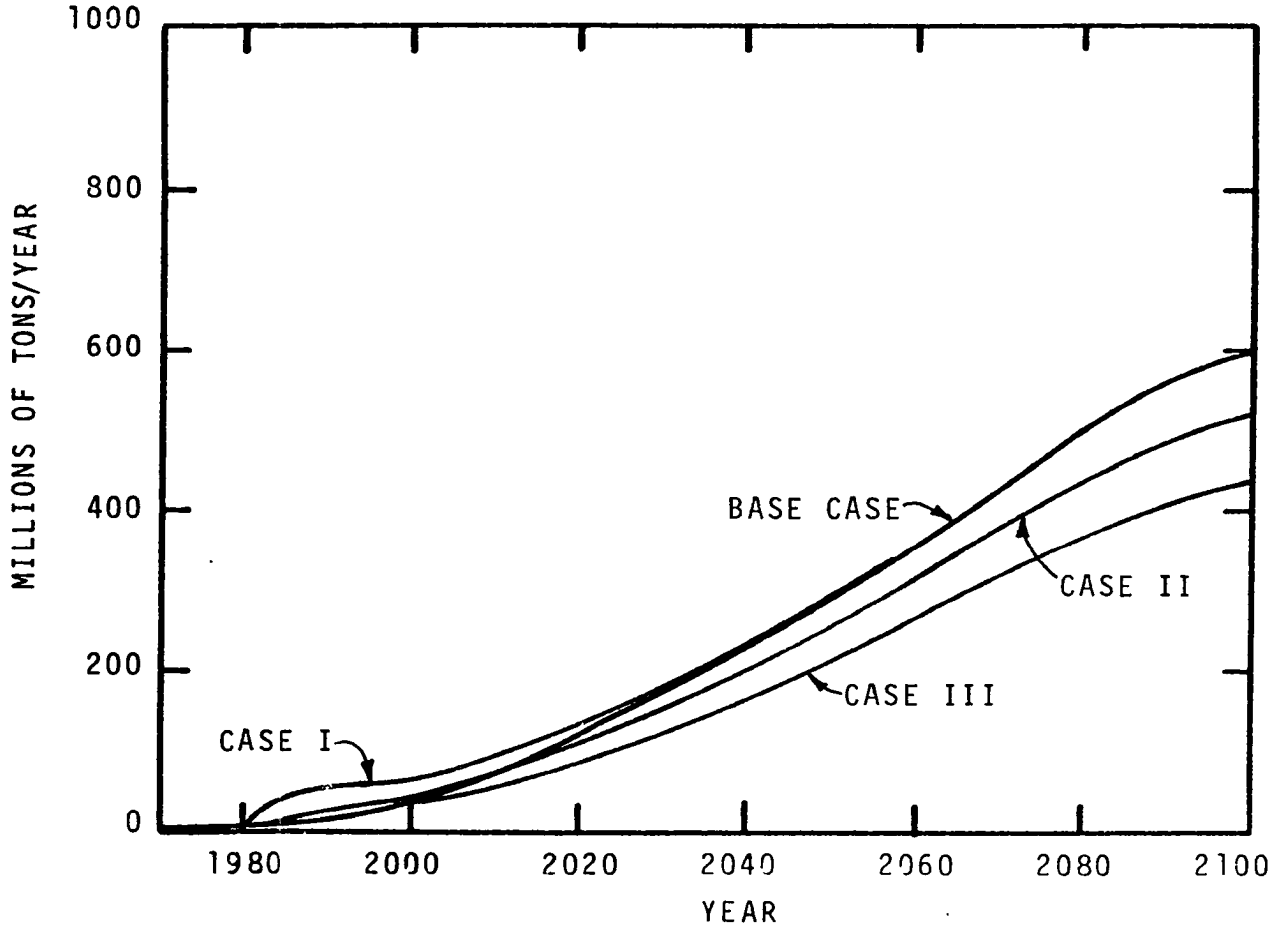


Figure VII-9. Annual Sulfur Production--Oil Supply Alternatives.

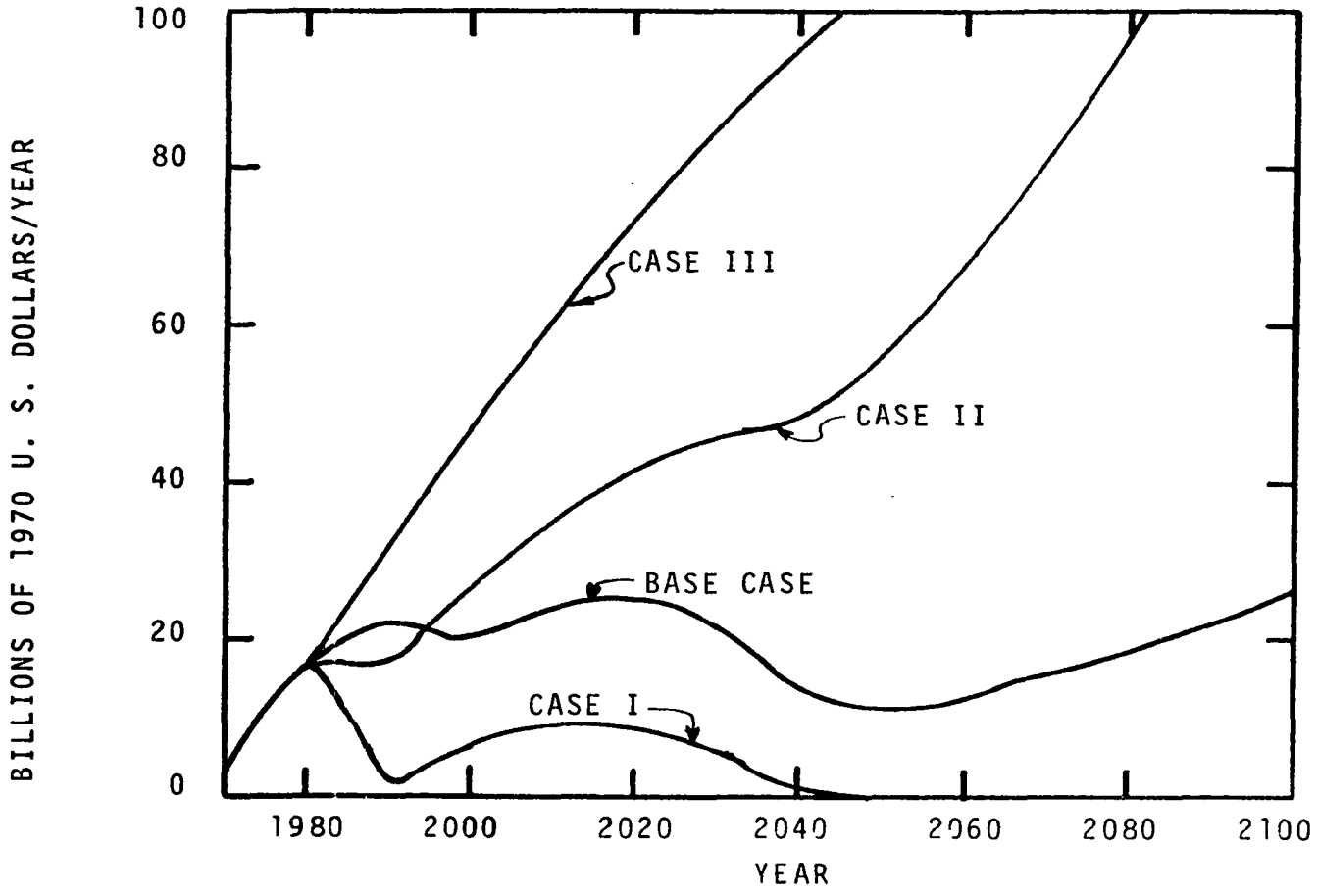


Figure VII-10. Balance of Payments Deficit--Oil Supply Alternatives.

CHAPTER VIII

POPULATION ALTERNATIVE

The United States birth rate has decreased dramatically to approximately 2.03 children per family in 1972 and 1973. The effect of this decreased birth rate on the U.S. energy resource requirements, the balance of payments, and on the environment was determined using the U.S. energy model.

Assumptions

The United States population was projected using the data for the two children per family curve, Figure III-2. Then the projected number of households, Figure VIII-1 was determined using the persons per household, Figure III-2, and the new projected population. The gross national product was projected, Figure VIII-2, using the GNP versus population, Figure III-5, and the new projected population.

All projections for this population alternative were made using the base case assumptions and Figures VIII-1 and VIII-2.

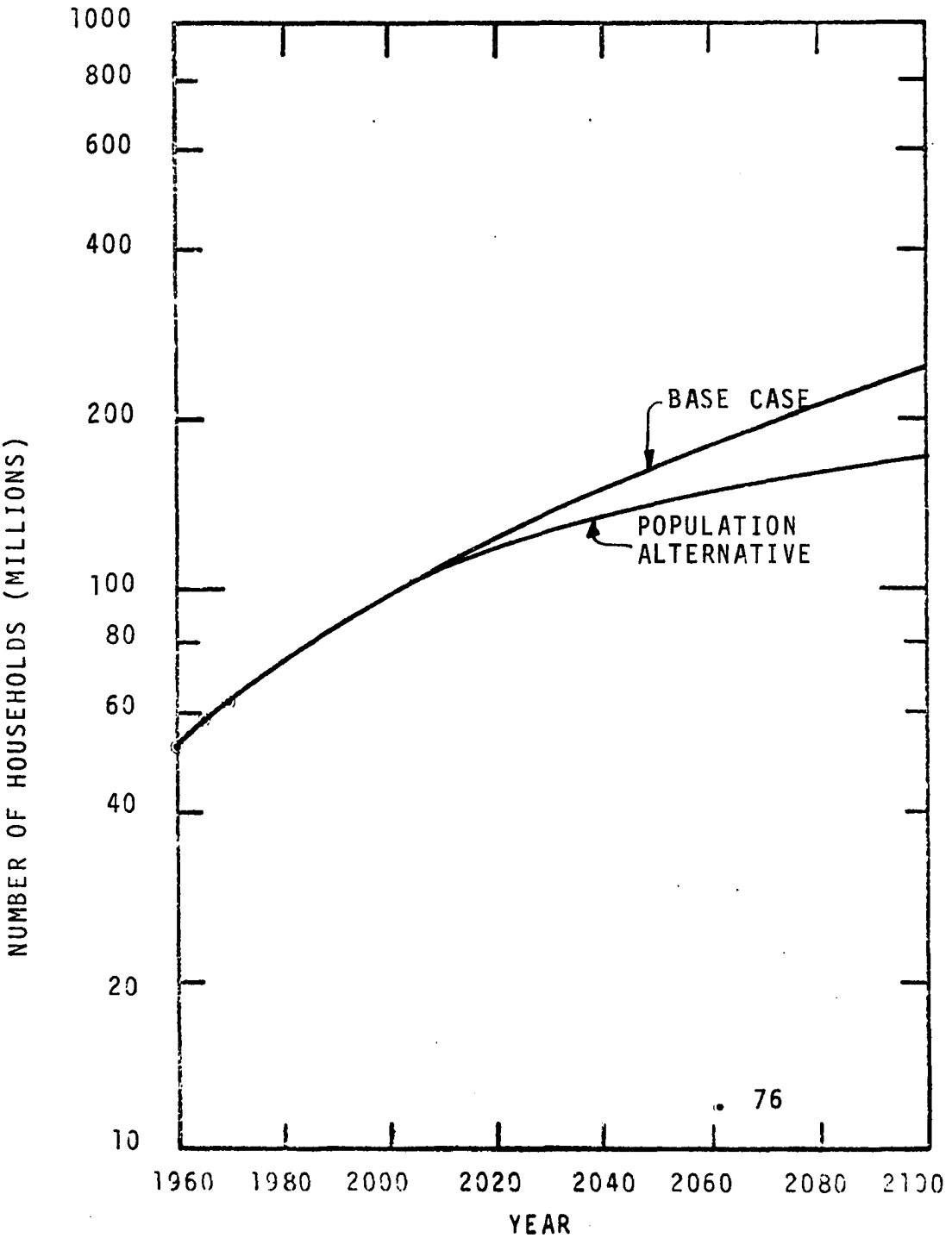


Figure VIII-1. Projected Number of Households--Population Alternative.

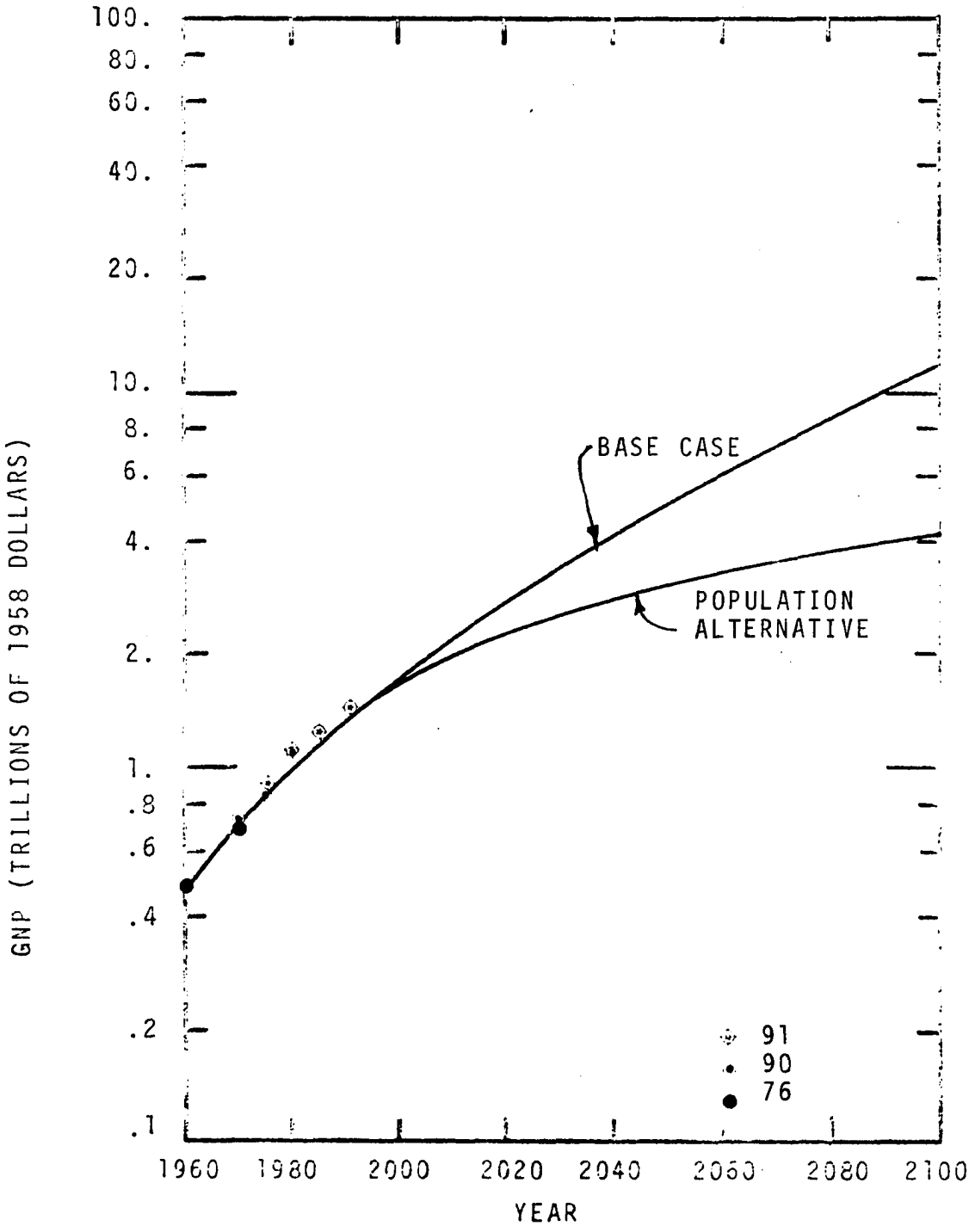


Figure VIII-2. Projected Gross National Product--Population Alternative.

Results

The total resource requirements and end utilization energy demands for the population alternative are shown in Figure III-3. To obtain all resource requirements, environmental impacts and balance of payments, simply multiply the base case results by the ratio of the total energy resource requirements for the population alternative to the base case requirements, the 'Correction Factor', Figure VIII-4.

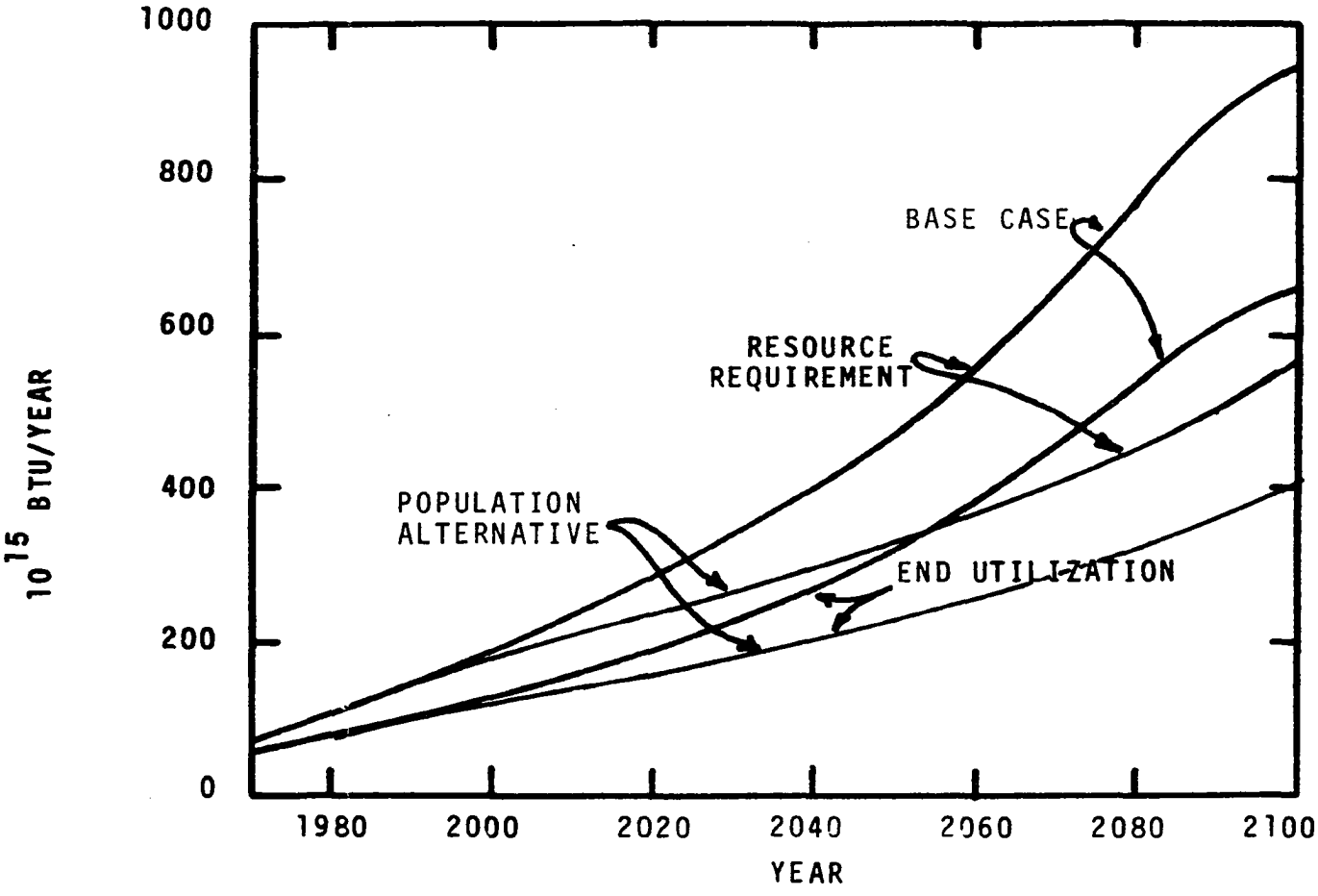


Figure VIII-3. Total Resource Requirements and End Utilization Energy Demands--Population Alternative.

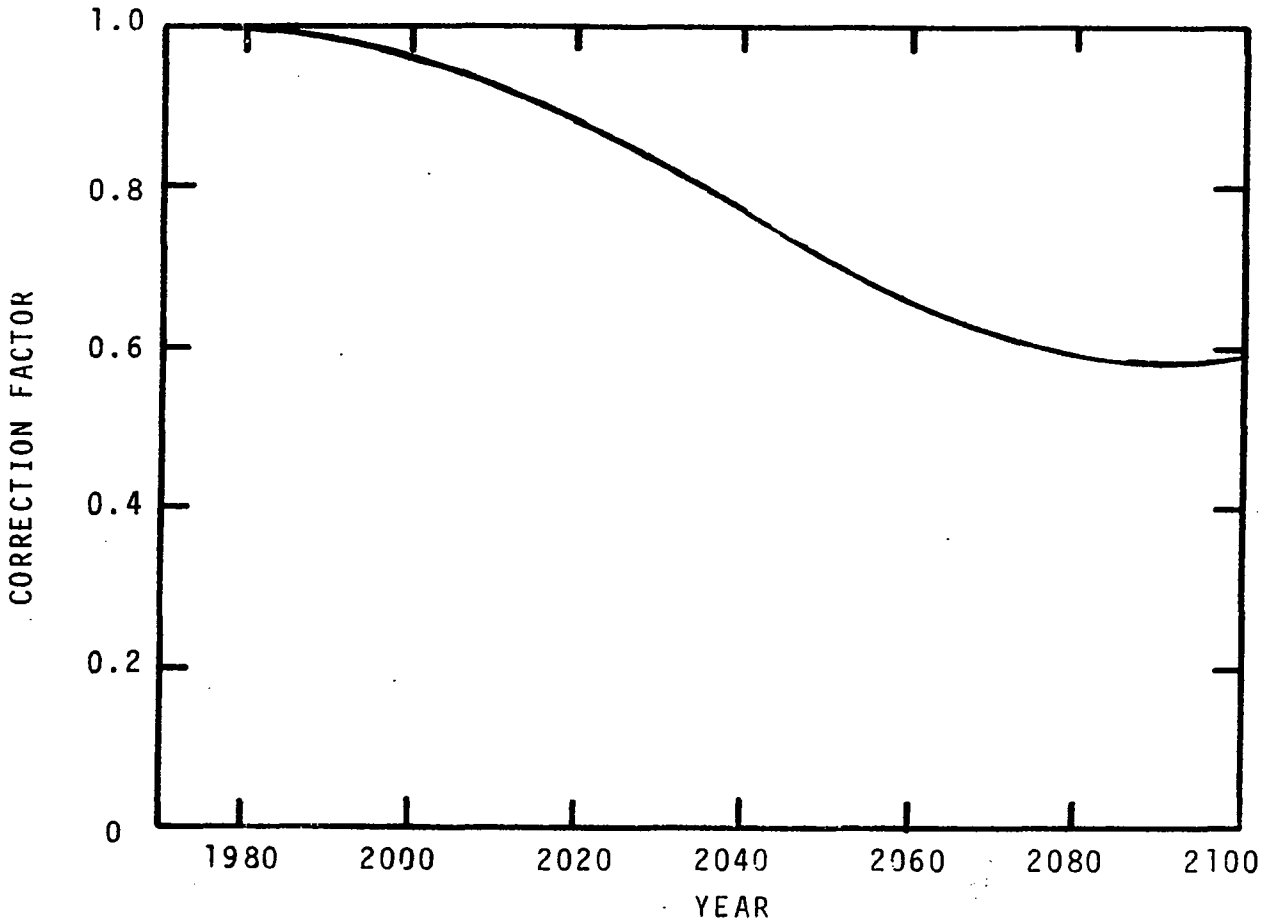


Figure VIII-4. Correction Factor for Base Case Resource Requirements and Environmental Impacts--Population Alternative.

CHAPTER IX

TRANSPORTATION FUEL ALTERNATIVES

Transportation accounts for a large portion of our energy requirements, Figure IV-7. Since by nature transportation requires a portable fuel, the transportation sector has historically consumed predominately petroleum products. However, due to limited petroleum supplies and environmental awareness, alternate transportation fuels have been proposed. Hydrogen is one fuel that has been prominently mentioned as a possible answer to both the energy crisis and transportation-related air pollution such as photochemical smog. Methanol is another portable fuel that could be used for transportation. Electricity has also been proclaimed as a reasonable solution to pollution and energy crises.

Viable transportation fuel alternatives include the use of hydrogen for all transportation except shipping. However, due to cost, refueling, and safety considerations, hydrogen will probably be limited to commercial transportation such as airplanes, buses, railroads and trucks with automobiles fueled by electricity, methanol, or gasoline. Another proposed alternative is a methanol based transportation system.

However, when any of these fuel alternatives are analyzed, it must be on a complete systems analysis basis. All effects on the U.S. energy system and the environment from resource production to end utilization must be evaluated. The Manergy model was used to determine the effects on energy resources, the balance of payments, and the environment for these transportation fuel alternatives:

Case I: As of the year 1990, all transportation modes, except ships, are fueled with hydrogen. Shipping fuel fractions remain as projected in the base case. The transportation fuel fraction for electricity remains the same as for the base case.

Case II. As of the year 1990, airplanes, buses, trucks, and railroads are fueled with hydrogen. Automobiles are all fueled by electricity. Shipping fuel fractions remain as projected in the base case. The transportation fuel fraction for electricity remains the same as for the base case.

Case III: As of the year 1990, airplanes, buses, trucks, and railroads are fueled with hydrogen. Automobiles are all fueled by methanol. Shipping fuel fractions remain as projected in the base case. The transportation fuel fraction for electricity remains the same as for the base case.

Case IV: As of the year 1990, airplanes, automobiles, buses, trucks, and railroads are fueled with methanol.

Shipping fuel fractions remain as projected in the base case. The transportation fuel fraction for electricity remains the same as for the base case.

Assumptions

The analysis of the transportation fuel alternatives was based on the following assumptions:

1. Existing internal combustion engine and existing turbine technology were assumed.
2. The propulsion efficiency of hydrogen is the same as the efficiency of the fuel it replaces.
3. The electrical automobile efficiency is 0.84 percent (58).
4. The propulsion efficiency of methanol is the same as the efficiency of the fuel it replaces.

Results

Energy Resources

The hydrogen alternatives shift the energy resource requirements to nuclear power, Figure IX-1, while the methanol alternative (Case IV) shifts the resource requirements to coal, Figure IX-2. For all cases there is a tremendous increase in energy resource requirements for the same end utilization use, i.e., more energy is required to provide the alternate fuels, with Case I having the worst effect on the resources, Figure IX-3.

The dramatic effect of hydrogen production on nuclear energy production, Figure IX-4, creates large impacts on the

nuclear fuel cycle components, Figures IX-5, IX-6, and IX-7.

The annual coal production, Figure IX-8, increases initially for the hydrogen alternatives due to coal required for electrical generation, Figure IX-9, then it decreases by approximately 20 percent due to the reduced synthetic crude petroleum requirements and the slightly increased syngas requirements, Figures IX-10 and IX-11, respectively.

The 60 percent reduction in crude petroleum demand, Figure IX-12, creates the same reduction in syncrude, oil imports, oil shale and tar sands requirements, Figures IX-13, IX-14, IX-15 and IX-16.

Electrolytic hydrogen production causes increased electrical power requirements for the hydrogen alternatives. This increases the amount of geothermal energy and liquefied natural gas imports (Figures IX-17 and IX-18).

Environmental Impact

The airborne emission for Case I, Figure IX-19, are substantially lower than the base case except for SO_2 emissions from 1990 to 2020. The SO_2 emissions are increased due to the number of coal-fired electrical generating plants required to meet the electrical demand for electrolytic hydrogen. The airborne emissions for Case IV, Figure IX-20, are greater than for Case I due to methanol production and the less clean methanol combustion (than hydrogen combustion) in transportation vehicles.

The large nuclear requirements for electrolytic hydrogen production also dramatically increase the projected population exposure and tritium and krypton-85 releases, Figures IX-21, IX-22, and IX-23, and the amount of long-lived radioactive waste, Figure IX-24.

The annual solid waste and sulfur production, Figures IX-25 and IX-26, are decreased by 10 to 15 percent due to less coal liquefaction and reduced tar sands and oil shale production.

The hydrogen alternatives almost double the annual water requirements, Figure IX-27, due to the feed water and cooling water requirements for electrolytic hydrogen production and cooling water for electrical generating plants.

Balance of Payments Deficit

The balance of payments deficit, Figure IX-28 still approaches 20 billion dollars per year until the year 2000. However, as the transportation alternatives lessen the strain on petroleum based fuels, the balance of payments deficit decreases to approximately 7.5 billion dollars per year until 2100.

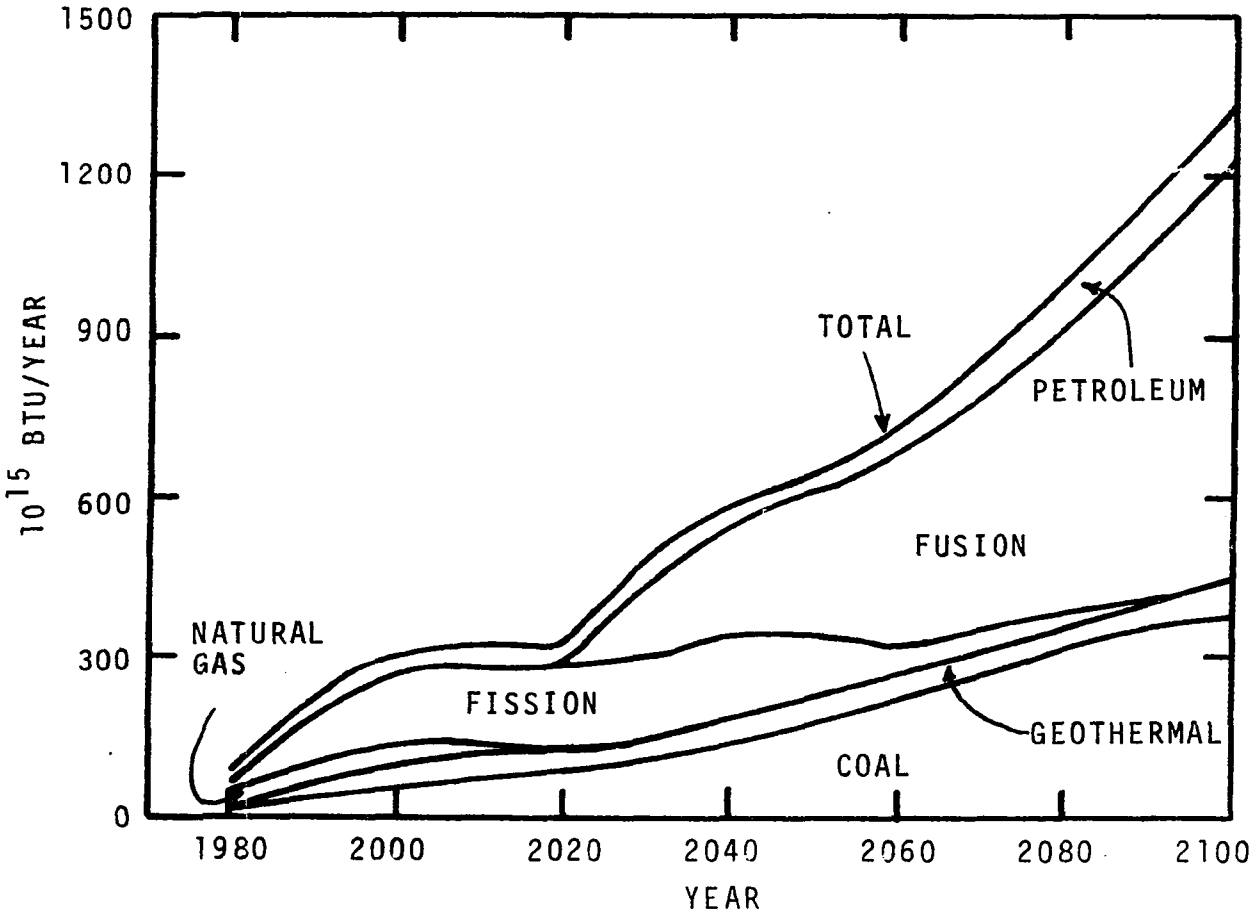


Figure IX-1. Composite Energy Resource Requirements--Transportation Alternatives: Case I.

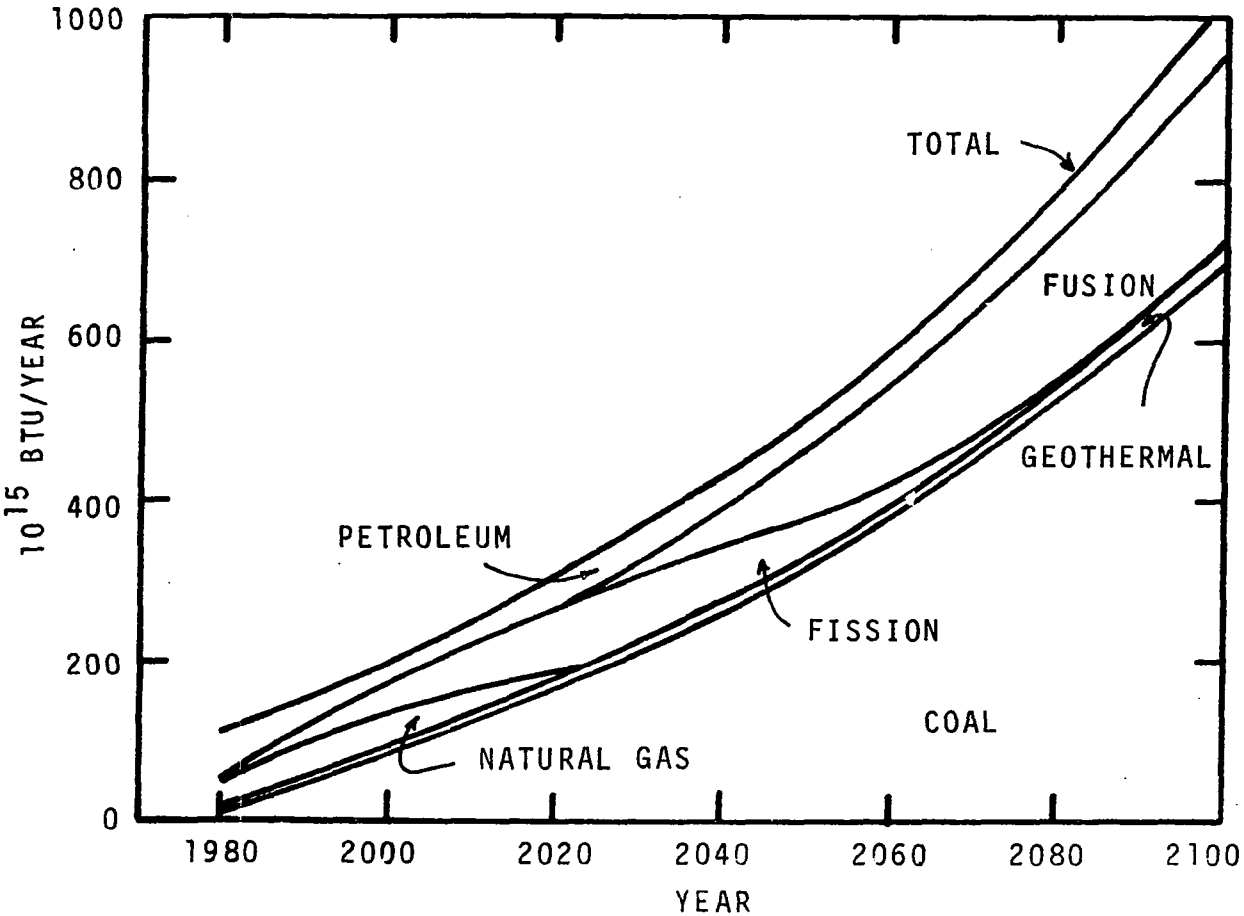


Figure IX-2. Composite Energy Resource Requirements--Transportation Alternatives: Case IV.

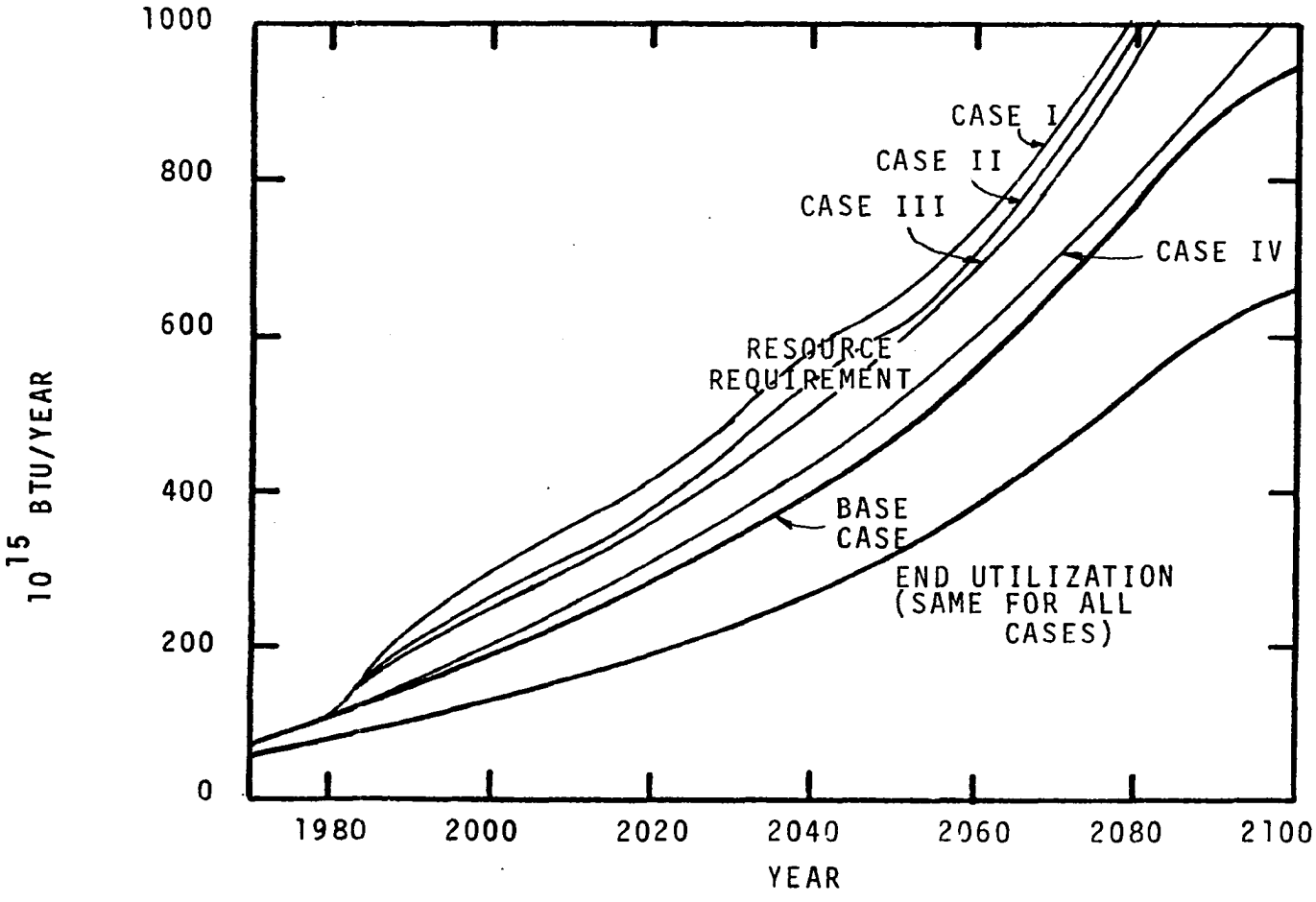


Figure IX-3. Total Annual Energy Production and Net End Utilization--Transportation Alternatives.

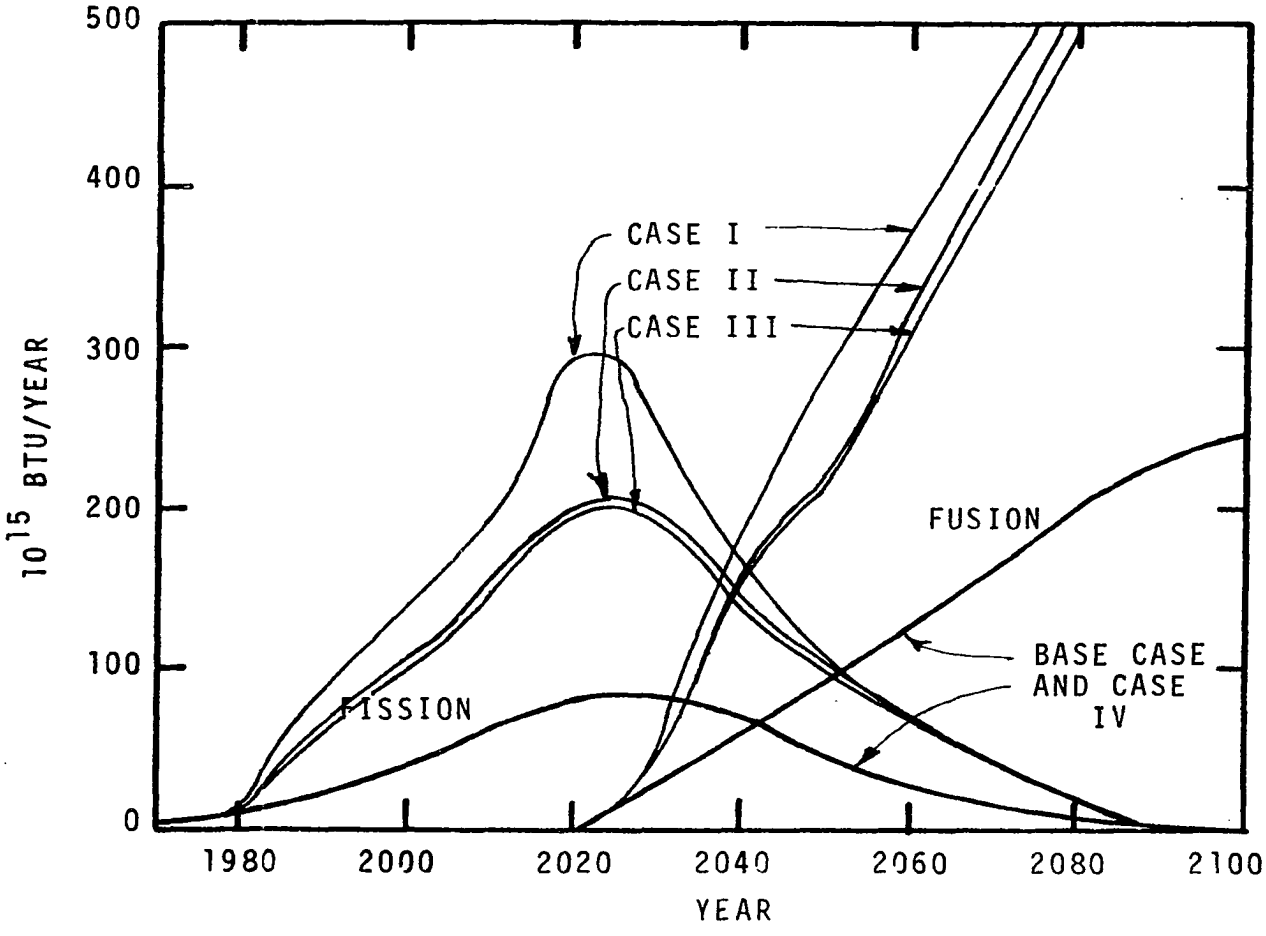


Figure IX-4. Nuclear Power Energy Production--Transportation Alternatives.

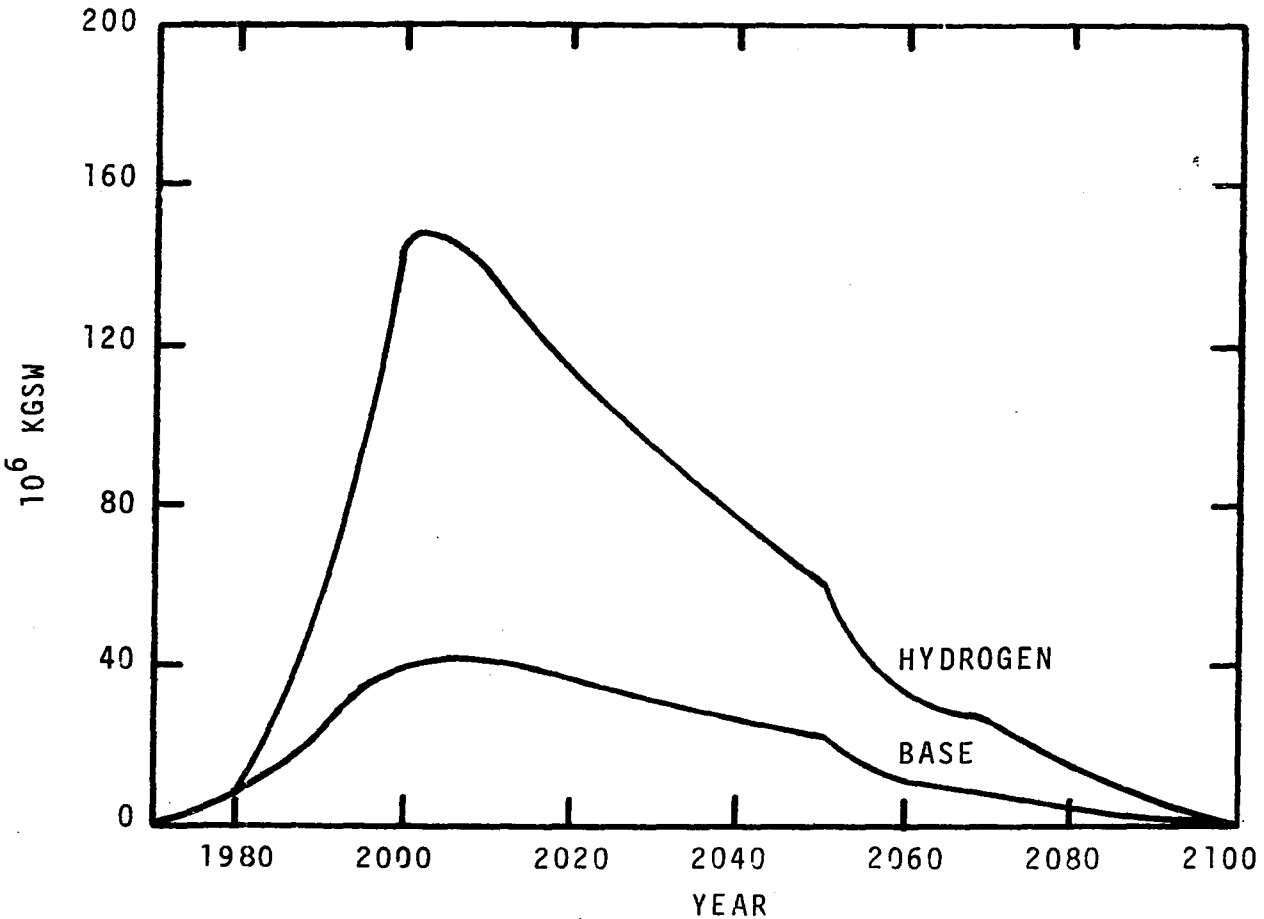


Figure IX-5. Annual Uranium Enrichment Requirements--Transportation Alternatives.

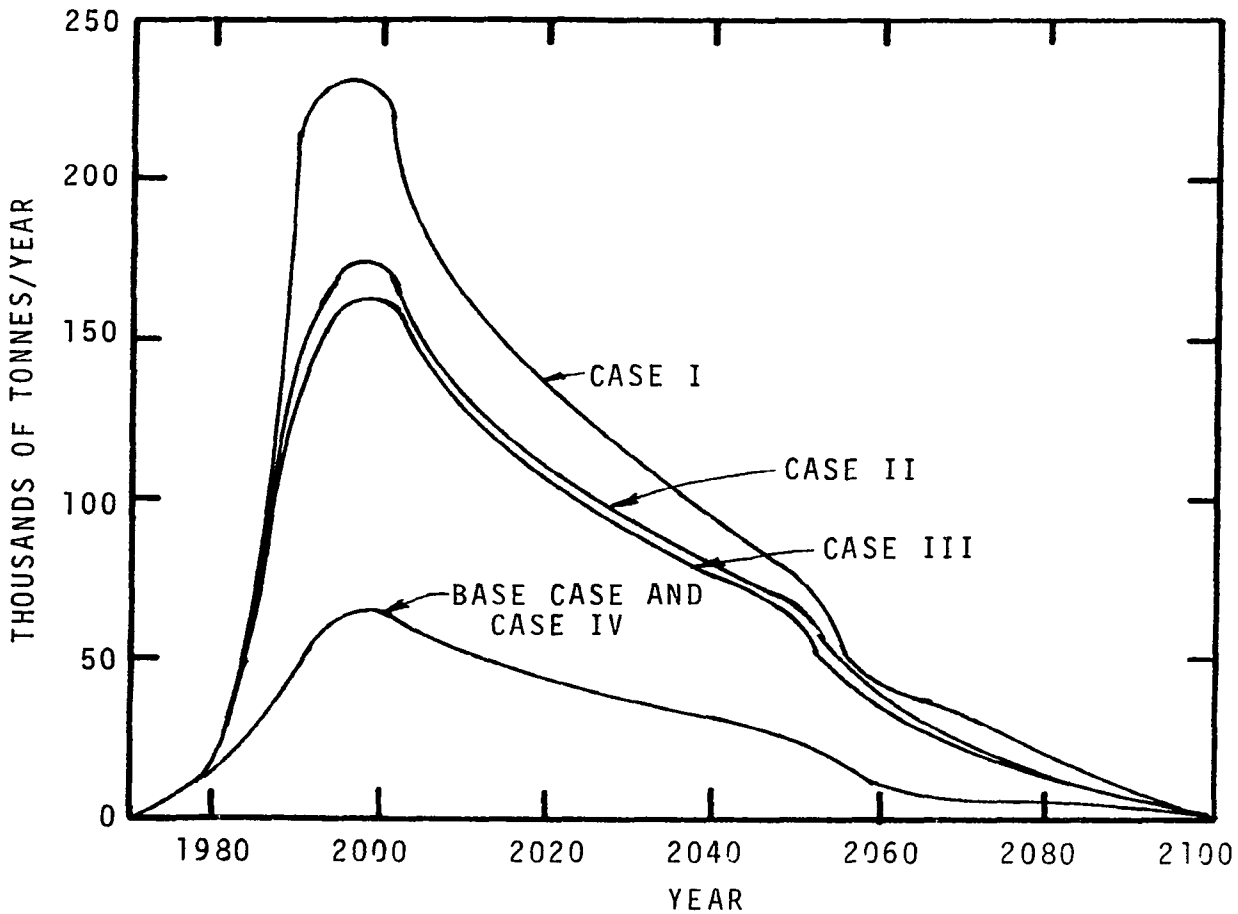


Figure IX-6. Annual U_3O_8 Production Requirements--Transportation Alternatives.

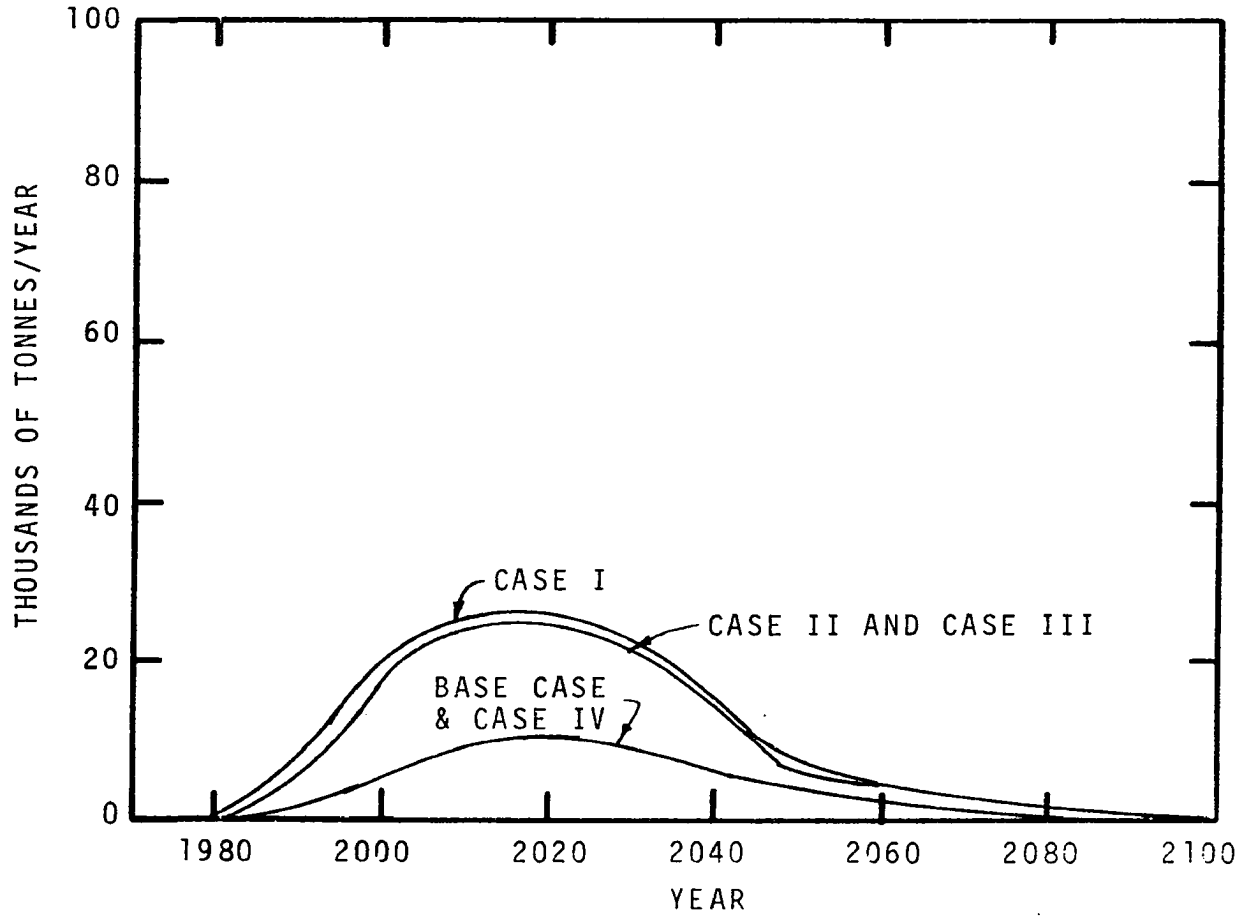


Figure IX-7. Annual ThO_2 Production Requirements--Transportation Alternatives.

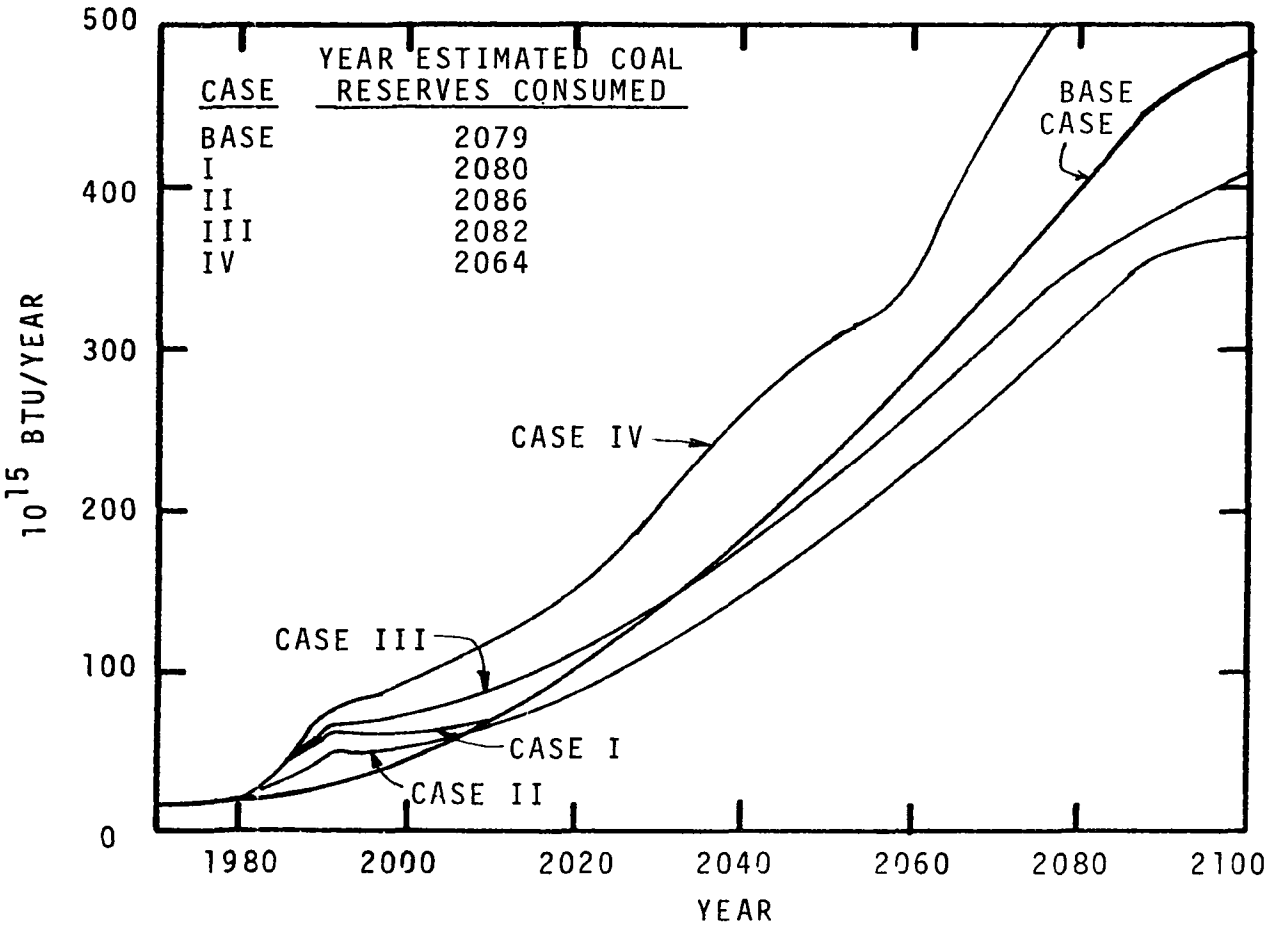


Figure IX-8. Annual Coal Production--Transportation Alternatives.

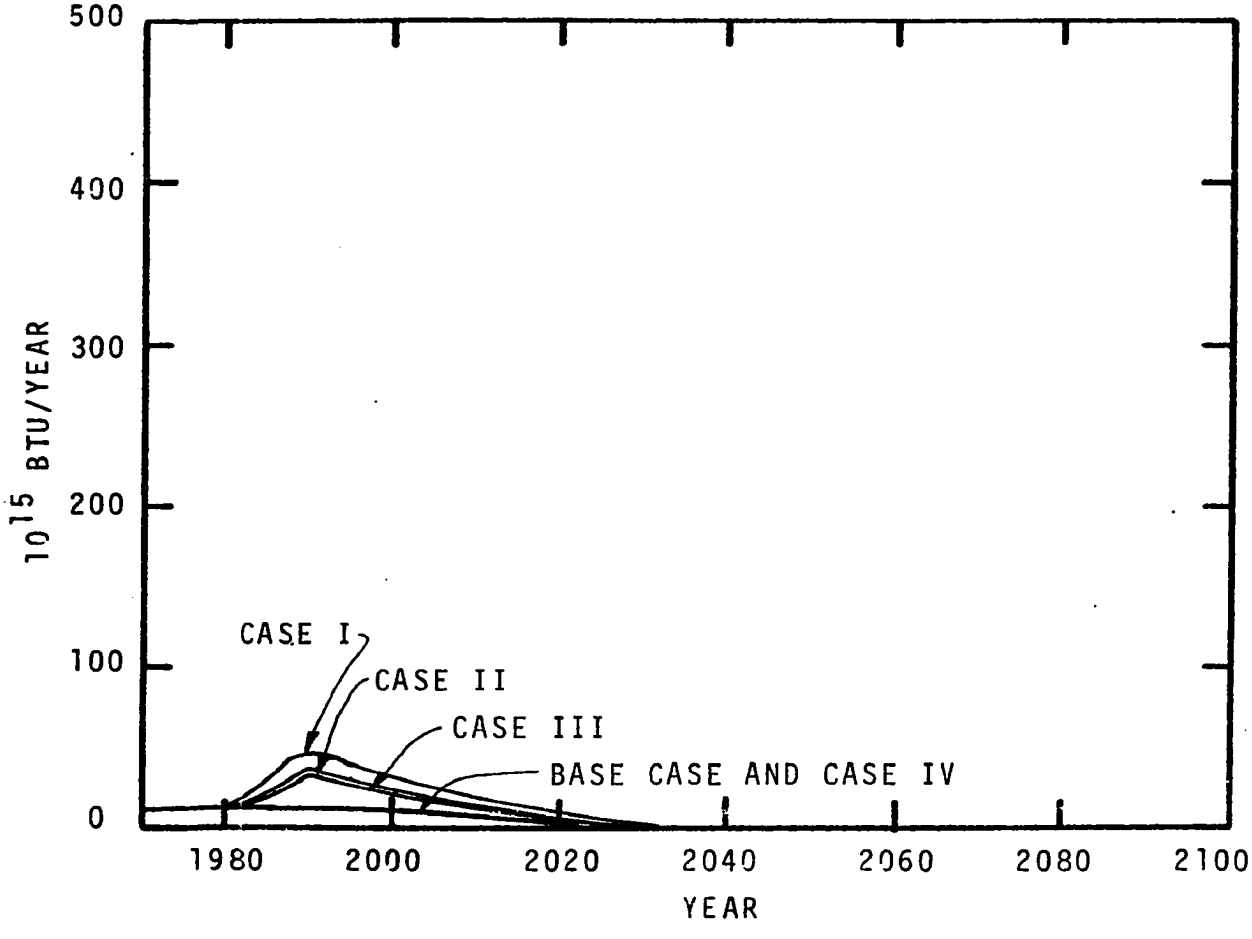


Figure IX-9. Annual Coal Requirements for Electrical Power Generation--Transportation Alternatives.

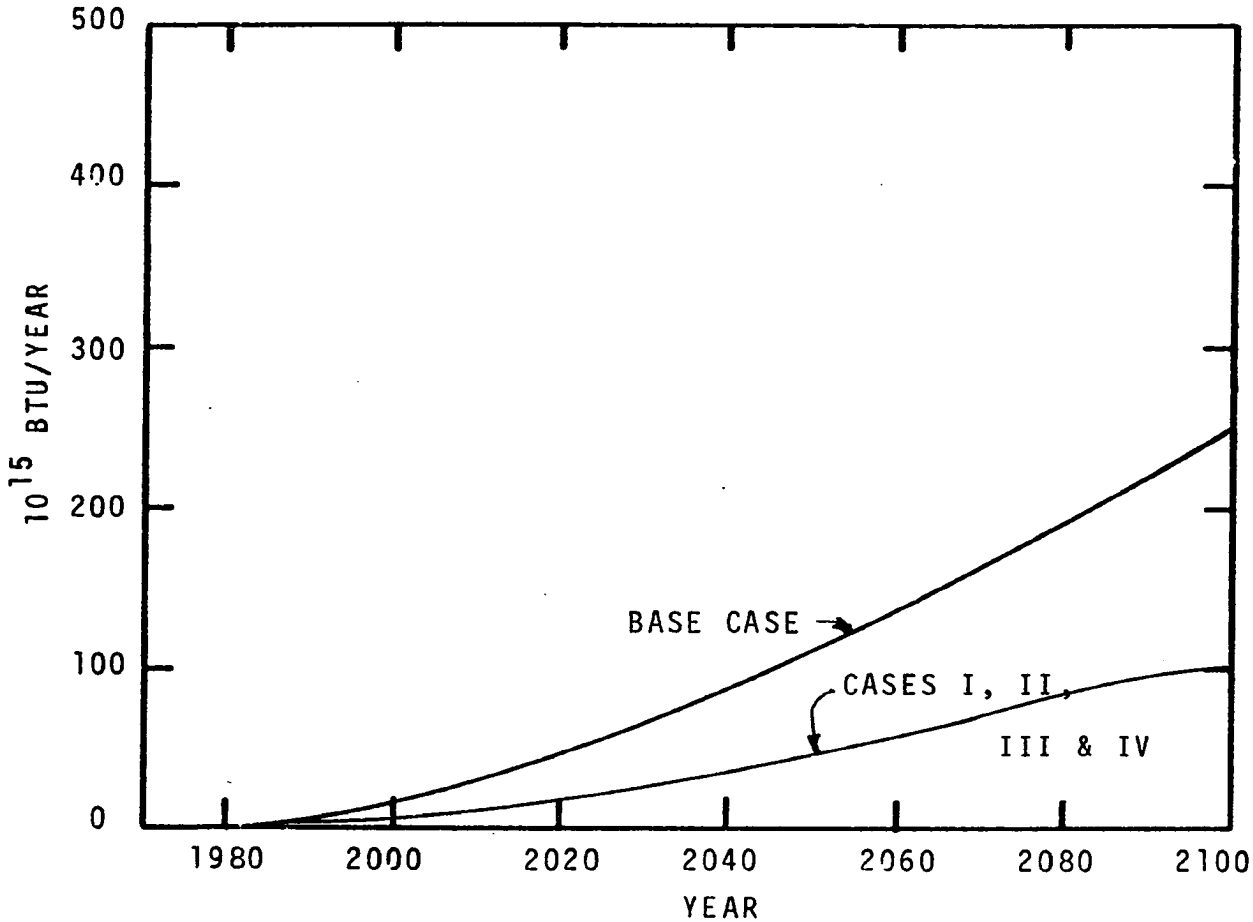


Figure IX-10. Annual Coal Requirements for Synthetic Crude Oil Production--Transportation Alternatives.

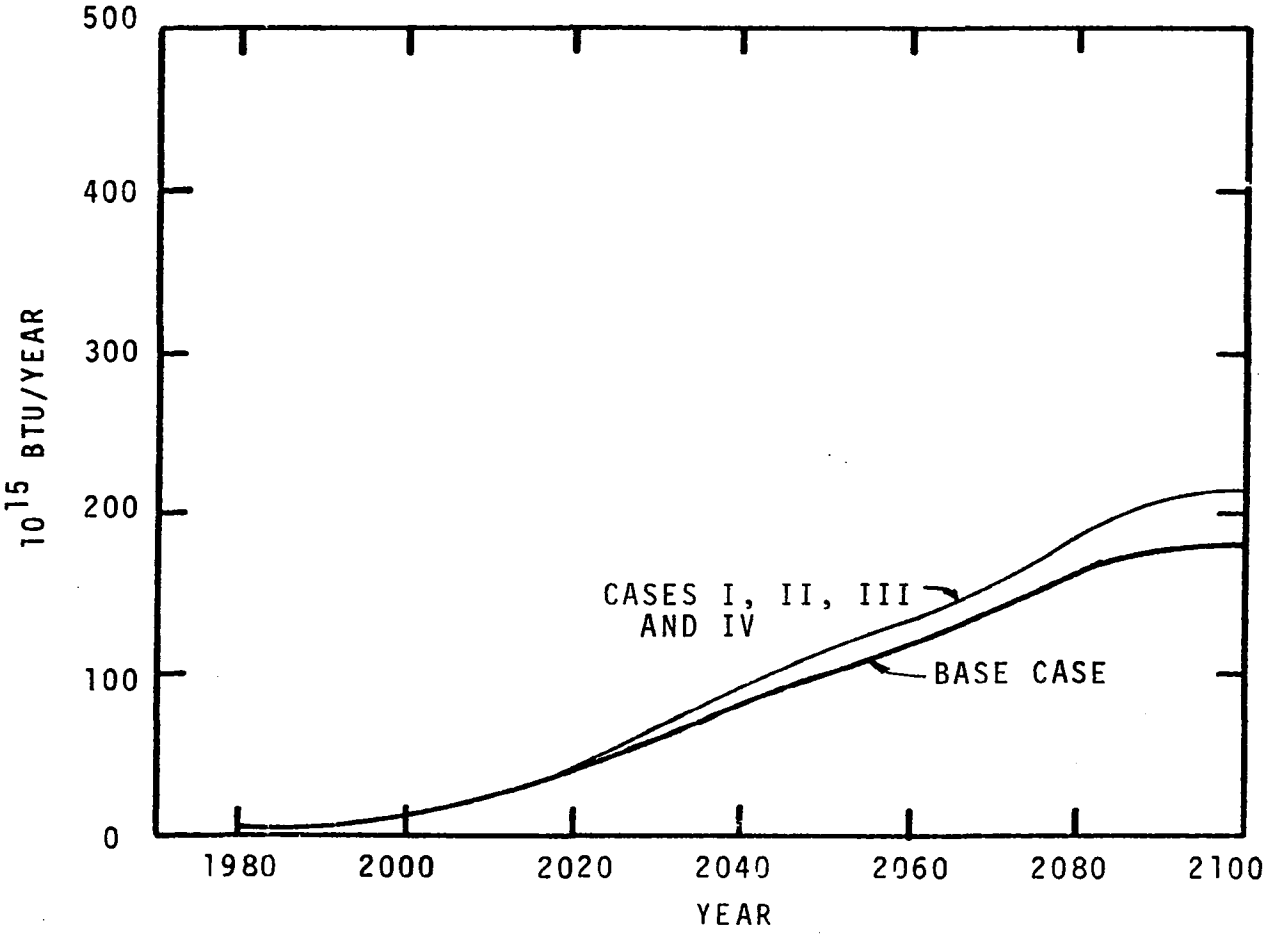


Figure IX-11. Annual Coal Requirements for Synthetic Natural Gas Production--Transportation Alternatives.

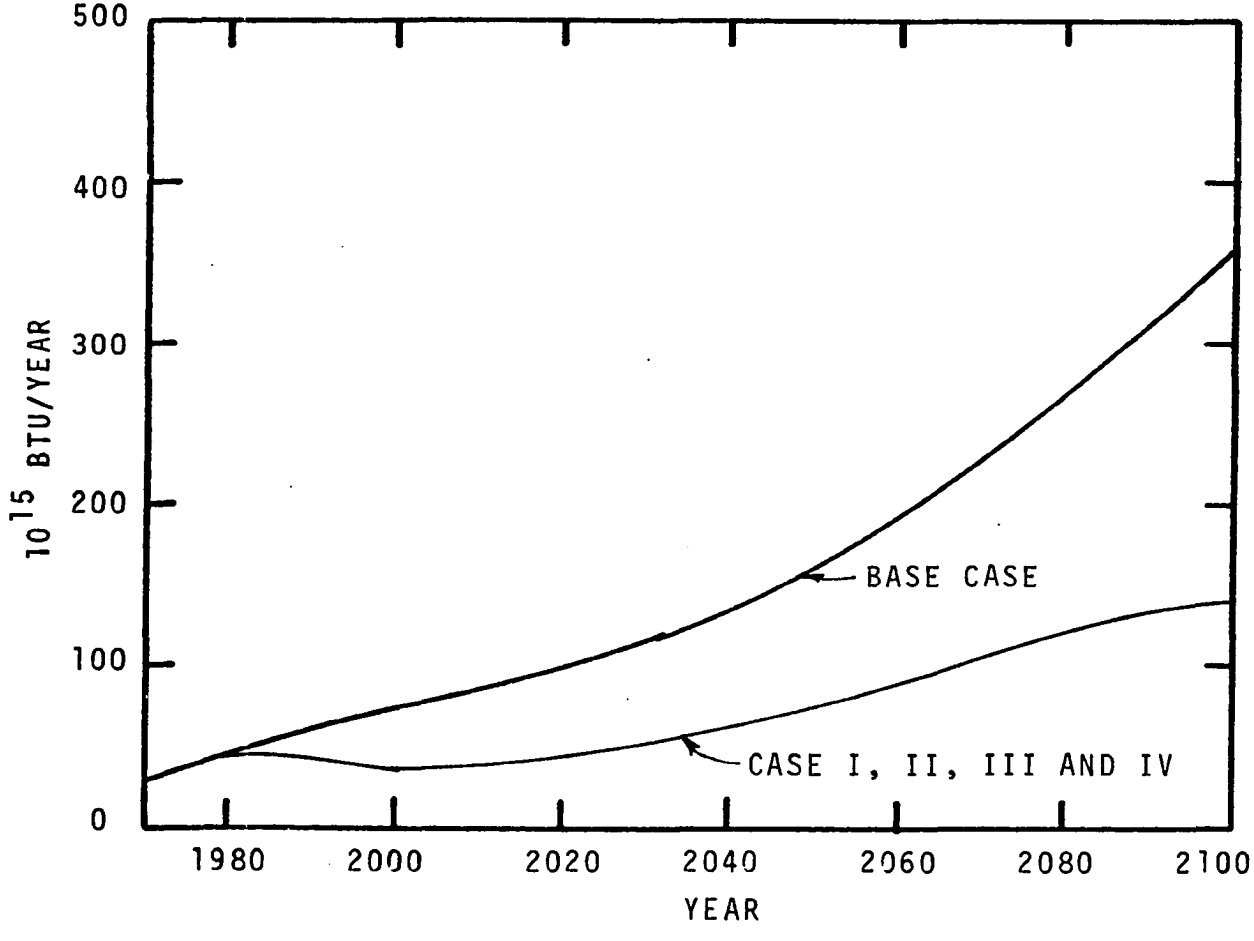


Figure IX-12. Annual Crude Petroleum Demand--Transportation Alternatives.

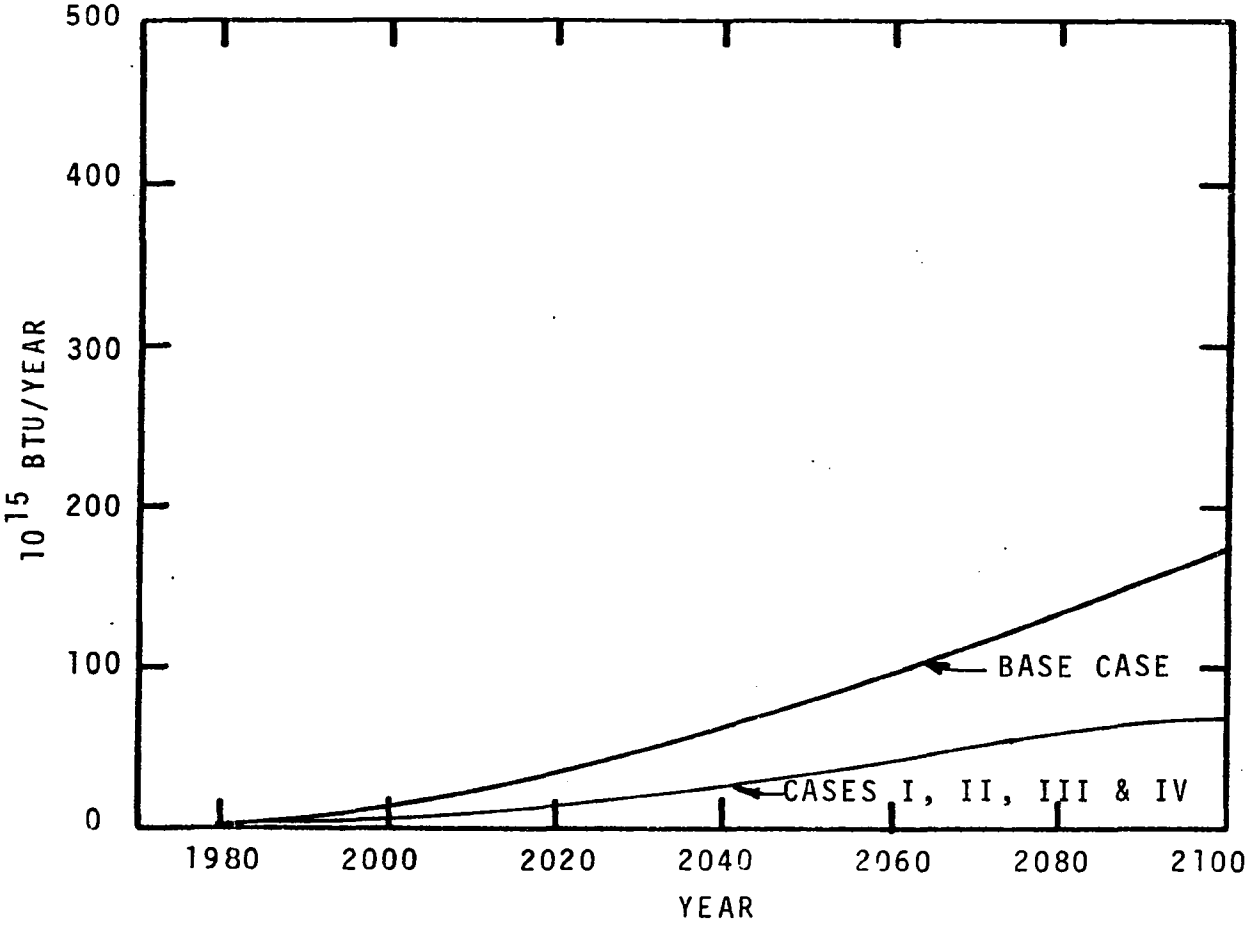


Figure IX-13. Annual Synthetic Crude Oil Demand--Transportation Alternatives.

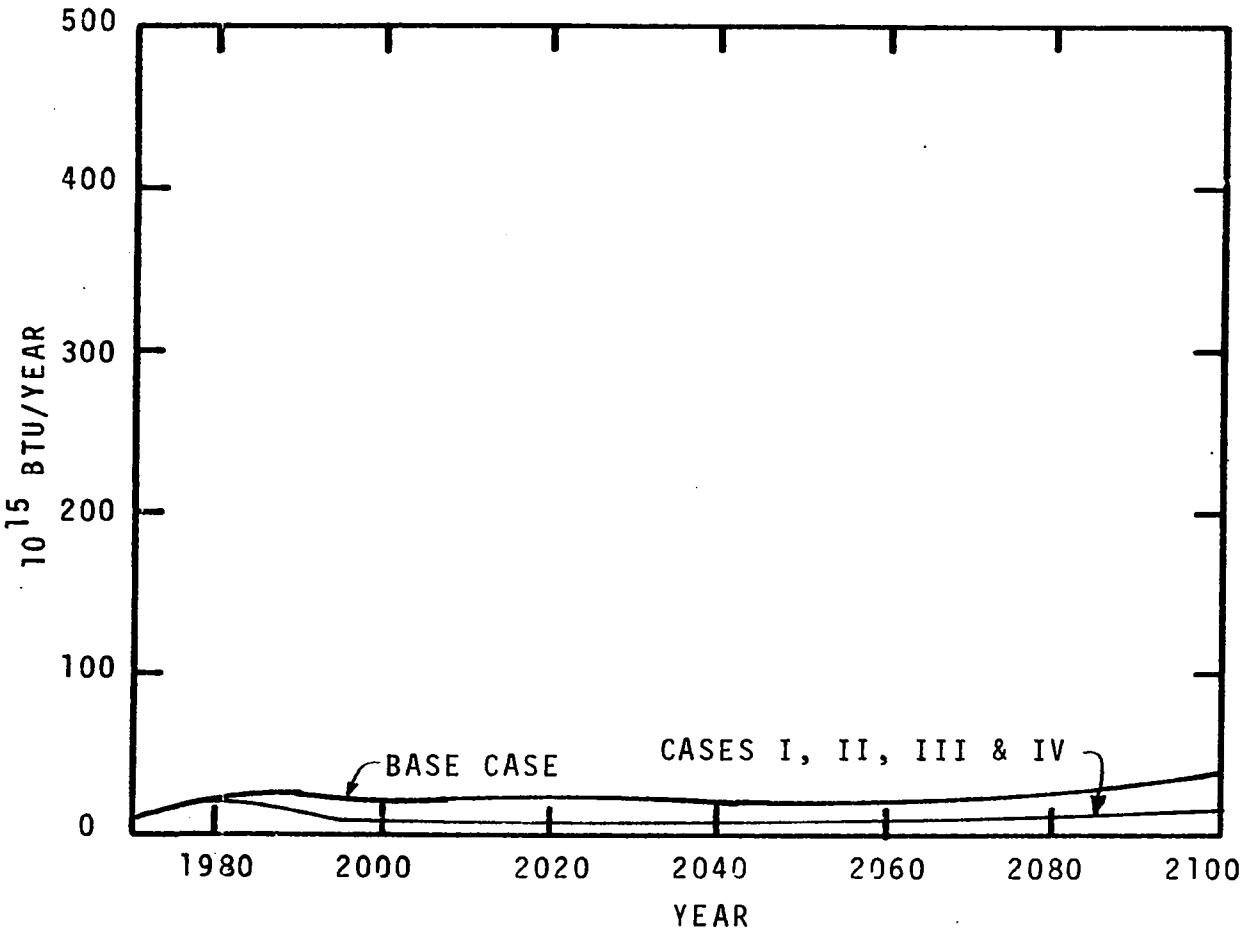


Figure IX-14. Annual Crude Oil Imports--
Transportation Alternatives.

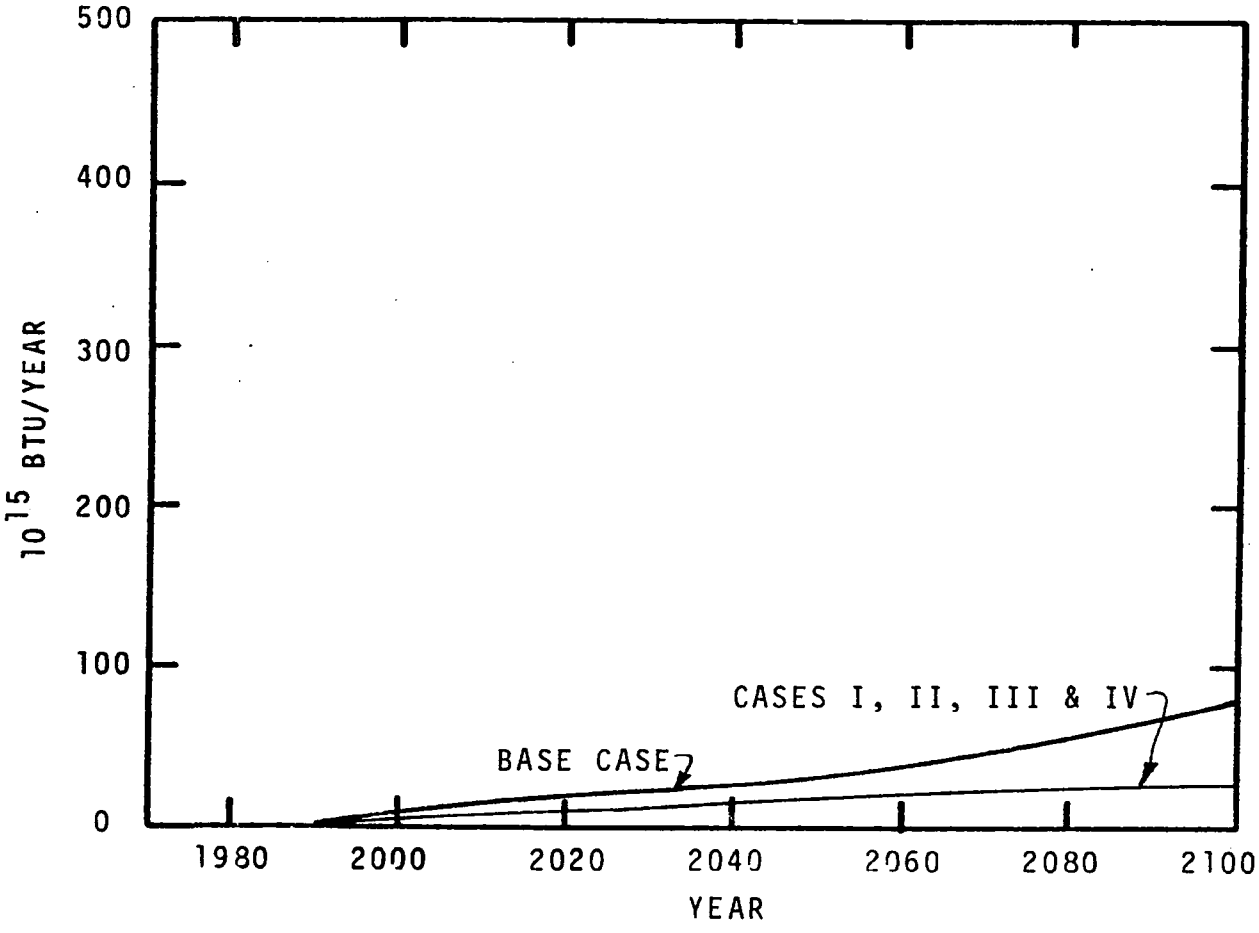


Figure IX-15. Annual Oil Shale Production--Transportation Alternatives.

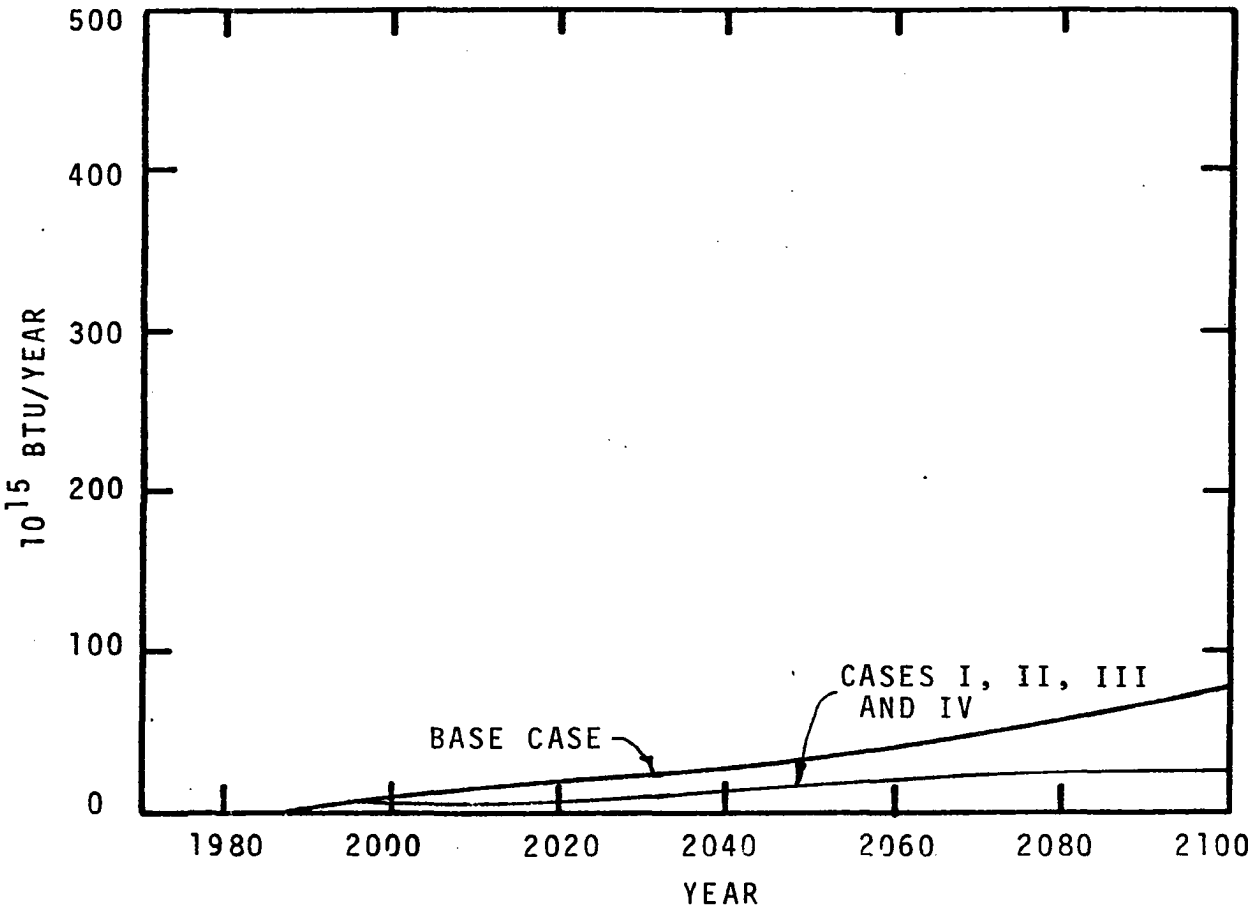


Figure IX-16. Annual Tar Sands Production--Transportation Alternatives.

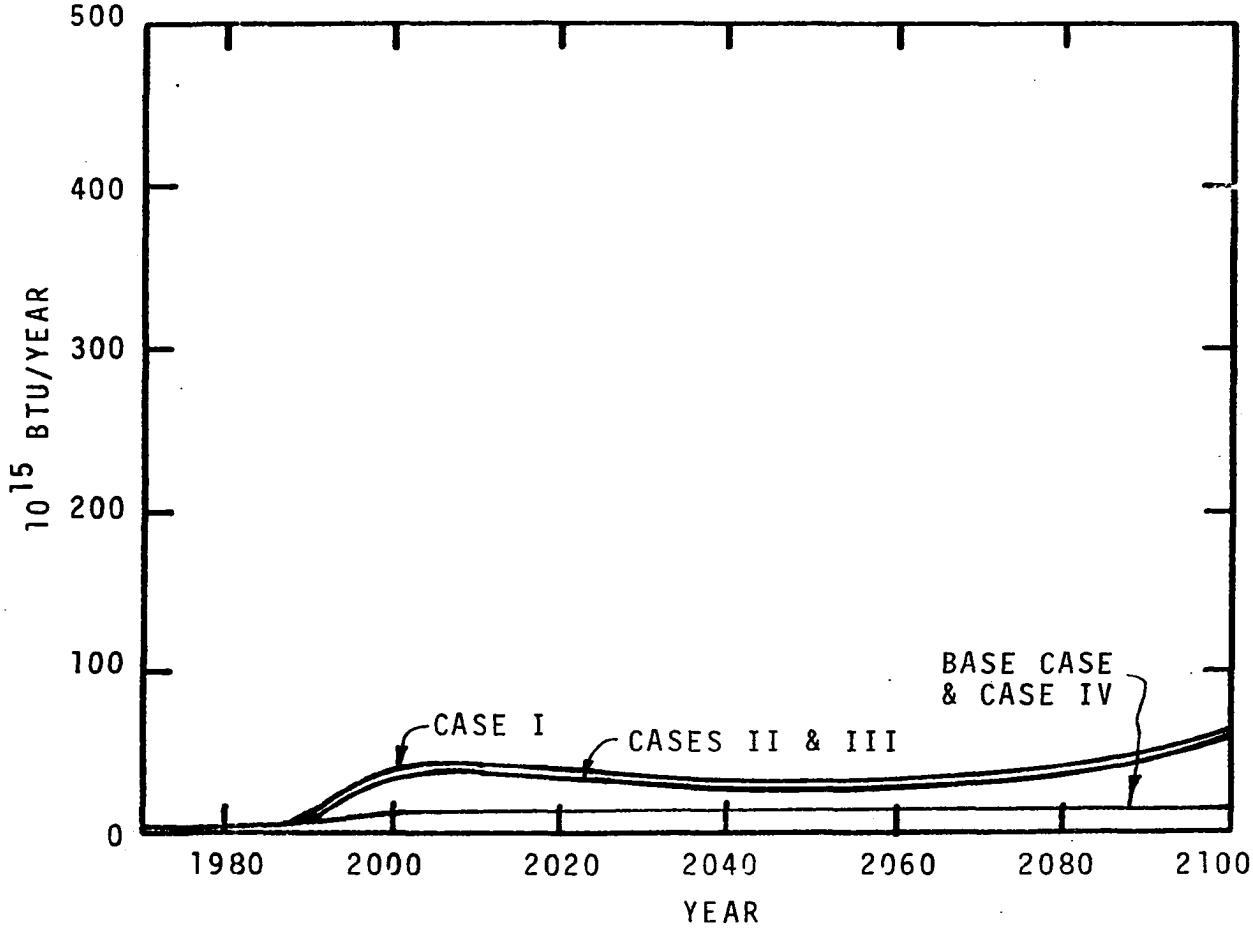


Figure IX-17. Annual Geothermal Energy Resource Production--Transportation Alternatives.

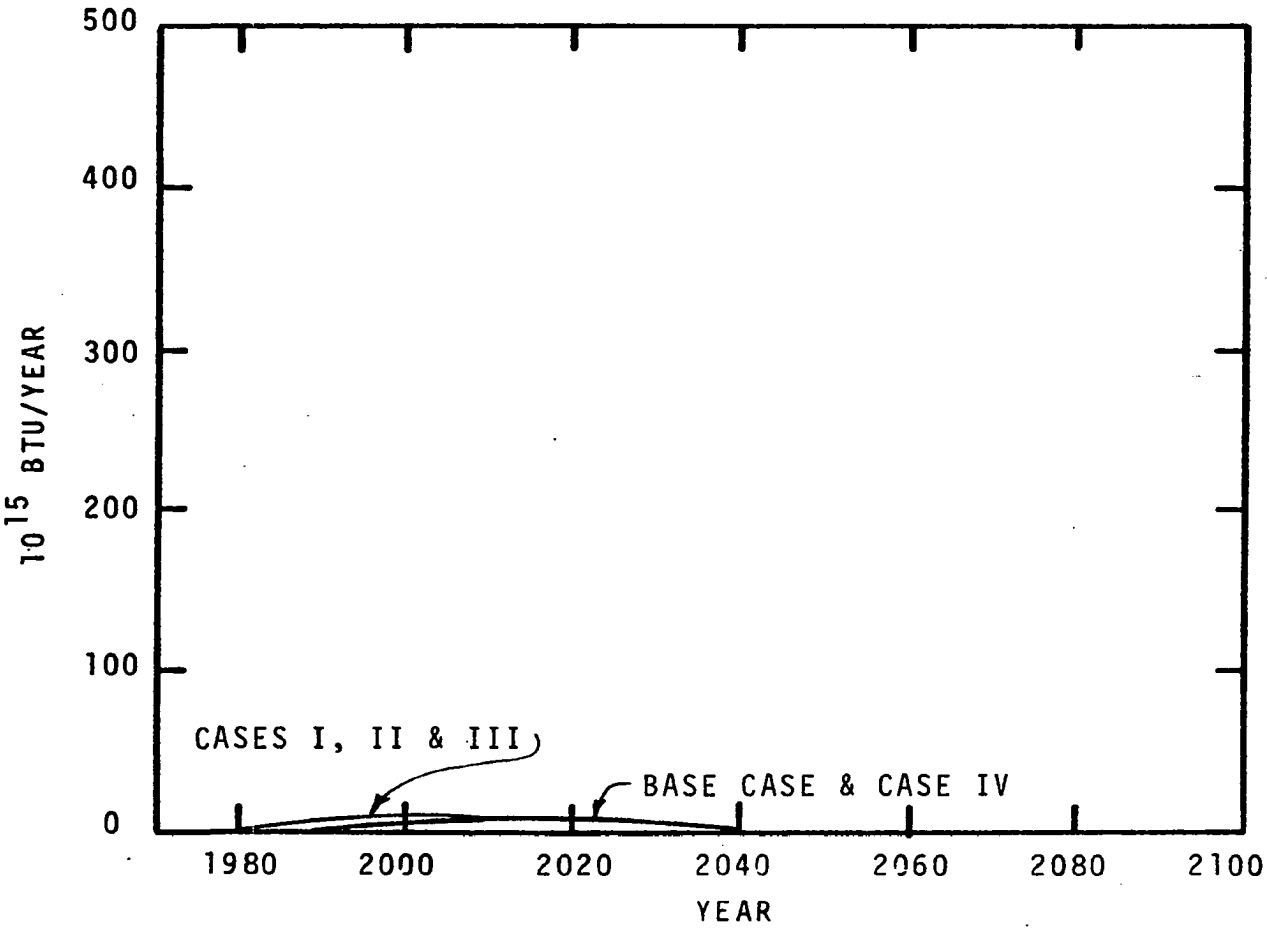


Figure IX-18. Annual Liquefied Natural Gas Imports--Transportation Alternatives.

