Japan International Cooperation Agency (JICA)

The Organization for Energy Planning,
The Arab Republic of Egypt

THE STUDY
ON
BUILDING ENERGY-ECONOMIC MODEL
FOR
THE ARAB REPUBLIC OF EGYPT

FINAL REPORT
(Main Report)

January, 2001

The Institute of Energy Economics, Japan (IEEJ)

The Study on Building Energy-Economic Model for The Arab Republic of Egypt

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List of Abbreviations

CAIP	The Cairo Air Improvement Project
CAPMAS	Central Agency for Public Mobilization and Statistics
EEA	Egyptian Electricity Authority
EEAA	Egyptian Environmental Affaires Agency
EGPC	Egyptian General Petroleum Corporation
ERSAP	Economic Reform and Structural Adjustment Program
FEI	Federation of Egyptian Industries
GOFI	General Organization For Industrialization
IDSC	The Cabinet Information and Decision Support Center
IEA	International Energy Agency
IEEJ	The Institute of Energy Economics, Japan
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency
MOI	Ministry of Industry
MOP	Ministry of Planning
NREA	New and Renewable Energy Authority
OEP	The Organization for Energy Planning
WB	World Bank

1. Preface

1.1 Background and Objectives

1.1.1 Background

Egypt promulgated ERSAP (Economic Reform and Structural Adjustment Program) in 1991 and has since then promoted drastic structural adjustment and liberalization policies. These measures include an austere fiscal policy, a change in economic development from what was administered by the government to what was led by the private sector, an exchange rate stabilization policy, and a tight monetary policy. Due to these economic policies, stable economic growth was realized in the 1990s. The real economic growth between 1990 and 1996 recorded 4.2% and reached 5.7% in 1997. The economy of Egypt in the 1990s is characterized by higher growth in the private sector than the growth in the public sector--in other words, a private-led economic growth. Furthermore, the private sector yields higher labor productivity and plays a growing role in the entire business structure. On the other hand, revenues from oil exports and the Suez Canal are controlled by the government, keeping the public sector in an essential position. Egypt thus presents a mixed economy.

Noted in both ERSAP and the five-year plan for economic development, the energy sector has a critical need for policy decisions on prices of oil products and energy such as electricity and on subsidies in this field. The government is considering reducing energy-related subsidies, increasing domestic prices of oil products and natural gas to the level of international market prices as a measure to improve the fiscal balance, and reviewing the utility rate to make it consistent with generation and distribution costs. Such measures are expected to bring not only direct economic impact but also energy conservation effects (decrease in energy consumption) due to energy price adjustments (for increase). In addition, energy conservation and a decrease in domestic energy consumption can lead to an expansion in exportation of crude oil and oil products and will result in an improved fiscal balance. Another expected result from energy conservation is an enhancement of competitiveness in domestic industries.

Lately, the energy situation in Egypt has been changing dramatically. Stagnant oil production, development of gas fields, utilization of natural gas, and new energy use have encouraged the conversion from a crude oil and oil-product-oriented economy to a more diversified economy. In specific figures, crude oil production decreased from 44.3 million toe (MTOE) in 1994/95 to 40.1 MTOE in 1997/98 and to 39.3 MTOE in 1998/99. This is mainly due to the decrease in production by Gulf of Suez Oil Company, whose production accounts for 80% of the entire domestic crude oil production. On the other hand, natural gas production increased from 11.8 MTOE in 1994/95 to 12.4 in 1995/96 and to 16.2 MTOE in 1998/99. Natural gas is expected to become an essential resource in future energy supply. A power plant construction program with BOOT (Build, Own, Operate & Transfer) was introduced, and the construction of power plants with foreign capital is being promoted for future privatization. With regard to new energy, wind generation has been in experimental operation; the government is actively seeking new power sources.