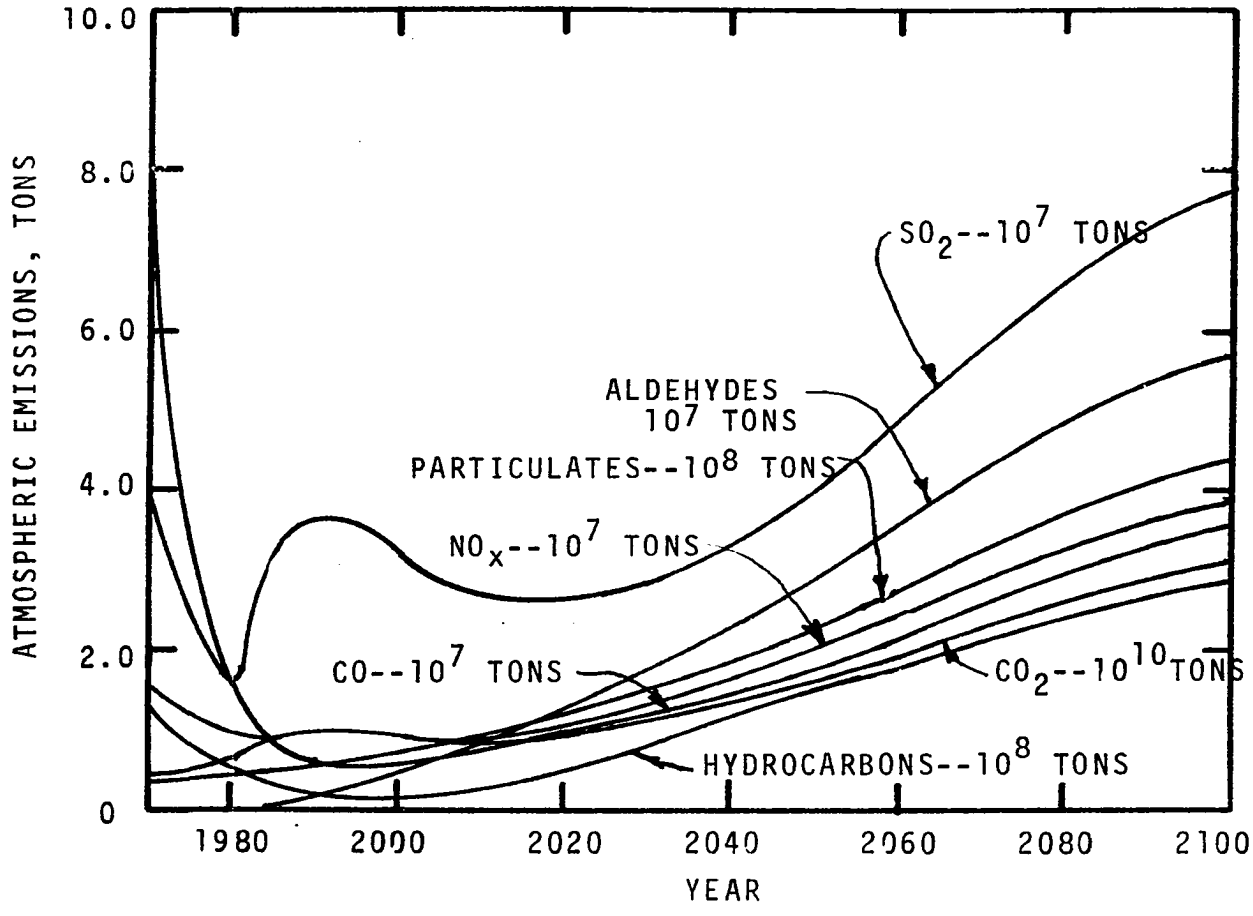


Figure IX-19. Annual Airborne Emissions--Transportation Alternatives: Case I.

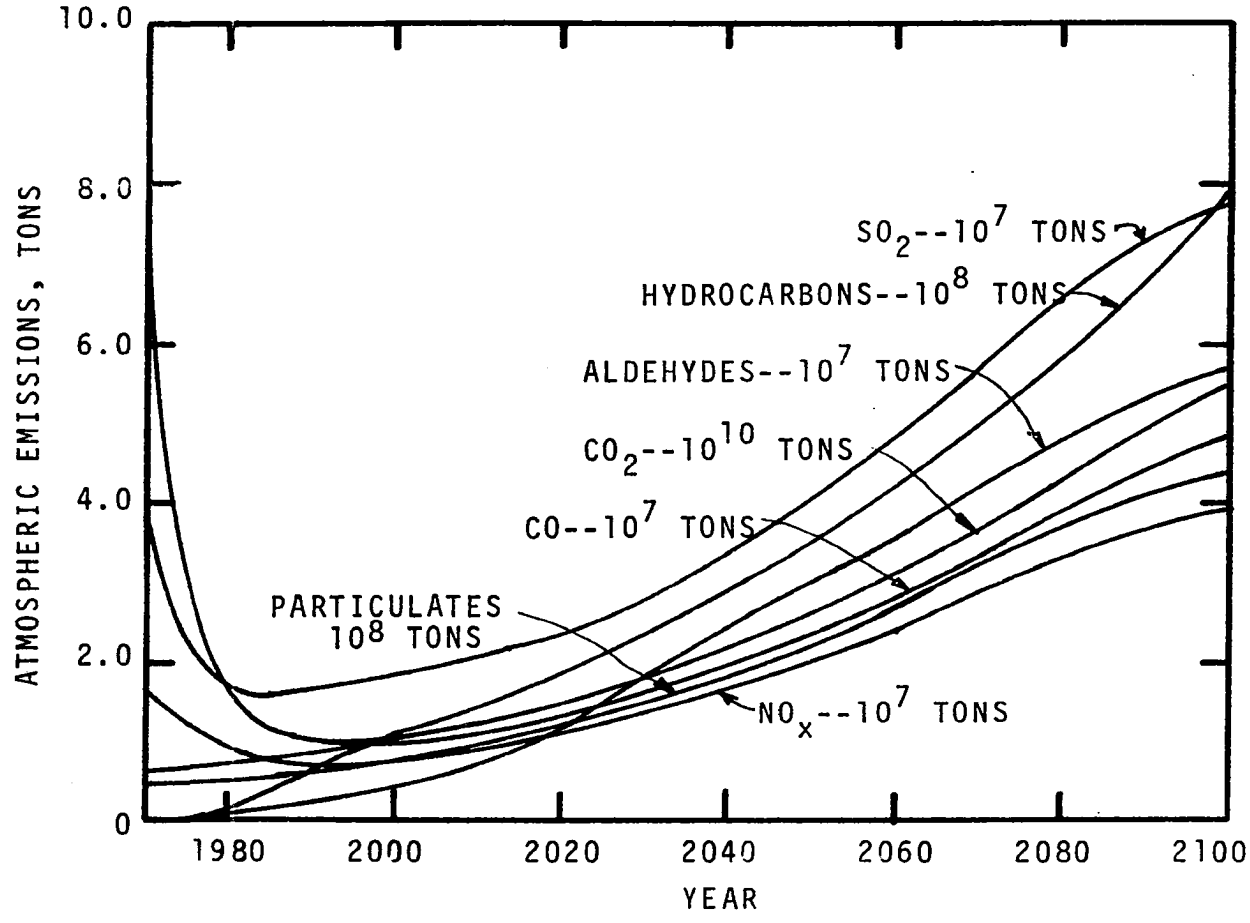


Figure IX-20. Annual Airborne Emissions--Transportation Alternatives: Case IV.

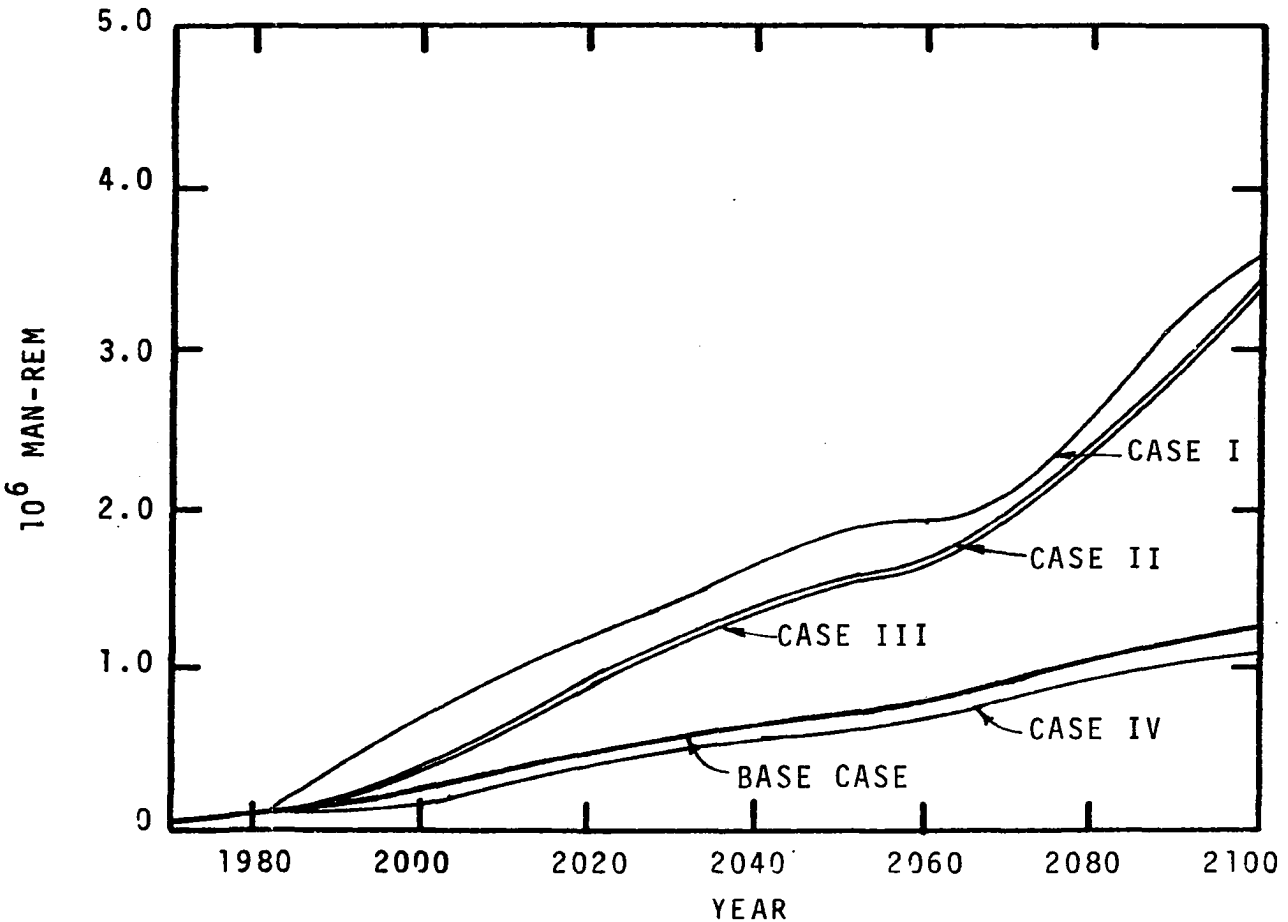


Figure IX-21. Annual Population Exposure to Ionizing Radiation--Transportation Alternatives.

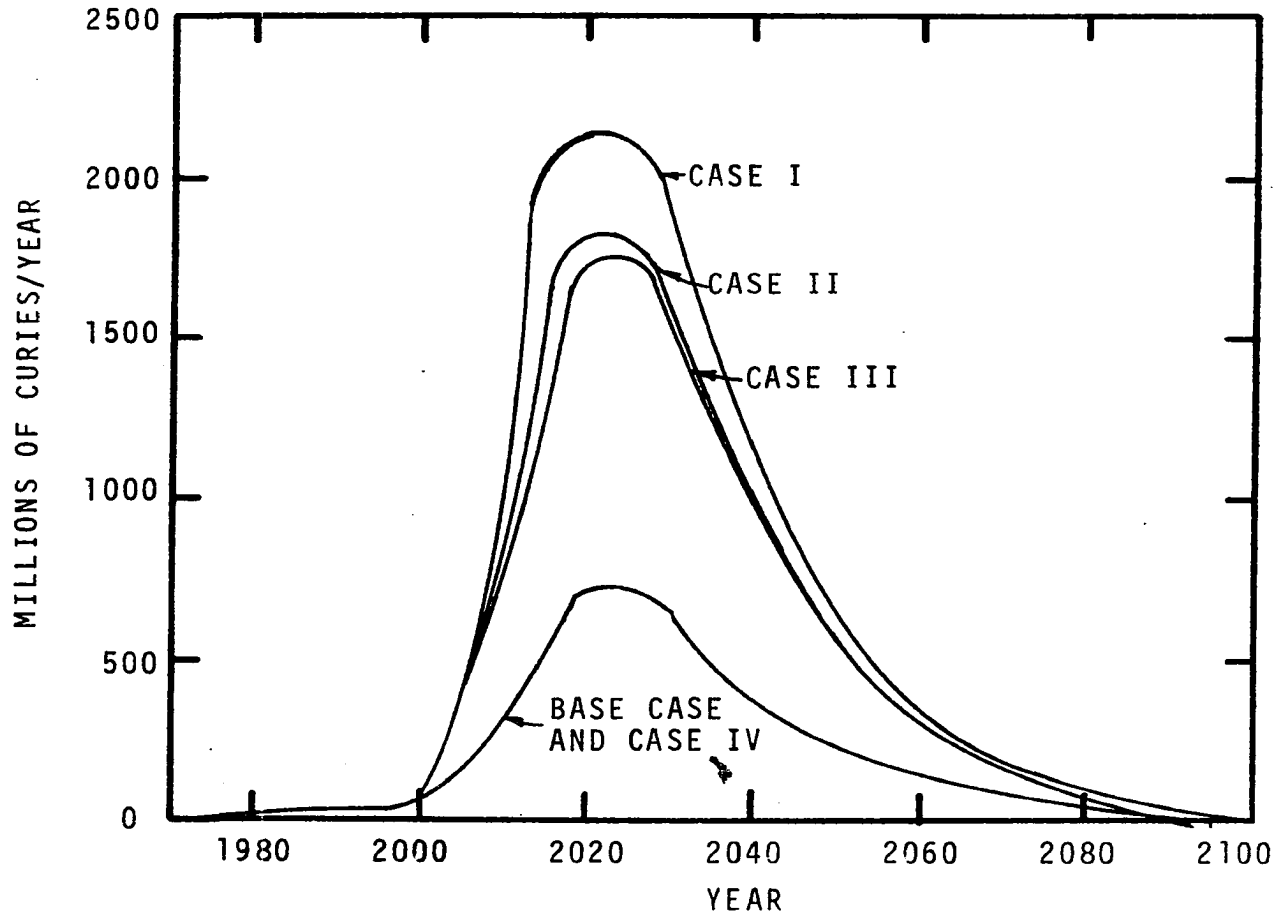


Figure IX-22. Annual Tritium Releases--Transportation Alternatives.

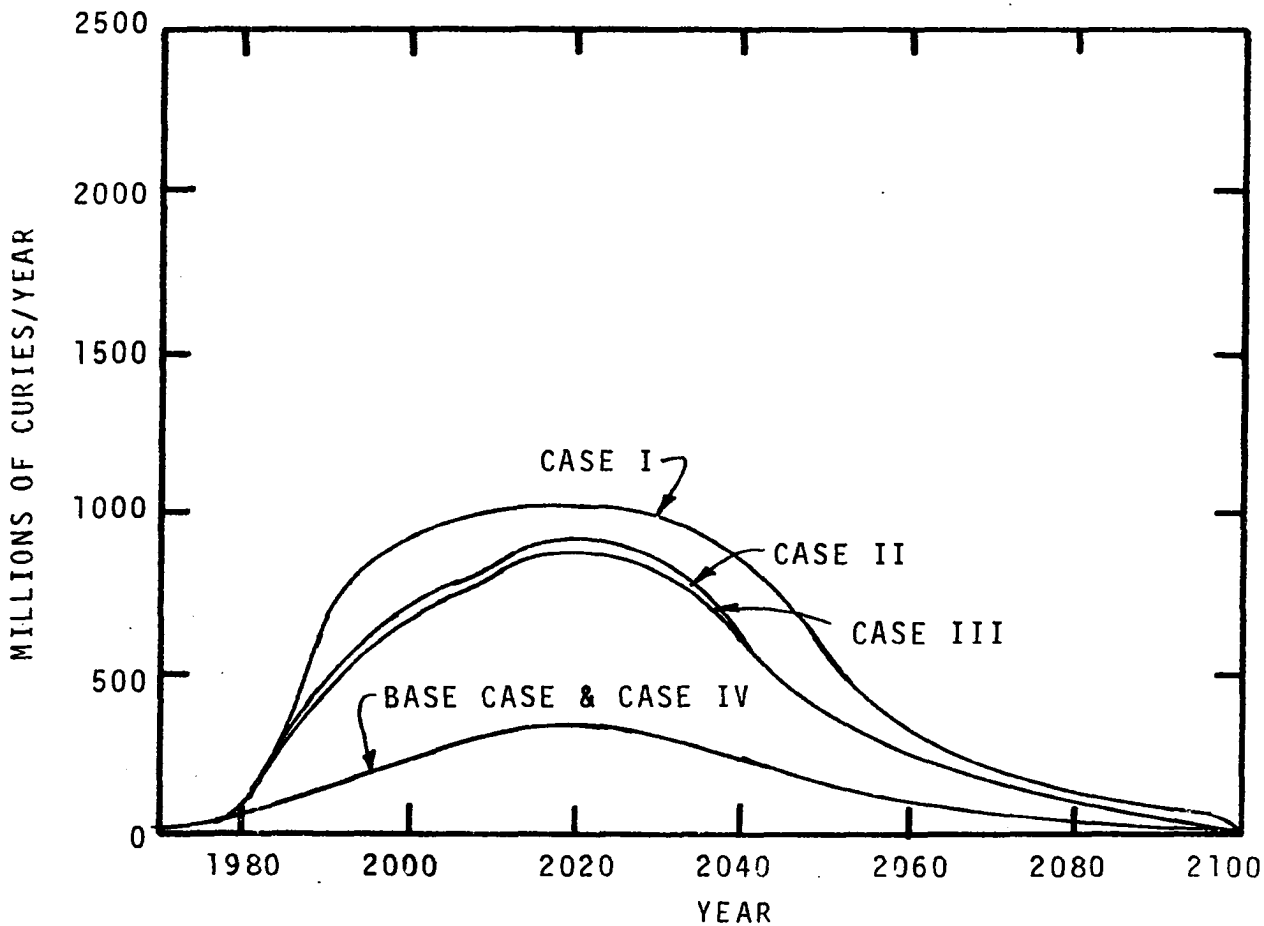


Figure IX-23. Annual Krypton-85 Releases--Transportation Alternatives.

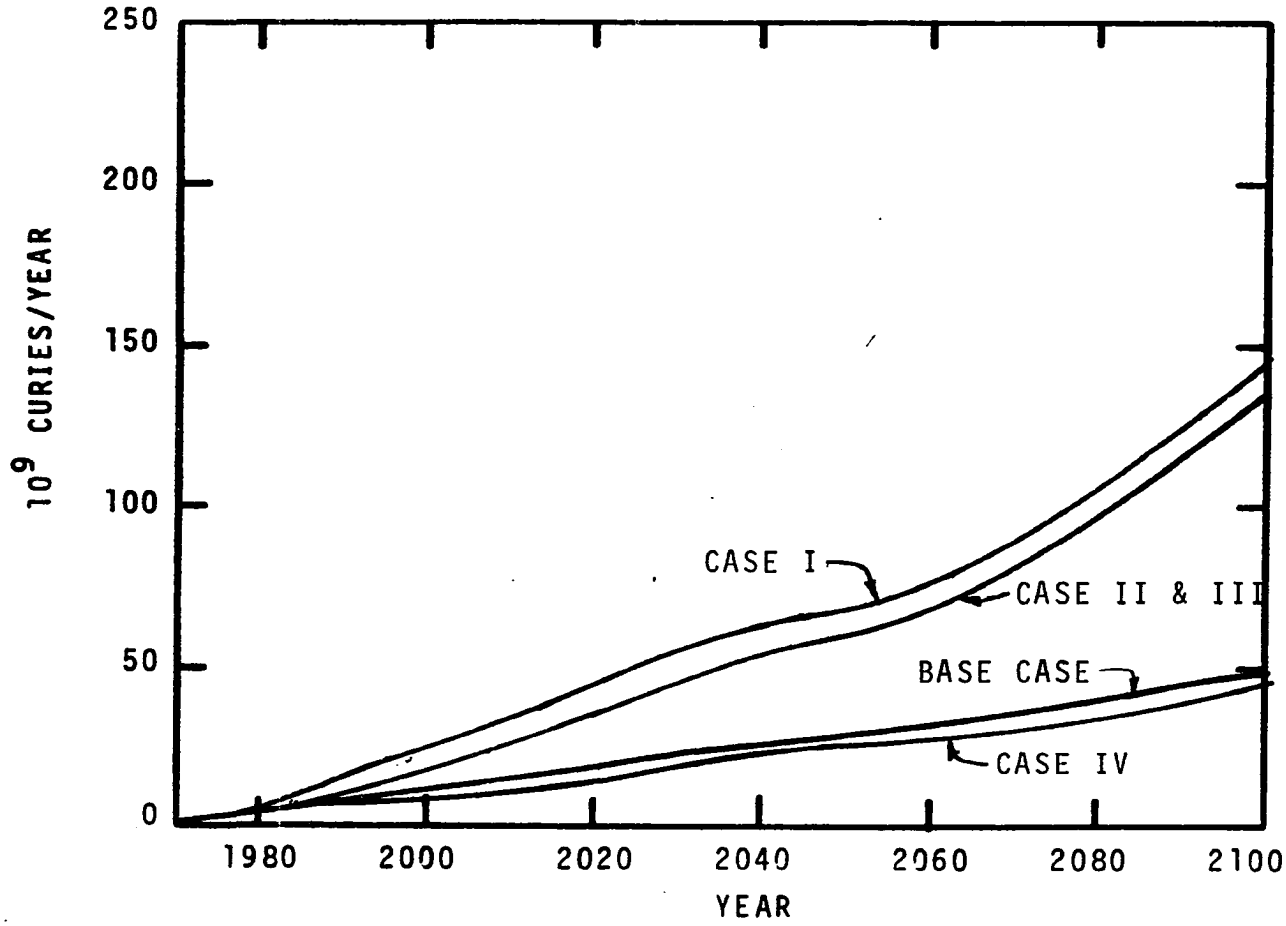


Figure IX-24. Annual Long-Lived Radioactive Solid Waste Production--Transportation Alternatives.

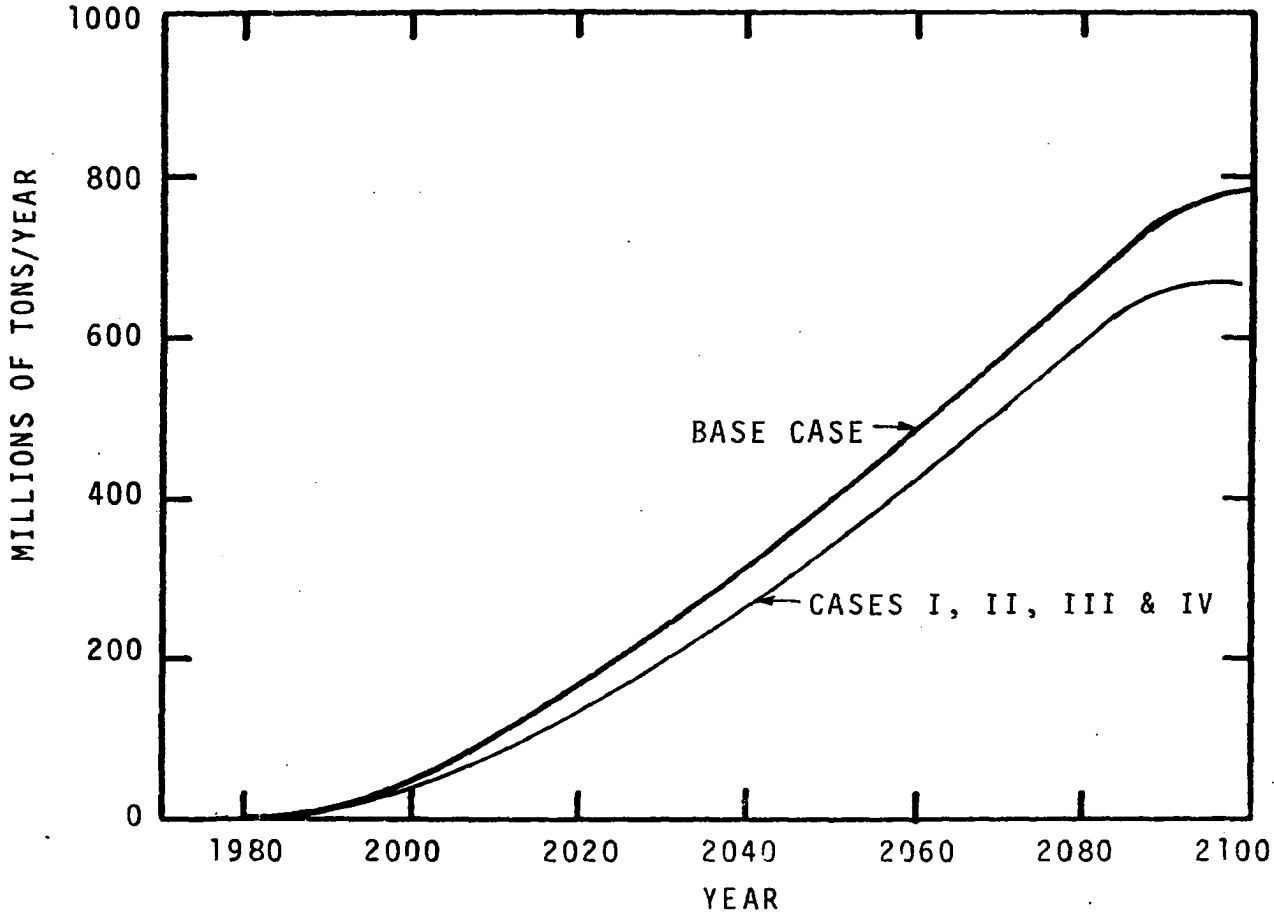


Figure IX-25. Annual Solid Waste Production--Transportation Alternatives.

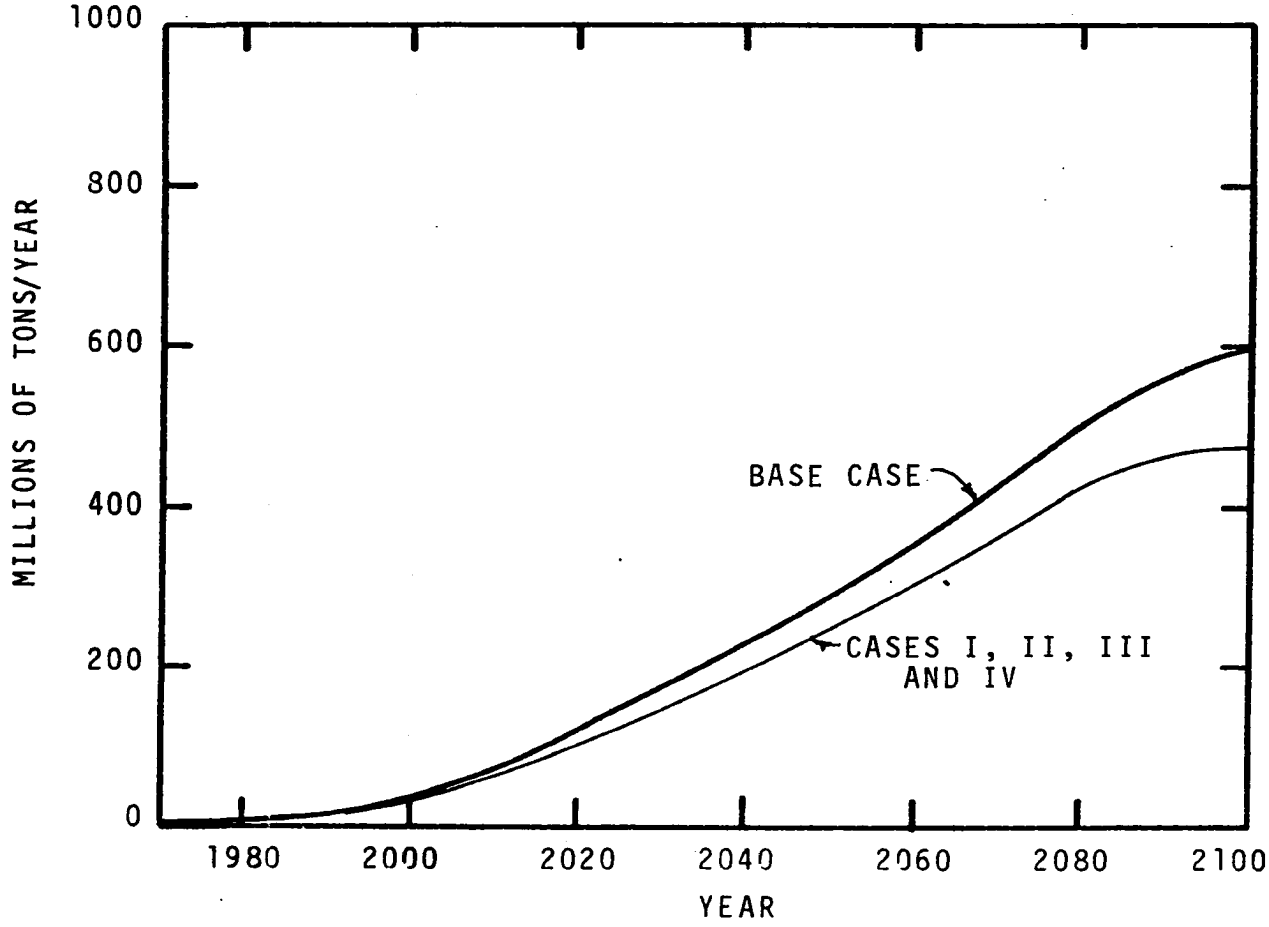


Figure IX-26. Annual Elemental Sulfur Production--
Transportation Alternatives.

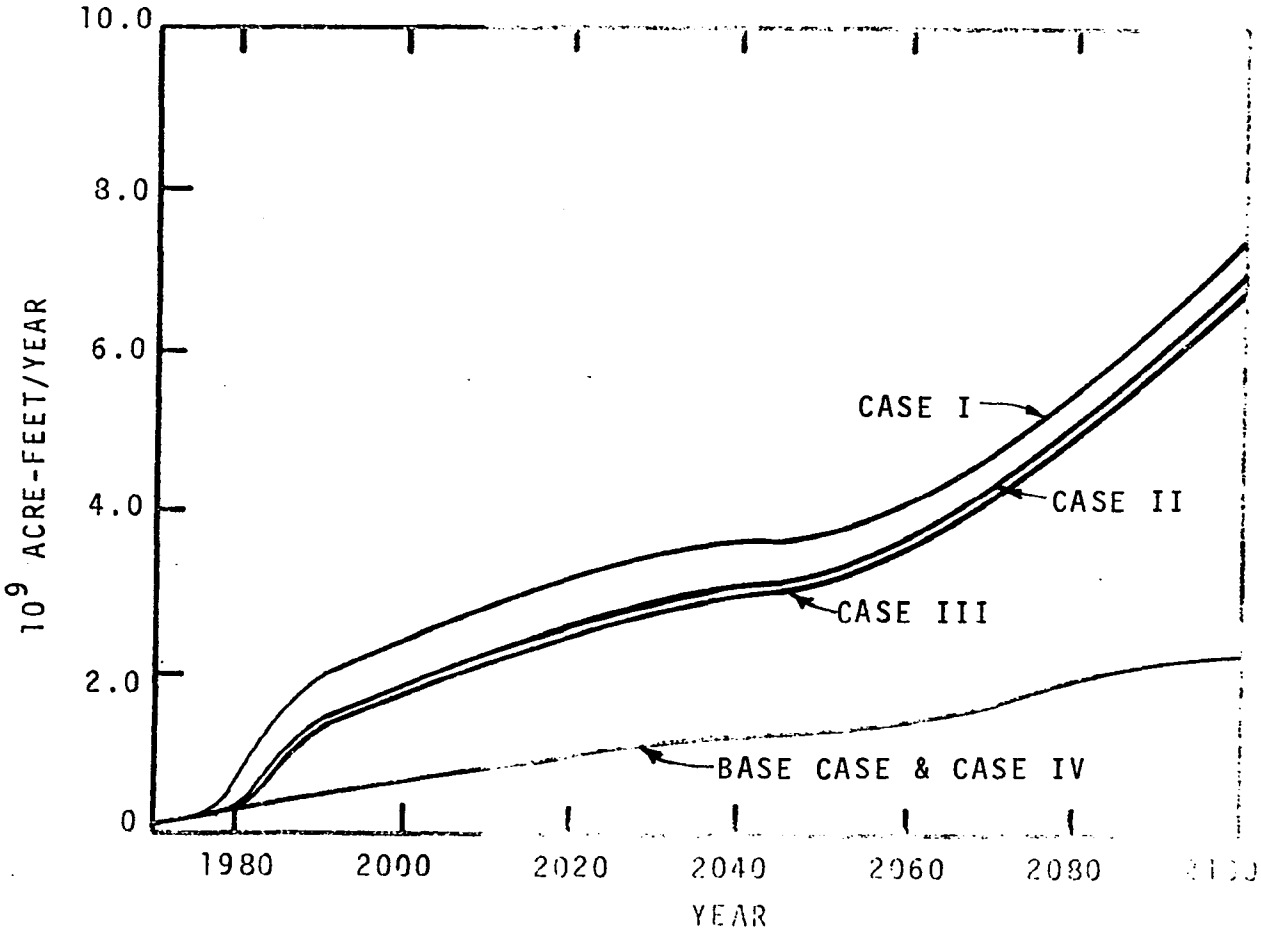


Figure IX-27. Annual Water Consumption--Transportation Alternatives.

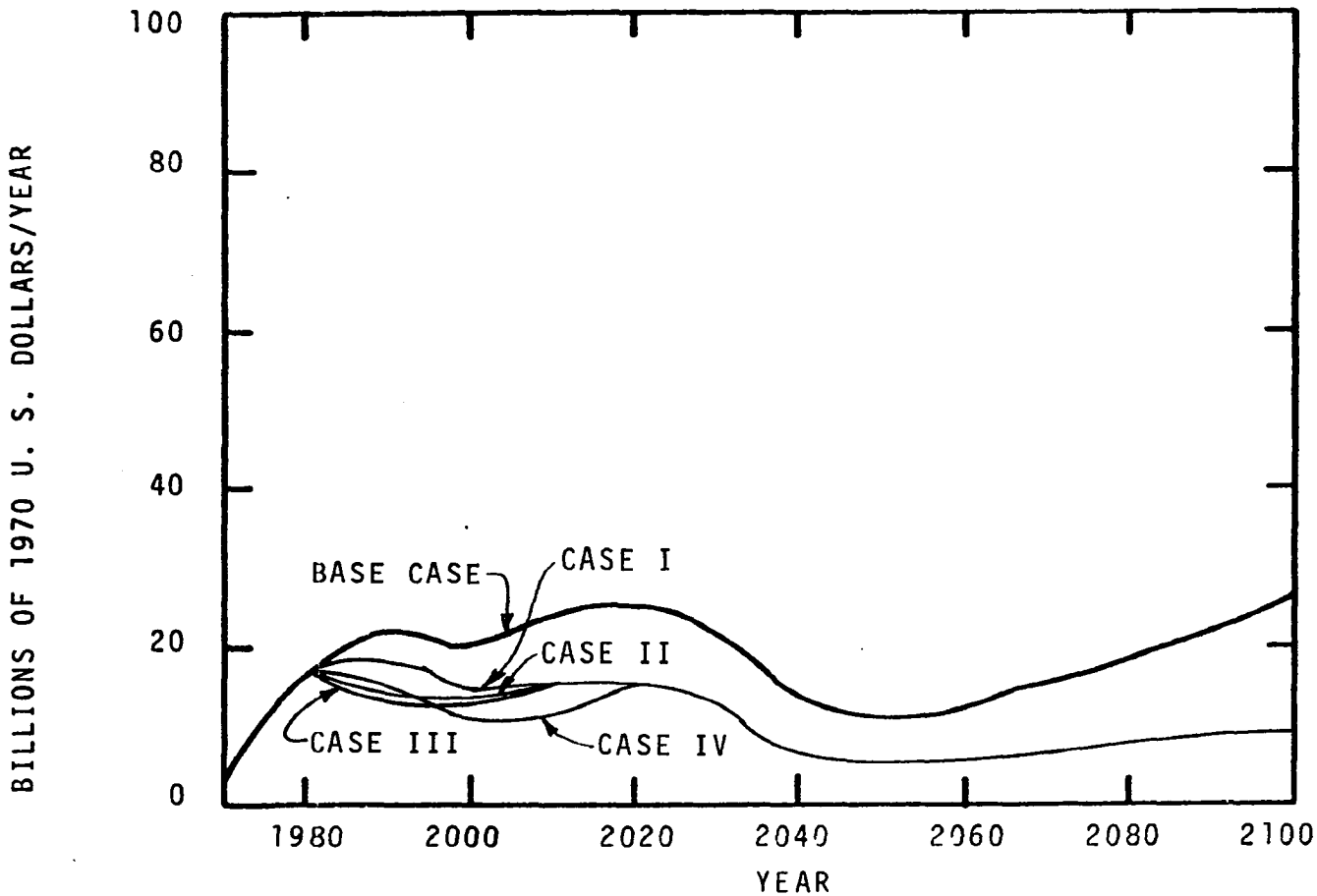


Figure IX-28. Annual Balance of Payments Deficit--Transportation Alternatives.

CHAPTER X

WATER RESOURCE ALTERNATIVE

The base case results indicate a tremendously large amount of water required for waste heat removal due to the large fraction of once-through waste heat removal systems, Figure IV-2.

Assumptions

The base case waste heat removal system fractions were changed to eliminate once-through cooling by 1980 using the cooling system split shown in Figure X-1.

Results

The total energy resource requirements, Figure X-2, are increased slightly due to the power penalty associated with alternate waste heat removal systems. However, the annual water consumption is decreased by approximately a factor of 30 due to water consumption by evaporation and spray drift losses only (Figure X-3).

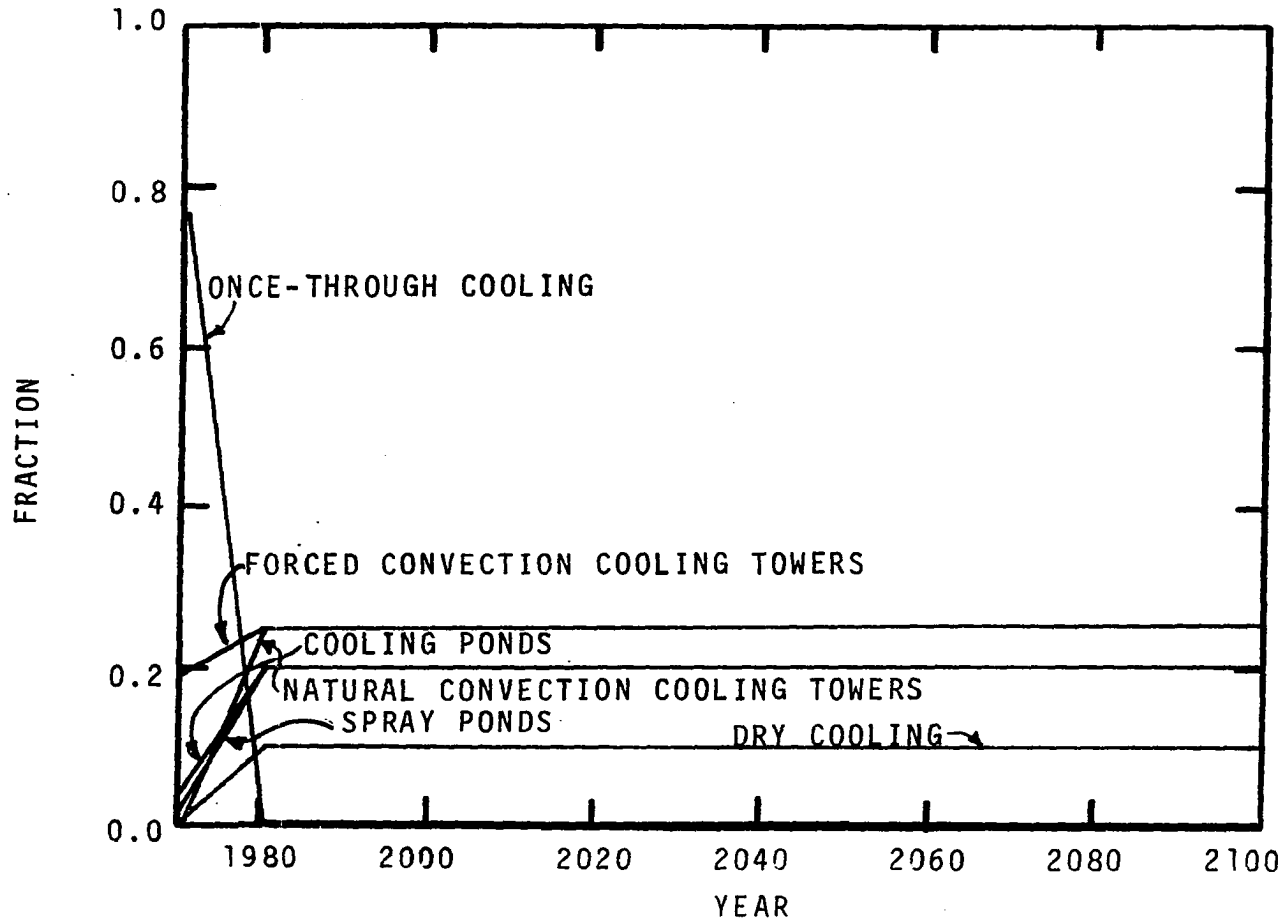


Figure X-1. Projected Electrical Generation Station Waste Heat Removal System Fraction--Water Resource Alternative.

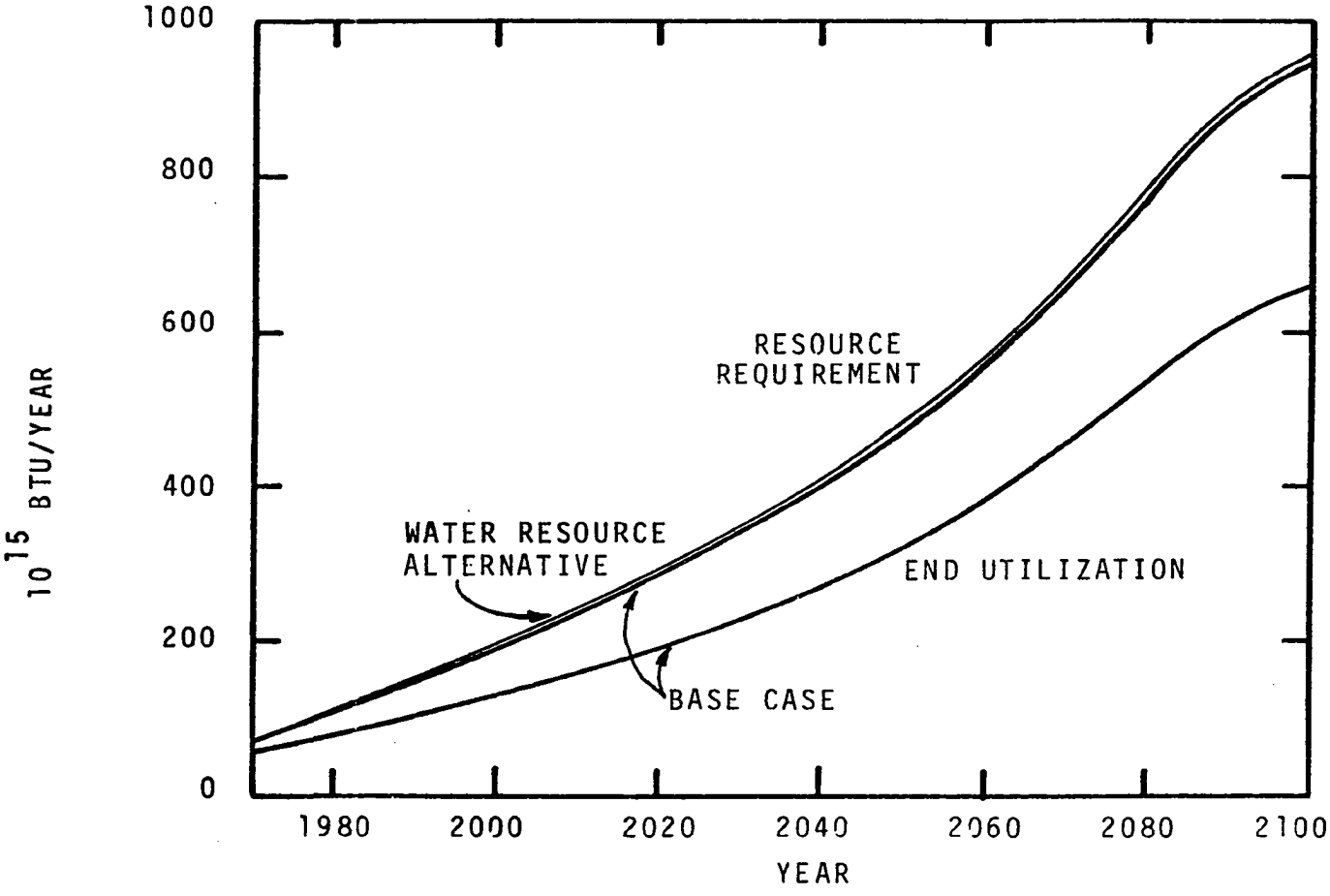


Figure X-2. Total Annual Energy Production and Net End Utilization--Water Resource Alternative.

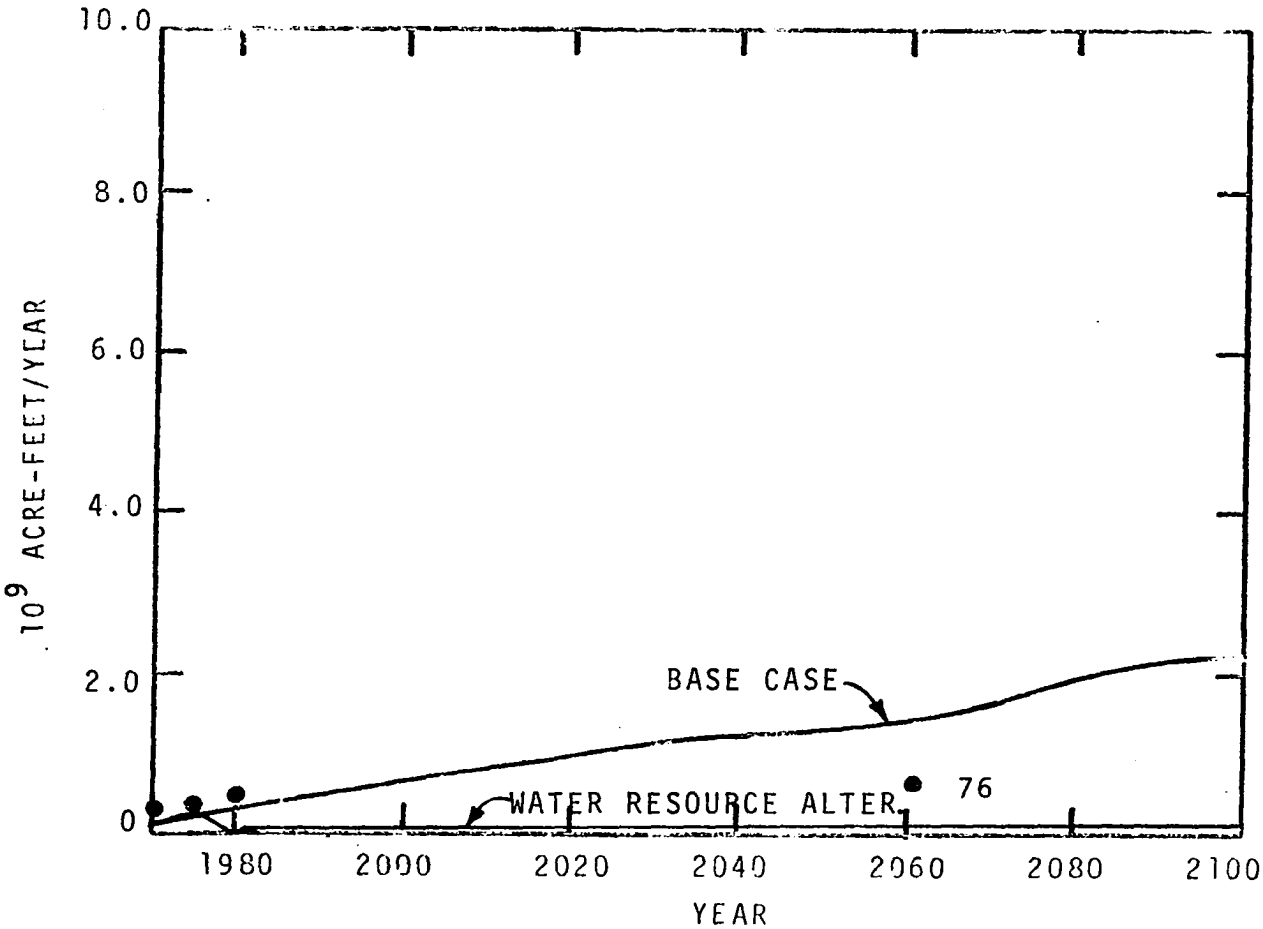


Figure X-3. Annual Water Consumption--Water Resource Alternative.

CHAPTER XI

SUMMARY OF RESEARCH AND RECOMMENDATIONS FOR FUTURE STUDY

A Fortran IV model of the United States energy system for IBM 360/370 computers has been developed. The model is designed for use as a management tool for assessing the consequences of resource and fuel alternatives, environmental controls, and technological advances. The assessment guidelines are presented as resource consumptions, environmental impacts, and balance of payment deficits to the year 2100.

The model's capabilities and its inherent flexibility have been demonstrated for a baseline case and several alternatives. The base case was based on current energy use patterns, diversified resource development, projected fuel splits, population and gross national product projections, and reasonable advances in technology. The alternatives included:

1. nuclear powered crude petroleum refineries, which use high-temperature gas-cooled reactors for process heat;
2. different natural gas substitutes including various combinations of liquefied natural gas imports, substitute natural gas from coal, petroleum syngas, and gas pipeline imports;

3. different crude petroleum substitutes including various combinations of crude oil imports, syncrude from coal, and tar sands and oil shale production;
4. the current trend in population growth rate to two children per family;
5. clean transportation fuels such as hydrogen, electricity, and methanol; and
6. water resource conservation by alternative systems for waste heat removal.

The model has sufficient flexibility to include the results of the many existing and future studies on energy supply and demand. It quantifies the impacts of energy policy decisions into acceptable indices. As such, it has the capability to provide energy management guidelines necessary for making decisions on research and development priorities, legislation, and regulations.

Analyses of the base case and of the various alternatives have reconfirmed that the United States is indeed faced with an "energy crisis." The United States annual energy demands are optimistically projected by the model to increase by a factor of 10 or more in the next century. It appears that the short term effects of the energy crisis cannot be alleviated by increasing petroleum and liquefied natural gas imports. Increasing imports will most likely lead to an economic balance of payments "crisis."

Synthesis of the base case and the alternatives indicates that liquefied natural gas and oil imports will have to be limited to 10 to 15 percent of the total oil and gas demands due to economic considerations. Alternate waste heat removal systems must be incorporated in electric generating stations to reduce water resource demands. The current Environmental Protection Agency emission standards will have to be made even more stringent. Geothermal energy, solar energy and other emerging energy or fuel technology must continue to be developed to their fullest potential.

The limited availability of domestic natural gas and crude petroleum reserves requires the development of the technology needed for coal gasification and liquefaction, oil shale and domestic tar sands production, and nuclear stimulation and tertiary recovery methods. The base case projections indicate that domestic reserves of coal tar sand and oil shale will be consumed through gasification and liquefaction shortly after 2100. These projections can be significantly altered by the reduction of projected population (i.e., continuation of the declining birth rate), by a national awareness to economize energy use, and through the use of mass transit systems. Since population has essentially an exponential effect on energy consumption, any changes in population have substantial effects on energy resources. Economy in energy use would result in smaller end utilization demands and therefore reduce resource demands. Mass transit systems

could significantly reduce the large transportation energy demands projected for the last two thirds of the next century.

Analysis of alternate transportation fuels indicated that electrolytic hydrogen will most likely be limited to commercial fleets and public transportation due to limited nuclear resources, capital requirements, and safety considerations. Methanol from coal, as a transportation fuel, does not appear to solve any major resource or environmental problems.

To surmount the projected energy supply deficits, the output of the Manergy model indicates all energy resources and energy utilization technology must be developed to their ultimate potential. The fast breeder reactors (both the liquid metal fast breeder reactor and the gas-cooled fast breeder reactor) must be developed as rapidly as technologically possible. The breeder reactors can help fill the energy supply-demand gap but their full implementation will be retarded by the supply of reactor grade plutonium fuel. A breeder reator's initial load of plutonium must come from existing light water reactors production and sister breeder reactors. The breeder reactor's doubling time for its plutonium inventory is on the order of 8 to 12 years depending on the reactor type and its fuel cycle. This doubling time will most likely impose limits on the rate of growth of the electrical generating capacity of fast breeder reactor power plants during the next 30 to 40 years.

Not only must fission nuclear power be developed to the fullest extent possible but technological advances must also be made to permit the early introduction of fusion power. Even though nuclear energy offers some answers to the energy crisis, it will be no panacea. Limited nuclear resources indicate the need for fusion reactors by 2020.

Nuclear reactors should be developed for process heat applications. The nuclear powered refinery, in which a high-temperature gas-cooled reactor (HTGR) was used as the process heat source, reduced petroleum demands and natural gas demands by 3.5 to 7 percent. Also, the HTGR exhibits definite promise as an energy source for coal gasification, tar sands production and upgrading, and oil shale conversion. Perhaps the most significant use of nuclear energy may be to provide process heat for tertiary recovery of natural gas and crude petroleum. Tertiary recovery methods and stimulation methods could increase recoverable reserves of oil and gas by 100 to 200 percent.

Since all methods of energy production and conversion require large amounts of water, water resource conservation is very important. The water requirements for waste heat removal and energy resource conversion, as projected in the base case, are probably unattainable. The shifting of waste heat removal systems to dry cooling and water recycle systems, as examined in the water resource case, can reduce the projected demands by a factor of 20 to 30. These lower

water consumption rates appear to be attainable. However, to reduce water consumption, a penalty must be paid in the form of 1.5 to 3 percent higher annual energy resource consumption.

The most dramatic effects on energy resources and the environment are caused by population growth and gross national product changes. The current birth rate trend to 2 children per family dramatically reduces energy consumption and environmental impacts, but only after 2020. Near term reductions can only occur through directed research and development, meaningful legislation and realistic regulations on energy resources and environmental controls. The Manergy model, developed for this purpose, provides acceptable indices of the impact of such decisions so that the best energy management can be effected.

In keeping with its role as a useful management tool the Manergy model should be further refined to include:

1. A method for quantifying the environmental effects in the form of a cost penalty against the end use fuel. The cost penalty should correspond to the decrease in thermodynamic availability (where applicable) or to the clean-up costs.
2. Anticipated capital cost requirements.
3. A comparative cost-benefit analysis based on the cost of energy and gross capital requirements for production, transportation, conversion, storage, and distribution of energy.

4. An environmental-benefit assessment.
5. An optimal fuel-mix analysis based on the cost-benefit and environmental-benefit analyses.
6. Improvements in projecting transportation energy requirements.
7. Improvements in the projection of electrical generation station types and generation fractions.
8. Projected resource production should be incorporated in the model for world petroleum reserves, world natural gas supplies, and United States coal production.

APPENDICES

APPENDIX A

PROJECTION OF END UTILIZATION ENERGY REQUIREMENTS

Residential Projection

The residential end utilization energy requirements, Figure III-1, are projected using the number of households in the United States projection, Figure III-4. The residential energy demand is generated from six different use categories: space heating, air conditioning, water heating, cooking, refrigeration, and miscellaneous usage.

Space Heating

The residential space heating use is projected using the projected number of households, Figure III-4; the residential unit energy requirements for space heating, Table A-1; the projected residential space heating fuel fraction, Figure A-1; and the projected residential space heating efficiency, Figure A-2. The residential space heating use for fuel J in year I is given by

$$RSHD(J) = RSSH(I) \times HHLD(I) \times UDRSH(J) \times RSHHF \times \frac{RSHEF(1970,J)}{RSHEF(I,J)} \qquad (A\text{-}1)$$

where

RSHD(J) = U.S. residential space heating demand for fuel J

TABLE A-1

1970 RESIDENTIAL UNIT ENERGY DEMANDS (13, 44, 62)

Demand Type	Fuel Type	Energy Requirement **
Room air conditioning	electric	4.74
Central air conditioning	electric	18.2
Central air conditioning	gas	110.0
Cooking	electric	4.01
Cooking	gas	12.2
Refrigeration	electric	3.88
Refrigeration	gas	14.
Space heat	electric	46.8
Space heat	gas	100.8
Space heat	distillate oil	124.1
Space heat	residual oil	128.4
Water heat	electric	15.41
Water heat	gas	26.2
Miscellaneous	electric	8.0*

*502.7 trillion Btu/year total in 1970

**Units: million Btu/unit-household-year.

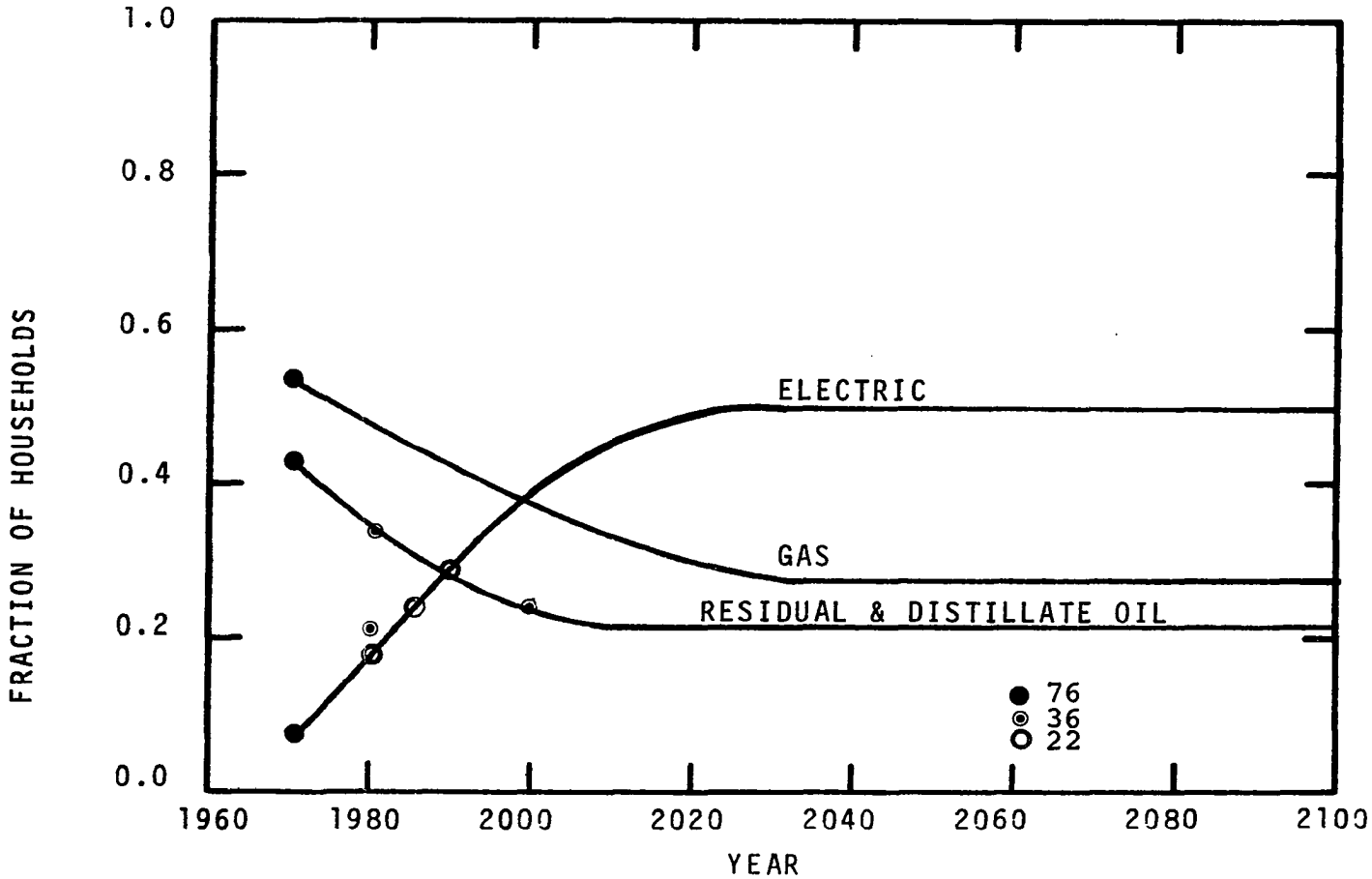


Figure A-1. Residential Space Heating Fuel Fraction Projection.

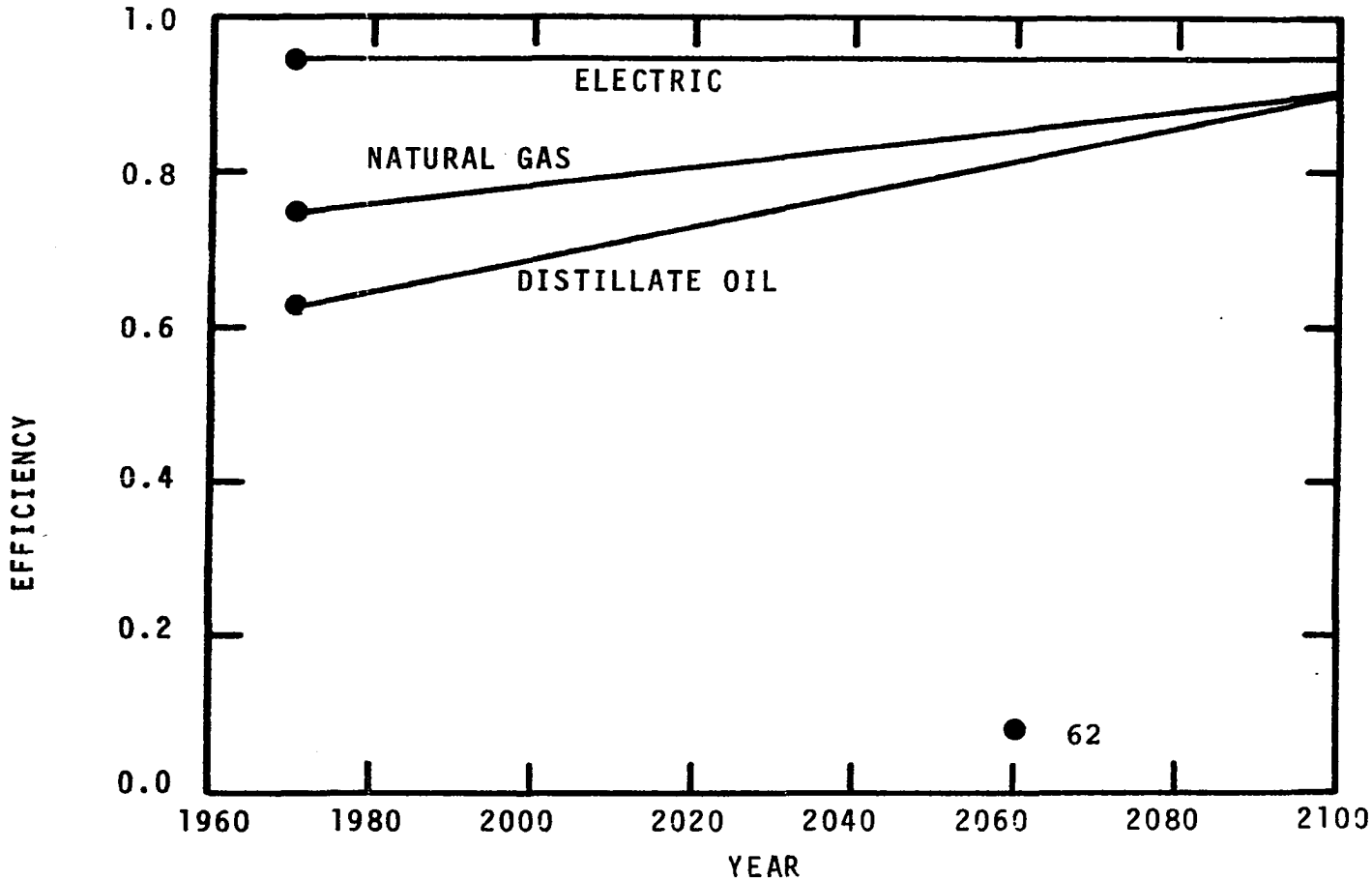


Figure A-2. Residential Space Heating Efficiency Projection.

RSSH(I) = fraction of households with space heating in year I (assume RSSH(I) = 1. for all I)

HHLD(I) = number of households in year I

UDRSH(J) = unit demand of residential space heating for fuel J

RSHHF(I,J) = fraction of households with space heat supplied by fuel J in year I

RSHEF(I,J) = efficiency of residential space heating for fuel J in year I

The total residential space heating demand for all fuels is determined by summing the residential space heating demand for fuel J from Equation A-1 over all fuel types.

$$RSHDT = \sum_{J=1}^{21} RSHD(J) \qquad (A-2)$$

where

RSHDT = total U.S. residential space heating demand in trillion Btu/year

Air Conditioning

The residential air conditioning energy demand is projected by using the projected number of households, Figure III-4; the projected fraction of households with central and room air conditioning, Figure A-3; the residential unit energy requirements for room and central air conditioning, Table A-1; the projected residential air conditioning fuel fraction, Figure A-4; and the projected coefficient of performance for residential air conditioners, Figure A-5. The residential air conditioning energy requirements for fuel J in year I is given by

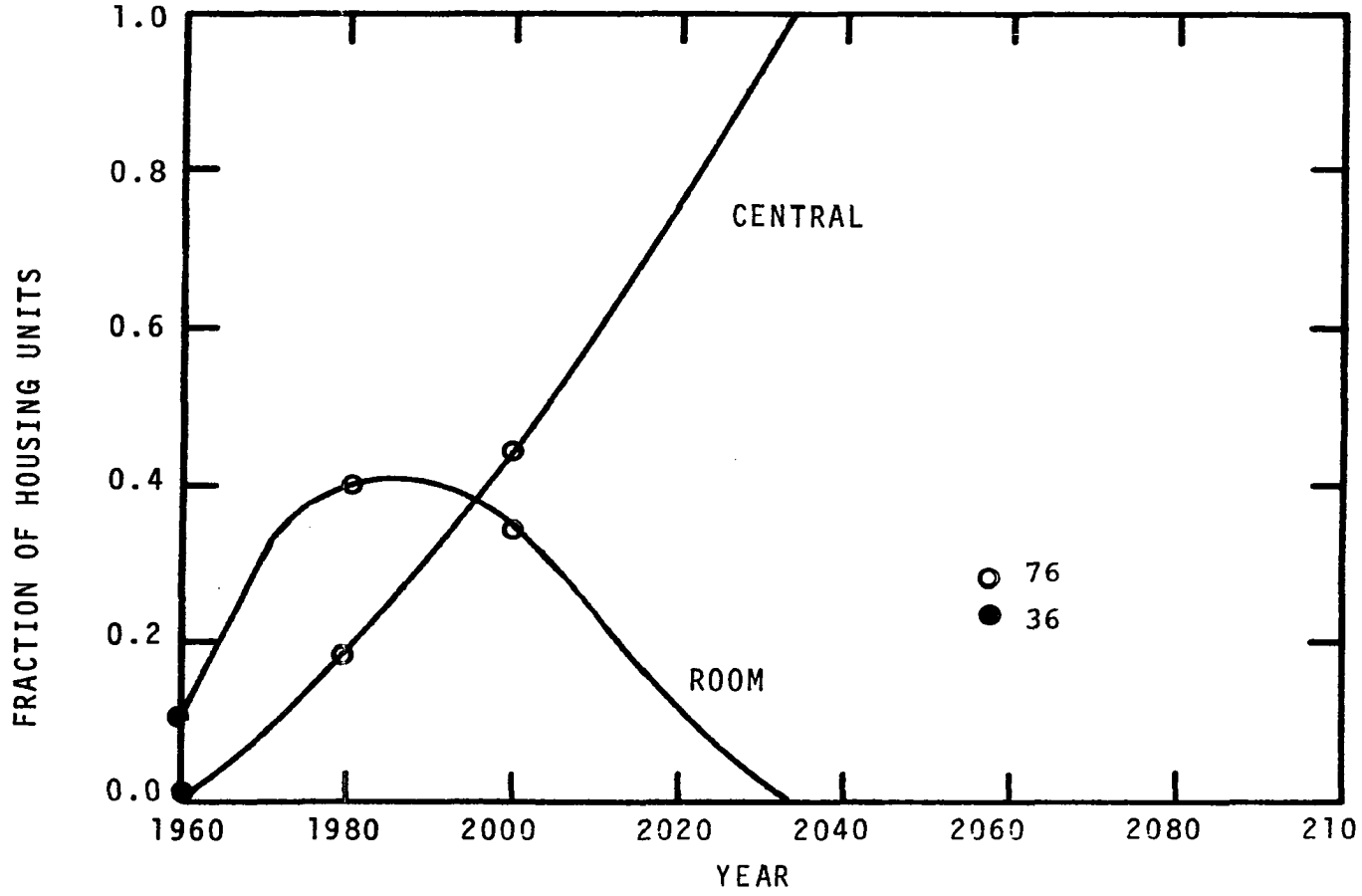


Figure A-3. Projected Fraction of Households with Air Conditioning.

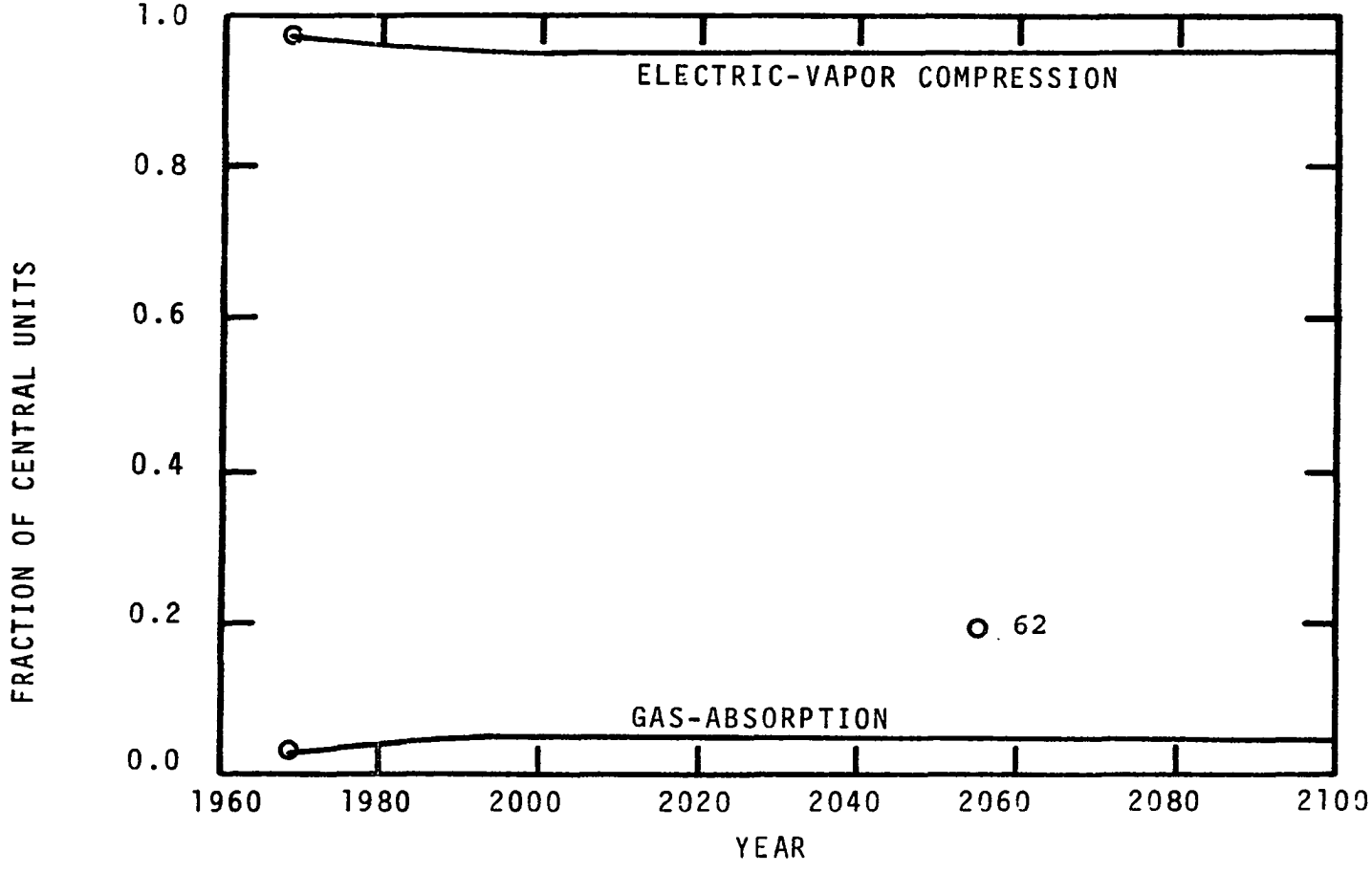


Figure A-4. Projected Residential Air Conditioning Fuel Fraction.

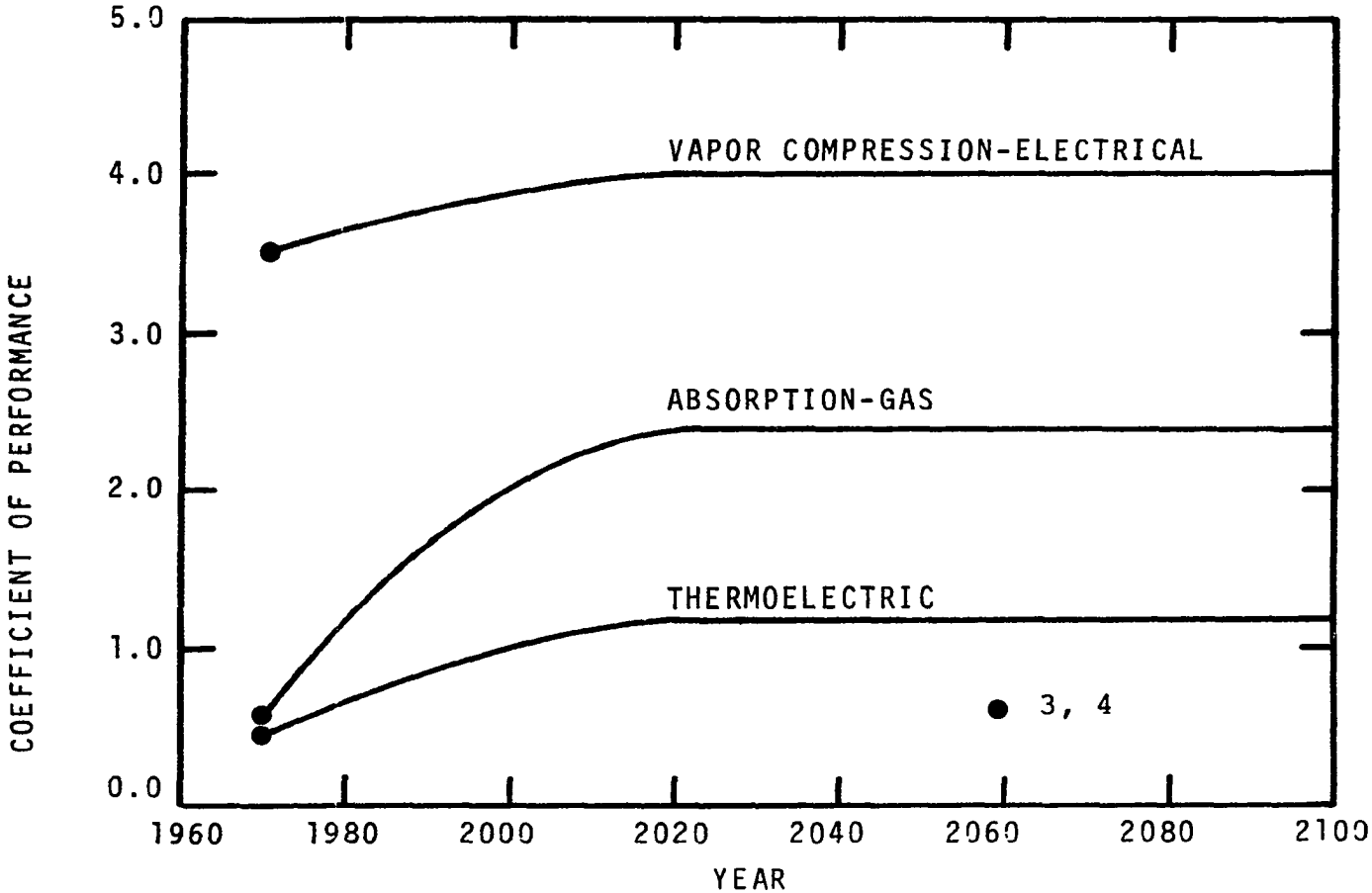


Figure A-5. Projected Residential Air Conditioning Coefficient of Performance.

$$RACD(J) = [RSRAC(I) \times HHLD(J) \times UDRRAC(J) \times RRACHF(I,J) \times \frac{RRACEF(1970,J)}{RRACEF(I,J)}] + [RSCAC(I) \times HHLD(I) \times UDRCAC(J) \times RCACHF(I,J) \times \frac{RCACEF(1970,J)}{RCACEF(I,J)}] \quad (A-3)$$

where

RACD(J) = U.S. residential air conditioning demand for fuel J

RSRAC(I) = fraction of households with room air conditioners in year I

HHLD(I) = millions of U.S. households in year I

UDRRAC(J) = unit demand of residential room air conditioning for fuel J

RRACHF(I,J) = fraction of residential room air conditioners using fuel J in year I

RRACEF(I,J) = residential room air conditioners coefficient of performance for fuel J in year I

RSCAC(I) = fraction of households with central air conditioning in year I

UDRCAC(J) = fraction of residential central air conditioners using fuel J in year I

RCACEF(I,J) = residential central air conditioning coefficient of performance for fuel J in year I

The total residential air conditioning demand for all fuels is determined by summing the residential air conditioning demand for fuel J from Equation A-3 over all fuel types.

$$RACDT = \sum_{J=1}^{21} RACD(J) \quad (A-4)$$

where

RACDT = the total U.S. residential air conditioning demand in trillion Btu/year

Water Heating

The residential water heating use is projected using the projected number of households, Figure III-4; the residential unit energy requirements for water heating, Table A-1; the projected fraction of households with water heating using fuel J, Figure A-6; and the projected residential water heating efficiency, Figure A-7. The residential water use for fuel J in year I is given by

$$RWHD(J) = RSWH(I) \times HHLD(I) \times UDRWH(J) \times RWHHF(I,J) \times \frac{RWHEF(1970,J)}{RWHEF(I,J)} \quad \text{(A-5)}$$

where

RWHD(J) = residential water heating demand for fuel J

RSWH(I) = fraction of households with water heaters in year I

HHLD(I) = number of households in year I

UDRWH(J) = unit demand of residential water heating for fuel J

RWHHF(I,J) = fraction of households with water heating supplied by fuel J in year I

RWHEF(I,J) = efficiency of residential water heating for fuel J in year I

The total residential water heating demand for all fuels is determined by summing the residential water heating demand for fuel J from Equation A-5 over all fuels.

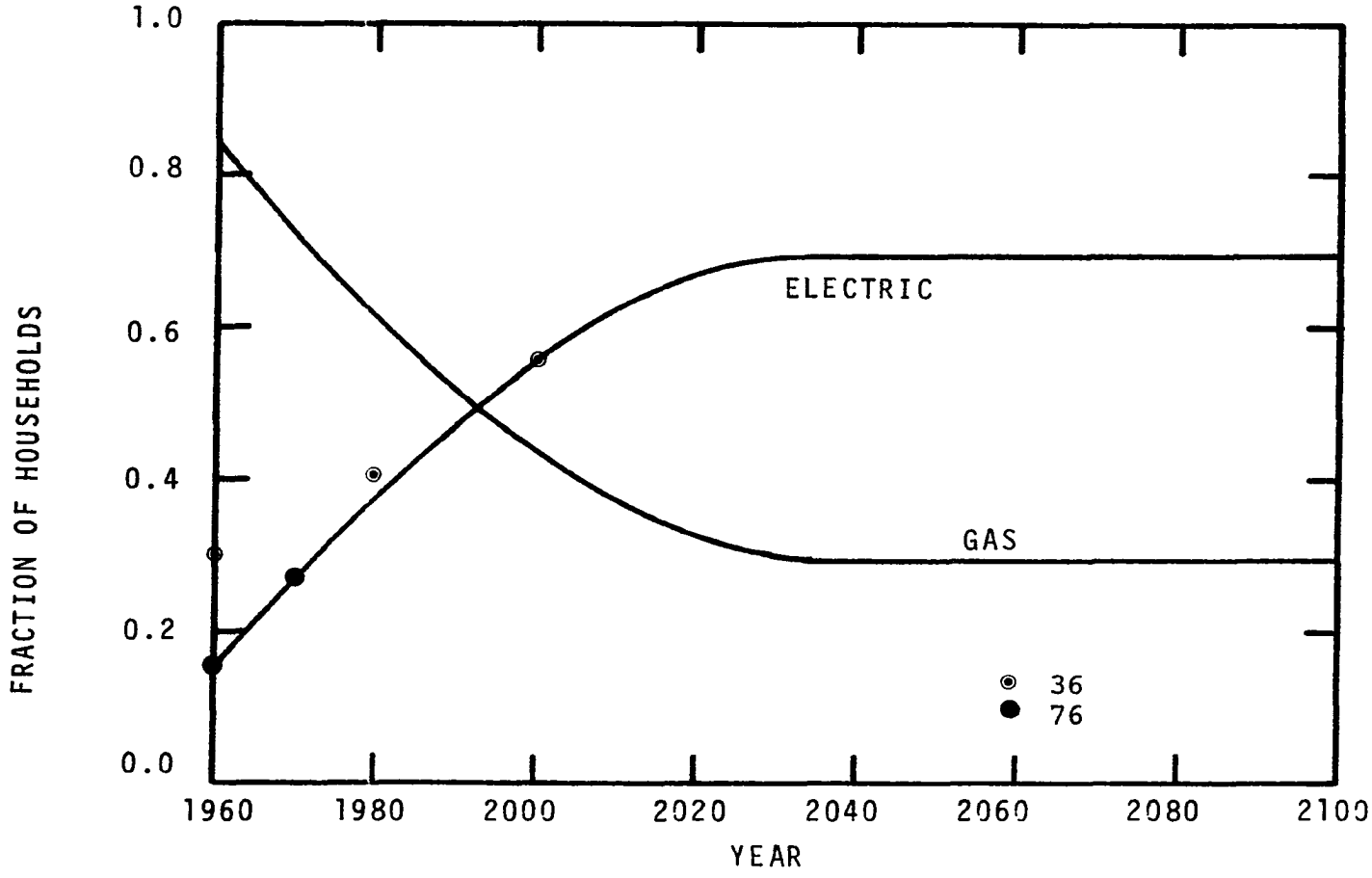


Figure A-6. Residential Water Heating Fraction Projection.

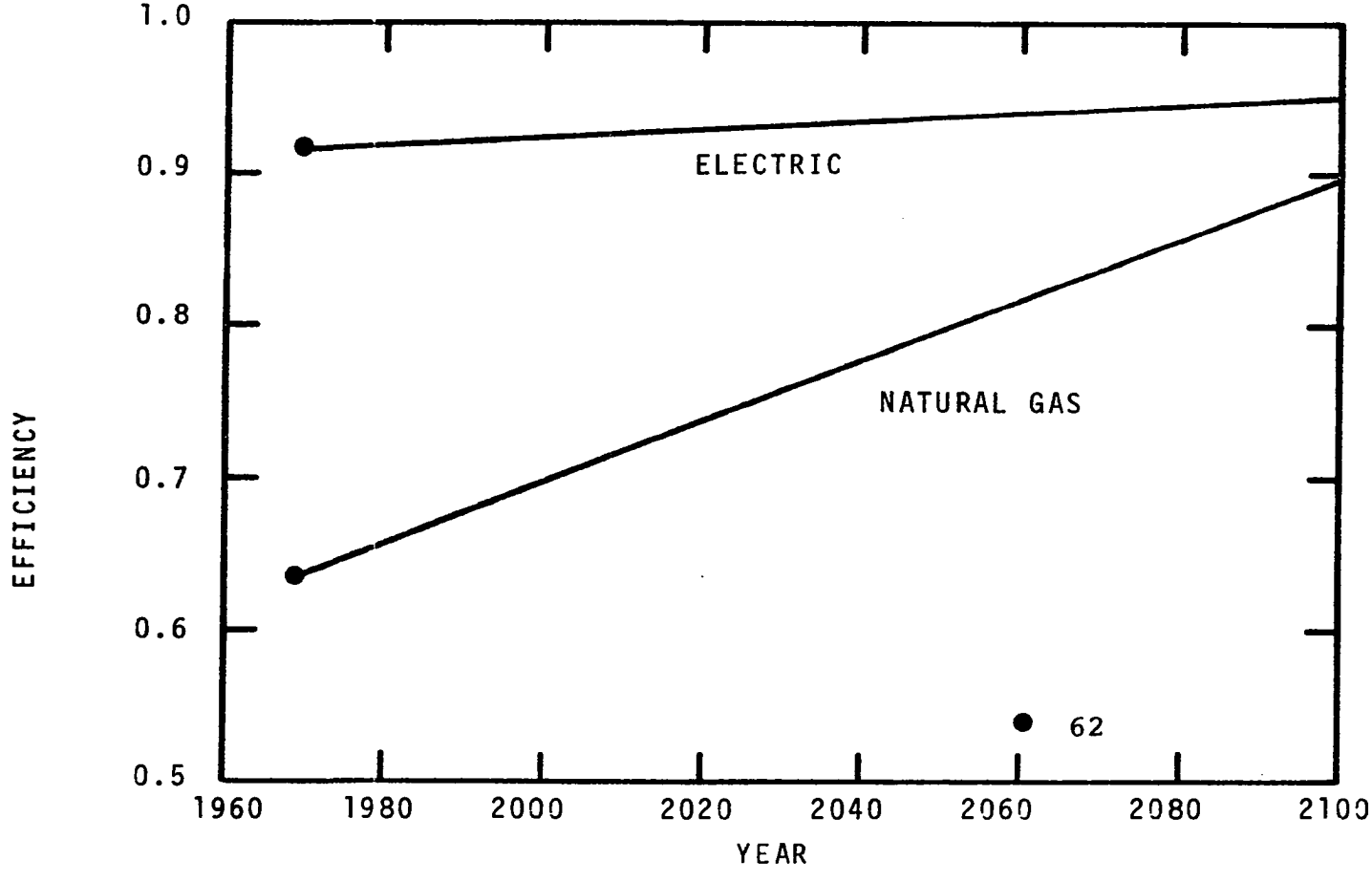


Figure A-7. Residential Water Heating Efficiency Projection.

$$RWHDT = \sum_{J=1}^{21} RWHD(J) \qquad (A\text{-}6)$$

where

RWHDT = the total residential water heating energy demand in trillion Btu/year

Cooking

The residential cooking use is projected using the projected number of households, Figure III-4; the projected fraction of households with ranges, Figure A-8; the residential unit energy requirements for cooking, Table A-1; the projected residential fraction of households with ranges using fuel J, Figure A-9; and the projected residential cooking efficiency, Figure A-10. The residential cooking use for fuel J in year I is given by

$$RCD(J) = RSC(I) \times HHLD(I) \times UDRC(J) \times RCHF(I,J) \times \frac{RCEF(1970,J)}{RCEF(I,J)} \qquad (A\text{-}7)$$

where

RCD(J) = U.S. residential cooking demand for fuel J

RSC(I) = fraction of households with ranges in year I

HHLD(I) = number of households in year I

UDRC(J) = unit demand of residential cooking for fuel J

RCHF(I,J) = fraction of households with ranges supplied by fuel J in year I

RCEF(I,J) = efficiency of residential cooking for fuel J in year I

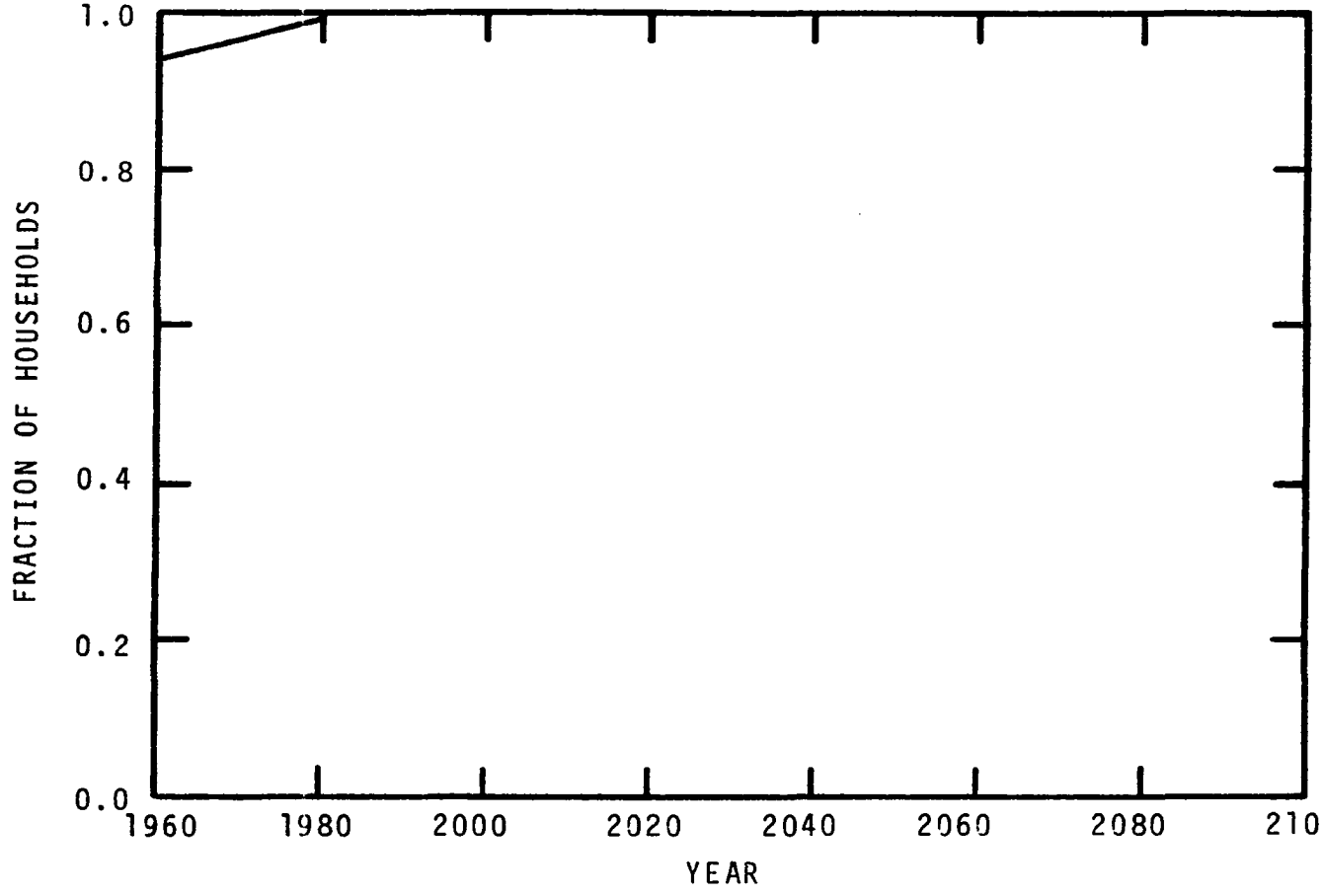


Figure A-8. Fraction of Households with Ranges Projection.

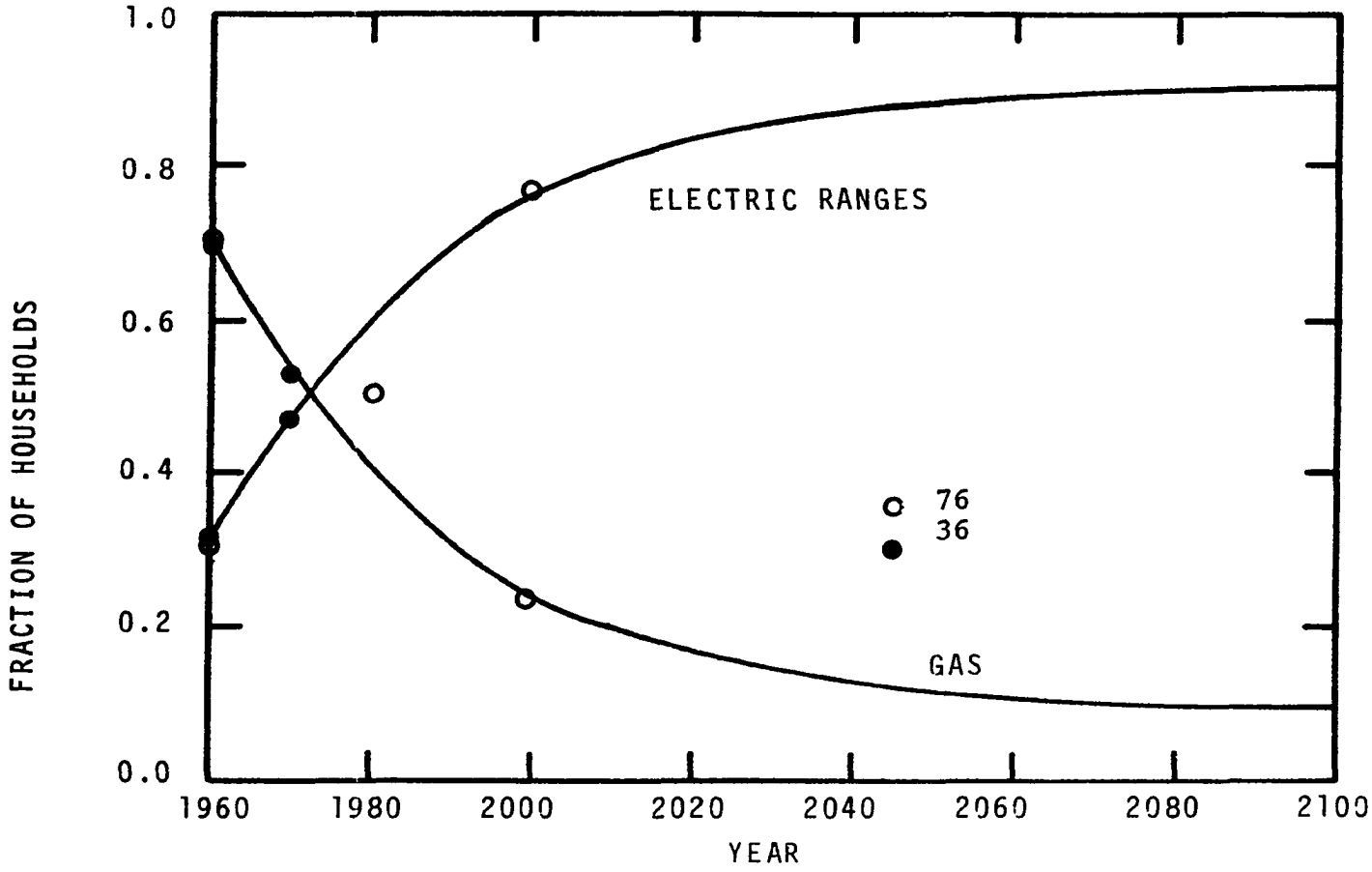


Figure A-9. Fraction of Households with Electric and Gas Ranges Projection.

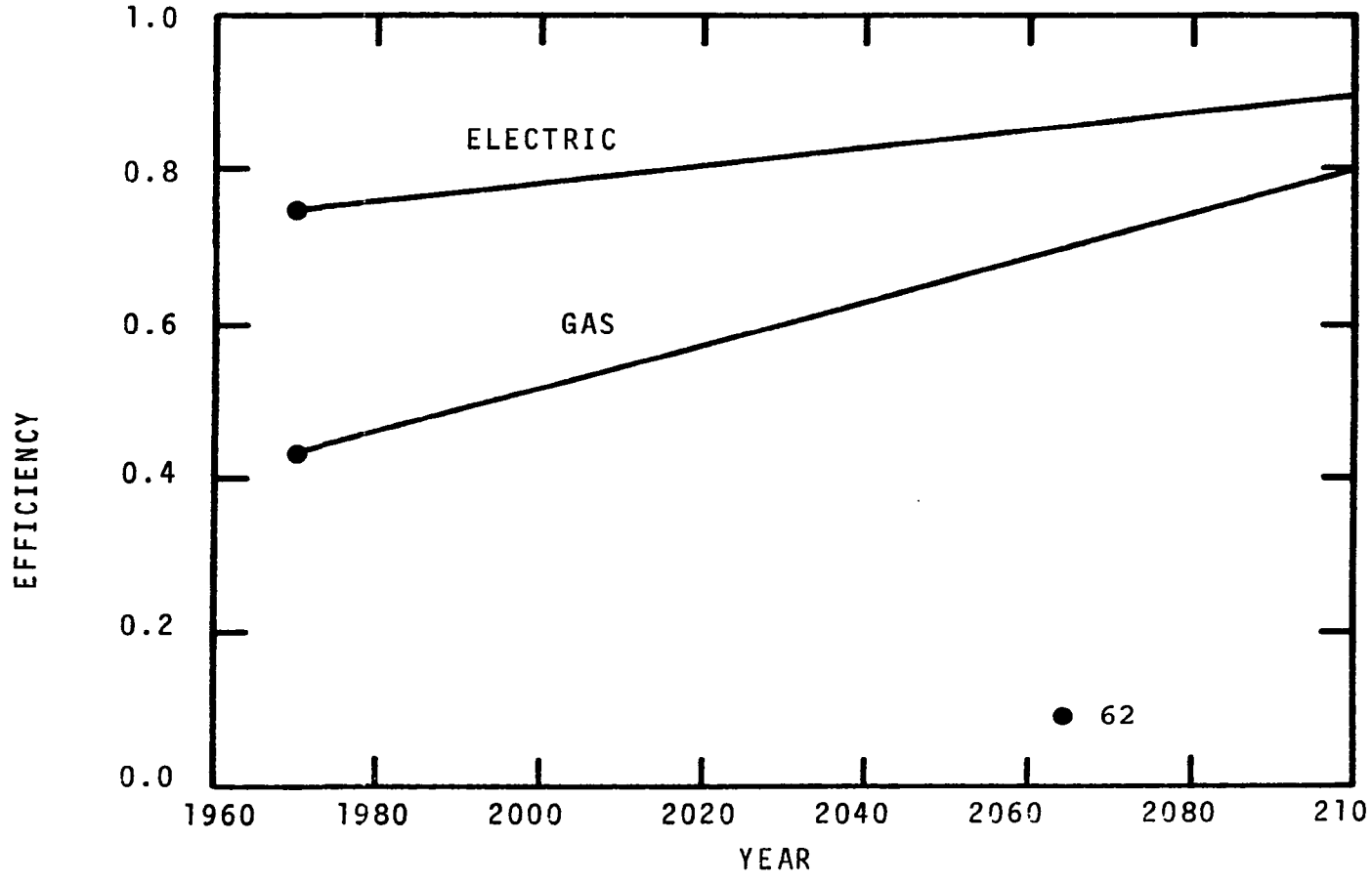


Figure A-10. Residential Cooking Efficiency Projection.

The total residential cooking demand for all fuels is determined by summing the residential cooking demand for fuel J from Equation A-7 over all fuels.

$$RCDT = \sum_{J=1}^{21} RCD(J) \qquad \text{(A-8)}$$

where

RCDT = total U.S. residential cooking demand in trillion Btu/year

Refrigeration

The residential refrigeration use is projected using the projected number of households, Figure III-4; the residential unit energy requirements for refrigeration, Table A-1; the projected residential households with refrigerators, Figure A-11; the projected residential refrigeration fuel fraction; and the projected residential refrigeration efficiency, Figure A-12. The residential refrigeration use for fuel J in year I is given by

$$RRD(J) = RSR(I) \times HHLD(I) \times UDRR(J) \times RRHF(I,J) \times \frac{RREF(1970,J)}{RREF(I,J)} \qquad \text{(A-9)}$$

where

RRD(J) = U.S. residential refrigeration demand for fuel J

RSR(I) = fraction of households with refrigerators in year I

HHLD(I) = number of households in year I

UDRR(J) = unit demand of residential refrigeration for fuel J

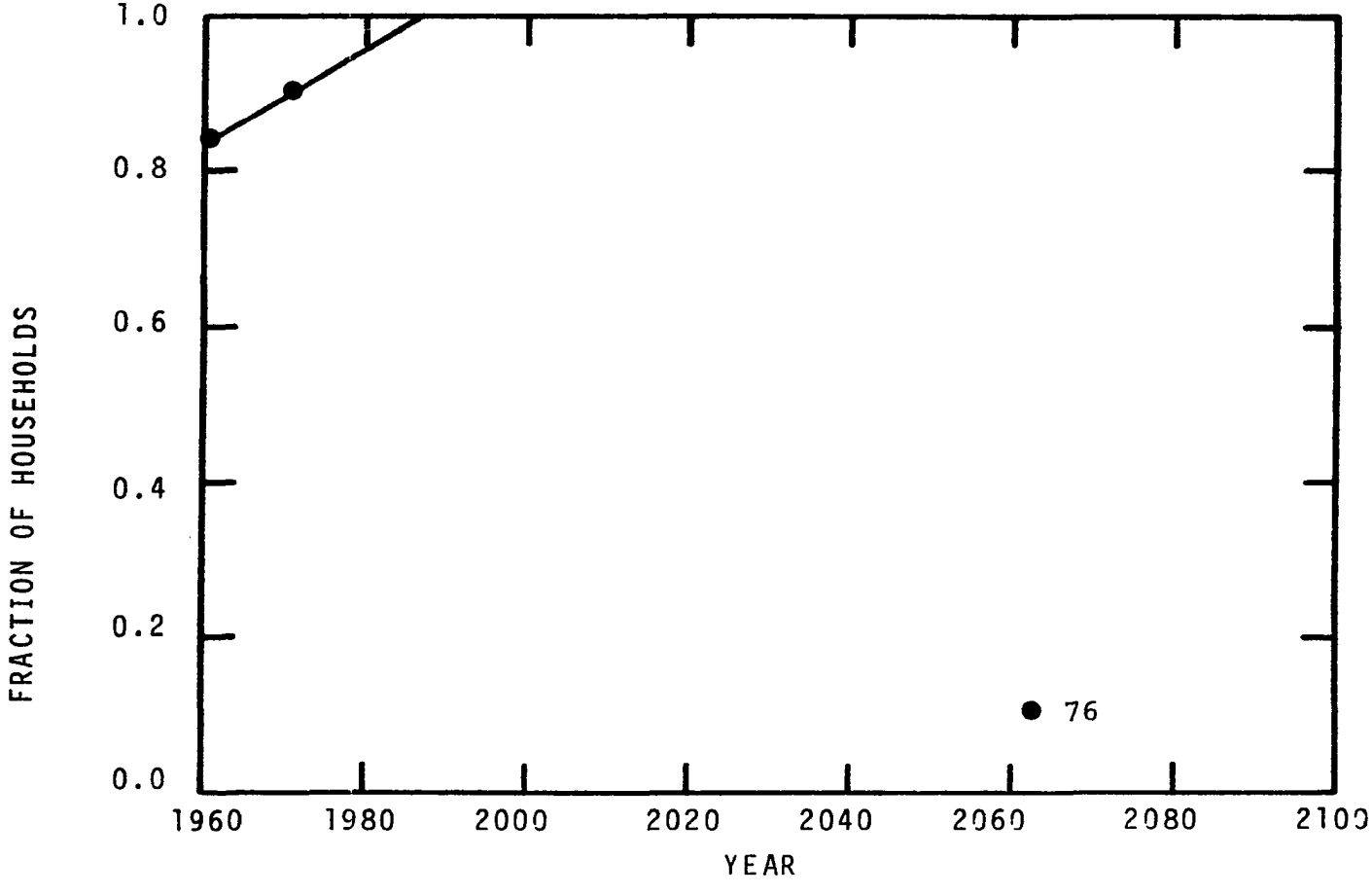


Figure A-11. Fraction of Households with Refrigerators Projection.

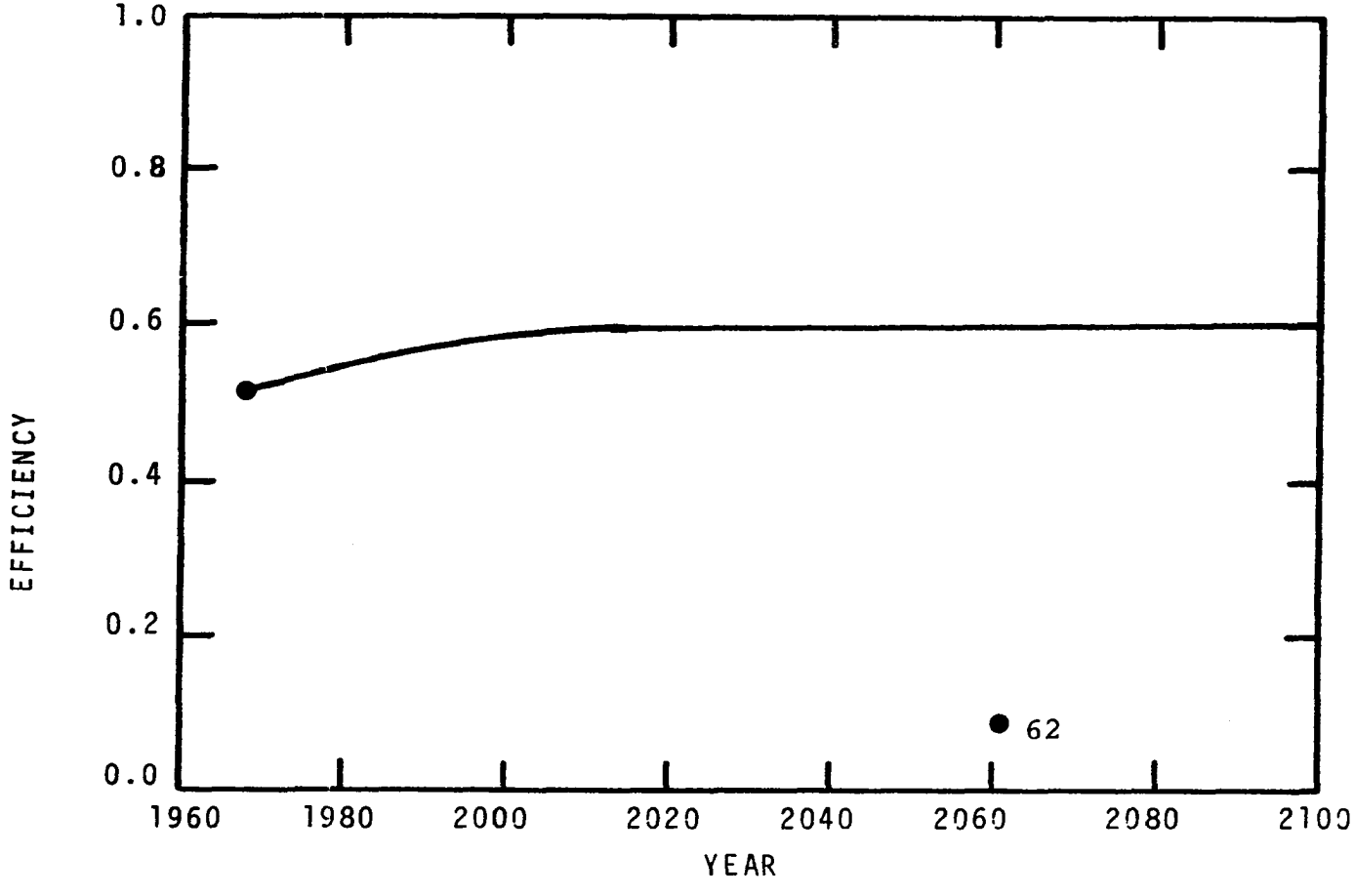


Figure A-12. Residential Refrigeration Efficiency Projection.

RRHF(I,J) = fraction of households with refrigeration supplied by fuel J in year I (assumed to be electricity only)

RREF(I,J) = efficiency of residential refrigeration for fuel J in year I

The total residential refrigeration demand for all fuels is determined by summing the residential refrigeration demand for fuel J from Equation A-9 over all fuels.

$$RRDT = \sum_{J=1}^{21} RRD(J) \qquad \text{(A-10)}$$

where

RRDT = total U.S. residential refrigeration demand in trillion Btu/year

Miscellaneous

The miscellaneous residential use includes such demands as lighting, clothes drying, electric appliances, etc. The residential miscellaneous use is projected using the projected number of households, Figure III-4; the 1970 residential miscellaneous demands for each fuel not accounted for in space heating, air conditioning, water heating, cooking and refrigeration uses, Table A-1. The miscellaneous use for fuel J in year I is given by

$$RMD(J) = \frac{HHLD(I)}{HHDL(1970)} \times DRM70(J) \qquad \text{(A-11)}$$

where

RMD(J) = miscellaneous residential demand for fuel J in year I

HHLD(I) = number of households in the year I

DRM70(J) = miscellaneous residential demands in 1970 for fuel J

The total residential miscellaneous demand for all fuels is determined by summing the residential miscellaneous demand for fuel J from Equation A-11 over all fuels.

$$RMDT = \sum_{J=1}^{21} RMD(J) \qquad \text{(A-12)}$$

where

RMDT = total U.S. residential miscellaneous energy demand in trillion Btu/year

The total residential energy demand for fuel J is determined by

$$TRD(J) = RSHD(J) + RACD(J) + RWHD(J) + RCD(J) + RRD(J) + RMD(J) \qquad \text{(A-13)}$$

where

TRD(J) = total U.S. residential demand for fuel J

RSHD(J) = residential space heating demand for fuel J (Equation A-1)

RACD(J) = residential air conditioning demand for fuel J (Equation A-3)

RWHD(J) = residential water heating demand for fuel J (Equation A-5)

RCD(J) = residential cooking demand for fuel J (Equation A-7)

RRD(J) = residential refrigeration demand for fuel J (Equation A-9)

RMD(J) = residential miscellaneous demand for fuel J (Equation A-11)

The total residential energy demand is

$$TDRT = \sum_{J=1}^{21} TRD(J) \qquad \text{(A-14)}$$

where

TRDT = total U.S. residential demand for all fuels in trillion Btu/year

Commercial Projection

The commercial end utilization energy requirements, Figure III-1, are projected using the projected gross national product, Figure III-6. The commercial energy demand is generated from six different use categories: space heating, air conditioning, water heating, cooling, refrigeration, and miscellaneous usage.

Space Heating

The commercial space heating use is projected using the projected gross national product, Figure III-6; the commercial 1970 space heating energy requirements, Table A-2; the projected commercial space heating fuel fraction, Figure A-13; and the projected commercial space heating efficiency, Figure A-14. The commercial space heating use for fuel J in year I is given by

$$CSHD(J) = CSHB \times GNPR70(I) \times CSHDF(I,J) \times \frac{CSHEF(1970,J)}{CSHEF(I,J)} \qquad \text{(A-15)}$$

where

CSHD(J) = U.S. commercial space heating demand for fuel J

TABLE A-2

1970 COMMERCIAL ENERGY DEMANDS (62)

Demand Type	1970 Energy Consumption trillion Btu/year
Air conditioning	247.5*
Space heating	3539.5
Water heating	403.2*
Cooking	86.16
Refrigeration	260.9
Miscellaneous	1479.7

*The air conditioning and water heating energy consumptions are net consumptions which do not include the efficiency of utilization for each fuel type.

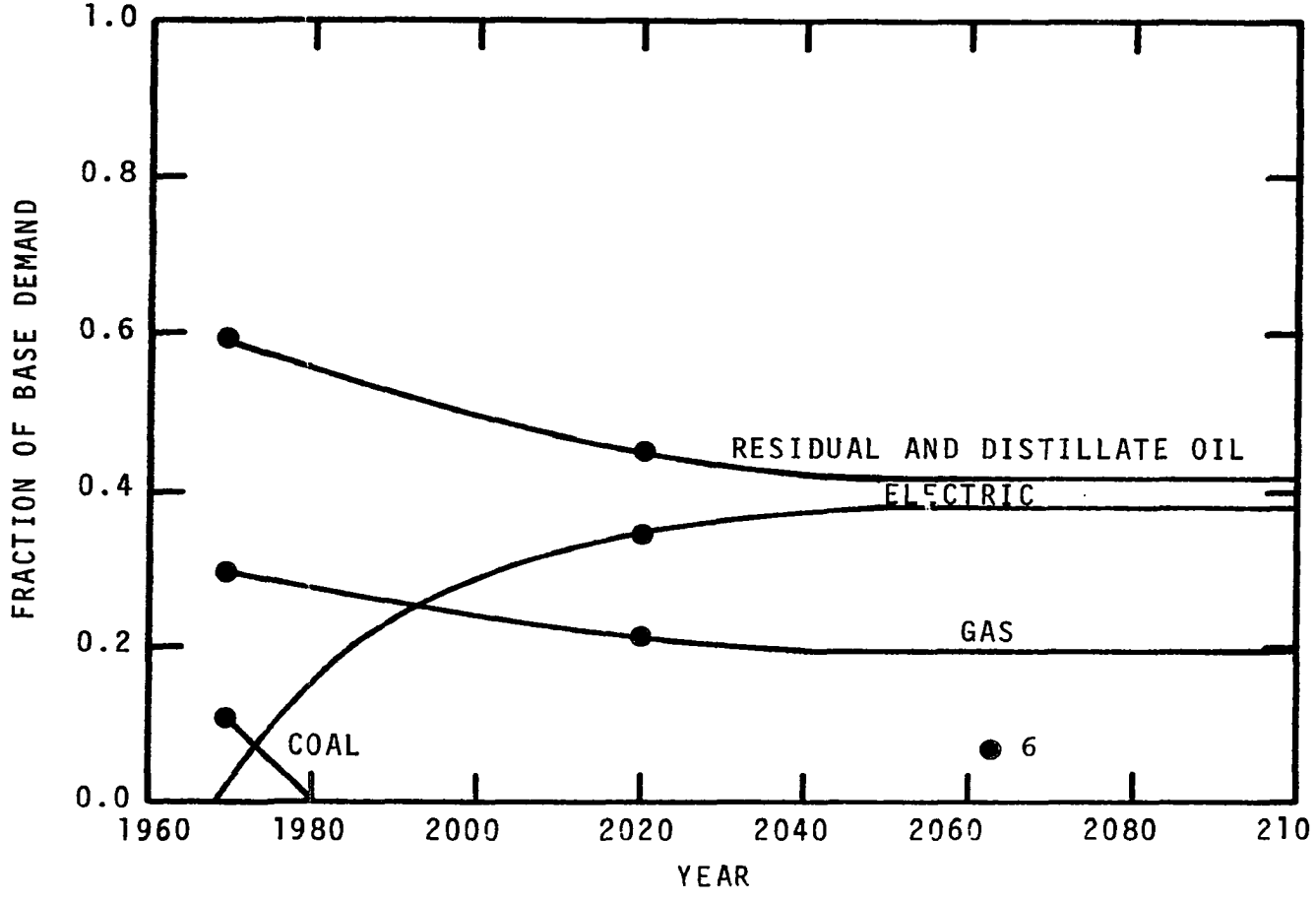


Figure A-13. Commercial Space Heat Fuel Fractions Projection.

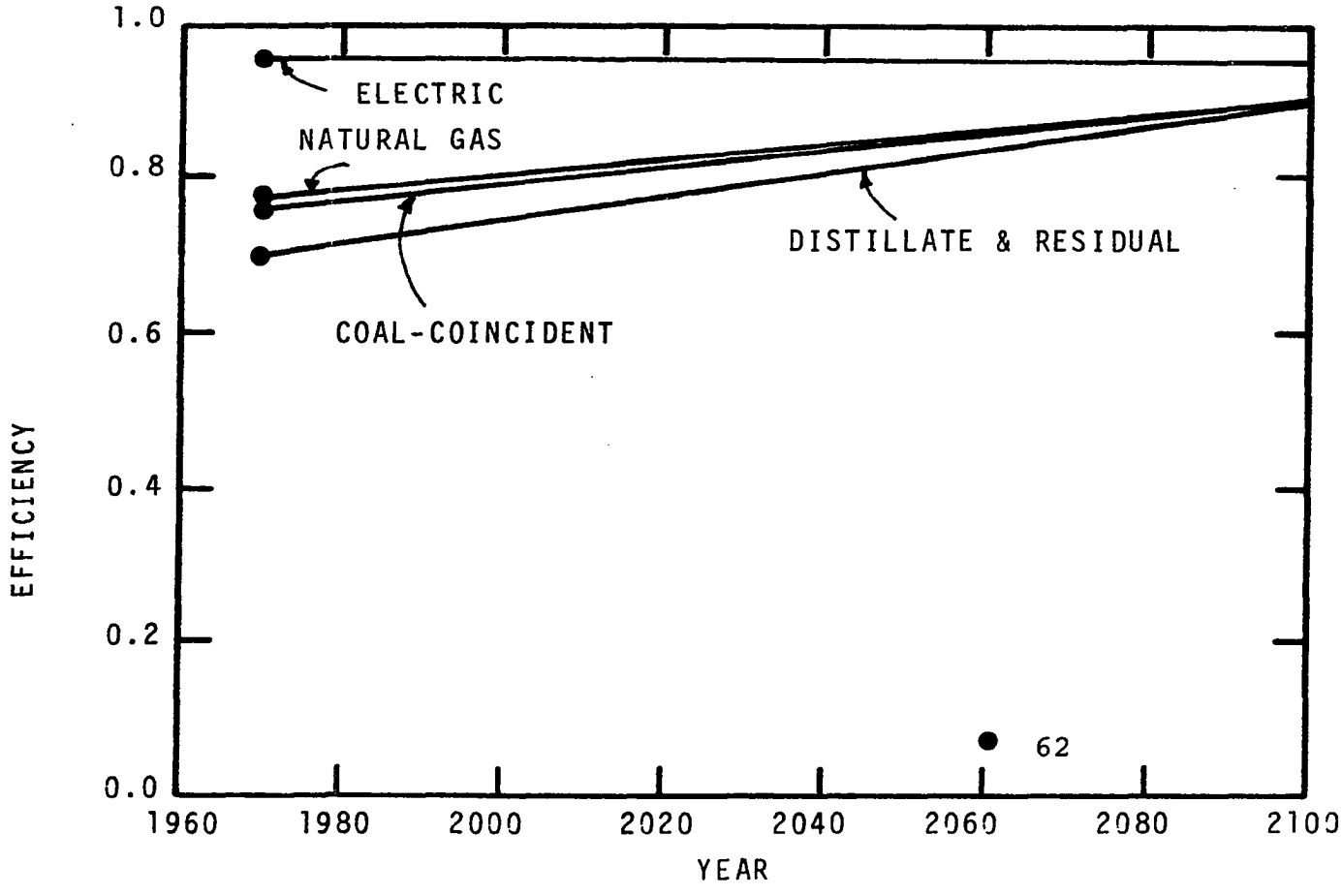


Figure A-14. Commercial Space Heating Efficiency Projection.

CSHB = commercial space heating demand, 1970

GNPR70(I) = GNP(I)/GNP(1970) (A-16)

CSHDF(I,J) = commercial space heating demand fraction for fuel J in year I

CWHEF(I,J) = commercial space heating efficiency for fuel J in year I

The total commercial space heating demand for all fuels is determined by summing the commercial space heating demand for fuel J from Equation A-15 over all fuels.

$$CSHDT = \sum_{J=1}^{21} CSHD(J) \quad \text{(A-17)}$$

where

CSHDT = total U.S. commercial space heating demand in trillion Btu/year

Air Conditioning

The commercial air conditioning energy demand is projected by using the projected gross national product, Figure III-6; the commercial 1970 air conditioning energy requirements, Table A-2; the projected commercial air conditioning unit fraction by fuel type, Figure A-15; and the projected commercial air conditioning coefficient of performance, Figure A-16. The commercial air conditioning use for fuel J in year I is given by

$$CACD(J) = CACB \times GNPR70(I) \times CACDF(I,J) \times \frac{1}{CACEF(I,J)} \quad \text{(A-18)}$$

where

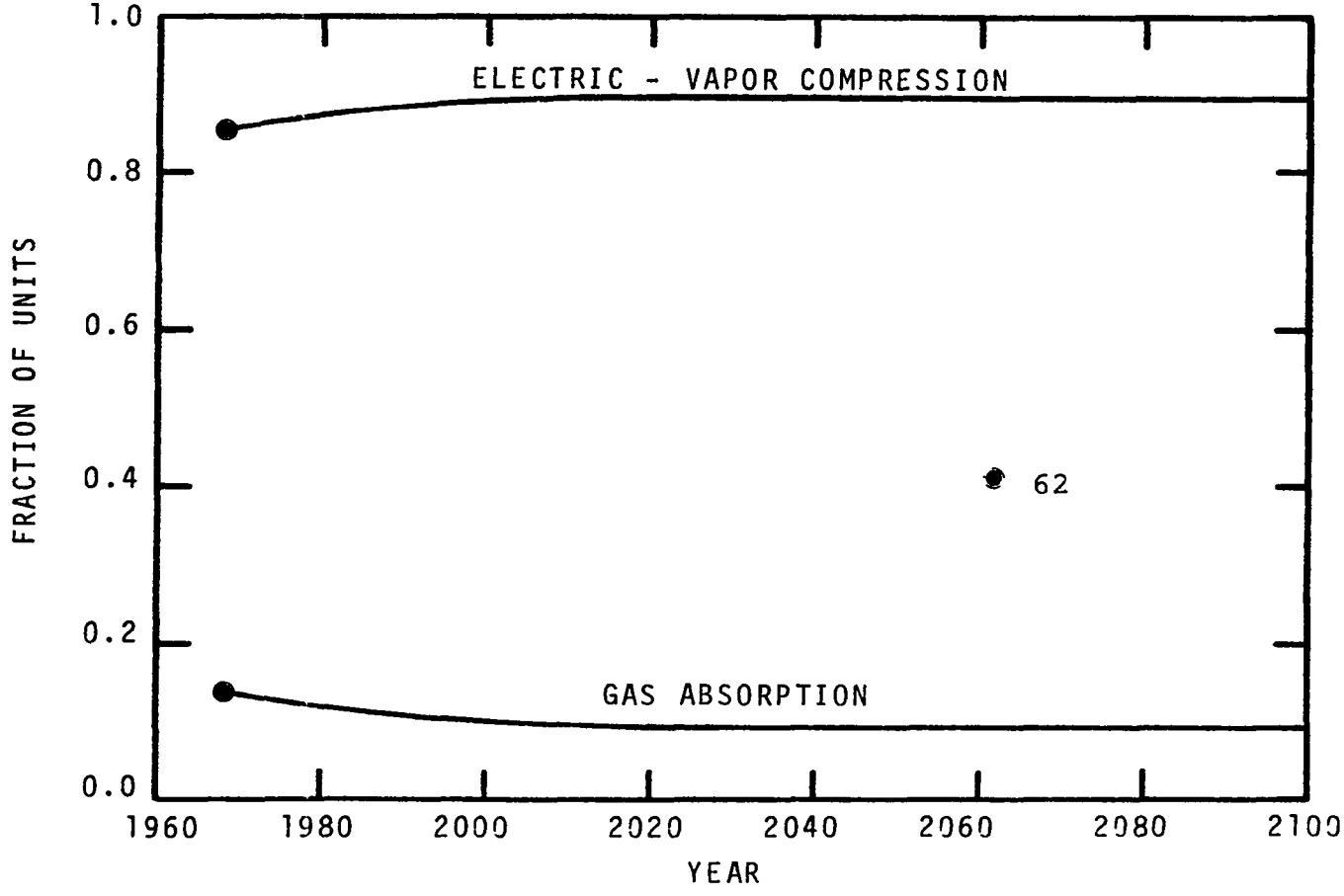


Figure A-15. Commercial Air Conditioning Unit Type Projections.

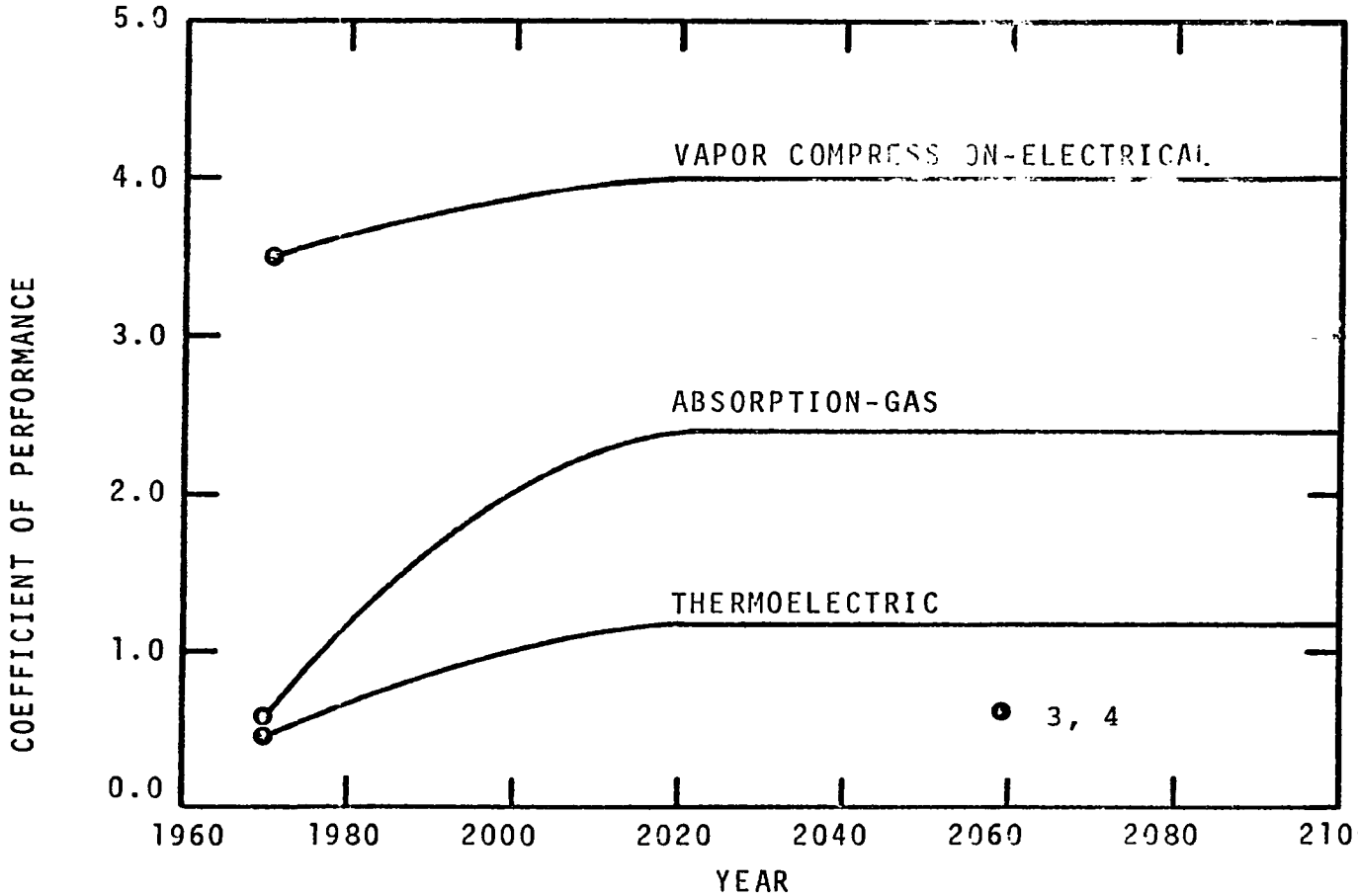


Figure A-16. Commercial Air Conditioning Coefficient of Performance Projections.

CACD(J) = U.S. commercial air conditioning demand for fuel J

CACB = commercial air conditioning demand in 1970

GNPR70(I) = GNP(I)/GNP(1970)

GNP(I) = gross national product in year I

CACDF(I,J) = commercial air conditioning demand fraction for fuel J in year I

CACEF(I,J) = commercial air conditioning coefficient of performance

The total commercial air conditioning demand for all fuels is determined by summing the commercial air conditioning demand for fuel J from Equation A-18 over all fuels.

$$CACDT = \sum_{J=1}^{21} CACD(J) \qquad \text{(A-19)}$$

where

CACDT = total U.S. commercial air conditioning demand in trillion Btu/year

Water Heating

The commercial water heating energy demand is projected by using the projected gross national product, Figure III-6; the commercial 1970 water heating energy requirements, Table A-2; the projected commercial water heating demand fraction, Figure A-17; and the projected commercial water heating efficiency, Figure A-18. The commercial water heating use for fuel J in the year I is given by

$$CWHD(J) = CWHB \times GNPR70(I) \times CWHDF(I,J) \times \frac{1}{CWHEF(I,J)} \qquad \text{(A-20)}$$

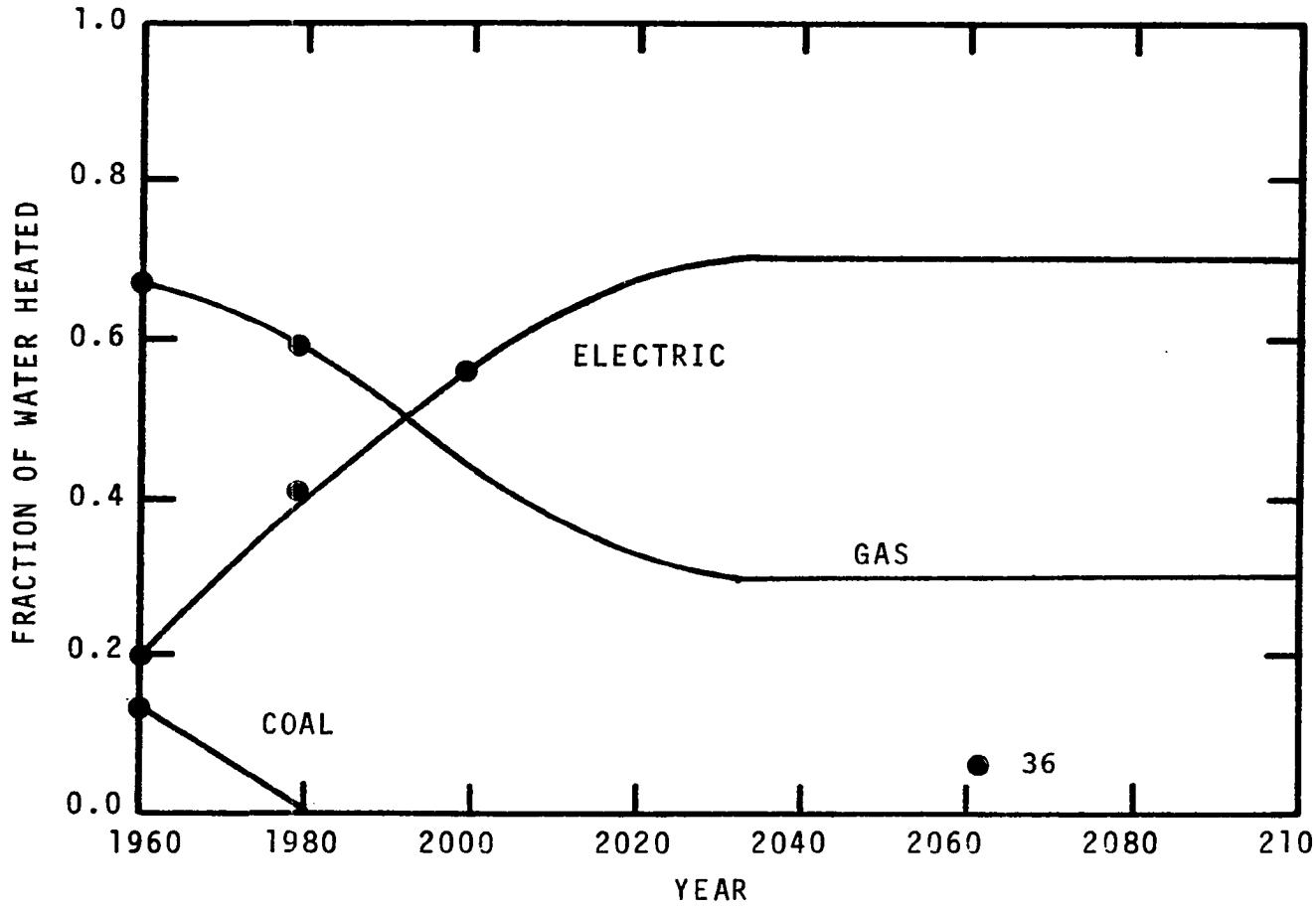


Figure A-17. Commercial Water Heating Heater Type Projection.

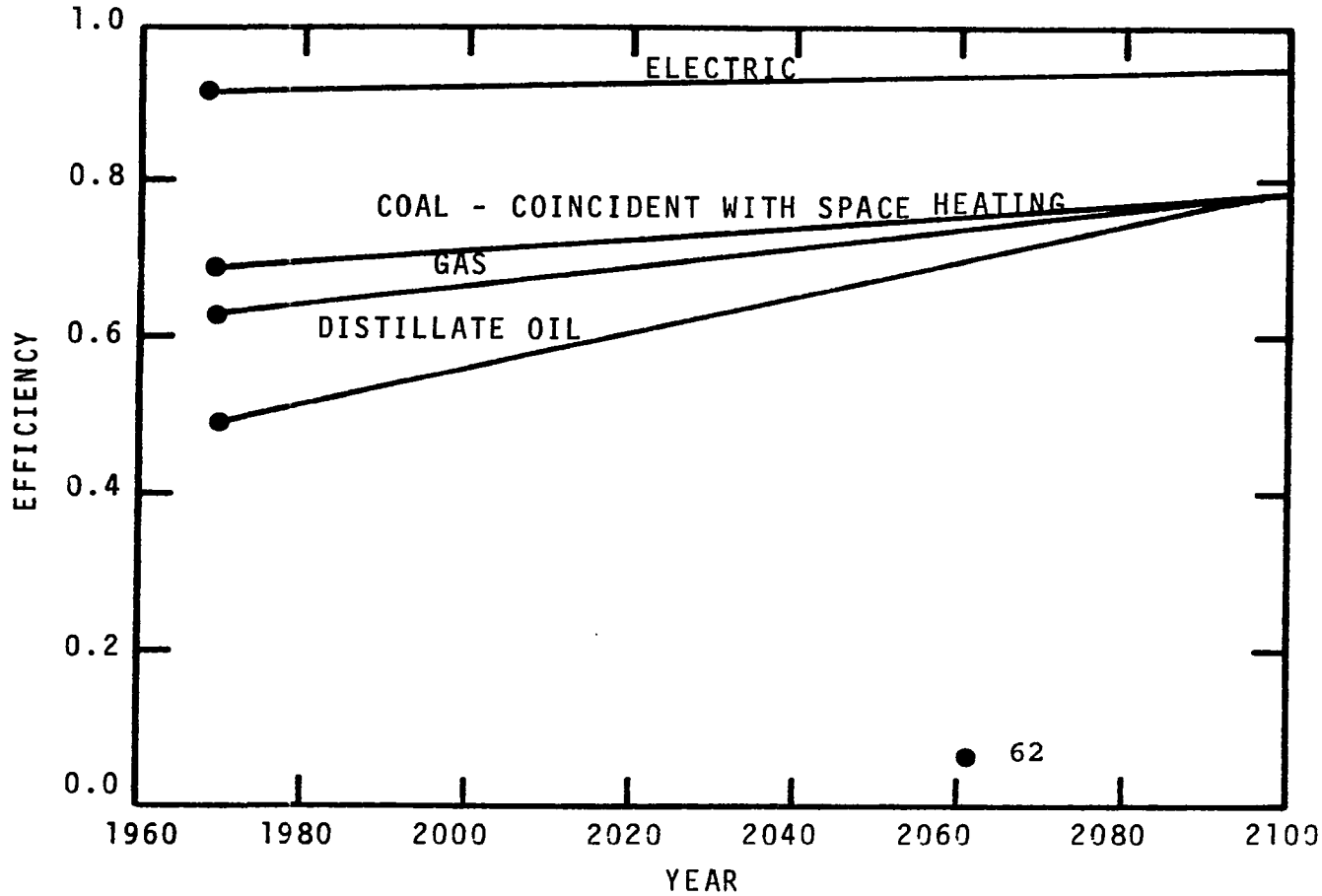


Figure A-18. Commercial Water Heating Efficiency Projection.

where

CWHD(J) = U.S. commercial water heating demand for fuel J

CWHB = commercial water heating demand in 1970

GNPR70(I) = GNP(I)/GNP(1970)

GNP(I) = gross national product in year I

CWHDF(I,J) = commercial water heating demand fraction for fuel J in year I

CWHEF(I,J) = commercial water heating efficiency for fuel J in year I

The total commercial water heating demand for all fuels is determined by summing the commercial water heating demand for fuel J from Equation A-20 over all fuels.

$$CWHDT = \sum_{J=1}^{21} CWHD(J) \qquad \text{(A-21)}$$

where

CWHDT = total U.S. commercial water heating demand in trillion Btu/year

Cooking

The commercial cooking energy demand is projected by using the projected gross national product, Figure III-6; the commercial 1970 cooking energy requirements, Table A-2; the projected commercial cooking demand fraction, Figure A-19; and the projected commercial cooking efficiency, Figure A-20. The commercial cooking use for fuel J in year I is given by

$$CCD(J) = CCB \times GNPR70(I) \times CCDF(I,J) \times \frac{CCEF(1970,J)}{CCEF(I,J)} \qquad \text{(A-22)}$$

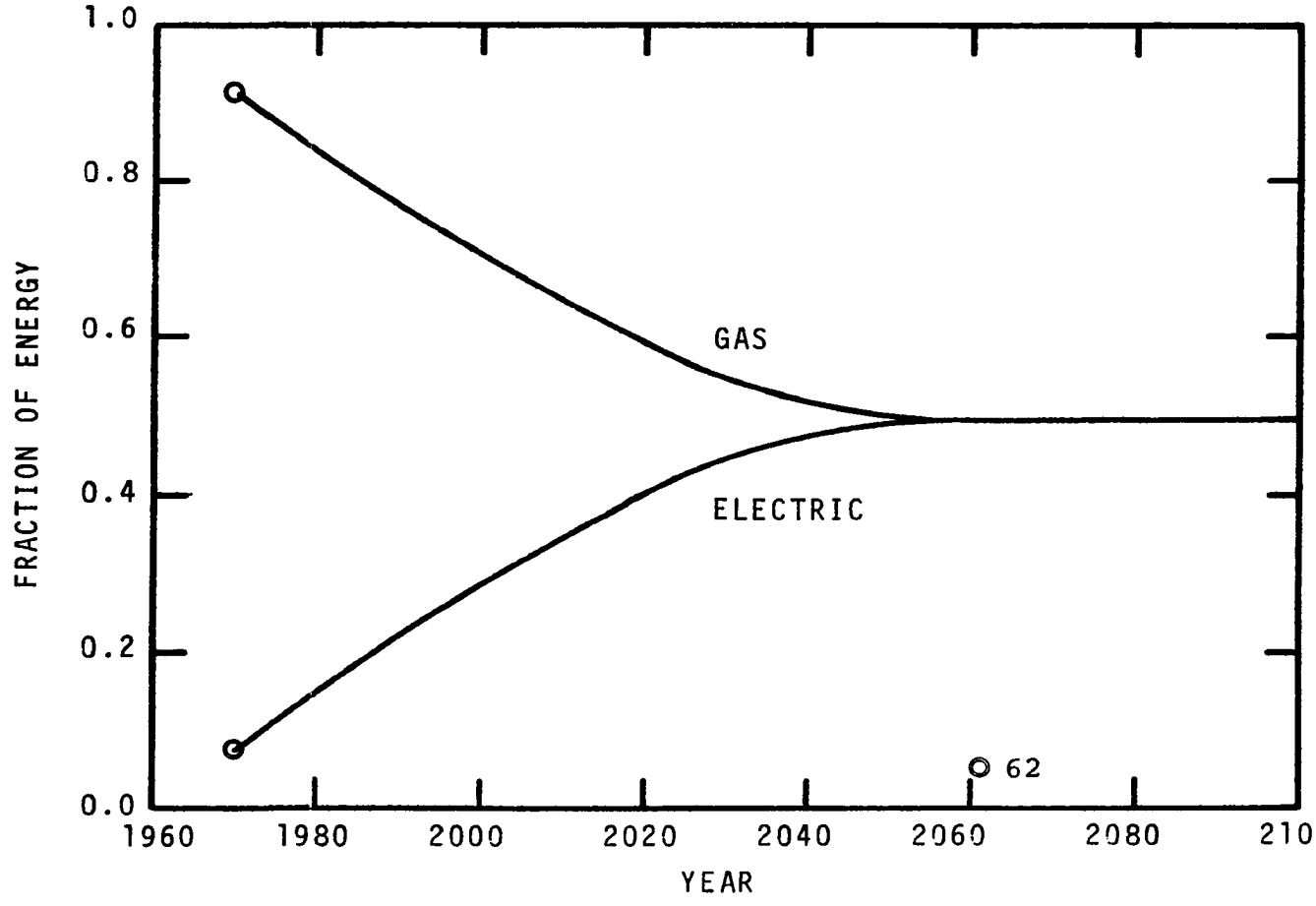


Figure A-19. Commercial Cooking Energy Supply Projections.

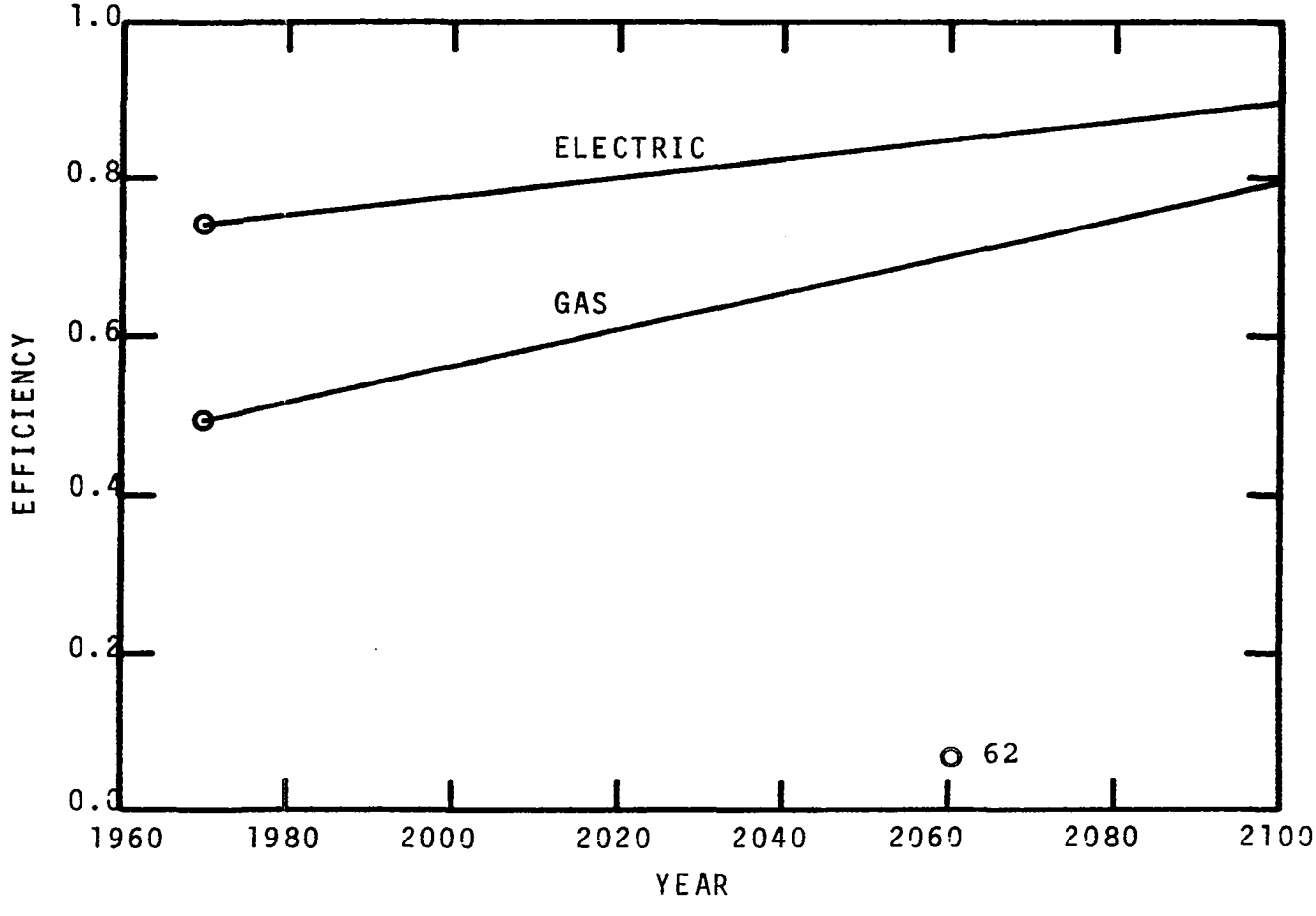


Figure A-20. Commercial Cooking Efficiency Projection.

where

CCD(J) = U.S. commercial cooking demand for fuel J

CCB = commercial cooking demand in 1970

GNPR70(I) = GNP(I)/GNP(1970)

GNP(I) = gross national product in year I

CCDF(I,J) = commercial cooking demand fraction for fuel J in year I

CCEF(I,J) = commercial cooking efficiency for fuel J in year I

The total commercial cooking demand for all fuels is determined by summing the commercial cooking demand for fuel J from Equation A-22 over all fuels.

$$CCDT = \sum_{J=1}^{21} CCD(J) \qquad \text{(A-23)}$$

where

CCDT = total U.S. commercial cooking demand in trillion Btu/year

Refrigeration

The commercial refrigeration energy demand is projected by using the projected gross national product, Figure III-6; the commercial 1970 refrigeration energy requirements, Table A-2; the projected commercial refrigeration demand fraction; and the projected commercial refrigeration efficiency, Figure A-21. The commercial refrigeration use for fuel J in year I is given by

$$CRD(J) = CRB \times GNPR70(I) \times CRDF(I,J) \times \frac{CREF(1970,J)}{CREF(I,J)} \qquad \text{(A-24)}$$

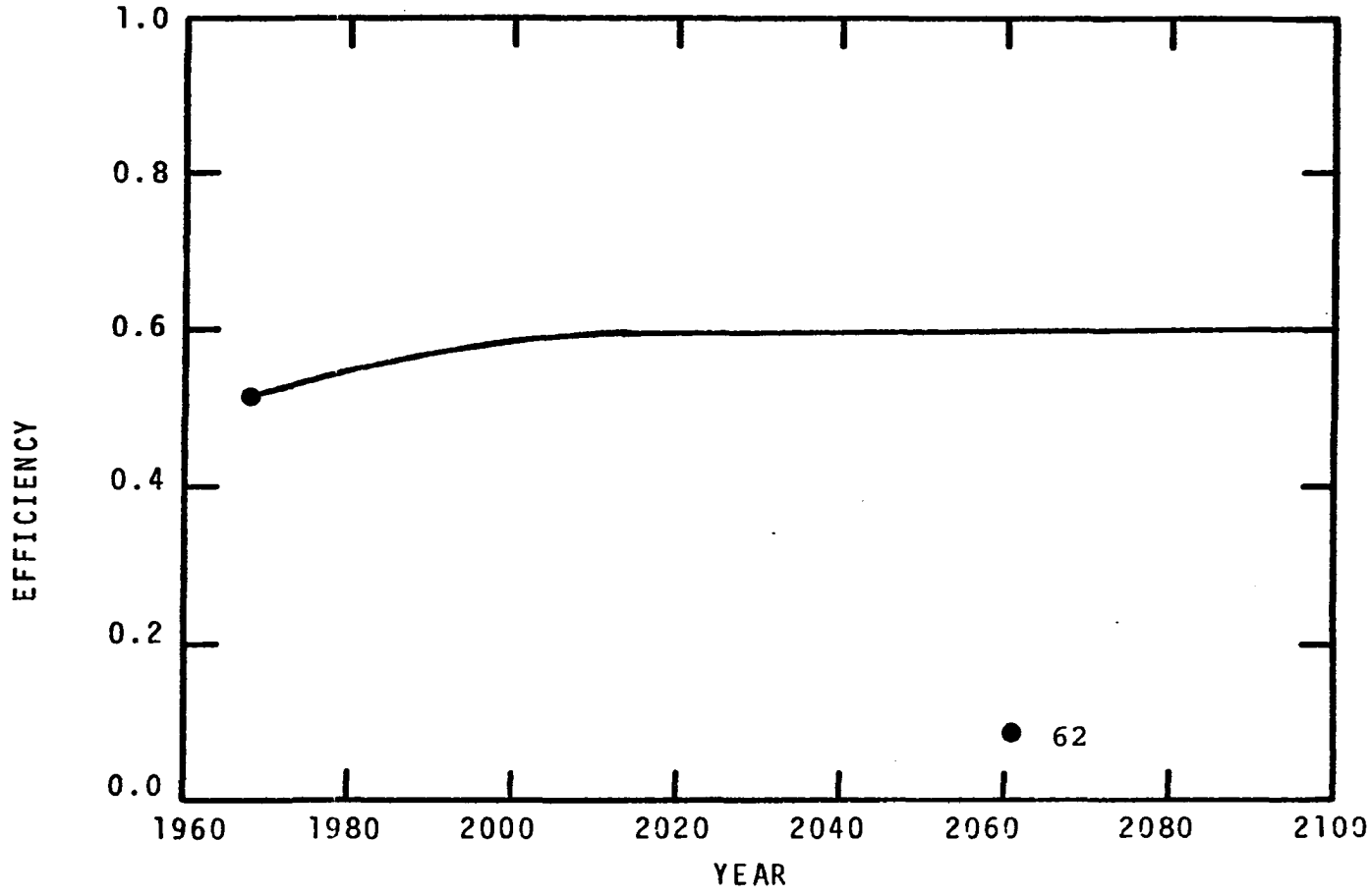


Figure A-21. Commercial Refrigeration Efficiency Projection.

where

CRD(J) = U.S. commercial refrigeration demand for fuel J

CRB = commercial refrigeration demand in 1970

GNPR70(I) = GNP(I)/GNP(1970)

GNP(I) = gross national product in year I

CRDF(I,J) = commercial refrigeration demand fraction for fuel J in year I

CREF(I,J) = commercial refrigeration efficiency for fuel J in year I

The total commercial refrigeration demand for all fuels is determined by summing the commercial refrigeration demand for fuel J from Equation A-24 over all fuels.

$$CRDT = \sum_{J=1}^{21} CRD(J) \qquad \text{(A-25)}$$

where

CRDT = total U.S. commercial refrigeration demand in trillion Btu/year

Miscellaneous

The miscellaneous commercial use includes such demands as lighting, electrical appliances, etc. The commercial miscellaneous use is projected using the projected gross national product, Figure III-6, and the 1970 commercial miscellaneous demands for each fuel not accounted for in space heating, air conditioning, water heating, cooking, and refrigeration uses, Table A-2. The miscellaneous use for fuel J in year I is given by

$$CMD(J) = CMB \times GNPR70(I) \times CMDF(I,J) \times \frac{CMEF(1970,J)}{CMEF(I,J)} \quad \text{(A-26)}$$

where

CMD(J) = U.S. commercial miscellaneous demand for fuel J

CMB = commercial miscellaneous demand in 1970

GNPR70(I) = GNP(I)/GNP(1970)

GNP(I) = gross national product in year I

CMDF(I,J) = commercial miscellaneous demand for fuel J in year I

CMEF(I,J) = commercial miscellaneous efficiency for fuel J in year I

The total commercial miscellaneous demand for all fuels is determined by summing the commercial miscellaneous demand for fuel J from Equation A-26 over all fuels.

$$CMDT = \sum_{J=1}^{21} CMD(J) \quad \text{(A-27)}$$

where

CMDT = total U.S. commercial miscellaneous energy demand in trillion Btu year

The total commercial energy demand for fuel J is determined by

$$TCD(J) = CSHD(J) + CACD(J) + CWHD(J) + CCD(J) + CRD(J) + CMD(J) \quad \text{(A-28)}$$

where

TCD(J) = total U.S. commercial demand for fuel J

CSHD(J) = commercial space heating demand for fuel J (Equation A-15)

CACD(J) = commercial air conditioning demand for fuel J (Equation A-18)

CWHD(J) = commercial water heating demand for fuel J (Equation A-20)

CCD(J) = commercial cooking demand for fuel J (Equation A-22)

CRD(J) = commercial refrigeration demand for fuel J (Equation A-24)

CMD(J) = commercial miscellaneous demand for fuel J (Equation A-26)

The total commercial energy demand is

$$TCDT = \sum_{J=1}^{21} TCD(J) \qquad \text{(A-29)}$$

where

TCDT = total U.S. commercial demand for all fuels in trillion Btu/year

Industrial Projection

The industrial energy demand is generated from the sixteen major energy consuming categories of industry: alumina, primary aluminum, secondary aluminum, cement, caustic soda and chlorine, primary copper, refined copper, primary magnesium, secondary magnesium, primary zinc, secondary zinc, pig iron, steel, chemicals and/or petrochemicals, chemical feed stocks and other raw materials, and miscellaneous usage.

Alumina

The energy demand for U.S. domestic alumina production is determined by projecting the domestic alumina

production; the energy required per ton of alumina produced, Table A-3; and the fuel supply fraction for alumina plants, Table A-4. The domestic alumina production is projected using literature projections to the year 2000, Figure A-22, and subsequently using the projected gross national product, Figure III-6, as the projection basis.

$$ALP(I) = ALP(2000) \times GNP(I)/GNP(2000) \text{ for } I \geq 2000 \quad \text{(A-30)}$$

where

ALP(I) = domestic alumina production in year I for $I \geq 2000$

GNP(I) = gross national product in year I

ALP(2000) = domestic alumina production in the year 2000 from Figure A-22

The alumina energy demand for fuel J in year I is given by

$$ALD(J) = ALP(I) \times ALFD(I,J) \times ALUD(I) \quad \text{(A-31)}$$

where

ALD(J) = U.S. alumina energy demand for fuel J

ALP(I) = domestic alumina production in year I from Equation A-30

ALFD(I,J) = alumina energy demand fraction for fuel J in year I, Table A-4

ALUD(I) = energy required per ton alumina in year I Table A-4

The total alumina energy demand for all fuels is determined by summing the U.S. alumina energy demand for fuel J

TABLE A-3

INDUSTRIAL UNIT ENERGY DEMANDS

Demand Type	Energy Requirement (million Btu/ton product)
Alumina (69)	21.0
Aluminum--primary (62)	87.0
Aluminum--secondary (62)	20.7
Cement (78, 83, 84)	1.28*
Chlorine (21, 46, 78)	40.2
Copper--primary (62)	40.1
Copper--refined (62)	6.8
Magnesium--primary (59, 62)	92.6
Magnesium--secondary (59, 62)	7.98
Miscellaneous Industrial Consumption Fossil Fuels 1970 (44)	10,911.4 trillion Btu**
1980 (44)	13,699.0 trillion Btu**
1990 (44)	16,699.0 trillion Btu**
Miscellaneous Industrial Consumption Electricity 1970 (44)	1375.5 yrillion Btu***
1980 (44)	2706.4 trillion Btu***
1990 (44)	5426.3 trillion Btu***
Petrochemical and Industrial Raw Material (46, 79, 83, 84) 1970	4010.5 trillion Btu****
1980	6593.2 trillion Btu****
1990	10,848.4 trillion Btu****

*Million Btu/376 lb-bbl

**Escalated at: 1970-1980--2.39 percent per year
1980-1990--2.0 percent per year

***Escalated at: 1970-1980--7.0 percent per year
1980-1990--7.2 percent per year

****Escalated at: 1970-1990--5.1 percent per year

TABLE A-3--Continued

Demand Type	Energy Requirement (million Btu/ton product)
Steel--electric furnace (6)	3.70
Steel--BOF (6)	6.61
Steel--open hearth (6)	5.53
Zinc--primary (62, 83, 84)	45.0
Zinc--secondary (62, 83, 84)	32.4

TABLE A-4

FUEL SUPPLY FRACTION FOR INDUSTRIAL ENERGY DEMANDS

Demand Type	Coal	Nat. Gas	Distil. Oil	Residual Oil	Electri-city
Alumina (69, 78)	0.19	0.36	0.08	0.34	0.03
Aluminim--primary (62)	0.23	0.165	--	--	0.605
Aluminum--secondary (62)	--	0.668	--	---	0.332
Cement (78, 83, 84)	0.474	0.393	0.075	--	0.058
Chlorine (21, 46, 78)	0.195	0.360	0.07	0.35	0.025
Copper--primary (62)	--	0.961	--	--	0.039
Copper--refined (62)	--	0.691	--	--	0.309
Magnesium--primary (59, 62)	--	0.590	--	--	0.410
Magnesium--secondary (59, 62)	--	0.70	0.020	--	0.10
Miscellaneous Industrial Consumption Fossil Fuels (44)	0.282	0.649	0.029	0.040	--
Miscellaneous Industrial Consumption Electricity (44)	--	--	--	--	1.0
Petrochemical and Industrial Raw Material (46, 79, 83, 84)	0.040	0.040	0.803	--	--
Steel--Electric (6)	--	--	0.378	--	0.622
Steel--BOF (6)	--	0.916	0.002	--	0.082
Steel--Open hearth (6)	--	0.602	0.345	--	0.053
Zinc--primary (62, 83, 84)	0.430	0.175	--	--	0.395
Zinc--secondary (62, 83, 84)	0.666	--	--	--	0.334

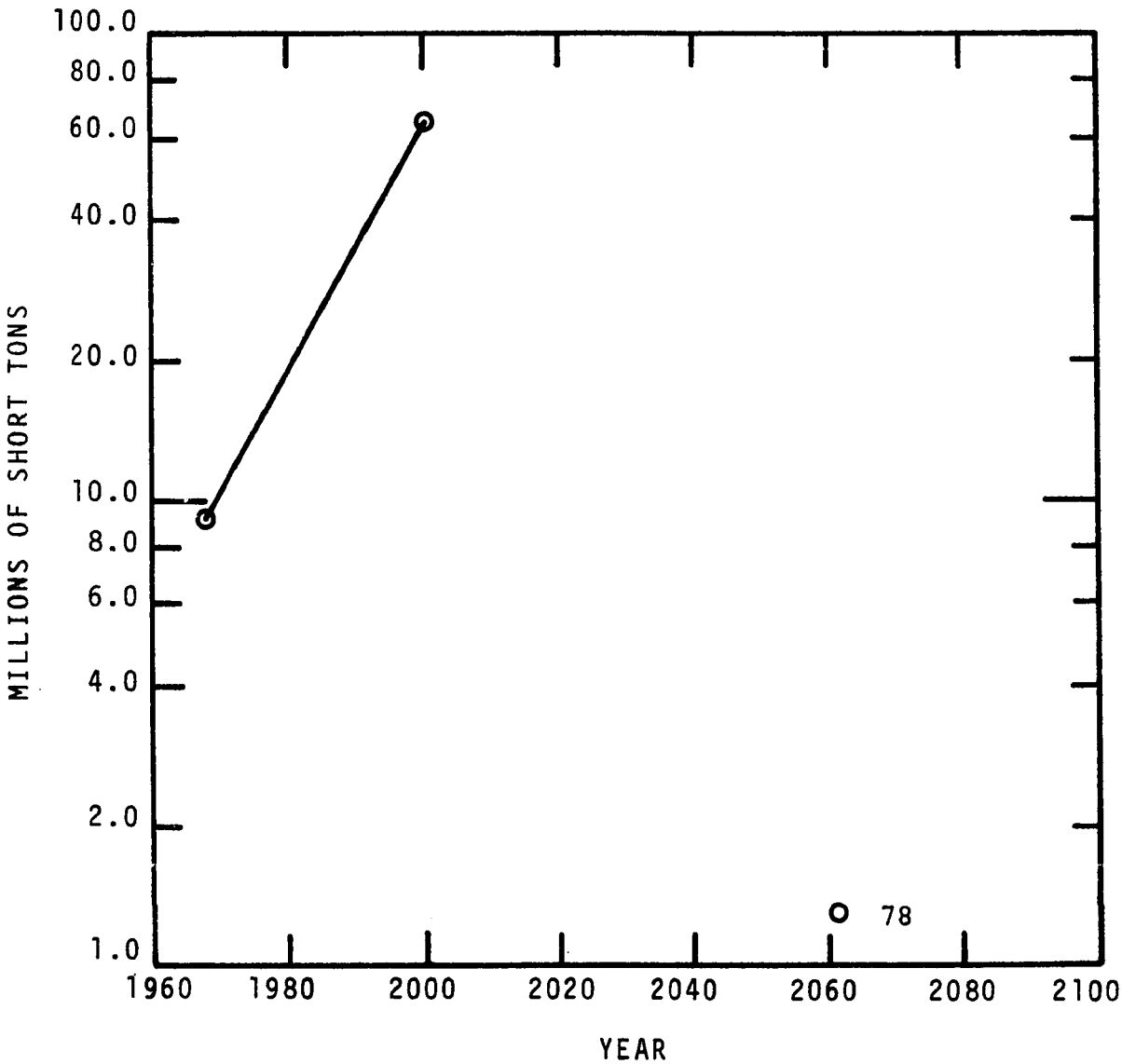


Figure A-22. Projected U.S. Domestic Alumina Production.

from Equation A-31 over all fuels.

$$ALDT = \sum_{J=1}^{21} ALD(J) \qquad \text{(A-32)}$$

where

ALDT = total U.S. alumina energy demand in trillion Btu/year

Aluminum

The energy demand for U.S. domestic aluminum production is determined by projecting domestic primary and secondary aluminum production; the energy required per ton of primary aluminum produced and the energy required per ton of secondary aluminum produced, Table A-3; and the fuel supply fraction for primary aluminum plants and for secondary aluminum plants, Table A-4. The domestic primary and secondary aluminum production is projected using literature projections to the year 2000, Figure A-23, and subsequently using the projected gross national product, Figure III-6.

$$ALPP(I) = ALPP(2000) \times GNP(I)/GNP(2000) \quad \text{for } I \geq 2000 \qquad \text{(A-33)}$$

$$ALSP(I) = ALSP(2000) \times GNP(I)/GNP(2000) \quad \text{for } I \geq 2000 \qquad \text{(A-34)}$$

where

ALPP(I) = domestic primary aluminum production in year I for $I \geq 2000$

ALSP(I) = domestic secondary aluminum production in year I for $I \geq 2000$

GNP(I) = gross national product in year I

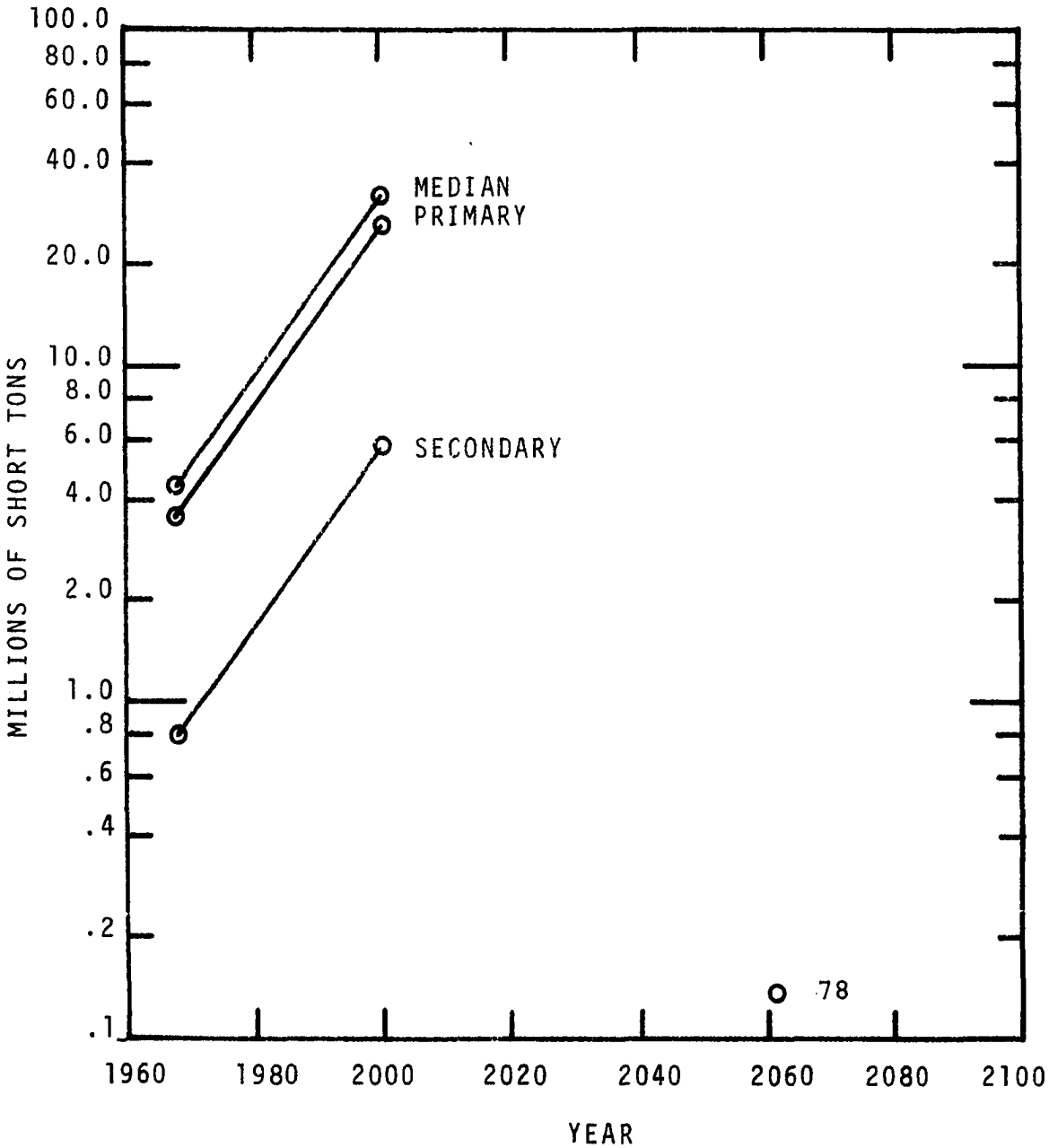


Figure A-23. Projected U.S. Domestic Aluminum Production.

ALPP(2000) = domestic primary aluminum production in year 2000, from Figure A-23

ALSP(2000) = domestic secondary aluminum production in year 2000, from Figure A-23

The primary aluminum energy demand for fuel J in year I is given by

$$ALPD(J) = ALPP(I) \times ALDFD(I,J) \times ALPUD(I) \quad (A-35)$$

where

ALPD(J) = U.S. primary aluminum energy demand for fuel J

ALPP(I) = domestic primary aluminum production in year I from Equation A-33

ALPFD(I,J) = primary aluminum energy demand fraction for fuel J in year I, Table A-4

ALPUD(I) = energy required per ton primary aluminum in year I, Table A-3

The secondary aluminum energy demand for fuel J in year I is given by

$$ALSD(J) = ALSP(I) \times ALSFD(I,J) \times ALSUD(I) \quad (A-36)$$

where

ALSD(J) = U.S. industrial aluminum energy demand for fuel J

ALSP(I) = domestic secondary aluminum production in year I from Equation A-34

ALSFD(I,J) = secondary aluminum energy demand fraction for fuel J in year I, Table A-4

ALSUD(I) = energy required per ton secondary aluminum in year I, Table A-3

The total primary aluminum energy demand and secondary aluminum energy demand for all fuels are determined by summing Equations A-35 and A-36, respectively, over all fuels.

$$ALPDT = \sum_{J=1}^{21} ALPD(J) \qquad (A\text{-}37)$$

where

ALPDT = total U.S. primary aluminum energy demand in trillion Btu/year

$$ALSDT = \sum_{J=1}^{21} ALSD(J) \qquad (A\text{-}38)$$

where

ALSDT = total U.S. secondary aluminum energy demand in trillion Btu/year

Cement

The energy demand for U.S. cement production is determined by projecting the domestic cement production; the energy requirements per barrel of cement produced, Table A-3; and the fuel supply fraction for cement plants, Table A-4. The domestic cement production is projected using literature projections to the year 2000, Figure A-24, and subsequently using the projected gross national product, Figure III-6, as the projection basis.

$$CEP(I) = CEP(2000)\ GNP(I)/GNP(2000) \text{ for } I \geq 2000 \qquad (A\text{-}39)$$

where

CEP(I) = domestic cement production in year I for $I \geq 2000$

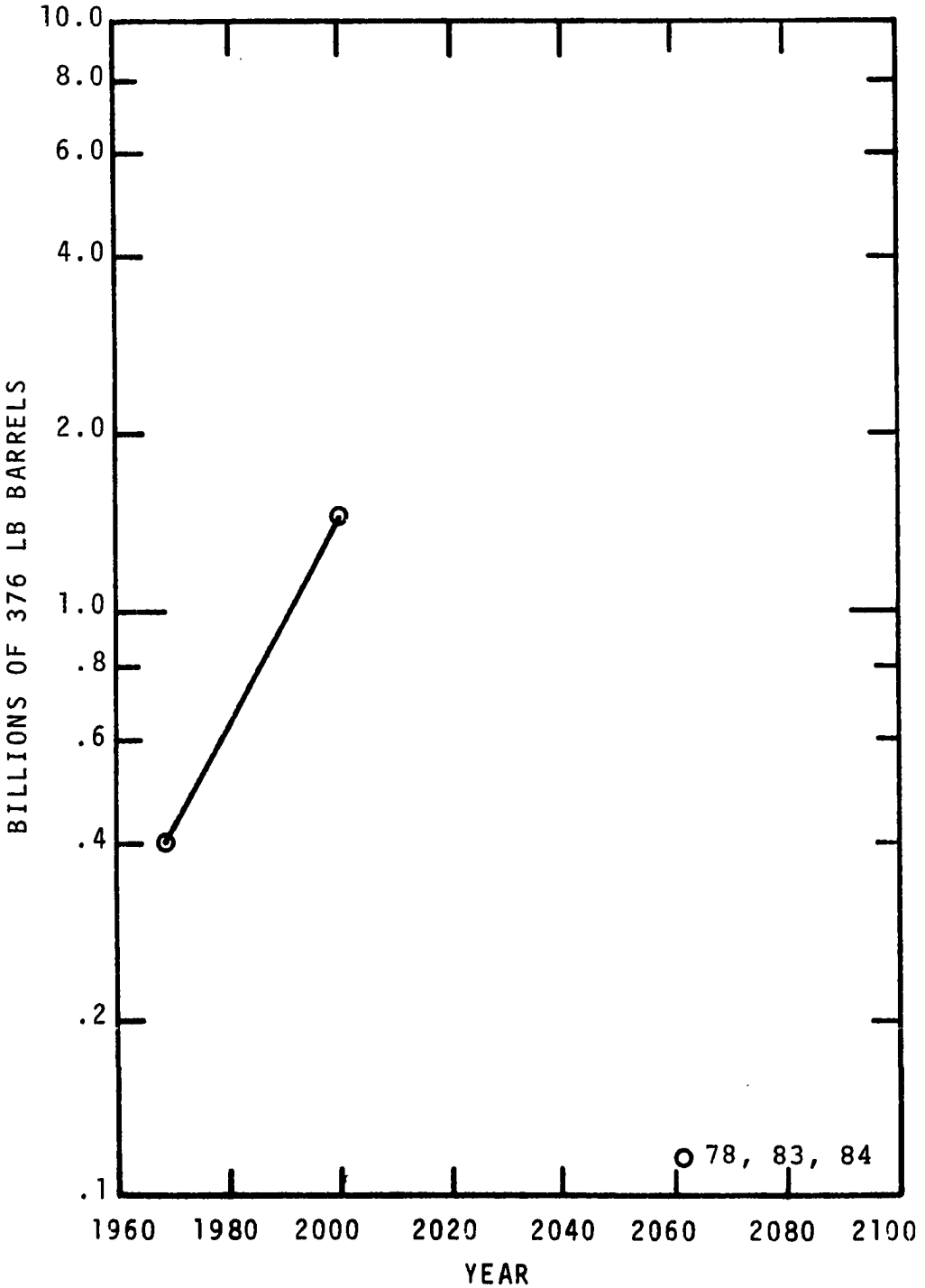


Figure A-24. Projected U.S. Cement Production.

GNP(I) = gross national product in year I

CEP(2000) = domestic cement production in the year 2000 from Figure A-24

The cement energy demand for fuel J in year I is given by

$$CED(J) = CEP(I) \times CEFD(I,J) \times CEUD(I) \qquad (A-40)$$

where

CED(J) = U.S. cement energy demand for fuel J

CEP(I) = domestic cement production in year I

CEFD(I,J) = cement energy demand fraction for fuel J in year I, Table A-4

CEUD(I) = energy required per barrel cement in year I, Table A-3

The total cement energy demand for all fuels is determined by summing the U.S. cement energy demand for fuel J from Equation A-40 over all fuels.

$$CEDT = \sum_{J=1}^{21} CED(J) \qquad (A-41)$$

where

CEDT = total U.S. cement energy demand in trillion Btu/year

Chlorine

The energy demand for U.S. chlorine production is determined by projecting the domestic chlorine production; the energy requirements per ton of chlorine produced, Table A-3; and the fuel supply fraction for chlorine plants, Table

A-4. The domestic chlorine production is projected using literature projections to the year 2000, Figure A-25, and subsequently using the projected gross national product, Figure III-6, as the projection basis.

$$CHP(I) = CHP(2000) \times GNP(I)/GNP(2000) \text{ for } I \geq 2000 \quad \text{(A-42)}$$

where

CHP(I) = domestic chlorine production in year I for $I \geq 2000$

GNP(I) = gross national product in year I

CHP(2000) = domestic cement production in the year 2000 from Figure A-25

The industrial chlorine energy demand for fuel J in year I is given by

$$CHD(J) = CHP(I) \times CHFD(I,J) \times CHUD(I) \quad \text{(A-43)}$$

where

CUD(J) = U.S. chlorine energy demand for fuel J

CHP(I) = domestic chlorine production in year I from Equation A-42

CHFD(I,J) = chlorine energy demand fraction for fuel J in year I, Table A-4

CHUD(I) = energy required per ton chlorine in year I, Table A-3

The total chlorine energy demand for all fuels is determined by summing the U.S. chlorine energy demand for fuel J from Equation A-43 over all fuels.

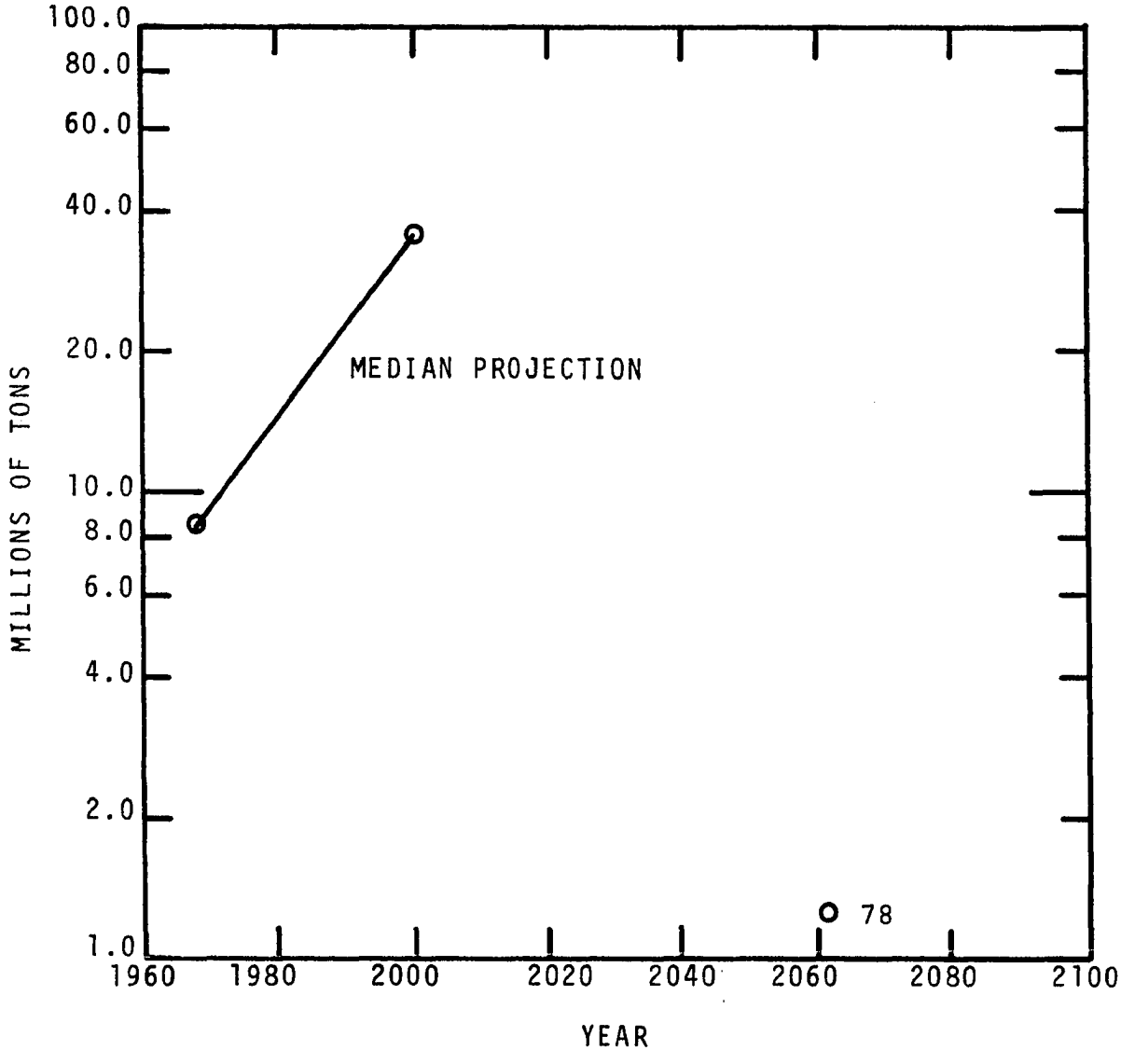


Figure A-25. Projected U.S. Chlorine Production.

$$CHDT = \sum_{J=1}^{21} CHD(J) \qquad \text{(A-44)}$$

where

CHDT = total U.S. chlorine energy demand in trillion Btu/year

Copper

The energy demand for U.S. copper production is determined by projecting domestic primary and refined copper production; the energy required per ton of primary copper produced and the energy required per ton of refined copper produced, Table A-3; and the fuel supply fraction for primary copper plants and refined copper plants, Table A-4. The domestic primary and refined copper production is projected using literature projections to the year 2000, Figure A-26, and subsequently using the projected gross national product, Figure III-6.

$$CUPP(I) = CUPP(2000) \times GNP(I)/GNP(2000) \text{ for } I \geq 2000 \qquad \text{(A-45)}$$

$$CURP(I) = CURP(2000) \times GNP(I)/GNP(2000) \text{ for } I \geq 2000 \qquad \text{(A-46)}$$

where

CUPP(I) = domestic primary copper production in year I for $I \geq 2000$

CURP(I) = domestic refined copper production in year I for $I \geq 2000$

GNP(I) = gross national product in year I

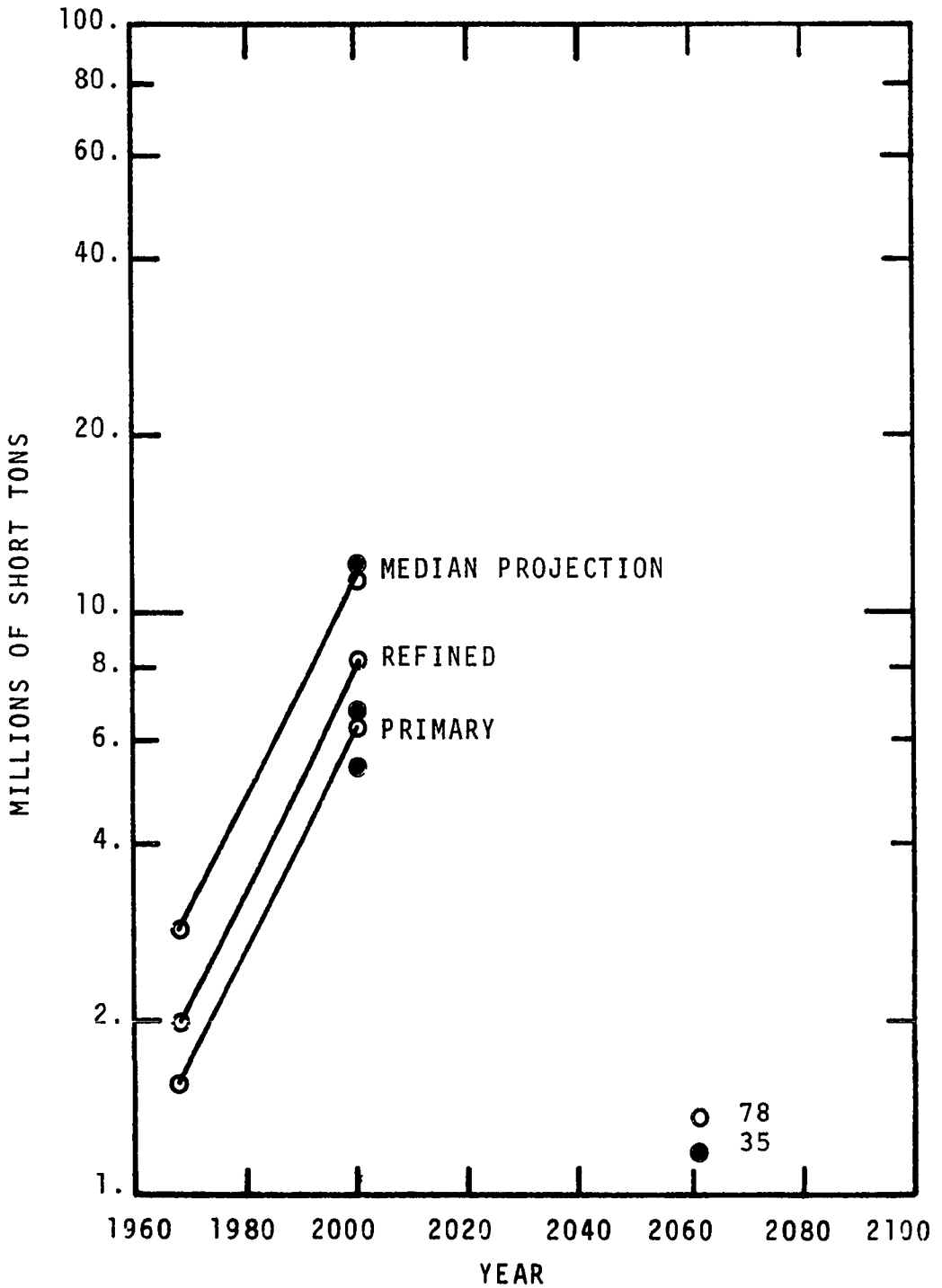


Figure A-26. Projected U.S. Domestic Copper Production.

CUPP(2000) = domestic primary copper production in year 2000 from Figure A-26

CURP(2000) = domestic refined copper production in year 2000 from Figure A-26

The primary copper production energy demand for fuel J in year I is given by

$$CUPD(J) = CUPP(I) \times CUPFD(I,J) \times CUPUD(I) \qquad (A-47)$$

where

CUPD(J) = U.S. primary copper energy demand for fuel J

CUPP(I) = domestic primary copper production in year I, Equation A-45

CUPFD(I,J) = primary copper energy demand fraction for fuel J in year I, Table A-4

CUPUD(I) = energy required per ton primary copper in year I, Table A-3

The refined copper production demand for fuel J in year I is given by

$$CURD(J) = CURP(I) \times CURFD(I,J) \times CURUD(I) \qquad (A-48)$$

where

CURD(J) = U.S. refined copper energy demand for fuel J

CURP(I) = domestic refined copper production in year I, Equation A-46

CURFD(I,J) = refined copper energy demand fraction for fuel J in year I, Table A-4

CURUD(I) = energy required per ton refined copper in year I, Table A-3

The total primary copper energy demand and refined copper energy demand for all fuels are determined by summing Equations A-47 and A-48, respectively, over all fuels.

$$CUPDT = \sum_{J=1}^{21} CUPD(J) \qquad (A-49)$$

where

CUPDT = total U.S. primary copper energy demand in trillion Btu/year

$$CURDT = \sum_{J=1}^{21} CURD(J) \qquad (A-50)$$

where

CURDT = total U.S. refined copper energy demand in trillion Btu/year

Magnesium

The energy demand for U.S. magnesium production is determined by projecting domestic primary and secondary magnesium production; the energy required per ton of primary magnesium and the energy required per ton of secondary magnesium produced, Table A-3; and the fuel supply fraction for primary magnesium plants and for secondary magnesium plants, Table A-4. The domestic primary and secondary magnesium production is projected using literature projections to the year 2000, Figure A-27, and subsequently using the projected gross national product, Figure III-6.

$$MGPP(I) = MGPP(2000) \times GNP(I)/GNP(2000) \qquad (A-51)$$

$$MGSP(I) = MGSP(2000) \times GNP(I)/GNP(2000) \qquad (A-52)$$

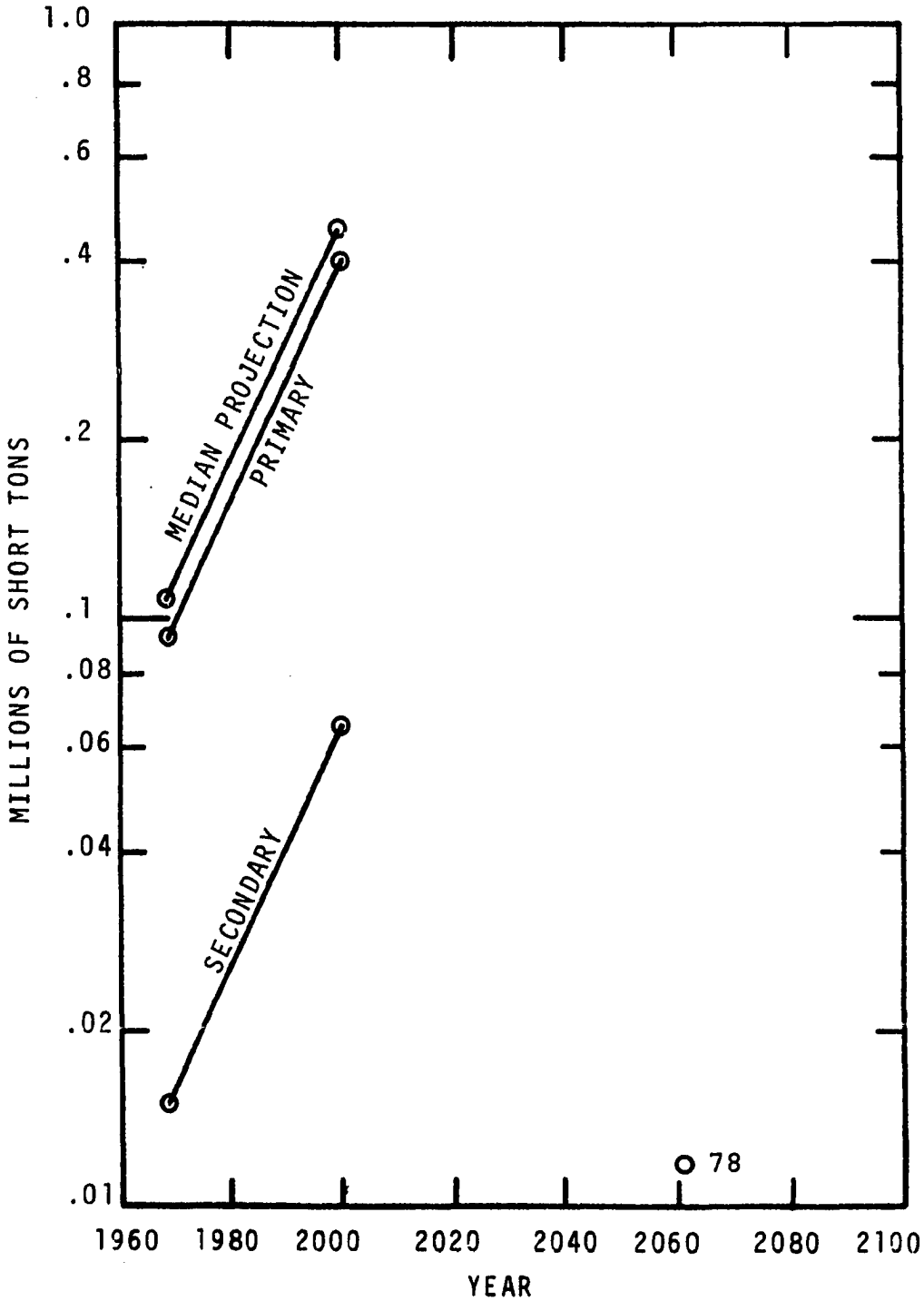


Figure A-27. Projected U.S. Domestic Magnesium Production.

where

MGPP(I) = domestic primary magnesium production in year I for I $\geq$ 2000

MGSP(I) = domestic secondary magnesium production in year I for I $\geq$ 2000

GNP(I) = gross national product in year I

MGPP(2000) = domestic primary magnesium production in year 2000 from Figure A-27

MGSP(2000) = domestic secondary magnesium production in year 2000 from Figure A-27

The primary magnesium energy demand for fuel J in year I is given by

$$MGPD(J) = MGPP(I) \times MGPFD(I,J) \times MGPUD(I) \qquad (A-53)$$

where

MGPD(J) = U.S. primary magnesium energy demand for fuel J

MGPP(I) = primary magnesium production in year I, Equation A-51

MGPFD(I,J) = primary magnesium energy demand fraction for fuel J in year I, Table A-4

MGPUD(I) = energy required per ton primary magnesium in year I, Table A-3

The secondary magnesium energy demand for fuel J in year I is given by

$$MGSD(J) = MGSP(I) \times MGSFD(I,J) \times MGSUD(I) \qquad (A-54)$$

where

MGSD(J) = U.S. secondary magnesium energy demand for fuel J

MGSP(I) = domestic secondary magnesium production in year I, Equation A-52

MGSFD(I,J) = secondary magnesium energy demand fraction for fuel J in year I, Table A-4

MGSUD(I) = energy required per ton secondary magnesium in year I, Table A-3

The total primary magnesium energy demand and secondary magnesium energy demand for all fuels are determined by summing Equations A-53 and A-54, respectively, over all fuels.

$$MGPDT = \sum_{J=1}^{21} MGPD(J) \qquad \text{(A-55)}$$

where

MGPDT = total U.S. primary magnesium energy demand in trillion Btu/year

$$MGSDT = \sum_{J=1}^{21} MGSD(J) \qquad \text{(A-56)}$$

where

MGSDT = total U.S. secondary magnesium energy demand in trillion Btu/year

Miscellaneous Fossil Fuel

The energy demand for U.S. miscellaneous fossil fuel usage is determined by projecting the miscellaneous industrial use of fossil fuels and the fossil fuel supply fraction, Table A-4. The domestic miscellaneous fossil energy usage is projected using literature projections to the year 1990, Table A-3, and subsequently using the projected gross national product, Figure III-6, as the projection basis.

$$IMFP(I) = IMFP(1990) \times GNP(I)/GNP(1990) \quad \text{for } I \geq 1990 \qquad \text{(A-57)}$$

where

IMFP(I) = miscellaneous industrial fossil fuel energy requirements in the year I for I ≥ 1990

GNP(I) = gross national product in year I

IMFP(1990) = miscellaneous industrial fossil fuel energy requirements in the year 1990 from Table A-3

The miscellaneous industrial fossil fuel energy demand for fuel J in year I is given by

$$IMFD(J) = IMFP(I) \times IMFFD(I,J) \qquad \text{(A-58)}$$

where

IMFD(J) = miscellaneous industrial fossil fuel energy demand for fuel J

IMFP(I) = miscellaneous industrial fossil fuel energy requirements in the year I

IMFFD(I,J) = miscellaneous industrial fossil fuel energy demand fraction for fuel J in year I, Table A-4

The total miscellaneous industrial fossil fuel energy demand for all fossil fuels is determined by summing the U.S. miscellaneous industrial fossil energy demand for fuel J from Equation A-58 over all fossil fuels.

$$IMFDT = \sum_{J=12}^{15} IMFD(J) \qquad \text{(A-59)}$$

where

IMFDT = total U.S. miscellaneous industrial fossil energy demand in trillion Btu/year

$$IMFP(I) = IMFP(1990) \times GNP(I)/GNP(1990) \quad \text{for } I \geq 1990 \qquad \text{(A-57)}$$

where

IMFP(I) = miscellaneous industrial fossil fuel energy requirements in the year I for I ≥ 1990

GNP(I) = gross national product in year I

IMFP(1990) = miscellaneous industrial fossil fuel energy requirements in the year 1990 from Table A-3

The miscellaneous industrial fossil fuel energy demand for fuel J in year I is given by

$$IMFD(J) = IMFP(I) \times IMFFD(I,J) \qquad \text{(A-58)}$$

where

IMFD(J) = miscellaneous industrial fossil fuel energy demand for fuel J

IMFP(I) = miscellaneous industrial fossil fuel energy requirements in the year I

IMFFD(I,J) = miscellaneous industrial fossil fuel energy demand fraction for fuel J in year I, Table A-4

The total miscellaneous industrial fossil fuel energy demand for all fossil fuels is determined by summing the U.S. miscellaneous industrial fossil energy demand for fuel J from Equation A-58 over all fossil fuels.

$$IMFDT = \sum_{J=12}^{15} IMFD(J) \qquad \text{(A-59)}$$

where

IMFDT = total U.S. miscellaneous industrial fossil energy demand in trillion Btu/year

Miscellaneous Electrical

The energy demand for U.S. miscellaneous industrial electrical usage is determined by projecting the miscellaneous industrial use of electricity. The miscellaneous industrial use of electricity is projected using literature projections to the year 1990, Table A-3, and subsequently using the projected gross national product, Figure III-6, as the projection basis.

$$IMED(I) = IMEP(I) \text{ for } I \leq 1990 \quad \text{(A-60)}$$

$$IMED(I) = IMEP(1990) \times GNP(I)/GNP(1990) \text{ for } I \geq 1990 \quad \text{(A-61)}$$

where

IMED(I) = miscellaneous industrial electrical energy demand in year I

GNP(I) = gross national product in year I

IMEP(1990) = miscellaneous industrial electrical energy demand projection for the year 1990 from Table A-3

Petrochemical and Industrial Raw Material

The energy demand for U.S. petrochemical and industrial raw material uses is determined by projecting the energy consumption of the domestic chemicals, petrochemicals, chemical feed stocks and other raw material industries, Figure A-28 and Table A-3, and the energy supply fraction, Table A-4. The domestic petrochemical and raw material energy usage is projected using literature projections to the year 1990, Figure A-28, and subsequently using the projected gross

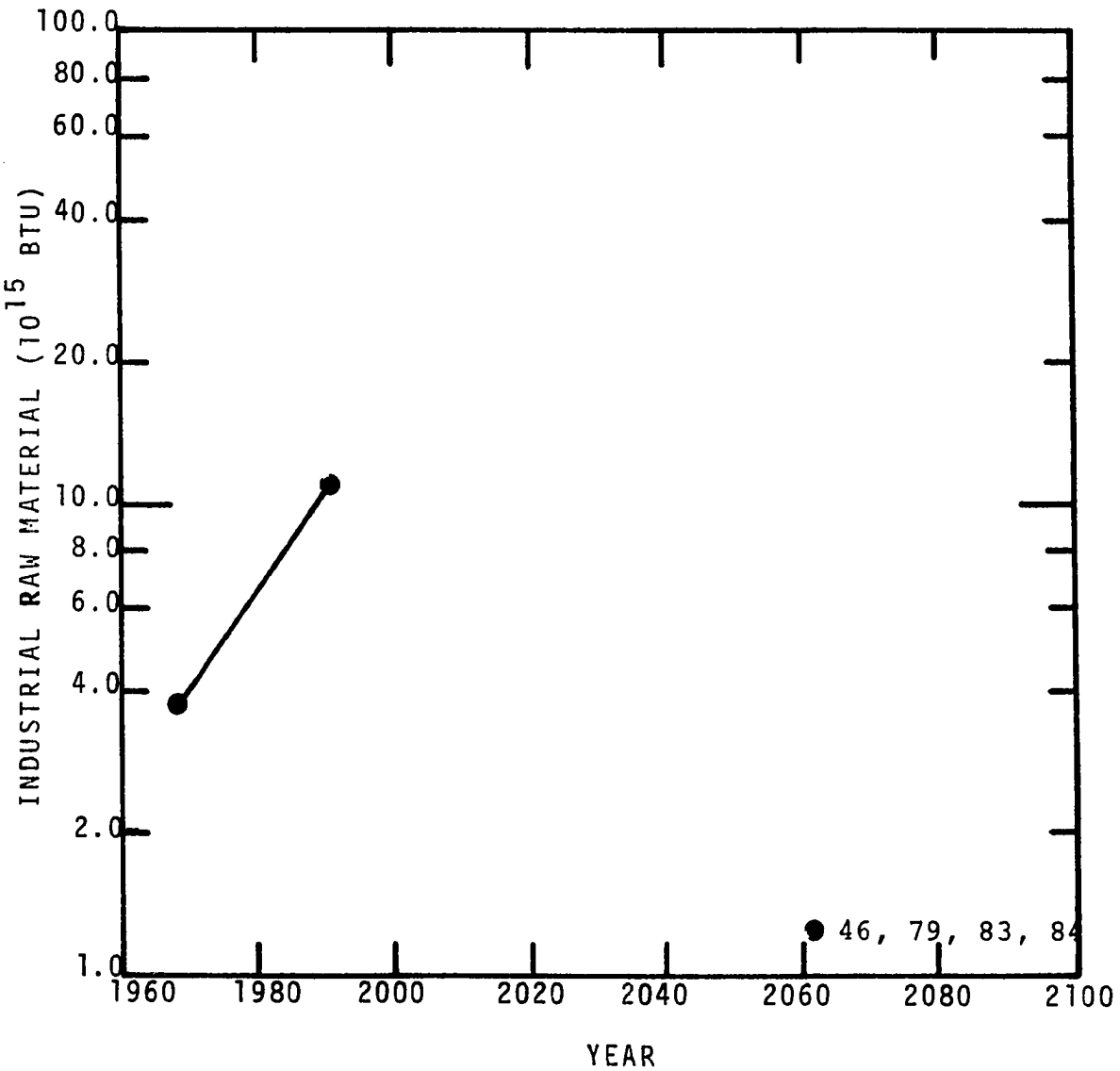


Figure A-28. Projected U.S. Petrochemical and Industrial Raw Material Requirements.

national product, Figure III-6, as the projection basis.

$$IRMP(I) = IRMP(1990) \times GNP(I)/GNP(1990) \quad \text{for } I \geq 1990 \qquad \text{(A-62)}$$

where

IRMP(I) = petrochemical and industrial raw material energy usage in the year I for I ≥ 1990

GNP(I) = gross national product in year I

IRMP(1990) = petrochemical and industrial raw material energy usage in the year 1990 from Figure A-28

The petrochemical and industrial raw material energy demand for fuel J in year I is given by

$$IRMD(J) = IRMP(I) \times IRMFD(I,J) \qquad \text{(A-63)}$$

where

IRMD(J) = U.S. petrochemical and industrial raw material energy demand for fuel J

IRMP(I) = U.S. petrochemical and industrial raw material energy use in year I, Equation A-62

IRMFD(I,J) = petrochemical and industrial raw material energy demand fraction for fuel J in year I, Table A-4

The total petrochemical and industrial raw material energy demand for all fuels is determined by summing the U.S. petrochemical and industrial raw material energy demand for fuel J from Equation A-63 over all fuels.

$$IRMDT = \sum_{J=1}^{21} IRMD(J) \qquad \text{(A-64)}$$

where

IRMDT = total U.S. petrochemical and industrial raw material energy demand in trillion Btu/year

Pig Iron

The energy demand for U.S. pig iron production is determined by projecting the domestic pig iron production; the energy required per ton of pig iron produced, Figure A-30; and the pig iron fuel fraction, Figure A-31. The domestic pig iron production is projected using literature projections to the year 2000, Figure A-29, and subsequently using the projected gross national product, Figure III-6, as the projection basis.

$$PIP(I) = PIP(2000) \times GNP(I)/GNP(2000) \quad \text{for } I \geq 2000 \qquad \text{(A-65)}$$

where

PIP(I) = domestic pig iron production in year I for $I \geq 2000$

GNP(I) = gross national product in year I

PIP(2000) = domestic pig iron production in year 2000 from Figure A-29

The pig iron energy demand for fuel J in year I is given by

$$PID(J) = PIP(I) \times PIUD(I) \times PIFD(I,J) \qquad \text{(A-66)}$$

where

PID(J) = U.S. pig iron energy demand for fuel J

PIP(I) = domestic pig iron production in year I, Equation A-65

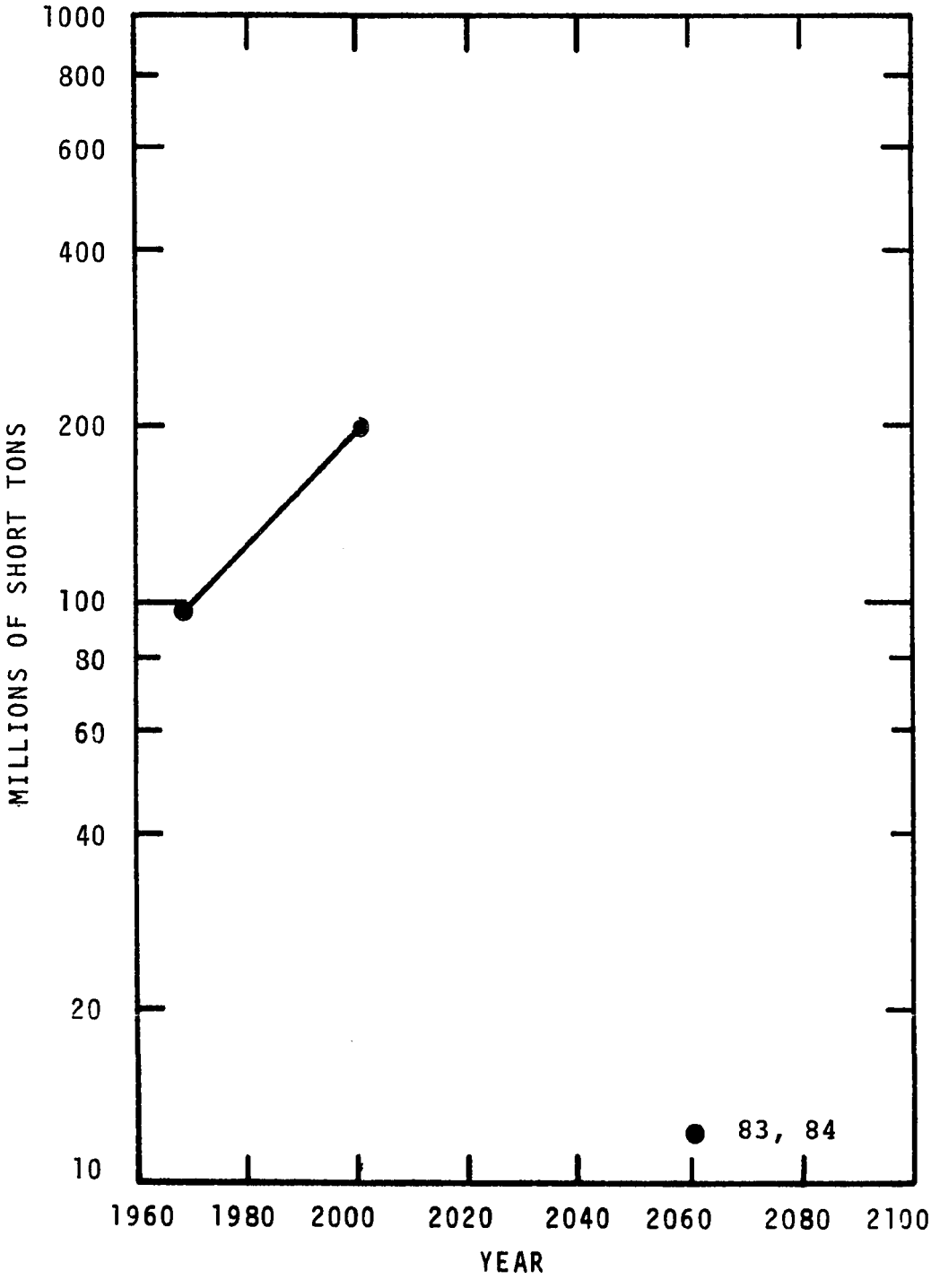


Figure A-29. Projected U.S. Pig Iron Production.