1.1.2 Objectives and Targets of the Study

(1) Objectives

The objectives of the Study are to develop Energy-Economic models (short-term forecasting-simulation models) for Egypt to evaluate the impact of public energy policies on its economy and to transfer the technology for building and operating of these models. The models are expected to be a basis for national energy planning and to work toward a comprehensive plan for energy/economic development with targets to be met by the year 2004/5.

More specifically, the Study seeks mainly to develop econometric models for analyzing the impact of various policy variables, analyzing the correlation between energy and economy and forecasting energy demand. The Study also aims to prepare a supply optimization plan and to develop an analytical tool for evaluating energy consumption and its impact on the environment. The Study on model works is expected to reflect the interaction between energy sectors and the rest of economy and contribute to the handling of the issues of economic reform, energy conservation and environmental protection.

(2) Targets

According to the S/W and M/M signed between JICA and OEP on the 19th of May 1999, the major policy issues to be analyzed are summarized as shown in Table 1.1.1. These policy issues are also our output targets by energy economic model. These policy issues will be tackled with the consideration of the transitional characteristics of the Egyptian economy as described below.

a) Egypt is currently in a transition phase from a command economy to a market economy. The factors of changes in industrial structure and energy demand-supply structure in Egypt during this transitional period should be analyzed, and the study results should be applied to model building.
b) The impact of energy price fluctuation during the transition of the economy on the industry and economy should be quantitatively analyzed, and the analysis should contribute to the models for government policy making.
c) The impact of technical factors and policies regarding energy conservation and the environment on the energy sector or the entire economy of Egypt should be analyzed.
d) The impact of industrial and economic policy or energy policy with regard to the introduction of oil-alternative energy on energy demand should be analyzed, and the best mix of energy should be calculated from the models.

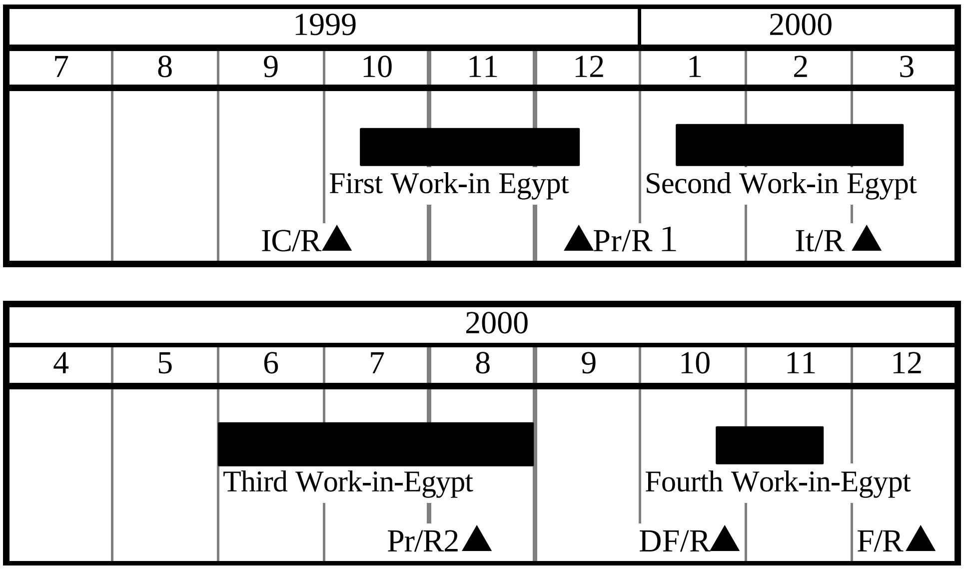
Table 1.1.1 Main Policy Issues to be Analyzed