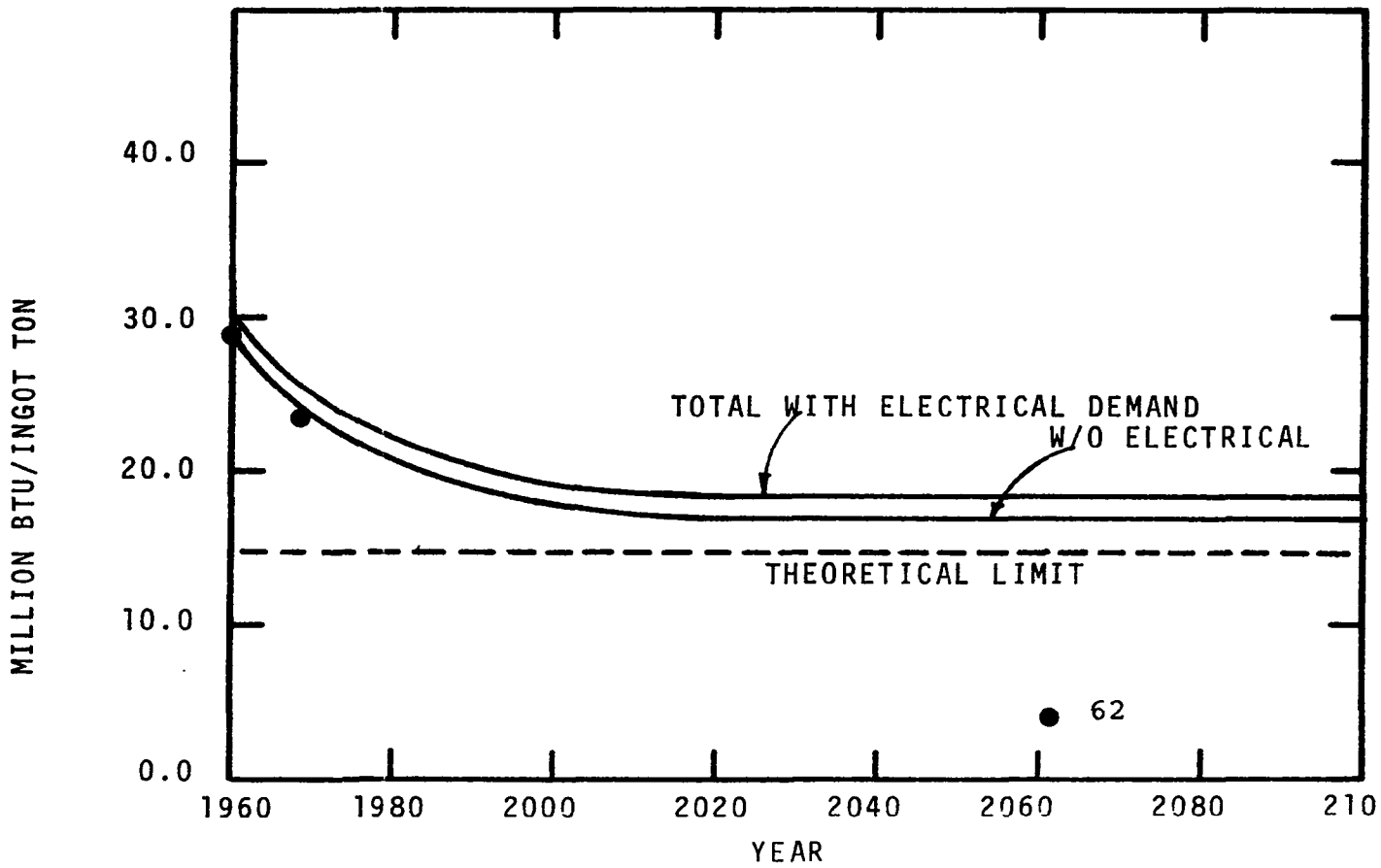


Figure A-30. Projected Pig Iron Production Energy Requirements per Ingot Ton.

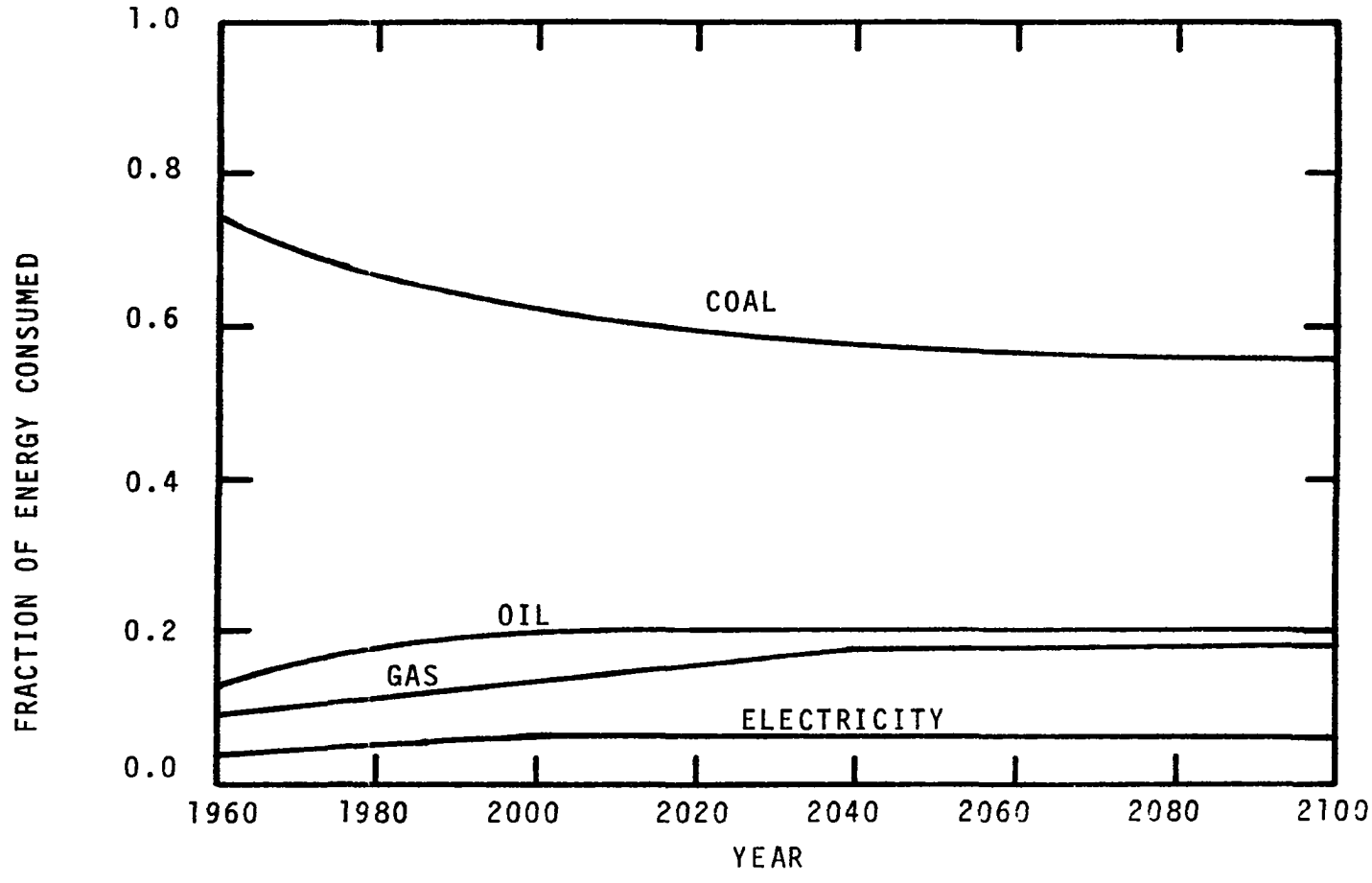


Figure A-31. Projected Pig Iron Fuel Fraction (36).

PIUD(I) = energy required per ton pig iron in year I, Figure A-30

PIFD(I,J) = pig iron energy demand fraction for fuel J in year I, Figure A-31

The total pig iron energy demand for all fuels is determined by summing the U.S. pig iron energy demand for fuel J from Equation A-66 over all fuels.

$$PIDT = \sum_{J=1}^{21} PID(J) \qquad \text{(A-67)}$$

where

PIDT = total U.S. pig iron energy demand in trillion Btu/year

Steel

The energy demand for U.S. domestic steel production is determined by projecting the domestic steel production; the fraction of steel made in each furnace type, Figure A-33; the energy required per ton of steel produced for each furnace type, Table A-3; and the fuel supply fraction for each furnace type, Table A-4. The domestic steel production is projected using literature projections to the year 2000, Figure A-32, and subsequently using the projected gross national product, Figure III-6, as the projection basis.

$$STP(I) = STP(2000) \times GNP(I)/GNP(2000) \quad \text{for } I \geq 2000 \qquad \text{(A-68)}$$

where

STP(I) = domestic steel production in year I for $I \geq 2000$

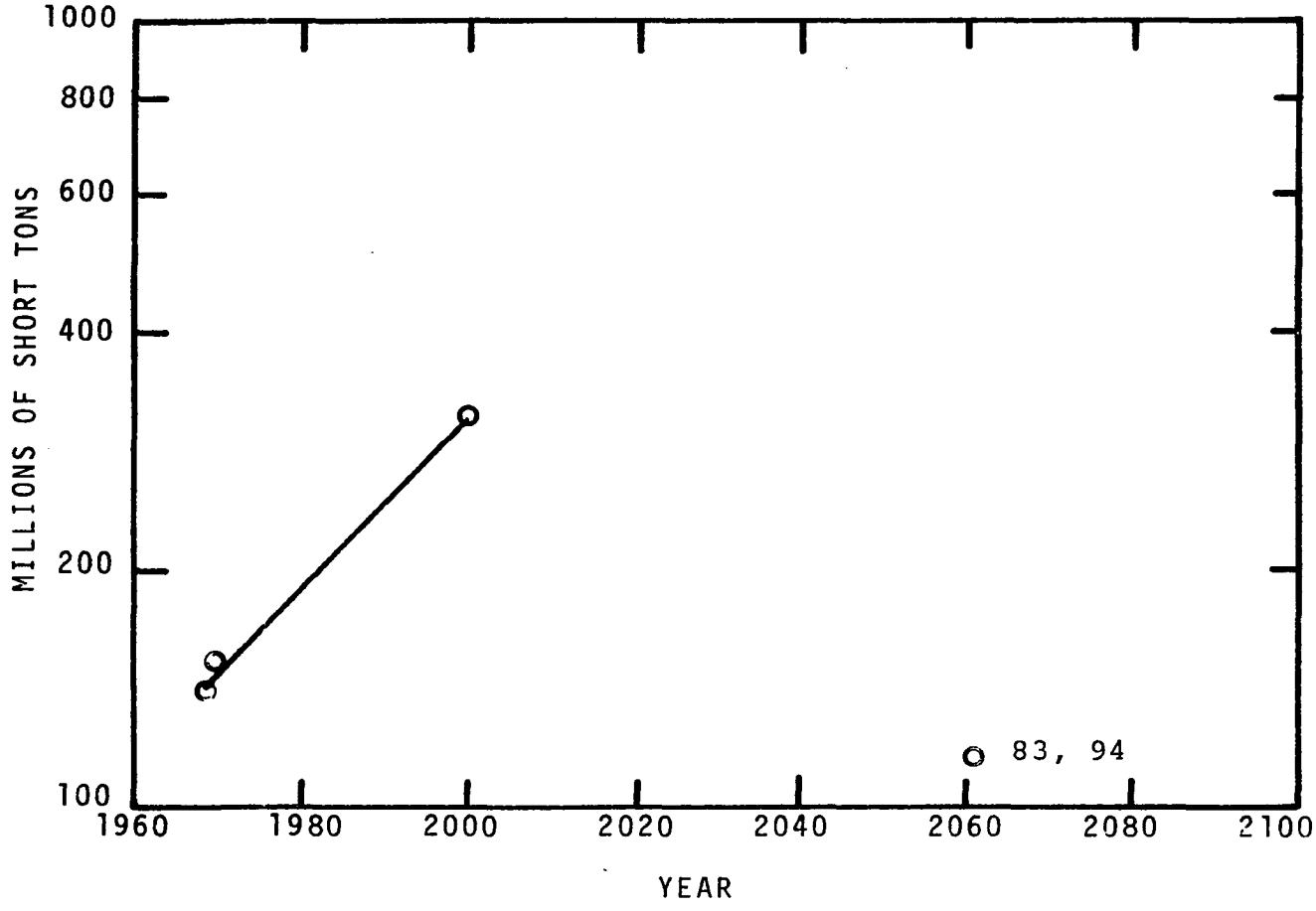


Figure A-32. Projected U.S. Steel Production.

GNP(I) = gross national product in year I

STP(2000) = domestic steel production in the year 2000 from Figure A-32

The steel energy demand for fuel J in year I is given by

$$STD(J) = STP(I)[BOF(I) \times BOFUD \times BOFFD(I,J) + SEL(I) \times SELUD \times SELFD(I,J) + OH(I) \times OHUD \times OHFD(I,J)] \quad \text{(A-69)}$$

where

STD(J) = U.S. steel energy demand for fuel J

STP(I) = domestic steel production in year I, Equation A-68

BOF(I) = fraction of steel produced in BOF plants in year I, Figure A-33

BOFUD = energy requirement per ton steel in BOF plant, Table A-3

BOFFD(I,J) = BOF steel energy demand fraction for fuel J in year I, Table A-4

SEL(I) = fraction of steel produced in electric arc furnaces in year I, Figure A-33

SELUD = energy required per ton steel in electric arc plant, Table A-3

SELFD(I,J) = electric arc steel energy demand fraction for fuel J in year I, Table A-4

OH(I) = fraction of steel produced in open hearth plants in year I, Figure A-33

OHUD = energy required per ton steel in an open hearth plant, Table A-3

OHFD(I,J) = open hearth steel energy demand fraction for fuel J in year I, Table A-4

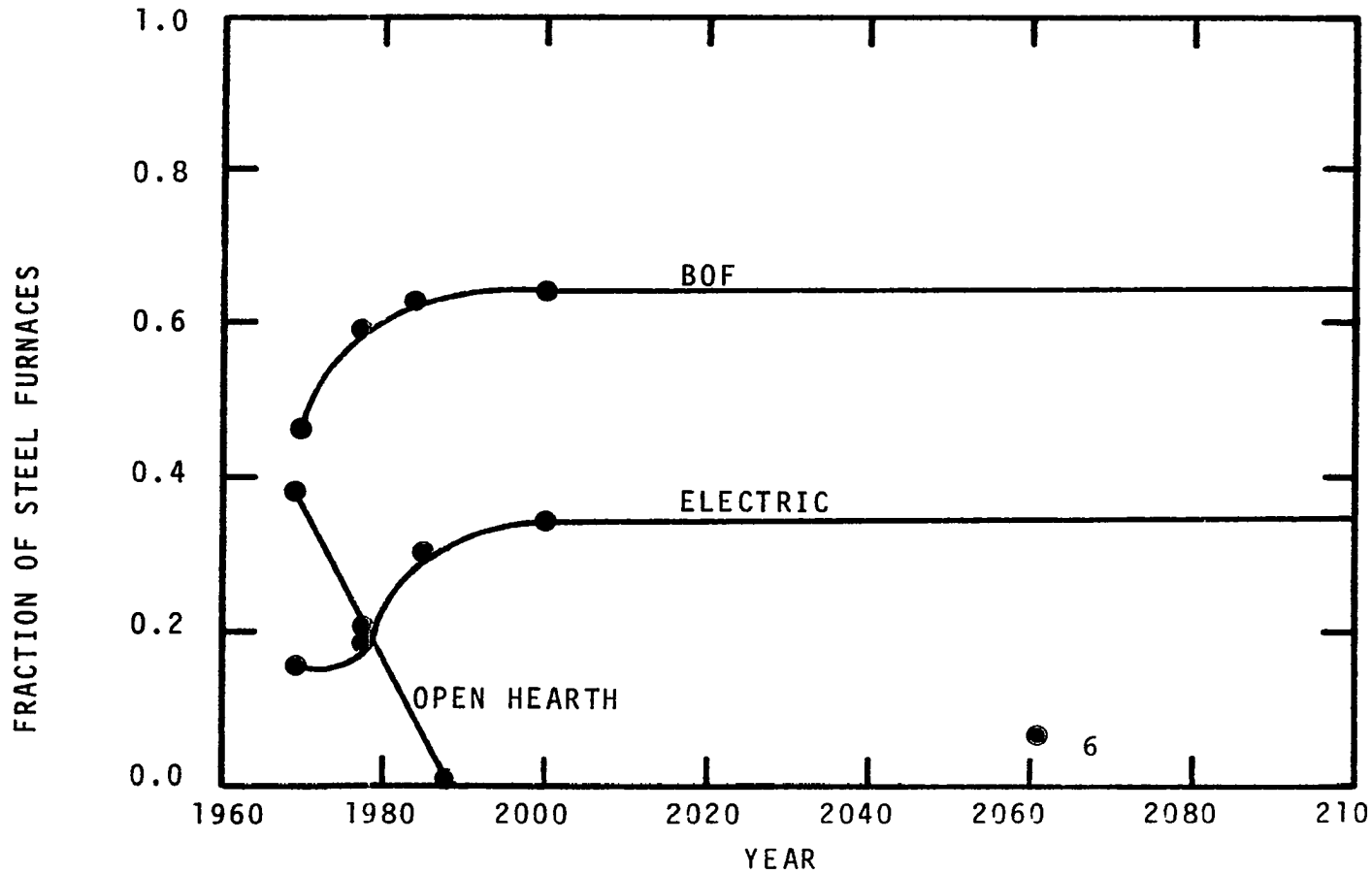


Figure A-33. Projected U.S. Steel Furnace Fractions.

The total steel energy demand for all fuels is determined by summing the U.S. steel energy demand for fuel J from Equation A-69 over all fuels

$$STDT = \sum_{J=1}^{21} STD(J) \qquad \text{(A-70)}$$

where

STDT = total U.S. steel energy demand in trillion Btu/year

Zinc

The energy demand for U.S. domestic zinc production is determined by projecting the domestic primary and secondary zinc production; the energy required per ton of primary zinc produced and the energy required per ton of secondary zinc produced, Table A-3; and the fuel supply fraction for primary zinc plants and for secondary zinc plants, Table A-4. The domestic primary and secondary zinc production is projected using literature projections to the year 2000, Figure A-34, and subsequently using the projected gross national product, Figure III-6.

$$ZNPP(I) = ZNPP(2000) \times GNP(I)/GNP(2000) \text{ for } I \geq 2000 \qquad \text{(A-71)}$$

$$ZNSP(I) = ZNSP(2000) \times GNP(I)/GNP(2000) \text{ for } I \geq 2000 \qquad \text{(A-72)}$$

where

ZNPP(I) = domestic primary zinc production in year I for $I \geq 2000$

ZNSP(I) = domestic secondary zinc production in year I for $I \geq 2000$

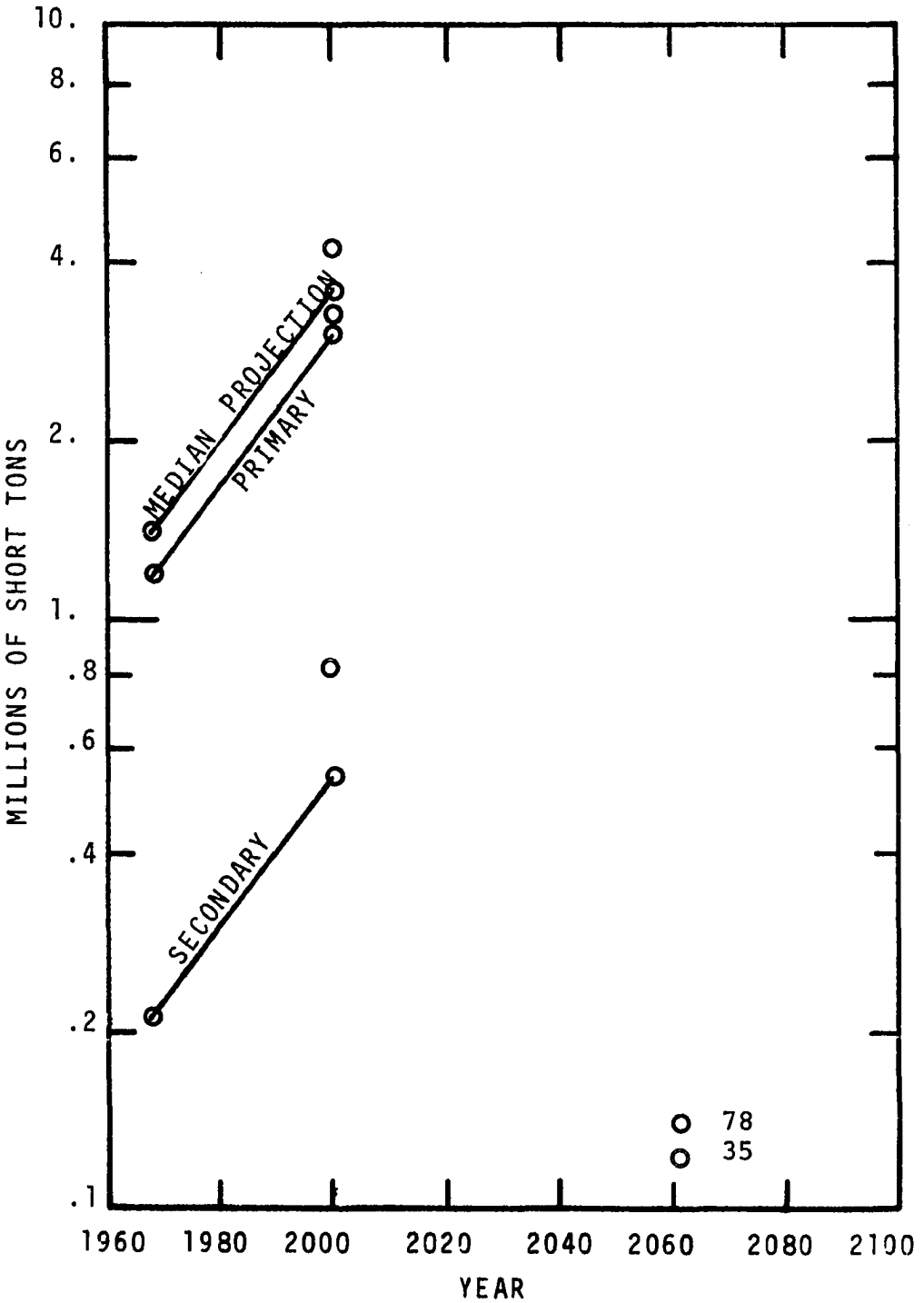


Figure A-34. Projected U.S. Zinc Production.

GNP(I) = gross national product in year I

ZNPP(2000) = domestic primary zinc production in year 2000 from Figure A-34

ZNSP(2000) = domestic secondary zinc production in year 2000 from Figure A-34

The primary zinc energy demand for fuel J in year I is given by

$$ZNPD(J) = ZNPP(I) \times ZNPUD(I) \times ZNPFD(I,J) \quad (A-73)$$

where

ZNPD(J) = U.S. primary zinc energy demand for fuel J

ZNPP(I) = domestic primary zinc production in year I, Equation A-72

ZNPFD(I,J) = primary zinc energy demand fraction for fuel J in year I, Table A-4

ZNPUD(I) = energy required per ton primary zinc in year I, Table A-3

The secondary zinc energy demand for fuel J in year I is given by

$$ZNSD(J) = ZNSP(I) \times ZNSUD(I) \times ZNSFD(I,J) \quad (A-74)$$

where

ZNSD(J) = U.S. secondary zinc energy demand for fuel J

ZNSP(I) = domestic secondary zinc production in year I

ZNSFD(I,J) = secondary zinc energy demand fraction for fuel J in year I, Table A-4

ZNSUD(I) = energy required per ton secondary zinc in year I, Table A-3

The total primary zinc energy demand and secondary zinc energy demand for all fuels are determined by summing Equations A-73 and A-74, respectively, over all fuels.

$$ZNPDT = \sum_{J=1}^{21} ZNPD(J) \qquad (A-75)$$

where

ZNPDT = total U.S. primary zinc energy demand in trillion Btu/year

$$ZNSDT = \sum_{J=1}^{21} ZNSD(J) \qquad (A-76)$$

where

ZNSDT = total U.S. secondary zinc energy demand in trillion Btu/year

Transportation Projections

The transportation energy demand is generated from six different categories of transportation: airplanes, automobiles, buses, railroads, ships (or barges), and trucks.

Airplanes

The energy demand for air passenger and freight transportation is projected by using the average air transportation energy demand projection, Figure A-35, and the projected airplane fuel fraction. The airplane transportation energy demand for fuel J in year I is given by

$$APD(J) = APBI(I) \times APDF(I,J) \qquad (A-77)$$

where

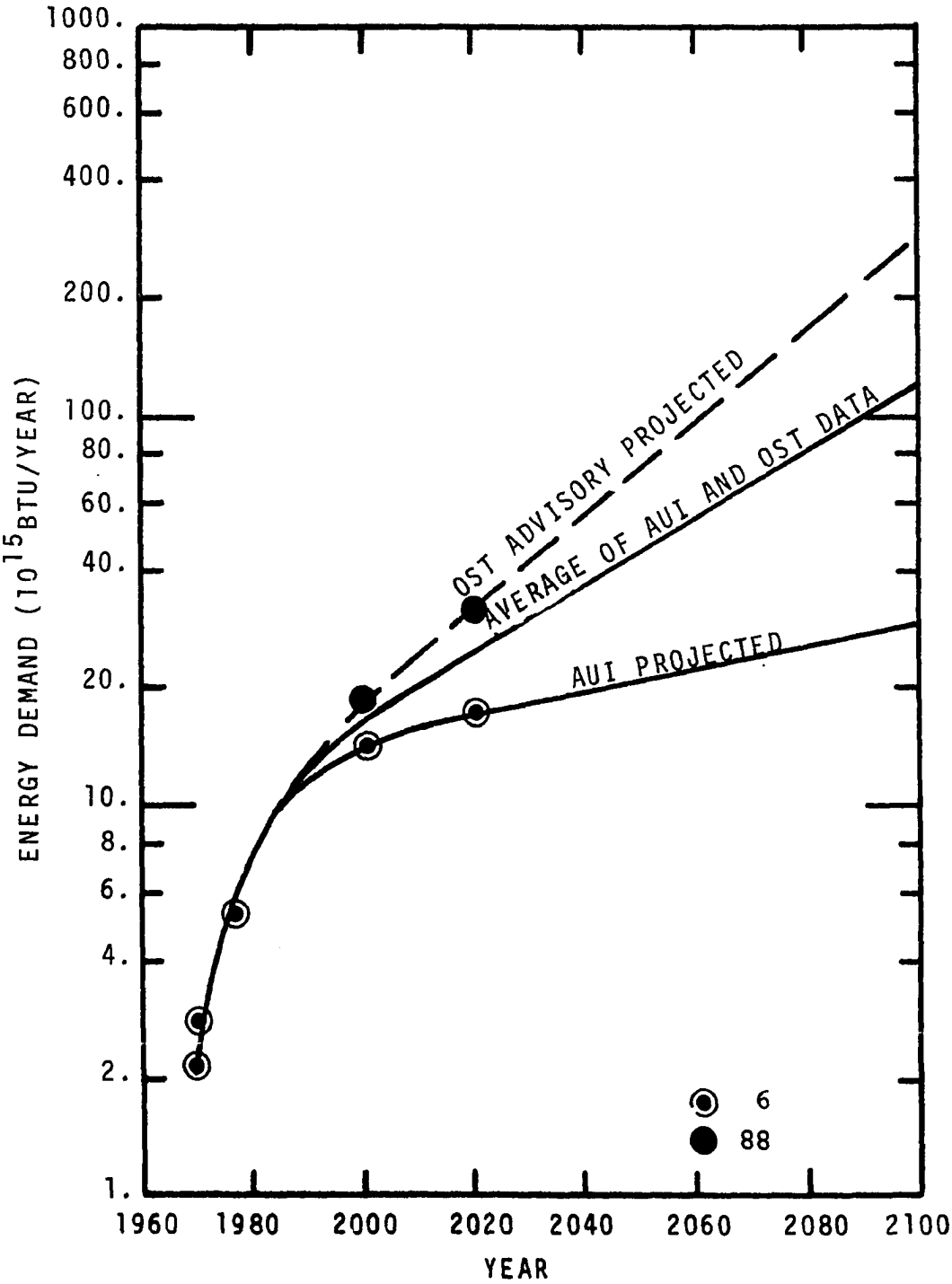


Figure A-35. Air Transportation Energy Demand Projection.

APD(J) = U.S. airplane transportation energy demand for fuel J

APBI(I) = projected airplane transportation energy requirements in year I

APDF(I,J) = airplane energy demand fraction for fuel J in year I

The total airplane transportation energy demand for all fuels is determined by summing the airplane transportation energy demand for fuel J from Equation A-77 over all fuel types.

$$APDT = \sum_{J=1}^{21} APD(J) \qquad (A-78)$$

where

APDT = total U.S. airplane transportation energy demand in trillion Btu/year

Automobiles

The energy demand for automobile transportation is projected by using the automobile energy demand projection, Figure A-36, and the projected automobile fuel fraction. The automobile transportation energy demand for fuel J in year I is given by

$$AUD(J) = AUBI(I) \times AUDF(I,J) \qquad (A-79)$$

where

AUD(J) = U.S. automobile transportation energy demand for fuel J

AUBI(I) = projected automobile transportation energy requirements in year I

AUDF(I,J) = automobile energy demand fraction for fuel J in year I

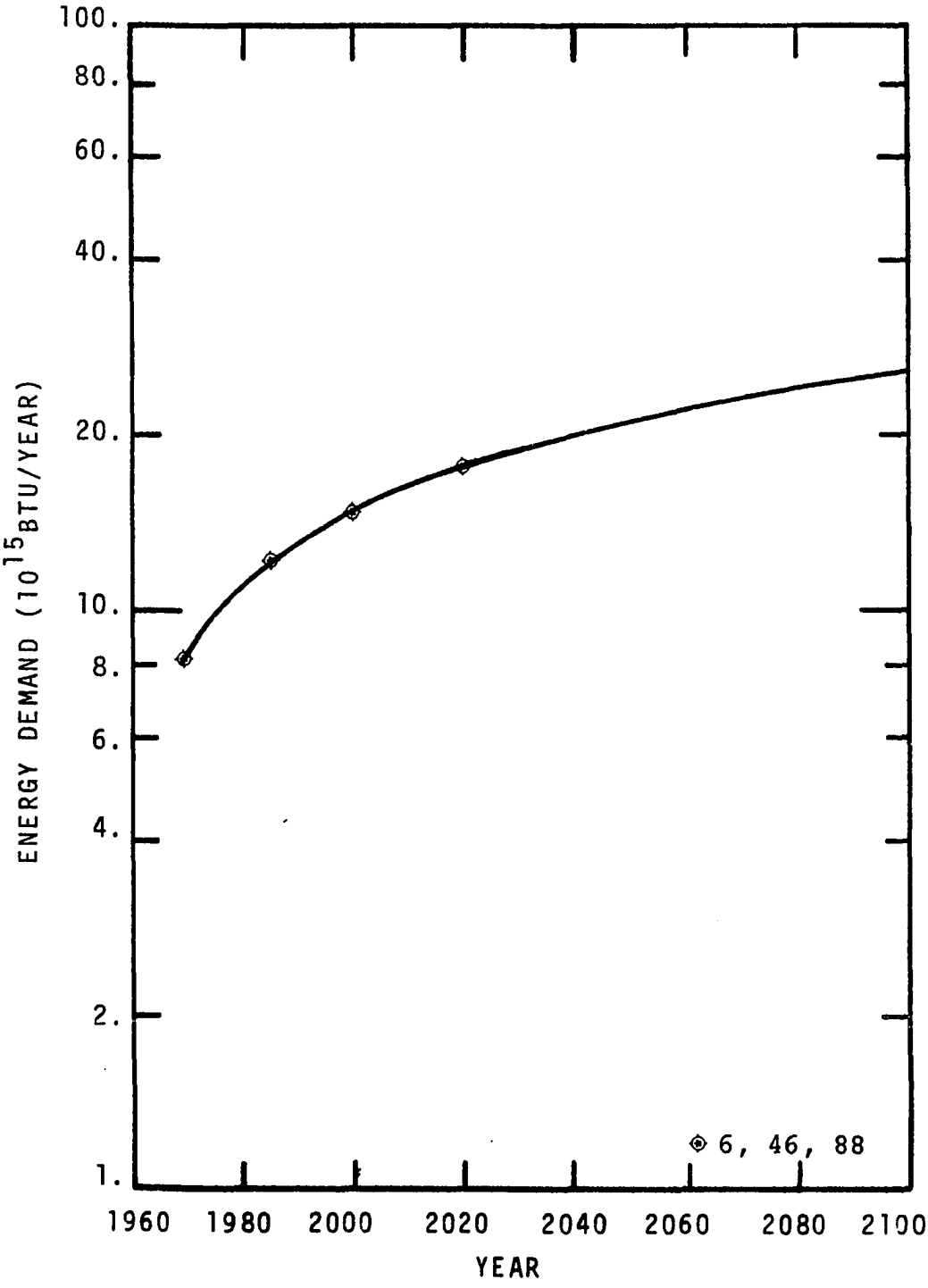


Figure A-36. Automobile Energy Demand Projection.

The total automobile transportation energy demand for all fuels is determined by summing the automobile transportation energy demand for fuel J from Equation A-79 over all fuel types.

$$AUDT = \sum_{J=1}^{21} AUD(J) \qquad (A-80)$$

where

AUDT = total U.S. automobile transportation energy energy demand in trillion Btu/year

Bus

The energy demand for bus transportation is projected by using the bus transportation energy demand projection, Figure A-37, and the projected bus fuel fraction, Figure A-38. The bus transportation energy demand for fuel J in year I is given by

$$BD(J) = BBI(J) \times BDF(I,J) \qquad (A-81)$$

where

BD(J) = U.S. bus transportation energy demand for fuel J

BBI(J) = projected bus transportation energy requirements in year I

BDF(I,J) = bus energy demand fraction for fuel J in year I

The total bus transportation energy demand for all fuels is determined by summing the bus transportation energy demand for fuel J from Equation A-81 over all fuel types.

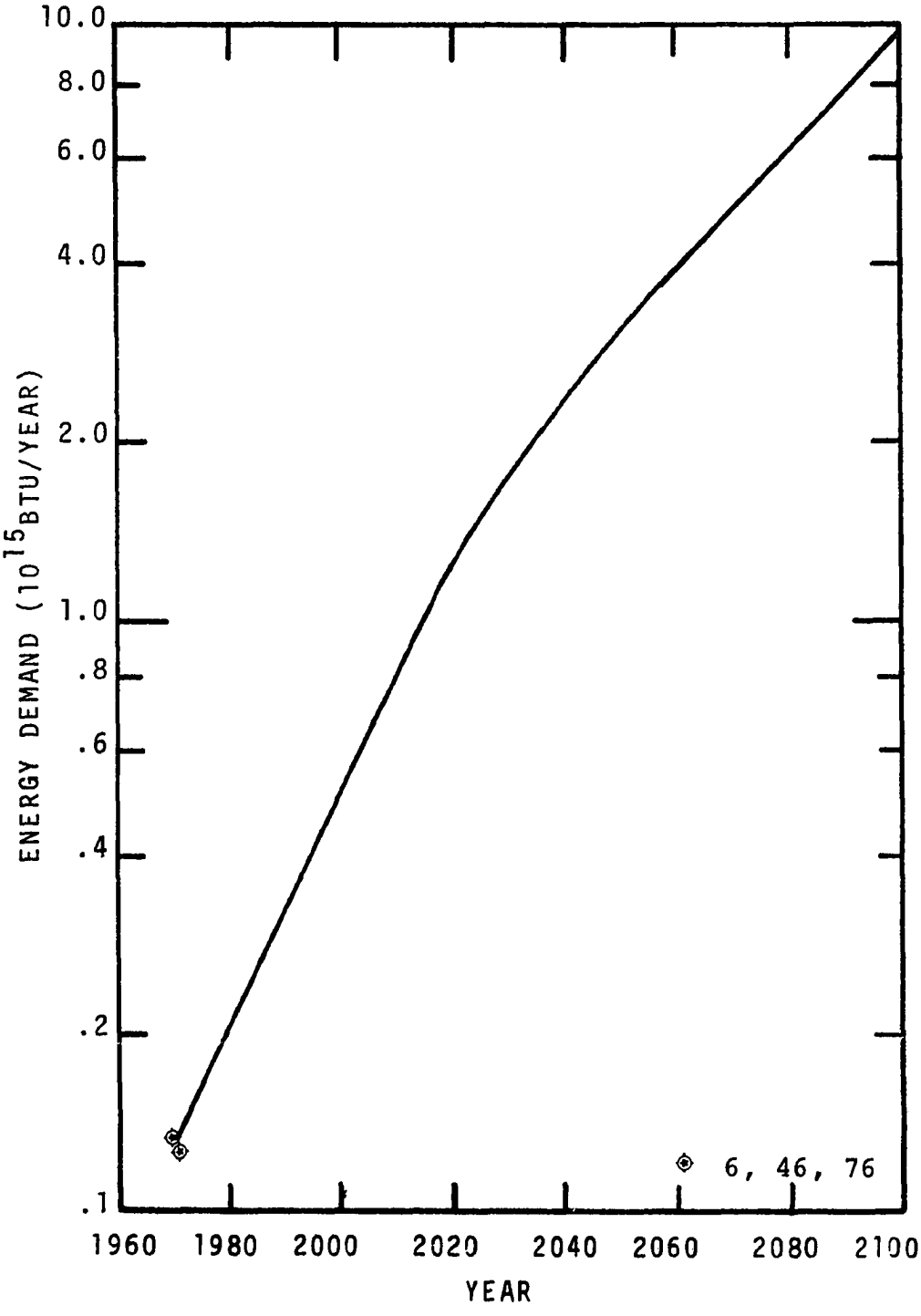


Figure A-37. Bus Transportation Energy Demand Projection.

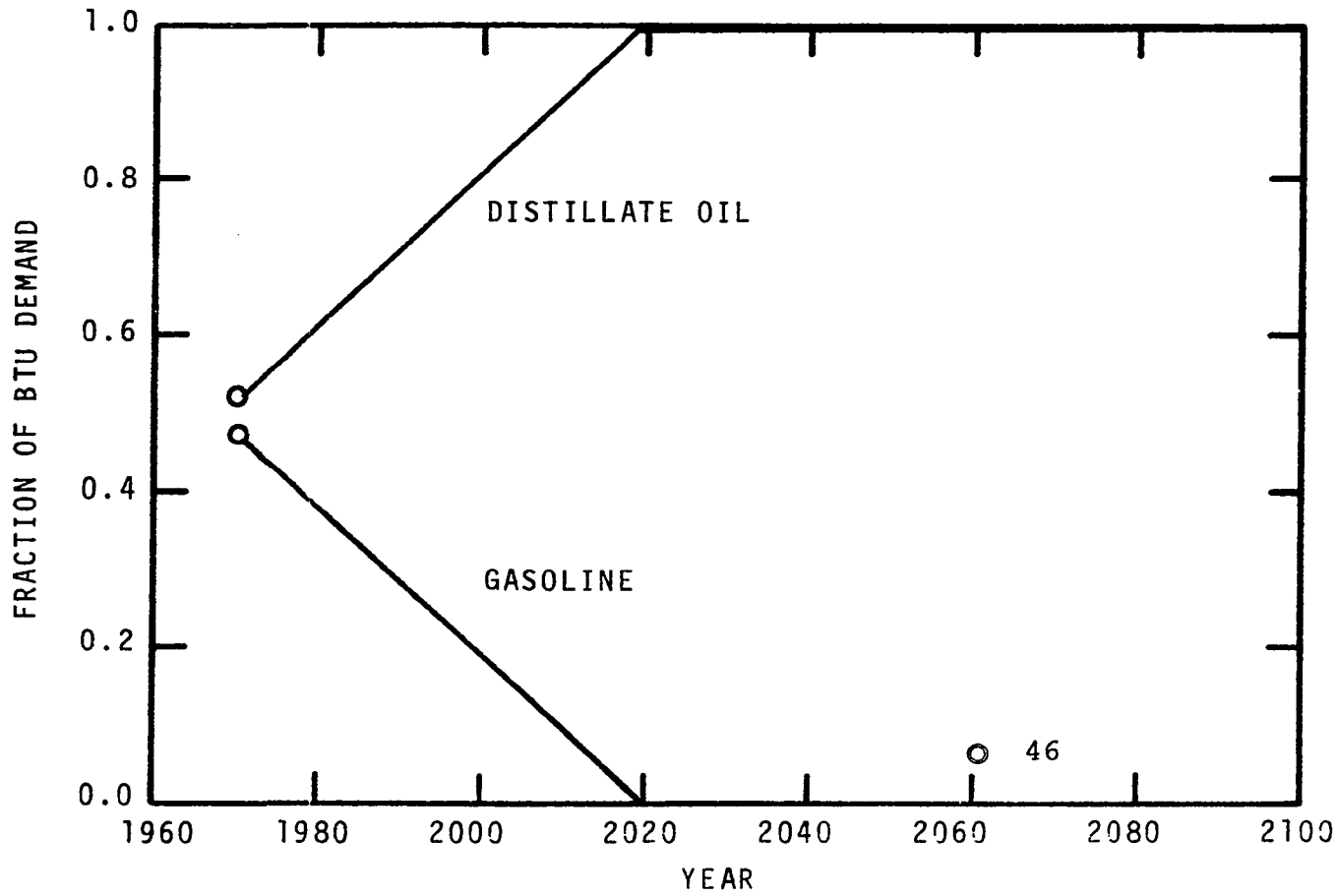


Figure A-38. Bus Fuel Fraction Projection.

$$BDT = \sum_{J=1}^{21} BD(J) \qquad \text{(A-82)}$$

where

BDT = total U.S. bus transportation energy demand in trillion Btu/year

Railroad

The energy demand for railroad transportation is projected by using the railroad transportation energy demand projection, Figure A-39, and the projected railroad fuel fraction, Figure A-40. The railroad transportation energy demand for fuel J in year I is given by

$$RRRD(J) = RRBI(I) \times RRDF(I,J) \qquad \text{(A-83)}$$

where

RRRD(J) = U.S. railroad transportation energy demand for fuel J

RRBI(I) = projected railroad transportation energy requirements in year I

RRDF(I,J) = railroad energy demand fraction for fuel J in year I

The total railroad transportation energy demand for all fuels is determined by summing the railroad transportation energy demand for fuel J from Equation A-83 over all fuel types.

$$RRDT = \sum_{J=1}^{21} RRRD(J) \qquad \text{(A-84)}$$

where

RRDT = total U.S. railroad transportation energy demand in trillion Btu/year

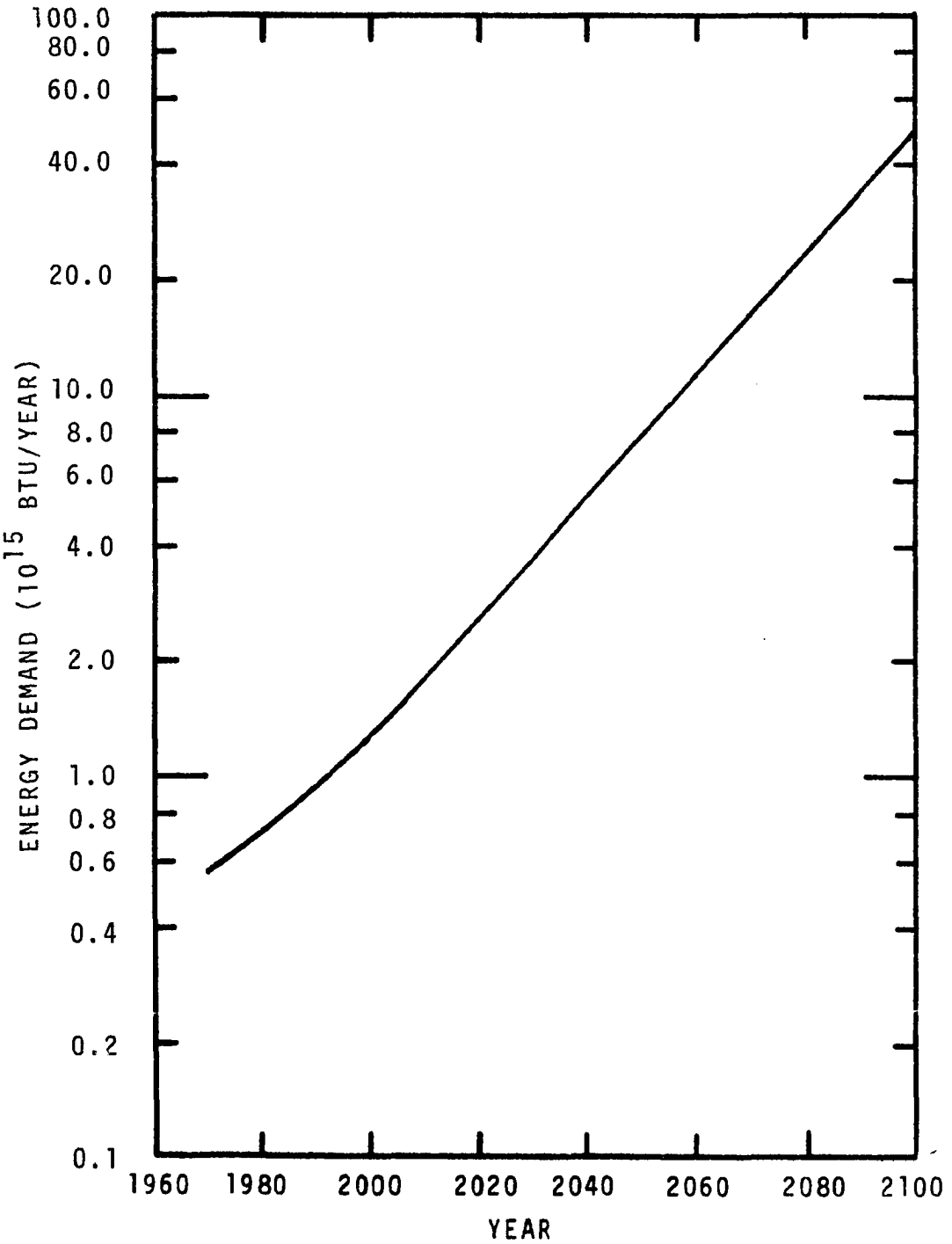


Figure A-39. Railroad Transportation Energy Demand Projection (6, 46, 88).

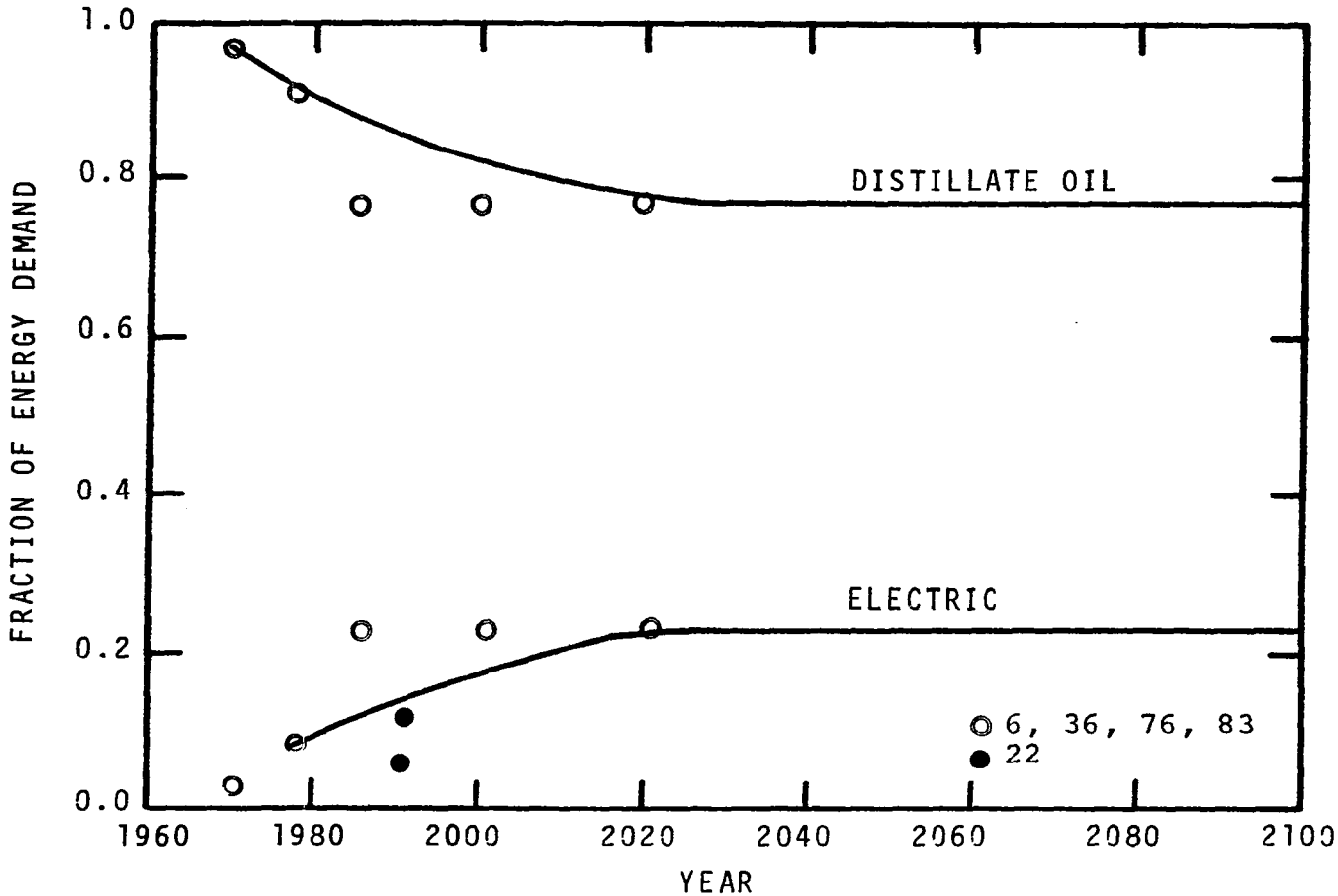


Figure A-40. Railroad Fuel Fraction Projection.

Ships (or Barges)

The energy demand for ship (or barge) transportation is projected by using the average ship or barge transportation energy demand projection, Figure A-41, and the projected ship (or barge) fuel fraction, Figure A-42. The ship (or barge) transportation energy demand for fuel J in year I is given by

$$SD(J) = SBI(I) \times SDF(I,J) \qquad \text{(A-85)}$$

where

SD(J) = U.S. ship (or barge) transportation energy demand for fuel J

SBI(I) = projected ship transportation energy requirements in the year I

SDF(I,J) = ship energy demand fraction for fuel J in year I

The total ship transportation energy demand for all fuels is determined by summing the ship (or barge) transportation energy demand for fuel J from Equation A-85 over all fuel types.

$$SDT = \sum_{J=1}^{21} SD(J) \qquad \text{(A-86)}$$

where

SDT = total U.S. ship (or barge) transportation energy demand in trillion Btu/year

Truck

The energy demand for truck transportation is projected by using the truck energy demand projection, Figure

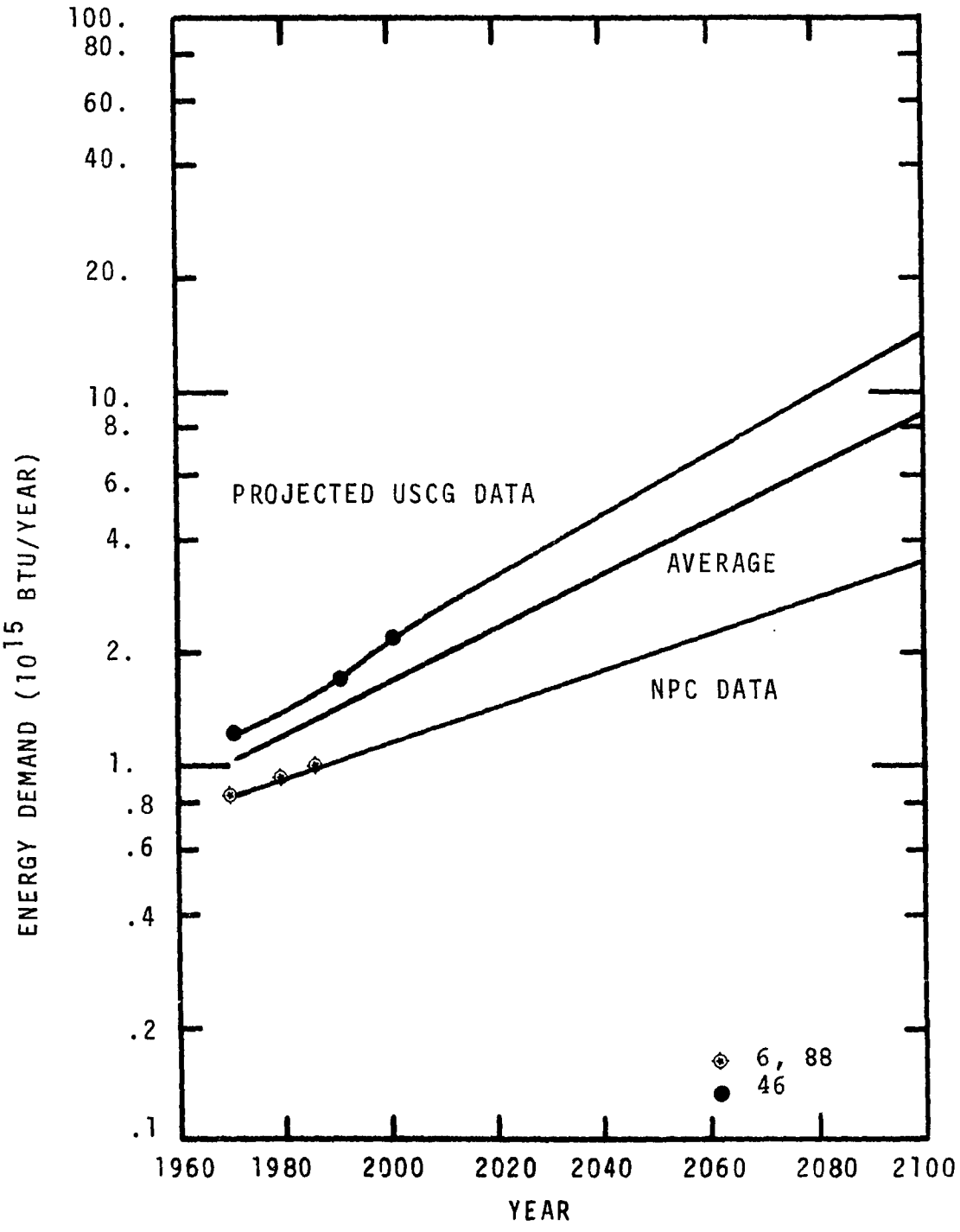


Figure A-41. Ship (or Barge) Transportation Energy Demand.

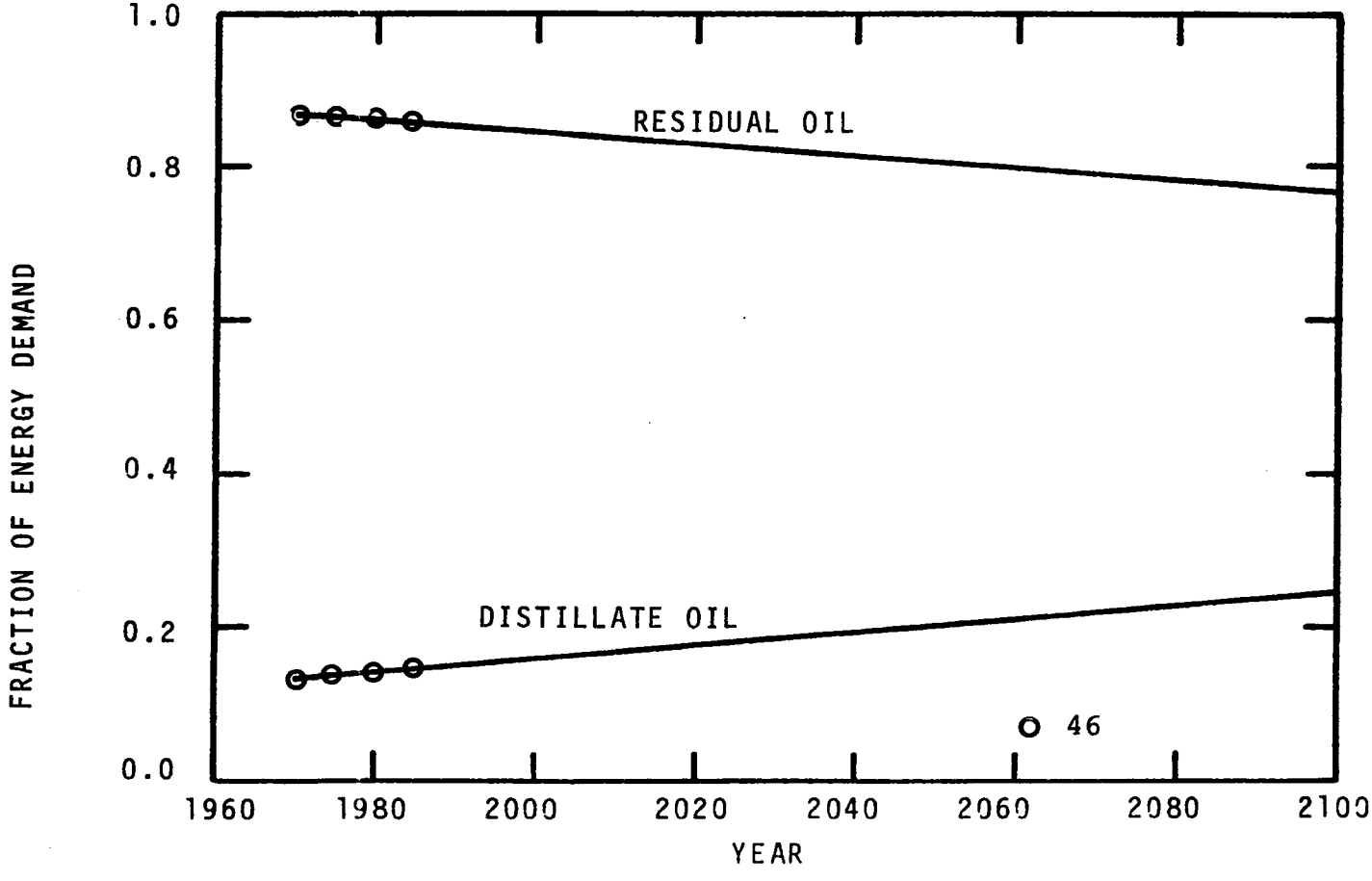


Figure A-42. Ship (or Barge) Fuel Fraction Projection.

A-43, and the projected truck fuel fraction, Figure A-44. The truck transportation energy demand for fuel J in year I is given by

$$TD(J) = TBI(I) \times TDF(I,J) \qquad \text{(A-87)}$$

where

TD(J) = U.S. Truck transportation energy demand for fuel J

TBI(I) = projected truck transportation energy requirements in the year I

TDF(I,J) = truck energy demand fraction for fuel J in year I

The total truck transportation energy demand for all fuels is determined by summing the truck transportation energy demand for fuel J from Equation A-87 over all fuel types.

$$TDT = \sum_{J=1}^{21} TD(J) \qquad \text{(A-88)}$$

where

TDT = total U.S. truck transportation energy demand in trillion Btu/year

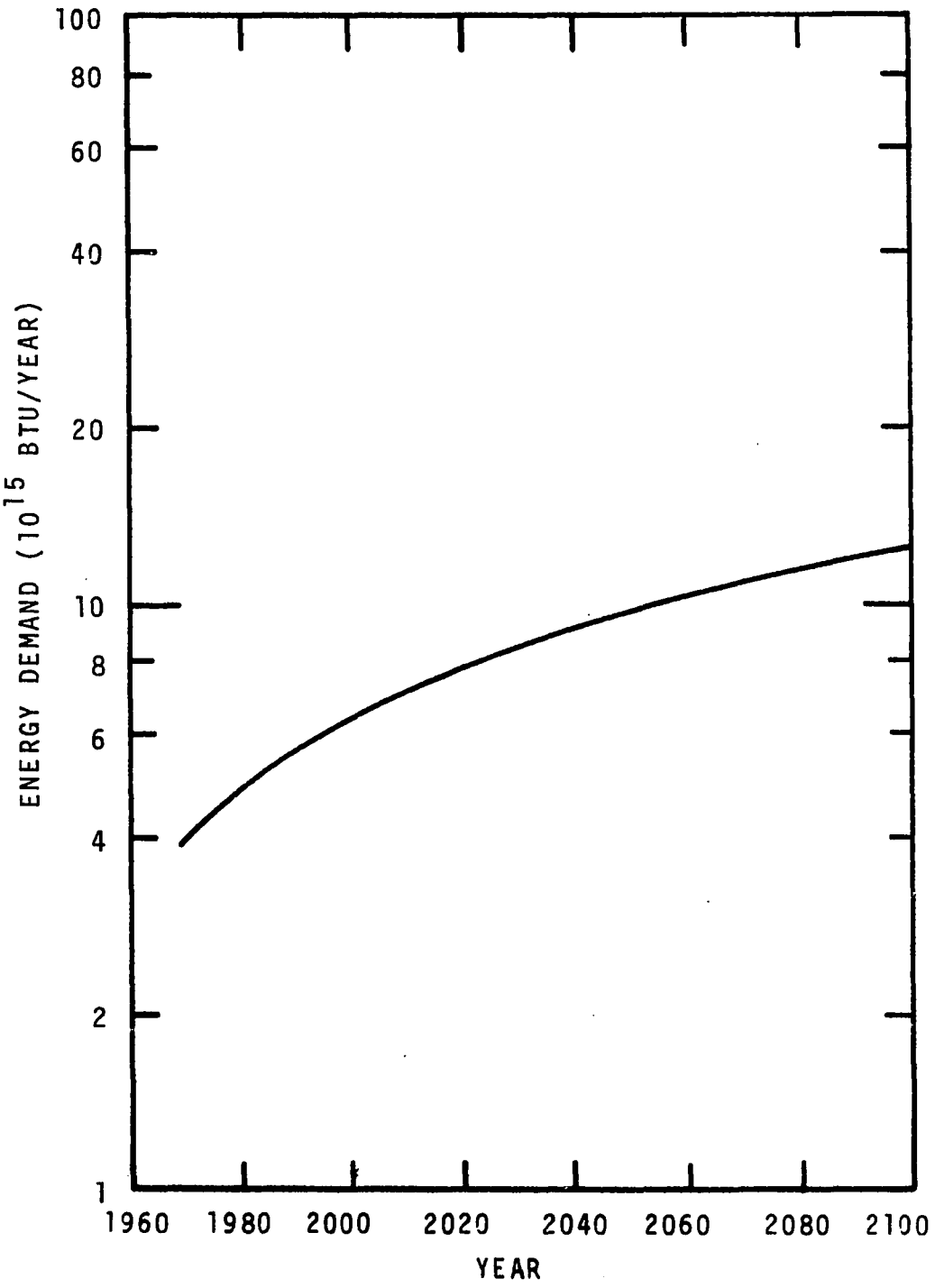


Figure A-43. Truck Transportation Energy Demand Projection (6, 46, 76).

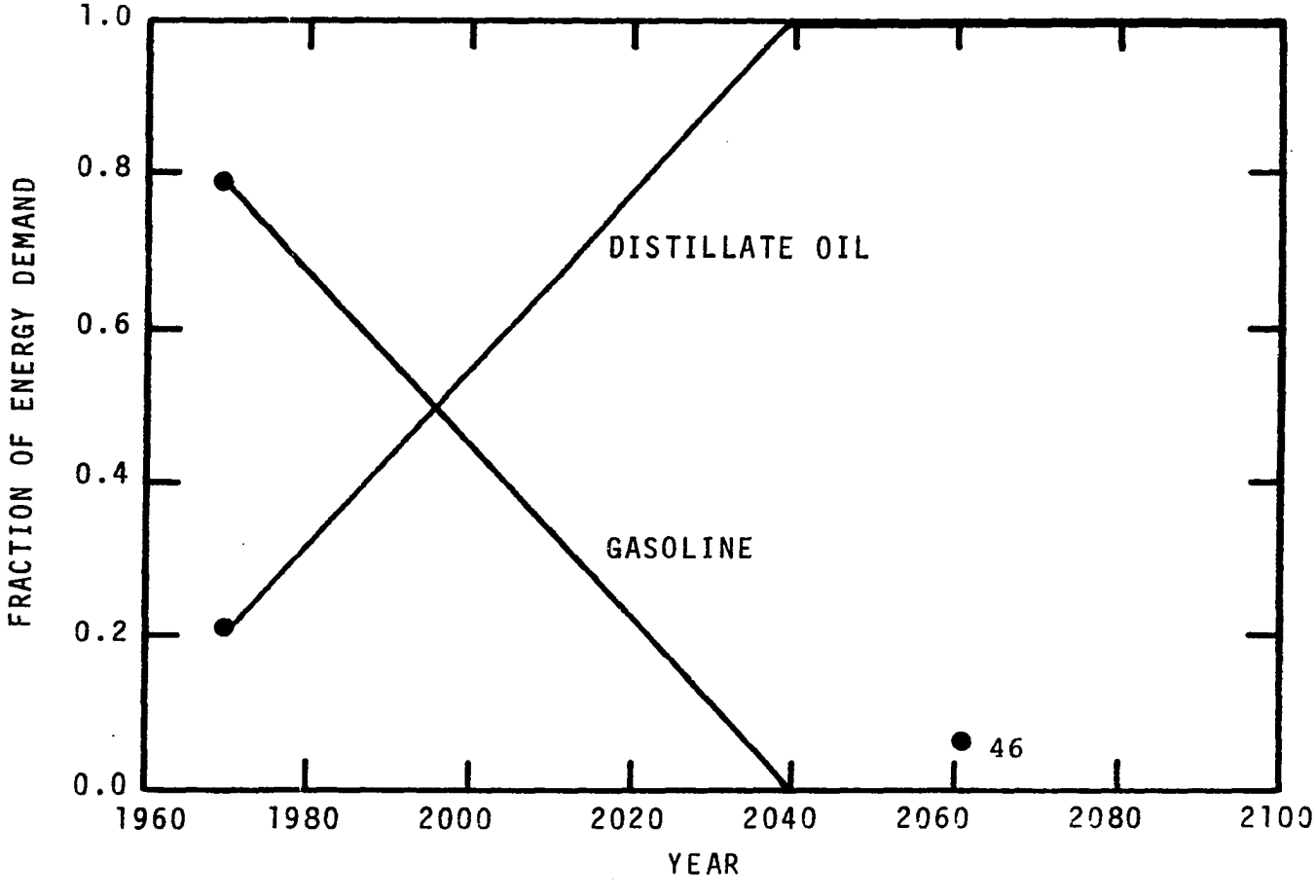


Figure A-44. Truck Fuel Fraction Projection.

APPENDIX B

MANERGY PROGRAM LISTING

This appendix contains the computer program listing of MANERGY--A U.S. ENERGY SYSTEM MODEL. The main program controls the model's calculations. All data for the main program and all subroutines are contained in the Block Data set. By changing applicable data in the Block Data set, various fuel, resource and technology alternatives may be evaluated.

The model is separated into subroutines. The purpose of each subroutine is as follows.

Subroutine AMMON(I)

Subroutine AMMON(I) calculates the hydrogen and electrical fuel demands created by using ammonia as a liquid fossil fuel substitute. It assumes all ammonia is made from electrolytic hydrogen and air.

Subroutine COAL(I)

Subroutine COAL(I) determines the ecological impact of coal production in terms of land use and coal production requirements for both strip mining and underground mining.

Subroutine COMMD(I)

Subroutine COMMD(I) calculates the commercial end utilization energy demands for the 21 fuel types and the airborne emission for each of the six commercial use categories.

Subroutine CONVG(Calc, Assum, Test)

Subroutine CONVG(Calc, Assum, Test) determines if the main program iterations have converged to within the specified limit.

Subroutine CRUDE(I)

Subroutine CRUDE(I) determines the petroleum demand and balances this demand with domestic crude production, oil shale production, tar sands production, syncrude from coal, and oil imports. It also determines the environmental impacts of crude oil demands in terms of airborne emission, solid waste, elemental sulfur and land use for petroleum production.

Subroutine ELGEN(I)

Subroutine ELGEN(I) calculates the electrical power production energy demands for each of the 21 fuel types, corrects the electrical power requirements for transmission and distribution losses, calculates the amount of separative work, and calculates power required for separative work.

Subroutine GAS(I)

Subroutine GAS(I) balances gas demand with domestic natural gas supply, LNG imports, coal gasification, syngas from petroleum and Canadian gas pipeline imports. It corrects the gas demand for transmission losses and corrects the domestic production for lease losses and plant fuel use. The environment effects (airborne emissions, elemental sulfur production and solid waste production) of syngas production are also calculated.

Subroutine HYDGEN(I)

Subroutine HYDGEN(I) calculates the electrical and water requirements for electrolytic hydrogen production.

Subroutine INDUST(I)

Subroutine INDUST(I) calculates the industrial end utilization energy demands for the 21 fuel types and the airborne emissions for each of the 16 industrial use categories.

Subroutine METHOL(I)

Subroutine METHOL(I) calculates the coal resources demands and environmental impacts created by methanol production from coal. The methanol production is balanced in the methanol demand as a liquid fossil fuel substitute.

Subroutine OUTPUT(I)

Subroutine OUTPUT(I) prints all of Manergy's output and calculates the summary matrices, the U_3O_8 and ThO_2

requirements, radioactive releases and emissions, cooling water consumption, land use, solid waste, elemental sulfur and balance of payments effects.

Subroutine PETREF(I)

Subroutine PETREF(I) calculates the amount of crude petroleum that must be supplied to the refinery to meet petroleum demands, the petroleum refinery energy demands, and the environmental impact due to petroleum refining.

Subroutine RESIDD(I)

Subroutine RESIDD(I) calculates the residential end utilization energy demands for the 21 fuel types and the airborne emissions for each of the six residential end use categories.

Subroutine TRANS(I)

Subroutine TRANS(I) calculates the transportation end utilization energy demands for the 21 fuel types and the airborne emissions for each of the six transportation end use categories.

```
C      THIS IS THE CONTROL PROGRAM FOR THE U.S. ENERGY MODEL.
       COMMON /MC/TITLE1(3,21),TITLE2(3,7),NYEAR(14)
      1,SCON(14,21,7),TSCON(14,21,7)
      2,BED(21),XXBED(21),XBED(21),SYNCD(21),PRD(24),SGFR(21),
      3SCFR(21),XXP(21),ELGD(21)
      4,SFFR(21),APGTT(7),APBED(7)
       COMMON /TC/APBI(14),AUBI(14),BBI(14),RRBI(14),SBI(14),TBI(14),
      1APDF(14,21),AUDF(14,21),BDF(14,21),RRDF(14,21),SDF(14,21),TDF(14,
      221)
      3,TTD(21)
      4,APTT(7),TTDT
       COMMON/TA/PIAU70(7,21),PIAP(7,21),PIAU(7,21),PIB(7,21),PIRR(7,21),
      1PIS(7,21),PIT(7,21)
      2,          APD(21),AUD(21),BD(21),RRRD(21),SD(21),TD(21),
      3APOLAP(21,7),APOLAU(21,7),APOLB(21,7),APOLRR(21,7),APOLS(21,7),
      4APOLT(21,7),
      5APAP(7),APAU(7),ARB(7),APRRR(7),APS(7),APT(7)
       COMMON /CC/CACDF(14,21),CWHDF(14,21),CSHDF(14,21),CCDF(14,21),CMDF
      1(14,21),CRDF(14,21),CACB,CSHB,CWHB,CCB,CMB,CRB,
      2CACEF(14,21),CWHEF(14,21),CSHEF(14,21),CCEF(14,21),CMEF(14,21),CRE
      3F(14,21),GNPR70(14)
      4,TCD(21)
      5,APCT(7),TCDT
       COMMON/CA/PIC(7,21)
      1,          APCAC(7),APCSH(7),APCC(7),APCM(7)          ,APCWH(7),APCR(
      27)
      3,                  CACD(21),CRD(21),CSHD(21),CWHD(21),CCD(21),CMD(2
      41)
      5,          APLCAC(21,7),APLCSH(21,7),APLCWH(21,7),APLCC(21,7),APLCM
      6(21,7),APLCR(21,7)
       COMMON /MRC/RSRAC(14),RSCAC(14),RSC(14),RSR(14),RSSH(14),RSWH(14),
      1RRACHF(14,21),RCACHF(14,21),RCHF(14,21),RRHF(14,21),RSHHF(14,21),
      2RWHHF(14,21),HHLD(14),
      3RRACEF(14,21),RCACEF(14,21),RCEF(14,21),RREF(14,21),RSHEF(14,21),
      4RWHEF(14,21)
      5,TRD(21)
```

```
6,APRT(7),TRDT
 COMMON/RA/APRAC(7),APRSH(7),APRWH(7),APPR(7),APRM(7)          ,APRC(
17),RRACD(21),RCACD(21),RACD(21),RRD(21),RSHD(21),RWHD(21),RCD(21),
2RMD(21),          DRM70(21)
3,          PIR(7,21)
4,          APLRAC(7,21),APLRSH(7,21),APLRWH(7,21),APLRR(7,21),APLRC
5(7,21),APLRM(7,21)
6,          UDRRAC(21),UDRCAC(21),UDRC(21),UDRR(21),UDRSH(21),UDRWH(
721)
 COMMON/IC/ALP(14),ALPP(14),CEP(14),ALSP(14),CHP(14),CUPP(14),
1CURP(14),XMGPP(14),XMGSP(14),ZNPP(14),ZNSP(14),PIP(14),XIMEP(14),
2XIMFP(14),STP(14),BOF(14),SEL(14),OH(14),XIRMP(14),GNPR90(14),
3GNPR20(14),ALFD(14,21),ALPFD(14,21),ALSFD(14,21),CEFD(14,21),
4CHFD(14,21),CUPFD(14,21),CURFD(14,21),XMGPFD(14,21),XMGSFD(14,21),
5ZNPFD(14,21),ZNSFD(14,21),PIFD(14,21),XIMEFD(14,21),XIMFFD(14,21),
6SELFD(14,21),BOFFD(14,21),OHFD(14,21),XIRMFD(14,21),
7ALUD(14),ALPUD(14),ALSUD(14),CEUD(14),CHUD(14),CUPUD(14),CURUD(14)
8,XMGPUD(14),XMGSUD(14),ZNPUD(14),ZNSUD(14),PIUD(14)
9,TID(21),APIT(7),TIDT
 COMMON/IA/APALT(7),APALPT(7),APALST(7),APCET(7),APCHT(7),APCUPT(7)
1,APCURT(7),APMGPT(7),APZNPT(7),APZNST(7),APIMET(7),APIMFT(7),
2APIRMT(7),APSTT(7),APMGST(7),APPIT(7)
 COMMON/IB/ALPI(2,7),ALPPI(2,7),ALSPI(2,7),CEPI(2,7),CHPI(2,7),
1CUPPI(2,7),CURPI(2,7),XMGPPI(2,7),XMGSPI(2,7),ZNPPI(2,7),
2ZNSPI(2,7),PIPI(2,7),XIMFPI(2,7),XIMFPI(2,7),XIRMPI(2,7),BOFPI(2,7
3),SELPI(2,7),OHPI(2,7)
 COMMON/ID/XIMED(21),XIMFD(21),ALPD(21),ALSD(21),CED(21),CHD(21),
1CUPD(21),CURD(21),XMGPD(21),XMGSD(21),ZNPD(21),ZNSD(21),PID(21),
2STD(21),XIRMD(21),PII(7,21),APAL(7,21),APALP(7,21),APALS(7,21),
3APCE(7,21),APCUP(7,21),APCUR(7,21),APMGS(7,21),APZNP(7,21),
4APZNS(7,21),APPI(7,21),APST(7,21),APIME(7,21),APIMF(7,21),APIRM(7,
521),APCH(7,21),APMGP(7,21),          ALD(21)
 COMMON/AMC/AMH2D,AMELD
 COMMON/GASC/DNGP(14),XLNGF(14),SGASF(14),    SGEF(21),SGASFF(14,21)
1,APSG(7,21),APSGT(7),CLG,PISG(7,21)
2,CGPLIF(14)
```

```
     3,CORGD,CGPLI,XLNGI,SGASR,SGSUL,SGSW
      COMMON/PRC/PREF(14,24),PRUD(14),CTSR(14),PIPR(7,24),          APPRT(
     17),APPR(7,24),PSCON(14,24,7),PIPRS(7)
     2,CTS,PRDTT
      COMMON/EGC/EGFD(14,21),EGEF(14,21),XKGSW(14,21),UEDSW(14),U308UD(1
     14,21),TH02UD(14,21),WUOT(21),WCCT(21),WCOT(21),WCCP(21),PEFAC(21),
     2RLL(21),XLDUS(21),SLDW(21),  XKR85F(21),TRF(21),PIEG70(7,21),PIEG(7
     3,21),FREC(14),APEGT(7),RLLCI(21),FROT(14),FRNC(14),FRSP(14),
     4FRCP(14),FRDC(14),APEG(7,21),SWREQ(21),TP(21),RLLC(21),PE(21),
     5RLLW(21),CWC(21),CWU(21),XLDU(21),XLDUC(21),XKR85(21)
     6,XLUCTF,XLUSPF,XLUCPF,XLUETF,XLUCMF
     7,SWREQT,PRSW,TTH02,TTU308,TKR85,TTR,TRLLC,TPE,TRLLW,TCWC,TCWU,TLU
      COMMON/CRC/DCP(14),OIF(14),TSF(14),OSF(14),SCF(14),FCL(14),
     1CLC,FCLG(14),FFCL(21),APSCT(7),
     2PISCL(7),PISCLG(7),SCSW,SCSUL,OI,TS,OS,TSLU,OSLU,TSSW,OSSW
     3,TPETD,SC
      COMMON/METHC/XMEFF(14),APMETH(7),PIMETH(7)
     1,XMED
       COMMON/HYC/HEEFF(14),TWRHE,WRF,WRCT
     1,HED
      COMMON/COALC/CSMF(14),CUMF(14),STRIPC,XLUCM,UNGRDC
     1,COALP
      COMMON/BOPC/OIC(14),XLNGC(14),CGC(14)
       DIMENSION ASGFR(21)
      DO 100 I=1,14
      CALL RESIDD(I)
      CALL COMMD(I)
      CALL INDUST(I)
      CALL TRANS(I)
C     SUMMATION OF ALL BASIC  ENERGY DEMANDS.
      TBED=0.
      DO 101 J=1,21
      BED(J)=TRD(J)+TCD(J)+TID(J)+TTD(J)
      TBED=TBED+BED(J)
  101 CONTINUE
C      CORRECTION FOR GEOTHERMAL ELECTRICAL POWER GENERATION
```

```
      F= 1. - EGFD(I,2)
      DO 3301 J=1,21
      IF(J.EQ.2) GO TO 3301
      EGFD(I,J) = F*EGFD(I,J)
 3301 CONTINUE
C     START OF OUTER ITERATION ON ELECTRICAL DEMAND
      DO 1 J=1,21
      XXBED(J) = BED(J)
       XBED(J) = BED(J)
    1 CONTINUE
      CALL AMMON(I)
C     ADDITION OF HYDROGEN REQUIRED FOR AMMONIA PRODUCTION TO XXBED
      XXBED(3) = XXBED(3) + AMH2D
C     ADDITION OF ELECTRICAL REQUIREMENTS FOR AMMONIA PRODUCTION TO XXBED.
      XXBED(16) = XXBED(16) + AMELD
      CALL METHOL(I)
C     ADDITION OF COAL REQUIREMENTS FOR METHANOL PRODUCTION TO XXBED.
      XXBED(1) = XXBED(1) + XMED
      CALL HYDGEN(I)
C     ADDITION OF ELECTRICAL REQUIREMENTS FOR HYDROGEN PRODUCTION TO XXBED.
      XXBED(16) = XXBED(16) + HED
       XBED(16) =  XBED(16) + HED
      CLG = 0.
      DO 1999 J=1,21
      XBED(J) = XXBED(J)
      PRD(J)=0.
 1999 SGER(J)=0.
      IELCNT = 0
 2000 CONTINUE
      APRD=PRD(16)
      CALL ELGEN(I)
C     START OF INNER PETROLEUM REFINERY ITERATION.
      ICRCNT = 0
 3500 CONTINUE
      IPRCNT = 0
 3000 CONTINUE
```

```
      DO 3001 J=1,21
3001  ASGFR(J) = SGFR(J)
      CALL PETREF(I)
      CALL GAS(I)
       IPRCNT = IPRCNT + 1
      IF(IPRCNT.EQ.40) GO TO 3003
       DO 3002 J=12,15
      CALL CONVG(SGFR(J),ASGFR(J),ITEST)
       SGFR(J)=ASGFR(J)
       IF(ITEST.LT.1) GO TO 3000
3002  CONTINUE
3003  CONTINUE
      ACLG=CLG
      CALL CRUDE(I)
      IF(ICRCNT.EQ.50) GO TO 3020
       CALL CONVG(CLG,ACLG,ITEST)
       CLG  = ACLG
       ICRCNT = ICRCNT + 1
      IF(ITEST.LT.1) GO TO 3500
3020  CONTINUE
      CALL CONVG(PRD(16),APRD,ITEST)
      IF(IELCNT.EQ.50) GO TO 3030
      IELCNT = IELCNT + 1
       PRD(16) = APRD
       IF(ITEST.LT.1) GO TO 2000
3030  CONTINUE
      DO 102 J=1,21
 102   XXBED(J) = XXBED(J) + PRD(J) + SCFR(J)
6000  CONTINUE
7000  CONTINUE
      CALL COAL(I)
      CALL OUTPUT(I)
 100  CONTINUE
      STOP
      END
```

```
      SUBROUTINE AMMON(I)
C     SUBROUTINE AMMON CALCULATES THE BASIC FUEL DEMANDS BASED ON
C      AMMONIA AS A LIQUID FOSSIL  FUEL SUBSTITUTE.
C     ALL AMMONIA IS MADE FROM H2 MADE BY ELECTROLYSIS.
C     FOR AMMONIA CALCULATION USE J=20 FOR AMMONIA DEMAND
      COMMON /MC/TITLE1(3,21),TITLE2(3,7),NYEAR(14)
     1,SCON(14,21,7),TSCON(14,21,7)
     2,BED(21),XXBED(21),XBED(21),SYNCD(21),PRD(24),SGFR(21),
     3SCFR(21),XXP(21),ELGD(21)
     4,SFFR(21),APGTT(7),APBED(7)
      COMMON/AMC/AMH2D,AMELD
C      CALCULATION OF HYDROGEN REQUIREMENTS
      AMH2D =1.142 * BED(20)
C     CALCULATION OF ELECTRICAL REQUIREMENTS
      AMELD = 0.0010279 * BED(20)
C     NO AIR POLLUTION EMMISSIONS ARE  INVOLVED
      RETURN
      END
```

```
 BLOCK DATA
 COMMON /MC/TITLE1(3,21),TITLE2(3,7),NYEAR(14)
1,SCON(14,21,7),TSCON(14,21,7)
2,BED(21),XXBED(21),XBED(21),SYNCD(21),PRD(24),SGFR(21),
3SCFR(21),XXP(21),ELGD(21)
4,SFFR(21),APGTT(7),APBED(7)
 COMMON /TC/APBI(14),AUBI(14),BBI(14),RRBI(14),SBI(14),TBI(14),
1APDF(14,21),AUDF(14,21),BDF(14,21),RRDF(14,21),SDF(14,21),TDF(14,
221)
3,TTD(21)
4,APTT(7),TTDT
 COMMON/TA/PIAU70(7,21),PIAP(7,21),PIAU(7,21),PIB(7,21),PIRR(7,21),
1PIS(7,21),PIT(7,21)
2,          APD(21),AUD(21),BD(21),RRRD(21),SD(21),TD(21),
3APOLAP(21,7),APOLAU(21,7),APOLB(21,7),APOLRR(21,7),APOLS(21,7),
4APOLT(21,7),
5APAP(7),APAU(7),APB(7),APRRR(7),APS(7),APT(7)
 COMMON /CC/CACOF(14,21),CWHOF(14,21),CSHOF(14,21),CCOF(14,21),CMOF
1(14,21),CROF(14,21),CACB,CSHB,CWHB,CCB,CMB,CRB,
2CACEF(14,21),CWHEF(14,21),CSHEF(14,21),CCEF(14,21),CMEF(14,21),CRE
3F(14,21),GNPR70(14)
4,TCD(21)
5,APCT(7),TCDT
 COMMON/CA/PIC(7,21)
1,          APCAC(7),APCSH(7),APCC(7),APCM(7)          ,APCWH(7),APCR(
27)
3,                  CACD(21),CRD(21),CSHD(21),CWHD(21),CCD(21),CMD(2
41)
5,          APLCAC(21,7),APLCSH(21,7),APLCWH(21,7),APLCC(21,7),APLCM
6(21,7),APLCR(21,7)
 COMMON /MRC/RSRAC(14),RSCAC(14),RSC(14),RSR(14),RSSH(14),RSWH(14),
1RRACHF(14,21),RCACHF(14,21),RCHF(14,21),RRHF(14,21),RSHHF(14,21),
2RWHHF(14,21),HHLD(14),
3RRACEF(14,21),RCACEF(14,21),RCEF(14,21),RREF(14,21),RSHEF(14,21),
4RWHEF(14,21)
5,TRD(21)
```

```
6,APRT(7),TRDT
 COMMON/RA/APRAC(7),APRSH(7),APRWH(7),APRR(7),APRM(7)          ,APRC(
17),RRACD(21),RCACD(21),RACD(21),RRD(21),RSHD(21),RWHD(21),RCD(21),
2RMD(21),          DRM70(21)
3,          PIR(7,21)
4,          APLRAC(7,21),APLRSH(7,21),APLRWH(7,21),APLRR(7,21),APLRC
5(7,21),APLRM(7,21)
6,          UDRRAC(21),UDRCAC(21),UDRC(21),UDRR(21),UDRSH(21),UDRWH(
721)
 COMMON/IC/ALP(14),ALPP(14),CEP(14),ALSP(14),CHP(14),CUPP(14),
1CURP(14),XMGPP(14),XMGSP(14),ZNPP(14),ZNSP(14),PIP(14),XIMEP(14),
2XIMFP(14),STP(14),BOF(14),SEL(14),OH(14),XIRMP(14),GNPR90(14),
3GNPR20(14),ALFD(14,21),ALPFD(14,21),ALSFD(14,21),CEFD(14,21),
4CHFD(14,21),CUPFD(14,21),CURFD(14,21),XMGPFD(14,21),XMGSFD(14,21),
5ZNPFD(14,21),ZNSFD(14,21),PIFD(14,21),XIMEFD(14,21),XIMFFD(14,21),
6SELFD(14,21),BOFFD(14,21),OHFD(14,21),XIRMFD(14,21),
7ALUD(14),ALPUD(14),ALSUD(14),CEUD(14),CHUD(14),CUPUD(14),CURUD(14)
8,XMGPUD(14),XMGSUD(14),ZNPUD(14),ZNSUD(14),PIUD(14)
9,TID(21),APIT(7),TIDT
 COMMON/IA/APALT(7),APALPT(7),APALST(7),APCET(7),APCHT(7),APCUPT(7)
1,APCURT(7),APMGPT(7),APZNPT(7),APZNST(7),APIMET(7),APIMFT(7),
2APIRMT(7),APSTT(7),APMGST(7),APPIT(7)
 COMMON/IB/ALPI(2,7),ALPPI(2,7),ALSPI(2,7),CEPI(2,7),CHPI(2,7),
1CUPPI(2,7),CURPI(2,7),XMGPPI(2,7),XMGSPI(2,7),ZNPPI(2,7),
2ZNSPI(2,7),PIPI(2,7),XIMEPI(2,7),XIMFPI(2,7),XIRMPI(2,7),BOFPI(2,7
3),SELPI(2,7),OHPI(2,7)
 COMMON/ID/XIMED(21),XIMFD(21),ALPD(21),ALSD(21),CED(21),CHD(21),
1CUPD(21),CURD(21),XMGPD(21),XMGSD(21),ZNPD(21),ZNSD(21),PID(21),
2STD(21),XIRMD(21),PII(7,21),APAL(7,21),APALP(7,21),APALS(7,21),
3APCE(7,21),APCUP(7,21),APCUR(7,21),APMGS(7,21),APZNP(7,21),
4APZNS(7,21),APPI(7,21),APST(7,21),APIME(7,21),APIMF(7,21),APIRM(7,
521),APCH(7,21),APMGP(7,21),          ALD(21)
 COMMON/AMC/AMH2D,AMELD
 COMMON/GASC/DNGP(14),XLNGF(14),SGASF(14),    SGEF(21),SGASFF(14,21)
1,APSG(7,21),APSGT(7),CLG,PISG(7,21)
2,CGPLIF(14)
```

```
3,CORGD,CGPLI,XLNGI,SGASR,SGSUL,SGSW
 COMMON/PRC/PRFF(14,24),PRUD(14),CTSR(14),PIPR(7,24),          APPRT(
17),APPR(7,24),PSCON(14,24,7),PIPRS(7)
2,CTS,PRDTT
 COMMON/EGC/EGFD(14,21),EGEF(14,21),XKGSW(14,21),UEDSW(14),U3O8UD(1
14,21),THO2UD(14,21),WUOT(21),WCCT(21),WCOT(21),WCCP(21),PEFAC(21),
2RLL(21),XLDUS(21),SLDW(21), XKR85F(21),TRF(21),PIEG7O(7,21),PIEG(7
3,21),FRFC(14),APEGT(7),RLLCI(21),FROT(14),FRNC(14),FRSP(14),
4FRCP(14),FRDC(14),APEG(7,21),SWREQ(21),TR(21),RLLC(21),PE(21),
5RLLW(21),CWC(21),CWU(21),XLDU(21),XLDUC(21),XKR85(21)
6,XLUCTF,XLUSPF,XLUCPF,XLUETF,XLUCMF
7,SWREQT,PRSW,TTHO2,TTU3O8,TKR85,TTR,TRLLC,TPE,TRLLW,TCWC,TCWU,TLU
 COMMON/CRC/DCP(14),OIF(14),TSF(14),OSF(14),SCF(14),FCL(14),
1CLC,FCLG(14),FFCL(21),APSCT(7),
2PISCL(7),PISCLG(7),SCSW,SCSUL,OI,TS,OS,TSLU,OSLU,TSSW,OSSW
3,TPETD,SC
 COMMON/METHC/XMEFF(14),APMETH(7),PIMETH(7)
1,XMED
  COMMON/HYC/HEEFF(14),TWRHE,WRF,WRCT
1,HED
 COMMON/COALC/CSMF(14),CUMF(14),STRIPC,XLUCM,UNGRDC
1,COALP
 COMMON/BOPC/OIC(14),XLNGC(14),CGC(14)
 DATA TITLE1/' COA','L   ',','    ',' GEO','THER','MAL ',' HYD','ROGE
1','N   ',' NAT','URAL',' GAS',' GCF','R   ',','    ',' HTG','R   ','
2    ',' LFR','    ',','    ',' LMF','BR  ',','    ',' LWR','    ','
3 ',' MSB','R   ',','    ',' MCF','R   ',','    ',' GAS','OLIN','E   ',
4' JET',' FUE','L   ',' DIS','TIL.',' OIL',' RES','ID. ','OIL ',' E
5LE','CTRI','CITY',' MET','HANO','L   ',' SOL','AR  ',','    ',' TID'
6,'AL  ',','    ',' WIN','D   ',','    ',' HYD','RO.E','LEC.'/
 DATA TITLE2/' CO2',','    ',','    ',' CO ',','    ',','    ',' SO2',','
1',','    ',' NOX',','    ',','    ',' PAR','TICU','LATE',' HYD','ROCA','
3RBON',' ALD','EHYD','E   '/
 DATA NYEAR/1970,1980,1990,2000,2010,2020,2030,2040,2050,2060,2070,
12080,2090,2100/
 DATA APBI/2732.7,7700.,12500.,16300.,20200.,24500.,30000.,36500.,
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144500.,54000.,66000.,80000.,97000.,118000./
 DATA AUBI/8291.,10900.,12900.,14700.,16200.,17500.,18800.,20000.,
121000.,22000.,23000.,24000.,25000.,25800./
 DATA BBI/124.1,215.,337.,525.,830.,1300.,1800.,2350.,3080.,3940.,
15000.,6250.,7800.,9800./
 DATA RRBI/526.,700.,910.,1240.,1800.,2600.,3800.,5500.,8000.,
1 11500.,16000.,24800.,35900.,52000./
 DATA SBI/829.9,1140.,1420.,1700.,2000.,2350.,2770.,3300.,3880.,
14600.,5400.,6400.,7550.,9000./
 DATA TBI/3916.6,4850.,5700.,6500.,7200.,7800.,8500.,9100.,9750.,
110400.,11000.,11600.,12200.,12800./
 DATA APDF/154*0.,.06,.03,12*0.,.94,.97,12*1.,112*0./
 DATA AUDF/154*0.,14*1.,126*0./
 DATA BDF/154*0.,.474,.375,.3,.183,.09,9*0.,14*0.,.526,.625,.7,.817
1,.91,9*1.,98*0./
 DATA RRDF/182*0.,.94,.9,.86,.82,.795,.775,8*.77,14*0.,.06,.1,.14,.
118,.205,.225,8*.23,70*0./
 DATA TDF/154*0.,.784,.675,.565,.45,.32,.225,.11,7*0.,14*0.,.216,.3
125,.435,.55,.68,.775,.89,7*1.,98*0./
 DATA SDF/182*0.,.134,.145,.15,.155,.165,.175,.18,.19,.195,.205,.21
15,.22,.23,.24,.866,.855,.85,.845,.835,.825,.82,.81,.805,.795,.785,
2.78,.77,.76,84*0./
 DATA SCON/588*1.0,2.8,13*.83,168*1.,14*.6,2.253,13*.75,1260*1./
 DATA PSCON/672*1.0,2.8,13*.83,168*1.,14*.6,2.253,13*.75,1470*1./
 DATA TSCON/588*1.0,2.8,13*.83,168*1.,14*1.,2.253,13*.75,1260*1./
 DATA PIAU70/77*0.,149.,17.08,.4,1.46,.071,2.992,.021,63*0./
 DATA PIAP/24*0.,.0276,52*0.,149.,1.07,.082,.206,.329,.7,.021,149.,
11.07,.082,.206,.329,.7,.021,21*0.,149.,.135,.0,.0064,.0,.0277,.0,
228*0./
 DATA PIAU/24*0.,.0276,52*0.,149.,.78,.04,.092,.071,.094,.021,28*0.
1,149.,.135,.0,.0064,.0,.0277,.0,28*0./
 DATA  PIB/24*0.,.0276,52*0.,149.,.78,.04,.092,.071,.094,.021,7*0.,
1170.,.77,.194,1.32,.094,.59,.022,14*0.,149.,.135,.0,.0064,.0,.0277
2,.0,28*0./
 DATA PIRR/24*0.,.0276,66*0.,170.,0.77,.194,1.32,.094,.590,.022,14*
10.,149.,.135,.0,.0064,.0,.0277,.0,28*0./
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 DATA  PIS/24*0.,.0276,56*0.,170.,.77,.194,1.32,.094,.59,.022,170.,
1.00134,1.049,.267,.1536,.02,.00668,7*0.,149.,.135,.0,.0064,.0,
2.0277,.0,28*0./
 DATA  PIT/24*0.,.0276,52*0.,149.,.78,.04,.092,.071,.094,.021,7*0.,
1170.,.77,.194,1.32,.094,.59,.022,14*0.,149.,.135,.0,.0064,.0,.0277
2,.0,28*0./
 DATA CACDF/42*0.,.135,.125,.11,.105,10*.1,154*0.,.865,.875,.89,
1.895,10*.9,70*0./
 DATA CSHDF/.1,13*0.,28*0.,.295,.28,.26,.24,.23,.22,.205,7*.2,126*0
1.,.51,.4,.38,.36,.34,.33,.315,.305,6*.3,.07,.15,.14,.14,.13,9*.12,
2.025,.17,.22,.26,.3,.33,.36,7*.38,70*0./
 DATA CCDF/42*0.,.917,.845,.775,.71,.65,.595,.55,.52,.505,5*.5,
1154*0.,.083,.155,.225,.29,.35,.405,.45,.48,.495,5*.5,70*0./
 DATA CRDF/210*0.,14*1.,70*0./
 DATA CMDF/42*0.,14*.256,126*0.,14*.314,14*.12,14*.31,70*0./
 DATA CWHDF/.062,13*0.,28*0.,.638,.6,.515,.44,.375,.33,8*.3,154*0.,
1.3,.4,.485,.56,.625,.67,8*.7,70*0./
 DATA CACEF/42*1.,.65,1.25,1.7,2.05,2.3,9*2.4,154*1.,3.5,3.65,3.8,
13.9,3.95,9*4.0,70*1./
 DATA CCEF/42*1.,.5,.52,.545,.57,.59,.615,.64,.66,.685,.705,.73,
1.75,.78,.8,154*1.,.75,.76,.775,.785,.8,.81,.82,.83,.845,.855,.87,
2.88,.89,.9,70*1./
 DATA CMEF/42*1.,14*.6,126*1.,14*.65,14*.65,14*.9,70*1./
 DATA CREF/210*1.,.52,.56,.575,.59,.595,9*.6,70*1./
 DATA CSHEF/14*.7,28*1.,.77,.78,.79,.8,.81,.82,.83,.84,.85,.86,.87,
1.88,.89,.9,126*1.,.77,.78,.79,.8,.81,.82,.83,.84,.85,.86,.87,
2.88,.89,.9,.77,.78,.79,.8,.81,.82,.83,.84,.85,.86,.87,.88,
3.89,.9,14*.95,70*1./
 DATA CWHEF/.7,.71,.715,.72,.73,.74,.745,.75,.76,.765,.77,.78,.79,
1.8,28*1.,.64,.65,.67,.68,.69,.7,.71,.72,.74,.75,.76,.77,.79,.8
2,154*1.,.92,.92,.92,.925,.93,.932,.938,.94,.942,.945,.95,.95,.95,
3.95,70*1./
 DATA PIC/224.,.378,1.4394,.227,.1515,.1136,.000189,14*0.,122.,.02,
1.0006,.1,.019,.008,.01,63*0.,170.,.00144,1.024,.288,.108,.0216,.01
244,170.,.00134,1.049,.267,.1536,.02,.00668,42*0./
 DATA CACB,CSHB,CWHB,CCB,CMB,CRB/247.5,3539.5,403.2,86.16,1479.7,
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1260.9/
 DATA RRACEF/210*1.,3.52,3.68,3.8,3.9,3.98,9*4.,70*1./
 DATA RCACEF/42*1.,.65,1.2,1.68,2.02,2.28,9*2.4,154*1.,3.52,3.67,
13.8,3.9,3.97,9*4.,70*1./
 DATA RCEF/42*1.,.438,.465,.49,.52,.55,.58,.61,.635,.66,.69,.72,.75
1,.77,.8,154*1.,.75,.76,.77,.785,.795,.805,.82,.83,.84,.855,.865,
2.875,.89,.9,70*1./
 DATA RREF/42*1.,14*.5,154*1.,.53,.56,.57,.59,.598,9*.6,70*1./
 DATA RSHEF/42*1.,.75,.76,.77,.78,.8,.81,.82,.83,.85,.86,.87,.88,
1.89,.9,126*1.,.63,.65,.67,.69,.71,.73,.75,.77,.79,.82,.84,.86,.88,
2.9,.63,.65,.67,.69,.71,.73,.75,.77,.79,.82,.84,.86,.88,.9,14*.95,
370*1./
 DATA RWHEF/42*1.,.64,.662,.682,.707,.72,.74,.76,.78,.8,.82,.84,
1.858,.88,.9,154*1.,.92,.922,.925,.928,.93,.932,.935,.938,.94,
2.942,.945,.948,.95,.95,70*1./
 DATA RRACHF/210*0.,14*1.,70*0./
 DATA RCACHF/42*0.,.035,.04,.045,.05,10*.05,154*0.,.965,.96,.955,11
1*.95,70*0./
 DATA RCHF/42*0.,.52,.41,.3,.23,.2,.17,.15,.13,.12,.11,.11,3*.1,
1154*0.,.48,.59,.70,.77,.8,.83,.85,.87,.88,.89,.89,3*.9,70*0./
 DATA RRHF/42*0.,.005,13*0.,154*0.,.995,13*1.,70*0./
 DATA RSHHF/42*0.,.53,.48,.42,.38,.34,.3,8*.28,126*0.,.30,.25,.21,
1.17,10*.16,.11,.09,.08,.07,10*.06,.07,.17,.29,.38,.44,.49,8*.5,70*
20./
 DATA RWHHF/42*0.,.73,.618,.518,.44,.379,.33,.302,7*.3,154*0.,.27,
1.382,.482,.56,.621,.67,.698,7*.7,70*0./
 DATA RSRAC/.335,.41,.41,.356,.24,.115,.03,7*0./
 DATA RSCAC/.085,.18,.3,.44,.58,.75,.925,7*1./
 DATA RSC/.98,13*1./
 DATA RSR/.91,.96,12*1./
 DATA RSSH/14*1./
 DATA RSWH/.97,13*1./
 DATA PIR/21*0.,122.,.02,.0006,.05,.019,.008,.01,63*0.,170.,.036,1.
1024,.086,.072,.0216,.0144,170.,.036,1.024,.086,.072,.0216,.0144,
242*0./
 DATA DRM70/15*0.,502.7,5*0./
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      DATA UDRRAC/15*0.,4.74,5*0./
      DATA UDRCAC/3*0.,110.,11*0.,18.2,5*0./
      DATA UDRC/3*0.,12.2,11*0.,4.01,5*0./
      DATA UDRR/3*0.,14.,11*0.,3.88,5*0./
      DATA UDRSH/3*0.,100.8,9*0.,124.1,128.4,46.8,5*0./
      DATA UDRWH/3*0.,26.2,11*0.,15.41,5*0./
      DATA ALFD/14*.19,28*0.,14*.36,126*0.,14*.08,14*.34,14*.03,70*0./
      DATA ALPFD/14*.23,28*0.,14*.165,154*0.,14*.605,70*0./
      DATA ALSFD/42*0.,14*.668,154*0.,14*.332,70*0./
      DATA CEFD/14*.474,28*0.,14*.393,126*0.,14*.075,14*0.,14*.058,70*0.
     1/
      DATA CHFD/14*.195,28*0.,14*.36,126*0.,14*.07,14*.35,14*.025,70*0./
      DATA CUPFD/42*0.,14*.961,154*0.,14*.039,70*0./
      DATA CURFD/42*0.,14*.691,154*0.,14*.309,70*0./
      DATA XMGPFD/42*0.,14*.59,154*0.,14*.41,70*0./
      DATA XMGSFD/42*0.,14*.7,126*0.,14*.2,14*0.,14*.1,70*0./
      DATA XIMEFD/210*0.,14*1.,70*0./
      DATA XIMFFD/14*.282,28*0.,14*.649,126*0.,14*.029,14*.040,84*0./
      DATA XIRMFD/14*.04,28*0.,14*.157,126*0.,14*.803,98*0./
      DATA ZNPFD/14*.43,28*0.,14*.175,154*0.,14*.395,70*0./
      DATA ZNSFD/14*.666,196*0.,14*.334,70*0./
      DATA PIFD/.7,.67,.64,.62,.61,.6,.59,.58,.575,.57,.568,.565,.562,.5
     16,28*0.,.1,.11,.12,.13,.13,.14,.15,.16,.165,.17,.172,.175,.178,.18
     2,126*0.,.15,.17,.18,.19,10*.2,14*0.,.05,.05,12*.06,70*0./
      DATA BOFFD/42*0.,14*.916,126*0.,14*.002,14*.0,14*0.082,70*0./
      DATA SELFD/182*0.,14*.378,14*0.,14*.622,70*0./
      DATA JHFD/42*0.,14*.602,126*0.,14*.345,14*0.,14*.053,70*0./
      DATA XIRMP/4010.5,6593.3,12*10848.4/
      DATA ALP/10.05,19.2,35.,11*64.5/
      DATA ALPP/3.9,7.25,13.5,11*25.8/
      DATA ALSP/.95,1.73,3.2,11*5.8/
      DATA CEP/420.,660.,950.,11*1430./
      DATA CHP/9.1,14.3,22.0,11*35.72/
      DATA CUPP/1.68,2.6,4.07,11*6.38/
      DATA CURP/2.13,3.31,5.4,11*8.13/
      DATA XMGPP/.099,.167,.25,11*.395/
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      DATA XMGSP/.0162,.0256,.0405,11*.0644/
      DATA ZNPP/1.25,1.68,2.25,11*3.043/
      DATA ZNSP/.223,.3,.4,11*.537/
      DATA PIP/99.,124.,155.,11*198./
      DATA STP/148.,190.,245.,11*316./
      DATA BOF/.48,.61,.645,11*.65/
      DATA SEL/.175,.245,.335,11*.35/
      DATA OH/.35,.16,12*0./
      DATA XIMEP/1375.5,2706.4,12*5426.3/
      DATA XIMFP/10921.4,13699.,12*16699./
      DATA ALUD/14*21.0/
      DATA ALPUD/14*87./
      DATA ALSUD/14*20.7/
      DATA CEUD/14*1.28/
      DATA CHUD/14*40.2/
      DATA CUPUD/14*40.1/
      DATA CURUD/14*6.8/
      DATA XMGPUD/14*92.6/
      DATA XMGSUD/14*7.98/
      DATA ZNPUD/14*45./
      DATA ZNSUD/14*32.4/
      DATA PIUD/24.8,21.9,20.2,19.2,18.7,18.3,8*18.1/
      DATA PII/224.,.0758,1.4394,.5682,1.7235,.0379,.00189,14*0.,122.,.0
     1004,.0006,.12,.018,.04,.003,63*0.,170.,.00144,1.024,.288,.108,.021
     26,.0144,170.,.00134,1.049,.267,.1536,.02,.00668,42*0./
      DATA ALPI/8*0.,10.,10.,4*0./
      DATA ALPPI/8*0.,80.,80.,4*0./
      DATA ALSPI/8*0.,4.3,1.3,4*0./
      DATA CEPI/8*0.,54.,4.,4*0./
      DATA CHPI/14*0./
      DATA CUPPI/4*0.,312.,31.2,2*0.,34.,3.,4*0./
      DATA CURPI/8*0.,65.,3.25,4*0./
      DATA XMGPPI/8*0.,4.,.4,4*0./
      DATA XMGSPI/8*0.,4.,.4,4*0./
      DATA ZNPPI/4*0.,1100.,110.,2*0.,220.,22.,4*0./
      DATA ZNSPI/8*0.,46.,22.,4*0./
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 DATA PIPI/2750.,2750.,44.,44.,3.,3.,2*0.,192.,4.,4*0./
 DATA XIMEPI/14*0./
 DATA XIMFPI/14*0./
 DATA XIRMPI/14*0./
 DATA BOFPI/4*0.,3.,3.,2*0.,46.,.92,4*0./
 DATA SELPI/2*0.,18.,18.,.2,.2,11.,.22,4*0./
 DATA OHPI/6*0.,.1,.1,22.,.44,4*0./
 DATA HHLD/62.887,74.5,86.9,99.5,112.,125.,137.5,152.,166.,180.,195
1.,206.,214.,222./
 DATA GNPR70/1.0,1.3948,1.8230,2.3892,3.08,3.8669,4.8060,5.8694,
17.1123,8.5624,10.192,12.0149,13.8517,14.0865/
 DATA GNPR90/1.,1.,1.,1.3106,1.6894,2.1212,2.6364,3.2197,3.9015,
14.697,5.5909,6.5909,7.5985,7.7273/
 DATA GNPR20/3*1.,1.,1.289,1.6185,2.0116,2.4566,2.9769,3.5838,4.265
19,5.0289,5.7977,5.896/
 DATA DNGP/23194.,25847.,25143.,19184.,12129.,6793.,3552.,1791.,
1885.,435.,212.,103.,50.,25./
 DATA SGEF/.663,10*1.,.91,.90,.90,.84,6*1.0/
 DATA PISG/80.5,.0,.0,.0,.0,3.92,.65,70*0.,58.6,6*.0,59.3,6*0.,63.5
1,6*0.,42*0./
 DATA PRFF/14*.004,28*0.,14*.382,98*0.,42*0.,14*.112,14*.025,70*0.,
114*.006,14*.358,14*.113/
 DATA PRUD/.1199,.1155,.1138,.1128,.1124,9*.1121/
 DATA CTSR/1.0572,1.0551,1.0543,1.0538,1.0536,9*1.0535/
 DATA PIPR/224.,.0758,1.4394,0.5682,1.7235,.0379,.000189,14*0.,
1122.,.0004,.0006,.12,.018,.040,.003,70*0.,170.,.00134,1.049,.267,
2.1536,.02,.00668,42*0.,122.,.0004,.0006,.12,.018,.040,.003,
3122.,.0004,.0006,.12,.018,.040,.003,
4224.,.00134,1.049,0.267,0.1536,0.020,.00668/
 DATA PIPRS/0.,.634,.0212,.0025,.0028,.0242,.0011/
 DATA EGFD/.464,.368,.266,.166,.0785,.0192,8*0.,.0004586,.005819,
1.02005,.08278,.06,.05,.04,.03,6*.02,14*0.,.242,.140,
1.0735,.034,.0125,.0023,8*0.,4*0.,.112,.172,.25,.15,.10,.05,.025,
2.013,.006,0.,0.,.0040,.14,.352,.330,.210,.130,.080,.05,.02,.015,.0
308,.004,.0,6*0.,.192,.646,.717,.859,.916,.955,.974,.991,3*0.,.108,
4.218,.332,.22,.11,.05,.025,.01,.005,.002,.0,.015,.245,.368,.25,.12
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5,.09,.08,.06,.05,.02,.015,.006,.003,5*0.0,.075,.138,.10,.05,.025,
6.01,.005,.002,.001,.0,42*0.,.01,.013, .008,.003,.0009,.0002,8*0.,
7.122,.123,.072,.027,.0081,.0013,8*0.,70*0.,.162,.107,.072,.060,
8.045,.035,.028,.023,.019,.016,.013,.011,.01,.009/
 DATA EGEF/.273,.342,.372,.40,.40,.40,8*.40,                          COAL
114*.143,                                                             GEOTHERM
214*.3,                                                               HYDROGEN
3.309,.330,.350,.384,.384,.40,8*.40,                                  NAT.GAS
45*.395,9*.398,                                                           GCFR
514*.407,                                                             HTGR
614*.50,                                                              LFR
74*.371,.392,.40,.40,7*.42,                                           LMFBR
814*.325,                                                             LWR
914*.44,                                                              MSBR
114*.50,                                                              MCFR
214*.30,                                                              GASOLINE
314*.30,                                                              JET FUEL
4.317,.342,.372,11*.4,                                                DIST.OIL
5.317,.342,.372,11*.4,                                                RESID
614*1.0,                                                              ELEC
7.317,.330,.350,.384,.384,9*.4,                                       METHANOL
814*.3,                                                               SOLAR
914*.2,                                                               TIDAL
114*.2,14*.76/                                                        WIND
 DATA XKGSW/70*0.,14*.00149,28*0.,.001435,.001109,12*.001016,168*0.
1/
 DATA UEDSW/10.53,8.23,8.32,7.55,10*7.04/
 DATA U308UD/70*0.,14*.00000163,28*0.,.00000285,3*.00000225,
110*.00000154,168*0./
 DATA THO2UD/70*0.,14*.000000351,42*0.,14*.000000417,154*0./
 DATA WUOT/4*8000.,7*6670.,4*8000.,0.,2*8000.,3*0./
 DATA WCCT/4*124.,7*152.,4*124.,0.,2*124.,3*0./
 DATA WCOT/4*53.,7*61.,4*53.,0.,2*53.,3*0./
 DATA WCCP/4*71.,7*84.,4*71.,0.,2*71.,3*0./
 DATA PEFAC/4*0.,4*.00000455,.0000045,.0000055,2*.00000455,9*0./
 DATA RLL/4*0.,4*.00000304,.00000345,.00000518,2*.00000304,9*0./
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 DATA RLLCI/4*0.,4*.18,.16,.18,2*.18,9*0./
 DATA XLDUS/.0000342,.0001338,2*.00000513,7*.00001,2*0.,2*.00000856
1,0.,0.0000856,.0000636,.0,.0,0.0392/
 DATA SLDW/.00379,20*0./
 DATA XKR85F/4*0.,.00167,.0082,0.,.00167,.0073,.0082,11*0./
 DATA TRF/4*0.,.00045,.00025,0.,.00045,.000265,.066,4.69,10*0./
 DATA PIEG70/224.,.0379,1.4394,.6818,.9848,.0136,.000189,14*0.,
1122.,.0004,.0006,.390,.015,.04,.003,63*0.,170.,.000267,1.0488,.701
2,.053,.0134,.0067,170.,.000267,1.0488,.701,.053,.0134,.0067,42*0./
 DATA PIEG/224.,.0379,1.2,.07,.020,.0136,.000189,14*0.,122.,.0004,
1.0006,.2,.015,.040,.0030,63*0.,170.,.000267,.8,.3,.054,.0134,.0067
2,170.,.000267,.8,.3,.054,.0134,.0067,42*0./
 DATA XLUCTF/.000000298/
 DATA XLUSPF/.000000298/
 DATA XLUCPF/.000022/
 DATA XLUETF/.000407/
 DATA XLUCMF/.0000134/
 DATA PIMETH/87.2,4*0.,4.95,0./
 DATA XMEFF/.60,.60,.62,.64,10*.66/
 DATA HEEFF/.604,.705,.747,.768,10*.778/
 DATA CSMF/14*.5/
 DATA CUMF/14*.5/
 DATA DCP/22564.,24335.,22886.,18316.,12888.,8293.,5043.,2964.,
11707.,972.,551.,312.,176.,98./
 DATA FCL/0.,13*.50/
 DATA FCLG/1.,13*.50/
 DATA FFCL/1.,20*0./
 DATA PISCL/62.5,6*0./
 DATA PISCLG/72.,5*0.,.142/
 DATA OIC/.4172,13*.714/
 DATA XLNGC/.775,13*1.211/
 DATA CGC/.250,13*.32/
 DATA CGPLIF/.999029,.302,.25,.20,.15,.10,.05,7*.0/
 DATA FROT/14*.766/
 DATA FRNC/14*0./
 DATA FRFC/14*.191/
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      DATA FRSP/14*.01/
      DATA FRCP/14*0.033/
      DATA FRDC/14*0./
      DATA SGASFF/.0,.1,.5,.8,10*1.,140*0.,.0,.45,.25,.1,10*0.,.0,.15,
     1.08,.03,10*0.,.0,.15,.08,.03,10*0.,.0,.15,.09,.04,10*0.,84*0./
      DATA XLNGF/.000971,.552,.50,.40,.30,.20,.10,7*0./
      DATA SGASF/.0,.146,.25,.40,.55,.70,.85,7*1.0/
      DATA OIF/1.0,.95,.70,.35,.30,.25,.20,.15,6*.1/
      DATA TSF/.0,.0,.10,.20,10*.20/
      DATA OSF/.0,.0,.10,.20,10*.20/
      DATA SCF/.0,.05,.10,.25,.30,.35,.40,.45,6*.50/
      END
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      SUBROUTINE COAL(I)
C     SUBROUTINE COAL DETERMINES ECOLOGICAL IMPACT OF COAL AND COAL REQ-
C      UIREMENTS.
      COMMON /MC/TITLE1(3,21),TITLE2(3,7),NYEAR(14)
     1,SCON(14,21,7),TSCON(14,21,7)
     2,BED(21),XXBED(21),XBED(21),SYNCD(21),PRD(24),SGFR(21),
     3SCFR(21),XXP(21),ELGD(21)
     4,SFFR(21),APGTT(7),APBED(7)
      COMMON/COALC/CSMF(14),CUMF(14),STRIPC,XLUCM,UNGRDC
     1,COALP
      COMMON/CRC/DCP(14),OIF(14),TSF(14),OSF(14),SCF(14),FCL(14),
     1CLC,FCLG(14),FFCL(21),APSCT(7),
     2PISCL(7),PISCLG(7),SCSW,SCSUL,OI,TS,OS,TSLU,OSLU,TSSW,OSSW
     3,TPETD,SC
C     CALCULATION OF COAL PRODUCTION.
      COALP = XXBED(1) - CLC
C     CALCULATION OF STRIP MINED COAL.
      STRIPC = CSMF(I)*COALP
      UNGRDC = CUMF(I)*COALP
C     CALCULATION OF LAND USE BY STRIP MINING.
      XLUCM  =  STRIPC*(.0000134)*(10**6)
      RETURN
      END
```

```
C     SUBROUTINE COMMD CALCULATES THE EFFECT OF COMMERCIAL USAGE OF
C          ENERGY RESOURCES AND THE ENVIRONMENT.
C     CACDF(J) = THE COMMERCIAL AIR CONDITIONING ENERGY DEMAND FRACTION
C          FOR FUEL 'J' IN YEAR 'I'.
C     C--DF(J) = THE COMMERCIAL     - -          ENERGY DEMAND FRACTION
C          FOR FUEL 'J' IN YEAR 'I'.
C     CACD(J) = COMMERCIAL AIR CONDITIONING ENERGY DEMAND FOR FUEL 'J'.
C     C--D(J) = COMMERCIAL      - -          ENERGY DEMAND FOR FUEL 'J'.
C     TCDT = TOTAL COMMERCIAL ENERGY DEMAND.
C     APLCAC(J,K) = AIR POLLUTION OF TYPE 'K' FOR FUEL 'J' FOR COM. A/C.
C     APLC--(J,K) = AIR POLLUTION OF TYPE 'K' FOR FUEL 'J' FOR COM. - -.
C     APCAC(K) = TOTAL AIR POLLUTION OF TYPE 'K' DUE TO COMMERCIAL A/C.
C     APCT(K) = TOTAL AIR POLLUTION OF TYPE 'K' DUE TO COMMERCIAL USES.
C     CACEF(J) = EFFICIENCY OF COMMERCIAL AIR COND. FOR FUEL 'J'.
C     C--EF(J) = EFFICIENCY OF COMMERCIAL -- FOR FUEL 'J'.
      SUBROUTINE COMMD(I)
      COMMON /MC/TITLE1(3,21),TITLE2(3,7),NYEAR(14)
     1,SCON(14,21,7),TSCON(14,21,7)
     2,BED(21),XXBED(21),XBED(21),SYNCD(21),PRD(24),SGFR(21),
     3SCFR(21),XXP(21),ELGD(21)
     4,SFER(21),APGTT(7),APBED(7)
      COMMON /CC/CACDF(14,21),CWHDF(14,21),CSHDF(14,21),CCDF(14,21),CMDF
     1(14,21),CRDF(14,21),CACB,CSHB,CWHB,CCB,CMB,CRB,
     2CACEF(14,21),CWHEF(14,21),CSHEF(14,21),CCEF(14,21),CMEF(14,21),CRE
     3F(14,21),GNPR70(14)
     4,TCD(21)
     5,APCT(7),TCDT
      COMMON/CA/PIC(7,21)
     1,          APCAC(7),APCSH(7),APCC(7),APCM(7)          ,APCWH(7),APCR(
     27)
     3,                    CACD(21),CRD(21),CSHD(21),CWHD(21),CCD(21),CMD(2
     41)
     5,          APLCAC(21,7),APLCSH(21,7),APLCWH(21,7),APLCC(21,7),APLCM
     6(21,7),APLCR(21,7)
      CACDT = 0.
       CRDT = 0.
```

```
      CWHDT = 0.
      CSHDT = 0.
       CCDT = 0.
       CMDT = 0.
       TCDT = 0.
      DO 90 J = 1,21
      TCD(J) =0.
      CACD(J) = CACB*GNPR70(I)*CACDF(I,J)*(CACEF(1,J)/CACEF(I,J))
     1/CACEF(1,J)
      CCD(J) = CCB*GNPR70(I)*CCDF(I,J)*(CCEF(1,J)/CCEF(I,J))
      CMD(J) = CMB*GNPR70(I)*CMDF(I,J)*(CMEF(1,J)/CMEF(I,J))
      CRD(J) = CRB*GNPR70(I)*CRDF(I,J) *(CREF(1,J)/CREF(I,J))
      CSHD(J) = CSHB*GNPR70(I)*CSHDF(I,J)*(CSHEF(1,J)/CSHEF(I,J))
      CWHD(J) = CWHB*GNPR70(I)*CWHDF(I,J)*(CWHEF(1,J)/CWHEF(I,J))
     1/CWHEF(1,J)
       TCD(J) = CACD(J) + CSHD(J) + CWHD(J) + CCD(J) + CMD(J)
     1 + CRD(J)
      CACDT = CACDT + CACD(J)
       CRDT = CRDT + CRD(J)
      CSHDT = CSHDT + CSHD(J)
      CWHDT = CWHDT + CWHD(J)
      CCDT = CCDT + CCD(J)
      CMDT = CMDT + CMD(J)
       TCDT = TCDT + TCD(J)
   90 CONTINUE
      DO 101 K = 1,7
      APCAC(K) = 0.
      APCSH(K) = 0.
      APCWH(K) = 0.
       APCC(K) = 0.
       APCM(K) = 0.
      APCR(K) = 0.
       APCT(K) = 0.
      DO 100 J=1,21
      APLCAC(J,K) = PIC(K,J)*CACD(J)*500.
     1*SCON(I,J,K)
```

```
      APLCSH(J,K) = PIC(K,J)*CSHD(J)*500.
     1*SCON(I,J,K)
      APLCWH(J,K) = PIC(K,J)*CWHD(J)*500.
     1*SCON(I,J,K)
      APLCC(J,K) = PIC(K,J)*CCD(J)*500.
     1*SCON(I,J,K)
      APLCM(J,K) = PIC(K,J)*CMD(J)*500.
     1*SCON(I,J,K)
      APLCR(J,K) = PIC(K,J)*CRD(J)*500.
     1*SCON(I,J,K)
      APCAC(K) = APCAC(K) + APLCAC(J,K)
      APCSH(K) = APCSH(K) + APLCSH(J,K)
      APCWH(K) = APCWH(K) + APLCWH(J,K)
      APCC(K) = APCC(K) + APLCC(J,K)
      APCM(K) = APCM(K) + APLCM(J,K)
      APCR(K) = APCR(K) + APLCR(J,K)
  100 CONTINUE
      APCT(K) = APCAC(K) + APCSH(K) + APCWH(K) +APCC(K) + APCM(K)
     1 + APCR(K)
  101 CONTINUE
      WRITE (6,1000) NYEAR(I)
 1000 FORMAT ('1',53X,' YEAR: ',I5//)
 1100 FORMAT (55X,' COMMERCIAL',//)
      WRITE (6,1100)
      WRITE (6,1150)
 1150 FORMAT (45X,'ENERGY DEMAND:  TRILLION BTUS'//)
      WRITE(6,1200)
 1200 FORMAT (20X,' AIR.COND.',7X,'REFRIG.',7X,' SPACE HT.',6X,' WATER H
     1T.',6X,' COOKING',9X,' MISC.',10X,' TOTAL'//)
      DO 150 KK = 1,21
      WRITE (6,210) (TITLE1(J,KK),J=1,3),CACD(KK),CRD(KK),CSHD(KK),CWHD(
     1KK),CCD(KK),CMD(KK),TCD(KK)
  150 CONTINUE
  210 FORMAT (3A4,3X,7(5X,F10.1))
      WRITE (6,220) CACDT,CRDT,CSHDT,CWHDT,CCDT,CMDT,TCDT
  220 FORMAT ( //' TOTAL',10X,7(5X,F10.1))
```

```
      WRITE (6,1000) NYEAR(I)
      WRITE (6,1100)
      WRITE (6,500)
      WRITE (6,1200)
      DO 160 KK = 1,7
      WRITE (6,510) (TITLE2(J,KK),J=1,3),APCAC(KK),APCR(KK),APCSH(KK),
     1APCWH(KK),APCC(KK),APCM(KK),APCT(KK)
  160 CONTINUE
  500 FORMAT ('0',50X,' AIR POLLUTION (TONS)'//)
  510 FORMAT (3A4,3X,7(3X,E12.6))
      RETURN
      END
```

```
      SUBROUTINE CONVG(CALC,ASSUM,ITEST)
      ITEST=0
      CONT=0.001
     IF(CALC.EQ.0.) GO TO 1
      TEST= ABS((CALC-ASSUM)/CALC)
      IF (TEST.LT.CONT) ITEST=1
      F = 0.25
      ASSUM=F*(CALC-ASSUM) + ASSUM
     GO TO 2
   1 ASSUM = CALC
     ITEST = 1
   2 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE CRUDE(I)
C     SUBROUTINE CRUDE  BALANCES CRUDE DEMAND WITH DOMESTIC SUPPLY.
C      IMPORTS, SYNCRUDE, TAR SANDS, AND SHALE OIL.
      COMMON /MC/TITLE1(3,21),TITLE2(3,7),NYEAR(14)
     1,SCON(14,21,7),TSCON(14,21,7)
     2,BED(21),XXBED(21),XBED(21),SYNCD(21),PRD(24),SGFR(21),
     3SCFR(21),XXP(21),FLGD(21)
     4,SFFR(21),APGTT(7),APBED(7)
      COMMON/GASC/DNGP(14),XLNGF(14),SGASF(14),    SGEF(21),SGASFF(14,21)
     1,APSG(7,21),APSGT(7),CLG,PISG(7,21)
     2,CGPLIF(14)
     3,CORGD,CGPLI,XLNGI,SGASR,SGSUL,SGSW
      COMMON/CRC/DCP(14),OIF(14),TSF(14),OSF(14),SCF(14),FCL(14),
     1CLC,FCLG(14),FFCL(21),APSCT(7),
     2PISCL(7),PISCLG(7),SCSW,SCSUL,OI,TS,OS,TSLU,OSLU,TSSW,OSSW
     3,TPETD,SC
      COMMON/PRC/PRFF(14,24),PRUD(14),CTSR(14),PIPR(7,24),         APPRT(
     17),APPR(7,24),PSCON(14,24,7),PIPRS(7)
     2,CTS,PRDTT
C     DCP= DOMESTIC CRUDE PRODUCTION
C     OIF= OIL IMPORT FRACTION OF PETROLEUM SUPPLY.
C     TSF= TAR SANDS  FRACTION OF PETPOLEUM SUPPLY.
C     OSF= OIL SHALE  FRACTION OF PETROLEUM SUPPLY.
C     SCF= SYNCRUDE FROM COAL FRACTION OF PETROLEUM SUPPLY.
C     CLG= SYNGAS PRODUCED BY COAL LIQUIFACTION.
C     SCFR= SYNCRUDE FUEL SUPPLY SPLIT.
C     CLC = REFINED COAL PRODUCED
C
C     SUMMATION OF PETROLEUM DEMAND AND CORRECTION FOR PET,REF, EFF.
      PETD = XXBED(12) + XXBED(13) + XXBED(14) + XXBED(15)
     1+ PRD(12) + PRD(13) + PRD(14) + PRD(15)
      TPETD=CTSR(I)*PETD
C     CALCULATION OF PETROLEUM DEMAND IN EXCESS OF DOMESTIC SUPPLY.
      PETREQ = TPETD - DCP(I)
       IF(PETREQ.LT.0.) PETREQ = 0.
C     CALCULATION OF OIL IMPORTS.
```

```
      OI = OIF(I)*PETREQ
C     CALCULATION OF TAR SANDS REQUIREMENTS.
      TS = TSF(I)*PETREQ
C     CALCULATION OF OIL SHALE REQUIREMENTS.
      OS = OSF(I)*PETREQ
C     CALCULATION OF SYNCRUDE REQUIREMENTS
      SC = SCF(I)*PETREQ
C     COAL  LIQUIFACTION PLANT
      SCCL =FCL(I)*SC
C     COMBINED COAL LIQUIFACTION AND GASIFICATION PLANT.
      SCCLG=FCLG(I)*SC
      CLG= SCCLG*.323/.604
      CLC= SCCLG*.073/.604
C     CALCULATION OF COAL REQUIREMENTS
      DO 100 J=1,21
      SCFR(J)=(SCCL/.85 + SCCLG/.446)*FFCL(J)
  100 CONTINUE
C     CALCULATION OF AIR POLLUTION EFFECTS DUE TO COAL LIQUIFACTION.
      DO 101 K=1,7
      APSCT(K)=(PISCL(K)*SCCL + PISCLG(K)*SCCLG)*500.
  101 CONTINUE
C     CALCULATION OF SOLID WASTE PRODUCED
      SCSW =(SCCLG*3.82 +SCCL*3.82)*500.
C     CALCULATION OF ELEMENTAL SULFUR PRODUCED.
      SCSUL = 3.30*(SCCLG+SCCL)*500.
C      CALCULATION OF TAR SAND LAND USE (ASSUME 1/100TH OF OIL SHALE).
      TSLU = .6987*TS/30.
C      CALCULATION OF OIL SHALE LAND USE (ASSUME DEPOSIT 30 FEET THICK).
      OSLU = 69.87*OS/30.
C     CALCULATION OF TAR SAND SOLID WASTE
      TSSW = 0.5862*TS
C     CALCULATION OF OIL SHALE SOLID WASTE.
      OSSW = 0.4055*OS
      RETURN
      END
```

```
      SUBROUTINE ELGEN(I)
C     SUBROUTINE  ELGEN CALCULATES THE BASE ENERGY DEMANDS FOR ELECTRICAL
C      POWER PRODUCTION AND CORRECTS FOR TRANSMISSION AND DISTRIBUTION
C      LOSSES. IT ALSO STARTS THE CALCULATION OF URANIUM AND THORIUM
C      DEMANDS.
      COMMON /MC/TITLE1(3,21),TITLE2(3,7),NYEAR(14)
     1,SCON(14,21,7),TSCON(14,21,7)
     2,BED(21),XXBED(21),XBED(21),SYNCD(21),PRD(24),SGFR(21),
     3SCFR(21),XXP(21),ELGD(21)
     4,SFFR(21),APGTT(7),APBED(7)
      COMMON/EGC/EGFD(14,21),EGFF(14,21),XKGSW(14,21),UEDSW(14),U308UD(1
     14,21),TH02UD(14,21),WUOT(21),WCCT(21),WCOT(21),WCCP(21),PEFAC(21),
     2RLL(21),XLDUS(21),SLDW(21), XKR85F(21),TRF(21),PIEG70(7,21),PIEG(7
     3,21),FRFC(14),APEGT(7),RLLCI(21),FROT(14),FRNC(14),FRSP(14),
     4FRCP(14),FRDC(14),APEG(7,21),SWREQ(21),TR(21),RLLC(21),PE(21),
     5RLLW(21),CWC(21),CWU(21),XLDU(21),XLDUC(21),XKR85(21)
     6,XLUCTF,XLUSPF,XLUCPF,XLUETF,XLUCMF
     7,SWREQT,PRSW,TTH02,TTU308,TKR85,TTR,TRLLC,TPE,TRLLW,TCWC,TCWU,TLU
      PRSW=0.
      COUNT = 0.
      XBED(16) = XBED(16) + PRD(16)
C     CORRECTION FOR DISTRIBUTION AND TRANSMISSION LOSSES.
 1001 EDC = ( XBED(16)  +PRSW)* 1.091
C     CALCULATION OF FUEL DEMAND FOR ELECTRICAL GENERATION.
      DO 90 J=1,21
   90 ELGD(J)=EDC*EGFD(I,J)/EGFF(I,J)*(FROT(I)+FRNC(I)*1.045+(FRFC(I)+
     1FRSP(I))*1.0175+FRDC(I)*1.075 + FRCP(I))
C     CALCULATION OF KILOGRAMS SEPARATIVE WORK
      SWREQT=0.
      DO 101 J=1,21
      SWREQ(J)=XKGSW(I,J)*( XBED(J)  +ELGD(J))*(10**6)
  101 SWREQT= SWREQT +SWREQ(J)
      SWREQT = SWREQT +990000.
C     CALCULATION OF POWER REQUIRED FOR SEPARATIVE WORK.AND CORRECTION
C    *OF ELECTRICAL ENERG DEMAND.
      PRSW    = SWREQT* UEDSW(I)/(10**6)
```

```
      TEED = ( XBED(16)    + PRSW)*1.091
      ELCONT =(TEED - EDC)/PRSW
C     WRITE(6,2000) COUNT,TEED,ELCONT
C2000 FORMAT(' COUNT = ',F5.1,2X,' TEED = ',E12.6,2X,' ELCONT = ',E12.6)
      IF(ELCONT.LE..00001) GO TO 1002
       COUNT = COUNT + 1.
      IF (COUNT.GT.10.) GO TO 1002
      GO TO 1001
 1002 CONTINUE
      EDC = TEED
      XBED(16) = XBED(16) - PRD(16)
      RETURN
      END
```

```
      SUBROUTINE GAS(I)
C     SUBROUTINE GAS BALANCES GAS DEMAND WITH DOMISTIC NATURAL GAS SUPPY
C     LNG IMPORTS, COAL GASIFICATION AND SYNGAS FROM PETROLEUM.
C     CLG = GAS PRODUCED BY COAL LIQUIFACTION IN COMBINED PROCESS.
C     CORGD = GAS DEMAND CORRECTED FOR TRANSMISSION LOSSES.
C     GASREQ = GAS REQUIRED IN EXCESS OF DOMESTIC PRODUCTION
C     XLNGI = LNG IMPORTS
C     SGASR = SYNGAS REQUIRED
C     SGASF = SYNGAS FRACTION OF  GAS REQUIREMENT IN EXCESS OF SUPPLY
C     TGSFR = TOTAL  FUEL REQUIREMENTS FOR SYNGAS PRODUCTION
C     SGFR  = SYNGAS FUEL REQUIREMENT  FOR FUEL J.
C     APSGT = TOTAL  AIR POLLUTION DUE TO SYNGAS PRODUCTION
C     SGSUL = TOTAL ELEMENTAL SULFUR PRODUCED BY SYNGAS PRODUCTION.
C     SGSW  = TOTA  SOLID WASTE PRODUCED BY SYNGAS PRODUCTION
C     SGASEF=  SYNGAS FRACTION SUPPLIED BY FUEL TYPE J.
C     CGPLI = CANADIAN GAS PIPELINE IMPORTS
      COMMON /MC/TITLE1(3,21),TITLE2(3,7),NYEAR(14)
     1,SCON(14,21,7),TSCON(14,21,7)
     2,BFD(21),XXBFD(21),XBFD(21),SYNCD(21),PRD(24),SGFR(21),
     3SCFR(21),XXP(21),ELGD(21)
     4,SFFR(21),APGTT(7),APBFD(7)
      COMMON/GASC/DNGP(14),XLNGF(14),SGASF(14),   SGFF(21),SGASFF(14,21)
     1,APSG(7,21),APSGT(7),CLG,PISG(7,21)
     2,CGPLIF(14)
     3,CORGD,CGPLI,XLNGI,SGASR,SGSUL,SGSW
C     CORRECTION OF GAS DEMAND FOR TRANSMISSION LOSSES.
      CORGD =(XXBFD(4) + PRD(4))/0.96343
C     CALCULATION OF GAS REQUIREMENTS IN EXCESS OF SUPPLY.
      GASREQ = CORGD-(DNGP(I)*.903737  + CLG )
      IF(GASREQ.LT.0.) GASREQ=0.
C     CALCULATION OF GAS IMPORTS FROM CANADA VIA GAS PIPELINE.
      CGPLI = CGPLIF(I)*GASREQ
C     CALCULATION OF LNG IMPORTS
      XLNGI = XLNGF(I)*GASREQ
C     CALCULATION OF SYNGAS REQUIREMENTS FROM COAL AND PETROLEUM
      SGASR =SGASF(I)*GASREQ
```

```
C       CALCULATION OF FUEL REQUIREMENTS FOR GASIFICATION
        TSGFR=0.
        DO 100 J=1,21
        SGFR(J)= SGASFF(I,J)/SGFF(J)*SGASR
  100   TSGFR = TSGFR + SGFR(J)
C       CALCULATION OF POLLUTION EFFECTS.
        DO 101 K=1,7
        APSGT(K)=0.
        DO 101 J=1,21
        APSG(K,J) = PISG(K,J)*SGASR*SGASFF(I,J)* 500.
        APSGT(K)= APSGT(K)+ APSG(K,J)
  101   CONTINUE
C       CALCULATION OF SULFUR PRODUCED (ELEMENTAL).
        SGSUL= 5.23*SGASR*SGASFF(I,1) *500.
C       CALCULATION OF SOLID WASTE PRODUCED.
        SGSW =7.84 *SGASR*SGASFF(I,1) *500.
        RETURN
        END
```

```
      SUBROUTINE HYDGEN(I)
C       SUBROUTINE HYDGEN   CALCULATES THE ELECTRICAL AND WATER REQUIRE-
C       MENTS FOR ELECTROLYTIC HYDROGEN PRODUCTION
C      TWRHE= TOTAL WATER REQUIREMENTS FOR ELECTROLYSIS
C      WRF  =        WATER REQUIREMENTS FOR FEED WATER.
C      WRCT =        WATER REQUIREMENTS FOR COOLING TOWER.
       COMMON /MC/TITLE1(3,21),TITLE2(3,7),NYEAR(14)
     1,SCON(14,21,7),TSCON(14,21,7)
     2,BED(21),XXBED(21),XBED(21),SYNCD(21),PRD(24),SGFR(21),
     3SCFR(21),XXP(21),FLGD(21)
     4,SFFR(21),APGTT(7),APBED(7)
       COMMON/HYC/HEEFF(14),TWRHF,WRF,WRCT
     1,HED
C      CALCULATION OF ELECTRICAL POWER REQUIREMENTS FOR ELECTROLYSIS.
       HED = XXBED(3)/HEEFF(I)
C      CALCULATION OF WATER REQUIREMENTS.
       WRF = 19.17 * XXBED(3) * (10**6)
       WRCT=23.85*XXBED(3)*(10**6)
       TWRHF= WRF +WRCT
       RETURN
       END
```

```
 SUBROUTINE INDUST(I)
 COMMON /MC/TITLE1(3,21),TITLE2(3,7),NYEAR(14)
1,SCON(14,21,7),TSCON(14,21,7)
2,BED(21),XXBED(21),XBED(21),SYNCD(21),PRD(24),SGFR(21),
3SCFR(21),XXP(21),ELGD(21)
4,SFFR(21),APGTT(7),APBED(7)
 COMMON/IC/ALP(14),ALPP(14),CEP(14),ALSP(14),CHP(14),CUPP(14),
1CURP(14),XMGPP(14),XMGSP(14),ZNPP(14),ZNSP(14),PIP(14),XIMEP(14),
2XIMFP(14),STP(14),BOF(14),SEL(14),OH(14),XIRMP(14),GNPR90(14),
3GNPR20(14),ALFD(14,21),ALPFD(14,21),ALSFD(14,21),CEFD(14,21),
4CHFD(14,21),CUPFD(14,21),CURFD(14,21),XMGPFD(14,21),XMGSFD(14,21),
5ZNPFD(14,21),ZNSFD(14,21),PIFD(14,21),XIMEFD(14,21),XIMFFD(14,21),
6SELFD(14,21),BOFFD(14,21),OHFD(14,21),XIRMFD(14,21),
7ALUD(14),ALPUD(14),ALSUD(14),CEUD(14),CHUD(14),CUPUD(14),CURUD(14)
8,XMGPUD(14),XMGSUD(14),ZNPUD(14),ZNSUD(14),PIUD(14)
9,TID(21),APIT(7),TIDT
 COMMON/IA/APALT(7),APALPT(7),APALST(7),APCET(7),APCHT(7),APCUPT(7)
1,APCURT(7),APMGPT(7),APZNPT(7),APZNST(7),APIMET(7),APIMFT(7),
2APIRMT(7),APSTT(7),APMGST(7),APPIT(7)
 COMMON/IB/ALPI(2,7),ALPPI(2,7),ALSPI(2,7),CEPI(2,7),CHPI(2,7),
1CUPPI(2,7),CURPI(2,7),XMGPPI(2,7),XMGSPI(2,7),ZNPPI(2,7),
2ZNSPI(2,7),PIPI(2,7),XIMEPI(2,7),XIMFPI(2,7),XIRMPI(2,7),BOFPI(2,7
3),SELPI(2,7),OHPI(2,7)
 COMMON/ID/XIMED(21),XIMFD(21),ALPD(21),ALSD(21),CED(21),CHD(21),
1CUPD(21),CURD(21),XMGPD(21),XMGSD(21),ZNPD(21),ZNSD(21),PID(21),
2STD(21),XIRMD(21),PII(7,21),APAL(7,21),APALP(7,21),APALS(7,21),
3APCE(7,21),APCUP(7,21),APCUR(7,21),APMGS(7,21),APZNP(7,21),
4APZNS(7,21),APPI(7,21),APST(7,21),APIME(7,21),APIMF(7,21),APIRM(7,
521),APCH(7,21),APMGP(7,21),          ALD(21)
 DATA N/1/
 ALDT=0.
 ALPDT=0.
 ALSDT=0.
 CEDT=0.
 CHDT=0.
 CUPDT=0.
```

```
      CURDT=0.
      XMGSDT=0.
      XMGPDT=0.
      ZNPDT=0.
      ZNSDT=0.
      PIDT=0.
      STDT=0.
      XIMEDT=0.
      XIMFDT=0.
      XIRMDT=0.
      TIDT=0.
      DO 90 J=1,21
      TID(J)=0.
      ALD(J)=ALP(I)*GNPR20(I)*ALFD(I,J)*ALUD(I)
      ALPD(J) = ALPP(I)*GNPR20(I)*ALPFD(I,J)*ALPUD(I)
      ALSD(J) = ALSP(I)*GNPR20(I)*ALSFD(I,J)*ALSUD(I)
      CED(J) = CEP(I)*GNPR20(I)*CEFD(I,J)*CEUD(I)
      CHD(J) = CHP(I)*GNPR20(I)*CHFD(I,J)*CHUD(I)
      CUPD(J)=CUPP(I)*GNPR20(I)*CUPFD(I,J)*CUPUD(I)
      CURD(J)=CURP(I)*GNPR20(I)*CURFD(I,J)*CURUD(I)
      XMGPD(J) = XMGPP(I)*GNPR20(I)*XMGPFD(I,J)*XMGPUD(I)
      XMGSD(J) = XMGSP(I)*GNPR20(I)*XMGSFD(I,J)*XMGSUD(I)
      ZNPD(J)=ZNPP(I)*GNPR20(I)*ZNPFD(I,J)*ZNPUD(I)
      ZNSD(J)=ZNSP(I)*GNPR20(I)*ZNSFD(I,J)*ZNSUD(I)
      PID(J)=PIP(I)*GNPR20(I)*PIFD(I,J)*PIUD(I)
      STD(J)=STP(I)*GNPR20(I)*(BOF(I)*6.61*BOFFD(I,J) + SEL(I)*3.7*SELFD
     1(I,J) + OH(I)*5.53*OHFD(I,J))
      XIMED(J) = XIMEP(I)*GNPR90(I)*XIMEFD(I,J)
      XIMFD(J)=XIMFP(I)*GNPR90(I)*XIMFFD(I,J)
      XIRMD(J)=XIRMP(I)*GNPR90(I)*XIRMFD(I,J)
      TID(J) = ALD(J) + ALPD(J) + ALSD(J) + CED(J) + CHD(J) +CUPD(J) +
     1CURD(J) + XMGPD(J) + XMGSD(J) + ZNPD(J) +ZNSD(J) + PID(J) + STD(J)
     2 + XIMED(J) + XIMFD(J) + XIRMD(J)
      ALDT = ALDT + ALD(J)
      ALPDT=ALPDT + ALPD(J)
      ALSDT=ALSDT+ALSD(J)
```

```
      CEDT=CEDT+CED(J)
      CHDT=CHDT+CHD(J)
      CUPDT=CUPDT+CUPD(J)
      CURDT=CURDT+CURD(J)
      XMGPDT=XMGPDT+XMGPD(J)
      XMGSDT=XMGSDT+XMGSD(J)
      ZNPDT=ZNPDT+ZNPD(J)
      ZNSDT=ZNSDT+ZNSD(J)
      PIDT=PIDT+PID(J)
      STDT=STDT+STD(J)
      XIMEDT=XIMEDT+XIMED(J)
      XIMFDT=XIMFDT+XIMFD(J)
      XIRMDT=XIRMDT+XIRMD(J)
      TIDT=TIDT+TID(J)
   90 CONTINUE
      DO 101 K = 1,7
      APALT(K)=0.
      APALPT(K)=0.
      APALST(K)=0.
      APCET(K)=0.
      APCHT(K)=0.
      APCUPT(K)=0.
      APCURT(K)=0.
      APMGPT(K)=0.
      APMGST(K)=0.
      APZNPT(K)=0.
      APZNST(K)=0.
      APPIT(K)=0.
      APIMET(K)=0.
      APIMFT(K)=0.
      APIRMT(K)=0.
      APSTT(K)=0.
      APIT(K)=0.
      DO 100 J=1,21
      APAL(K,J)=PII(K,J)*ALD(J)    *500.
     1*SCON(I,J,K)
```

```
      APALP(K,J)=PII(K,J)*ALPD(J) *500.
     1*SCON(I,J,K)
      APALS(K,J)=PII(K,J)*ALSD(J) *500.
     1*SCON(I,J,K)
      APCE(K,J)=PII(K,J)*CED(J)   *500.
     1*SCON(I,J,K)
      APCH(K,J)=PII(K,J)*CHD(J)   *500.
     1*SCON(I,J,K)
      APCUP(K,J)=PII(K,J)*CUPD(J) *500.
     1*SCON(I,J,K)
      APCUR(K,J)=PII(K,J)*CURD(J) *500.
     1*SCON(I,J,K)
      APMGP(K,J)=PII(K,J)*XMGPD(J)*500.
     1*SCON(I,J,K)
      APMGS(K,J)=PII(K,J)*XMGSD(J)*500.
     1*SCON(I,J,K)
      APZNP(K,J)=PII(K,J)*ZNPD(J) *500.
     1*SCON(I,J,K)
      APZNS(K,J)=PII(K,J)*ZNSD(J) *500.
     1*SCON(I,J,K)
      APPI(K,J)=PII(K,J)*PID(J)   *500.
     1*SCON(I,J,K)
      APST(K,J)=PII(K,J)*STD(J)   *500.
     1*SCON(I,J,K)
      APIME(K,J)=PII(K,J)*XIMED(J)*500.
     1*SCON(I,J,K)
      APIMF(K,J)=PII(K,J)*XIMFD(J)*500.
     1*SCON(I,J,K)
      APIRM(K,J)=0.0
      APALT(K) = APALT(K) +APAL(K,J)
      APALPT(K)=APALPT(K)+APALP(K,J)
      APALST(K)=APALST(K)+APALS(K,J)
      APCET(K)=APCET(K)+APCE(K,J)
      APCHT(K)=APCHT(K)+APCH(K,J)
      APCUPT(K)=APCUPT(K)+APCUP(K,J)
      APCURT(K)=APCURT(K)+APCUR(K,J)
```

```
      APMGPT(K)=APMGPT(K)+APMGP(K,J)
      APMGST(K)=APMGST(K)+APMGS(K,J)
      APZNPT(K)=APZNPT(K)+APZNP(K,J)
      APZNST(K)=APZNST(K)+APZNS(K,J)
      APPIT(K)=APPIT(K)+APPI(K,J)
      APIMET(K)=APIMET(K)+APIME(K,J)
      APIMFT(K)=APIMFT(K)+APIMF(K,J)
      APIRMT(K)=APIRMT(K)+APIRM(K,J)
      APSTT(K)=APSTT(K)+APST(K,J)
  100 CONTINUE
      APALT(K)=APALT(K)+ALPI(N,K)*ALP(I)*GNPR20(I)
     1*500.
      APALPT(K)=APALPT(K)+ALPPI(N,K)*ALPP(I)*GNPR20(I)
     1*500.
      APALST(K)=APALST(K)+ALSPI(N,K)*ALSP(K)*GNPR20(I)
     1*500.
      APCET(K)=APCET(K)+CEPI(N,K)*CEP(I)*GNPR20(I)
     1*500.
      APCHT(K)=APCHT(K)+CHPI(N,K)*CHP(I)*GNPR20(I)
     1*500.
      APCUPT(K)=APCUPT(K)+CUPPI(N,K)*CUPP(I)*GNPR20(I)
     1*500.
      APCURT(K)=APCURT(K)+CURPI(N,K)*CURP(I)*GNPR20(I)
     1*500.
      APMGPT(K)=APMGPT(K)+XMGPPI(N,K)*XMGPP(I)*GNPR20(I)
     1*500.
      APMGST(K)=APMGST(K)+XMGSPI(N,K)*XMGSP(I)*GNPR20(I)
     1*500.
      APZNPT(K)=APZNPT(K)+ZNPPI(N,K)*ZNPP(I)*GNPR20(I)
     1*500.
      APZNST(K)= APZNST(K)+ZNSPI(N,K)*ZNSP(I)*GNPR20(I)
     1*500.
      APPIT(K)=APPIT(K)+PIPI(N,K)*PIP(I)*GNPR20(I)
     1*500.
      APIMET(K)=APIMET(K)+XIMEPI(N,K)*XIMEP(I)*GNPR90(I)
     1*500.
```

```
      APIMFT(K)=APIMFT(K)+XIMFPI(N,K)*XIMFP(I)*GNPR90(I)
     1*500.
      APIRMT(K)=APIRMT(K)+XIRMPI(N,K)*XIRMP(I)*GNPR90(I)
     1*500.
      APSTT(K)=APSTT(K)+STP(I)*(BOF(I)*BOFPI(N,K)+SEL(I)*SELPI(N,K)+OH(I
     1)*OHPI(N,K))*GNPR20(I)
     1*500.
      APIT(K) = APALT(K)+APALPT(K)+APALST(K)+APCET(K)+APCHT(K)+APCUPT(K)
     1+APCURT(K)+APMGPT(K)+APMGST(K)+APZNPT(K)+APZNST(K)+APPIT(K)+APIMET
     2(K)+APIMFT(K)+APIRMT(K)+APSTT(K)
  101 CONTINUE
      WRITE (6,1000) NYEAR(I)
      WRITE (6,1100)
      WRITE (6,1150)
      WRITE(6,1200)
 1000 FORMAT ('1',53X,' YEAR: ',I5//)
 1100 FORMAT (54X,' INDUSTRIAL ',//)
 1150 FORMAT (45X,'ENERGY DEMAND:  TRILLION BTUS'//)
 1200 FORMAT(20X,17X,'PRIMARY',7X,'SECONDARY',38X,'PRIMARY',8X,'REFINED'
     1/24X,'ALUMINA',7X,'ALUMINUM',6X,'ALUMINUM',9X,'CEMENT',9X,'CHLORIN
     2E',8X,'COPPER',8X,'COPPER'//)
      DO 150 KK = 1,21
      WRITE (6,210) (TITLE1(J,KK),J=1,3),ALD(KK),ALPD(KK),ALSD(KK),CED(K
     1K),CHD(KK),CUPD(KK),CURD(KK)
  150 CONTINUE
  210 FORMAT (3A4,3X,7(5X,F10.1))
      WRITE(6,220) ALDT,ALPDT,ALSDT,CEDT,CHDT,CUPDT,CURDT
  220 FORMAT ( //' TOTAL',9X,7(5X,F10.1))
      WRITE (6,1000) NYEAR(I)
      WRITE (6,1100)
      WRITE (6,1150)
      WRITE (6,1201)
 1201 FORMAT(22X,'PRIMARY',7X,'SECONDARY',8X,'PRIMARY',7X,'SECONDARY',/
     121X,'MAGNESIUM',6X,'MAGNESIUM',9X,'ZINC',11X,'ZINC',9X,'PIG IRON',
     29X,'STEEL',7X,'MISC.ELEC.'//)
      DO 160 KK =1,21
```

```
      WRITE(6,210)(TITLE1(J,KK),J=1,3),XMGPD(KK),XMGSD(KK),ZNPD(KK),
     1ZNSD(KK),PID(KK),STD(KK),XIMED(KK)
  160 CONTINUE
      WRITE(6,220)XMGPDT,XMGSDT,ZNPDT,ZNSDT,PIDT,STDT,XIMEDT
      WRITE (6,1000) NYEAR(I)
      WRITE (6,1100)
      WRITE (6,1150)
      WRITE (6,1202)
 1202 FORMAT(22X,'MISC.FOSL.',6X,'RAW MATL',8X'TOTAL'//)
      DO 170 KK=1,21
      WRITE(6,210)(TITLE1(J,KK),J=1,3),XIMFD(KK),XIRMD(KK),TID(KK)
  170 CONTINUE
      WRITE(6,220) XIMFDT,XIRMDT,TIDT
      WRITE (6,1000) NYEAR(I)
      WRITE (6,1100)
      WRITE (6,500)
      WRITE (6,1200)
      DO 180 KK=1,7
      WRITE(6,510)(TITLE2(J,KK),J=1,3),APALT(KK),APALPT(KK),APALST(KK),
     1APCET(KK),APCHT(KK),APCUPT(KK),APCURT(KK)
  180 CONTINUE
      WRITE (6,1000) NYEAR(I)
      WRITE (6,1100)
      WRITE (6,500)
      WRITE(6,1201)
      DO 190 KK=1,7
      WRITE(6,510)(TITLE2(J,KK),J=1,3),APMGPT(KK),APMGST(KK),APZNPT(KK),
     1APZNST(KK),APPIT(KK),APSTT(KK),APIMET(KK)
  190 CONTINUE
      WRITE (6,1000) NYEAR(I)
      WRITE (6,1100)
      WRITE (6,500)
      WRITE(6,1202)
      DO 195 KK=1,7
      WRITE(6,510)(TITLE2(J,KK),J=1,3),APIMFT(KK),APIRMT(KK),APIT(KK)
  195 CONTINUE
```

```
500 FORMAT ('0',50X,' AIR POLLUTION (TONS)'//)
510 FORMAT (3A4,3X,7(3X,E12.6))
    RETURN
    END
```

```
      SUBROUTINE METHOL(I)
C     SUBROUTINE METHOL CALCULATES THE BASIC ENERGY DEMANDS BASED ON
C      METHANOL AS A LIQUID FOSSIL  FUEL SUBSTITUTE.
      COMMON /MC/TITLE1(3,21),TITLE2(3,7),NYEAR(14)
     1,SCON(14,21,7),TSCON(14,21,7)
     2,BED(21),XXBED(21),XBED(21),SYNCD(21),PRD(24),SGFR(21),
     3SCFR(21),XXP(21),ELGD(21)
     4,SFFR(21),APGTT(7),APBED(7)
      COMMON/METHC/XMEFF(14),APMETH(7),PIMETH(7)
     1,XMED
C     ALL METHANOL IS MADE FROM COAL (ASSUMPTION).
C     BED(17)=BASIC ENERGY DEMAND FOR METHANOL.
      XMED =BED(17)/XMEFF(I)
C     CALCULATION OF AIR POLLUTION EFFECTS OF METHANOL PRODUCTION
      DO 100 K=1,7
      APMETH(K)= PIMETH(K)* BED(17)
     1*500.
  100 CONTINUE
      RETURN
      END
```

```
 SUBROUTINE OUTPUT(I)
 COMMON /MC/TITLE1(3,21),TITLE2(3,7),NYEAR(14)
1,SCON(14,21,7),TSCON(14,21,7)
2,BED(21),XXBED(21),XBED(21),SYNCD(21),PRD(24),SGFR(21),
3SCFR(21),XXP(21),ELGD(21)
4,SFFR(21),APGTT(7),APBED(7)
 COMMON /TC/APBI(14),AUBI(14),BBI(14),RRBI(14),SBI(14),TBI(14),
1APDF(14,21),AUDF(14,21),BDF(14,21),RRDF(14,21),SDF(14,21),TDF(14,
221)
3,TTD(21)
4,APTT(7),TTDT
 COMMON/TA/PIAU70(7,21),PIAP(7,21),PIAU(7,21),PIB(7,21),PIRR(7,21),
1PIS(7,21),PIT(7,21)
2,          APD(21),AUD(21),BD(21),RRRD(21),SD(21),TD(21),
3APOLAP(21,7),APOLAU(21,7),APOLB(21,7),APOLRR(21,7),APOLS(21,7),
4APOLT(21,7),
5APAP(7),APAU(7),APB(7),APRRR(7),APS(7),APT(7)
 COMMON /CC/CACDF(14,21),CWHDF(14,21),CSHDF(14,21),CCDF(14,21),CMDF
1(14,21),CRDF(14,21),CACB,CSHB,CWHB,CCB,CMB,CRB,
2CACEF(14,21),CWHEF(14,21),CSHEF(14,21),CCEF(14,21),CMEF(14,21),CRE
3F(14,21),GNPR70(14)
4,TCD(21)
5,APCT(7),TCDT
 COMMON/CA/PIC(7,21)
1,          APCAC(7),APCSH(7),APCC(7),APCM(7)          ,APCWH(7),APCR(
27)
3,                  CACD(21),CRD(21),CSHD(21),CWHD(21),CCD(21),CMD(2
41)
5,          APLCAC(21,7),APLCSH(21,7),APLCWH(21,7),APLCC(21,7),APLCM
6(21,7),APLCR(21,7)
 COMMON /MRC/RSRAC(14),RSCAC(14),RSC(14),RSR(14),RSSH(14),RSWH(14),
1RRACHF(14,21),RCACHF(14,21),RCHF(14,21),RRHF(14,21),RSHHF(14,21),
2RWHHF(14,21),HHLD(14),
3RRACEF(14,21),RCACEF(14,21),RCEF(14,21),RREF(14,21),RSHEF(14,21),
4RWHEF(14,21)
5,TRD(21)
```

```
6,APRT(7),TRDT
 COMMON/RA/APRAC(7),APRSH(7),APRWH(7),APRR(7),APRM(7)          ,APRC(
17),RRACD(21),RCACD(21),RACD(21),RRD(21),RSHD(21),RWHD(21),RCD(21),
2RMD(21),          DRM70(21)
3,          PIR(7,21)
4,          APLRAC(7,21),APLRSH(7,21),APLRWH(7,21),APLRR(7,21),APLRC
5(7,21),APLRM(7,21)
6,          UDRRAC(21),UDRCAC(21),UDRC(21),UDRR(21),UDRSH(21),UDRWH(
721)
 COMMON/IC/ALP(14),ALPP(14),CEP(14),ALSP(14),CHP(14),CUPP(14),
1CURP(14),XMGPP(14),XMGSP(14),ZNPP(14),ZNSP(14),PIP(14),XIMEP(14),
2XIMFP(14),STP(14),BOF(14),SEL(14),OH(14),XIRMP(14),GNPR90(14),
3GNPR20(14),ALFD(14,21),ALPFD(14,21),ALSFD(14,21),CEFD(14,21),
4CHFD(14,21),CUPFD(14,21),CURFD(14,21),XMGPFD(14,21),XMGSFD(14,21),
5ZNPFD(14,21),ZNSFD(14,21),PIFD(14,21),XIMEFD(14,21),XIMFFD(14,21),
6SELFD(14,21),BOFFD(14,21),OHFD(14,21),XIRMFD(14,21),
7ALUD(14),ALPUD(14),ALSUD(14),CEUD(14),CHUD(14),CUPUD(14),CURUD(14)
8,XMGPUD(14),XMGSUD(14),ZNPUD(14),ZNSUD(14),PIUD(14)
9,TID(21),APIT(7),TIDT
 COMMON/IA/APALT(7),APALPT(7),APALST(7),APCET(7),APCHT(7),APCUPT(7)
1,APCURT(7),APMGPT(7),APZNPT(7),APZNST(7),APIMET(7),APIMFT(7),
2APIRMT(7),APSTT(7),APMGST(7),APPIT(7)
 COMMON/IB/ALPI(2,7),ALPPI(2,7),ALSPI(2,7),CEPI(2,7),CHPI(2,7),
1CUPPI(2,7),CURPI(2,7),XMGPPI(2,7),XMGSPI(2,7),ZNPPI(2,7),
2ZNSPI(2,7),PIPI(2,7),XIMEPI(2,7),XIMFPI(2,7),XIRMPI(2,7),BOFPI(2,7
3),SELPI(2,7),OHPI(2,7)
 COMMON/ID/XIMED(21),XIMFD(21),ALPD(21),ALSD(21),CED(21),CHD(21),
1CUPD(21),CURD(21),XMGPD(21),XMGSD(21),ZNPD(21),ZNSD(21),PID(21),
2STD(21),XIRMD(21),PII(7,21),APAL(7,21),APALP(7,21),APALS(7,21),
3APCE(7,21),APCUP(7,21),APCUR(7,21),APMGS(7,21),APZNP(7,21),
4APZNS(7,21),APPI(7,21),APST(7,21),APIME(7,21),APIMF(7,21),APIRM(7,
521),APCH(7,21),APMGP(7,21),          ALD(21)
 COMMON/AMC/AMH2D,AMELD
 COMMON/GASC/DNGP(14),XLNGF(14),SGASF(14),    SGEF(21),SGASFF(14,21)
1,APSG(7,21),APSGT(7),CLG,PISG(7,21)
2,CGPLIF(14)
```

```
     3,CORGD,CGPLI,XLNGI,SGASR,SGSUL,SGSW
      COMMON/PRC/PRFF(14,24),PRUD(14),CTSR(14),PIPR(7,24),          APPRT(
     17),APPR(7,24),PSCON(14,24,7),PIPRS(7)
     2,CTS,PRDTT
      COMMON/EGC/EGFD(14,21),EGEF(14,21),XKGSW(14,21),UEDSW(14),U3O8UD(1
     14,21),THO2UD(14,21),WUOT(21),WCCT(21),WCOT(21),WCCP(21),PEFAC(21),
     2RLL(21),XLDUS(21),SLDW(21), XKR85F(21),TRF(21),PIEG7O(7,21),PIEG(7
     3,21),FRFC(14),APEGT(7),RLLCI(21),FROT(14),FRNC(14),FRSP(14),
     4FRCP(14),FRDC(14),APEG(7,21),SWREQ(21),TR(21),RLLC(21),PE(21),
     5RLLW(21),CWC(21),CWU(21),XLDU(21),XLDUC(21),XKR85(21)
     6,XLUCTF,XLUSPF,XLUCPF,XLUETF,XLUCMF
     7,SWREQT,PRSW,TTHO2,TTU3O8,TKR85,TTR,TRLLC,TPE,TRLLW,TCWC,TCWU,TLU
      COMMON/CRC/DCP(14),OIF(14),TSF(14),OSF(14),SCF(14),FCL(14),
     1CLC,FCLG(14),FFCL(21),APSCT(7),
     2PISCL(7),PISCLG(7),SCSW,SCSUL,OI,TS,OS,TSLU,OSLU,TSSW,OSSW
     3,TPETD,SC
      COMMON/METHC/XMEFF(14),APMETH(7),PIMETH(7)
     1,XMED
       COMMON/HYC/HEEFF(14),TWRHE,WRF,WRCT
     1,HED
      COMMON/COALC/CSMF(14),CUMF(14),STRIPC,XLUCM,UNGRDC
     1,COALP
      COMMON/BOPC/OIC(14),XLNGC(14),CGC(14)
C     SUMMATION OF ALL BASIC  ENERGY DEMANDS.
      TBED=0.
      DO 101 J=1,21
      BED(J)=TRD(J)+TCD(J)+TID(J)+TTD(J)
      TBED=TBED+BED(J)
  101 CONTINUE
      WRITE(6,1000)NYEAR(I)
      WRITE(6,1100)
      WRITE(6,1150)
      WRITE(6,1200)
      DO 150  J=1,21
      WRITE(6,210)(TITLE1(KK,J),KK=1,3),TRD(J),TCD(J),TID(J),TTD(J),BED(
     1J)
```

```
  150 CONTINUE
      WRITE(6,220) TRDT,TCDT,TIDT,TTDT,TBED
C **  OUTPUT OF BASIC ENERGY DEMAND AIR POLLUTION.
      WRITE(6,1000)NYEAR(I)
      WRITE(6,500)
      WRITE(6,1200)
      DO 170 K=1,7
      APBED(K)=APRT(K)+APCT(K)+APIT(K)+APTT(K)
      WRITE(6,510)(TITLE2(J,K),J=1,3),APRT(K),APCT(K),APIT(K),APTT(K),
     1APBED(K)
  170 CONTINUE
C     CALCULATION OF AIR POLLUTION INDEX.
      DO 100 K=1,7
      APEGT(K)=0.
      DO 100 J=1,21
      IF(I.EQ.1) GO TO 99
      APEG(K,J)= PIEG(K,J)*ELGD(J)*SCON(I,J,K)
     1*500.
      APEGT(K)= APEGT(K)+ APEG(K,J)
      GO TO 100
   99 APEG(K,J)=PIEG70(K,J)*ELGD(J)*SCON(I,J,K)
     1*500.
      APEGT(K)= APEGT(K) + APEG(K,J)
  100 CONTINUE
C     CALCULATION OF TONNES OF U308 REQUIRED AND TONNES TH02 REQUIRED.
      TTTH02=0.
      TTU308 =0.
      DO  102  J=1,21
      TU308= U308UD(I,J)* (XXBED(J))
     1*(10**6)
      TTU308= TTU308+ TU308
      TTH02 = TH02UD(I,J)*(XXBED(J))
     1*(10**6)
  102 TTTH02= TTTH02+ TTH02
C     CALCULATION OF RADIATION RELEASED AND RADIOACTIVE WASTE.
      TKR85=0.
```

```
      TTR =0.
      TRLLC =0.
      TPE   =0.
      TRLLW =0.
      DO 103 J=1,21
      XKR85(J)=XKR85F(J)*XXBED(J)*(10**6)
      TR(J)   =TRF(J)   *XXBED(J)*(10**6)
      RLLC (J)=RLLCI(J) *XXBED(J)*(10**6)
      PE(J)   =PEFAC(J) *XXBED(J)*(10**6)
      RLLW(J) =RLL(J)   *XXBED(J)*(10**6)
      TKR85   =TKR85  + XKR85(J)
      TTR     =TTR    + TR(J)
      TRLLC   =TRLLC  + RLLC(J)
      TPE     =TPE    + PE(J)
      TRLLW   =TRLLW  + RLLW(J)
  103 CONTINUE
C     NORMALIZATION OF 1970 TRITIUM AND KRYPTOM-85 RELEASES.
      IF(I.EQ.1) TTR = .239*TTR
      IF(I.EQ.1) TKR85 = TKR85*1.275
      TCWC   =0.
      TCWU =0.
      TLU =0.
      DO 104 J=1,21
C     CALCULATION OF COOLING  WATER  CONSUMED
      CWC(J)=(FROT(I)*WCOT(J)+(FRNC(I)+FRFC(I))*WCCT(J) + (FRSP(I)+
     1FRCP(I))*WCCP(J))*ELGD(J)*(1. - EGEF(I,J))
     1*(10**6)
      TCWC   = TCWC   + CWC(J)
C     CALCULATION OF COOLING WATER THROUGH CONDENSOR.
      CWU(J)=FROT(I)*WUOT(J)*ELGD(J)*(1. - EGEF(I,J))
     1*(10**6)
      TCWU =TCWU+CWU(J)
C     CALCULATION OF LAND USE.FOR POWER PLANTS, COOLING TOWERS & TRANS.
      XLDU(J) = XLDUS(J)*ELGD(J)*EGEF(I,J)
     1*(10**6)
      XLDUC(J)=(XLUCTF*FRNC(I)+XLUCPF*FRCP(I)+XLUSPF*FRSP(I))*ELGD(J)
```

```
      TTR =0.
      TRLLC =0.
      TPE   =0.
      TRLLW =0.
      DO 103 J=1,21
      XKR85(J)=XKR85F(J)*XXBED(J)*(10**6)
      TR(J)   =TRF(J)   *XXBED(J)*(10**6)
      RLLC (J)=RLLCI(J) *XXBED(J)*(10**6)
      PE(J)   =PEFAC(J) *XXBED(J)*(10**6)
      RLLW(J) =RLL(J)   *XXBED(J)*(10**6)
      TKR85   =TKR85  + XKR85(J)
      TTR     =TTR    + TR(J)
      TRLLC   =TRLLC  + RLLC(J)
      TPE     =TPE    + PE(J)
      TRLLW   =TRLLW  + RLLW(J)
  103 CONTINUE
C     NORMALIZATION OF 1970 TRITIUM AND KRYPTOM-85 RELEASES.
      IF(I.EQ.1) TTR = .239*TTR
      IF(I.EQ.1) TKR85 = TKR85*1.275
      TCWC   =0.
      TCWU =0.
      TLU =0.
      DO 104 J=1,21
C     CALCULATION OF COOLING  WATER  CONSUMED
      CWC(J)=(FROT(I)*WCOT(J)+(FRNC(I)+FRFC(I))*WCCT(J) + (FRSP(I)+
     1FRCP(I))*WCCP(J))*ELGD(J)*(1. - EGEF(I,J))
     1*(10**6)
      TCWC   = TCWC   + CWC(J)
C     CALCULATION OF COOLING WATER THROUGH CONDENSOR.
      CWU(J)=FROT(I)*WUOT(J)*ELGD(J)*(1. - EGEF(I,J))
     1*(10**6)
      TCWU =TCWU+CWU(J)
C     CALCULATION OF LAND USE.FOR POWER PLANTS, COOLING TOWERS & TRANS.
      XLDU(J) = XLDUS(J)*ELGD(J)*EGEF(I,J)
     1*(10**6)
      XLDUC(J)=(XLUCTF*FRNC(I)+XLUCPF*FRCP(I)+XLUSPF*FRSP(I))*ELGD(J)
```

```
     1*(10**6)*(1. - EGEF(I,J))
  104 TLU= TLU + XLDU(J)+ XLDUC(J)
      XLUET =  XLUETF* EDC
      TLU= TLU+XLUET
C     CONVERSION TO ACRE-FEET
      TCWC = TCWC/325851.4
      TCWU = TCWU/325851.4
      WRF = WRF/325851.4
      WRCT = WRCT/325851.4
      TWRHE = TWRHE/325851.4
      CWCOS = OS*81.18
      CWCTS = TS*81.18
      CWCCG = SGASR*75.
      CWCCL = (SC+CLG)*10.39
C **  OUTPUT OF ENERGY DEMANDS
      WRITE(6,1000)NYEAR(I)
      WRITE(6,1101)
      WRITE(6,1150)
      WRITE(6,1201)
      TELGD = 0.
      TPRD  = 0.
      TSGFR = 0.
      TSCFR = 0.
      TSFFR = 0.
      DO 160 J=1,21
      SFFR(J)=XXBED(J)-ELGD(J)-PRD(J)-SGFR(J)-SCFR(J)-BED(J)
      IF(J.EQ.16) XXBED(16) =0.0
      TELGD = TELGD + ELGD(J)
      TPRD = TPRD + PRD(J)
      TSCFR = TSCFR + SCFR(J)
      TSGFR = TSGFR + SGFR(J)
      TSFFR = TSFFR + SFFR(J)
      WRITE(6,210) (TITLE1(K,J),K=1,3),   BED(J),ELGD(J),PRD(J),SGFR(J),
     1  SCFR(J),SFFR (J),XXBED(J)
  160 CONTINUE
      GTFR = TBED + TELGD + TPRD + TSGFR + TSCFR + TSFFR -BED(16) -
```

```
     1 PRD(16) - SFFR(16)
       WRITE(6,220) TBED,TELGD,TPRD,TSGFR,TSCFR,TSFFR,GTFR
C **   OUTPUT OF SUMMARY AIR POLLUTION.
       WRITE(6,1000)NYEAR(I)
       WRITE(6,500)
       WRITE(6,1202)
       DO 171 K=1,7
       APGTT(K)=APBED(K)+APSCT(K)+APEGT(K)+APSGT(K)+APMETH(K)+APPRT(K)
       WRITE(6,510) (TITLE2(J,K),J=1,3),APBED(K),APEGT(K),APPRT(K),APSGT(
      1K),APSCT(K),APMETH(K),APGTT(K)
  171  CONTINUE
C **   OUTPUT OF SUMMARY SOLID WASTE.
       GTSW=SCSW+SGSW+TSSW+OSSW
       WRITE(6,1000)NYEAR(I)
       WRITE(6,501)
       WRITE(6,502) SCSW,TSSW,OSSW,SGSW,GTSW
C **   OUTPUT OF ELEMENTAL SULFUR.
       GTSUL=SCSUL+SGSUL
       WRITE(6,503)
       WRITE(6,504)SCSUL,SGSUL,GTSUL
C **   OUTPUT OF LAND USE
       GTLU= XLUCM+TSLU+OSLU+TLU
       WRITE(6,505)
       WRITE(6,506)XLUCM,TSLU,OSLU,TLU,GTLU
C **   OUTPUT OF RADIOACTIVE MATERIAL.
       WRITE(6,507)
       WRITE(6,508)TTR,TKR85,TRLLC,TRLLW,TPE
C **   OUTPUT OF COOLING WATER CONSUMED.
       TCW=TCWU+TCWC+TWRHE
      1+CWCOS+CWCTS+CWCCG+CWCCL
       WRITE(6,509)
       WRITE(6,511)TCWC,TCWU,TWRHE,WRF,WRCT,CWCOS,CWCTS,CWCCG,CWCCL,TCW
C **   OUTPUT OF COAL RESOURCE DEMANDS
       TCOALD=BED(1)+SCFR(1)+ELGD(1)+SGFR(1)+XMED+PRD(1)
       WRITE(6,1000)NYEAR(I)
       WRITE(6,11)
```

```
      WRITE(6,12) BED(1),SCFR(1),SGFR(1),XMED,ELGD(1),PRD(1),TCOALD
C **  OUTPUT OF  PETROLEUM RESOURCE DEMANDS.
      GTCP= TS+OS+SC+ DCP(I) + OI
      WRITE(6,13)
      WRITE(6,14)TPETD,TS,OS,SC,DCP(I),OI,GTCP
C **  OUTPUT OF NATURAL GAS RESOURCE DEMANDS.
      GASREQ = CORGD-(DNGP(I)*.903737  + CLG )
      IF(GASREQ.LT.0.) GO TO 90
   89 TSYNG=SGASR +CLG
      GTGP=DNGP(I)+CGPLI+XLNGI+SGASR+CLG
      GO TO 91
   90 DNGP(I) = DNGP(I) + GASREQ/.903737
      DNGP(I+1) = DNGP(I+1) - GASREQ/.903737
      GO TO 89
   91 CONTINUE
      WRITE(6,15)
      WRITE(6,16) XXBED(4),CORGD,DNGP(I),CGPLI,XLNGI,TSYNG,GTGP
C **  OUTPUT OF NUCLEAR FUELS RESOURCE DEMANDS.
      WRITE(6,17)
      WRITE(6,18)SWREQT,PRSW,TTTHO2,TTU3O8
C **  SUMMARY OF FUELS RESOURCE REQUIREMENTS
      WRITE(6,1000)NYEAR(I)
      WRITE(6,19)
      WRITE(6,21)
      XNUCFI=XXBED(5)+XXBED(6)+XXBED(8)+XXBED(9)+XXBED(10)
      XNUCFU=XXBED(7)+XXBED(11)
      DTGP = DNGP(I) + CGPLI + XLNGI
      DTCP = TS + OS + DCP(I) + OI
      SGTTL=TCOALD+XXBED(2)+DTGP+XNUCFI+XNUCFU+XXBED(18)+
     1XXBED(19)+XXBED(20)+XXBED(21) + DTCP
      WRITE(6,22) TCOALD,
     1XXBED(2)      ,XXBED(3),DTGP,XNUCFI,XNUCFU,DTCP,
     2 XXBED(17),XXBED(18),XXBED(19)
      WRITE(6,23)                    XXBED(20),XXBED(21),SGTTL
C     CALCULATION OF BALANCE OF PAYMENTS EFFECTS
      CCPI = OI*OIC(I)
```

```
      CLNGI = XLNGI*XLNGC(I)
      CCGI = CGPLI*CGC(I)
      TBOPD = CCPI + CLNGI + CCGI
      WRITE(6,24)
      WRITE(6,25)
      WRITE(6,26) CCPI,CLNGI,CCGI,TBOPD
   11 FORMAT('0',42X,'COAL RESOURCE DEMANDS (TRILLION BTU)'//)
   12 FORMAT(' TOTAL BED',5X,F10.2/,' SYNCRUDE ',5X,F10.2,/' SYNGAS   ',
     15X,F10.2,/' METHANOL ',5X,F10.2,/' ELEC.GEN.',5X,F10.2,/' PET.REF.
     2 ',5X,F10.2,//' TOTAL    ',5X,F10.2//)
   13 FORMAT('0',39X,' PETROLEUM RESOURCE DEMANDS (TRILLION BTU)'//)
   14 FORMAT(' TOTAL PET. DEMAND  ',5X,F12.2//,' TAR SANDS REQ.     ',5X
     1,F12.2/' OIL SHALE REQ      ',5X,F12.2/' SYNCRUDE REQ.      ',5X,
     2F12.2/' DOMESTIC CRUDE PROD.',4X,F12.2/,' CRUDE OIL IMPORTS  ',5X,
     3F12.2//' TOTAL CRUDE PROD.  ',5X,F12.2//)
   15 FORMAT('0',38X,' NATURAL GAS RESOURCE DEMANDS (TRILLION BTU)'//)
   16 FORMAT(' TOTAL DEMAND  ',5X,F12.2/' CORRECTED DMD.',5X,F12.2/' DOM
     1. NAT. GAS',6X,F12.2/' CANADA P.L.IMP.',4X,F12.2/' LNG IMPORTS   '
     2,5X,F12.2/' SYNGAS        ',5X,F12.2//' TOTAL GAS PRD.',5X,F12.2 /
     3/)
   17 FORMAT('0',45X,' NUCLEAR FUEL RESOURCE DEMANDS'//)
   18 FORMAT(' SEP.WORK REQ. ',5X,E12.6,2X,'KGSW'/' PWR REQ. KGSW ',5X,
     1F10.2,4X,'TRILLION BTU'/' THORIUM (THO2) ',4X,E12.6,2X,'TONNES'/
     2' URANIUM (U3O8)',5X,E12.6,2X,'TONNES'//)
   19 FORMAT(43X,' SUMMARY OF RESOURCE REQUIREMENTS'//)
   21 FORMAT(// ' RESOURCE',16X,'ANNUAL PROD.'//)
   22 FORMAT(' COAL     ',12X,F12.2 ,' TRILLION BTU '/
     1' GEOTHERMAL     ', 5X,F12.2 ,' TRILLION BTU '/
     2' (HYDROGEN)     ', 5X,F12.2 ,' TRILLION BTU' /
     3' NATURAL GAS    ', 5X,F12.2 ,' TRILLION BTU' /
     4' NUCLEAR-FISSION', 5X,F12.2 ,' TRILLION BTU' /
     5' NUCLEAR-FUSION ', 5X,F12.2 ,' TRILLION BTU' /
     6' PETROLEUM      ', 5X,F12.2 ,' TRILLION BTU' /
     7' (METHANOL)     ', 5X,F12.2 ,' TRILLION BTU' /
     8' SOLAR          ', 5X,F12.2 ,' TRILLION BTU' /
     9' TIDAL          ', 5X,F12.2 ,' TRILLION BTU' )
```

```
 23 FORMAT(' WIND           ',6X,F12.2,' TRILLION BTU'/
   1' HYDROELECTRIC  ', 5X,F12.2 ,' TRILLION BTU'//
   2' TOTAL          ',5X,F12.2,' TRILLION BTU'//)
 24 FORMAT(//' SUMMARY OF BALANCE OF PAYMENTS FOR ENERGY IMPORTS')
 25 FORMAT(12X,'(MILLIONS OF 1970 DOLLARS)'//)
 26 FORMAT(' COST OF CRUDE PETROLEUM IMPORTS    ',5X,F12.2/
   1' COST OF LIQUIFIED NATURAL GAS IMPORTS   ',F12.2/
   2' COST OF CANADIAN GAS IMPORTS   ', 9X,F12.2//
   3' TOTAL BALANCE OF PAYMENTS DEFICIT  ',5X,F12.2//)
210 FORMAT(3A4,3X,7(5X,F10.1))
220 FORMAT(//' TOTAL          ',7(5X,F10.1))
500 FORMAT('0',50X,' AIR POLLUTION (TONS)'//)
501 FORMAT('0',50X' SOLID WASTE (TONS)'//)
502 FORMAT(    ' SYNCRUDE ',5X,E12.6,/' TAR SANDS',5X,E12.6,/' OIL SHA
   1LE',5X,E12.6,/' SYNGAS   ',5X,E12.6,//' TOTAL    ',5X,E12.6)
503 FORMAT('0',44X' ELEMENTAL SULFUR PRODUCED (TONS)'//)
504 FORMAT(    ' SYNCRUDE ',5X,E12.6,/' SYNGAS   ',5X,E12.6,//' TOTAL
   1   ',5X,E12.6)
505 FORMAT('0',41X,'LAND USE BY ENERGY PRODUCTION (ACRES)'//)
506 FORMAT(    ' COAL (STRIP MINING)',5X,E12.6,/' TAR SANDS          '
   1,5X,E12.6/,' OIL SHALE          ',5X,E12.6,/' ELEC. GEN. & TRANS.'
   2,5X,E12.6,//' TOTAL              ',5X,E12.6)
507 FORMAT('0',37X,' RADIOACTIVE MATERIAL PRODUCTION AND RELEASES'//)
508 FORMAT(' TRITIUM RELEASED   ',5X,E12.6,2X,'CURIES'/' KRYPTON-85 RE
   1LEASED',5X,E12.6,2X,'CURIES'/' LONG-LIVED RAD.WASTE',4X,E12.6,2X,'
   2CURIES'/' LONG LIVED RAD.WASTE',4X,E12.6,2X,'CUBIC FEET'/' POPULAT
   3ION EXPOSURE',5X,E12.6,2X,' MAN-REM'//)
509 FORMAT('0',22X,' COOLING WATER REQUIREMENTS FOR ENERGY PRODUCTION
   1 (ACRE-FEET)'//)
510 FORMAT(3A4,3X,7(3X,E12.6))
511 FORMAT(' COOLING WATER CONSUMED BY EVAPORATION ',10X,E12.6/' COOLI
   1NG WATER USED IN ONCE-THRU CONDENSORS ',5X,E12.6/' WATER REQUIRED
   2FOR H2 BY ELECTROLYSIS      ',5X,E12.6/10X,' (FEED WATER   ',5X,E
   312.6,')'/10X,' (COOLING TOWER',5X,E12.6,')'/
   4' OIL SHALE WATER REQUIREMENTS',20X,E12.6/
   5' TAR SANDS WATER REQUIREMENTS',20X,E12.6/
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     6' COAL GASIFICATION WATER REQUIREMENTS',12X,E12.6/
     7' COAL LIQUEFACTION WATER REQUIREMENTS',12X,E12.6//
     8 '  TOTAL    ',39X,E12.6//)
1000 FORMAT ('1',53X,' YEAR: ',I5//)
1100 FORMAT(47X,' TOTAL BASE ENERGY DEMAND',//)
1101 FORMAT(48X,'SUMMARY OF ENERGY DEMANDS'//)
1150 FORMAT (45X,'ENERGY DEMAND:  TRILLION BTUS'//)
1200 FORMAT(19X,'RESIDENTIAL',5X,'COMMERCIAL',5X,'INDUSTRIAL',3X,'TRANS
    1PORTATION',6X,'TOTAL'//)
1201 FORMAT(21X,'TTL B.E.D',4X,'ELEC. GEN.',5X,'PET. REF. ',5X,'SYNTH.
    1GAS',5X,'SYN. CRUDE',5X,'SYN. FUELS',5X,'  TOTAL'//)
1202 FORMAT(15X,'TTL B.E.D.',4X,'ELEC. GEN.',5X,'PET. REF. ',5X,'SYNTH.
     1 GAS',5X,'SYN. CRUDE',5X,' METHANOL ',5X,'  TOTAL'//)
       RETURN
       END
```

```
      SUBROUTINE PETREF(I)
C     SUBROUTINE PETREF CALCULATES THE CRUDE TO STILLS AND ENERGY DEMAND
C      FOR PETROLEUM REFINING.
C     PETD = PETROLEUM DEMAND (GAS + KERO. + DIST + RESID.)
C     CTS  = CRUDE TO STILLS IN TRILLION BTU.
C     J=22 FOR LPG, J=23 FOR REFINERY GAS, J=24 FOR PETROLEUM COKE.
      COMMON /MC/TITLE1(3,21),TITLE2(3,7),NYEAR(14)
     1,SCON(14,21,7),TSCON(14,21,7)
     2,BED(21),XXBED(21),XBED(21),SYNCD(21),PRD(24),SGFR(21),
     3SCFR(21),XXP(21),ELGD(21)
     4,SFFR(21),APGTT(7),APBED(7)
      COMMON/PRC/PREF(14,24),PRUD(14),CTSR(14),PIPR(7,24),        APPRT(
     17),APPR(7,24),PSCON(14,24,7),PIPRS(7)
     2,CTS,PRDTT
       DO 1000 J=1,21
 1000 XXBED(J) = XBED(J) + SGFR(J) + ELGD(J)
      DO 1 J=1,21
    1 PRD(J) = 0.
      COUNT = 0.
      PRDT = 0.
 1001 OPRDT = PRDT
      PETD= XXBED(12)+XXBED(13)+XXBED(14)+XXBED(15)
     1 + PRD(12) + PRD(13) + PRD(14) + PRD(15)
      CTS =CTSR(I)*PETD
      PRDTT = 0.
C     USE 1.3323 TO CORRECT PRD(J) TO 1970 VALUES
      IF(I.NE.1) GO TO 91
      DO 90 J=1,24
      PRD(J) = PREF(I,J)*PRUD(I)*CTS/1.3323
      PRDTT = PRDTT + PRD(J)
   90 CONTINUE
      GO TO 92
   91 CONTINUE
      DO 92 J=1,24
      PRD(J) = PREF(I,J)*PRUD(I)*CTS
      PRDTT = PRDTT + PRD(J)
```

```
  92 CONTINUE
     PRDT = PRDTT - (PRD(22) + PRD(23) + PRD(24))
     PRCONT =(PRDT - OPRDT)/PRDT
     IF(PRCONT.LE..00001) GO TO 1002
      COUNT = COUNT + 1.
     IF (COUNT.GT.10.) GO TO 1002
     GO TO 1001
1002 CONTINUE
     DO 101 K=1,7
     APPRT(K)=0.
     DO 100 J=1,24
     APPR(K,J) = PIPR(K,J)*PRD(J)*500.*PSCON(I,J,K)
     APPRT(K)  = APPRT(K)+ APPR(K,J)
 100 CONTINUE
     APPRT(K) = APPRT(K)+ PIPRS(K)*CTS
 101 CONTINUE
     RETURN
     END
```

```
C      SUBROUTINE RESIDD CALCULATES THE EFFECT OF THE RESIDENTIAL USAGE
C        ON ENERGY RESOURCES AND THE ENVIRONMENT.
C      RRACHF(I,J) = RESIDENTIAL ROOM A/C HOUSEHOLD FRACTION FOR FUEL 'J'
C        IN YEAR 'I'
C      R---HF(I,J) = RESIDENTIAL  - - -   HOUSEHOLD FRACTION FOR FUEL 'J'
C        IN YEAR 'I'
C      RACD(J) = RESIDENTIAL A/C ENERGY DEMAND FOR FUEL 'J'.
C      R--D(J) = RESIDENTIAL - - ENERGY DEMAND FOR FUEL 'J'.
C      TRDT = TOTAL RESIDENTIAL ENERGY DEMAND.
C      APLRAC(K,J) = AIR POLLUTION OF TYPE 'K' WITH FUEL 'J' FOR RESIDEN-
C        IAL A/C.
C      RRACEF = EFFICIENCY OF RESIDENTIAL ROOM A/C FOR FUEL 'J'.
C      PIR(K,J) = POLLUTION INDES FOR FUEL 'J' OF POLLUTION TYPE 'K'.
       SUBROUTINE RESIDD(I)
       COMMON /MC/TITLE1(3,21),TITLE2(3,7),NYEAR(14)
      1,SCON(14,21,7),TSCON(14,21,7)
      2,BED(21),XXBED(21),XBED(21),SYNCD(21),PRD(24),SGFR(21),
      3SCFR(21),XXP(21),ELGD(21)
      4,SFFR(21),APGTT(7),APBED(7)
       COMMON /MRC/RSRAC(14),RSCAC(14),RSC(14),RSR(14),RSSH(14),RSWH(14),
      1RRACHF(14,21),RCACHF(14,21),RCHF(14,21),RRHF(14,21),RSHHF(14,21),
      2RWHHF(14,21),HHLD(14),
      3RRACEF(14,21),RCACEF(14,21),RCEF(14,21),RREF(14,21),RSHEF(14,21),
      4RWHEF(14,21)
      5,TRD(21)
      6,APRT(7),TRDT
       COMMON/RA/APRAC(7),APRSH(7),APRWH(7),APRR(7),APRM(7)          ,APRC(
      17),RRACD(21),RCACD(21),RACD(21),RRD(21),RSHD(21),RWHD(21),RCD(21),
      2RMD(21),          DPM70(21)
      3,          PIR(7,21)
      4,          APLRAC(7,21),APLRSH(7,21),APLRWH(7,21),APLRR(7,21),APLRC
      5(7,21),APLRM(7,21)
      6,          UDRRAC(21),UDRCAC(21),UDRC(21),UDRR(21),UDRSH(21),UDRWH(
      721)
       RACDT = 0.
       RRDT = 0.
```

```
      RWHDT = 0.
      RSHDT = 0.
       RMDT = 0.
       TRDT = 0.
      RCDT = 0.
      DO 90 J = 1,21
      TRD(J) =0.
      RRACD(J) = RSRAC(I)*HHLD(I)*UDRRAC(J)  *RRACHF(I,J)*(RRACEF(1,J)/
     1RRACEF(I,J))
      RCACD(J) = RSCAC(I)*HHLD(I)*UDRCAC(J)  *RCACHF(I,J)*(RCACEF(1,J)/
     1RCACEF(I,J))
      RACD(J) = RRACD(J) + RCACD(J)
      RRD(J) = RSR(I)*HHLD(I)*UDRR(J)  *RRHF(I,J)*(RREF(1,J)/
     1RREF(I,J))
      RSHD(J) = RSSH(I)*HHLD(I)*UDRSH(J)  *RSHHF(I,J)*(RSHEF(1,J)/
     1RSHEF(I,J))
      RWHD(J) = RSWH(I)*HHLD(I)*UDRWH(J)  *RWHHF(I,J)*(RWHEF(1,J)/
     1RWHEF(I,J))
      RCD(J) = RSC(I)*HHLD(I)*UDRC(J)  *RCHF(I,J)*(RCEF(1,J)/RCEF(I,J))
      RMD(J) = (HHLD(I)/62.874)*DRM70(J)
      TRD(J) = RACD(J) + RRD(J) + RSHD(J) + RWHD(J) + RCD(J) + RMD(J)
      RACDT = RACDT + RACD(J)
       RRDT = RRDT + RRD(J)
      RSHDT = RSHDT + RSHD(J)
      RWHDT = RWHDT + RWHD(J)
      RCDT = RCDT + RCD(J)
      RMDT = RMDT + RMD(J)
       TRDT = TRDT + TRD(J)
   90 CONTINUE
      DO 101 K = 1,7
      APRAC(K) = 0.
      APRSH(K) = 0.
      APRWH(K) = 0.
       APRC(K) = 0.
       APRM(K) = 0.
      APRR(K) = 0.
```

```
      APRT(K) = 0.
      DO 100 J=1,21
      APLRAC(K,J) = PIR(K,J)*RACD(J)*500.
     1*SCON(I,J,K)
      APLRSH(K,J) = PIR(K,J)*RSHD(J)*500.
     1*SCON(I,J,K)
      APLRWH(K,J) = PIR(K,J)*RWHD(J) *500.
     1*SCON(I,J,K)
      APLRR(K,J) = PIR(K,J)*RRD(J)*500.
     1*SCON(I,J,K)
      APLRC(K,J) = PIR(K,J)*RCD(J)   *500.
     1*SCON(I,J,K)
      APLRM(K,J) = PIR(K,J)*RMD(J)   *500.
     1*SCON(I,J,K)
      APRAC(K) = APRAC(K) + APLRAC(K,J)
      APRSH(K) = APRSH(K) + APLRSH(K,J)
      APRWH(K) = APRWH(K) + APLRWH(K,J)
      APRC(K) = APRC(K) + APLRC(K,J)
      APRM(K) = APRM(K) + APLRM(K,J)
      APRR(K) = APRR(K) + APLRR(K,J)
  100 CONTINUE
      APRT(K) = APRAC(K) + APRSH(K)+APRWH(K)+APRC(K)+APRM(K)+APRR(K)
  101 CONTINUE
      WRITE (6,1000) NYEAR(I)
 1000 FORMAT ('1',53X,' YEAR: ',I5//)
      WRITE (6,1100)
 1100 FORMAT (54X,' RESIDENTIAL',//)
      WRITE (6,1150)
 1150 FORMAT (45X,'ENERGY DEMAND:  TRILLION BTUS'//)
      WRITE(6,1200)
 1200 FORMAT (20X,' AIR.COND.',7X,'REFRIG.',7X,' SPACE HT.',6X,' WATER H
     1T.',6X,' COOKING',9X,' MISC.',10X,' TOTAL'//)
      DO 150 KK = 1,21
      WRITE (6,210) (TITLE1(J,KK),J=1,3),RACD(KK),RRD(KK),RSHD(KK),RWHD(
     1KK),RCD(KK),RMD(KK),TRD(KK)
  150 CONTINUE
```

```
210 FORMAT (3A4,3X,7(5X,F10.1))
    WRITE (6,220) RACDT,RRDT,RSHDT,RWHDT,RCDT,RMDT,TRDT
220 FORMAT ( //' TOTAL',10X,7(5X,F10.1))
    WRITE (6,1000) NYEAR(I)
    WRITE (6,1100)
    WRITE (6,500)
    WRITE (6,1200)
    DO 160 KK = 1,7
    WRITE (6,510) (TITLE2(J,KK),J=1,3),APRAC(KK),APRR(KK),APRSH(KK),
   1APRWH(KK),APRC(KK),APRM(KK),APRT(KK)
160 CONTINUE
500 FORMAT ('0',50X,' AIR POLLUTION (TONS)'//)
510 FORMAT (3A4,3X,7(3X,E12.6))
    RETURN
    END
```

```
C     SUBROUTINE TRANS CALCULATES THE EFFECT OF TRANSPORTATION DEMANDS
C     ON ENERGY RESOURCES AND THE ENVIRONMENT.
C     APR = AIRPLANE PROJECTED ENERGY DEMAND BASE IN TRILLIONS OF BTUS.
C     AUR = AUTO     PROJECTED ENERGY DEMAND BASE IN TRILLIONS OF BTUS.
C      BR = BUS      PROJECTED ENERGY DEMAND BASE IN TRILLIONS OF BTUS.
C     RBR = RAILROAD PROJECTED ENERGY DEMAND BASE IN TRILLIONS OF BTUS.
C      SR = SHIPS    PROJECTED ENERGY DEMAND BASE IN TRILLIONS OF BTUS.
C      TR = TRUCKS   PROJECTED ENERGY DEMAND BASE IN TRILLIONS OF BTUS.
C     APD(J) = FUEL 'J' ENERGY DEMAND FOR AIRPLANES IN TRILLIONS OF BTUS
C     --D(J) = FUEL 'J' ENERGY DEMAND FOR   --      IN TRILLIONS OF BTUS
C     J = FUEL TYPE
C     J = 1 FOR COAL
C     J = 2 FOR GEOTHERMAL
C     J = 3 FOR HYDROGEN
C     J = 4 FOR NATURAL GAS
C     J = 5 FOR GCFR
C     J = 6 FOR HTGR
C     J = 7 FOR LFR
C     J = 8  FOR LMFBR
C     J = 9  FOR LWR
C     J =10  FOR MSBR
C     J =11  FOR MCFR
C     J =12  FOR GASOLINE
C     J =13  FOR JET FUEL
C     J =14  FOR DISTILLATE OIL
C     J =15  FOR RESIDUAL OIL
C     J =16  FOR ELECTRICITY
C     J =17  FOR METHANOL
C     J = 18 FOR SOLAR
C     J =19  FOR TIDAL
C     J =20       WIND
C     J =21       HYDROELECTRIC
C     K = AIR POLLUTION CATEGORY
C     K = 1 FOR CO2
C     K = 2 FOR CO
C     K = 3 FOR SO2
```

```
C      K = 4 FOR NOX
C      K = 5 FOR PARTICULATE
C      K = 6 FOR HYDROCARBONS
C      K = 7 FOR ALDEHYDES
C      PI--(K,J) = AIR POLLUTION FACTOR FOR THE FUEL =J" AND INDEX "K" IN
C           POUNDS PER MILLION BTUS FOR DEMAND --.
C
C      APOL--(J,K) = AIR POLLUTION FOR FUEL "J" OF POLLUTION TYPE "K" FOR
C           DEMAND --.
C      APDT = TOTAL AIRPLANE ENERGY DEMAND IN TRILLION BTUS.
C      --DT = TOTAL   --      ENERGY DEMAND IN TRILLION BTUS.
C      TTD(J) = TOTAL TRANSPORTATION DEMAND FOR FUEL "J".
C      TTDT = TOTAL TRANSPORTATION DEMAND.
C      APAP(K) = TONS OF POLLUTION "K" FROM ALL FUELS FOR AIRPLANES.
C      AP--(K) = TONS OF POLLUTION "K" FROM ALL FUELS FOR   --  .
       SUBROUTINE TRANS(I)
       COMMON /MC/TITLE1(3,21),TITLE2(3,7),NYEAR(14)
      1,SCON(14,21,7),TSCON(14,21,7)
      2,BED(21),XXBED(21),XBED(21),SYNCD(21),PRD(24),SGFR(21),
      3SCFR(21),XXP(21),ELGD(21)
      4,SFFR(21),APGTT(7),APBED(7)
       COMMON /TC/APBI(14),AUBI(14),BBI(14),RRBI(14),SBI(14),TBI(14),
      1APDF(14,21),AUDF(14,21),BDF(14,21),RRDF(14,21),SDF(14,21),TDF(14,
      221)
      3,TTD(21)
      4,APTT(7),TTDT
       COMMON/TA/PIAU70(7,21),PIAP(7,21),PIAU(7,21),PIB(7,21),PIRR(7,21),
      1PIS(7,21),PIT(7,21)
      2,          APD(21),AUD(21),BD(21),RRPD(21),SD(21),TD(21),
      3APOLAP(21,7),APOLAU(21,7),APOLB(21,7),APOLRR(21,7),APOLS(21,7),
      4APOLT(21,7),
      5APAP(7),APAU(7),APB(7),APRRR(7),APS(7),APT(7)
       APDT = 0.
       AUDT = 0.
        BDT = 0.
        SDT = 0.
```

```
      TDT = 0.
      TTDT = 0.
      RRDT = 0.
      DO 90 J=1,21
      TTD(J) =0.
      APD(J) = APDF(I,J)*APBI(I)
      AUD(J) = AUDF(I,J)*AUBI(I)
       BD(J) =  BDF(I,J)*BBI(I)
      RRRD(J) = RRDF(I,J)*RRBI(I)
       SD(J) =  SDF(I,J)*SBI(I)
       TD(J) =  TDF(I,J)*TBI(I)
      TTD(J) = APD(J) + AUD(J) +BD(J) + RRRD(J)+ SD(J) +TD(J)
      APDT = APDT + APD(J)
      AUDT = AUDT + AUD(J)
      BDT  = BDT + BD(J)
      RRDT = RRDT +RRRD(J)
       SDT = SDT + SD(J)
        TDT = TDT + TD(J)
      TTDT = TTDT + TTD(J)
   90 CONTINUE
      DO 101 K = 1,7
      APAP(K) = 0.
      APAU(K) = 0.
       APB(K) = 0.
      APRRR(K) = 0.
       APS(K) = 0.
       APT(K) = 0.
      APTT(K) = 0.
      DO 100 J=1,21
      APOLAP(J,K) = PIAP(K,J)*APD(J)*500.
     1*TSCON(I,J,K)
      IF(I.NE.1) GO TO 5000
      APOLAU(J,K) = PIAU70(K,J)*AUD(J)*500.
     1*TSCON(I,J,K)
      GO TO 5001
5000  APOLAU(J,K) = PIAU(K,J)*AUD(J)*500.
```

```
     1*TSCON(I,J,K)
5001   APOLB(J,K) =  PIB(K,J)* BD(J)*500.
     1*TSCON(I,J,K)
      APOLRR(J,K) = PIRR(K,J)*RRRD(J)*500.
     1*TSCON(I,J,K)
       APOLS(J,K) =  PIS(K,J)* SD(J)*500.
     1*TSCON(I,J,K)
       APOLT(J,K) =  PIT(K,J)* TD(J)*500.
     1*TSCON(I,J,K)
      APAP(K) = APAP(K) + APOLAP(J,K)
      APAU(K) = APAU(K) + APOLAU(J,K)
       APB(K) =  APB(K) + APOLB(J,K)
      APRRR(K) = APRRR(K) + APOLRR(J,K)
       APS(K) =  APS(K) + APOLS(J,K)
       APT(K) =  APT(K) + APOLT(J,K)
 100 CONTINUE
      APTT(K) = APAP(K) + APAU(K) + APB(K) + APRRR(K) + APS(K) + APT(K)
 101 CONTINUE
      WRITE (6,1000) NYEAR(I)
      WRITE (6,1100)
      WRITE (6,1150)
      WRITE (6,1200)
1000 FORMAT ('1',53X,' YEAR: ',I5//)
1100 FORMAT (53X,'TRANSPORTATION',//)
1150 FORMAT (45X,'ENERGY DEMAND:  TRILLION BTUS'//)
1200 FORMAT (21X,' AIRPLANE',9X,' AUTO',12X,' BUS',9X,' RAILROAD',9X,'S
    1HIP',10X,' TRUCK',9X,' TOTAL')
      DO 150 KK = 1,21
      WRITE (6,210) (TITLE1(J,KK),J=1,3),APD(KK),AUD(KK),BD(KK),RRRD(KK)
     1,SD(KK),TD(KK),TTD(KK)
 150 CONTINUE
 210 FORMAT ( 3A4,3X,7(5X,F10.1))
      WRITE (6,220)APDT,AUDT,BDT,RRDT,SDT,TDT,TTDT
 220 FORMAT ( //' TOTAL',10X,7(5X,F10.1))
      WRITE (6,1000) NYEAR(I)
      WRITE (6,1100)
```

```
      WRITE (6,500)
      WRITE (6,1200)
      DO 160 KK=1,7
      WRITE (6,510) (TITLE2(J,KK),J=1,3),APAP(KK),APAU(KK),APB(KK),APRRR
     1(KK),APS(KK),APT(KK),APTT(KK)
  160 CONTINUE
  500 FORMAT ('0',50X,' AIR POLLUTION (TONS)'//)
  510 FORMAT (3A4,3X,7(3X,E12.6))
      RETURN
      END
```