No.	Policy issues	Analysis items
1	Energy pricing	a) Impact of rising domestic energy prices on demand pattern and economic growth (GDP) b) Impact of changes in world oil price on Egyptian economy c) Effect of ERSAP policy measures on domestic energy sector
2	Energy efficiency /conservation and environmental impact	a) Evaluation of technical change in energy production and consumption on production activities and economy b) Energy policy – efficiency interaction c) Air pollution and GHGs abatement measures.
3	Energy substitution	a) Impact of introduction of oil alternative energy resources on energy and socioeconomic indicators b) Effect of energy policies concerning natural gas and specific oil products c) Role of new and renewable energy resources in energy mix
4	Energy demand	a) Energy demand by scenario (economic policy) b) Energy for supplying fresh water (energy demand for desalination plants) c) The most advantageous energy mix for socioeconomic development

1.2 Study Schedule and Study Items

The Study is scheduled for 15 months , between October 1999 and December 2000. Figure 1.2.1 shows the overall work step in Egypt.

Figure 1.2.1 Flow Chart of the Study Schedule



(Note) IC/R : Inception Report
Pr/R1: Progress Report 1
It/R : Interim Report
Pr/R2: Progress Report 2
DF/R: Draft Final Report
F/R : Final Report

1.2.1 First Work-in-Egypt

The main tasks of the first work-in-Egypt (for two months, Ocober 17 – December 14, 1999) were 1) to explain and discuss the Inception Report, 2) to collect and review the exsisting information and data after the confirmation of study direction, 3) to analyze the current societal, economical and energy situations, and 4) to discuss the framework of each model. Also, the workshop for building and handling of the energy-economic model was held. The study results of this stage were summarized in the Progress Report 1.

(1) Explanation and Discussion on Inception Report
The Study Team presented and discussed the Inception Report with the Egyptian counterpart. The discussed results were summarized as M/M, and both parties confirmed it mutually. The Study Team also presented the technology transfer plan and brought about a better mutual understanding on the outline of the Study.

(2) Material Collection for the Study

Various materials and information needed for the study, especially related to model building, were collected.

(3) Analysis of the Current Societal, Economical and Energy Situations (1st Stage)

In order to understand the policies concerning society, economy and energy, the Study Team visited energy-related governmental agencies/institutions and typical plants (a power station and a oil refinery), in collaboration with OEP, as shown in Table 1.2.1.

Table 1.2.1 List of Visited Organizations

No	Date	Visited Organizations and Institutions
1	Nov. 3	New and Renewable Energy Authority (NREA)
2	Nov. 7	General Organization for Industrialization (GOFI, Ministry of Industry)
3	Nov. 7	Egyptian General Petroleum Corporation (EGPC)
4	Nov. 8	Egyptian Environmental Affaires Agency (EEAA)
5	Nov. 9	The Cabinet Information and Decision Support Centre (IDSC)
6	Nov. 9	Egyptian Electricity Authority (EEA)
7	Nov. 10	Central Agency for Public Mobilization and Statistics (CAPMAS)
8	Nov. 10	Ministry of Planning (MOP)
9	Nov. 11	Federation of Egyptian Industries (FEI)
10	Nov. 15	Shoubra El Khiena Power Plant (Cairo Electricity Company)
11	Nov. 18	Ameria Oil Refining Company (Alexandria)
12	Nov. 22	Tabbin Institute for Metallurgical Studies (Ministry of Industry)

(4) Workshop for Energy-Economic Model Building Concept

A one-week-workshop for model building concept was preceded with materials prepared in advance, and the contents were provided increase preliminary understanding and common recognition concerning methodologies of model building. The basic purpose of the workshop, which included both lecture and computer practice, was to introduce concept on energy models and to promote the mutual understanding between both sides. The computer practice used simple examples of econometric method/models, energy-demand forecasting models and supply planning models. The Study Team believes that the workshop was actually a computer-aided practice seminar, and all participants were able to visualize the model-building concept through this seminar. Table 1.2.2 shows the program description of the workshop.