APPENDIX C

MANERGY OUTPUT FOR BASE CASE ASSUMPTIONS

The Appendix contains the detailed output of the MANERGY model for the base case assumptions delineated in Chapter III, Chapter IV and Appendix A. The detailed output is presented on an annual basis from 1970 to 2100 at 10 year intervals.

At each 10 year interval, MANERGY'S output consists of:

1. Matrices of end utilization energy demand in trillions of Btu's per year versus the twenty-one energy sources for each residential, commercial, industrial and transportation demand category.
2. Matrix of energy demand in trillions of Btu's per year versus the twenty-one energy sources for the total end utilization (or base) demand, electrical generation, petroleum refining, synthetic gas production, synthetic crude production, synthetic fuels manufacture.
3. Matrices of air pollution generated (CO_2, CO, SO_2, NO_x, particulates, hydrocarbons and aldehydes) versus each of the end utilization energy demand categories, electrical generation, petroleum refining, synthetic gas production,

synthetic crude oil production and synthetic fuels manufacturing.

4. The amount of solid waste in tons per year from syngas, syncrude, tar sands and oil shale production.
5. The amount of elemental sulfur in tons per year from syncrude and syngas production.
6. Land use by energy production and transmission sectors in acres (strip mined coal, tar sands, oil shale, electrical generation and electrical transmission).
7. Radioactive material production and releases including tritium, krypton-85, long-lived radioactive waste and population exposure to ionizing radiation.
8. Cooling water requirements for energy production in terms of evaporation and once-through consumption for electrical generation, H_2 production, tar sands, oil shale, syngas and syncrude production.
9. Coal resource balance in terms of requirements for end utilization energy demands, electrical generation, syncrude production, syngas production, methanol production, and petroleum refining.
10. Petroleum resource balance in terms of tar sand, oil shale, syncrude requirements, domestic crude production and crude oil imports.
11. Natural gas resource balance in terms of domestic natural gas production, Canadian pipeline imports, liquefied natural gas imports and synthetic gas production.

12. Nuclear resource balance in terms of kilograms of separative work required, power required for separative work, thorium production and uranium production.
13. Summary of annual resource requirements in trillions of Btu's per year for coal, geothermal, natural gas, nuclear fission, nuclear fusion, petroleum (including tar sands and oil shale), solar, tidal, wind and hydroelectric resources. Also the annual requirements of hydrogen and methanol are presented.
14. Summary of balance of payments (in millions of 1970 dollars annually) for crude oil imports, liquefied natural gas imports and Canadian pipeline gas imports.

YEAR: 1970

RESIDENTIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	20.6	4.0	3359.7	1166.7	391.0	0.0	4941.9
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	2341.3	0.0	0.0	0.0	2341.3
RESID. OIL	0.0	0.0	888.2	0.0	0.0	0.0	888.2
ELECTRICITY	193.7	220.9	206.0	253.8	118.6	502.8	1495.9
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	214.3	224.9	6795.2	1420.5	509.6	502.8	9667.3

YEAR: 1970

RESIDENTIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.125536E 07	0.244360E 06	0.479447E 09	0.711682E 08	0.238495E 08	0.0	0.575964E 09
CO	0.205747E 03	0.400590E 02	0.917276E 05	0.116669E 05	0.390976E 04	0.0	0.107550E 06
SO2	0.617392E 01	0.120177E 01	0.174484E 07	0.350008E 03	0.117293E 03	0.0	0.174531E 07
NOX	0.514493E 03	0.100147E 03	0.222860E 06	0.291673E 05	0.977439E 04	0.0	0.262416E 06
PARTICULATE	0.195508E 03	0.380560E 02	0.148179E 06	0.110836E 05	0.371427E 04	0.0	0.163210E 06
HYDROCARBON	0.823189E 02	0.160236E 02	0.483172E 05	0.466677E 04	0.156390E 04	0.0	0.546463E 05
ALDEHYDE	0.102899E 03	0.200295E 02	0.400507E 05	0.583346E 04	0.195488E 04	0.0	0.479620E 05

YEAR: 1970

COMMERCIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	353.9	35.7	0.0	0.0	389.7
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	51.4	0.0	1044.2	401.9	79.0	378.8	1955.3
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	1805.1	0.0	0.0	464.6	2269.8
RESID. OIL	0.0	0.0	247.8	0.0	0.0	177.6	425.3
ELECTRICITY	61.2	260.9	88.5	131.5	7.2	458.7	1007.9
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	112.6	260.9	3539.5	569.1	86.2	1479.7	6048.0

YEAR: 1970

COMMERCIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.313563E 07	0.0	0.277833E 09	0.285180E 08	0.481953E 07	0.776931E 08	0.391998E 09
CO	0.514038E 03	0.0	0.788036E 05	0.107690E 05	0.790087E 03	0.424152E 04	0.951181E 05
SO2	0.154211E 02	0.0	0.156990E 07	0.720858E 05	0.237026E 02	0.352673E 06	0.198570E 07
NOX	0.257019E 04	0.0	0.385398E 06	0.241503E 05	0.395043E 04	0.109551E 06	0.525620E 06
PARTICULATE	0.488336E 03	0.0	0.153217E 06	0.652361E 04	0.750582E 03	0.423253E 05	0.203325E 06
HYDROCARBON	0.205615E 03	0.0	0.462541E 05	0.363620E 04	0.316035E 03	0.830880E 04	0.587208E 05
ALDEHYDE	0.257019E 03	0.0	0.190788E 05	0.201307E 04	0.395043E 03	0.583238E 04	0.275763E 05

YEAR: 1970

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
COAL	40.1	78.0	0.0	254.8	71.3	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	76.0	56.0	13.1	211.3	131.7	64.7	10.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	16.9	0.0	0.0	40.3	25.6	0.0	0.0
RESID. OIL	71.8	0.0	0.0	0.0	128.0	0.0	0.0
ELECTRICITY	6.3	205.3	6.5	31.2	9.1	2.6	4.5
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	211.0	339.3	19.7	537.6	365.8	67.4	14.5

YEAR: 1970

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
COAL	0.0	0.0	24.2	4.8	1718.6	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	5.4	0.1	9.8	0.0	245.5	602.6	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	0.0	0.0	368.3	136.0	0.0
RESID. OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ELECTRICITY	3.8	0.0	22.2	2.4	122.8	113.3	1375.5
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	9.2	0.1	56.2	7.2	2455.2	851.9	1375.5

YEAR: 1970

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	MISC.FOSL.	RAW MATL	TOTAL
COAL	3079.8	160.4	5432.2
GEOTHERMAL	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0
NATURAL GAS	7088.0	629.6	9143.9
GCFR	0.0	0.0	0.0
HTGR	0.0	0.0	0.0
LFR	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0
LWR	0.0	0.0	0.0
MSBR	0.0	0.0	0.0
MCFR	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0
DISTIL. OIL	316.7	3220.4	4124.3
RESID. OIL	436.9	0.0	636.6
ELECTRICITY	0.0	0.0	1905.5
METHANOL	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0
WIND	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0
TOTAL	10921.4	4010.5	21242.5

YEAR: 1970

INDUSTRIAL

AIR POLLUTION (TONS)

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
CO2	0.166603E 08	0.121554E 08	0.801309E 06	0.448552E 08	0.290827E 08	0.394917E 07	0.610514E 06
CO	0.159520E 04	0.296887E 04	0.262724E 01	0.972903E 04	0.283415E 04	0.129481E 02	0.200169E 01
SO2	0.170811E 06	0.157278E 06	0.394086E 01	0.525957E 06	0.302958E 06	0.262099E 06	0.300253E 01
NOX	0.279618E 05	0.255299E 05	0.788172E 03	0.908776E 05	0.489483E 05	0.388443E 04	0.600505E 03
PARTICULATE	0.919121E 05	0.223754E 06	0.125882E 05	0.115637E 08	0.738740E 05	0.291426E 05	0.693150E 05
HYDROCARBON	0.317936E 04	0.259853E 04	0.262724E 03	0.948986E 04	0.554262E 04	0.129481E 04	0.200169E 03
ALDEHYDE	0.513094E 03	0.157723E 03	0.197043E 02	0.848025E 03	0.876970E 03	0.971109E 02	0.150126E 02

YEAR: 1970

INDUSTRIAL

AIR POLLUTION (TONS)

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
CO2	0.329934E 06	0.771777E 04	0.330947E 07	0.538942E 06	0.374893E 09	0.483161E 08	0.0
CO	0.108175E 01	0.367143E-01	0.918673E 03	0.182374E 03	0.224345E 07	0.233318E 06	0.0
SO2	0.162263E 01	0.796985E 01	0.736245E 06	0.969690E 04	0.372504E 07	0.151107E 06	0.0
NOX	0.324525E 03	0.915273E 01	0.746228E 04	0.136708E 04	0.556028E 06	0.200777E 06	0.0
PARTICULATE	0.246679E 03	0.346106E 02	0.158432E 06	0.927571E 04	0.110071E 08	0.221648E 07	0.0
HYDROCARBON	0.108175E 03	0.208910E 01	0.655227E 03	0.911870E 02	0.414560E 05	0.135202E 05	0.0
ALDEHYDE	0.811314E 01	0.321897E 00	0.376228E 02	0.454732E 01	0.464400E 04	0.335993E 06	0.0

YEAR: 1970

INDUSTRIAL

AIR POLLUTION (TONS)

	MISC.FOSL.	RAW MATL	TOTAL
CO2	0.841362E 09	0.0	0.137687E 10
CO	0.118664E 06	0.0	0.261368E 07
SO2	0.682230E 07	0.0	0.128632E 08
NOX	0.140419E 07	0.0	0.236874E 07
PARTICULATE	0.276849E 07	0.0	0.282243E 08
HYDROCARBON	0.207912E 06	0.0	0.286312E 06
ALDEHYDE	0.172819E 05	0.0	0.360497E 06

YEAR: 1970

TRANSPORTATION

ENERGY DEMAND: TRILLION BTUS

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	164.0	8291.0	58.8	0.0	0.0	3070.6	11584.4
JET FUEL	2568.7	0.0	0.0	0.0	0.0	0.0	2568.7
DISTIL. OIL	0.0	0.0	65.3	494.4	111.2	846.0	1516.9
RESID. OIL	0.0	0.0	0.0	0.0	718.7	0.0	718.7
ELECTRICITY	0.0	0.0	0.0	31.6	0.0	0.0	31.6
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	2732.7	8291.0	124.1	526.0	829.9	3916.6	16420.3

YEAR: 1970

TRANSPORTATION

AIR POLLUTION (TONS)

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
CO2	0.203586E 09	0.617679E 09	0.993085E 07	0.420274E 08	0.705414E 08	0.300669E 09	0.124443E 10
CO	0.146199E 07	0.708051E 08	0.480726E 05	0.190359E 06	0.432960E 05	0.152324E 07	0.740720E 08
SO2	0.112041E 06	0.165820E 07	0.750829E 04	0.479607E 05	0.860065E 06	0.143473E 06	0.282924E 07
NOX	0.281458E 06	0.605243E 07	0.457884E 05	0.326330E 06	0.169342E 06	0.699598E 06	0.757495E 07
PARTICULATE	0.449529E 06	0.294330E 06	0.515623E 04	0.232387E 05	0.604223E 05	0.148768E 06	0.981444E 06
HYDROCARBON	0.956445E 06	0.124033E 08	0.220213E 05	0.145860E 06	0.399929E 05	0.393884E 06	0.139615E 09
ALDEHYDE	0.286933E 05	0.870554E 05	0.133569E 04	0.543884E 04	0.362370E 04	0.415473E 05	0.167694E 06

YEAR: 1970

TOTAL BASE ENERGY DEMAND

ENERGY DEMAND: TRILLION BTUS

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
COAL	0.0	389.7	5432.2	0.0	5821.8
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	4941.9	1955.3	9143.9	0.0	16041.1
GCFR	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	11584.4	11584.4
JET FUEL	0.0	0.0	0.0	2568.7	2568.7
DISTIL. OIL	2341.3	2269.8	4124.3	1516.9	10252.2
RESID. OIL	888.2	425.3	636.6	718.7	2668.9
ELECTRICITY	1495.9	1007.9	1905.5	31.6	4440.9
METHANOL	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0
TOTAL	9667.3	6048.0	21242.5	16420.3	53378.1

YEAR: 1970

AIR POLLUTION (TONS)

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
CO2	0.575954E 09	0.391998E 09	0.137687E 10	0.124443E 10	0.358927E 10
CO	0.107550E 06	0.951181E 05	0.261368E 07	0.740720E 08	0.768883E 08
SO2	0.174531E 07	0.198570E 07	0.128632E 08	0.282924E 07	0.194234E 08
NOX	0.262416E 06	0.525620E 06	0.236874E 07	0.757495E 07	0.107317E 08
PARTICULATE	0.163210E 06	0.203325E 06	0.282243E 08	0.981444E 06	0.295723E 08
HYDROCARBON	0.546463E 05	0.587208E 05	0.286312E 06	0.139615E 08	0.143612E 08
ALDEHYDE	0.479620E 05	0.275763E 05	0.360497E 06	0.167694E 06	0.603729E 06

YEAR: 1970

SUMMARY OF ENERGY DEMANDS

ENERGY DEMAND: TRILLION BTUS

	TTL B.E.D	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	SYN. FUELS	TOTAL
COAL	5821.8	8415.7	11.2	0.0	0.0	-0.0	14248.8
GEOTHERMAL	0.0	15.9	0.0	0.0	0.0	0.0	15.9
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	15041.1	3877.9	1070.3	0.0	0.0	-0.0	20989.3
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	228.5	0.0	0.0	0.0	0.0	228.5
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	11584.4	0.0	0.0	0.0	0.0	0.0	11584.4
JET FUEL	2568.7	0.0	0.0	0.0	0.0	0.0	2568.7
DISTIL. OIL	10252.2	156.2	0.0	0.0	0.0	-0.0	10408.4
RESID. OIL	2668.9	1905.6	313.8	0.0	0.0	-0.0	4888.3
ELECTRICITY	4440.9	0.0	70.0	0.0	0.0	-0.1	0.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	1055.5	0.0	0.0	0.0	0.0	1055.5
TOTAL	53378.1	15655.3	1465.4	0.0	0.0	-0.1	65987.6

YEAR: 1970

AIR POLLUTION (TONS)

	TTL B.F.O.	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	METHANOL	TOTAL
CO2	0.358927E 10	0.135437E 10	0.190895E 09	0.0	0.0	0.0	0.513453E 10
CO	0.768883E 08	0.160529E 06	0.210044E 05	0.0	0.0	0.0	0.770698E 08
SO2	0.194234E 08	0.192608E 08	0.560774E 06	0.0	0.0	0.0	0.392450E 08
NOX	0.107317E 08	0.434778E 07	0.212839E 06	0.0	0.0	0.0	0.152923E 08
PARTICULATE	0.295723E 08	0.422763E 07	0.769748E 05	0.0	0.0	0.0	0.338769E 08
HYDROCARBON	0.143612E 08	0.148599E 06	0.490750E 05	0.0	0.0	0.0	0.145589E 08
ALDEHYDE	0.603729E 06	0.135192E 05	0.527631E 04	0.0	0.0	0.0	0.622525E 06

YEAR: 1970

SOLID WASTE (TONS)

SYNCRUDE	0.0
TAR SANDS	0.0
OIL SHALE	0.0
SYNGAS	0.0
TOTAL	0.0

ELEMENTAL SULFUR PRODUCED (TONS)

SYNCRUDE	0.0
SYNGAS	0.0
TOTAL	0.0

LAND USE BY ENERGY PRODUCTION (ACRES)

COAL (STRIP MINING)	0.954668E 05
TAR SANDS	0.0
OIL SHALE	0.0
ELEC. GEN. & TRANS.	0.315431E 08
TOTAL	0.316385E 08

RADIOACTIVE MATERIAL PRODUCTION AND RELEASES

TRITIUM RELEASED	0.144740E 05	CURIES
KRYPTON-85 RELEASED	0.212705E 07	CURIES
LONG-LIVED RAD.WASTE	0.212175E 10	CURIES
LONG LIVED RAD.WASTE	0.360050E 05	CUBIC FEET
POPULATION EXPOSURE	0.537374E 05	MAN-REM

COOLING WATER REQUIREMENTS FOR ENERGY PRODUCTION (ACRE-FEET)

COOLING WATER CONSUMED BY EVAPORATION		0.214940E 07
COOLING WATER USED IN ONCE-THRU CONDENSORS		0.194611E 09
WATER REQUIRED FOR H2 BY ELECTROLYSIS		0.0
(FEED WATER	0.0)	
(COOLING TOWER	0.0)	
OIL SHALE WATER REQUIREMENTS		0.0
TAR SANDS WATER REQUIREMENTS		0.0
COAL GASIFICATION WATER REQUIREMENTS		0.0
COAL LIQUEFACTION WATER REQUIREMENTS		0.0
TOTAL		0.196760E 09

YEAR: 1970

COAL RESOURCE DEMANDS (TRILLION BTU)

TOTAL BED	5821.84
SYNCRUDE	0.0
SYNGAS	0.0
METHANOL	0.0
ELEC.GEN.	8415.74
PET.REF.	11.21
TOTAL	14248.79

PETROLEUM RESOURCE DEMANDS (TRILLION BTU)

TOTAL PET. DEMAND	31134.38
TAR SANDS REQ.	0.0
OIL SHALE REQ	0.0
SYNCRUDE REQ.	0.0
DOMESTIC CRUDE PROD.	22564.00
CRUDE OIL IMPORTS	8570.38
TOTAL CRUDE PROD.	31134.38

NATURAL GAS RESOURCE DEMANDS (TRILLION BTU)

TOTAL DEMAND	20989.32
CORRECTED D+D.	21786.04
DOM. NAT. GAS	23194.00
CANADA P.L.IMP.	823.96
LNG IMPORTS	0.80
SYNGAS	0.0
TOTAL GAS PRD.	24018.76

NUCLEAR FUEL RESOURCE DEMANDS

SEP.WORK REQ.	0.131794E 07	KGSW
PWR REQ. KGSW	13.88	TRILLION BTU
THORIUM (THO2)	0.0	TONNES
URANIUM (U3O8)	0.651313E 03	TONNES

YEAR: 1970

SUMMARY OF RESOURCE REQUIREMENTS

RESOURCE	ANNUAL PROD.	
COAL	14248.79	TRILLION BTU
GEOTHERMAL	15.89	TRILLION BTU
(HYDROGEN)	0.0	TRILLION BTU
NATURAL GAS	24018.76	TRILLION BTU
NUCLEAR-FISSION	228.53	TRILLION BTU
NUCLEAR-FUSION	0.0	TRILLION BTU
PETROLEUM	31134.38	TRILLION BTU
(METHANOL)	0.0	TRILLION BTU
SOLAR	0.0	TRILLION BTU
TIDAL	0.0	TRILLION BTU
WIND	0.0	TRILLION BTU
HYDROELECTRIC	1055.45	TRILLION BTU
TOTAL	70701.75	TRILLION BTU

SUMMARY OF BALANCE OF PAYMENTS FOR ENERGY IMPORTS
(MILLIONS OF 1970 DOLLARS)

COST OF CRUDE PETROLEUM IMPORTS	3575.56
COST OF LIQUIFIED NATURAL GAS IMPORTS	0.62
COST OF CANADIAN GAS IMPORTS	205.99
TOTAL BALANCE OF PAYMENTS DEFICIT	3782.17

YEAR: 1980

RESIDENTIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	32.0	0.0	3557.2	1166.2	351.0	0.0	5106.3
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	2240.2	0.0	0.0	0.0	2240.2
RESID. OIL	0.0	0.0	834.4	0.0	0.0	0.0	834.4
ELECTRICITY	363.2	262.6	592.7	437.6	173.9	595.7	2425.8
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	395.2	262.6	7224.6	1603.8	525.0	595.7	10606.8

YEAR: 1980

RESIDENTIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.194959E 07	0.0	0.478335E 09	0.711373E 08	0.214117E 08	0.0	0.572833E 09
CO	0.319605E 03	0.0	0.909159E 05	0.116619E 05	0.351011E 04	0.0	0.106407E 06
SO2	0.958814E 01	0.0	0.100969E 07	0.349856E 03	0.105303E 03	0.0	0.101015E 07
NOX	0.799011E 03	0.0	0.221140E 06	0.291546E 05	0.877527E 04	0.0	0.259869E 06
PARTICULATE	0.303624E 03	0.0	0.144481E 06	0.110788E 05	0.333460E 04	0.0	0.159198E 06
HYDROCARBON	0.127842E 03	0.0	0.474352E 05	0.466474E 04	0.140404E 04	0.0	0.536318E 05
ALDEHYDE	0.159802E 03	0.0	0.399235E 05	0.583093E 04	0.175505E 04	0.0	0.476693E 05

YEAR: 1980

COMMERCIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	34.5	0.0	1364.6	519.1	97.6	528.4	2544.2
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	1949.4	0.0	0.0	648.1	2597.5
RESID. OIL	0.0	0.0	731.0	0.0	0.0	247.7	978.7
ELECTRICITY	82.8	337.9	839.3	244.5	18.4	639.8	2162.6
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	117.3	337.9	4984.4	763.6	116.0	2063.9	8283.1

YEAR: 1980

COMMERCIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.210579E 07	0.0	0.311081E 09	0.316664E 08	0.595621E 07	0.108366E 09	0.459175E 09
CO	0.345217E 03	0.0	0.155394E 05	0.519121E 04	0.976428E 03	0.591607E 04	0.279684E 05
SO2	0.103564E 02	0.0	0.886849E 06	0.155736E 03	0.292928E 02	0.296668E 06	0.118371E 07
NOX	0.172606E 04	0.0	0.446543E 06	0.259561E 05	0.488214E 04	0.152802E 06	0.631909E 06
PARTICULATE	0.327952E 03	0.0	0.174377E 06	0.493166E 04	0.927607E 03	0.590353E 05	0.239600E 06
HYDROCARBON	0.138085E 03	0.0	0.338227E 05	0.207649E 04	0.390571E 03	0.115891E 05	0.480170E 05
ALDEHYDE	0.172606E 03	0.0	0.233006E 05	0.259561E 04	0.488214E 03	0.813500E 04	0.346921E 05

YEAR: 1980

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
COAL	76.6	145.1	0.0	400.4	112.1	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	145.2	104.1	23.9	332.0	206.9	100.2	15.6
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	32.3	0.0	0.0	63.4	40.2	0.0	0.0
RESID. OIL	137.1	0.0	0.0	0.0	201.2	0.0	0.0
ELECTRICITY	12.1	381.6	11.9	49.0	14.4	4.1	7.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	403.2	630.7	35.8	844.8	574.9	104.3	22.5

YEAR: 1980

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
COAL	0.0	0.0	32.5	6.5	1819.5	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	9.1	0.1	13.2	0.0	298.7	802.9	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	0.0	0.0	461.7	124.6	0.0
RESID. OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ELECTRICITY	6.3	0.0	29.9	3.2	135.8	178.9	2706.4
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	15.5	0.2	75.6	9.7	2715.6	1106.4	2706.4

YEAR: 1980

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	MISC.FOSL.	RAW MATL	TOTAL
COAL	3963.1	263.7	6719.5
GEOTHERMAL	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0
NATURAL GAS	8890.6	1035.1	11977.8
GCFR	0.0	0.0	0.0
HTGR	0.0	0.0	0.0
LFR	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0
LWR	0.0	0.0	0.0
MSBR	0.0	0.0	0.0
MCFR	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0
DISTIL. OIL	397.3	5294.4	6413.9
RESID. OIL	548.0	0.0	886.2
ELECTRICITY	0.0	0.0	3540.5
METHANOL	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0
WIND	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0
TOTAL	13699.0	6593.3	29537.9

YEAR: 1980

INDUSTRIAL

AIR POLLUTION (TONS)

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
CO2	0.318286E 08	0.225966E 08	0.145922E 07	0.704866E 08	0.457013E 08	0.611182E 07	0.948734E 06
CO	0.334754E 04	0.551905E 04	0.478434E 01	0.152885E 05	0.445366E 04	0.200387E 02	0.311060E 01
SO2	0.109641E 06	0.866903E 05	0.717651E 01	0.258764E 06	0.158533E 06	0.405630E 06	0.466590E 01
NOX	0.534195E 05	0.474595E 05	0.143530E 04	0.142808F 06	0.769188E 05	0.601162E 04	0.933181E 03
PARTICULATE	0.175593E 06	0.415953E 06	0.126853E 05	0.181715E 08	0.116088E 06	0.451017E 05	0.107715E 06
HYDROCARBON	0.607400E 04	0.483059E 04	0.478434E 03	0.149126E 05	0.870984E 04	0.200388E 04	0.311060E 03
ALDEHYDE	0.990239E 03	0.293204E 03	0.358826E 02	0.133261E 04	0.137810E 04	0.150291E 03	0.233295E 02

YEAR: 1980

INDUSTRIAL

AIR POLLUTION (TONS)

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
CO2	0.556556E 06	0.121960E 05	0.444792E 07	0.725034E 06	0.431740E 09	0.595739E 08	0.0
CO	0.182477E 01	0.580177E-01	0.123470E 04	0.245346E 03	0.279735E 07	0.419200E 06	0.0
SO2	0.273716E 01	0.125943E 02	0.943422E 06	0.386696E 04	0.141476E 07	0.217034E 06	0.0
NOX	0.547432E 03	0.144636E 02	0.100293E 05	0.183913E 04	0.601307E 06	0.323669E 06	0.0
PARTICULATE	0.416115E 03	0.546933E 02	0.212933E 06	0.124785E 05	0.134995E 08	0.301405E 07	0.0
HYDROCARBON	0.182477E 03	0.330129E 01	0.880625E 03	0.122673E 03	0.454387E 05	0.174050E 05	0.0
ALDEHYDE	0.136858E 02	0.508677E 00	0.505650E 02	0.611747E 01	0.549134E 04	0.602596E 06	0.0

YEAR: 1980

INDUSTRIAL

AIR POLLUTION (TONS)

	MISC.FOSL.	RAW MATL	TOTAL
CO2	0.105534E 10	0.0	0.173153E 10
CO	0.149843E 06	0.0	0.339521E 07
SO2	0.264790E 07	0.0	0.624626E 07
NOX	0.176131E 07	0.0	0.302770E 07
PARTICULATE	0.347259E 07	0.0	0.392566E 08
HYDROCARBON	0.260789E 06	0.0	0.362142E 06
ALDEHYDE	0.216771E 05	0.0	0.634029E 06

YEAR: 1980

TRANSPORTATION

ENERGY DEMAND: TRILLION BTUS

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	231.0	10900.0	80.6	0.0	0.0	3273.7	14485.4
JET FUEL	7469.0	0.0	0.0	0.0	0.0	0.0	7469.0
DISTIL. OIL	0.0	0.0	134.4	630.0	165.3	1576.2	2505.9
RESID. OIL	0.0	0.0	0.0	0.0	974.7	0.0	974.7
ELECTRICITY	0.0	0.0	0.0	70.0	0.0	0.0	70.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	7700.0	10900.0	215.0	700.0	1140.0	4850.0	25505.0

YEAR: 1980

TRANSPORTATION

AIR POLLUTION (TONS)

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
CO2	0.573649E 09	0.812050E 09	0.174284E 08	0.535500E 08	0.969000E 08	0.377875E 09	0.193145E 10
CO	0.411949E 07	0.425100E 07	0.831781E 05	0.242550E 06	0.642935E 05	0.188362E 07	0.106441E 08
SO2	0.315700E 06	0.218000E 06	0.146469E 05	0.611100E 05	0.399457E 06	0.218371E 06	0.122728E 07
NOX	0.793099E 06	0.501400E 06	0.923961E 05	0.415800E 06	0.239220E 06	0.119092E 07	0.323283E 07
PARTICULATE	0.126665E 07	0.386950E 06	0.917780E 04	0.296100E 05	0.826260E 05	0.190302E 06	0.196531E 07
HYDROCARBON	0.269500E 07	0.512300E 06	0.434300E 05	0.185850E 06	0.585105E 05	0.618860E 06	0.411394E 07
ALDEHYDE	0.808499E 05	0.114450E 06	0.232469E 04	0.693000E 04	0.507379E 04	0.517131E 05	0.261341E 06

YEAR: 1980

TOTAL BASE ENERGY DEMAND

ENERGY DEMAND: TRILLION BTUS

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
COAL	0.0	0.0	6719.5	0.0	6719.5
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	5106.3	2544.2	11977.8	0.0	19628.4
GCFR	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	14485.4	14485.4
JET FUEL	0.0	0.0	0.0	7469.0	7469.0
DISTIL. OIL	2240.2	2597.5	6413.9	2505.9	13757.5
RESID. OIL	834.4	978.7	886.2	974.7	3674.1
ELECTRICITY	2425.8	2162.6	3540.5	70.0	8198.9
METHANOL	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0
TOTAL	13606.8	8283.1	29537.9	25505.0	73932.7

YEAR: 1980

AIR POLLUTION (TONS)

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
CO2	0.572933E 09	0.459175E 09	0.173153E 10	0.193145E 10	0.469499E 10
CO	0.106407E 06	0.279684E 05	0.339521E 07	0.106441E 08	0.141737E 08
SO2	0.101015E 07	0.118371E 07	0.624626E 07	0.122728E 07	0.966741E 07
NOX	0.259869E 06	0.631909E 06	0.302770E 07	0.323283E 07	0.715230E 07
PARTICULATE	0.159199E 06	0.239600E 06	0.392566E 08	0.196531E 07	0.416207E 08
HYDROCARBON	0.536318E 05	0.480170E 05	0.362142E 06	0.411394E 07	0.457773E 07
ALDEHYDE	0.476693E 05	0.346921E 05	0.634029E 06	0.261341E 06	0.977732E 06

YEAR: 1980

SUMMARY OF ENERGY DEMANDS

ENERGY DEMAND: TRILLION BTUS

	TTL B.E.D	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	SYN. FUELS	TOTAL
COAL	5719.5	9844.1	21.5	63.3	1566.0	-0.0	18214.4
GEOTHERMAL	0.0	374.5	0.0	0.0	0.0	0.0	374.5
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	19628.4	3881.2	2050.5	0.0	0.0	-0.0	25560.1
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	89.9	0.0	0.0	0.0	0.0	89.9
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	6896.7	0.0	0.0	0.0	0.0	6896.7
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	14485.4	0.0	0.0	207.6	0.0	-0.0	14692.9
JET FUEL	7469.0	0.0	0.0	70.0	0.0	-0.0	7539.0
DISTIL. OIL	13757.5	347.8	0.0	70.0	0.0	-0.0	14175.2
RESID. OIL	3674.1	3290.3	601.2	75.0	0.0	-0.0	7640.5
ELECTRICITY	8198.9	0.0	134.1	0.0	0.0	-0.1	0.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	1288.0	0.0	0.0	0.0	0.0	1288.0
TOTAL	73932.7	26012.5	2807.3	485.8	1566.0	-0.2	96471.0

YEAR: 1980

AIR POLLUTION (TONS)

	TTL B.E.D.	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	METHANOL	TOTAL
CO2	0.469499E 10	0.164853E 10	0.365709E 09	0.110916E 08	0.372223E 08	0.0	0.675754E 10
CO	0.141737E 08	0.187808E 06	0.318888E 05	0.0	0.0	0.0	0.143934E 08
SO2	0.966741E 07	0.597409E 07	0.569650E 06	0.0	0.0	0.0	0.162111E 08
NOX	0.715230E 07	0.127838E 07	0.407715E 06	0.0	0.0	0.0	0.883839E 07
PARTICULATE	0.416207E 08	0.225778E 06	0.147428E 06	0.0	0.0	0.0	0.419939E 08
HYDROCARBON	0.457773E 07	0.168940E 06	0.936970E 05	0.822841E 05	0.0	0.0	0.492265E 07
ALDEHYDE	0.977732E 06	0.189396E 05	0.100937E 05	0.136440E 05	0.392979E 05	0.0	0.105971E 07

YEAR: 1980

SOLID WASTE (TONS)

SYNCRUDE	0.211434E 07
TAR SANDS	0.0
OIL SHALE	0.0
SYNGAS	0.164568E 06
TOTAL	0.227891E 07

ELEMENTAL SULFUR PRODUCED (TONS)

SYNCRUDE	0.182652E 07
SYNGAS	0.109782E 06
TOTAL	0.193630E 07

LAND USE BY ENERGY PRODUCTION (ACRES)

COAL (STRIP MINING).	0.121589E 06
TAR SANDS	0.0
OIL SHALE	0.0
ELEC. GEN. & TRANS.	0.385475E 08
TOTAL	0.386691E 08

RADIOACTIVE MATERIAL PRODUCTION AND RELEASES

TRITIUM RELEASED	0.185009E 07	CURIES
KRYPTON-85 RELEASED	0.510828E 08	CURIES
LONG-LIVED RAD.WASTE	0.376438E 10	CURIES
LONG LIVED RAD.WASTE	0.687333E 05	CUBIC FEET
POPULATION EXPOSURE	0.982968E 05	MAN-REM

COOLING WATER REQUIREMENTS FOR ENERGY PRODUCTION (ACRE-FEET)

COOLING WATER CONSUMED BY EVAPORATION		0.358376E 07
COOLING WATER USED IN ONCE-THRU CONDENSORS		0.295601E 09
WATER REQUIRED FOR H2 BY ELECTROLYSIS		0.0
(FEED WATER	0.0)	
(COOLING TOWER	0.0)	
OIL SHALE WATER REQUIREMENTS		0.0
TAR SANDS WATER REQUIREMENTS		0.0
COAL GASIFICATION WATER REQUIREMENTS		0.314863E 05
COAL LIQUEFACTION WATER REQUIREMENTS		0.145768E 05
TOTAL		0.299230E 09

YEAR: 1980

COAL RESOURCE DEMANDS (TRILLION BTU)

TOTAL BED	6719.49
SYNCRUDE	1566.03
SYNGAS	63.32
METHANOL	0.0
ELEC.GEN.	9844.14
PET.REF.	21.47
TOTAL	18214.45

PETROLEUM RESOURCE DEMANDS (TRILLION BTU)

TOTAL PET. DEMAND	46474.69
TAR SANDS REQ.	0.0
OIL SHALE REQ	0.0
SYNCRUDE REQ.	1106.98
DOMESTIC CRUDE PROD.	24335.00
CRUDE OIL IMPORTS	21032.70
TOTAL CRUDE PROD.	46474.68

NATURAL GAS RESOURCE DEMANDS (TRILLION BTU)

TOTAL DEMAND	25560.12
CORRECTED DMD.	26530.33
DOM. NAT. GAS	25847.00
CANADA P.L.IMP.	868.39
LNG IMPORTS	1587.25
SYNGAS	715.80
TOTAL GAS PRD.	29018.44

NUCLEAR FUEL RESOURCE DEMANDS

SEP.WORK REQ.	0.877236E 07	KGSW
PWR REQ. KGSW	72.20	TRILLION BTU
THORIUM (THO2)	0.315593E 02	TONNES
URANIUM (U3O8)	0.156640E 05	TONNES

YEAR: 1980

SUMMARY OF RESOURCE REQUIREMENTS

RESOURCE	ANNUAL PROD.	
COAL	18214.45	TRILLION BTU
GEOTHERMAL	374.46	TRILLION BTU
(HYDROGEN)	0.0	TRILLION BTU
NATURAL GAS	28302.64	TRILLION BTU
NUCLEAR-FISSION	6986.57	TRILLION BTU
NUCLEAR-FUSION	0.0	TRILLION BTU
PETROLEUM	45367.70	TRILLION BTU
(METHANOL)	0.0	TRILLION BTU
SOLAR	0.0	TRILLION BTU
TIDAL	0.0	TRILLION BTU
WIND	0.0	TRILLION BTU
HYDROELECTRIC	1288.03	TRILLION BTU
TOTAL	100533.81	TRILLION BTU

SUMMARY OF BALANCE OF PAYMENTS FOR ENERGY IMPORTS
(MILLIONS OF 1970 DOLLARS)

COST OF CRUDE PETROLEUM IMPORTS	15017.34
COST OF LIQUIFIED NATURAL GAS IMPORTS	1922.16
COST OF CANADIAN GAS IMPORTS	277.88
TOTAL BALANCE OF PAYMENTS DEFICIT	17217.39

YEAR: 1990

RESIDENTIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	49.9	0.0	3583.4	1106.7	284.3	0.0	5024.4
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	2129.5	0.0	0.0	0.0	2129.5
RESID. OIL	0.0	0.0	839.3	0.0	0.0	0.0	839.3
ELECTRICITY	576.2	313.5	1179.4	642.0	237.6	694.8	3643.4
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	626.1	313.5	7731.7	1748.7	521.9	694.8	11636.7

YEAR: 1990

RESIDENTIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.394565E 07	0.0	0.470941E 09	0.675112E 08	0.173424E 08	0.0	0.558840E 09
CO	0.439287E 03	0.0	0.892734E 05	0.110674E 05	0.284301E 04	0.0	0.103683E 06
SO2	0.149786E 02	0.0	0.977562E 06	0.332022E 03	0.852903E 02	0.0	0.977995E 06
NOX	0.124822E 04	0.0	0.217246E 06	0.276685E 05	0.710752E 04	0.0	0.253270E 06
PARTICULATE	0.474323E 03	0.0	0.140921E 06	0.105140E 05	0.270086E 04	0.0	0.154610E 06
HYDROCARBON	0.199715E 03	0.0	0.463972E 05	0.442696E 04	0.113720E 04	0.0	0.521611E 05
ALDEHYDE	0.249543E 03	0.0	0.392928E 05	0.553370E 04	0.142150E 04	0.0	0.464976E 05

YEAR: 1990

COMMERCIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	29.2	0.0	1635.2	565.0	111.7	690.6	3031.6
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	2389.9	0.0	0.0	847.0	3236.9
RESID. OIL	0.0	0.0	880.5	0.0	0.0	323.7	1204.2
ELECTRICITY	105.7	430.1	1419.6	387.5	34.2	836.2	3213.3
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	134.9	430.1	6325.1	952.5	145.9	2697.5	10685.9

YEAR: 1990

COMMERCIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.178088E 07	0.0	0.377726E 09	0.344642E 08	0.681235E 07	0.141634E 09	0.562417E 09
CO	0.291948E 03	0.0	0.156624E 05	0.564988E 04	0.111678E 04	0.773230E 04	0.334533E 05
SO2	0.875843E 01	0.0	0.108102E 07	0.169496E 03	0.335033E 02	0.387744E 06	0.146897E 07
NOX	0.145974E 04	0.0	0.543445E 06	0.282494E 05	0.558389E 04	0.199711E 06	0.778450E 06
PARTICULATE	0.277350E 03	0.0	0.212208E 06	0.536738E 04	0.106094E 04	0.771590E 05	0.296073E 06
HYDROCARBON	0.115779E 03	0.0	0.411562E 05	0.225995E 04	0.446711E 03	0.151469E 05	0.591266E 05
ALDEHYDE	0.145974E 03	0.0	0.283238E 05	0.282494E 04	0.558389E 03	0.106324E 05	0.424855E 05

YEAR: 1990

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
COAL	139.6	270.1	0.0	576.4	172.5	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	264.6	193.8	44.2	477.9	318.4	156.8	25.4
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	58.8	0.0	0.0	91.2	61.9	0.0	0.0
RESID. OIL	249.9	0.0	0.0	0.0	309.5	0.0	0.0
ELECTRICITY	22.0	710.6	22.0	70.5	22.1	6.4	11.3
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	735.0	1174.5	66.2	1216.0	884.4	163.2	36.7

YEAR: 1990

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
COAL	0.0	0.0	43.5	8.6	2003.8	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	13.7	0.2	17.7	0.0	375.7	956.8	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.1	0.0	0.0	563.6	116.9	0.0
RESID. OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ELECTRICITY	9.5	0.0	40.0	4.3	187.9	274.5	5426.3
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	23.1	0.3	101.2	13.0	3131.0	1348.2	5426.3

YEAR: 1990

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	MISC.FOSL.	RAW MATL	TOTAL
COAL	4709.1	433.9	8357.7
GEOTHERMAL	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0
NATURAL GAS	10837.6	1703.2	15386.1
GCFR	0.0	0.0	0.0
HTGR	0.0	0.0	0.0
LFR	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0
LWR	0.0	0.0	0.0
MSBR	0.0	0.0	0.0
MCFR	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0
DISTIL. OIL	494.3	8711.3	10088.0
RESID. OIL	668.0	0.0	1227.4
ELECTRICITY	0.0	0.0	6807.5
METHANOL	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0
WIND	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0
TOTAL	16699.0	10848.4	41866.6

YEAR: 1990

INDUSTRIAL

AIR POLLUTION (TONS)

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
CO2	0.580208E 08	0.420764E 08	0.269914E 07	0.101458E 09	0.703097E 08	0.956735E 07	0.154778E 07
CO	0.555541E 04	0.102769E 05	0.884965E 01	0.220061E 05	0.685179E 04	0.313683E 02	0.507470E 01
SO2	0.199867E 06	0.161423E 06	0.132745E 02	0.372463E 06	0.243897E 06	0.634967E 06	0.761205E 01
NOX	0.973793E 05	0.883728E 05	0.265490E 04	0.205556E 06	0.118336E 06	0.941050E 04	0.152241E 04
PARTICULATE	0.320092E 06	0.774533E 06	0.128682E 05	0.261559E 08	0.178597E 06	0.706015E 05	0.175728E 06
HYDROCARBON	0.110724E 05	0.899490E 04	0.884965E 03	0.214652E 05	0.133997E 05	0.313684E 04	0.507469E 03
ALDEHYDE	0.178689E 04	0.545966E 03	0.663724E 02	0.191815E 04	0.212015E 04	0.235263E 03	0.380602E 02

YEAR: 1990

INDUSTRIAL

AIR POLLUTION (TONS)

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
CO2	0.813159E 06	0.192944E 05	0.595704E 07	0.966712E 06	0.508378E 09	0.682996E 08	0.0
CO	0.273170E 01	0.917858E-01	0.165361E 04	0.327128E 03	0.348643E 07	0.738950E 06	0.0
SO2	0.409755E 01	0.199246E 02	0.126351E 07	0.515595E 04	0.160274E 07	0.281437E 06	0.0
NOX	0.919509E 03	0.228818E 02	0.134321E 05	0.245217E 04	0.672989E 06	0.525651E 06	0.0
PARTICULATE	0.622925E 03	0.865265E 02	0.285178E 06	0.166381E 05	0.166406E 08	0.364950E 07	0.0
HYDROCARBON	0.273170E 03	0.522275E 01	0.117941E 04	0.163564E 03	0.515739E 05	0.203983E 05	0.0
ALDEHYDE	0.204877E 02	0.804742E 00	0.677210E 02	0.815663E 01	0.651498E 04	0.106104E 07	0.0

YEAR: 1990

INDUSTRIAL

AIR POLLUTION (TONS)

	MISC.FOSL.	RAW MATL	TOTAL
CO2	0.128646E 10	0.0	0.215659E 10
CO	0.191439E 06	0.0	0.445353E 07
SO2	0.322777E 07	0.0	0.799327E 07
NOX	0.214702E 07	0.0	0.388562E 07
PARTICULATE	0.423306E 07	0.0	0.525140E 08
HYDROCARBON	0.317900E 06	0.0	0.450955E 06
ALDEHYDE	0.264243E 05	0.0	0.110079E 07

YEAR: 1990

TRANSPORTATION

ENERGY DEMAND: TRILLION BTUS

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	12900.0	101.1	0.0	0.0	3220.5	16221.6
JET FUEL	12500.0	0.0	0.0	0.0	0.0	0.0	12500.0
DISTIL. OIL	0.0	0.0	235.9	782.6	213.0	2479.5	3711.0
RESID. OIL	0.0	0.0	0.0	0.0	1207.0	0.0	1207.0
ELECTRICITY	0.0	0.0	0.0	127.4	0.0	0.0	127.4
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	12500.0	12900.0	337.0	910.0	1420.0	5700.0	33767.0

YEAR: 1990

TRANSPORTATION

AIR POLLUTION (TONS)

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
CO2	0.931250E 09	0.961050E 09	0.275834E 08	0.665210E 08	0.120700E 09	0.450684E 09	0.255779E 10
CO	0.669750E 07	0.503100E 07	0.130250E 06	0.301301E 06	0.828136E 05	0.221060E 07	0.144435E 08
SO2	0.512500E 06	0.258000E 06	0.249043E 05	0.759121E 05	0.495464E 06	0.304921E 06	0.167170E 07
NOX	0.128750E 07	0.593400E 06	0.160344E 06	0.516516E 06	0.301714E 06	0.178461E 07	0.464408E 07
PARTICULATE	0.205625E 07	0.457950E 06	0.146763E 05	0.367822E 05	0.102709E 06	0.230864E 06	0.289923E 07
HYDROCARBON	0.437500E 07	0.606300E 06	0.743421E 05	0.230867E 06	0.749049E 05	0.882816E 06	0.624422E 07
ALDEHYDE	0.131250E 06	0.135450E 06	0.365645E 04	0.860859E 04	0.637438E 04	0.610997E 05	0.346429E 06

YEAR: 1990

TOTAL BASE ENERGY DEMAND

ENERGY DEMAND: TRILLION BTUS

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
COAL	0.0	0.0	8357.7	0.0	8357.7
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	5024.4	3031.6	15386.1	0.0	23442.1
GCFR	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	16221.6	16221.6
JET FUEL	0.0	0.0	0.0	12500.0	12500.0
DISTIL. OIL	2129.5	3236.9	10088.0	3711.0	19165.3
RESID. OIL	839.3	1204.2	1227.4	1207.0	4477.9
ELECTRICITY	3643.4	3213.3	6807.5	127.4	13791.6
METHANOL	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0
TOTAL	11636.7	10685.9	41866.6	33767.0	97956.1

YEAR: 1990

AIR POLLUTION (TONS)

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
CO2	0.558840E 09	0.562417E 09	0.215659E 10	0.255779E 10	0.583563E 10
CO	0.103693E 06	0.334533E 05	0.445353E 07	0.144435E 08	0.190341E 08
SO2	0.977995E 06	0.146897E 07	0.799327E 07	0.167170E 07	0.121119E 08
NOX	0.253270E 06	0.778450E 06	0.388562E 07	0.464408E 07	0.956142E 07
PARTICULATE	0.154610E 06	0.296073E 06	0.525140E 08	0.289923E 07	0.558638E 08
HYDROCARBON	0.521611E 05	0.591266E 05	0.450955E 06	0.624422E 07	0.680647E 07
ALDEHYDE	0.464976E 05	0.424855E 05	0.110079E 07	0.346429E 06	0.153620E 07

YEAR: 1990

SUMMARY OF ENERGY DEMANDS

ENERGY DEMAND: TRILLION BTUS

	TTL B.E.D	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	SYN. FUELS	TOTAL
COAL	8357.7	10880.1	27.5	1253.6	5314.3	-0.0	25833.2
GEOTHERMAL	0.0	2177.1	0.0	0.0	0.0	0.0	2177.1
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	23442.1	3195.3	2627.9	0.0	0.0	-0.0	29265.3
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	5233.9	0.0	0.0	0.0	0.0	5233.9
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	17229.0	0.0	0.0	0.0	0.0	17229.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	16221.6	0.0	0.0	456.7	0.0	-0.0	16678.2
JET FUEL	12500.0	0.0	0.0	147.8	0.0	-0.0	12647.8
DISTIL. OIL	19165.3	327.2	0.0	147.8	0.0	-0.0	19640.3
RESID. OIL	4477.9	2945.0	770.5	178.1	0.0	-0.0	8371.5
ELECTRICITY	13791.6	0.0	171.9	0.0	0.0	-0.1	0.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	1441.5	0.0	0.0	0.0	0.0	1441.5
TOTAL	97956.1	43429.1	3597.8	2183.9	5314.3	-0.2	138517.3

YEAR: 1990

AIR POLLUTION (TONS)

	TTL B.E.O.	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	METHANOL	TOTAL
CO2	0.583553E 10	0.169162E 10	0.468689E 09	0.537944E 08	0.126313E 09	0.0	0.817605E 10
CO	0.190341E 08	0.207254E 06	0.414324E 05	0.0	0.0	0.0	0.192828E 08
SO2	0.121119E 08	0.638128E 07	0.730077E 06	0.0	0.0	0.0	0.192233E 08
NOX	0.956142E 07	0.119117E 07	0.522526E 06	0.0	0.0	0.0	0.112751E 08
PARTICULATE	0.558638E 08	0.221116E 06	0.188945E 06	0.0	0.0	0.0	0.562739E 08
HYDROCARBON	0.680647E 07	0.159815E 06	0.120103E 06	0.162903E 07	0.0	0.0	0.871541E 07
ALDEHYDE	0.153620E 07	0.167830E 05	0.129369E 05	0.270119E 06	0.133356E 06	0.0	0.196939E 07

YEAR: 1990

SOLID WASTE (TONS)

SYNCRUDE	0.717495E 07
TAR SANDS	0.220207E 04
OIL SHALE	0.152327E 04
SYNGAS	0.325905E 07
TOTAL	0.104367E 08

ELEMENTAL SULFUR PRODUCED (TONS)

SYNCRUDE	0.619925E 07
SYNGAS	0.217342E 07
TOTAL	0.837167E 07

LAND USE BY ENERGY PRODUCTION (ACRES)

COAL (STRIP MINING)	0.171561E 06
TAR SANDS	0.874893E 02
OIL SHALE	0.874893E 04
ELEC. GEN. & TRANS.	0.432388E 08
TOTAL	0.434192E 08

RADIOACTIVE MATERIAL PRODUCTION AND RELEASES

TRITIUM RELEASED	0.587415E 07	CURIES
KRYPTON-85 RELEASED	0.168690E 09	CURIES
LONG-LIVED RAD.WASTE	0.670082E 10	CURIES
LONG LIVED RAD.WASTE	0.126053E 06	CUBIC FEET
POPULATION EXPOSURE	0.177231E 06	MAN-REM

COOLING WATER REQUIREMENTS FOR ENERGY PRODUCTION (ACRE-FEET)

COOLING WATER CONSUMED BY EVAPORATION			0.623998E 07
COOLING WATER USED IN ONCE-THRU CONDENSORS			0.472300E 09
WATER REQUIRED FOR H2 BY ELECTROLYSIS			0.0
	(FEED WATER	0.0)	
	(COOLING TOWER	0.0)	
OIL SHALE WATER REQUIREMENTS			0.304954E 06
TAR SANDS WATER REQUIREMENTS			0.304954E 06
COAL GASIFICATION WATER REQUIREMENTS			0.124671E 06
COAL LIQUEFACTION WATER REQUIREMENTS			0.494662E 05
TOTAL			0.479323E 09

YEAR: 1990

COAL RESOURCE DEMANDS (TRILLION BTU)

TOTAL BED	8357.68
SYNCRUDE	5314.27
SYNGAS	1253.60
METHANOL	0.0
ELEC.GEN.	10880.11
PET.REF.	27.52
TOTAL	25833.18

PETROLEUM RESOURCE DEMANDS (TRILLION BTU)

TOTAL PET. DEMAND	60451.20
TAR SANDS REQ.	3756.52
OIL SHALE REQ	3756.52
SYNCRUDE REQ.	3756.52
DOMESTIC CRUDE PROD.	22886.00
CRUDE OIL IMPORTS	26295.63
TOTAL CRUDE PROD.	60451.18

NATURAL GAS RESOURCE DEMANDS (TRILLION BTU)

TOTAL DEMAND	29265.32
CORRECTED DMD.	30376.17
DOM. NAT. GAS	25143.00
CANADA P.L.IMP.	1662.27
LNG IMPORTS	3324.55
SYNGAS	2666.70
TOTAL GAS PRD.	32796.52

NUCLEAR FUEL RESOURCE DEMANDS

SEP.WORK REQ.	0.262932E 08	KGSW
PWR REQ. KGSW	218.76	TRILLION BTU
THORIUM (TH32)	0.183711E 04	TONNES
URANIUM (U308)	0.472964E 05	TONNES

YEAR: 1990

SUMMARY OF RESOURCE REQUIREMENTS

RESOURCE	ANNUAL PROD.	
COAL	25833.18	TRILLION BTU
GEOTHERMAL	2177.05	TRILLION BTU
(HYDROGEN)	0.0	TRILLION BTU
NATURAL GAS	30129.82	TRILLION BTU
NUCLEAR-FISSION	22462.89	TRILLION BTU
NUCLEAR-FUSION	0.0	TRILLION BTU
PETROLEUM	56694.67	TRILLION BTU
(METHANOL)	0.0	TRILLION BTU
SOLAR	0.0	TRILLION BTU
TIDAL	0.0	TRILLION BTU
WIND	0.0	TRILLION BTU
HYDROELECTRIC	1441.50	TRILLION BTU
TOTAL	138738.94	TRILLION BTU

SUMMARY OF BALANCE OF PAYMENTS FOR ENERGY IMPORTS
(MILLIONS OF 1970 DOLLARS)

COST OF CRUDE PETROLEUM IMPORTS	18775.08
COST OF LIQUIFIED NATURAL GAS IMPORTS	4026.02
COST OF CANADIAN GAS IMPORTS	531.93
TOTAL BALANCE OF PAYMENTS DEFICIT	23333.03

YEAR: 2000

RESIDENTIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	77.5	0.0	3664.7	1038.3	235.2	0.0	5015.6
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	1916.6	0.0	0.0	0.0	1916.6
RESID. OIL	0.0	0.0	816.5	0.0	0.0	0.0	816.5
ELECTRICITY	834.7	346.8	1769.5	851.2	293.5	795.5	4891.4
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	912.2	346.8	8167.3	1889.6	528.7	795.5	12640.2

YEAR: 2000

RESIDENTIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.472639E 07	0.0	0.455862E 09	0.633384E 08	0.143453E 08	0.0	0.538272E 09
CO	0.774818E 03	0.0	0.858433E 05	0.103833E 05	0.235170E 04	0.0	0.993531E 05
SO2	0.232446E 02	0.0	0.903434E 06	0.311500E 03	0.705509E 02	0.0	0.903839E 06
NOX	0.193705E 04	0.0	0.209142E 06	0.259584E 05	0.587924E 04	0.0	0.242917E 06
PARTICULATE	0.736077E 03	0.0	0.133208E 06	0.986417E 04	0.223411E 04	0.0	0.146042E 06
HYDROCARBON	0.303027E 03	0.0	0.441767E 05	0.415334E 04	0.940677E 03	0.0	0.495806E 05
ALDEHYDE	0.387409E 03	0.0	0.380026E 05	0.519167E 04	0.117585E 04	0.0	0.447569E 05

YEAR: 2000

COMMERCIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	30.3	0.0	1953.5	623.3	128.2	905.0	3640.3
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	2930.2	0.0	0.0	1110.1	4040.3
RESID. OIL	0.0	0.0	1139.5	0.0	0.0	424.2	1563.8
ELECTRICITY	135.7	549.4	2198.7	583.2	57.0	1095.9	4620.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	166.0	549.4	8221.9	1206.5	185.2	3535.3	13864.3

YEAR: 2000

COMMERCIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.184753E 07	0.0	0.465088E 09	0.380230E 08	0.782062E 07	0.185624E 09	0.698403E 09
CO	0.302874E 03	0.0	0.224679E 05	0.623327E 04	0.128207E 04	0.101338E 05	0.403599E 05
SO2	0.908622E 01	0.0	0.134900E 07	0.186998E 03	0.384620E 02	0.508172E 06	0.185741E 07
NOX	0.151437E 04	0.0	0.671748E 06	0.311664E 05	0.641034E 04	0.261739E 06	0.972578E 06
PARTICULATE	0.297730E 03	0.0	0.264304E 06	0.592161E 04	0.121797E 04	0.101124E 06	0.372855E 06
HYDROCARBON	0.121150E 03	0.0	0.508552E 05	0.249331E 04	0.512827E 03	0.198514E 05	0.738339E 05
ALDEHYDE	0.151437E 03	0.0	0.346708E 05	0.311664E 04	0.641034E 03	0.139347E 05	0.525146E 05

YEAR: 2000

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
COAL	257.4	516.3	0.0	867.6	280.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	487.6	370.4	80.2	719.3	516.9	245.9	38.2
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	108.4	0.0	0.0	137.3	100.5	0.0	0.0
RESID. OIL	460.5	0.0	0.0	0.0	502.6	0.0	0.0
ELECTRICITY	40.6	1358.0	39.9	106.2	35.9	10.0	17.1
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	1354.5	2244.6	120.1	1830.4	1435.9	255.8	55.3

YEAR: 2000

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
COAL	0.0	0.0	58.9	11.6	2357.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	21.6	0.4	24.0	0.0	494.2	1243.6	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.1	0.0	0.0	722.3	157.4	0.0
RESID. OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ELECTRICITY	15.0	0.1	54.1	5.8	228.1	365.9	7111.7
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	36.6	0.5	136.9	17.4	3801.6	1766.9	7111.7

YEAR: 2000

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	MISC.FOSL.	RAW MATL	TOTAL
COAL	6171.8	568.7	11089.2
GEOTHERMAL	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0
NATURAL GAS	14203.8	2232.2	20678.3
GCFR	0.0	0.0	0.0
HTGR	0.0	0.0	0.0
LFR	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0
LWR	0.0	0.0	0.0
MSBR	0.0	0.0	0.0
MCFR	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0
DISTIL. OIL	634.7	11417.0	13277.6
RESID. OIL	875.4	0.0	1838.5
ELECTRICITY	0.0	0.0	9388.2
METHANOL	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0
WIND	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0
TOTAL	21885.7	14217.9	56271.8

YEAR: 2000

INDUSTRIAL

AIR POLLUTION (TONS)

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
CO2	0.106924E 09	0.804127E 08	0.489220E 07	0.152721E 09	0.114157E 09	0.149975E 08	0.233027E 07
CO	0.102378E 05	0.196402E 05	0.160400E 02	0.331251E 05	0.111248E 05	0.491720E 02	0.764024E 01
SO2	0.368326E 06	0.308498E 06	0.240600E 02	0.560655E 06	0.395999E 06	0.995354E 06	0.114604E 02
NOX	0.179456E 06	0.168890E 06	0.481200E 04	0.309417E 06	0.192135E 06	0.147516E 05	0.229207E 04
PARTICULATE	0.589884E 06	0.148022E 07	0.131918E 05	0.393715E 08	0.289976E 06	0.110673E 06	0.264569E 06
HYDROCARBON	0.204348E 05	0.171902E 05	0.160400E 04	0.323107E 05	0.217563E 05	0.491720E 04	0.764024E 03
ALDEHYDE	0.329299E 04	0.104340E 04	0.120300E 03	0.288732E 04	0.344235E 04	0.368790E 03	0.573018E 02

YEAR: 2000

INDUSTRIAL

AIR POLLUTION (TONS)

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
CO2	0.131641E 07	0.306805E 05	0.805656E 07	0.129781E 07	0.627775E 09	0.892415E 08	0.0
CO	0.431608E 01	0.145951E 00	0.223642E 04	0.439169E 03	0.444595E 07	0.995762E 06	0.0
SO2	0.647412E 01	0.316826E 02	0.170883E 07	0.692185E 04	0.192699E 07	0.367886E 06	0.0
NOX	0.129482E 04	0.363849E 02	0.181662E 05	0.329203E 04	0.803285E 06	0.705584E 06	0.0
PARTICULATE	0.984223E 03	0.137588E 03	0.385687E 06	0.223366E 05	0.210826E 08	0.474389E 07	0.0
HYDROCARBON	0.431609E 03	0.830481E 01	0.159509E 04	0.219585E 03	0.623500E 05	0.265729E 05	0.0
ALDEHYDE	0.323706E 02	0.127964E 01	0.915888E 02	0.109503E 02	0.816925E 04	0.142774E 07	0.0

YEAR: 2000

INDUSTRIAL

AIR POLLUTION (TONS)

	MISC.FOSL.	RAW MATL	TOTAL
CO2	0.168603E 10	0.0	0.289018E 10
CO	0.237794E 06	0.0	0.575638E 07
SO2	0.423031E 07	0.0	0.108698E 08
NOX	0.291389E 07	0.0	0.521730E 07
PARTICULATE	0.554785E 07	0.0	0.739034E 08
HYDROCARBON	0.416640E 06	0.0	0.606764E 06
ALDEHYDE	0.346317E 05	0.0	0.148389E 07

YEAR: 2000

TRANSPORTATION

ENERGY DEMAND: TRILLION BTUS

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	14700.0	96.1	0.0	0.0	2925.0	17721.1
JET FUEL	16300.0	0.0	0.0	0.0	0.0	0.0	16300.0
DISTIL. OIL	0.0	0.0	428.9	1016.8	263.5	3575.0	5284.2
RESID. OIL	0.0	0.0	0.0	0.0	1436.5	0.0	1436.5
ELECTRICITY	0.0	0.0	0.0	223.2	0.0	0.0	223.2
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	16300.0	14700.0	525.0	1240.0	1700.0	6500.0	40965.0

YEAR: 2000

TRANSPORTATION

AIR POLLUTION (TONS)

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
CO2	0.121435E 10	0.109515E 10	0.436162E 08	0.864280E 08	0.144500E 09	0.521787E 09	0.310583E 10
CO	0.872050E 07	0.573300E 07	0.202605E 06	0.391468E 06	0.102410E 06	0.251712E 07	0.176671E 08
SO2	0.669300E 06	0.294000E 06	0.435272E 05	0.986295E 05	0.590642E 06	0.405275E 06	0.210037E 07
NOX	0.167930E 07	0.676200E 06	0.287510E 06	0.671088E 06	0.365682E 06	0.249405E 07	0.617342E 07
PARTICULATE	0.268135E 07	0.521850E 06	0.235701E 05	0.477896E 05	0.122708E 06	0.271862E 06	0.366913E 07
HYDROCARBON	0.570500E 07	0.690900E 06	0.131048E 06	0.299956E 06	0.920973E 05	0.119210E 07	0.811110E 07
ALDEHYDE	0.171150E 06	0.154350E 06	0.572696E 04	0.111848E 05	0.769640E 04	0.700374E 05	0.420145E 06

YEAR: 2000

TOTAL BASE ENERGY DEMAND

ENERGY DEMAND: TRILLION BTUS

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
COAL	0.0	0.0	11089.2	0.0	11089.2
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	5015.6	3640.3	20678.3	0.0	29334.3
GCFR	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	17721.1	17721.1
JET FUEL	0.0	0.0	0.0	16300.0	16300.0
DISTIL. OIL	1916.6	4040.3	13277.6	5284.2	24518.7
RESID. OIL	816.5	1563.8	1838.5	1436.5	5655.3
ELECTRICITY	4891.4	4620.0	9388.2	223.2	19122.7
METHANOL	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0
TOTAL	12640.2	13864.3	56271.8	40965.0	123741.2

YEAR: 2000

AIR POLLUTION (TONS)

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
CO2	0.538272E 09	0.698403E 09	0.289018E 10	0.310583E 10	0.723268E 10
CO	0.993531E 05	0.403599E 05	0.575638E 07	0.176671E 08	0.235632E 08
SO2	0.903939E 06	0.185741E 07	0.108698E 08	0.210037E 07	0.157315E 08
NOX	0.242917E 06	0.972578E 06	0.521730E 07	0.617342E 07	0.126062E 08
PARTICULATE	0.146042E 06	0.372855E 06	0.739034E 08	0.366913E 07	0.780915E 08
HYDROCARBON	0.495806E 05	0.738339E 05	0.606764E 06	0.811110E 07	0.884127E 07
ALDEHYDE	0.447569E 05	0.525146E 05	0.148389E 07	0.420145E 06	0.200130E 07

YEAR: 2000

SUMMARY OF ENERGY DEMANDS

ENERGY DEMAND: TRILLION BTUS

	TTL B.E.D	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	SYN. FUELS	TOTAL
COAL	11089.2	8184.9	32.3	7029.8	18822.4	-0.0	45158.5
GEOTHERMAL	0.0	12447.4	0.0	0.0	0.0	0.0	12447.4
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	29334.3	1746.3	3082.5	0.0	0.0	-0.0	34163.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	17057.3	0.0	0.0	0.0	0.0	17057.3
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	5741.3	0.0	0.0	0.0	0.0	5741.3
LWR	0.0	15171.2	0.0	0.0	0.0	0.0	15171.2
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	17721.1	0.0	0.0	640.2	0.0	-0.0	18361.3
JET FUEL	16300.0	0.0	0.0	194.2	0.0	-0.0	16494.2
DISTIL. OIL	24518.7	147.9	0.0	194.2	0.0	-0.0	24860.9
RESID. OIL	5655.3	1331.3	903.8	277.4	0.0	-0.0	8167.8
ELECTRICITY	19122.7	0.0	201.6	0.0	0.0	-0.1	0.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	1557.0	0.0	0.0	0.0	0.0	1557.0
TOTAL	123741.2	63384.6	4220.1	8335.8	18822.4	-0.1	199179.6

YEAR: 2000

AIR POLLUTION (TONS)

	TTL B.E.D.	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	METHANOL	TOTAL
CO2	0.723268E 10	0.114896E 10	0.549759E 09	0.215398E 09	0.447382E 09	0.0	0.959418E 10
CO	0.235632E 08	0.155650E 06	0.489976E 05	0.0	0.0	0.0	0.237678E 08
SO2	0.157315E 08	0.451146E 07	0.856373E 06	0.0	0.0	0.0	0.210993E 08
NOX	0.126062E 08	0.682975E 06	0.612910E 06	0.0	0.0	0.0	0.139021E 08
PARTICULATE	0.780915E 08	0.134884E 06	0.221629E 06	0.0	0.0	0.0	0.784480E 08
HYDROCARBON	0.934127E 07	0.100493E 06	0.140992E 06	0.913511E 07	0.0	0.0	0.182177E 08
ALDEHYDE	0.200130E 07	0.834816E 04	0.151753E 05	0.151475E 07	0.472329E 06	0.0	0.401190E 07

YEAR: 2000

SOLID WASTE (TONS)

SYNCRUDE	0.254126E 08
TAR SANDS	0.623953E 04
OIL SHALE	0.431615E 04
SYNGAS	0.182702E 08
TOTAL	0.436934E 08

ELEMENTAL SULFUR PRODUCED (TONS)

SYNCRUDE	0.219533E 08
SYNGAS	0.121879E 08
TOTAL	0.341412E 08

LAND USE BY ENERGY PRODUCTION (ACRES)

COAL (STRIP MINING)	0.297175E 06
TAR SANDS	0.247899E 03
OIL SHALE	0.247900E 05
ELEC. GEN. & TRANS.	0.469166E 08
TOTAL	0.472388E 08

RADIOACTIVE MATERIAL PRODUCTION AND RELEASES

TRITIUM RELEASED	0.108683E 08	CURIES
KRYPTON-85 RELEASED	0.260208E 09	CURIES
LONG-LIVED RAD.WASTE	0.983618E 10	CURIES
LONG LIVED RAD.WASTE	0.177467E 06	CUBIC FEET
POPULATION EXPOSURE	0.255548E 06	MAN-REM

COOLING WATER REQUIREMENTS FOR ENERGY PRODUCTION (ACRE-FEET)

COOLING WATER CONSUMED BY EVAPORATION			0.946262E 07
COOLING WATER USED IN ONCE-THRU CONDENSORS			0.705679E 09
WATER REQUIRED FOR H2 BY ELECTROLYSIS			0.0
	(FEED WATER	0.0)	
	(COOLING TOWER	0.0)	
OIL SHALE WATER REQUIREMENTS			0.864083E 06
TAR SANDS WATER REQUIREMENTS			0.864083E 06
COAL GASIFICATION WATER REQUIREMENTS			0.436948E 06
COAL LIQUEFACTION WATER REQUIREMENTS			0.175202E 06
TOTAL			0.717481E 09

YEAR: 2000

COAL RESOURCE DEMANDS (TRILLION BTU)

TOTAL BED	11089.16
SYNCRUDE	18822.40
SYNGAS	7029.82
METHANOL	0.0
ELEC.GEN.	8184.86
PET.REF.	32.28
TOTAL	45158.52

PETROLEUM RESOURCE DEMANDS (TRILLION BTU)

TOTAL PET. DEMAND	71536.19
TAR SANDS REQ.	10644.04
OIL SHALE REQ	10644.04
SYNCRUDE REQ.	13305.05
DOMESTIC CRUDE PROD.	18316.00
CRUDE OIL IMPORTS	18627.06
TOTAL CRUDE PROD.	71536.13

NATURAL GAS RESOURCE DEMANDS (TRILLION BTU)

TOTAL DEMAND	34163.00
CORRECTED DMD.	35459.76
DOM. NAT. GAS	19184.00
CANADA P.L.IMP.	2912.98
LNG IMPORTS	5825.97
SYNGAS	9383.52
TOTAL GAS PRD.	37306.47

NUCLEAR FUEL RESOURCE DEMANDS

SEP.WORK REQ.	0.418193E 08	KGSW
PWR REQ. KGSW	315.74	TRILLION BTU
THORIUM (THO2)	0.598713E 04	TONNES
URANIUM (U3O8)	0.619386E 05	TONNES

YEAR: 2000

SUMMARY OF RESOURCE REQUIREMENTS

RESOURCE	ANNUAL PROD.	
COAL	45158.52	TRILLION BTU
GEOTHERMAL	12447.41	TRILLION BTU
(HYDROGEN)	0.0	TRILLION BTU
NATURAL GAS	27922.95	TRILLION BTU
NUCLEAR-FISSION	37969.88	TRILLION BTU
NUCLEAR-FUSION	0.0	TRILLION BTU
PETROLEUM	58231.13	TRILLION BTU
(METHANOL)	0.0	TRILLION BTU
SOLAR	0.0	TRILLION BTU
TIDAL	0.0	TRILLION BTU
WIND	0.0	TRILLION BTU
HYDROELECTRIC	1557.04	TRILLION BTU
TOTAL	183286.88	TRILLION BTU

SUMMARY OF BALANCE OF PAYMENTS FOR ENERGY IMPORTS
(MILLIONS OF 1970 DOLLARS)

COST OF CRUDE PETROLEUM IMPORTS	13299.72
COST OF LIQUIFIED NATURAL GAS IMPORTS	7055.24
COST OF CANADIAN GAS IMPORTS	932.16
TOTAL BALANCE OF PAYMENTS DEFICIT	21287.11

YEAR: 2010

RESIDENTIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	101.9	0.0	3598.6	988.6	217.6	0.0	4906.6
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	1973.3	0.0	0.0	0.0	1973.3
RESID. OIL	0.0	0.0	765.6	0.0	0.0	0.0	765.6
ELECTRICITY	1108.5	385.1	2306.3	1060.3	339.0	895.5	6094.7
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	1210.4	385.1	8643.8	2048.8	556.6	895.5	13740.2

YEAR: 2010

RESIDENTIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.621322E 07	0.0	0.452320E 09	0.603025E 08	0.132754E 08	0.0	0.532111E 09
CO	0.101856E 04	0.0	0.852861E 05	0.988566E 04	0.217630E 04	0.0	0.983664E 05
SO2	0.305568E 02	0.0	0.901275E 06	0.296570E 03	0.652890E 02	0.0	0.901667E 06
NOX	0.254640E 04	0.0	0.207737E 06	0.247142E 05	0.544075E 04	0.0	0.240439E 06
PARTICULATE	0.967632E 03	0.0	0.132787E 06	0.939137E 04	0.206749E 04	0.0	0.145214E 06
HYDROCARBON	0.407424E 03	0.0	0.439745E 05	0.395426E 04	0.870520E 03	0.0	0.492067E 05
ALDEHYDE	0.509280E 03	0.0	0.377130E 05	0.494283E 04	0.108815E 04	0.0	0.442533E 05

YEAR: 2010

COMMERCIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	33.1	0.0	2383.6	674.9	146.2	1166.7	4404.5
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	3523.5	0.0	0.0	1431.0	4954.6
RESID. OIL	0.0	0.0	1347.2	0.0	0.0	546.9	1894.1
ELECTRICITY	173.7	702.3	3270.5	834.6	87.1	1412.8	6480.9
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	206.8	702.3	10524.8	1509.5	233.3	4557.5	17734.1

YEAR: 2010

COMMERCIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.202175E 07	0.0	0.559411E 09	0.411702E 08	0.891696E 07	0.239294E 09	0.850814E 09
CO	0.331434E 03	0.0	0.272752E 05	0.674921E 04	0.146180E 04	0.130639E 05	0.488815E 05
SO2	0.994303E 01	0.0	0.161311E 07	0.202476E 03	0.438539E 02	0.655102E 06	0.226846E 07
NOX	0.165717E 04	0.0	0.806420E 06	0.337461E 05	0.730898E 04	0.337417E 06	0.118655E 07
PARTICULATE	0.314863E 03	0.0	0.316381E 06	0.641175E 04	0.138871E 04	0.130362E 06	0.454858E 06
HYDROCARBON	0.132574E 03	0.0	0.610605E 05	0.269968E 04	0.584719E 03	0.255911E 05	0.900686E 05
ALDEHYDE	0.165717E 03	0.0	0.417369E 05	0.337461E 04	0.730898E 03	0.179637E 05	0.640218E 05

YEAR: 2010

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
COAL	331.7	665.5	0.0	1118.3	360.9	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	628.5	477.4	103.4	927.2	666.3	316.9	49.2
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	139.7	0.0	0.0	177.0	129.6	0.0	0.0
RESID. OIL	593.6	0.0	0.0	0.0	647.8	0.0	0.0
ELECTRICITY	52.4	1750.4	51.4	136.8	46.3	12.9	22.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	1745.9	2893.3	154.8	2359.4	1850.9	329.8	71.3

YEAR: 2010

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
COAL	0.0	0.0	75.9	14.9	2911.3	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	27.8	0.5	30.9	0.0	620.4	1603.1	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.1	0.0	0.0	954.5	202.9	0.0
RESID. OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ELECTRICITY	19.3	0.1	69.7	7.5	286.4	471.6	9167.2
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	47.1	0.7	176.5	22.4	4772.6	2277.5	9167.2

YEAR: 2010

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	MISC.FOSL.	RAW MATL	TOTAL
COAL	7955.6	733.1	14167.3
GEOTHERMAL	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0
NATURAL GAS	18309.1	2877.4	26638.2
GCFR	0.0	0.0	0.0
HTGR	0.0	0.0	0.0
LFR	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0
LWR	0.0	0.0	0.0
MSBR	0.0	0.0	0.0
MCFR	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0
DISTIL. OIL	818.1	14716.8	17138.7
RESID. OIL	1128.5	0.0	2369.9
ELECTRICITY	0.0	0.0	12093.9
METHANOL	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0
WIND	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0
TOTAL	28211.3	18327.3	72408.0

YEAR: 2010

INDUSTRIAL

AIR POLLUTION (TONS)

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
CO2	0.137825E 09	0.103652E 09	0.630605E 07	0.196857E 09	0.147149E 09	0.193317E 08	0.300372E 07
CO	0.131966E 05	0.253162E 05	0.206756E 02	0.426982E 05	0.143399E 05	0.633826E 02	0.984827E 01
SO2	0.474772E 06	0.397654E 06	0.310133E 02	0.722684E 06	0.510443E 06	0.128301E 07	0.147724E 02
NOX	0.231319E 06	0.217699E 06	0.620266E 04	0.398838E 06	0.247662E 06	0.190148E 05	0.295448E 04
PARTICULATE	0.760360E 06	0.190800E 07	0.170042E 05	0.507499E 08	0.373779E 06	0.142657E 06	0.341029E 06
HYDROCARBON	0.263018E 05	0.221582E 05	0.206756E 04	0.416485E 05	0.280439E 05	0.633827E 04	0.984827E 03
ALDEHYDE	0.424466E 04	0.134494E 04	0.155067E 03	0.372176E 04	0.443719E 04	0.475370E 03	0.738620E 02

YEAR: 2010

INDUSTRIAL

AIR POLLUTION (TONS)

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
CO2	0.169685E 07	0.395472E 05	0.103849E 08	0.167288E 07	0.795979E 09	0.115032E 09	0.0
CO	0.556343E 01	0.188130E 00	0.288274E 04	0.566089E 03	0.572603E 07	0.128354E 07	0.0
SO2	0.934514E 01	0.408389E 02	0.220268E 07	0.892227E 04	0.241532E 07	0.474205E 06	0.0
NOX	0.166903E 04	0.469001E 02	0.234162E 05	0.424343E 04	0.100178E 07	0.909498E 06	0.0
PARTICULATE	0.126866E 04	0.177351E 03	0.497150E 06	0.247919E 05	0.270672E 08	0.611487E 07	0.0
HYDROCARBON	0.556343E 03	0.107049E 02	0.205606E 04	0.283045E 03	0.778871E 05	0.342524E 05	0.0
ALDEHYDE	0.417257E 02	0.164945E 01	0.118058E 03	0.141149E 02	0.105545E 05	0.184293E 07	0.0

YEAR: 2010

INDUSTRIAL

AIR POLLUTION (TONS)

	MISC.FOSL.	RAW MATL	TOTAL
CO2	0.217334E 10	0.0	0.371227E 10
CO	0.306523E 06	0.0	0.741519E 07
SO2	0.545299E 07	0.0	0.139428E 08
NOX	0.362718E 07	0.0	0.669153E 07
PARTICULATE	0.715134E 07	0.0	0.951535E 08
HYDROCARBON	0.537061E 06	0.0	0.779649E 06
ALDEHYDE	0.446412E 05	0.0	0.191275E 07

YEAR: 2010

TRANSPORTATION

ENERGY DEMAND: TRILLION BTUS

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	16200.0	74.7	0.0	0.0	2304.0	18578.7
JET FUEL	20200.0	0.0	0.0	0.0	0.0	0.0	20200.0
DISTIL. OIL	0.0	0.0	755.3	1431.0	330.0	4896.0	7412.3
RESID. OIL	0.0	0.0	0.0	0.0	1670.0	0.0	1670.0
ELECTRICITY	0.0	0.0	0.0	369.0	0.0	0.0	369.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	20200.0	16200.0	830.0	1800.0	2000.0	7200.0	48230.0

YEAR: 2010

TRANSPORTATION

AIR POLLUTION (TONS)

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
CO2	0.150490E 10	0.120690E 10	0.697656E 08	0.121635E 09	0.170000E 09	0.587807E 09	0.366101E 10
CO	0.108070E 08	0.631800E 07	0.319923E 06	0.550935E 06	0.128169E 06	0.278352E 07	0.209075E 08
SO2	0.828199E 06	0.324000E 06	0.747579E 05	0.138807E 06	0.688946E 06	0.520991E 06	0.257570E 07
NOX	0.208060E 07	0.745199E 06	0.501934E 06	0.944460E 06	0.440744E 06	0.333734E 07	0.805027E 07
PARTICULATE	0.332290E 07	0.575100E 06	0.381509E 05	0.672569E 05	0.143766E 06	0.311904E 06	0.445907E 07
HYDROCARBON	0.707000E 07	0.761400E 06	0.226324E 06	0.422145E 06	0.114050E 06	0.155261E 07	0.101465E 08
ALDEHYDE	0.212100E 06	0.170100E 06	0.909264E 04	0.157410E 05	0.920779E 04	0.780479E 05	0.494289E 06

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TOTAL BASE ENERGY DEMAND

ENERGY DEMAND: TRILLION BTUS

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
COAL	0.0	0.0	14167.3	0.0	14167.3
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	4906.6	4404.5	26638.2	0.0	35949.3
GCFR	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	18578.7	18578.7
JET FUEL	0.0	0.0	0.0	20200.0	20200.0
DISTIL. OIL	1973.3	4954.6	17138.7	7412.3	31478.8
RESID. OIL	765.6	1894.1	2369.9	1670.0	6699.6
ELECTRICITY	6094.7	6480.9	12093.9	369.0	25038.5
METHANOL	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0
TOTAL	13740.2	17734.1	72408.0	48230.0	152112.3

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AIR POLLUTION (TONS)

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
CO2	0.532111E 09	0.850814E 09	0.371227E 10	0.366101E 10	0.875620E 10
CO	0.983664E 05	0.488815E 05	0.741519E 07	0.209075E 08	0.284699E 08
SO2	0.901657E 06	0.226846E 07	0.139428E 08	0.257570E 07	0.196886E 08
NOX	0.240439E 06	0.118655E 07	0.669153E 07	0.805027E 07	0.161688E 08
PARTICULATE	0.145214E 06	0.454858E 06	0.951535E 08	0.445907E 07	0.100213E 09
HYDROCARBON	0.492067E 05	0.900686E 05	0.779649E 06	0.101465E 08	0.110654E 08
ALDEHYDE	0.442533E 05	0.640218E 05	0.191275E 07	0.494289E 06	0.251532E 07