Table 1.2.2 Program of Workshop for Energy Model Building (1st Work-in-Egypt)

Date	Time	Program
Oct. 31 (Sun)	9:00 –15:00	Introduction to Econometrics and Simple E
Nov. 1 (Mon)	9:00 –15:00	Introduction to Macroeconomic Models
Nov. 2 (Tue)	9:00 –15:00	Introduction to Energy Economics
Nov. 3 (Wed)	9:00 –15:00	Introduction to Energy Demand Forecasting Model Building
Nov. 4 (Thu)	9:00 –15:00	Introduction to LP Methods and LP Model Building

(5) Discussion on Framework of Models Concept
After the workshop on model building, the Study Team discussed with OEP Team regarding model framework/structure in a preliminary way.

(6) Explanation and Discussion on Progress Report 1
The Study Team presented and discussed the Progress Report 1 with the Egyptian counterpart. The discussed results were summarized as M/M, and both parties confirmed it mutually.

1.2.2 Second Work-in-Egypt

In this second work-in-Egypt (for two months, January 15 – March 14, 2000), database creation and energy-economic model building were tried. During the work, the Study Team also collected necessary data for the designs/development of models and database and data/information for the analyses of energy supply-demand structure. The framework of models and database were completed, and the analyzed results were summarized in Interim Report. The main tasks of the work were as follows.

(1) Analysis of the Current societal, Economical and Energy Situations (2nd Stage)
The current situation of socio-economics and energy supply/demand was analyzed. Historical data were collected and classified for the model building.

(2) Discussion and Analysis of the Energy Datsbase (1st Stage)
Items, year and accuracy of database were examined, and the gathered data were classified to meet database (Energy Balance Table).

(3) Development of Models (1st Stage)
Based on the data and information gatherd and classified, energy-economic models (macro-economy model, energy demand forecasting model and energy supply planning model) for Egypt were designed and developed.

(4) Workshop for Energy-Economic Model Building Concept
Model explanation/workshop for database creation and model building were held to increase preliminary understanding and common recognition concerning methodologies of model building. Table 1.2.3 shows the program description of the workshop.

Table 1.2.3 Program of Workshop for Energy Model Building (2nd Work-in Egypt)

Date	Time	Program
Feb. 9 (Wed)	10:00 –14:00	Energy Flow & Energy Balance Table
		Concept of Macroeconomic Model
Feb. 10 (Thu)	10:00 –14:00	Results of Factor Analysis
		Framework of Energy Supply Planning Model
Feb. 21 (Mon)	1o:00 –15:00	Practice of Macroeconomic Model
Feb. 22 (Tue)	10:00 –15:00	Practice of Macroeconomic Model
		Explanation of Energy Demand Forecasting Model
Feb. 23 (Wed)	10:00 –15:00	Explanation of Energy Supply Planning Model
Feb. 24 (Thu)	10:00 –11:30	Practice of Energy Demand Forecasting Model

(5) Explanation and Discussion on Interim Report
The Study Team presented and discussed the Interim Report with the Egyptian counterpart. The discussed results were summarized as M/M, and both parties confirmed it mutually.

1.2.3 Third Work-in-Egypt

In the third work-in-Egypt (for three months, June 6 - September 1), model building, simulation of models, making of manuals and the technology transfer concerning model building and operation are carried out. Technology transfer was especially stressed in this stage. Main tasks in this survey are as follows. The study results of this stage were summarized in the Progress Report 2.

(1) Analysis / Evaluation and Update of Database (2nd Stage)
Database creation was carried out continuously from the second work in Egypt.

(2) Development of Models (2nd Stage)
The most suitable Energy-Economic model for Egypt was developed continuously from the second work in Egypt. The models that were developed in this stage were simulated. Whether it was the most suitable model for Egypt or not was verified, and the model was corrected if necessary.

(3) Technology Transfer
The framework of tchnology transfer procedure was little changed and was concretely focussed on computer practice according to M/M, signed between OEP and JICA Study Team on the 12th of March 2000. The contents of the technology transfer include 1) the theories and concepts underlying individual models, 2) the tools and methods of model building, 3) the

technique of building the Energy-Economic model, 4) the energy database and the database development tool, and 5) the model and its maintenance.