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SUMMARY OF ENERGY DEMANDS

ENERGY DEMAND: TRILLION BTUS

	TTL B.E.D	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	SYN. FUELS	TOTAL
COAL	14167.3	5164.6	37.2	21007.5	29672.6	-0.1	70049.3
GEOTHERMAL	0.0	11746.7	0.0	0.0	0.0	0.0	11746.7
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	35949.3	856.7	3555.3	0.0	0.0	-0.0	40361.3
GCFR	0.0	7461.9	0.0	0.0	0.0	0.0	7461.9
HTGR	0.0	21337.8	0.0	0.0	0.0	0.0	21337.8
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	14635.2	0.0	0.0	0.0	0.0	14635.2
LWR	0.0	9716.9	0.0	0.0	0.0	0.0	9716.9
MSBR	0.0	4485.8	0.0	0.0	0.0	0.0	4485.8
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	18578.7	0.0	0.0	0.0	0.0	0.0	18578.7
JET FUEL	20200.0	0.0	0.0	0.0	0.0	0.0	20200.0
DISTIL. OIL	31478.8	59.2	0.0	0.0	0.0	-0.0	31538.0
RESID. OIL	5699.6	532.9	1042.4	0.0	0.0	-0.0	8275.0
ELECTRICITY	25038.5	0.0	232.5	0.0	0.0	-0.1	0.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	1558.2	0.0	0.0	0.0	0.0	1558.2
TOTAL	152112.3	77555.8	4867.5	21007.5	29672.6	-0.2	259944.4

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AIR POLLUTION (TONS)

	TTL B.E.D.	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	METHANOL	TOTAL
CO2	0.975620E 10	0.681023E 09	0.634097E 09	0.560601E 09	0.705277E 09	0.0	0.113372E 11
CO	0.284699E 08	0.981198E 05	0.567004E 05	0.0	0.0	0.0	0.286247E 08
SO2	0.196386E 08	0.274632E 07	0.987753E 06	0.0	0.0	0.0	0.234226E 08
NOX	0.161688E 08	0.355246E 06	0.706936E 06	0.0	0.0	0.0	0.172310E 09
PARTICULATE	0.100213E 09	0.740584E 05	0.255630E 06	0.0	0.0	0.0	0.100542E 09
HYDROCARBON	0.110654E 08	0.562198E 05	0.162513E 06	0.272989E 08	0.0	0.0	0.385830E 08
ALDEHYDE	0.251532E 07	0.375665E 04	0.175036E 05	0.452660E 07	0.744605E 06	0.0	0.780778E 07

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SOLID WASTE (TONS)

SYNCRUDE	0.400618E 08
TAR SANDS	0.819695E 04
OIL SHALE	0.567018E 04
SYNGAS	0.545977E 08
TOTAL	0.946734E 08

ELEMENTAL SULFUR PRODUCED (TONS)

SYNCRUDE	0.346084E 08
SYNGAS	0.364217E 08
TOTAL	0.710301E 08

LAND USE BY ENERGY PRODUCTION (ACRES)

COAL (STRIP MINING)	0.460837E 06
TAR SANDS	0.325668E 03
OIL SHALE	0.325669E 05
ELEC. GEN. & TRANS.	0.469826E 08
TOTAL	0.474764E 08

RADIOACTIVE MATERIAL PRODUCTION AND RELEASES

TRITIUM RELEASED	0.313913E 09	CURIES
KRYPTON-85 RELEASED	0.319588E 09	CURIES
LONG-LIVED RAD.WASTE	0.135246E 11	CURIES
LONG LIVED RAD.WASTE	0.245281E 06	CUBIC FEET
POPULATION EXPOSURE	0.350559E 06	MAN-REM

COOLING WATER REQUIREMENTS FOR ENERGY PRODUCTION (ACRE-FEET)

COOLING WATER CONSUMED BY EVAPORATION		0.114616E 08
COOLING WATER USED IN ONCE-THRU CONDENSORS		0.815133E 09
WATER REQUIRED FOR H2 BY ELECTROLYSIS		0.0
(FEED WATER	0.0)	
(COOLING TOWER	0.0)	
OIL SHALE WATER REQUIREMENTS		0.113516E 07
TAR SANDS WATER REQUIREMENTS		0.113516E 07
COAL GASIFICATION WATER REQUIREMENTS		0.104460E 07
COAL LIQUEFACTION WATER REQUIREMENTS		0.276198E 06
TOTAL		0.830185E 09

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COAL RESOURCE DEMANDS (TRILLION BTU)

TOTAL BED	14167.28
SYNCRUDE	29672.64
SYNGAS	21007.53
METHANOL	0.0
ELEC.GEN.	5164.62
PET.REF.	37.23
TOTAL	70049.25

PETROLEUM RESOURCE DEMANDS (TRILLION BTU)

TOTAL PET. DEMAND	82804.00
TAR SANDS REQ.	13983.20
OIL SHALE REQ	13983.20
SYNCRUDE REQ.	20974.79
DOMESTIC CRUDE PROD.	12888.00
CRUDE OIL IMPORTS	20974.79
TOTAL CRUDE PROD.	82803.94

NATURAL GAS RESOURCE DEMANDS (TRILLION BTU)

TOTAL DEMAND	40361.33
CORRECTED DMD.	41893.37
DOM. NAT. GAS	12129.00
CANADA P.L.IMP.	3798.54
LNG IMPORTS	7597.09
SYNGAS	19536.31
TOTAL GAS PRD.	43060.94

NUCLEAR FUEL RESOURCE DEMANDS

SEP.WORK REQ.	0.425556E 08	KGSW
PWR REQ. KGSW	300.30	TRILLION BTU
THORIUM (TH02)	0.936011E 04	TONNES
URANIUM (U308)	0.497445E 05	TONNES

YEAR: 2010

SUMMARY OF RESOURCE REQUIREMENTS

RESOURCE	ANNUAL PROD.	
COAL	70049.25	TRILLION BTU
GEOTHERMAL	11746.72	TRILLION BTU
(HYDROGEN)	0.0	TRILLION BTU
NATURAL GAS	23524.63	TRILLION BTU
NUCLEAR-FISSION	57637.53	TRILLION BTU
NUCLEAR-FUSION	0.0	TRILLION BTU
PETROLEUM	61829.18	TRILLION BTU
(METHANOL)	0.0	TRILLION BTU
SOLAR	0.0	TRILLION BTU
TIDAL	0.0	TRILLION BTU
WIND	0.0	TRILLION BTU
HYDROELECTRIC	1558.22	TRILLION BTU
TOTAL	226345.38	TRILLION BTU

SUMMARY OF BALANCE OF PAYMENTS FOR ENERGY IMPORTS
(MILLIONS OF 1970 DOLLARS)

COST OF CRUDE PETROLEUM IMPORTS	14976.00
COST OF LIQUIFIED NATURAL GAS IMPORTS	9200.07
COST OF CANADIAN GAS IMPORTS	1215.53
TOTAL BALANCE OF PAYMENTS DEFICIT	25391.60

YEAR: 2020

RESIDENTIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	139.6	0.0	3500.0	934.7	195.8	0.0	4770.1
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	2142.0	0.0	0.0	0.0	2142.0
RESID. OIL	0.0	0.0	831.1	0.0	0.0	0.0	831.1
ELECTRICITY	1486.4	428.4	2866.5	1274.0	387.6	999.4	7442.3
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	1626.0	428.4	9339.6	2208.7	583.4	999.4	15185.5

YEAR: 2020

RESIDENTIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.851855E 07	0.0	0.466211E 09	0.570168E 08	0.119425E 08	0.0	0.543689E 09
CO	0.139449E 04	0.0	0.885154E 05	0.934702E 04	0.195778E 04	0.0	0.101217E 06
SO2	0.418945E 02	0.0	0.978206E 06	0.280411E 03	0.587335E 02	0.0	0.978587E 06
NOX	0.349121E 04	0.0	0.215342E 06	0.233676E 05	0.489445E 04	0.0	0.247095E 06
PARTICULATE	0.132666E 04	0.0	0.140281E 06	0.887967E 04	0.185989E 04	0.0	0.152347E 06
HYDROCARBON	0.598593E 03	0.0	0.461092E 05	0.373881E 04	0.783112E 03	0.0	0.511897E 05
ALDEHYDE	0.598241E 03	0.0	0.389062E 05	0.467351E 04	0.978891E 03	0.0	0.452568E 05

YEAR: 2020

COMMERCIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	39.9	0.0	2827.5	735.0	161.2	1464.8	5228.4
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	4241.3	0.0	0.0	1796.7	6037.9
RESID. OIL	0.0	0.0	1542.3	0.0	0.0	686.6	2228.9
ELECTRICITY	215.3	874.4	4516.7	1120.8	124.9	1773.8	8625.9
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	255.2	874.4	13127.7	1855.9	286.1	5721.8	22121.1

YEAR: 2020

COMMERCIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.243252E 07	0.0	0.664079E 09	0.448362E 08	0.983128E 07	0.300431E 09	0.102161E 10
CO	0.398773E 03	0.0	0.323621E 05	0.735019E 04	0.161168E 04	0.164016E 05	0.581243E 05
SO2	0.119632E 02	0.0	0.191045E 07	0.220506E 03	0.483505E 02	0.822472E 06	0.273321E 07
NOX	0.199387E 04	0.0	0.958011E 06	0.367510E 05	0.805842E 04	0.423622E 06	0.142844E 07
PARTICULATE	0.378835E 03	0.0	0.374336E 06	0.698268E 04	0.153110E 04	0.163668E 06	0.546896E 06
HYDROCARBON	0.159509E 03	0.0	0.725384E 05	0.294008E 04	0.644673E 03	0.321293E 05	0.108412E 06
ALDEHYDE	0.199387E 03	0.0	0.498258E 05	0.367510E 04	0.805842E 03	0.225532E 05	0.770593E 05

YEAR: 2020

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
COAL	416.5	835.6	0.0	1404.2	453.2	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	789.2	599.4	129.8	1164.3	836.7	397.9	61.8
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	175.4	0.0	0.0	222.2	162.7	0.0	0.0
RESID. OIL	745.4	0.0	0.0	0.0	813.4	0.0	0.0
ELECTRICITY	65.8	2197.9	64.5	171.8	58.1	16.1	27.6
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	2192.3	3632.9	194.3	2962.5	2324.1	414.1	89.5

YEAR: 2020

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
COAL	0.0	0.0	95.3	18.8	3518.7	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	34.9	0.6	38.8	0.0	821.0	2012.8	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.2	0.0	0.0	1172.9	254.8	0.0
RESID. OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ELECTRICITY	24.3	0.1	87.5	9.4	351.9	592.2	11510.3
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	59.2	0.8	221.6	28.2	5864.5	2859.7	11510.3

YEAR: 2020

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	MISC.FOSL.	RAW MATL	TOTAL
COAL	9989.0	920.5	17651.7
GEOTHERMAL	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0
NATURAL GAS	22988.8	3612.8	33488.9
GCFR	0.0	0.0	0.0
HTGR	0.0	0.0	0.0
LFR	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0
LWR	0.0	0.0	0.0
MSBR	0.0	0.0	0.0
MCFR	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0
DISTIL. OIL	1027.2	18478.3	21493.6
RESID. OIL	1416.9	0.0	2975.7
ELECTRICITY	0.0	0.0	15177.5
METHANOL	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0
WIND	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0
TOTAL	35421.9	23011.6	90787.3

YEAR: 2020

INDUSTRIAL

AIR POLLUTION (TONS)

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
CO2	0.173057E 09	0.130148E 09	0.791803E 07	0.247179E 09	0.184764E 09	0.242734E 08	0.377155E 07
CO	0.165699E 05	0.317877E 05	0.259607E 02	0.536129E 05	0.180055E 05	0.795849E 02	0.123657E 02
SO2	0.596136E 06	0.499304E 06	0.389411E 02	0.907420E 06	0.640924E 06	0.161098E 07	0.185486E 02
NOX	0.290450E 06	0.273349E 06	0.778822E 04	0.500791E 06	0.310971E 06	0.238755E 05	0.370972E 04
PARTICULATE	0.954727E 06	0.239573E 07	0.213509E 05	0.637228E 08	0.469326E 06	0.179124E 06	0.428204E 06
HYDROCARBON	0.330252E 05	0.278224E 05	0.259607E 04	0.522949E 05	0.352126E 05	0.795849E 04	0.123657E 04
ALDEHYDE	0.532970E 04	0.168874E 04	0.194706E 03	0.467313E 04	0.557144E 04	0.596886E 03	0.927430E 02

YEAR: 2020

INDUSTRIAL

AIR POLLUTION (TONS)

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
CO2	0.213060E 07	0.496564E 05	0.130395E 08	0.210051E 07	0.984507E 09	0.144437E 09	0.0
CO	0.693557E 01	0.236221E 00	0.361964E 04	0.710795E 03	0.718455E 07	0.161164E 07	0.0
SO2	0.104784E 02	0.512783E 02	0.276574E 07	0.112030E 05	0.294314E 07	0.595424E 06	0.0
NOX	0.209567E 04	0.588889E 02	0.294020E 05	0.532816E 04	0.121781E 07	0.114199E 07	0.0
PARTICULATE	0.159297E 04	0.222686E 03	0.624234E 06	0.361518E 05	0.338674E 08	0.767798E 07	0.0
HYDROCARBON	0.698558E 03	0.134413E 02	0.258165E 04	0.355398E 03	0.957666E 05	0.430082E 05	0.0
ALDEHYDE	0.523918E 02	0.207109E 01	0.148237E 03	0.177230E 02	0.130015E 05	0.231403E 07	0.0

YEAR: 2020

INDUSTRIAL

AIR POLLUTION (TONS)

	MISC.FOSL.	RAW MATL	TOTAL
CO2	0.272883E 10	0.0	0.464620E 10
CO	0.384868E 06	0.0	0.930549E 07
SO2	0.684675E 07	0.0	0.174171E 08
NOX	0.455427E 07	0.0	0.836188E 07
PARTICULATE	0.897918E 07	0.0	0.119358E 09
HYDROCARBON	0.674330E 06	0.0	0.976900E 06
ALDEHYDE	0.560512E 05	0.0	0.240145E 07

YEAR: 2020

TRANSPORTATION

ENERGY DEMAND: TRILLION BTUS

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	17500.0	0.0	0.0	0.0	1755.0	19255.0
JET FUEL	24500.0	0.0	0.0	0.0	0.0	0.0	24500.0
DISTIL. OIL	0.0	0.0	1300.0	2015.0	411.2	6045.0	9771.2
RESID. OIL	0.0	0.0	0.0	0.0	1938.7	0.0	1939.7
ELECTRICITY	0.0	0.0	0.0	585.0	0.0	0.0	585.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	24500.0	17500.0	1300.0	2600.0	2350.0	7800.0	56050.0

YEAR: 2020

TRANSPORTATION

AIR POLLUTION (TONS)

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
CO2	0.182525E 10	0.130375E 10	0.110500E 09	0.171275E 09	0.199750E 09	0.644572E 09	0.425510E 10
CO	0.131075E 08	0.682500E 07	0.500500E 06	0.775775E 06	0.159630E 06	0.301177E 07	0.243801E 08
SO2	0.100450E 07	0.350000E 06	0.126100E 06	0.195455E 06	0.802547E 06	0.621464E 06	0.310006E 07
NOX	0.252350E 07	0.805000E 06	0.858J00E 06	0.132990E 07	0.530248E 06	0.407042E 07	0.101171E 08
PARTICULATE	0.403025E 07	0.621250E 06	0.611000E 05	0.947049E 05	0.168225E 06	0.346417E 06	0.532194E 07
HYDROCARBON	0.857500E 07	0.822500E 06	0.383500E 06	0.594425E 06	0.140706E 06	0.186576E 07	0.123819E 08
ALDEHYDE	0.257250E 06	0.183750E 06	0.143000E 05	0.221650E 05	0.109992E 05	0.849224E 05	0.573386E 06

YEAR: 2020

TOTAL BASE ENERGY DEMAND

ENERGY DEMAND: TRILLION BTUS

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
COAL	0.0	0.0	17651.7	0.0	17651.7
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	4770.1	5228.4	33488.9	0.0	43487.4
GCFR	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	19255.0	19255.0
JET FUEL	0.0	0.0	0.0	24500.0	24500.0
DISTIL. OIL	2142.0	6037.9	21493.6	9771.2	39444.8
RESID. OIL	831.1	2228.9	2975.7	1938.7	7974.4
ELECTRICITY	7442.3	8625.9	15177.5	585.0	31830.7
METHANOL	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0
TOTAL	15185.5	22121.1	90787.3	56050.0	184143.8

YEAR: 2020

AIR POLLUTION (TONS)

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
CO2	0.543689E 09	0.102161E 10	0.464620E 10	0.425510E 10	0.104666E 11
CO	0.101217E 06	0.581243E 05	0.930549E 07	0.243801E 08	0.338449E 08
SO2	0.978587E 06	0.273321E 07	0.174171E 08	0.310006E 07	0.242289E 08
NOX	0.247095E 06	0.142844E 07	0.836188E 07	0.101171E 08	0.201545E 08
PARTICULATE	0.152347E 06	0.546896E 06	0.119358E 09	0.532194E 07	0.125379E 09
HYDROCARBON	0.511897E 05	0.108412E 06	0.976900E 06	0.123819E 08	0.135184E 08
ALDEHYDE	0.452568E 05	0.770593E 05	0.240145E 07	0.573386E 06	0.309715E 07

YEAR: 2020

SUMMARY OF ENERGY DEMANDS

ENERGY DEMAND: TRILLION BTUS

	TTL B.E.D	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	SYN. FUELS	TOTAL
COAL	17651.7	1615.5	43.7	37150.1	44156.9	-0.1	100617.9
GEOTHERMAL	0.0	12387.5	0.0	0.0	0.0	0.0	12387.5
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	43487.4	193.5	4174.0	0.0	0.0	-0.0	47855.0
GCFR	0.0	14545.1	0.0	0.0	0.0	0.0	14545.1
HTGR	0.0	17365.9	0.0	0.0	0.0	0.0	17365.9
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	27935.1	0.0	0.0	0.0	0.0	27935.1
LWR	0.0	9320.3	0.0	0.0	0.0	0.0	9320.3
MSBR	0.0	10556.0	0.0	0.0	0.0	0.0	10556.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	19255.0	0.0	0.0	0.0	0.0	0.0	19255.0
JET FUEL	24500.0	0.0	0.0	0.0	0.0	0.0	24500.0
DISTIL. OIL	39444.8	16.8	0.0	0.0	0.0	-0.0	39461.6
RESID. OIL	7974.4	109.4	1223.8	0.0	0.0	-0.0	9307.6
ELECTRICITY	31830.7	0.0	273.0	0.0	0.0	-0.1	0.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	1550.0	0.0	0.0	0.0	0.0	1550.0
TOTAL	184143.8	95595.0	5714.6	37150.1	44156.9	-0.2	334656.4

YEAR: 2020

AIR POLLUTION (TONS)

	TTL B.E.D.	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	METHANOL	TOTAL
CO2	0.104666E 11	0.203472E 09	0.744444E 09	0.991377E 09	0.104955E 10	0.0	0.134554E 11
CO	0.338449E 08	0.306697E 05	0.667325E 05	0.0	0.0	0.0	0.339423E 08
SO2	0.242289E 08	0.841443E 06	0.115965E 07	0.0	0.0	0.0	0.262300E 08
NOX	0.201545E 08	0.948278E 05	0.829959E 06	0.0	0.0	0.0	0.210792E 08
PARTICULATE	0.125379E 09	0.210144E 05	0.300116E 06	0.0	0.0	0.0	0.125700E 09
HYDROCARBON	0.135184E 08	0.157017E 05	0.190801E 06	0.482758E 08	0.0	0.0	0.620007E 08
ALDEHYDE	0.309715E 07	0.865770E 03	0.205500E 05	0.800491E 07	0.110807E 07	0.0	0.122316E 08

YEAR: 2020

SOLID WASTE (TONS)

SYNCRUDE	0.596175E 08
TAR SANDS	0.104556E 05
OIL SHALE	0.723257E 04
SYNGAS	0.965516E 08
TOTAL	0.156187E 09

ELEMENTAL SULFUR PRODUCED (TONS)

SYNCRUDE	0.515020E 08
SYNGAS	0.644087E 08
TOTAL	0.115911E 09

LAND USE BY ENERGY PRODUCTION (ACRES)

COAL (STRIP MINING) .	0.661502E 06
TAR SANDS	0.415405E 03
OIL SHALE	0.415405E 05
ELEC. GEN. & TRANS.	0.467979E 08
TOTAL	0.475014E 08

RADIOACTIVE MATERIAL PRODUCTION AND RELEASES

TRITIUM RELEASED	0.722621E 09	CURIES
KRYPTON-85 RELEASED	0.367939E 09	CURIES
LONG-LIVED RAD.WASTE	0.176295E 11	CURIES
LONG LIVED RAD.WASTE	0.327302E 06	CUBIC FEET
POPULATION EXPOSURE	0.459909E 06	MAN-REM

COOLING WATER REQUIREMENTS FOR ENERGY PRODUCTION (ACRE-FEET)

COOLING WATER CONSUMED BY EVAPORATION		0.141297E 08
COOLING WATER USED IN ONCE-THRU CONDENSORS		0.974382E 09
WATER REQUIRED FOR H2 BY ELECTROLYSIS		0.0
(FEED WATER	0.0)	
(COOLING TOWER	0.0)	
OIL SHALE WATER REQUIREMENTS		0.144794E 07
TAR SANDS WATER REQUIREMENTS		0.144794E 07
COAL GASIFICATION WATER REQUIREMENTS		0.184729E 07
COAL LIQUEFACTION WATER REQUIREMENTS		0.411021E 06
TOTAL		0.993665E 09

YEAR: 2020

COAL RESOURCE DEMANDS (TRILLION BTU)

TOTAL BED	17651.68
SYNCRUDE	44156.94
SYNGAS	37150.07
METHANOL	0.0
ELEC.GEN.	1615.52
PET.REF.	43.71
TOTAL	100617.88

PETROLEUM RESOURCE DEMANDS (TRILLION BTU)

TOTAL PET. DEMAND	97474.00
TAR SANDS REQ.	17836.20
OIL SHALE REQ	17836.20
SYNCRUDE REQ.	31213.34
DOMESTIC CRUDE PROD.	8293.00
CRUDE OIL IMPORTS	22295.25
TOTAL CRUDE PROD.	97473.94

NATURAL GAS RESOURCE DEMANDS (TRILLION BTU)

TOTAL DEMAND	47854.98
CORRECTED DMD.	49671.46
DOM. NAT. GAS	6793.00
CANADA P.L.IMP.	3518.64
LNG IMPORTS	7037.29
SYNGAS	32976.45
TOTAL GAS PRD.	50325.37

NUCLEAR FUEL RESOURCE DEMANDS

SEP.WORK REQ.	0.363346E 08	KGSW
PWR REQ. KGSW	255.80	TRILLION BTU
THORIUM (THO2)	0.104973E 05	TONNES
URANIUM (U3O8)	0.426597E 05	TONNES

YEAR: 2020

SUMMARY OF RESOURCE REQUIREMENTS

RESOURCE	ANNUAL PROD.	
COAL	130617.88	TRILLION BTU
GEOTHERMAL	12387.48	TRILLION BTU
(HYDROGEN)	0.0	TRILLION BTU
NATURAL GAS	17348.93	TRILLION BTU
NUCLEAR-FISSION	79722.38	TRILLION BTU
NUCLEAR-FUSION	0.0	TRILLION BTU
PETROLEUM	66260.63	TRILLION BTU
(METHANOL)	0.0	TRILLION BTU
SOLAR	0.0	TRILLION BTU
TIDAL	0.0	TRILLION BTU
WIND	0.0	TRILLION BTU
HYDROELECTRIC	1549.98	TRILLION BTU
TOTAL	277887.13	TRILLION BTU

SUMMARY OF BALANCE OF PAYMENTS FOR ENERGY IMPORTS
(MILLIONS OF 1970 DOLLARS)

COST OF CRUDE PETROLEUM IMPORTS	15918.80
COST OF LIQUIFIED NATURAL GAS IMPORTS	8522.15
COST OF CANADIAN GAS IMPORTS	1125.97
TOTAL BALANCE OF PAYMENTS DEFICIT	25566.92

YEAR: 2030

RESIDENTIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	189.5	0.0	3549.5	916.2	180.7	0.0	4835.8
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	2293.4	0.0	0.0	0.0	2293.4
RESID. OIL	0.0	0.0	889.8	0.0	0.0	0.0	889.8
ELECTRICITY	1952.4	471.3	3217.5	1455.2	428.7	1099.4	8624.4
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	2141.8	471.3	9950.2	2371.4	609.3	1099.4	16643.4

YEAR: 2030

RESIDENTIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.115568E 08	0.0	0.487090E 09	0.558865E 08	0.110212E 08	0.0	0.565554E 09
CO	0.189456E 04	0.0	0.927923E 05	0.916172E 04	0.180675E 04	0.0	0.105655E 06
SO2	0.568369E 02	0.0	0.104727E 07	0.274852E 03	0.542025E 02	0.0	0.104766E 07
NOX	0.473641E 04	0.0	0.225614E 06	0.229043E 05	0.451687E 04	0.0	0.257772E 06
PARTICULATE	0.179983E 04	0.0	0.148315E 06	0.870363E 04	0.171641E 04	0.0	0.160534E 06
HYDROCARBON	0.757925E 03	0.0	0.485764E 05	0.366469E 04	0.722699E 03	0.0	0.537216E 05
ALDEHYDE	0.947281E 03	0.0	0.406664E 05	0.458086E 04	0.903374E 03	0.0	0.470979E 05

YEAR: 2030

COMMERCIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	49.6	0.0	3235.1	818.8	177.9	1820.5	6101.9
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	4971.1	0.0	0.0	2233.0	7204.0
RESID. OIL	0.0	0.0	1893.7	0.0	0.0	853.4	2747.1
ELECTRICITY	267.6	1086.7	6123.9	1446.1	170.4	2204.5	11299.3
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	317.2	1086.7	16223.8	2264.9	348.4	7111.4	27352.4

YEAR: 2030

COMMERCIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.302327E 07	0.0	0.780850E 09	0.499455E 08	0.108535E 08	0.373393E 09	0.121806E 10
CO	0.495618E 03	0.0	0.371993E 05	0.818779E 04	0.177927E 04	0.203848E 05	0.680467E 05
SO2	0.148685E 02	0.0	0.227302E 07	0.245634E 03	0.533781E 02	0.102222E 07	0.329555E 07
NOx	0.247809E 04	0.0	0.113040E 07	0.409389E 05	0.889634E 04	0.526502E 06	0.170922E 07
PARTICULATE	0.479837E 03	0.0	0.444609E 06	0.777840E 04	0.169031E 04	0.203415E 06	0.657964E 06
HYDROCARBON	0.199247E 03	0.0	0.855652E 05	0.327512E 04	0.711708E 03	0.399321E 05	0.129682E 06
ALDEHYDE	0.247809E 03	0.0	0.582923E 05	0.409390E 04	0.889635E 03	0.280304E 05	0.915541E 05

YEAR: 2030

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
COAL	517.7	1038.5	0.0	1745.3	563.3	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	980.9	745.0	161.3	1447.0	1039.9	494.6	76.8
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	218.0	0.0	0.0	276.2	202.2	0.0	0.0
RESID. OIL	926.4	0.0	0.0	0.0	1011.0	0.0	0.0
ELECTRICITY	81.7	2731.7	80.2	213.6	72.2	20.1	34.4
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	2724.7	4515.2	241.5	3682.0	2888.5	514.6	111.2

YEAR: 2030

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	MISC.FOSL.	RAW MATL	TOTAL
COAL	12415.1	1144.0	21819.0
GEOTHERMAL	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0
NATURAL GAS	28572.4	4490.3	41683.7
GCFR	0.0	0.0	0.0
HTGR	0.0	0.0	0.0
LFR	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0
LWR	0.0	0.0	0.0
MSBR	0.0	0.0	0.0
MCFR	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0
DISTIL. OIL	1276.7	22966.4	26698.1
RESID. OIL	1761.0	0.0	3698.4
ELECTRICITY	0.0	0.0	18859.0
METHANOL	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0
WIND	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0
TOTAL	44025.2	28600.7	112758.1

YEAR: 2030

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
COAL	0.0	0.0	118.4	23.3	4253.4	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	43.4	0.7	48.2	0.0	1081.4	2501.7	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.2	0.0	0.0	1441.8	316.6	0.0
RESID. OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ELECTRICITY	30.2	0.1	108.8	11.7	432.5	736.0	14305.9
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	73.6	1.0	275.5	35.0	7209.2	3554.3	14305.9

YEAR: 2030

INDUSTRIAL

AIR POLLUTION (TONS)

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
CO2	0.215089E 09	0.161758E 09	0.984115E 07	0.307214E 09	0.229639E 09	0.301689E 08	0.468758E 07
CO	0.205944E 05	0.395082E 05	0.322660E 02	0.666343E 05	0.223787E 05	0.989143E 02	0.153691E 02
SO2	0.740925E 06	0.620574E 06	0.483991E 02	0.112781E 07	0.796592E 06	0.200225E 07	0.230536E 02
NOX	0.360994E 06	0.339739E 06	0.967982E 04	0.622423E 06	0.386499E 06	0.296743E 05	0.461073E 04
PARTICULATE	0.118661E 07	0.297760E 07	0.265366E 05	0.791998E 08	0.583315E 06	0.222629E 06	0.532206E 06
HYDROCARBON	0.410464E 05	0.345799E 05	0.322661E 04	0.649963E 05	0.437650E 05	0.989143E 04	0.153691E 04
ALDEHYDE	0.662418E 04	0.209890E 04	0.241995E 03	0.580814E 04	0.692462E 04	0.741857E 03	0.115268E 03

YEAR: 2030

INDUSTRIAL

AIR POLLUTION (TONS)

	MISC.FOSL.	RAW MATL	TOTAL
CO2	0.339161E 10	0.0	0.576361E 10
CO	0.478346E 06	0.0	0.115611E 08
SO2	0.850969E 07	0.0	0.215709E 08
NOX	0.566041E 07	0.0	0.103601E 08
PARTICULATE	0.111601E 08	0.0	0.148244E 09
HYDROCARBON	0.838112E 06	0.0	0.121294E 07
ALDEHYDE	0.696650E 05	0.0	0.298458E 07

YEAR: 2030

INDUSTRIAL

AIR POLLUTION (TONS)

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
CO2	0.264808E 07	0.617169E 05	0.162066E 08	0.261067E 07	0.121256E 10	0.179518E 09	0.0
CO	0.869223E 01	0.293594E 00	0.449878E 04	0.883433E 03	0.892499E 07	0.200307E 07	0.0
SO2	0.130233E 02	0.637327E 02	0.343748E 07	0.139240E 05	0.358147E 07	0.740040E 06	0.0
NOX	0.260467E 04	0.731918E 02	0.365431E 05	0.662225E 04	0.148090E 07	0.141935E 07	0.0
PARTICULATE	0.197986E 04	0.276771E 03	0.775848E 06	0.449323E 05	0.419894E 08	0.954280E 07	0.0
HYDROCARBON	0.868223E 03	0.167059E 02	0.320867E 04	0.441717E 03	0.117801E 06	0.534539E 05	0.0
ALDEHYDE	0.651157E 02	0.257412E 01	0.184240E 03	0.220276E 02	0.160227E 05	0.287606E 07	0.0

YEAR: 2030

TRANSPORTATION

ENERGY DEMAND: TRILLION BTUS

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	18800.0	0.0	0.0	0.0	935.0	19735.0
JET FUEL	30000.0	0.0	0.0	0.0	0.0	0.0	30000.0
DISTIL. OIL	0.0	0.0	1800.0	2926.0	498.6	7565.0	12789.6
RESID. OIL	0.0	0.0	0.0	0.0	2271.4	0.0	2271.4
ELECTRICITY	0.0	0.0	0.0	874.0	0.0	0.0	874.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	30000.0	18800.0	1800.0	3800.0	2770.0	8500.0	65669.9

YEAR: 2030

TRANSPORTATION

AIR POLLUTION (TONS)

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
CO2	0.223500E 10	0.140060E 10	0.153000E 09	0.248710E 09	0.235450E 09	0.712682E 09	0.498544E 10
CO	0.160500E 08	0.733200E 07	0.693000E 06	0.112651E 07	0.193483E 06	0.327717E 07	0.286721E 08
SO2	0.123000E 07	0.376000E 06	0.174600E 06	0.283822E 06	0.941875E 06	0.752504E 06	0.375880E 07
NOX	0.309000E 07	0.864799E 06	0.118800E 07	0.193116E 07	0.632308E 06	0.503590E 07	0.127422E 08
PARTICULATE	0.493500E 07	0.667400E 06	0.845999E 05	0.137522E 06	0.197878E 06	0.388747E 06	0.641114E 07
HYDROCARBON	0.105000E 08	0.883600E 06	0.531000E 06	0.863170E 06	0.169801E 06	0.227562E 07	0.152232E 08
ALDEHYDE	0.315000E 06	0.197400E 06	0.198000E 05	0.321860E 05	0.130711E 05	0.930324E 05	0.670489E 06

YEAR: 2030

TOTAL BASE ENERGY DEMAND

ENERGY DEMAND: TRILLION BTUS

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
COAL	0.0	0.0	21819.0	0.0	21819.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	4835.8	6101.9	41683.7	0.0	52621.4
GCFR	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	19735.0	19735.0
JET FUEL	0.0	0.0	0.0	30000.0	30000.0
DISTIL. OIL	2293.4	7204.0	26698.1	12789.6	48985.1
RESID. OIL	889.8	2747.1	3698.4	2271.4	9606.7
ELECTRICITY	8624.4	11299.3	18859.0	874.0	39656.7
METHANOL	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0
TOTAL	16643.4	27352.4	112758.1	65669.9	222423.8

YEAR: 2030

AIR POLLUTION (TONS)

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
CO2	0.565554E 09	0.121806E 10	0.576361E 10	0.498544E 10	0.125327E 11
CO	0.105655E 06	0.680467E 05	0.115611E 08	0.286721E 08	0.404069E 08
SO2	0.104766E 07	0.329555E 07	0.215709E 08	0.375880E 07	0.296729E 08
NOX	0.257772E 06	0.170922E 07	0.103601E 08	0.127422E 08	0.250693E 08
PARTICULATE	0.160534E 06	0.657964E 06	0.148244E 09	0.641114E 07	0.155474E 09
HYDROCARBON	0.537216E 05	0.129682E 06	0.121294E 07	0.152232E 08	0.166195E 08
ALDEHYDE	0.470979E 05	0.915541E 05	0.298458E 07	0.670489E 06	0.379372E 07

YEAR: 2030

SUMMARY OF ENERGY DEMANDS

ENERGY DEMAND: TRILLION BTUS

	TTL R.E.D	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	SYN. FUELS	TOTAL
COAL	21819.0	0.0	51.9	57332.3	62590.5	-0.2	141793.6
GEOTHERMAL	0.0	12312.2	0.0	0.0	0.0	0.0	12312.2
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	52621.4	0.0	4952.5	0.0	0.0	0.0	57573.9
GCFR	0.0	26542.4	0.0	0.0	0.0	0.0	26542.4
HTGR	0.0	13496.8	0.0	0.0	0.0	0.0	13496.8
LFR	0.0	16226.1	0.0	0.0	0.0	0.0	16226.1
LMFBR	0.0	23240.5	0.0	0.0	0.0	0.0	23240.5
LWR	0.0	10401.4	0.0	0.0	0.0	0.0	10401.4
MSBR	0.0	9603.5	0.0	0.0	0.0	0.0	9603.5
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	19735.0	0.0	0.0	0.0	0.0	0.0	19735.0
JET FUEL	30000.0	0.0	0.0	0.0	0.0	0.0	30000.0
DISTIL. OIL	48985.1	0.0	0.0	0.0	0.0	0.0	48985.1
RESID. OIL	9606.7	0.0	1452.0	0.0	0.0	-0.0	11058.7
ELECTRICITY	39656.7	0.0	323.9	0.0	0.0	-0.1	0.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	1556.8	0.0	0.0	0.0	0.0	1556.8
TOTAL	222423.8	113379.6	6780.3	57332.3	62590.5	-0.3	422525.4

YEAR: 2030

AIR POLLUTION (TONS)

	TTL B.E.D.	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	METHANOL	TOTAL
CO2	0.125327E 11	0.0	0.883274E 09	0.152995E 10	0.148769E 10	0.0	0.164336E 11
CO	0.404069E 08	0.0	0.791773E 05	0.0	0.0	0.0	0.404860E 08
SO2	0.296729E 08	0.0	0.137591E 07	0.0	0.0	0.0	0.310488E 08
NOX	0.250693E 08	0.0	0.984738E 06	0.0	0.0	0.0	0.260540E 08
PARTICULATE	0.155474E 09	0.0	0.356084E 06	0.0	0.0	0.0	0.155830E 09
HYDROCARBON	0.166195E 08	0.0	0.226383E 06	0.745021E 08	0.0	0.0	0.913480E 08
ALDEHYDE	0.379372E 07	0.0	0.243823E 05	0.123537E 08	0.157064E 07	0.0	0.177424E 08

YEAR: 2030

SOLID WASTE (TONS)

SYNCRUDE	0.345351E 08
TAR SANDS	0.129678E 05
OIL SHALE	0.997037E 04
SYNGAS	0.149004E 09
TOTAL	0.233531E 09

ELEMENTAL SULFUR PRODUCED (TONS)

SYNCRUDE	0.730018E 08
SYNGAS	0.999996E 08
TOTAL	0.172401E 09

LAND USE BY ENERGY PRODUCTION (ACRES)

COAL (STRIP MINING)	0.932103E 06
TAR SANDS	0.515216E 03
OIL SHALE	0.515216E 05
ELEC. GEN. & TRANS.	0.470765E 08
TOTAL	0.480606E 08

RADIOACTIVE MATERIAL PRODUCTION AND RELEASES

TRITIUM RELEASED	0.662365E 09	CURIES
KRYPTON-85 RELEASED	0.348490E 09	CURIES
LONG-LIVED RAD.WASTE	0.212562E 11	CURIES
LONG LIVED RAD.WASTE	0.387323E 06	CUBIC FEET
POPULATION EXPOSURE	0.551171E 06	MAN-REM

COOLING WATER REQUIREMENTS FOR ENERGY PRODUCTION (ACRE-FEET)

COOLING WATER CONSUMED BY EVAPORATION		0.164147E 08
COOLING WATER USED IN ONCE-THRU CONDENSORS		0.111472E 10
WATER REQUIRED FOR H2 BY ELECTROLYSIS		0.0
(FEED WATER	0.0)	
(COOLING TOWER	0.0)	
OIL SHALE WATER REQUIREMENTS		0.179584E 07
TAR SANDS WATER REQUIREMENTS		0.179584E 07
COAL GASIFICATION WATER REQUIREMENTS		0.285085E 07
COAL LIQUEFACTION WATER REQUIREMENTS		0.582604E 06
TOTAL		0.113816E 10

YEAR: 2030

COAL RESOURCE DEMANDS (TRILLION BTU)

TOTAL BED	21819.04
SYNCRUDE	62590.49
SYNGAS	57332.27
METHANOL	0.0
ELEC.GEN.	0.0
PET.REF.	51.86
TOTAL	141793.56

PETROLEUM RESOURCE DEMANDS (TRILLION BTU)

TOTAL PET. DEMAND	115651.81
TAR SANDS REQ.	22121.76
OIL SHALE REQ	22121.76
SYNCRUDE RFQ.	44243.52
DOMESTIC CRUDE PROD.	5043.00
CRUDE OIL IMPORTS	22121.76
TOTAL CRUDE PROD.	115651.75

NATURAL GAS RESOURCE DEMANDS (TRILLION BTU)

TOTAL DEMAND	57573.86
CORRECTED DMD.	59759.26
DOM. NAT. GAS	3552.00
CANADA P.L.IMP.	2235.96
LNG IMPORTS	4471.91
SYNGAS	49841.30
TOTAL GAS PRD.	60101.18

NUCLEAR FUEL RESOURCE DEMANDS

SEP.WORK REQ.	0.316680E 08	KGSW
PWR REQ. KGSW	222.94	TRILLION BTU
THORIUM (TH02)	0.874205E 04	TONNES
URANIUM (U308)	0.380179E 05	TONNES

YEAR: 2030

SUMMARY OF RESOURCE REQUIREMENTS

RESOURCE	ANNUAL PROD.	
COAL	141793.56	TRILLION BTU
GEOTHERMAL	12312.22	TRILLION BTU
(HYDROGEN)	0.0	TRILLION BTU
NATURAL GAS	10259.87	TRILLION BTU
NUCLEAR-FISSION	83284.63	TRILLION BTU
NUCLEAR-FUSION	16226.13	TRILLION BTU
PETROLEUM	71408.25	TRILLION BTU
(METHANOL)	0.0	TRILLION BTU
SOLAR	0.0	TRILLION BTU
TIDAL	0.0	TRILLION BTU
WIND	0.0	TRILLION BTU
HYDROELECTRIC	1556.78	TRILLION BTU
TOTAL	336841.31	TRILLION BTU

SUMMARY OF BALANCE OF PAYMENTS FOR ENERGY IMPORTS
(MILLIONS OF 1970 DOLLARS)

COST OF CRUDE PETROLEUM IMPORTS	15794.93
COST OF LIQUIFIED NATURAL GAS IMPORTS	5415.48
COST OF CANADIAN GAS IMPORTS	715.51
TOTAL BALANCE OF PAYMENTS DEFICIT	21925.92

YEAR: 2040

RESIDENTIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	226.4	0.0	3876.5	980.3	166.3	0.0	5249.5
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	2469.4	0.0	0.0	0.0	2469.4
RESID. OIL	0.0	0.0	959.1	0.0	0.0	0.0	958.1
ELECTRICITY	2312.7	521.0	3556.8	1608.2	479.2	1215.3	9693.1
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	2539.1	521.0	10860.8	2588.4	645.5	1215.3	18370.1

YEAR: 2040

RESIDENTIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.138114E 08	0.0	0.527803E 09	0.597972E 08	0.101432E 08	0.0	0.611555E 09
CO	0.226417E 04	0.0	0.100460E 06	0.980282E 04	0.166283E 04	0.0	0.114189E 06
SO2	0.679249E 02	0.0	0.112766E 07	0.294084E 03	0.498848E 02	0.0	0.112807E 07
NOX	0.566041E 04	0.0	0.244294E 06	0.245071E 05	0.415707E 04	0.0	0.278619E 06
PARTICULATE	0.215096E 04	0.0	0.160216E 06	0.931267E 04	0.157969E 04	0.0	0.173259E 06
HYDROCARBON	0.905666E 03	0.0	0.525227E 05	0.392113E 04	0.665130E 03	0.0	0.580147E 05
ALDEHYDE	0.113209E 04	0.0	0.440604E 05	0.490141E 04	0.831413E 03	0.0	0.509253E 05

YEAR: 2040

COMMERCIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	60.5	0.0	3808.7	986.1	199.2	2223.3	7277.8
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	5808.3	0.0	0.0	2727.1	8535.3
RESID. OIL	0.0	0.0	2285.2	0.0	0.0	1042.2	3327.4
ELECTRICITY	326.9	1327.1	7894.4	1762.3	219.3	2692.3	14222.4
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	387.4	1327.1	19796.6	2748.4	418.6	8684.9	33363.0

YEAR: 2040

COMMERCIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.369221E 07	0.0	0.920276E 09	0.601495E 08	0.121523E 08	0.456012E 09	0.145228E 10
CO	0.605281E 03	0.0	0.438000E 05	0.986058E 04	0.199218E 04	0.248952E 05	0.811533E 05
SO2	0.181584E 02	0.0	0.268438E 07	0.295817E 03	0.597654E 02	0.124840E 07	0.393315E 07
NOX	0.302641E 04	0.0	0.133190E 07	0.493029E 05	0.996089E 04	0.642998E 06	0.203719E 07
PARTICULATE	0.575017E 03	0.0	0.525333E 06	0.936754E 04	0.189257E 04	0.248424E 06	0.785592E 06
HYDROCARBON	0.242112E 03	0.0	0.100816E 06	0.394423E 04	0.796872E 03	0.487677E 05	0.154567E 06
ALDEHYDE	0.302640E 03	0.0	0.684956E 05	0.493029E 04	0.996089E 03	0.342326E 05	0.108957E 06

YEAR: 2040

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
COAL	632.2	1268.2	0.0	2131.4	687.9	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	1197.9	909.8	197.0	1767.1	1269.9	604.0	93.8
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	266.2	0.0	0.0	337.2	246.9	0.0	0.0
RESID. OIL	1131.3	0.0	0.0	0.0	1234.6	0.0	0.0
ELECTRICITY	99.8	3336.0	97.9	260.8	88.2	24.5	42.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	3327.5	5514.1	294.9	4496.6	3527.5	628.5	135.8

YEAR: 2040

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	MISC.FOSL.	RAW MATL	TOTAL
COAL	15161.9	1397.1	26558.2
GEOTHERMAL	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0
NATURAL GAS	34894.0	5483.8	50993.9
GCFR	0.0	0.0	0.0
HTGR	0.0	0.0	0.0
LFR	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0
LWR	0.0	0.0	0.0
MSBR	0.0	0.0	0.0
MCFR	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0
DISTIL. OIL	1559.2	28047.7	32604.9
RESID. OIL	2150.6	0.0	4516.6
ELECTRICITY	0.0	0.0	23031.4
METHANOL	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0
WIND	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0
TOTAL	53765.8	34928.6	137704.9

YEAR: 2040

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
COAL	0.0	0.0	144.6	28.5	5106.3	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	53.0	0.9	58.9	0.0	1408.6	3055.1	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.3	0.0	0.0	1760.8	386.7	0.0
RESID. OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ELECTRICITY	36.8	0.1	132.9	14.3	528.2	898.8	17471.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	89.9	1.3	336.4	42.7	8803.9	4340.6	17471.0

YEAR: 2040

INDUSTRIAL

AIR POLLUTION (TONS)

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
CO2	0.262670E 09	0.197542E 09	0.120182E 08	0.375174E 09	0.280439E 09	0.368427E 08	0.572455E 07
CO	0.251502E 05	0.482481E 05	0.394038E 02	0.813749E 05	0.273292E 05	0.120796E 03	0.187690E 02
SO2	0.904830E 06	0.757856E 06	0.591058E 02	0.137730E 07	0.972811E 06	0.244518E 07	0.291535E 02
NOX	0.440852E 06	0.414896E 06	0.118211E 05	0.760113E 06	0.472000E 06	0.362388E 05	0.563070E 04
PARTICULATE	0.144911E 07	0.363630E 07	0.324069E 05	0.967201E 08	0.712354E 06	0.271878E 06	0.649939E 06
HYDROCARBON	0.531265E 05	0.422296E 05	0.394039E 04	0.793745E 05	0.534465E 05	0.120796E 05	0.187690E 04
ALDEHYDE	0.809955E 04	0.256322E 04	0.295529E 03	0.709300E 04	0.845646E 04	0.905969E 03	0.140768E 03

YEAR: 2040

INDUSTRIAL

AIR POLLUTION (TONS)

	MISC.FOSL.	RAW MATL	TOTAL
CO2	0.414201E 10	0.0	0.703424E 10
CO	0.584179E 06	0.0	0.141153E 08
SO2	0.103925E 08	0.0	0.262904E 08
NOX	0.691278E 07	0.0	0.126324E 08
PARTICULATE	0.136292E 08	0.0	0.180963E 09
HYDROCARBON	0.102354E 07	0.0	0.148139E 07
ALDEHYDE	0.853783E 05	0.0	0.364486E 07

YEAR: 2040

INDUSTRIAL

AIR POLLUTION (TONS)

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
CO2	0.323389E 07	0.753697E 05	0.197917E 08	0.318820E 07	0.147631E 10	0.219231E 09	0.0
CO	0.106029E 02	0.358542E 00	0.549398E 04	0.107886E 04	0.108960E 08	0.244619E 07	0.0
SO2	0.159043E 02	0.778315E 02	0.419791E 07	0.170042E 05	0.432119E 07	0.903749E 06	0.0
NOX	0.319387E 04	0.893831E 02	0.446270E 05	0.808720E 04	0.178877E 07	0.173334E 07	0.0
PARTICULATE	0.241784E 04	0.337998E 03	0.947478E 06	0.548720E 05	0.512031E 08	0.116538E 08	0.0
HYDROCARBON	0.106029E 04	0.204016E 02	0.391849E 04	0.539431E 03	0.143953E 06	0.652789E 05	0.0
ALDEHYDE	0.795217E 02	0.314356E 01	0.224997E 03	0.269004E 02	0.196161E 05	0.351229E 07	0.0

YEAR: 2040

TRANSPORTATION

ENERGY DEMAND: TRILLION BTUS

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	20000.0	0.0	0.0	0.0	0.0	20000.0
JET FUEL	36500.0	0.0	0.0	0.0	0.0	0.0	36500.0
DISTIL. OIL	0.0	0.0	2350.0	4235.0	627.0	9100.0	16312.0
RESID. OIL	0.0	0.0	0.0	0.0	2673.0	0.0	2673.0
ELECTRICITY	0.0	0.0	0.0	1265.0	0.0	0.0	1265.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	36500.0	20000.0	2350.0	5500.0	3300.0	9100.0	76749.8

YEAR: 2040

TRANSPORTATION

AIR POLLUTION (TONS)

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
CO2	0.271925E 10	0.149000E 10	0.199750E 09	0.359975E 09	0.280500E 09	0.773500E 09	0.582296E 10
CO	0.195275E 08	0.780000E 07	0.904750E 06	0.163047E 07	0.243186E 06	0.350350E 07	0.336093E 08
SO2	0.149650E 07	0.400000E 06	0.227950E 06	0.410794E 06	0.111231E 07	0.882700E 06	0.453025E 07
NOX	0.375950E 07	0.919999E 06	0.155100E 07	0.279510E 07	0.770665E 06	0.600600E 07	0.158023E 08
PARTICULATE	0.600425E 07	0.710000E 06	0.110450E 06	0.199045E 06	0.234755E 06	0.427700E 06	0.768619E 07
HYDROCARBON	0.127750E 08	0.940000E 06	0.693250E 06	0.124932E 07	0.211695E 06	0.268450E 07	0.185538E 08
ALDEHYDE	0.383250E 06	0.210000E 06	0.258500E 05	0.465850E 05	0.158248E 05	0.100100E 06	0.791609E 06

YEAR: 2040

TOTAL BASE ENERGY DEMAND

ENERGY DEMAND: TRILLION BTUS

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
COAL	0.0	0.0	26558.2	0.0	26558.2
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	5249.5	7277.8	50993.9	0.0	63521.3
GCFR	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	20000.0	20000.0
JET FUEL	0.0	0.0	0.0	36500.0	36500.0
DISTIL. OIL	2469.4	8535.3	32604.9	16312.0	59921.6
RESID. OIL	958.1	3327.4	4516.6	2673.0	11475.1
ELECTRICITY	9693.1	14222.4	23031.4	1265.0	48211.9
METHANOL	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0
TOTAL	18370.1	33363.0	137704.9	76749.8	266187.9

YEAR: 2040

AIR POLLUTION (TONS)

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
CO2	0.611555E 09	0.145228E 10	0.703424E 10	0.582296E 10	0.149210E 11
CO	0.114189E 06	0.811533E 05	0.141153E 08	0.336093E 08	0.479199E 08
SO2	0.112807E 07	0.393315E 07	0.262904E 08	0.453025E 07	0.358819E 08
NOX	0.278619E 06	0.203719E 07	0.126324E 08	0.158023E 08	0.307505E 08
PARTICULATE	0.173259E 06	0.785592E 06	0.180963E 09	0.768619E 07	0.189608E 09
HYDROCARBON	0.580147E 05	0.154567E 06	0.148139E 07	0.185538E 08	0.202477E 08
ALDEHYDE	0.509253E 05	0.108957E 06	0.364486E 07	0.781609E 06	0.458636E 07

YEAR: 2040

SUMMARY OF ENERGY DEMANDS

ENERGY DEMAND: TRILLION BTUS

	TTL B.E.D	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	SYN. FUELS	TOTAL
COAL	26558.2	0.0	61.2	81915.5	85038.5	-0.1	193573.3
GEOTHERMAL	0.0	11203.2	0.0	0.0	0.0	0.0	11203.2
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	63521.3	0.0	5847.2	0.0	0.0	-0.1	69368.4
GCFR	0.0	19522.6	0.0	0.0	0.0	0.0	19522.6
HTGR	0.0	10181.8	0.0	0.0	0.0	0.0	10181.8
LFR	0.0	66925.6	0.0	0.0	0.0	0.0	66925.6
LMFBR	0.0	13566.7	0.0	0.0	0.0	0.0	13566.7
LWR	0.0	9563.1	0.0	0.0	0.0	0.0	9563.1
MSBR	0.0	5886.4	0.0	0.0	0.0	0.0	5886.4
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	20000.0	0.0	0.0	0.0	0.0	0.0	20000.0
JET FUEL	36500.0	0.0	0.0	0.0	0.0	0.0	36500.0
DISTIL. OIL	59921.6	0.0	0.0	0.0	0.0	0.0	59921.6
RESID. OIL	11475.1	0.0	1714.3	0.0	0.0	-0.0	13189.5
ELECTRICITY	48211.9	0.0	382.5	0.0	0.0	-0.1	0.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	1567.6	0.0	0.0	0.0	0.0	1567.6
TOTAL	266187.9	138416.9	8005.2	81915.5	85038.5	-0.3	530969.3

YEAR: 2040

AIR POLLUTION (TONS)

	TTL B.E.D.	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	METHANOL	TOTAL
CO2	0.149210E 11	0.0	0.104284E 10	0.218598E 10	0.202125E 10	0.0	0.201711E 11
CO	0.479199E 08	0.0	0.934812E 05	0.0	0.0	0.0	0.480134E 08
SO2	0.359819E 08	0.0	0.162448E 07	0.0	0.0	0.0	0.375064E 08
NOX	0.307505E 08	0.0	0.116264E 07	0.0	0.0	0.0	0.319131E 08
PARTICULATE	0.189608E 09	0.0	0.420413E 06	0.0	0.0	0.0	0.190029E 09
HYDROCARBON	0.202477E 08	0.0	0.267280E 06	0.106448E 09	0.0	0.0	0.126963E 09
ALDEHYDE	0.458636E 07	0.0	0.287871E 05	0.176508E 08	0.213396E 07	0.0	0.243998E 08

YEAR: 2040

SOLID WASTE (TONS)

SYNCRUDE	0.114813E 09
TAR SANDS	0.156610E 05
OIL SHALE	0.108334E 05
SYNGAS	0.212995E 09
TOTAL	0.327734E 09

ELEMENTAL SULFUR PRODUCED (TONS)

SYNCRUDE	0.991839E 08
SYNGAS	0.142021E 09
TOTAL	0.241205E 09

LAND USE BY ENERGY PRODUCTION (ACRES)

COAL (STRIP MINING)	0.127260E 07
TAR SANDS	0.622220E 03
OIL SHALE	0.622220E 05
ELEC. GEN. & TRANS.	0.475424E 08
TOTAL	0.488779E 08

RADIOACTIVE MATERIAL PRODUCTION AND RELEASES

TRITIUM RELEASED	0.408470E 09	CURIES
KRYPTON-85 RELEASED	0.256829E 09	CURIES
LONG-LIVED RAD.WASTE	0.260250E 11	CURIES
LONG LIVED RAD.WASTE	0.459282E 06	CUBIC FEET
POPULATION EXPOSURE	0.667804E 06	MAN-REM

COOLING WATER REQUIREMENTS FOR ENERGY PRODUCTION (ACRE-FEET)

COOLING WATER CONSUMED BY EVAPORATION			0.187600E 08
COOLING WATER USED IN ONCE-THRU CONDENSORS			0.126046E 10
WATER REQUIRED FOR H2 BY ELECTROLYSIS			0.0
(FEED WATER	0.0	)	
(COOLING TOWER	0.0	)	
OIL SHALE WATER REQUIREMENTS			0.216882E 07
TAR SANDS WATER REQUIREMENTS			0.216882E 07
COAL GASIFICATION WATER REQUIREMENTS			0.407325E 07
COAL LIQUEFACTION WATER REQUIREMENTS			0.791554E 06
TOTAL			0.128843E 10

YEAR: 2040

COAL RESOURCE DEMANDS (TRILLION BTU)

TOTAL BED	26558.18
SYNCRUDE	85038.50
SYNGAS	81915.50
METHANOL	0.0
ELEC.GEN.	0.0
PET.REF.	61.23
TOTAL	193573.31

PETROLEUM RESOURCE DEMANDS (TRILLION BTU)

TOTAL PET. DEMAND	136545.00
TAR SANDS REQ.	26716.20
OIL SHALE REQ	26716.20
SYNCRUDE REQ.	60111.45
DOMESTIC CRUDE PROD.	2964.00
CRUDE OIL IMPORTS	20037.14
TOTAL CRUDE PROD.	136544.94

NATURAL GAS RESOURCE DEMANDS (TRILLION BTU)

TOTAL DEMAND	69368.38
CORRECTED DMD.	72001.44
DOM. NAT. GAS	1791.00
CANADA P.L.IMP.	0.0
LNG IMPORTS	0.0
SYNGAS	70382.81
TOTAL GAS PRD.	72173.81

NUCLEAR FUEL RESOURCE DEMANDS

SEP.WORK REQ.	0.258770E 08	KGSW
PWR REQ. KGSW	192.17	TRILLION BTU
THORIUM (THO2)	0.602843E 04	TONNES
URANIUM (U3O8)	0.313235E 05	TONNES

YEAR: 2040

SUMMARY OF RESOURCE REQUIREMENTS

RESOURCE	ANNUAL PROD.	
COAL	193573.31	TRILLION BTU
GEOTHERMAL	11203.23	TRILLION BTU
(HYDROGEN)	0.0	TRILLION BTU
NATURAL GAS	1791.00	TRILLION BTU
NUCLEAR-FISSION	58720.55	TRILLION BTU
NUCLEAR-FUSION	66925.63	TRILLION BTU
PETROLEUM	76433.50	TRILLION BTU
(METHANOL)	0.0	TRILLION BTU
SOLAR	0.0	TRILLION BTU
TIDAL	0.0	TRILLION BTU
WIND	0.0	TRILLION BTU
HYDROELECTRIC	1567.63	TRILLION BTU
TOTAL	410214.75	TRILLION BTU

SUMMARY OF BALANCE OF PAYMENTS FOR ENERGY IMPORTS
(MILLIONS OF 1970 DOLLARS)

COST OF CRUDE PETROLEUM IMPORTS	14306.52
COST OF LIQUIFIED NATURAL GAS IMPORTS	0.0
COST OF CANADIAN GAS IMPORTS	0.0
TOTAL BALANCE OF PAYMENTS DEFICIT	14306.52

YEAR: 2050

RESIDENTIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	247.3	0.0	4134.0	1043.8	161.3	0.0	5586.3
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	2628.5	0.0	0.0	0.0	2628.5
RESID. OIL	0.0	0.0	1019.9	0.0	0.0	0.0	1019.9
ELECTRICITY	2525.7	568.9	3884.4	1752.5	523.0	1327.2	10581.8
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	2773.0	568.9	11666.8	2796.4	684.3	1327.2	19816.6

YEAR: 2050

RESIDENTIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.150835E 08	0.0	0.562285E 09	0.636722E 08	0.983805E 07	0.0	0.650878E 09
CO	0.247271E 04	0.0	0.107011E 06	0.104381E 05	0.161279E 04	0.0	0.121534E 06
SO2	0.741812E 02	0.0	0.120035E 07	0.313142E 03	0.483838E 02	0.0	0.120078E 07
NOX	0.618177E 04	0.0	0.260230E 06	0.260952E 05	0.403199E 04	0.0	0.296539E 06
PARTICULATE	0.234907E 04	0.0	0.170615E 06	0.991617E 04	0.153215E 04	0.0	0.184412E 06
HYDROCARBON	0.989082E 03	0.0	0.559384E 05	0.417523E 04	0.645117E 03	0.0	0.617479E 05
ALDEHYDE	0.123635E 04	0.0	0.469382E 05	0.521904E 04	0.806397E 03	0.0	0.542000E 05

YEAR: 2050

COMMERCIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	73.3	0.0	4560.9	1162.6	225.9	2694.2	8716.9
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	6841.4	0.0	0.0	3304.6	10145.9
RESID. OIL	0.0	0.0	2736.6	0.0	0.0	1262.9	3999.4
ELECTRICITY	396.1	1608.2	9566.1	2131.0	269.2	3262.5	17233.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	469.4	1608.2	23705.0	3293.5	495.1	10524.1	40095.3

YEAR: 2050

COMMERCIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.447408E 07	0.0	0.109234E 10	0.709169E 08	0.137789E 08	0.552576E 09	0.173409E 10
CO	0.733455E 03	0.0	0.523686E 05	0.116257E 05	0.225884E 04	0.301670E 05	0.971536E 05
SO2	0.220036E 02	0.0	0.317954E 07	0.348771E 03	0.677653E 02	0.151275E 07	0.469273E 07
NOX	0.366728E 04	0.0	0.157854E 07	0.581286E 05	0.112942E 05	0.779159E 06	0.243079E 07
PARTICULATE	0.696782E 03	0.0	0.622932E 06	0.110444E 05	0.214590E 04	0.301030E 06	0.937849E 06
HYDROCARBON	0.293382E 03	0.0	0.119496E 06	0.465029E 04	0.903537E 03	0.590947E 05	0.184438E 06
ALDEHYDE	0.366728E 03	0.0	0.812027E 05	0.581286E 04	0.112942E 04	0.414816E 05	0.129993E 06

YEAR: 2050

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
COAL	766.1	1536.8	0.0	2582.8	833.6	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	1451.6	1102.5	238.7	2141.4	1538.9	731.9	113.7
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	322.6	0.0	0.0	408.7	299.2	0.0	0.0
RESID. OIL	1371.0	0.0	0.0	0.0	1496.1	0.0	0.0
ELECTRICITY	121.0	4042.6	118.7	316.0	106.9	29.7	50.9
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	4032.2	6681.9	357.4	5448.9	4274.7	761.6	164.6

YEAR: 2050

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	MISC.FOSL.	RAW MATL	TOTAL
COAL	18372.6	1693.0	32129.1
GEOTHERMAL	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0
NATURAL GAS	42283.1	6645.0	61846.1
GCFR	0.0	0.0	0.0
HTGR	0.0	0.0	0.0
LFR	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0
LWR	0.0	0.0	0.0
MSBR	0.0	0.0	0.0
MCFR	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0
DISTIL. OIL	1989.4	33987.0	39509.4
RESID. OIL	2606.0	0.0	5473.1
ELECTRICITY	0.0	0.0	27908.7
METHANOL	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0
WIND	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0
TOTAL	65151.1	42325.0	166866.4

YEAR: 2050

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
COAL	0.0	0.0	175.3	34.5	6134.4	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	64.2	1.1	71.3	0.0	1760.3	3702.2	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.3	0.0	0.0	2133.7	468.6	0.0
RESID. OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ELECTRICITY	44.6	0.2	161.0	17.3	640.1	1089.1	21170.7
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	108.9	1.5	407.6	51.8	10668.6	5259.9	21170.7

YEAR: 2050

INDUSTRIAL

AIR POLLUTION (TONS)

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
CO2	0.318302E 09	0.239380E 09	0.145636E 08	0.454635E 09	0.339835E 09	0.446459E 08	0.693699E 07
CO	0.304770E 05	0.584669E 05	0.477494E 02	0.986099E 05	0.331174E 05	0.146380E 03	0.227442E 02
SO2	0.109647E 07	0.918367E 06	0.716242E 02	0.166901E 07	0.117885E 07	0.296306E 07	0.341163E 02
NOX	0.534223E 06	0.502769E 06	0.143248E 05	0.921102E 06	0.571968E 06	0.439140E 05	0.682326E 04
PARTICULATE	0.175003E 07	0.440646E 07	0.392706E 05	0.117205E 09	0.863229E 06	0.329461E 06	0.787594E 06
HYDROCARBON	0.607432E 05	0.511736E 05	0.477495E 04	0.961858E 05	0.647664E 05	0.146380E 05	0.227442E 04
ALDEHYDE	0.980289E 04	0.310610E 04	0.358121E 03	0.859527E 04	0.102475E 05	0.109785E 04	0.170582E 03

YEAR: 2050

INDUSTRIAL

AIR POLLUTION (TONS)

	MISC.FOSL.	RAW MATL	TOTAL
CO2	0.501911E 10	0.0	0.852119E 10
CO	0.707885E 06	0.0	0.171028E 08
SO2	0.125932E 08	0.0	0.318264E 08
NOX	0.837662E 07	0.0	0.152957E 08
PARTICULATE	0.165153E 08	0.0	0.219245E 09
HYDRJCARBJN	0.124029E 07	0.0	0.179516E 07
ALDEHYDE	0.103094E 06	0.0	0.441686E 07

YEAR: 2050

INDUSTRIAL

AIR POLLUTION (TONS)

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
CO2	0.391980E 07	0.913328E 05	0.239836E 08	0.386345E 07	0.178626E 10	0.265663E 09	0.0
CO	0.128485E 02	0.434481E 00	0.665759E 04	0.130736E 04	0.132018E 08	0.296428E 07	0.0
SO2	0.192728E 02	0.943159E 02	0.508701E 07	0.206057E 05	0.520456E 07	0.109516E 07	0.0
NOX	0.385456E 04	0.108314E 03	0.540789E 05	0.980005E 04	0.215567E 07	0.210045E 07	0.0
PARTICULATE	0.292993E 04	0.409585E 03	0.114815E 07	0.664938E 05	0.620023E 08	0.141221E 08	0.0
HYDROCARBON	0.128485E 04	0.247225E 02	0.474841E 06	0.653682E 03	0.174498E 06	0.791047E 05	0.0
ALDEHYDE	0.963640E 02	0.330935E 01	0.272651E 03	0.325979E 02	0.238003E 05	0.425618E 07	0.0

YEAR: 2050

TRANSPORTATION

ENERGY DEMAND: TRILLION BTUS

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	21000.0	0.0	0.0	0.0	0.0	21000.0
JET FUEL	44500.0	0.0	0.0	0.0	0.0	0.0	44500.0
DISTIL. OIL	0.0	0.0	3080.0	6160.0	756.6	9750.0	19746.6
RESID. OIL	0.0	0.0	0.0	0.0	3123.4	0.0	3123.4
ELECTRICITY	0.0	0.0	0.0	1840.0	0.0	0.0	1840.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	44500.0	21000.0	3080.0	8000.0	3880.0	9750.0	90209.9

YEAR: 2050

TRANSPORTATION

AIR POLLUTION (TONS)

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
CO2	0.331525E 10	0.156450E 10	0.261800E 09	0.523600E 09	0.329800E 09	0.828750E 09	0.682369E 10
CO	0.238075E 08	0.819000E 07	0.118580E 07	0.237160E 07	0.293384E 06	0.375375E 07	0.396020E 08
SO2	0.182450E 07	0.420000E 06	0.298760E 06	0.597519E 06	0.130206E 07	0.945750E 06	0.538858E 07
NOX	0.459350E 07	0.965999E 06	0.203280E 07	0.406560E 07	0.916329E 06	0.643500E 07	0.189992E 08
PARTICULATE	0.732025E 07	0.745500E 06	0.144760E 06	0.289520E 06	0.275437E 06	0.458250E 06	0.923371E 07
HYDROCARBON	0.155750E 08	0.987000E 06	0.908600E 06	0.181720E 07	0.254431E 06	0.287625E 07	0.224184E 08
ALDEHYDE	0.467250E 06	0.220500E 06	0.338800E 05	0.677599E 05	0.187547E 05	0.107250E 06	0.915394E 06

YEAR: 2050

TOTAL BASE ENERGY DEMAND

ENERGY DEMAND: TRILLION BTUS

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
COAL	0.0	0.0	32129.1	0.0	32129.1
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	5586.3	8716.9	61846.1	0.0	76149.3
GCFR	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	21000.0	21000.0
JET FUEL	0.0	0.0	0.0	44500.0	44500.0
DISTIL. OIL	2628.5	10145.9	39509.4	19746.6	72030.5
RESID. OIL	1019.9	3999.4	5473.1	3123.4	13615.8
ELECTRICITY	10581.8	17233.0	27908.7	1840.0	57563.5
METHANOL	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0
TOTAL	19816.6	40095.3	166866.4	90209.9	316988.2

YEAR: 2050

AIR POLLUTION (TONS)

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
CO2	0.650878E 09	0.173409E 10	0.852119E 10	0.682369E 10	0.177298E 11
CO	0.121534E 06	0.971536E 05	0.171028E 08	0.396020E 08	0.569234E 08
SO2	0.120079E 07	0.469273E 07	0.318264E 08	0.538858E 07	0.431085E 08
NOX	0.296539E 06	0.243079E 07	0.152957E 08	0.189992E 08	0.370222E 08
PARTICULATE	0.194412E 06	0.937849E 06	0.219245E 09	0.923371E 07	0.229601E 09
HYDROCARBON	0.617479E 05	0.184438E 06	0.179516E 07	0.224184E 08	0.244598E 08
ALDEHYDE	0.542030E 05	0.129993E 06	0.441686E 07	0.915394E 06	0.551645E 07

YEAR: 2050

SUMMARY OF ENERGY DEMANDS

ENERGY DEMAND: TRILLION BTUS

	TTL B.E.D	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	SYN. FUELS	TOTAL
COAL	32129.1	0.0	72.4	96632.0	112933.8	-0.1	241767.3
GEOTHERMAL	0.0	8907.4	0.0	0.0	0.0	0.0	8907.4
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	76149.3	0.0	6910.1	0.0	0.0	-0.1	83059.3
GCFR	0.0	15682.0	0.0	0.0	0.0	0.0	15682.0
HTGR	0.0	7667.6	0.0	0.0	0.0	0.0	7667.6
LFR	0.0	89502.3	0.0	0.0	0.0	0.0	89502.3
LMFBR	0.0	7430.3	0.0	0.0	0.0	0.0	7430.3
LWR	0.0	9602.2	0.0	0.0	0.0	0.0	9602.2
MSBR	0.0	3546.3	0.0	0.0	0.0	0.0	3546.3
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	21000.0	0.0	0.0	0.0	0.0	0.0	21000.0
JET FUEL	44500.0	0.0	0.0	0.0	0.0	0.0	44500.0
DISTIL. OIL	72030.5	0.0	0.0	0.0	0.0	0.0	72030.5
RESID. OIL	13615.8	0.0	2026.0	0.0	0.0	-0.0	15641.8
ELECTRICITY	57563.5	0.0	452.0	0.0	0.0	-0.1	0.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	1560.4	0.0	0.0	0.0	0.0	1560.4
TOTAL	316988.2	143898.3	9460.4	96632.0	112933.8	-0.3	621896.9

YEAR: 2050

AIR POLLUTION (TONS)

	TTL B.E.D.	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	METHANOL	TOTAL
CO2	0.177298E 11	0.0	0.123242E 10	0.257870E 10	0.268428E 10	0.0	0.242252E 11
CO	0.569234E 08	0.0	0.110475E 06	0.0	0.0	0.0	0.570339E 08
SO2	0.431085E 08	0.0	0.191978E 07	0.0	0.0	0.0	0.450283E 08
NOX	0.370222E 08	0.0	0.137399E 07	0.0	0.0	0.0	0.383962E 08
PARTICULATE	0.229601E 09	0.0	0.496837E 06	0.0	0.0	0.0	0.230097E 09
HYDROCARBON	0.244598E 08	0.0	0.315967E 06	0.125571E 09	0.0	0.0	0.150347E 09
ALDEHYDE	0.551645E 07	0.0	0.340202E 05	0.208218E 08	0.283396E 07	0.0	0.292062E 08

YEAR: 2050

SOLID WASTE (TONS)

SYNCRUDE	0.152475E 09
TAR SANDS	0.187185E 05
OIL SHALE	0.129484E 05
SYNGAS	0.251143E 09
TOTAL	0.403649E 09

ELEMENTAL SULFUR PRODUCED (TONS)

SYNCRUDE	0.131719E 09
SYNGAS	0.167535E 09
TOTAL	0.299255E 09

LAND USE BY ENERGY PRODUCTION (ACRES)

COAL (STRIP MINING)	0.158752E 07
TAR SANDS	0.743695E 03
OIL SHALE	0.743695E 05
ELEC. GEN. & TRANS.	0.473338E 08
TOTAL	0.489964E 08

RADIOACTIVE MATERIAL PRODUCTION AND RELEASES

TRITIUM RELEASED	0.248916E 09	CURIES
KRYPTON-85 RELEASED	0.200648E 09	CURIES
LONG-LIVED RAD.WASTE	0.276055E 11	CURIES
LONG LIVED RAD.WASTE	0.480995E 06	CUBIC FEET
POPULATION EXPOSURE	0.705548E 06	MAN-REM

COOLING WATER REQUIREMENTS FOR ENERGY PRODUCTION (ACRE-FEET)

COOLING WATER CONSUMED BY EVAPORATION			0.189970E 08
COOLING WATER USED IN ONCE-THRU CONDENSORS			0.126489E 10
WATER REQUIRED FOR H2 BY ELECTROLYSIS			0.0
	(FEED WATER	0.0)	
	(COOLING TOWER	0.0)	
OIL SHALE WATER REQUIREMENTS			0.259224E 07
TAR SANDS WATER REQUIREMENTS			0.259224E 07
COAL GASIFICATION WATER REQUIREMENTS			0.480503E 07
COAL LIQUEFACTION WATER REQUIREMENTS			0.105121E 07
TOTAL			0.129493E 10

YEAR: 2050

COAL RESOURCE DEMANDS (TRILLION BTU)

TOTAL BED	32129.14
SYNCRUDE	112933.81
SYNGAS	96632.00
METHANOL	0.0
ELEC.GEN.	0.0
PET.REF.	72.36
TOTAL	241767.25

PETROLEUM RESOURCE DEMANDS (TRILLION BTU)

TOTAL PET. DEMAND	161366.81
TAR SANDS REQ.	31931.96
OIL SHALE REQ	31931.96
SYNCRUDE REQ.	79829.88
DOMESTIC CRUDE PROD.	1707.00
CRUDE OIL IMPORTS	15965.97
TOTAL CRUDE PROD.	161366.69

NATURAL GAS RESOURCE DEMANDS (TRILLION BTU)

TOTAL DEMAND	83059.31
CORRECTED DMD.	86212.06
DOM. NAT. GAS	885.00
CANADA P.L.IMP.	0.0
LNG IMPORTS	0.0
SYNGAS	85412.25
TOTAL GAS PRD.	86297.25

NUCLEAR FUEL RESOURCE DEMANDS

SEP.WORK REQ.	0.221706E 08	KGSW
PWR REQ. KGSW	156.08	TRILLION BTU
THORIUM (TH02)	0.417013E 04	TONNES
URANIUM (U308)	0.272856E 05	TONNES

YEAR: 2050

SUMMARY OF RESOURCE REQUIREMENTS

RESOURCE	ANNUAL PROD.	
COAL	241767.25	TRILLION BTU
GEOTHERMAL	8907.44	TRILLION BTU
(HYDROGEN)	0.0	TRILLION BTU
NATURAL GAS	885.00	TRILLION BTU
NUCLEAR-FISSION	43928.40	TRILLION BTU
NUCLEAR-FUSION	89502.25	TRILLION BTU
PETROLEUM	81536.81	TRILLION BTU
(METHANOL)	0.0	TRILLION BTU
SOLAR	0.0	TRILLION BTU
TIDAL	0.0	TRILLION BTU
WIND	0.0	TRILLION BTU
HYDROELECTRIC	1560.36	TRILLION BTU
TOTAL	468087.44	TRILLION BTU

SUMMARY OF BALANCE OF PAYMENTS FOR ENERGY IMPORTS
(MILLIONS OF 1970 DOLLARS)

COST OF CRUDE PETROLEUM IMPORTS	11399.70
COST OF LIQUIFIED NATURAL GAS IMPORTS	0.0
COST OF CANADIAN GAS IMPORTS	0.0
TOTAL BALANCE OF PAYMENTS DEFICIT	11399.70

YEAR: 2060

RESIDENTIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	268.1	0.0	4430.5	1104.2	153.3	0.0	5956.2
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	2745.9	0.0	0.0	0.0	2745.9
RESID. OIL	0.0	0.0	1065.4	0.0	0.0	0.0	1065.4
ELECTRICITY	2738.7	616.9	4212.0	1896.3	563.5	1439.2	11466.6
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	3006.9	616.9	12453.8	3000.5	716.8	1439.2	21234.2

YEAR: 2060

RESIDENTIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.163556E 08	0.0	0.594225E 09	0.673582E 08	0.935362E 07	0.0	0.687292E 09
CO	0.269125E 04	0.0	0.112909E 06	0.110423E 05	0.153338E 04	0.0	0.128166E 06
SO2	0.804374E 02	0.0	0.125400E 07	0.331270E 03	0.460014E 02	0.0	0.125445E 07
NOX	0.670312E 04	0.0	0.274650E 06	0.276058E 05	0.383345E 04	0.0	0.312793E 06
PARTICULATE	0.254718E 04	0.0	0.179298E 06	0.104902E 05	0.145671E 04	0.0	0.193792E 06
HYDROCARBON	0.107250E 04	0.0	0.588845E 05	0.441693E 04	0.613351E 03	0.0	0.649873E 05
ALDEHYDE	0.134062E 04	0.0	0.495942E 05	0.552116E 04	0.766689E 03	0.0	0.572227E 05

YEAR: 2060

COMMERCIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	88.3	0.0	5427.0	1380.9	261.6	3243.5	10401.3
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	8140.5	0.0	0.0	3978.3	12118.8
RESID. OIL	0.0	0.0	3256.2	0.0	0.0	1520.4	4776.6
ELECTRICITY	476.8	1936.1	11516.5	2557.3	323.6	3927.6	20737.9
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	565.1	1936.1	28340.2	3938.2	585.2	12669.8	48034.6

YEAR: 2060

COMMERCIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.538628E 07	0.0	0.129976E 10	0.842375E 08	0.159581E 08	0.665239E 09	0.207059E 10
CO	0.982996E 03	0.0	0.623128E 05	0.138094E 05	0.261608E 04	0.363177E 05	0.115939E 06
SO2	0.264899E 02	0.0	0.378129E 07	0.414283E 03	0.784825E 02	0.182118E 07	0.560499E 07
NOX	0.441498E 04	0.0	0.187828E 07	0.690471E 05	0.130804E 05	0.938019E 06	0.290284E 07
PARTICULATE	0.93984?E 03	0.0	0.741219E 06	0.131189E 05	0.248528E 04	0.362406E 06	0.112007E 07
HYDROCARBON	0.353198E 03	0.0	0.142187E 06	0.552377E 04	0.104643E 04	0.711433E 05	0.220254E 06
ALDEHYDE	0.441498E 03	0.0	0.966221E 05	0.690471E 04	0.130804E 04	0.499392E 05	0.155215E 06

YEAR: 2060

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
COAL	922.3	1850.2	0.0	3109.3	1003.5	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	1747.5	1327.3	287.4	2578.0	1852.6	881.1	136.9
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	388.3	0.0	0.0	492.0	360.2	0.0	0.0
RESID. OIL	1650.4	0.0	0.0	0.0	1801.1	0.0	0.0
ELECTRICITY	145.6	4866.7	142.8	380.5	128.7	35.8	61.2
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	4854.3	8044.2	430.3	6559.8	5146.1	916.9	198.1

YEAR: 2060

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	MISC.FOSL.	RAW MATL	TOTAL
COAL	22118.7	2038.2	38615.6
GEOTHERMAL	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0
NATURAL GAS	50904.4	7999.9	74520.0
GCFR	0.0	0.0	0.0
HTGR	0.0	0.0	0.0
LFR	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0
LWR	0.0	0.0	0.0
MSBR	0.0	0.0	0.0
MCFR	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0
DISTIL. OIL	2274.6	40916.8	47565.1
RESID. OIL	3137.4	0.0	6589.0
ELECTRICITY	0.0	0.0	33599.0
METHANOL	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0
WIND	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0
TOTAL	78435.1	50954.9	200888.6

YEAR: 2060

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
COAL	0.0	0.0	211.0	41.5	7320.9	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	77.3	1.3	85.9	0.0	2183.4	4457.0	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.4	0.0	0.0	2568.7	564.1	0.0
RESID. OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ELECTRICITY	53.7	0.2	193.8	20.8	770.6	1311.2	25487.3
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	131.1	1.8	490.7	62.4	12843.6	6332.3	25487.3

YEAR: 2060

INDUSTRIAL

AIR POLLUTION (TONS)

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
CO2	0.383195E 09	0.288183E 09	0.175327E 08	0.547321E 09	0.409117E 09	0.537479E 08	0.835123E 07
CO	0.366904E 05	0.703865E 05	0.574841E 02	0.118714E 06	0.398691E 05	0.176222E 03	0.273811E 02
SO2	0.132001E 07	0.110559E 07	0.862262E 02	0.200927E 07	0.141918E 07	0.354715E 07	0.410716E 02
NOX	0.643135E 06	0.605268E 06	0.172452E 05	0.110889E 07	0.688575E 06	0.528668E 05	0.821432E 04
PARTICULATE	0.211403E 07	0.530480E 07	0.472767E 05	0.141100E 09	0.103922E 07	0.396629E 06	0.948161E 06
HYDROCARBON	0.731259E 05	0.616064E 05	0.574841E 04	0.115795E 06	0.779703E 05	0.176223E 05	0.273811E 04
ALDEHYDE	0.118014E 05	0.373934E 04	0.431131E 03	0.103476E 05	0.123367E 05	0.132167E 04	0.205358E 03

YEAR: 2060

INDUSTRIAL

AIR POLLUTION (TONS)

	MISC.FOSL.	RAW MATL	TOTAL
CO2	0.604248E 10	0.0	0.102552E 11
CO	0.852219E 06	0.0	0.205871E 08
SO2	0.151608E 08	0.0	0.382769E 08
NOX	0.100846E 08	0.0	0.183999E 08
PARTICULATE	0.193827E 08	0.0	0.263888E 09
HYDROCARBON	0.149318E 07	0.0	0.216124E 07
ALDEHYDE	0.124115E 06	0.0	0.531736E 07

YEAR: 2060

INDUSTRIAL

AIR POLLUTION (TONS)

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
CO2	0.471773E 07	0.109953E 06	0.288731E 08	0.465109E 07	0.214715E 10	0.319823E 09	0.0
CO	0.154680E 02	0.523058E 00	0.801488E 04	0.157389E 04	0.158908E 08	0.356861E 07	0.0
SO2	0.232020E 02	0.113544E 03	0.612410E 07	0.248065E 05	0.622727E 07	0.131843E 07	0.0
NOX	0.464039E 04	0.130396E 03	0.651040E 05	0.117980E 05	0.258075E 07	0.252867E 07	0.0
PARTICULATE	0.352726E 04	0.493087E 03	0.138222E 07	0.800498E 05	0.745879E 08	0.170011E 08	0.0
HYDROCARBON	0.154683E 04	0.297627E 02	0.571647E 04	0.786948E 03	0.210140E 06	0.952317E 05	0.0
ALDEHYDE	0.116010E 03	0.458597E 01	0.328236E 03	0.392435E 02	0.286881E 05	0.512389E 07	0.0

YEAR: 2060

TRANSPORTATION

ENERGY DEMAND: TRILLION BTUS

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	22000.0	0.0	0.0	0.0	0.0	22000.0
JET FUEL	54000.0	0.0	0.0	0.0	0.0	0.0	54000.0
DISTIL. OIL	0.0	0.0	3940.0	8855.0	943.0	10400.0	24138.0
RESID. OIL	0.0	0.0	0.0	0.0	3657.0	0.0	3657.0
ELECTRICITY	0.0	0.0	0.0	2645.0	0.0	0.0	2645.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	54000.0	22000.0	3940.0	11500.0	4600.0	10400.0	106439.8

YEAR: 2060

TRANSPORTATION

AIR POLLUTION (TONS)

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
CO2	0.402300E 10	0.163900E 10	0.334900E 09	0.752674E 09	0.391000E 09	0.884000E 09	0.802456E 10
CO	0.288900E 08	0.858000E 07	0.151690E 07	0.340917E 07	0.365505E 06	0.400400E 07	0.467655E 08
SO2	0.221400E 07	0.440000E 06	0.382180E 06	0.858934E 06	0.153004E 07	0.100880E 07	0.643395E 07
NOX	0.556200E 07	0.101200E 07	0.260040E 07	0.584429E 07	0.111059E 07	0.686400E 07	0.229933E 08
PARTICULATE	0.888300E 07	0.781000E 06	0.185180E 06	0.416185E 06	0.325178E 06	0.488800E 06	0.110793E 08
HYDROCARBON	0.189000E 08	0.103400E 07	0.116230E 07	0.261222E 07	0.314755E 06	0.306800E 07	0.270912E 08
ALDEHYDE	0.567000E 06	0.231000E 06	0.433400E 05	0.974049E 05	0.225874E 05	0.114400E 06	0.107573E 07

YEAR: 2060

TOTAL BASE ENERGY DEMAND

ENERGY DEMAND: TRILLION BTUS

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
COAL	0.0	0.0	38615.6	0.0	38615.6
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	5956.2	10401.3	74520.0	0.0	90877.4
GCFR	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	22000.0	22000.0
JET FUEL	0.0	0.0	0.0	54000.0	54000.0
DISTIL. OIL	2745.9	12118.8	47565.1	24138.0	86567.9
RESID. OIL	1065.4	4776.6	6589.0	3657.0	16088.0
ELECTRICITY	11466.6	20737.9	33599.0	2645.0	68448.4
METHANOL	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0
TOTAL	21234.2	48034.6	200889.6	106439.8	376597.3

YEAR: 2060

AIR POLLUTION (TONS)

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
CO2	0.687292E 09	0.207059E 10	0.102552E 11	0.802456E 10	0.210377E 11
CO	0.128166E 06	0.115939E 06	0.205871E 08	0.467655E 08	0.675967E 08
SO2	0.125445E 07	0.560499E 07	0.382769E 08	0.643395E 07	0.515703E 08
NOX	0.312793E 06	0.290284E 07	0.183999E 08	0.229933E 08	0.446088E 08
PARTICULATE	0.193792E 06	0.112007E 07	0.263888E 09	0.110793E 08	0.276281E 09
HYDROCARBON	0.649873E 05	0.220254E 06	0.216124E 07	0.270912E 08	0.295377E 08
ALDEHYDE	0.572227E 05	0.155215E 06	0.531736E 07	0.107573E 07	0.660553E 07

YEAR: 2060

SUMMARY OF ENERGY DEMANDS

ENERGY DEMAND: TRILLION BTUS

	TTL B.E.D	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	SYN. FUELS	TOTAL
COAL	38615.6	0.0	85.5	116201.5	134228.1	-0.1	289130.7
GEOTHERMAL	0.0	10574.6	0.0	0.0	0.0	0.0	10574.6
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	90877.4	0.0	8167.8	0.0	0.0	0.0	99045.2
GCFR	0.0	9308.5	0.0	0.0	0.0	0.0	9308.5
HTGR	0.0	3641.1	0.0	0.0	0.0	0.0	3641.1
LFR	0.0	127297.0	0.0	0.0	0.0	0.0	127297.0
LMFBR	0.0	4410.5	0.0	0.0	0.0	0.0	4410.5
LWR	0.0	4559.8	0.0	0.0	0.0	0.0	4559.8
MSBR	0.0	1684.0	0.0	0.0	0.0	0.0	1684.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	22000.0	0.0	0.0	0.0	0.0	0.0	22000.0
JET FUEL	54000.0	0.0	0.0	0.0	0.0	0.0	54000.0
DISTIL. OIL	85567.9	0.0	0.0	0.0	0.0	0.0	85567.9
RESID. OIL	16088.0	0.0	2394.7	0.0	0.0	-0.0	18482.7
ELECTRICITY	68448.4	0.0	534.2	0.0	0.0	-1.5	0.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	1559.9	0.0	0.0	0.0	0.0	1559.9
TOTAL	376597.3	163035.3	11182.2	116201.5	134228.1	-1.6	732261.5

YEAR: 2060

AIR POLLUTION (TONS)

	TTL B.E.D.	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	METHANOL	TOTAL
CO2	0.210377E 11	0.0	0.145672E 10	0.310092E 10	0.319042E 10	0.0	0.287857E 11
CO	0.675967E 08	0.0	0.130582E 06	0.0	0.0	0.0	0.677273E 08
SO2	0.515703E 08	0.0	0.226920E 07	0.0	0.0	0.0	0.538394E 08
NOX	0.446088E 08	0.0	0.162406E 07	0.0	0.0	0.0	0.462328E 08
PARTICULATE	0.276281E 09	0.0	0.587264E 06	0.0	0.0	0.0	0.276868E 09
HYDROCARBON	0.295377E 08	0.0	0.373357E 06	0.151002E 09	0.0	0.0	0.180913E 09
ALDEHYDE	0.660553E 07	0.0	0.402120E 05	0.250385E 08	0.336832E 07	0.0	0.350526E 08

YEAR: 2060

SOLID WASTE (TONS)

SYNCRUDE	0.181225E 09
TAR SANDS	0.222490E 05
OIL SHALE	0.153899E 05
SYNGAS	0.302003E 09
TOTAL	0.483265E 09

ELEMENTAL SULFUR PRODUCED (TONS)

SYNCRUDE	0.156556E 09
SYNGAS	0.201464E 09
TOTAL	0.358019E 09

LAND USE BY ENERGY PRODUCTION (ACRES)

COAL (STRIP MINING)	0.189876E 07
TAR SANDS	0.883923E 03
OIL SHALE	0.883923E 05
ELEC. GEN. & TRANS.	0.474682E 08
TOTAL	0.494562E 08

RADIOACTIVE MATERIAL PRODUCTION AND RELEASES

TRITIUM RELEASED	0.119436E 09	CURIES
KRYPTON-85 RELEASED	0.998626E 08	CURIES
LONG-LIVED RAD.WASTE	0.310309E 11	CURIES
LONG LIVED RAD.WASTE	0.531092E 06	CUBIC FEET
POPULATION EXPOSURE	0.788070E 06	MAN-REM

COOLING WATER REQUIREMENTS FOR ENERGY PRODUCTION (ACRE-FEET)

COOLING WATER CONSUMED BY EVAPORATION			0.208693E 08
COOLING WATER USED IN ONCE-THRU CONDENSORS			0.139328E 10
WATER REQUIRED FOR H2 BY ELECTROLYSIS			0.0
	(FEED WATER	0.0)	
	(COOLING TOWER	0.0)	
OIL SHALE WATER REQUIREMENTS			0.309102E 07
TAR SANDS WATER REQUIREMENTS			0.309102E 07
COAL GASIFICATION WATER REQUIREMENTS			0.577812E 07
COAL LIQUEFACTION WATER REQUIREMENTS			0.124942E 07
TOTAL			0.142734E 10

YEAR: 2060

COAL RESOURCE DEMANDS (TRILLION BTU)

TOTAL BED	38615.61
SYNCRUDE	134228.13
SYNGAS	116201.50
METHANOL	0.0
ELEC.GEN.	0.0
PET.REF.	85.53
TOTAL	289130.69

PETROLEUM RESOURCE DEMANDS (TRILLION BTU)

TOTAL PET. DEMAND	190736.50
TAR SANDS REQ.	37952.89
OIL SHALE REQ	37952.89
SYNCRUDE REQ.	94882.25
DOMESTIC CRUDE PROD.	972.00
CRUDE OIL IMPORTS	18976.44
TOTAL CRUDE PROD.	190736.44

NATURAL GAS RESOURCE DEMANDS (TRILLION BTU)

TOTAL DEMAND	99045.19
CORRECTED DMD.	102804.75
DOM. NAT. GAS	435.00
CANADA P.L.IMP.	0.0
LNG IMPORTS	0.0
SYNGAS	102411.56
TOTAL GAS PRD.	102846.56

NUCLEAR FUEL RESOURCE DEMANDS

SEP.WORK REQ.	0.110479E 08	KGSW
PWR REQ. KGSW	77.78	TRILLION BTU
THORIUM (THO2)	0.198025E 04	TONNES
URANIUM (U3O8)	0.129570E 05	TONNES

YEAR: 2060

SUMMARY OF RESOURCE REQUIREMENTS

RESOURCE	ANNUAL PROD.	
COAL	289130.69	TRILLION BTU
GEOTHERMAL	10574.58	TRILLION BTU
(HYDROGEN)	0.0	TRILLION BTU
NATURAL GAS	435.00	TRILLION BTU
NUCLEAR-FISSION	23603.86	TRILLION BTU
NUCLEAR-FUSION	127297.00	TRILLION BTU
PETROLEUM	95854.19	TRILLION BTU
(METHANOL)	0.0	TRILLION BTU
SOLAR	0.0	TRILLION BTU
TIDAL	0.0	TRILLION BTU
WIND	0.0	TRILLION BTU
HYDROELECTRIC	1559.92	TRILLION BTU
TOTAL	548455.13	TRILLION BTU

SUMMARY OF BALANCE OF PAYMENTS FOR ENERGY IMPORTS
(MILLIONS OF 1970 DOLLARS)

COST OF CRUDE PETROLEUM IMPORTS	13549.18
COST OF LIQUIFIED NATURAL GAS IMPORTS	0.0
COST OF CANADIAN GAS IMPORTS	0.0
TOTAL BALANCE OF PAYMENTS DEFICIT	13549.18

YEAR: 2070

RESIDENTIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	290.5	0.0	4744.5	1167.8	159.2	0.0	6362.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	2903.9	0.0	0.0	0.0	2903.9
RESID. OIL	0.0	0.0	1126.7	0.0	0.0	0.0	1126.7
ELECTRICITY	2967.0	668.3	4563.0	2047.8	603.4	1559.1	12408.6
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	3257.4	668.3	13338.2	3215.6	762.6	1559.1	22801.2

YEAR: 2070

RESIDENTIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.177186E 08	0.0	0.632022E 09	0.712340E 08	0.971087E 07	0.0	0.730685E 09
CO	0.290468E 04	0.0	0.119957E 06	0.116777E 05	0.159195E 04	0.0	0.136171E 06
SO2	0.871405E 02	0.0	0.132617E 07	0.350331E 03	0.477583E 02	0.0	0.132665E 07
NOX	0.726171E 04	0.0	0.291931E 06	0.291942E 05	0.397986E 04	0.0	0.332367E 06
PARTICULATE	0.275945E 04	0.0	0.190176E 06	0.110938E 05	0.151235E 04	0.0	0.205542E 06
HYDROCARBON	0.116187E 04	0.0	0.625092E 05	0.467108E 04	0.636778E 03	0.0	0.689788E 05
ALDEHYDE	0.145234E 04	0.0	0.527434E 05	0.583885E 04	0.795972E 03	0.0	0.608305E 05

YEAR: 2070

COMMERCIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	105.1	0.0	6385.6	1622.1	300.7	3860.8	12274.3
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	9578.4	0.0	0.0	4735.5	14313.9
RESID. OIL	0.0	0.0	3831.4	0.0	0.0	1809.7	5641.1
ELECTRICITY	567.6	2304.5	11708.3	3028.0	378.5	4675.1	24662.1
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	672.7	2304.5	33503.7	4650.1	679.2	15081.1	56891.4

YEAR: 2070

COMMERCIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.641140E 07	0.0	0.152935E 10	0.989502E 08	0.183447E 08	0.791847E 09	0.244491E 10
CO	0.105105E 04	0.0	0.733156E 05	0.162213E 05	0.300733E 04	0.432296E 05	0.136829E 06
SO2	0.315314E 02	0.0	0.445156E 07	0.486640E 03	0.902200E 02	0.216779E 07	0.661996E 07
NOX	0.525524E 04	0.0	0.221006E 07	0.811067E 05	0.150367E 05	0.111654E 07	0.342600E 07
PARTICULATE	0.998496E 03	0.0	0.872146E 06	0.154103E 05	0.285697E 04	0.431379E 06	0.132279E 07
HYDROCARBON	0.420419E 03	0.0	0.167303E 06	0.648854E 04	0.120293E 04	0.846832E 05	0.260098E 06
ALDEHYDE	0.525524E 03	0.0	0.113689E 06	0.811067E 04	0.150367E 04	0.594436E 05	0.183273E 06

YEAR: 2070

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
COAL	1097.8	2202.3	0.0	3701.1	1194.5	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	2080.1	1579.9	342.1	3068.7	2205.2	1048.8	163.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	462.3	0.0	0.0	585.6	428.8	0.0	0.0
RESID. OIL	1964.6	0.0	0.0	0.0	2144.0	0.0	0.0
ELECTRICITY	173.3	5793.0	170.0	452.9	153.1	42.6	72.9
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	5778.2	9575.2	512.2	7808.3	6125.6	1091.4	235.8

YEAR: 2070

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	MISC.FOSL.	RAW MATL	TOTAL
COAL	26328.2	2426.1	45934.3
GEOTHERMAL	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0
NATURAL GAS	60592.2	9522.4	88733.0
GCFR	0.0	0.0	0.0
HTGR	0.0	0.0	0.0
LFR	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0
LWR	0.0	0.0	0.0
MSBR	0.0	0.0	0.0
MCFR	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0
DISTIL. OIL	2707.5	48703.8	56617.5
RESID. OIL	3734.5	0.0	7843.0
ELECTRICITY	0.0	0.0	39993.5
METHANOL	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0
WIND	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0
TOTAL	93362.3	60652.3	239121.1