Lecture and practice were given to the allocated counterparts by OEP (macroeconomic group, energy demand forecasting group, energy supply planning group and database group) during the seven-week (Third Work-in-Egypt). In general, model building for macroeconomic and energy demand forecasting models was based on econometrics method, and model building for energy supply model was based on mathematical method, requiring the knowledge of energy. The need for different background resulted in organizing two teams, which were an econometrics team, using "Simple-E" that was comprised of macroeconomics and energy demand forecasting groups and an engineering team using a LP tool that was comprised of energy supply planning and database groups.

Table 1.2.4 Curriculum for Technology Transfer (3rd Work-in –Egypt)

	Macroeconomic Model	Energy Demand Forecasting Model	Energy Supply Planning Model
1st week	Simple-E	Code name Agriculture sector	Guidance Coal flow
2nd week	Basic practice	Agriculture sector Industrial sector	Coal flow Gas flow
3rd week	Basic study	Industrial sector Residential/Commercial	Gas flow
4th week	Applied practice	Transportation sector Non-energy use	Total flow of energy system
5th week	Test of model	Simulation Conversion sector	Total flow of energy system
6th week	Simulation	Simulation Electricity sector	Simulation Prices & cost
7th week	Simulation	Total flow of model	Simulation

(4) Explanation and Discussion on Progress Report 2

The Study Team presented and discussed the Progress Report with the Egyptian counterpart. The discussed results were summarized as M/M, and both parties confirmed it mutually.

(5) Preparation of Model Manuals

The value of the model depends on an adequate operation as well as the design and the quality. Therefore, two kinds of manuals were prepared--1) the model manual, which describes the structure of the model and 2) an operation manual, which describes the maintenance/operation method and collecting data for model rolling

<Model manual>

The model manual addresses the content of the model.

a) Macroeconomic model

b) Energy demand forecasting model

c) Energy supply planning model

d) Environmental impact analysis model

<Operation manual>

The operation manual is a system manual including the model tool.

a) Simple E . operation manual

b) Large Scale LP operation manual

c) Database operation manual

1.2.4 Forth Work-in-Egypt

In the forth work-in-Egypt (for one month, October 23 – November 21), the Study Team submitted Draft Final Report and held the technology transfer seminar.

(1) Discussion of Draft Final Report

The Study Team presented and discussed the Progress Report with the Egyptian counterpart. The discussed results were summarized as the comments from OEP counterpart.

(2) Seminar for Technology Transfer of Energy-Economic Model Building

The seminar for model performance was held to increase mutual understanding concerning methodologies of model building and to expand the results to Egyptian public.

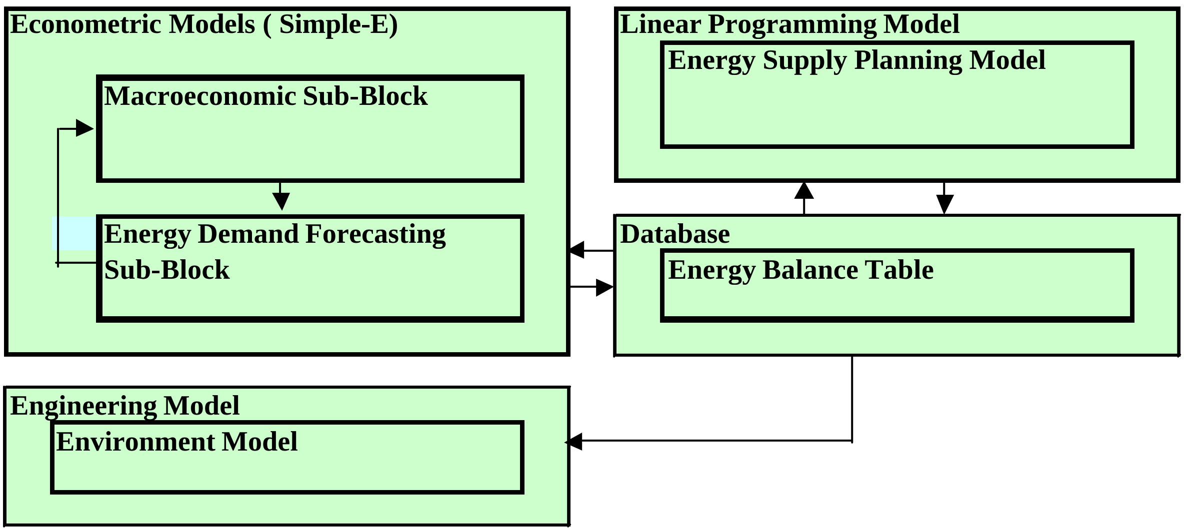
1.3 Configuration of Models

Figure 1.3.1 shows the configuration of an energy economic model. Models are comprised of a series of the Macroeconomic energy demand forecasting model (Macroeconomic-energy model), the Energy supply planning model, the Environmental impact analysis model and the Database. And models are categorized into the models to be developed by econometric tool (Macroeconomic model and Energy supply/demand model) and a model (Energy supply planning model) by linear programming tool.

Each model was developed separately. The Macroeconomic model and the Energy demand forecasting model were linked as one model system, which covers from final energy consumption to primary energy requirement. The Energy supply planning model is an optimization model to evaluate maximum benefit of the total energy supply system. As the Energy supply planning model involves objective function and constraints, the model is another model system for the Macroeconomic energy demand forecasting model. The Environment impact analysis model can link both the Macroeconomic energy demand and the Energy supply planning model through the Database as an interface.

The Macroeconomic energy demand forecasting model can simulate macroeconomic activities and energy demand by scenario. The Energy supply planning model receives the forecast energy demand and can simulate the best mix of energy to be the maximum benefit under the constraints of facilities' capacity. Both models can be used separately or simultaneously through the Database.

Figure 1.3.1 Block Diagram of Model Configuration



1.4 Steering Committee and Study Members

(1) Steering Committee (in Alphabetical Order)

Dr. Hani Alnakeeb	Chairman, OEP
Eng. Ismail Karara	Deputy Chairman, EGPC.
Eng. Mahmoud Zanoun	NREA, Chairman
Prof. Mohamd Hassan	Professor, Electric Department, Cairo University
Mr. Moustafa Mohamd Ahmed	Undersecretary for S/W Department, CAPMAS
Mr. Reda Awadallah	First Undersecretary, Ministry of Planning
Mr. Sherif Abou El-nasr	First Undersecretary, Ministry of Electricity & Energy

(2) OEP Study Team

Mr. Adel Mahmoud	Environmental Model
Mr. Tawfik Faik	Energy Supply Planning Model
Mr. Osama Kamal El-Din	Macroeconomic Model
Mr. Alaa Abu Samra	Macroeconomic Model
Ms. Neveen Hassan Ahmed	Macroeconomic Model
Ms. Sohair El-Tahawy	Energy Demand Forecasting Model
Mr. Kamal Moussa	Energy Demand Forecasting Model
Mr. Ahmed Roshdy	Energy Demand Forecasting Model
Mr. Alaa Taima	Database (Energy Balance Table)
Mr. Mohmed Khafagy	Energy Supply Planning Model
Mr. Wahid Roshdy	Database (Energy Balance Table)
Ms. Amal Hussin	Environmental Model / Database
Ms. Heba Atef	Environmental Model
Ms. Amany Nagy	Database (Energy Balance Table)
Ms. Shrouk Abdel Hameed	Energy Supply Planning Model

(3) JICA Study Team

Dr. Atsushi Fukushima	Team Leader, Energy Demand Forecasting Model
Dr. Kaoru Yamaguchi	Macroeconomic Model
Mr. Tomoyuki Inoue	Energy Supply Planning Model
Mr. Yoshihiko Kaneda	Database, Energy Balance Table
Mr. Toshiaki Yuasa	Environmental Model