YEAR: 2070

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
COAL	0.0	0.0	251.2	49.4	8683.6	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	92.1	1.5	102.2	0.0	2629.6	5305.3	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.4	0.0	0.0	3057.6	671.5	0.0
RESID. OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ELECTRICITY	64.0	0.2	230.7	24.8	917.3	1560.7	30337.9
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	156.0	2.2	584.2	74.2	15288.1	7537.5	30337.9

YEAR: 2070

INDUSTRIAL

AIR POLLUTION (TONS)

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
CO2	0.456127E 09	0.343032E 09	0.208696E 08	0.651493E 09	0.486984E 09	0.639776E 08	0.994071E 07
CO	0.436736E 05	0.837831E 05	0.684249E 02	0.141308E 06	0.474573E 05	0.209763E 03	0.325924E 02
SO2	0.157124E 07	0.131602E 07	0.102637E 03	0.239170E 07	0.168929E 07	0.424608E 07	0.498887E 02
NOX	0.765542E 06	0.720469E 06	0.205275E 05	0.131994E 07	0.819631E 06	0.629288E 05	0.977774E 04
PARTICULATE	0.251639E 07	0.631446E 07	0.562749E 05	0.167955E 09	0.123701E 07	0.472119E 06	0.112862E 07
HYDROCARBON	0.870449E 05	0.733319E 05	0.684250E 04	0.137834E 06	0.928102E 05	0.209763E 05	0.325925E 04
ALDEHYDE	0.140476E 05	0.445104E 04	0.513187E 03	0.123170E 05	0.146847E 05	0.157322E 04	0.244444E 03

YEAR: 2070

INDUSTRIAL

AIR POLLUTION (TONS)

	MISC.FOSL.	RAW MATL	TOTAL
CO2	0.719244E 10	0.0	0.122055E 11
CO	0.101441E 07	0.0	0.245042E 08
SO2	0.180461E 08	0.0	0.455436E 08
NOX	0.120038E 08	0.0	0.218948E 08
PARTICULATE	0.236656E 08	0.0	0.314086E 09
HYDROCARBON	0.177735E 07	0.0	0.257259E 07
ALDEHYDE	0.147736E 06	0.0	0.632943E 07

YEAR: 2070

INDUSTRIAL

AIR POLLUTION (TONS)

	MISC.FOSL.	RAW MATL	TOTAL
CO2	0.719244E 10	0.0	0.122055E 11
CO	0.101441E 07	0.0	0.245042E 08
SO2	0.180461E 08	0.0	0.455436E 08
NOX	0.120038E 08	0.0	0.218948E 08
PARTICULATE	0.236656E 08	0.0	0.314086E 09
HYDROCARBON	0.177735E 07	0.0	0.257259E 07
ALDEHYDE	0.147736E 06	0.0	0.632943E 07

YEAR: 2070

INDUSTRIAL

AIR POLLUTION (TONS)

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
CO2	0.561555E 07	0.130880E 06	0.343685E 08	0.553633E 07	0.255426E 10	0.380695E 09	0.0
CO	0.184120E 02	0.622611E 00	0.954033E 04	0.187345E 04	0.189141E 09	0.424782E 07	0.0
SO2	0.276180E 02	0.135155E 03	0.728969E 07	0.295279E 05	0.739424E 07	0.156937E 07	0.0
NOX	0.552359E 04	0.155214E 03	0.774951E 05	0.140435E 05	0.306509E 07	0.300995E 07	0.0
PARTICULATE	0.419860E 04	0.586935E 03	0.164530E 07	0.952857E 05	0.887581E 08	0.202369E 08	0.0
HYDROCARBON	0.184120E 04	0.354275E 02	0.680447E 04	0.936727E 03	0.250168E 06	0.113357E 06	0.0
ALDEHYDE	0.138090E 03	0.545881E 01	0.390709E 03	0.467128E 02	0.341653E 05	0.609912E 07	0.0

YEAR: 2070

TRANSPORTATION

ENERGY DEMAND: TRILLION BTUS

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	23000.0	0.0	0.0	0.0	0.0	23000.0
JET FUEL	66000.0	0.0	0.0	0.0	0.0	0.0	66000.0
DISTIL. OIL	0.0	0.0	5000.0	12320.0	1161.0	11000.0	29481.0
RESID. OIL	0.0	0.0	0.0	0.0	4239.0	0.0	4239.0
ELECTRICITY	0.0	0.0	0.0	3680.0	0.0	0.0	3680.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	66000.0	23000.0	5000.0	16000.0	5400.0	11000.0	126399.8

YEAR: 2070

TRANSPORTATION

AIR POLLUTION (TONS)

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
CO2	0.491700E 10	0.171350E 10	0.425000E 09	0.104720E 10	0.459000E 09	0.935000E 09	0.949668E 10
CO	0.353100E 08	0.897000E 07	0.192500E 07	0.474320E 07	0.449825E 06	0.423500E 07	0.956329E 08
SO2	0.270600E 07	0.460000E 06	0.485000E 06	0.119504E 07	0.178013E 07	0.106700E 07	0.769316E 07
NOX	0.679800E 07	0.105800E 07	0.330000E 07	0.813120E 07	0.133217E 07	0.726000E 07	0.278793E 08
PARTICULATE	0.108570E 08	0.816500E 06	0.235000E 06	0.579040E 06	0.380122E 06	0.517000E 06	0.133847E 08
HYDROCARBON	0.231000E 08	0.108100E 07	0.147500E 07	0.363440E 07	0.384885E 06	0.324500E 07	0.329202E 08
ALDEHYDE	0.693000E 06	0.241500E 06	0.550000E 05	0.135520E 06	0.269292E 05	0.121000E 06	0.127295E 07

YEAR: 2070

TOTAL BASE ENERGY DEMAND

ENERGY DEMAND: TRILLION BTUS

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
COAL	0.0	0.0	45934.3	0.0	45934.3
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	6362.0	12274.3	88733.0	0.0	107369.3
GCFR	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	23000.0	23000.0
JET FUEL	0.0	0.0	0.0	66000.0	66000.0
DISTIL. OIL	2903.9	14313.9	56617.5	29481.0	103316.2
RESID. OIL	1126.7	5641.1	7843.0	4239.0	18849.8
ELECTRICITY	12408.6	24662.1	39993.5	3680.0	80744.1
METHANOL	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0
TOTAL	22801.2	56891.4	239121.1	126399.8	445213.6

YEAR: 2070

AIR POLLUTION (TONS)

	TTL B.E.O.	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	METHANOL	TOTAL
CO2	0.248777E 11	0.0	0.172180E 10	0.367108E 10	0.378103E 10	0.0	0.340517E 11
CO	0.804102E 08	0.0	0.154344E 06	0.0	0.0	0.0	0.805645E 08
SO2	0.611833E 08	0.0	0.268212E 07	0.0	0.0	0.0	0.638654E 08
NOX	0.535345E 08	0.0	0.191959E 07	0.0	0.0	0.0	0.554541E 08
PARTICULATE	0.329999E 09	0.0	0.694130E 06	0.0	0.0	0.0	0.329693E 09
HYDROCARBON	0.358219E 08	0.0	0.441298E 06	0.178766E 09	0.0	0.0	0.215029E 09
ALDEHYDE	0.784648E 07	0.0	0.475295E 05	0.296423E 08	0.399187E 07	0.0	0.415281E 08

YEAR: 2070

SUMMARY OF ENERGY DEMANDS

ENERGY DEMAND: TRILLION BTUS

	TTL B.E.D	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	SYN. FUELS	TOTAL
COAL	45934.3	0.0	101.1	137567.1	159076.8	-0.1	342679.2
GEOTHERMAL	0.0	12471.0	0.0	0.0	0.0	0.0	12471.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	107369.3	0.0	9654.0	0.0	0.0	-0.1	117023.3
GCFR	0.0	5488.9	0.0	0.0	0.0	0.0	5488.9
HTGR	0.0	3220.5	0.0	0.0	0.0	0.0	3220.5
LFR	0.0	160087.3	0.0	0.0	0.0	0.0	160087.3
LMFBR	0.0	2080.6	0.0	0.0	0.0	0.0	2080.6
LWR	0.0	4033.1	0.0	0.0	0.0	0.0	4033.1
MSBR	0.0	993.0	0.0	0.0	0.0	0.0	993.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	23000.0	0.0	0.0	0.0	0.0	0.0	23000.0
JET FUEL	66000.0	0.0	0.0	0.0	0.0	0.0	66000.0
DISTIL. OIL	103316.2	0.0	0.0	0.0	0.0	0.0	103316.2
RESID. OIL	18849.8	0.0	2830.5	0.0	0.0	-0.0	21680.3
ELECTRICITY	80744.1	0.0	631.5	0.0	0.0	-1.6	0.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	1494.7	0.0	0.0	0.0	0.0	1494.7
TOTAL	445213.6	189868.9	13217.1	137567.1	159076.8	-1.7	863567.7

YEAR: 2070

AIR POLLUTION (TONS)

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
CO2	0.730685E 09	0.244491E 10	0.122055E 11	0.949668E 10	0.248777E 11
CO	0.136171E 06	0.136829E 06	0.245042E 08	0.556329E 08	0.804102E 08
SO2	0.132665E 07	0.661996E 07	0.455436E 08	0.769316E 07	0.611833E 08
NOX	0.332367E 06	0.342800E 07	0.218948E 08	0.278793E 08	0.535345E 08
PARTICULATE	0.205542E 06	0.132279E 07	0.314086E 09	0.133847E 08	0.328999E 09
HYDROCARBON	0.689789E 05	0.260098E 06	0.257259E 07	0.329202E 08	0.358219E 08
ALDEHYDE	0.608305E 05	0.183273E 06	0.632943E 07	0.127295E 07	0.784648E 07

YEAR: 2070

COAL RESOURCE DEMANDS (TRILLION BTU)

TOTAL BED	45934.30
SYNCRUDE	159076.75
SYNGAS	137567.13
METHANOL	0.0
ELEC.GEN.	0.0
PET.REF.	101.09
TOTAL	342679.19

PETROLEUM RESOURCE DEMANDS (TRILLION BTU)

TOTAL PET. DEMAND	225445.13
TAR SANDS REQ.	44978.82
OIL SHALE REQ	44978.82
SYNCRUDE REQ.	112447.06
DOMESTIC CRUDE PROD.	551.00
CRUDE OIL IMPORTS	22489.40
TOTAL CRUDE PROD.	225445.06

NATURAL GAS RESOURCE DEMANDS (TRILLION BTU)

TOTAL DEMAND	117023.25
CORRECTED DMD.	121465.19
DOM. NAT. GAS	212.00
CANADA P.L.IMP.	0.0
LNG IMPORTS	0.0
SYNGAS	121273.56
TOTAL GAS PRD.	121485.56

NUCLEAR FUEL RESOURCE DEMANDS

SEP.WORK REQ.	0.988624E 07	KGSW
PWR REQ. KGSW	69.60	TRILLION BTU
THORIUM (THO2)	0.154449E 04	TONNES
URANIUM (U3O8)	0.114604E 05	TONNES

YEAR: 2070

SUMMARY OF RESOURCE REQUIREMENTS

RESOURCE	ANNUAL PROD.	
COAL	342679.19	TRILLION BTU
GEOTHERMAL	12470.96	TRILLION BTU
(HYDROGEN)	0.0	TRILLION BTU
NATURAL GAS	212.00	TRILLION BTU
NUCLEAR-FISSION	15816.14	TRILLION BTU
NUCLEAR-FUSION	160087.31	TRILLION BTU
PETROLEUM	112998.00	TRILLION BTU
(METHANOL)	0.0	TRILLION BTU
SOLAR	0.0	TRILLION BTU
TIDAL	0.0	TRILLION BTU
WIND	0.0	TRILLION BTU
HYDROELECTRIC	1494.72	TRILLION BTU
TOTAL	645758.25	TRILLION BTU

SUMMARY OF BALANCE OF PAYMENTS FOR ENERGY IMPORTS
(MILLIONS OF 1970 DOLLARS)

COST OF CRUDE PETROLEUM IMPORTS	16057.43
COST OF LIQUIFIED NATURAL GAS IMPORTS	0.0
COST OF CANADIAN GAS IMPORTS	0.0
TOTAL BALANCE OF PAYMENTS DEFICIT	16057.43

YEAR: 2080

RESIDENTIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	306.9	0.0	4955.2	1207.8	146.8	0.0	6616.6
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	2996.4	0.0	0.0	0.0	2996.4
RESID. OIL	0.0	0.0	1162.6	0.0	0.0	0.0	1162.6
ELECTRICITY	3134.3	706.0	4820.4	2156.5	637.2	1647.0	13101.5
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	3441.2	706.0	13934.6	3364.3	784.0	1647.0	23877.1

YEAR: 2080

RESIDENTIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.187181E 08	0.0	0.655783E 09	0.736736E 08	0.895302E 07	0.0	0.757127E 09
CO	0.306854E 04	0.0	0.124414E 06	0.120776E 05	0.146771E 04	0.0	0.141028E 06
SO2	0.920562E 02	0.0	0.136841E 07	0.362329E 03	0.440312E 02	0.0	0.136891E 07
NOX	0.767135E 04	0.0	0.302717E 06	0.301941E 04	0.366927E 04	0.0	0.344252E 06
PARTICULATE	0.291511E 04	0.0	0.156798E 06	0.114738E 05	0.139432E 04	0.0	0.212581E 06
HYDROCARBON	0.122742E 04	0.0	0.647380E 05	0.483105E 04	0.587083E 03	0.0	0.713835E 05
ALDEHYDE	0.153427E 04	0.0	0.547209E 05	0.603882E 04	0.733854E 03	0.0	0.630278E 05

YEAR: 2080

COMMERCIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	123.9	0.0	7442.2	1887.4	345.1	4551.3	14349.9
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	11163.3	0.0	0.0	5582.4	16745.7
RESID. OIL	0.0	0.0	4465.3	0.0	0.0	2133.4	6598.7
ELECTRICITY	669.1	2716.7	16160.2	3569.6	441.1	5511.3	29068.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	793.0	2716.7	39230.9	5457.0	786.2	17778.4	66762.2

YEAR: 2080

COMMERCIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.755811E 07	0.0	0.178240E 10	0.115133E 09	0.210491E 08	0.933474E 09	0.285961E 10
CO	0.123903E 04	0.0	0.854509E 05	0.188743E 05	0.345068E 04	0.509615E 05	0.159976E 06
SO2	0.371710E 02	0.0	0.518812E 07	0.566229E 03	0.103520E 03	0.255552E 07	0.774434E 07
NOX	0.619517E 04	0.0	0.257573E 07	0.943714E 05	0.172534E 05	0.131624E 07	0.400980E 07
PARTICULATE	0.117708E 04	0.0	0.101645E 07	0.179306E 05	0.327814E 04	0.508534E 06	0.154737E 07
HYDROCARBON	0.495614E 03	0.0	0.194985E 06	0.754971E 04	0.138027E 04	0.998294E 05	0.304240E 06
ALDEHYDE	0.619517E 03	0.0	0.132500E 06	0.943714E 04	0.172534E 04	0.700754E 05	0.214358E 06

YEAR: 2080

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
COAL	1294.2	2596.2	0.0	4363.1	1408.1	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	2452.2	1862.5	403.3	3617.5	2599.6	1236.4	192.1
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	544.9	0.0	0.0	690.4	505.5	0.0	0.0
RESID. OIL	2316.0	0.0	0.0	0.0	2527.4	0.0	0.0
ELECTRICITY	204.3	6829.2	200.5	533.9	180.5	50.2	85.9
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	6811.6	11287.9	603.8	9204.9	7221.2	1286.6	278.0

YEAR: 2080

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	MISC.FOSL.	RAW MATL	TOTAL
COAL	31037.3	2860.0	54096.1
GEOTHERMAL	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0
NATURAL GAS	71429.8	11225.6	104658.0
GCFR	0.0	0.0	0.0
HTGR	0.0	0.0	0.0
LFR	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0
LWR	0.0	0.0	0.0
MSBR	0.0	0.0	0.0
MCFR	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0
DISTIL. OIL	3191.8	57415.0	66744.1
RESID. OIL	4402.5	0.0	9245.8
ELECTRICITY	0.0	0.0	47146.8
METHANOL	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0
WIND	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0
TOTAL	110061.3	71500.6	281890.8

YEAR: 2080

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
COAL	0.0	0.0	296.1	58.3	10182.7	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	108.5	1.8	120.5	0.0	3153.9	6254.2	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.5	0.0	0.0	3604.5	791.6	0.0
RESID. OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ELECTRICITY	75.4	0.3	272.0	29.2	1081.4	1839.9	35764.2
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	183.9	2.6	688.6	87.5	18022.5	8885.6	35764.2

YEAR: 2080

INDUSTRIAL

AIR POLLUTION (TONS)

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
CO2	0.537710E 09	0.404387E 09	0.246024E 08	0.768019E 09	0.574086E 09	0.754207E 08	0.117187E 08
CO	0.514953E 05	0.987686E 05	0.806635E 02	0.166583E 06	0.559456E 05	0.247281E 03	0.384220E 02
SO2	0.185227E 07	0.155140E 07	0.120995E 03	0.281948E 07	0.199144E 07	0.500553E 07	0.576330E 02
NOX	0.902467E 06	0.849332E 06	0.241990E 05	0.155602E 07	0.966230E 06	0.741843E 05	0.115266E 05
PARTICULATE	0.296647E 07	0.744386E 07	0.663402E 05	0.197996E 09	0.145826E 07	0.556562E 06	0.133049E 07
HYDROCARBON	0.102614E 06	0.864480E 05	0.806634E 04	0.162487E 06	0.109410E 06	0.247281E 05	0.384220E 04
ALDEHYDE	0.165601E 05	0.524716E 04	0.604976E 03	0.145201E 05	0.173112E 05	0.185461E 04	0.288165E 03

YEAR: 2080

INDUSTRIAL

AIR POLLUTION (TONS)

	MISC.FOSL.	RAW MATL	TOTAL
CO2	0.847890E 10	0.0	0.143858E 11
CO	0.119584E 07	0.0	0.288850E 08
SO2	0.212739E 08	0.0	0.536572E 08
NOX	0.141508E 08	0.0	0.257989E 08
PARTICULATE	0.278997E 08	0.0	0.370218E 09
HYDROCARBON	0.209525E 07	0.0	0.303278E 07
ALDEHYDE	0.174160E 06	0.0	0.746154E 07

YEAR: 2080

INDUSTRIAL

AIR POLLUTION (TONS)

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
CO2	0.662007E 07	0.154289E 06	0.405156E 08	0.652655E 07	0.300836E 10	0.448786E 09	0.0
CO	0.217051E 02	0.733972E 00	0.112467E 05	0.220854E 04	0.222950E 08	0.500758E 07	0.0
SO2	0.325577E 02	0.159329E 03	0.859353E 07	0.348093E 05	0.868450E 07	0.185096E 07	0.0
NOX	0.651154E 04	0.182976E 03	0.913559E 05	0.165553E 05	0.360120E 07	0.354831E 07	0.0
PARTICULATE	0.494955E 04	0.691915E 03	0.193958E 07	0.112328E 06	0.104587E 09	0.238565E 08	0.0
HYDROCARBON	0.217051E 04	0.417640E 02	0.802152E 04	0.110427E 04	0.294970E 06	0.133632E 06	0.0
ALDEHYDE	0.162789E 03	0.643517E 01	0.460591E 03	0.550678E 02	0.403061E 05	0.719001E 07	0.0

YEAR: 2080

TRANSPORTATION

ENERGY DEMAND: TRILLION BTUS

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	24000.0	0.0	0.0	0.0	0.0	24000.0
JET FUEL	80000.0	0.0	0.0	0.0	0.0	0.0	80000.0
DISTIL. OIL	0.0	0.0	6250.0	19096.0	1408.0	11600.0	38354.0
RESID. OIL	0.0	0.0	0.0	0.0	4992.0	0.0	4992.0
ELECTRICITY	0.0	0.0	0.0	5704.0	0.0	0.0	5704.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	80000.0	24000.0	6250.0	24800.0	6400.0	11600.0	153049.8

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TRANSPORTATION

AIR POLLUTION (TONS)

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
CO2	0.596000E 10	0.178800E 10	0.531250E 09	0.162316E 10	0.543999E 09	0.986000E 09	0.114324E 11
CO	0.428000E 08	0.936000E 07	0.240625E 07	0.735196E 07	0.545424E 06	0.446600E 07	0.669296E 08
SO2	0.328000E 07	0.480000E 06	0.606250E 06	0.185231E 07	0.210030E 07	0.112520E 07	0.944406E 07
NOX	0.824000E 07	0.110400E 07	0.412500E 07	0.126034E 08	0.159571E 07	0.765600E 07	0.353240E 08
PARTICULATE	0.131600E 08	0.852000E 06	0.293750E 06	0.897512E 06	0.449561E 06	0.545200E 06	0.161980E 08
HYDROCARBON	0.280000E 08	0.112800E 07	0.184375E 07	0.563332E 07	0.465280E 06	0.342200E 07	0.404923E 08
ALDEHYDE	0.940000E 06	0.252000E 06	0.687499E 05	0.210056E 06	0.321612E 05	0.127600E 06	0.153056E 07

YEAR: 2080

TOTAL BASE ENERGY DEMAND

ENERGY DEMAND: TRILLION BTUS

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
COAL	0.0	0.0	54096.1	0.0	54096.1
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	5616.6	14349.9	104658.0	0.0	125624.4
GCFR	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	24000.0	24000.0
JET FUEL	0.0	0.0	0.0	80000.0	80000.0
DISTIL. OIL	2996.4	16745.7	66744.1	38354.0	124840.1
RESID. OIL	1162.6	6598.7	9245.8	4992.0	21999.1
ELECTRICITY	13101.5	29068.0	47146.8	5704.0	95020.2
METHANOL	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0
TOTAL	23877.1	66762.2	281890.8	153049.8	525579.9

YEAR: 2080

AIR POLLUTION (TONS)

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
CO2	0.757127E 09	0.285961E 10	0.143858E 11	0.114324E 11	0.294349E 11
CO	0.141028E 06	0.159976E 06	0.288850E 08	0.669296E 08	0.961156E 08
SO2	0.136891E 07	0.774434E 07	0.536572E 08	0.944406E 07	0.722145E 08
NOX	0.344252E 06	0.400990E 07	0.257989E 08	0.353240E 08	0.654769E 08
PARTICULATE	0.212581E 06	0.154737E 07	0.370218E 09	0.161980E 08	0.388176E 09
HYDROCARBON	0.713835E 05	0.304240E 06	0.303278E 07	0.404923E 08	0.439007E 08
ALDEHYDE	0.630278E 05	0.214358E 06	0.746154E 07	0.153056E 07	0.926949E 07

YEAR: 2080

SUMMARY OF ENERGY DEMANDS

ENERGY DEMAND: TRILLION BTUS

	TTL B.E.D	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	SYN. FUELS	TOTAL
COAL	54096.1	0.0	120.1	160545.6	189205.8	-0.1	403967.5
GEOTHERMAL	0.0	14670.9	0.0	0.0	0.0	0.0	14670.9
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	125624.4	0.0	11467.8	0.0	0.0	-0.1	137092.3
GCFR	0.0	3357.8	0.0	0.0	0.0	0.0	3357.8
HTGR	0.0	2020.6	0.0	0.0	0.0	0.0	2020.6
LFR	0.0	196345.8	0.0	0.0	0.0	0.0	196345.8
LMFBR	0.0	1223.8	0.0	0.0	0.0	0.0	1223.8
LWR	0.0	1897.8	0.0	0.0	0.0	0.0	1897.8
MSBR	0.0	467.3	0.0	0.0	0.0	0.0	467.3
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	24000.0	0.0	0.0	0.0	0.0	0.0	24000.0
JET FUEL	80000.0	0.0	0.0	0.0	0.0	0.0	80000.0
DISTIL. OIL	124840.1	0.0	0.0	0.0	0.0	0.0	124840.1
RESID. OIL	21999.1	0.0	3362.3	0.0	0.0	0.0	25361.4
ELECTRICITY	95020.2	0.0	750.1	0.0	0.0	-1.4	0.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	1487.9	0.0	0.0	0.0	0.0	1487.9
TOTAL	525579.9	221471.7	15700.3	160545.6	189205.8	-1.6	1016732.1

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AIR POLLUTION (TONS)

	TTL R.E.D.	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	METHANOL	TOTAL
CO2	0.294349E 11	0.0	0.204529E 10	0.428428E 10	0.449716E 10	0.0	0.402617E 11
CO	0.961156E 08	0.0	0.183342E 06	0.0	0.0	0.0	0.962989E 08
SO2	0.722145E 08	0.0	0.318604E 07	0.0	0.0	0.0	0.754006E 08
NOX	0.654769E 08	0.0	0.228024E 07	0.0	0.0	0.0	0.677572E 08
PARTICULATE	0.398176E 09	0.0	0.824541E 06	0.0	0.0	0.0	0.389000E 09
HYDROCARBON	0.439007E 08	0.0	0.524208E 06	0.208626E 09	0.0	0.0	0.253051E 09
ALDEHYDE	0.926949E 07	0.0	0.564592E 05	0.345936E 08	0.474793E 07	0.0	0.486674E 08

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SOLID WASTE (TONS)

SYNCRUDE	0.255452E 09
TAR SANDS	0.313604E 05
OIL SHALE	0.216934E 05
SYNGAS	0.417252E 09
TOTAL	0.672756E 09

ELEMENTAL SULFUR PRODUCED (TONS)

SYNCRUDE	0.220678E 09
SYNGAS	0.278345E 09
TOTAL	0.499023E 09

LAND USE BY ENERGY PRODUCTION (ACRES)

COAL (STRIP MINING)	0.265243E 07
TAR SANDS	0.124596E 04
OIL SHALE	0.124596E 06
ELEC. GEN. & TRANS.	0.457092E 08
TOTAL	0.484874E 08

RADIOACTIVE MATERIAL PRODUCTION AND RELEASES

TRITIUM RELEASED	0.339094E 08	CURIES
KRYPTON-85 RELEASED	0.419059E 08	CURIES
LONG-LIVED RAD.WASTE	0.412394E 11	CURIES
LONG LIVED RAD.WASTE	0.698889E 06	CUBIC FEET
POPULATION EXPOSURE	0.104372E 07	MAN-REM

COOLING WATER REQUIREMENTS FOR ENERGY PRODUCTION (ACRE-FEET)

COOLING WATER CONSUMED BY EVAPORATION			0.278437E 08
COOLING WATER USED IN ONCE-THRU CONDENSORS			0.186156E 10
WATER REQUIRED FOR H2 BY ELECTROLYSIS			0.0
(FEED WATER	0.0	)	
(COOLING TOWER	0.0	)	
OIL SHALE WATER REQUIREMENTS			0.434295E 07
TAR SANDS WATER REQUIREMENTS			0.434295E 07
COAL GASIFICATION WATER REQUIREMENTS			0.798313E 07
COAL LIQUEFACTION WATER REQUIREMENTS			0.176116E 07
TOTAL			0.190783E 10

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COAL RESOURCE DEMANDS (TRILLION BTU)

TOTAL BED	54096.12
SYNCRUDE	189205.81
SYNGAS	160545.56
METHANOL	0.0
ELEC.GEN.	0.0
PET.REF.	120.08
TOTAL	403967.50

PETROLEUM RESOURCE DEMANDS (TRILLION BTU)

TOTAL PET. DEMAND	267801.06
TAR SANDS REQ.	53497.81
OIL SHALE REQ	53497.81
SYNCRUDE REQ.	133744.50
DOMESTIC CRUDE PROD.	312.00
CRUDE OIL IMPORTS	26748.89
TOTAL CRUDE PROD.	267800.94

NATURAL GAS RESOURCE DEMANDS (TRILLION BTU)

TOTAL DEMAND	137092.25
CORRECTED DMD.	142296.00
DOM. NAT. GAS	103.00
CANADA P.L.IMP.	0.0
LNG IMPORTS	0.0
SYNGAS	142202.81
TOTAL GAS PRD.	142305.81

NUCLEAR FUEL RESOURCE DEMANDS

SEP.WORK REQ.	0.592890E 07	KGSW
PWR REQ. KGSW	41.74	TRILLION BTU
THORIUM (TH02)	0.904086E 03	TONNES
URANIUM (U308)	0.621625E 04	TONNES

YEAR: 2080

SUMMARY OF RESOURCE REQUIREMENTS

RESOURCE	ANNUAL PROD.	
COAL	403967.50	TRILLION BTU
GEOTHERMAL	14670.89	TRILLION BTU
(HYDROGEN)	0.0	TRILLION BTU
NATURAL GAS	103.00	TRILLION BTU
NUCLEAR-FISSION	9967.25	TRILLION BTU
NUCLEAR-FUSION	196345.75	TRILLION BTU
PETROLEUM	134056.44	TRILLION BTU
(METHANOL)	0.0	TRILLION BTU
SOLAR	0.0	TRILLION BTU
TIDAL	0.0	TRILLION BTU
WIND	0.0	TRILLION BTU
HYDROELECTRIC	1487.88	TRILLION BTU
TOTAL	759598.63	TRILLION BTU

SUMMARY OF BALANCE OF PAYMENTS FOR ENERGY IMPORTS
(MILLIONS OF 1970 DOLLARS)

COST OF CRUDE PETROLEUM IMPORTS	19098.71
COST OF LIQUIFIED NATURAL GAS IMPORTS	0.0
COST OF CANADIAN GAS IMPORTS	0.0
TOTAL BALANCE OF PAYMENTS DEFICIT	19098.71

YEAR: 2090

RESIDENTIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	318.8	0.0	5039.8	1223.3	148.5	0.0	6780.4
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	3042.0	0.0	0.0	0.0	3042.0
RESID. OIL	0.0	0.0	1180.3	0.0	0.0	0.0	1180.3
ELECTRICITY	3256.1	733.4	5057.6	2235.5	650.8	1711.0	13594.5
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	3574.8	733.4	14319.7	3458.8	799.3	1711.0	24597.2

YEAR: 2090

RESIDENTIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.194450E 08	0.0	0.669376E 09	0.746213E 08	0.905913E 07	0.0	0.772501E 09
CO	0.318770E 04	0.0	0.126900E 06	0.122330E 05	0.148510E 04	0.0	0.143806E 06
SO2	0.956311E 02	0.0	0.139927E 07	0.366990E 03	0.445531E 02	0.0	0.138977E 07
NOX	0.796926E 04	0.0	0.308805E 06	0.305825E 05	0.371276E 04	0.0	0.351070E 06
PARTICULATE	0.302032E 04	0.0	0.200357E 06	0.116214E 05	0.141085E 04	0.0	0.216417E 06
HYDROCARBON	0.127508E 04	0.0	0.659603E 05	0.489320E 04	0.594041E 03	0.0	0.727225E 05
ALDEHYDE	0.159385E 04	0.0	0.558498E 05	0.611650E 04	0.742551E 03	0.0	0.643027E 05

YEAR: 2090

COMMERCIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	142.8	0.0	8483.5	2120.9	382.5	5247.1	16376.8
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	12725.3	0.0	0.0	6435.9	19161.1
RESID. OIL	0.0	0.0	5090.1	0.0	0.0	2459.6	7549.7
ELECTRICITY	771.4	3132.1	18630.7	4115.3	502.9	6353.9	33506.1
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	914.2	3132.1	44929.5	6236.1	885.4	20496.3	76593.6

YEAR: 2090

COMMERCIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.971358E 07	0.0	0.203188E 10	0.129374E 09	0.233337E 08	0.107618E 10	0.326940E 10
CO	0.142945E 04	0.0	0.974075E 05	0.212089E 05	0.382520E 04	0.587524E 05	0.182622E 06
SO2	0.428536E 02	0.0	0.591406E 07	0.636266E 03	0.114756E 03	0.294620E 07	0.886104E 07
NOX	0.714227E 04	0.0	0.293614E 07	0.106044E 06	0.191260E 05	0.151747E 07	0.458592E 07
PARTICULATE	0.135703E 04	0.0	0.115868E 07	0.201484E 05	0.363394E 04	0.586277E 06	0.177009E 07
HYDROCARBON	0.571381E 03	0.0	0.222268E 06	0.848354E 04	0.153008E 04	0.115091E 06	0.347944E 06
ALDEHYDE	0.714227E 03	0.0	0.151040E 06	0.106044E 05	0.191260E 04	0.807883E 05	0.245060E 06

YEAR: 2090

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
COAL	1492.1	2993.1	0.0	5030.1	1623.4	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	2827.1	2147.2	465.0	4170.6	2997.1	1425.4	221.5
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	528.2	0.0	0.0	795.9	582.8	0.0	0.0
RESID. OIL	2670.0	0.0	0.0	0.0	2913.8	0.0	0.0
ELECTRICITY	235.6	7873.2	231.1	615.5	208.1	57.8	99.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	7853.0	13013.5	696.1	10612.1	8325.2	1483.3	320.5

YEAR: 2090

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	MISC.FOSL.	RAW MATL	TOTAL
COAL	35782.2	3297.3	62303.9
GEOTHERMAL	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0
NATURAL GAS	82349.8	12941.7	120720.1
GCFR	0.0	0.0	0.0
HTGR	0.0	0.0	0.0
LFR	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0
LWR	0.0	0.0	0.0
MSBR	0.0	0.0	0.0
MCFR	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0
DISTIL. OIL	3679.7	66192.4	76947.8
RESID. OIL	5075.5	0.0	10659.3
ELECTRICITY	0.0	0.0	54354.4
METHANOL	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0
WIND	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0
TOTAL	126887.1	82431.4	324985.4

YEAR: 2090

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
COAL	0.0	0.0	341.4	67.2	11677.1	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	125.1	2.1	138.9	0.0	3698.4	7210.3	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.6	0.0	0.0	4155.6	912.6	0.0
RESID. OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ELECTRICITY	86.9	0.3	313.6	33.7	1246.7	2121.2	41231.7
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	212.1	3.0	793.9	100.9	20777.8	10244.0	41231.7

YEAR: 2090

INDUSTRIAL

AIR POLLUTION (TONS)

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
CO2	0.619913E 09	0.466209E 09	0.283635E 08	0.885430E 09	0.661850E 09	0.869508E 08	0.135102E 08
CO	0.593559E 05	0.113868E 06	0.929950E 02	0.192049E 06	0.644983E 05	0.285084E 03	0.442958E 02
SO2	0.213544E 07	0.178858E 07	0.139493E 03	0.325051E 07	0.229589E 07	0.577076E 07	0.664437E 02
NOX	0.134043E 07	0.979175E 06	0.278985E 05	0.179390E 07	0.111394E 07	0.855253E 05	0.132887E 05
PARTICULATE	0.341997E 07	0.858185E 07	0.764820E 05	0.228264E 09	0.168119E 07	0.641647E 06	0.153389E 07
HYDROCARBON	0.118301E 06	0.996639E 05	0.929950E 04	0.187328E 06	0.126137E 06	0.285085E 05	0.442958E 04
ALDEHYDE	0.190917E 05	0.604932E 04	0.697462E 03	0.167398E 05	0.199577E 05	0.213813E 04	0.332219E 03

YEAR: 2090

INDUSTRIAL

AIR POLLUTION (TONS)

	MISC.FOSL.	RAW MATL	TOTAL
CO2	0.977513E 10	0.0	0.165819E 11
CO	0.137966E 07	0.0	0.332986E 08
SO2	0.245252E 08	0.0	0.618230E 08
NOX	0.163142E 08	0.0	0.297290E 08
PARTICULATE	0.321649E 08	0.0	0.426763E 09
HYDROCARBON	0.241556E 07	0.0	0.349649E 07
ALDEHYDE	0.203785E 06	0.0	0.860227E 07

YEAR: 2090

INDUSTRIAL

AIR POLLUTION (TONS)

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
CO2	0.763212E 07	0.177876E 06	0.467095E 08	0.752431E 07	0.346509E 10	0.517395E 09	0.0
CO	0.250233E 02	0.846179E 00	0.129661E 05	0.254617E 04	0.257011E 08	0.577313E 07	0.0
SO2	0.375350E 02	0.183686E 03	0.990728E 07	0.401308E 05	0.997494E 07	0.213289E 07	0.0
NOX	0.750700E 04	0.210949E 03	0.105322E 06	0.190862E 05	0.413777E 07	0.409076E 07	0.0
PARTICULATE	0.570623E 04	0.797693E 03	0.223610E 07	0.129501E 06	0.120523E 09	0.275036E 08	0.0
HYDROCARBON	0.250233E 04	0.481488E 02	0.924782E 04	0.127309E 04	0.340130E 06	0.154061E 06	0.0
ALDEHYDE	0.187675E 03	0.741896E 01	0.531005E 03	0.634864E 02	0.465025E 05	0.828919E 07	0.0

YEAR: 2090

TRANSPORTATION

ENERGY DEMAND: TRILLION BTUS

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	25000.0	0.0	0.0	0.0	0.0	25000.0
JET FUEL	97000.0	0.0	0.0	0.0	0.0	0.0	97000.0
DISTIL. OIL	0.0	0.0	7800.0	27643.0	1736.5	12200.0	49379.5
RESID. OIL	0.0	0.0	0.0	0.0	5813.5	0.0	5813.5
ELECTRICITY	0.0	0.0	0.0	8257.0	0.0	0.0	8257.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	97000.0	25000.0	7800.0	35900.0	7550.0	12200.0	185449.8

YEAR: 2090

TRANSPORTATION

AIR POLLUTION (TONS)

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
CO2	0.722650E 10	0.186250E 10	0.663000E 09	0.234965E 10	0.641750E 09	0.103700E 10	0.137804E 11
CO	0.518950E 08	0.975000E 07	0.300300E 07	0.106426E 08	0.672447E 06	0.469700E 07	0.806599E 08
SO2	0.397700E 07	0.500000E 06	0.756600E 06	0.268137E 07	0.245532E 07	0.118340E 07	0.115537E 08
NOX	0.999100E 07	0.115000E 07	0.514800E 07	0.182444E 08	0.192219E 07	0.805200E 07	0.445075E 08
PARTICULATE	0.159565E 08	0.887500E 06	0.366600E 06	0.129922E 07	0.528092E 06	0.573400E 06	0.196113E 08
HYDROCARBON	0.339500E 08	0.117500E 07	0.230100E 07	0.815468E 07	0.570402E 06	0.359900E 07	0.497500E 08
ALDEHYDE	0.101850E 07	0.262500E 06	0.857999E 05	0.304073E 06	0.385186E 05	0.134200E 06	0.184359E 07

YEAR: 2090

TOTAL BASE ENERGY DEMAND

ENERGY DEMAND: TRILLION BTUS

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
COAL	0.0	0.0	62303.9	0.0	62303.9
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	5780.4	16376.8	120720.1	0.0	143877.3
GCFR	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	25000.0	25000.0
JET FUEL	0.0	0.0	0.0	97000.0	97000.0
DISTIL. OIL	3042.0	19161.1	76947.8	49379.5	148530.3
RESID. OIL	1180.3	7549.7	10659.3	5813.5	25202.8
ELECTRICITY	13594.5	33506.1	54354.4	8257.0	109711.9
METHANOL	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0
TOTAL	24597.2	76593.6	324985.4	185449.8	611626.1

YEAR: 2090

AIR POLLUTION (TONS)

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
CO2	0.772501E 09	0.326940E 10	0.165819E 11	0.137804E 11	0.344042E 11
CO	0.143806E 06	0.182622E 06	0.332986E 08	0.806599E 08	0.114285E 09
SO2	0.133977E 07	0.836104E 07	0.618230E 08	0.115537E 08	0.836275E 08
NOX	0.351070E 06	0.458592E 07	0.297290E 08	0.445075E 08	0.791735E 08
PARTICULATE	0.216417E 06	0.177009E 07	0.426763E 09	0.196113E 08	0.448360E 09
HYDROCARBON	0.727225E 05	0.347944E 06	0.349649E 07	0.497500E 08	0.536672E 08
ALDEHYDE	0.643027E 05	0.245060E 06	0.860227E 07	0.184359E 07	0.107552E 08

YEAR: 2090

SUMMARY OF ENERGY DEMANDS

ENERGY DEMAND: TRILLION BTUS

	TTL B.E.D	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	SYN. FUELS	TOTAL
COAL	62303.9	0.0	141.6	182714.4	223204.5	-0.1	468364.3
GEOTHERMAL	0.0	16938.8	0.0	0.0	0.0	0.0	16938.8
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	143877.3	0.0	13520.3	0.0	0.0	-0.1	157397.6
GCFR	0.0	1789.3	0.0	0.0	0.0	0.0	1789.3
HTGR	0.0	1166.5	0.0	0.0	0.0	0.0	1166.5
LFR	0.0	231208.7	0.0	0.0	0.0	0.0	231208.7
LMFBR	0.0	565.2	0.0	0.0	0.0	0.0	565.2
LWR	0.0	1095.6	0.0	0.0	0.0	0.0	1095.6
MSBR	0.0	269.8	0.0	0.0	0.0	0.0	269.8
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	25000.0	0.0	0.0	0.0	0.0	0.0	25000.0
JET FUEL	97000.0	0.0	0.0	0.0	0.0	0.0	97000.0
DISTIL. OIL	148530.3	0.0	0.0	0.0	0.0	0.0	148530.3
RESID. OIL	25202.8	0.0	3964.1	0.0	0.0	-0.0	29166.8
ELECTRICITY	109711.9	0.0	884.3	0.0	0.0	-1.5	0.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	1561.7	0.0	0.0	0.0	0.0	1561.7
TOTAL	611626.1	254595.4	18510.2	182714.4	223204.5	-1.7	1180052.0

YEAR: 2090

AIR POLLUTION (TONS)

	TTL B.E.D.	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	METHANOL	TOTAL
CO2	0.344042E 11	0.0	0.241135E 10	0.487587E 10	0.530526E 10	0.0	0.469967E 11
CO	0.114285E 09	0.0	0.216155E 06	0.0	0.0	0.0	0.114501E 09
SO2	0.936275E 08	0.0	0.375625E 07	0.0	0.0	0.0	0.873837E 08
NOX	0.791735E 08	0.0	0.268834E 07	0.0	0.0	0.0	0.818618E 08
PARTICULATE	0.449360E 09	0.0	0.972113E 06	0.0	0.0	0.0	0.449332E 09
HYDROCARBON	0.536672E 08	0.0	0.618027E 06	0.237434E 09	0.0	0.0	0.291719E 09
ALDEHYDE	0.107552E 08	0.0	0.665639E 05	0.393704E 08	0.560109E 07	0.0	0.557933E 08

YEAR: 2090

SOLID WASTE (TONS)

SYNCRUDE	0.301354E 09
TAR SANDS	0.369956E 05
OIL SHALE	0.255915E 05
SYNGAS	0.474863E 09
TOTAL	0.776284E 09

ELEMENTAL SULFUR PRODUCED (TONS)

SYNCRUDE	0.260332E 09
SYNGAS	0.316780E 09
TOTAL	0.577113E 09

LAND USE BY ENERGY PRODUCTION (ACRES)

COAL (STRIP MINING)	0.307416E 07
TAR SANDS	0.146985E 04
OIL SHALE	0.146985E 06
ELEC. GEN. & TRANS.	0.481230E 08
TOTAL	0.513456E 08

RADIOACTIVE MATERIAL PRODUCTION AND RELEASES

TRITIUM RELEASED	0.194450E 08	CURIES
KRYPTON-85 RELEASED	0.237070E 08	CURIES
LONG-LIVED RAD.WASTE	0.469752E 11	CURIES
LONG LIVED RAD.WASTE	0.794755E 06	CUBIC FEET
POPULATION EXPOSURE	0.118818E 07	MAN-REM

COOLING WATER REQUIREMENTS FOR ENERGY PRODUCTION (ACRE-FEET)

COOLING WATER CONSUMED BY EVAPORATION			0.318860E 08
COOLING WATER USED IN ONCE-THRU CONDENSORS			0.213247E 10
WATER REQUIRED FOR H2 BY ELECTROLYSIS			0.0
	(FEED WATER	0.0)	
	(COOLING TOWER	0.0)	
OIL SHALE WATER REQUIREMENTS			0.512334E 07
TAR SANDS WATER REQUIREMENTS			0.512334E 07
COAL GASIFICATION WATER REQUIREMENTS			0.908548E 07
COAL LIQUEFACTION WATER REQUIREMENTS			0.207763E 07
TOTAL			0.218576E 10

YEAR: 2090

COAL RESOURCE DEMANDS (TRILLION BTU)

TOTAL BED	62303.86
SYNCRUDE	223204.50
SYNGAS	182714.44
METHANOL	0.0
ELEC.GEN.	0.0
PET.REF.	141.57
TOTAL	468364.31

PETROLEUM RESOURCE DEMANDS (TRILLION BTU)

TOTAL PET. DEMAND	315730.56
TAR SANDS REQ.	63110.91
OIL SHALE REQ	63110.91
SYNCRUDE REQ.	157777.25
DOMESTIC CRUDE PROD.	176.00
CRUDE OIL IMPORTS	31555.44
TOTAL CRUDE PROD.	315730.50

NATURAL GAS RESOURCE DEMANDS (TRILLION BTU)

TOTAL DEMAND	157397.56
CORRECTED DMD.	163372.06
DOM. NAT. GAS	50.00
CANADA P.L.IMP.	0.0
LNG IMPORTS	0.0
SYNGAS	163326.81
TOTAL GAS PRD.	163376.81

NUCLEAR FUEL RESOURCE DEMANDS

SEP.WORK REQ.	0.384120E 07	KGSW
PWR REQ. KGSW	27.04	TRILLION BTU
THORIUM (TH32)	0.521923E 03	TONNES
URANIUM (U308)	0.358860E 04	TONNES

YEAR: 2090

SUMMARY OF RESOURCE REQUIREMENTS

RESOURCE	ANNUAL PROD.	
COAL	468364.31	TRILLION BTU
GEOTHERMAL	16938.83	TRILLION BTU
(HYDROGEN)	0.0	TRILLION BTU
NATURAL GAS	50.00	TRILLION BTU
NUCLEAR-FISSION	4886.33	TRILLION BTU
NUCLEAR-FUSION	231208.69	TRILLION BTU
PETROLEUM	157953.25	TRILLION BTU
(METHANOL)	0.0	TRILLION BTU
SOLAR	0.0	TRILLION BTU
TIDAL	0.0	TRILLION BTU
WIND	0.0	TRILLION BTU
HYDROELECTRIC	1561.71	TRILLION BTU
TOTAL	880963.06	TRILLION BTU

SUMMARY OF BALANCE OF PAYMENTS FOR ENERGY IMPORTS
(MILLIONS OF 1970 DOLLARS)

COST OF CRUDE PETROLEUM IMPORTS	22530.58
COST OF LIQUIFIED NATURAL GAS IMPORTS	0.0
COST OF CANADIAN GAS IMPORTS	0.0
TOTAL BALANCE OF PAYMENTS DEFICIT	22530.58

YEAR: 2100

RESIDENTIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	330.7	0.0	5221.4	1240.8	148.3	0.0	6941.2
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	3085.6	0.0	0.0	0.0	3085.6
RESID. OIL	0.0	0.0	1197.2	0.0	0.0	0.0	1197.2
ELECTRICITY	3377.8	760.9	5194.8	2319.1	667.7	1775.0	14095.2
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	3708.5	760.9	14699.0	3559.9	815.9	1775.0	25319.2

YEAR: 2100

RESIDENTIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.201719E 08	0.0	0.682547E 09	0.756907E 08	0.904537E 07	0.0	0.787454E 09
CO	0.330687E 04	0.0	0.129305E 06	0.124083E 05	0.148285E 04	0.0	0.146503E 06
SO2	0.992061E 02	0.0	0.140919E 07	0.372249E 03	0.444854E 02	0.0	0.140971E 07
NOX	0.826717E 04	0.0	0.314697E 06	0.310208E 05	0.370712E 04	0.0	0.357692E 06
PARTICULATE	0.314153E 04	0.0	0.203785E 06	0.117879E 05	0.140871E 04	0.0	0.220123E 06
HYDROCARBON	0.132275E 04	0.0	0.671401E 05	0.496332E 04	0.593139E 03	0.0	0.740193E 05
ALDEHYDE	0.165344E 04	0.0	0.569434E 05	0.620415E 04	0.741424E 03	0.0	0.655424E 05

YEAR: 2100

COMMERCIAL

ENERGY DEMAND: TRILLION BTUS

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	145.3	0.0	8531.4	2129.9	379.3	5336.0	16521.9
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.0	12797.2	0.0	0.0	6544.9	19342.1
RESID. OIL	0.0	0.0	5118.9	0.0	0.0	2501.3	7620.1
ELECTRICITY	784.4	3185.1	18946.5	4185.0	505.7	6461.6	34068.4
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	929.7	3185.1	45394.0	6314.9	885.0	20843.8	77552.4

YEAR: 2100

COMMERCIAL

AIR POLLUTION (TONS)

	AIR.COND.	REFRIG.	SPACE HT.	WATER HT.	COOKING	MISC.	TOTAL
CO2	0.996128E 07	0.0	0.204328E 10	0.129923E 09	0.231360E 08	0.109442E 10	0.329962E 10
CO	0.145267E 04	0.0	0.979580E 05	0.212988E 05	0.379279E 04	0.597483E 05	0.184250E 06
SO2	0.435800E 02	0.0	0.594748E 07	0.638963E 03	0.113784E 03	0.299613E 07	0.894441E 07
NOX	0.726334E 04	0.0	0.295273E 07	0.106494E 06	0.189639E 05	0.154319E 07	0.462864E 07
PARTICULATE	0.138004E 04	0.0	0.116522E 07	0.202338E 05	0.360315E 04	0.596215E 06	0.178666E 07
HYDROCARBON	0.581067E 03	0.0	0.223524E 06	0.851950E 04	0.151711E 04	0.117042E 06	0.351183E 06
ALDEHYDE	0.726334E 03	0.0	0.151894E 06	0.106494E 05	0.189639E 04	0.821577E 05	0.247324E 06

YEAR: 2100

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
COAL	1517.4	3043.9	0.0	5115.4	1650.9	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	2875.0	2183.6	472.9	4241.3	3047.9	1449.6	225.2
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	638.9	0.0	0.0	809.4	592.6	0.0	0.0
RESID. OIL	2715.3	0.0	0.0	0.0	2963.2	0.0	0.0
ELECTRICITY	239.6	8006.7	235.0	625.9	211.7	58.8	100.7
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	7986.1	13234.1	707.9	10792.0	8466.3	1508.4	326.0

YEAR: 2100

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	MISC.FOSL.	RAW MATL	TOTAL
COAL	36388.7	3353.2	63317.8
GEOTHERMAL	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0
NATURAL GAS	83745.7	13161.1	122808.8
GCFR	0.0	0.0	0.0
HTGR	0.0	0.0	0.0
LFR	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0
LWR	0.0	0.0	0.0
MSBR	0.0	0.0	0.0
MCFR	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0
DISTIL. OIL	3742.1	67314.5	78252.2
RESID. OIL	5161.5	0.0	10840.0
ELECTRICITY	0.0	0.0	55275.8
METHANOL	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0
WIND	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0
TOTAL	129037.9	83828.8	330494.5

YEAR: 2100

INDUSTRIAL

ENERGY DEMAND: TRILLION BTUS

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
COAL	0.0	0.0	347.2	68.3	11832.8	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	127.2	2.1	141.3	0.0	3803.4	7332.5	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JET FUEL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISTIL. OIL	0.0	0.6	0.0	0.0	4226.0	928.0	0.0
RESID. OIL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ELECTRICITY	88.4	0.3	318.9	34.3	1267.8	2157.1	41930.6
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	215.7	3.0	807.4	102.6	21130.1	10417.7	41930.6

YEAR: 2100

INDUSTRIAL

AIR POLLUTION (TONS)

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
CO2	0.630425E 09	0.474113E 09	0.288444E 08	0.900443E 09	0.673072E 09	0.884250E 08	0.137393E 08
CO	0.603623E 05	0.115799E 06	0.945718E 02	0.195305E 06	0.655919E 05	0.289918E 03	0.450468E 02
SO2	0.217155E 07	0.181890E 07	0.141858E 03	0.330562E 07	0.233481E 07	0.586860E 07	0.675703E 02
NOX	0.105807E 07	0.995777E 06	0.283715E 05	0.182432E 07	0.113283E 07	0.869754E 05	0.135141E 05
PARTICULATE	0.347796E 07	0.872736E 07	0.777788E 05	0.232135E 09	0.170970E 07	0.652526E 06	0.155990E 07
HYDROCARBON	0.123307E 06	0.101354E 06	0.945718E 04	0.190504E 06	0.128275E 06	0.289918E 05	0.450469E 04
ALDEHYDE	0.194155E 05	0.615189E 04	0.709289E 03	0.170237E 05	0.202961E 05	0.217439E 04	0.337852E 03

YEAR: 2100

INDUSTRIAL

AIR POLLUTION (TONS)

	ALUMINA	PRIMARY ALUMINUM	SECONDARY ALUMINUM	CEMENT	CHLORINE	PRIMARY COPPER	REFINED COPPER
CO2	0.630425E 09	0.474113E 09	0.288444E 08	0.900443E 09	0.673072E 09	0.884250E 08	0.137393E 08
CO	0.603623E 05	0.115799E 06	0.945718E 02	0.195305E 06	0.655919E 05	0.289918E 03	0.450468E 02
SO2	0.217155E 07	0.181890E 07	0.141858E 03	0.330562E 07	0.233481E 07	0.586860E 07	0.675703E 02
NOX	0.105807E 07	0.995777E 06	0.283715E 05	0.182432E 07	0.113283E 07	0.869754E 05	0.135141E 05
PARTICULATE	0.347796E 07	0.872736E 07	0.777788E 05	0.232135E 09	0.170970E 07	0.652526E 06	0.155990E 07
HYDROCARBON	0.120307E 06	0.101354E 06	0.945718E 04	0.190504E 06	0.128275E 06	0.289918E 05	0.450469E 04
ALDEHYDE	0.194155E 05	0.615189E 04	0.709289E 03	0.170237E 05	0.202961E 05	0.217439E 04	0.337852E 03

YEAR: 2100

INDUSTRIAL

AIR POLLUTION (TONS)

	MISC.FOSL.	RAW MATL	TOTAL
CO2	0.994082E 10	0.0	0.168608E 11
CO	0.140203E 07	0.0	0.338615E 08
SO2	0.249419E 08	0.0	0.628459E 08
NOX	0.165907E 08	0.0	0.302235E 08
PARTICULATE	0.327101E 08	0.0	0.433962E 09
HYDROCARBON	0.245651E 07	0.0	0.355581E 07
ALDEHYDE	0.234188E 06	0.0	0.874815E 07

YEAR: 2100

INDUSTRIAL

AIR POLLUTION (TONS)

	PRIMARY MAGNESIUM	SECONDARY MAGNESIUM	PRIMARY ZINC	SECONDARY ZINC	PIG IRON	STEEL	MISC.ELEC.
CO2	0.776152E 07	0.180892E 06	0.475014E 08	0.765189E 07	0.352168E 10	0.526168E 09	0.0
CO	0.254476E 02	0.860525E 00	0.131859E 05	0.258934E 04	0.261352E 08	0.587101E 07	0.0
SO2	0.381714E 02	0.186800E 03	0.100753E 08	0.408113E 05	0.101188E 08	0.216906E 07	0.0
NOX	0.763428E 04	0.214525E 03	0.107108E 06	0.194098E 05	0.419846E 07	0.416012E 07	0.0
PARTICULATE	0.580298E 04	0.811217E 03	0.227401E 07	0.131697E 06	0.122531E 09	0.279700E 08	0.0
HYDROCARBON	0.254476E 04	0.489651E 02	0.940462E 04	0.129467E 04	0.345941E 06	0.156673E 06	0.0
ALDEHYDE	0.190857E 03	0.754475E 01	0.540008E 03	0.645628E 02	0.473144E 05	0.842973E 07	0.0

YEAR: 2100

TRANSPORTATION

ENERGY DEMAND: TRILLION BTUS

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
COAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	25800.0	0.0	0.0	0.0	0.0	25800.0
JET FUEL	118000.0	0.0	0.0	0.0	0.0	0.0	118000.0
DISTIL. OIL	0.0	0.0	9800.0	40040.0	2160.0	12800.0	64800.0
RESID. OIL	0.0	0.0	0.0	0.0	6840.0	0.0	6840.0
ELECTRICITY	0.0	0.0	0.0	11960.0	0.0	0.0	11960.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	118000.0	25800.0	9800.0	52000.0	9000.0	12800.0	227399.8

YEAR: 2100

TRANSPORTATION

AIR POLLUTION (TONS)

	AIRPLANE	AUTO	BUS	RAILROAD	SHIP	TRUCK	TOTAL
CO2	0.879130E 10	0.192210E 10	0.833000E 09	0.340340E 10	0.764999E 09	0.108800E 10	0.168025E 11
CO	0.631300E 08	0.100620E 08	0.377300E 07	0.154154E 08	0.836182E 06	0.492800E 07	0.981445E 08
SO2	0.483800E 07	0.516000E 06	0.950600E 06	0.388388E 07	0.290020E 07	0.124160E 07	0.143303E 08
NOX	0.121540E 08	0.118680E 07	0.646800E 07	0.264264E 08	0.233874E 07	0.844800E 07	0.570219E 08
PARTICULATE	0.194110E 08	0.915900E 06	0.460600E 06	0.188188E 07	0.626831E 06	0.601600E 06	0.238977E 08
HYDROCARBON	0.413000E 08	0.121260E 07	0.289100E 07	0.118118E 08	0.705600E 06	0.377600E 07	0.616969E 08
ALDEHYDE	0.123900E 07	0.270900E 06	0.107800E 06	0.440440E 06	0.466056E 05	0.140800E 06	0.224554E 07

YEAR: 2100

TOTAL BASE ENERGY DEMAND

ENERGY DEMAND: TRILLION BTUS

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
COAL	0.0	0.0	63317.8	0.0	63317.8
GEOTHERMAL	0.0	0.0	0.0	0.0	0.0
HYDROGEN	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	6941.2	16521.9	122808.8	0.0	146271.8
GCFR	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0
LFR	0.0	0.0	0.0	0.0	0.0
LMFBR	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0
GASOLINE	0.0	0.0	0.0	25800.0	25800.0
JET FUEL	0.0	0.0	0.0	118000.0	118000.0
DISTIL. OIL	3085.6	19342.1	78252.2	64800.0	165479.8
RESID. OIL	1197.2	7620.1	10840.0	6840.0	26497.3
ELECTRICITY	14095.2	34068.4	55275.8	11960.0	115399.3
METHANOL	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	0.0	0.0	0.0	0.0
TOTAL	25319.2	77552.4	330494.5	227399.8	660765.9

YEAR: 2100

AIR POLLUTION (TONS)

	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
CO2	0.787454E 09	0.329962E 10	0.168608E 11	0.168025E 11	0.377504E 11
CO	0.146503E 06	0.184250E 06	0.338615E 08	0.981445E 08	0.132337E 09
SO2	0.140971E 07	0.894441E 07	0.628459E 08	0.143303E 08	0.875302E 08
NOX	0.357692E 06	0.462864E 07	0.302235E 08	0.570219E 08	0.922317E 08
PARTICULATE	0.220123E 06	0.178666E 07	0.433962E 09	0.238977E 08	0.459867E 09
HYDROCARBON	0.740193E 05	0.351183E 06	0.355581E 07	0.616969E 08	0.656779E 08
ALDEHYDE	0.655424E 05	0.247324E 06	0.874815E 07	0.224554E 07	0.113066E 08

YEAR: 2100

SUMMARY OF ENERGY DEMANDS

ENERGY DEMAND: TRILLION BTUS

	TTL B.E.D	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	SYN. FUELS	TOTAL
COAL	63317.8	0.0	160.7	180726.7	253499.9	-0.1	497705.1
GEOTHERMAL	0.0	17824.9	0.0	0.0	0.0	0.0	17824.9
HYDROGEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NATURAL GAS	145271.8	0.0	15351.0	0.0	0.0	-0.1	161622.8
GCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HTGR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LFR	0.0	247550.4	0.0	0.0	0.0	0.0	247550.4
LMFBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LWR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MSBR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MCFR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GASOLINE	25800.0	0.0	0.0	0.0	0.0	0.0	25800.0
JET FUEL	118000.0	0.0	0.0	0.0	0.0	0.0	118000.0
DISTIL. OIL	165479.8	0.0	0.0	0.0	0.0	0.0	165479.8
RESID. OIL	25497.3	0.0	4500.8	0.0	0.0	0.0	30998.1
ELECTRICITY	115399.3	0.0	1004.1	0.0	0.0	-1.6	0.0
METHANOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOLAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TIDAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WIND	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HYDRO.ELEC.	0.0	1479.1	0.0	0.0	0.0	0.0	1479.1
TOTAL	660765.9	266854.4	21016.6	180726.7	253499.9	-1.8	1266456.0

YEAR: 2100

AIR POLLUTION (TONS)

	TTL B.E.D.	ELEC. GEN.	PET. REF.	SYNTH. GAS	SYN. CRUDE	METHANOL	TOTAL
CO2	0.377504E 11	0.0	0.273786E 10	0.482283E 10	0.602534E 10	0.0	0.513364E 11
CO	0.132337E 09	0.0	0.245424E 06	0.0	0.0	0.0	0.132582E 09
SO2	0.875302E 08	0.0	0.426487E 07	0.0	0.0	0.0	0.917951E 08
NOX	0.922317E 08	0.0	0.305236E 07	0.0	0.0	0.0	0.952840E 08
PARTICULATE	0.459867E 09	0.0	0.110374E 07	0.0	0.0	0.0	0.460970E 09
HYDROCARBON	0.656779E 08	0.0	0.701712E 06	0.234851E 09	0.0	0.0	0.301230E 09
ALDEHYDE	0.113066E 08	0.0	0.755771E 05	0.389421E 08	0.636132E 07	0.0	0.566855E 08

YEAR: 2100

SOLID WASTE (TONS)

SYNCRUDE	0.342257E 09
TAR SANDS	0.420170E 05
OIL SHALE	0.290650E 05
SYNGAS	0.469702E 09
TOTAL	0.812029E 09

ELEMENTAL SULFUR PRODUCED (TONS)

SYNCRUDE	0.295667E 09
SYNGAS	0.313334E 09
TOTAL	0.609001E 09

LAND USE BY ENERGY PRODUCTION (ACRES)

COAL (STRIP MINING)	0.326207E 07
TAR SANDS	0.166935E 04
OIL SHALE	0.166935E 06
ELEC. GEN. & TRANS.	0.457449E 08
TOTAL	0.491756E 08

RADIOACTIVE MATERIAL PRODUCTION AND RELEASES

TRITIUM RELEASED	0.0	CURIES
KRYPTON-85 RELEASED	0.0	CURIES
LONG-LIVED RAD.WASTE	0.492031E 11	CURIES
LONG LIVED RAD.WASTE	0.830985E 06	CUBIC FEET
POPULATION EXPOSURE	0.124374E 07	MAN-REM

COOLING WATER REQUIREMENTS FOR ENERGY PRODUCTION (ACRE-FEET)

COOLING WATER CONSUMED BY EVAPORATION		0.333055E 08
COOLING WATER USED IN ONCE-THRU CONDENSORS		0.222803E 10
WATER REQUIRED FOR H2 BY ELECTROLYSIS		0.0
(FEED WATER	0.0)	
(COOLING TOWER	0.0)	
OIL SHALE WATER REQUIREMENTS		0.581873E 07
TAR SANDS WATER REQUIREMENTS		0.581873E 07
COAL GASIFICATION WATER REQUIREMENTS		0.898664E 07
COAL LIQUEFACTION WATER REQUIREMENTS		0.235962E 07
TOTAL		0.228431E 10

YEAR: 2100

COAL RESOURCE DEMANDS (TRILLION BTU)

TOTAL BED	63317.79
SYNCRUDE	253499.94
SYNGAS	180726.69
METHANOL	0.0
ELEC.GEN.	0.0
PET.REF.	160.74
TOTAL	497705.06

PETROLEUM RESOURCE DEMANDS (TRILLION BTU)

TOTAL PET. DEMAND	358482.50
TAR SANDS REQ.	71676.88
OIL SHALE REQ	71676.88
SYNCRUDE REQ.	179192.25
DOMESTIC CRUDE PROD.	98.00
CRUDE OIL IMPORTS	35838.43
TOTAL CRUDE PROD.	358482.38

NATURAL GAS RESOURCE DEMANDS (TRILLION BTU)

TOTAL DEMAND	161622.75
CORRECTED DMD.	167757.63
DOM. NAT. GAS	25.00
CANADA P.L.IMP.	0.0
LNG IMPORTS	0.0
SYNGAS	167735.00
TOTAL GAS PRD.	167760.00

NUCLEAR FUEL RESOURCE DEMANDS

SEP.WORK REQ.	0.990000E 06	KGSW
PWR REQ. KGSW	6.97	TRILLION BTU
THORIUM (THO2)	0.0	TONNES
URANIUM (U3O8)	0.0	TONNES

YEAR: 2100

SUMMARY OF RESOURCE REQUIREMENTS

RESOURCE	ANNUAL PROD.	
COAL	497705.06	TRILLION BTU
GEOTHERMAL	17824.95	TRILLION BTU
(HYDROGEN)	0.0	TRILLION BTU
NATURAL GAS	25.00	TRILLION BTU
NUCLEAR-FISSION	0.0	TRILLION BTU
NUCLEAR-FUSION	247550.44	TRILLION BTU
PETROLEUM	179290.13	TRILLION BTU
(METHANOL)	0.0	TRILLION BTU
SOLAR	0.0	TRILLION BTU
TIDAL	0.0	TRILLION BTU
WIND	0.0	TRILLION BTU
HYDROELECTRIC	1479.07	TRILLION BTU
TOTAL	943874.63	TRILLION BTU

SUMMARY OF BALANCE OF PAYMENTS FOR ENERGY IMPORTS
(MILLIONS OF 1970 DOLLARS)

COST OF CRUDE PETROLEUM IMPORTS	25588.64
COST OF LIQUIFIED NATURAL GAS IMPORTS	0.0
COST OF CANADIAN GAS IMPORTS	0.0
TOTAL BALANCE OF PAYMENTS DEFICIT	25588.64

APPENDIX D

AN INTEGRATED ENERGY RESOURCES CENTER USING A HIGH-TEMPERATURE GAS-COOLED REACTOR AS THE PRIMARY ENERGY SUPPLY FOR CRUDE OIL REFINING AND WASTE HEAT FOR DESALINATION

Introduction

In 1971 the United States crude petroleum energy consumption was over 23.1×10^{15} Btu and by 1985 the United States crude petroleum consumption is projected to be over 53.4×10^{15} Btu (43, 46, 80, 81). In 1971, 25.7 percent of the United States crude oil supply was imported (80). By 1985 over 56.6 percent of the U.S. crude oil requirements will most likely be supplied by imports (43, 46).

During 1971, U.S. crude oil refineries consumed over 2.79×10^{15} Btu of fuel to refine crude oil which yielded 23.1×10^{15} Btu of energy (80, 81). An excellent way to reduce fossil fuel consumption in petroleum refineries is to utilize a nuclear reactor as the primary energy source. A High-Temperature Gas-Cooled Nuclear Reactor (HTGR) can supply the energy required for petroleum refining at a sufficiently high temperature (1350° to 1550°F). The use of the HTGR as the crude oil refinery energy source could increase the available crude oil energy resources by 12.1 percent or by

approximately 3.6×10^{15} Btu annually by 1985.

By using a High-Temperature Gas-Cooled Reactor (HTGR) as the primary source of energy for a crude oil refinery, the crude oil refining thermal efficiency is increased, the crude oil throughput per unit product is reduced, net production rather than consumption of pipeline gas occurs, the available energy from current crude oil resources is increased, and the refinery's ecological impact on the environment is reduced.

The High-Temperature Gas-Cooled Reactor supplies the process heat and electrical power necessary for complete refining of the crude oil and may produce pure water using waste heat for desalination.

Energy Resources Center Concept

To meet the country's requirements for petroleum the United States will most likely use an energy resources center with a super-tanker port and an integrated nuclear/petroleum/water energy resources facility consisting of a nuclear heat source, a petroleum refinery and a desalination unit. It would be located on the United States' east or gulf coast and be supplied by crude petroleum super-tankers in the 200,000 ton class or larger. The tankers would discharge their crude at an artificial deep water mooring facility. This artificial "superport" would be located off-shore in at least 100 feet of water and would be suitable for handling any tanker or bulk carrier in existence today or on the drawing board.

The superport would be connected by pipeline to the integrated crude oil refinery. Projected future domestic refinery characteristics are (11):

1. The refinery will be large, that is, 200,000 to more than 500,000 barrels per day with no more than two processing trains.
2. The refinery will operate on imported crude oil which will most likely have a high sulfur content and originate in the Middle East.
3. It will be located near a deep water port and in turn, hopefully, near the main market centers in the Northeast portion of the United States.
4. The refinery will be of a more balanced nature and oriented towards the production of low sulfur fuels.
5. It will be basically clean, quiet, and unobtrusive, and will meet the requirements of the Environmental Protection Act.
6. It will be more efficient in terms of heat conservation than existing refineries.

The HTGR/crude oil refinery/desalination plant integrated facility meets all of these requirements.

High-Temperature Gas-Cooled Reactor

The high-temperature gas-cooled reactor (26, 27, 28, 60) provides 1400°F to 1500°F heat to the various units of the crude oil refinery, generates electrical power for refinery use, and its waste heat is used for desalination.

The HTGR uses helium gas as the reactor coolant and graphite as the moderator and core structural material. The fuel is a mixture of enriched uranium and thorium, used in the form of carbide particles individually clad with ceramic coatings.

The HTGR with all associated primary heat exchangers for each major heat load of the refinery and the electrical generation turbines and heat exchangers are housed in a steel-lined, Pre-stressed Concrete Reactor Vessel (PCRV), Figure D-1. In addition to housing the reactor, the PCRV provides the necessary biological shielding. The PCRV, in turn, is housed in a conventional reinforced concrete secondary containment building which provides an extra safety dimension.

Housing the major components of the primary system together with the turbo-compressor, recuperator, pre-cooler steam evaporator gas turbine and the major crude oil refinery heat loads in the reactor vessel permits a compact installation and eliminates major external primary coolant piping.

Core Design

An HTGR fuel element is a graphite block, hexagonal in cross-section, with a grid of longitudinal fuel holes and coolant channels (some additionally have control-rod channels). Several thousand of these fuel blocks, stacked in columns in a massive cylindrical array, constitute the active region of the core. The active region is surrounded by graphite reflector blocks and supported by graphite structural members.

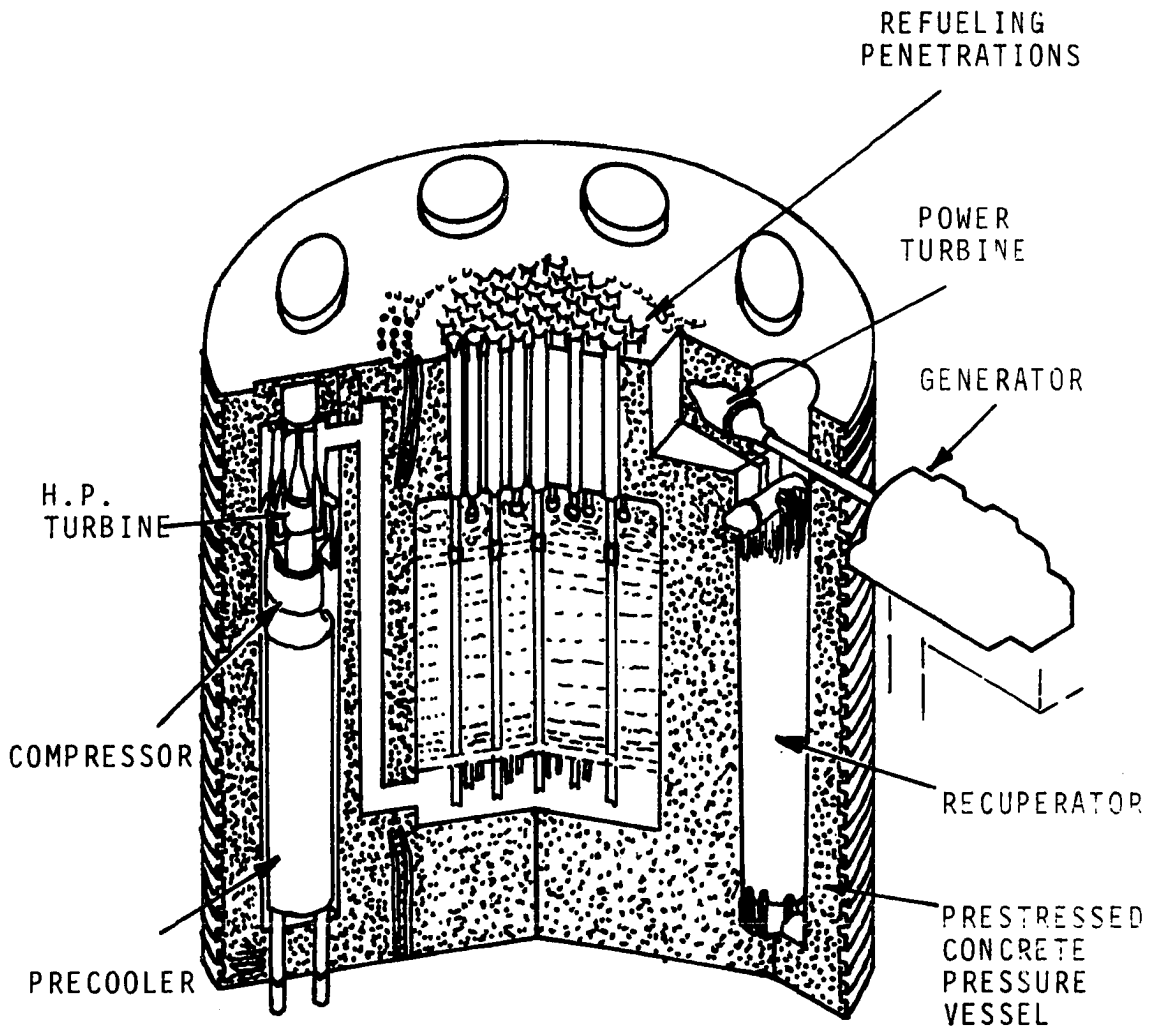


Figure D-1. Reactor Layout with a Closed Cycle Gas Turbine (26).

The fuel holes contain coated fuel particles. The ceramic particle coatings, applied by pyrolytic techniques, are multi-layered to ensure a high degree of fission-product confinement. A porous inner layer ("buffer" zone) accomodates the expansion of the irradiated fuel and provides storage space for gaseous fission products, thereby minimizing the build-up of internal pressure during fuel burn-up. The outer layer acts as a fission-product retention barrier and provides structural strength. In effect, the particle coatings function as miniature pressure vessels. They enable the fuel to maintain a high degree of fission-product confinement over the full range of burnup and temperature conditions experienced during power generation.

The HTGR core operates at very high specific power (approximately 1800 kilowatts of heat per kilogram of fissile fuel inventory) and with very high fuel burnup (in the range of 70,000 to 100,000 megawatt-days per metric ton of U-Th). High specific power translates to a low fissile inventory requirement. The high burnup and overall efficiency of HTGR fuel utilization translates to very low annual fissile make-up requirements.

The equilibrium fuel residence time in large HTGR's is three to four years; thus one-third to one-fourth of the fuel is normally replaced annually. The operator has latitude in scheduling the refueling date and the quantity of fuel replaced. Sizeable reductions in fuel cycle cost can be

achieved by refueling the core semi-annually. In that case, an eighth of the core is replaced at each refueling.

The HTGR core has a negative temperature coefficient of reactivity at all temperatures of interest--i.e., as the temperature increases, the rate of fission promptly decreases. Also, because helium is transparent to neutrons and makes no contribution to the reactivity of the system, changes in coolant density do not affect reactivity control. These features contribute to ease and predictability of reactor control. If desired, the power level can be adjusted by modifying the coolant flow rate, thereby minimizing the need for control-rod movement.

Nuclear Fuel Cycle

Various fuel cycles can be used with HTGR's. The standard cycle, in which thorium is used in combination with highly enriched uranium, has two principal advantages:

1. Uranium-233 (U^{233}), bred from thorium during reactor operation, has the highest eta value (neutron yield per fissile loss) of any fissile material in a thermal neutron environment. Since a significant fraction of the total energy output of HTGR's derives from the fission of bred U^{233}, higher conversion ratios can be achieved than are possible in nuclear power systems that operate with the low enrichment uranium cycle.

2. The use of thorium, which is available in abundance and at low cost, helps conserve uranium resources.

Electric Power Generation

The HTGR nuclear plant is coupled to closed-cycle gas turbines for electrical power generation (Figure D-2). The gas turbine and compressor operate at approximately 90 percent efficiency. A comparison of the thermal cycles of the HTGR, electrical power generation systems, steam and gas turbine is shown in Figure D-3.

For electrical power generation, the 1000 psia, 1500°F helium from the HTGR core provides the energy to a direct-heated, closed-cycle gas turbine plant yielding an overall efficiency of about 37.2 percent. The 1500°F helium poses no special problems to the gas turbine design and actually represents an easement of the conditions already met in existing industrial open-cycle gas turbines.

All heat exchange surfaces are housed inside the HTGR's PCRV with 13 feet i.d. by 40 feet cavities. It is assumed that each cavity will provide enough heat transfer area to provide approximately 800 million Btu/hr of available energy (54, 93). The heat loads and power requirements for the crude oil refinery are presented in the following section.

Crude Oil Refining

The proposed crude oil refinery is based on 1973 refinery technology. The refinery would consist of a crude

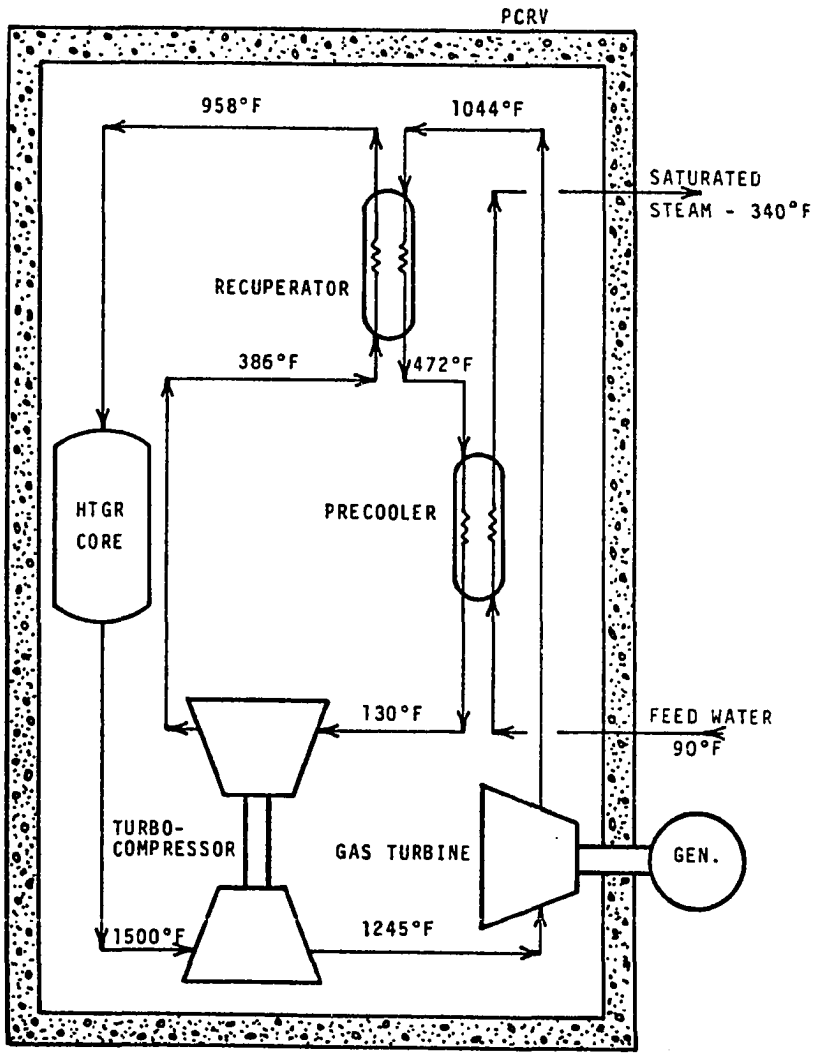


Figure D-2. HTGR Closed Gas Turbine Cycle.

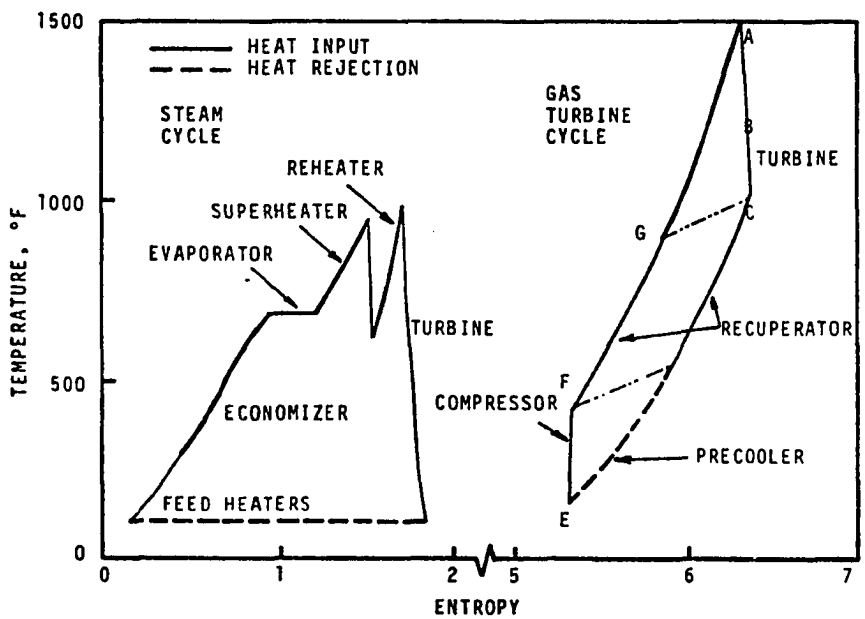


Figure D-3. Comparison of Steam Cycle with Gas Turbine Cycle.

oil vacuum distillation section, a hydro-cracking section, a desulfurization section, a hydrocarbon reforming section, a hydrogen plant, a fractionation section and a sulfur recovery plant (41).

Each section of the crude oil refinery would operate at the following temperature and pressures (49, 54, 93):

Crude vacuum unit	650°F and 20" Hg vac.
Hydrocracker	800°F and 2500 psia
Hydrogen Reformer	1350°F and 700 psia
Fractionation	650°F and 15 psia
Hydrocarbon reformer	1050°F and 300 psia

TABLE D-1

CRUDE OIL REFINERY POWER REQUIREMENTS

Unit	500,000 bpd	1,000,000 bpd
Electrical power	124.3 MW	248.6 MW
Crude vacuum	1900. *	3800.
Hydrocracker	1320.	2640.
Hydrogen plant	1840.	3680.
Reformer desulfurization	1900.	3800.
Steam plant	1610.	3220.
Fractionation	24.	48.
Sulfur recovery	134.	268.
Total heat load	8728.	17456.

*Units: MM Btu/hr.

Since the proposed crude oil refinery is a net producer of refinery gas rather than a consumer, the equivalent natural gas production is used for comparison purposes. The equivalent natural gas production, Table D-2, is the sum of refinery gas now available that would be burned in a conventional refinery (using a heating value of 850 Btu/scf

for refinery gas) and the amount of natural gas required to supply the remaining heat load (using a heating value of 1000 Btu/scf for natural gas) (41). Therefore the equivalent natural gas production is pipeline gas produced plus natural gas that would have been consumed if the refinery were conventionally powered.

TABLE D-2

EQUIVALENT NATURAL GAS PRODUCTION

Refinery Size	Refinery Gas Produced (850 Btu/scf) MMSCFD	Natural Gas Not Consumed (1000 Btu/scf) MMSCFD	Equivalent Natural Gas Production MMSCFD
500,000 bpd	103.	112.	225.
1,000,000 bpd	206.0	244.0	450

Desalination

The HTGR gas turbine waste heat is used to produce 340°F saturated steam in the helium precooler/steam generator (Figure D-4). The waste heat used for desalination is removed from the HTGR's helium cycle prior to compression and return to the HTGR core. The steam generated in the precooler/steam generator supplies heat to the multi-effect, multi-stage flash distillation plant (Figure D-5)(60).

The flash distillation unit generates pure water and brine. The brine could be further used as a primary mineral

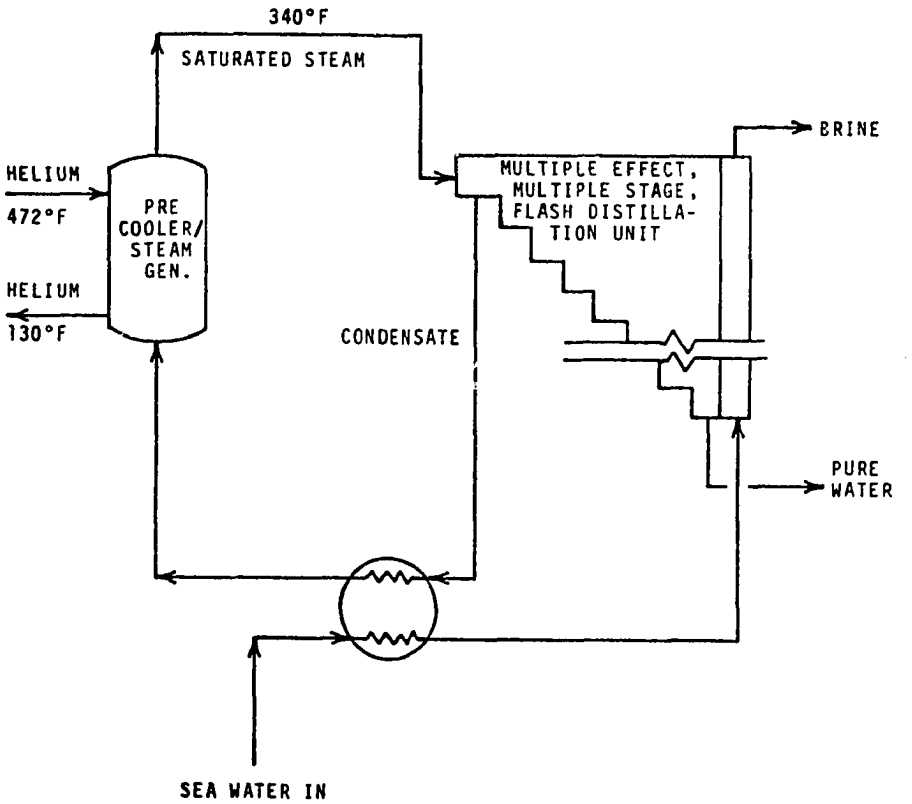


Figure D-4. Desalination Using HTGR Waste Heat.

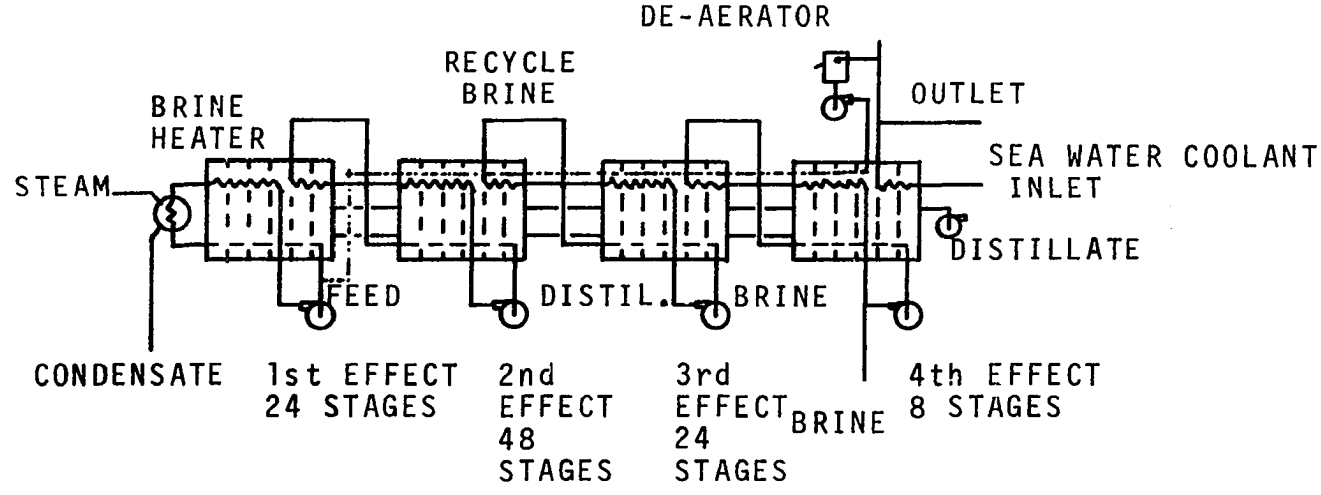


Figure D-5. Proposed Multi-Effect, Multi-Stage Flash Distillation Desalination Plant (11).

resource for an electrochemical plant for production of magnesium, sodium chlorate, chlorine and caustic. The pure water production is a function of net electrical power generated by the HTGR because the desalination plant energy supply is the gas turbine waste heat. The pure water production and electrical power requirements for the desalination plant are listed in Table D-3.

TABLE D-3

DESALINATION PLANT CHARACTERISTICS

Refinery Size	Net Water Production (10^6 gpd)	Electrical Power Requirements MW(t)
500,000 bpd	38.1	20.9
1,000,000 bpd	76.2	41.8

Integrated Nuclear/Petroleum/Water Energy Resources Facility

The integrated facility consists of the receiving port, the nuclear energy source, the petroleum refinery and the desalination unit. The energy balance for a 500,000 bpd/38 million gpd facility and for a one million bpd/76 million gpd facility are shown in Figures D-6 and D-7, respectively.

The capital costs involved in the construction of a 500,000 bpd energy resources center are shown in Table D-4 and for a 1,000,000 bpd in Table D-5. The capital costs are

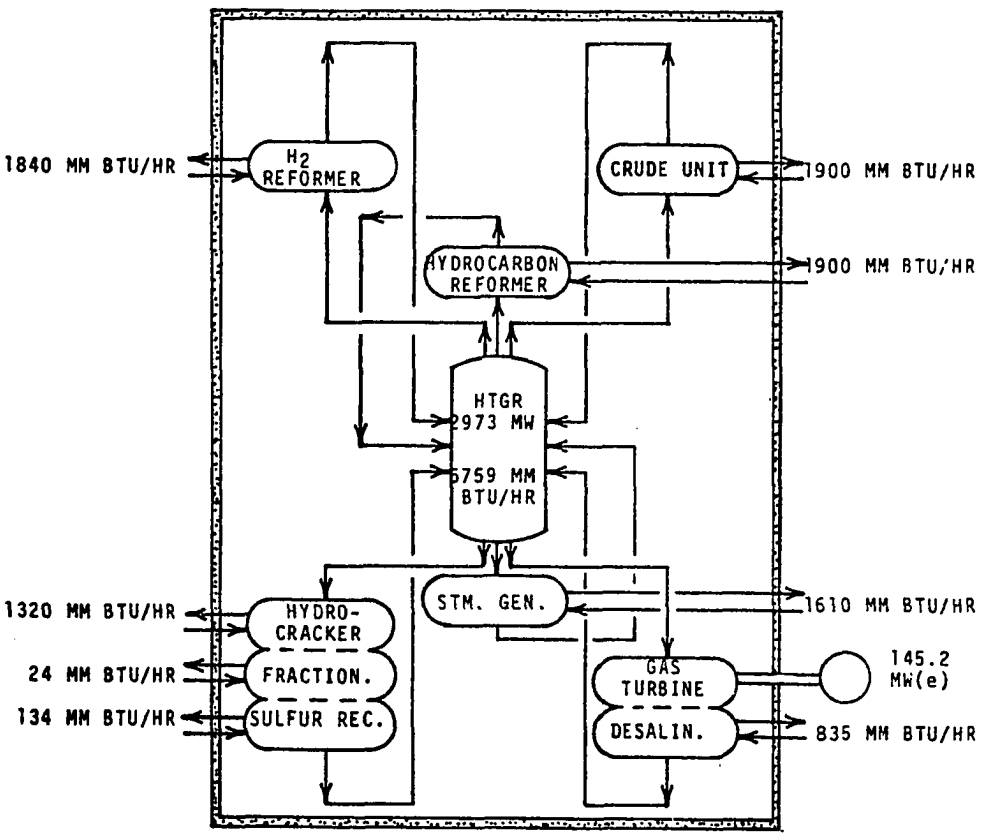


Figure D-6. Energy Balance for an HTGR-Crude Oil Refinery/Desalination Plant Based on 2,973 MW(t) and 500,000 bpd.

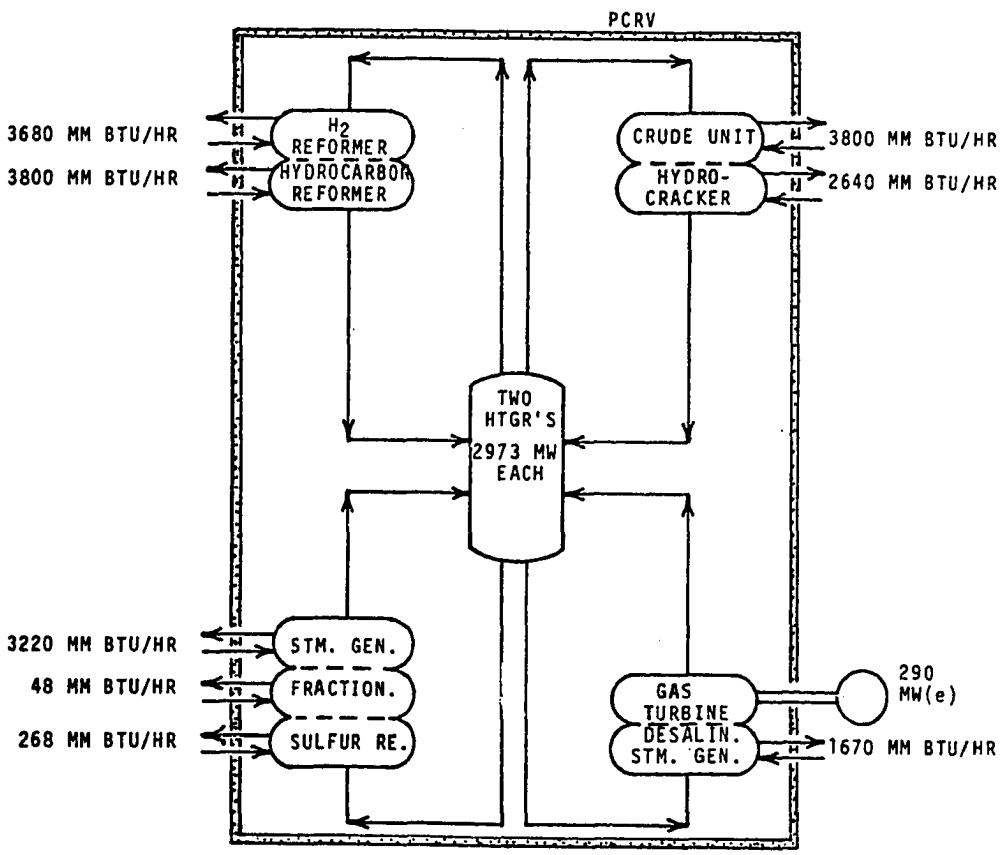


Figure D-7. Energy Balance for an Htgr/Crude Oil Refinery/Desalination Plant Based on Two 2973 MW(t) Reactors and 1,000,000 bpd.

TABLE D-4

CAPITAL COSTS FOR A 500,000 BPD ENERGY RESOURCES CENTER

Unit	Capacity	Unit Cost Millions 1970 Dollars
Nuclear Heat Source	2973 MW(t)	158.
Refinery	500,000 bpd	224.
Desalination	38.1 MMGPD	31.
TOTAL		413.

TABLE D-5

CAPITAL COSTS FOR A 1,000,000 BPD ENERGY RESOURCES CENTER

Unit	Capacity	Unit Cost Millions 1970 Dollars
Nuclear Heat Source (2)	5946 MW(t)	315.
Refinery	1,000,000 bpd	378.
Desalination	76.2 MMGPD	56.
TOTAL		749.

based on 1970 dollars. The nuclear heat source capital costs are based on separate 2973 MW(t) HTGR Plants (12, 26). Capital costs of the petroleum refinery are Nelson costs scaled as to size and inflated to 1970 dollars (48, 76). The capital costs of the desalination plants are determined by extrapolating 1970 cost data (60, 85).

Summary

A proposed crude oil refinery using a High-Temperature Gas-Cooled Reactor as its primary energy source can effectively increase the crude oil reserves by approximately 3.6×10^{15} Btu annually by 1985 (roughly reduce demand by 10 percent and add one year of reserves). The HTGR powered refinery would not only refine crude oil but it would also generate electricity, produce pure water from waste heat and provide natural gas for consumer use.

The proposed 500,000 barrel per day refinery located on the eastern or gulf coasts of the United States would produce 38.1 million gallons per day of pure water and 225 million standard cubic feet of natural gas in addition to the refined crude oil products from the 500,000 bpd refinery with a total capital cost of $413 million.

The proposed 1,000,000 barrel per day refinery would produce 76.2 million gallons per day of pure water, 244 million standard cubic feet of natural gas in addition to the refined crude oil products from the 1,000,000 bpd refinery with a total capital cost of $749 million.

The use of nuclear energy to convert crude oil resources to a usable form increases the crude oil refining thermal efficiency, reduces the crude oil throughput per unit product, increases the available energy from crude oil reserves and reduces the refinery's ecological impact on the environment.

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