2. Economy and Energy Demand in Transition

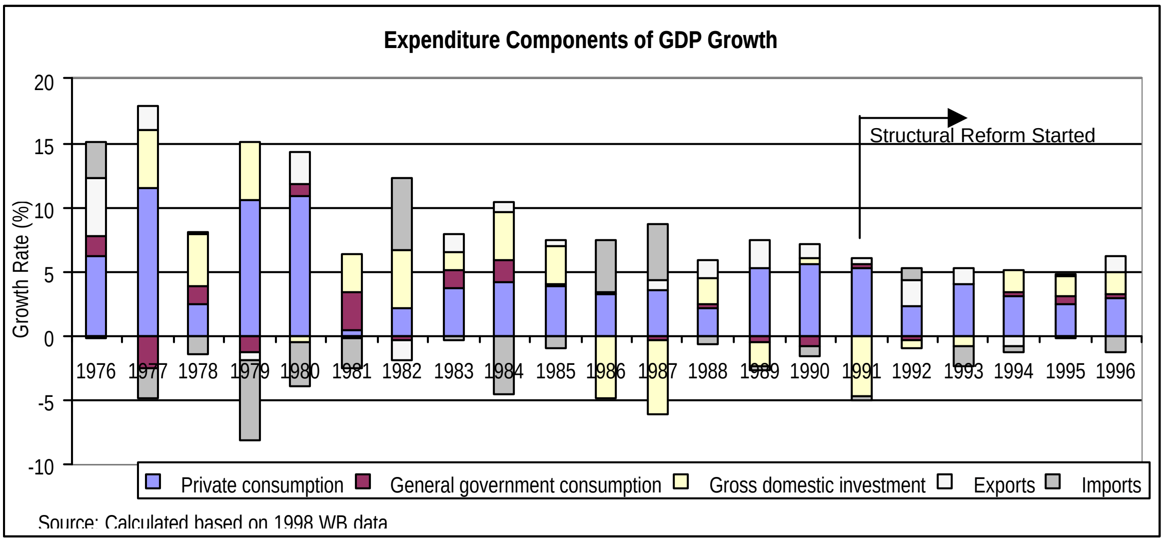
2.1 Economy in Transition

2.1.1 Historical Trends of Economy

Egypt is the most populous and the second largest economy among the countries of Arab world. Egypt is located in the centre of the Middle East, neighboring Sudan, Libya and Israel, and has traditionally played a leading role in the region. The Egyptian economy has passed through several stages since the 1952 Revolution. Under the leadership of Gamal Abdel Nasser, Egypt pursued an economic policy based on state-led growth. The nationalization of Suez Canal Company and the attack by Israel, France and the Great Britain in November 1956 led Egypt to build its public sector stronger. Banking, insurance, transportation, utilities, many hotels and department stores and significant trading operations were placed under state control. However, as Anwar Sadat succeeded the leadership in the early 70s, the policy took a big turn towards the reduction of the overblown public sector; he initiated the open door policy to encourage foreign and local investments. Although the role of the private sector increased as a result of this policy, the public sector remained as a dominant force, helped by the increased international crude oil prices. In 1981, President Husni Mubarak inherited the chronic problems of economic dependency in the public sector. The problem worsened as international crude oil price fell to the bottom. This situation led Egypt to embark upon an economic structural reform program in 1987.

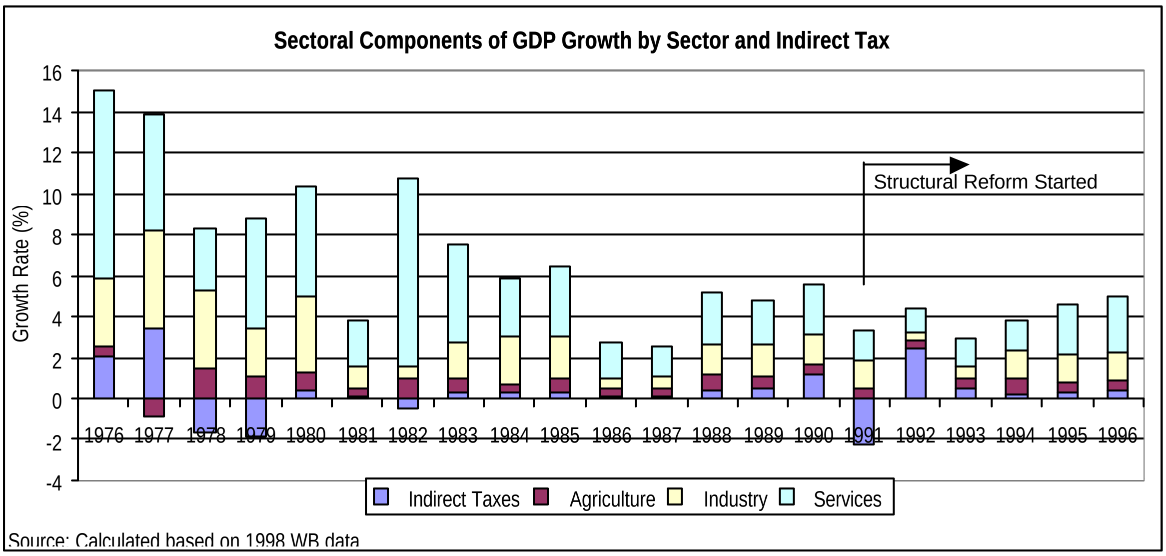
The next graph shows the contribution ratio of GDP growth from the point of expenditure. The period of high crude oil prices, between the mid 70s and the early 80s, could be characterized by the strong consumption and the strong investment. The imports and the government consumption were the major source of fluctuation. In the mid 80s, the international crude oil prices crashed. Since then, the decrease in investment and the weak government consumption were the characteristics until 1993.

Figure 2.1.1 Expenditure Components of GDP Growth



The next graph shows the sectoral contribution ratio of GDP growth. Through the whole period in the graph, the contribution of the service sector and the industrial sector is eminent compared to that of the agricultural sector. However, the contribution of the service sector and the industrial sector began to shrink in the early 80s and reached the bottom in 1987 just after the crash of the crude oil prices. The negative growth of indirect tax in the 1991 and the recovery in 1992 could be attributed to the introduction of sales tax to reduce the government budget deficit. The stable growth, although not strong compared to the past, seems to come back since 1993.

Figure 2.1.2 Sectoral Components of GDP Growth



These graphs show the stable growth trend since 1993. In fact, the phase I of the structural reform started in 1991. First, Egypt lifted most of the foreign exchange controls, unified the exchange rate, instituted sales tax, reduced the budget deficit, freed interest rates and began financing the deficit through Treasury bill auctions. Since then, a stable Egyptian pound (LE) exchange rate against the dollar and high interest rates have prompted “dedollarization” and fed a steady growth in the money supply.

At the same time, Egypt imposed strict fiscal and monetary policies. As a result, Egypt was able to reduce the inflation to approximately 7% from 25% in 1990. The budget deficit was reduced to 1% of GDP in 1997/98, down from 17% in 1990/1991. Furthermore, price controls on industrial products have been liberalized, except for some goods, such as pharmaceuticals, rationed sugar and edible oil. Now the level of energy prices reached to about 88% of the international level.

Based on the International Monetary Fund (IMF) and World Bank programs, the banking and capital markets have also been reinvigorated and liberalized. Then in 1993, when the phase II of structural reform began, IMF Extended Fund Facility Agreement was renewed, concentrating on further structural reforms. In early 1996, following the creation of a new Cabinet, Egypt entered a critical new phase of economic reform (phase III). The focus was on improving Egypt's export competitiveness, liberalizing its trading regime by encouraging the private sector, eliminating obstacles for doing business in Egypt and improving Egypt's investment climate.

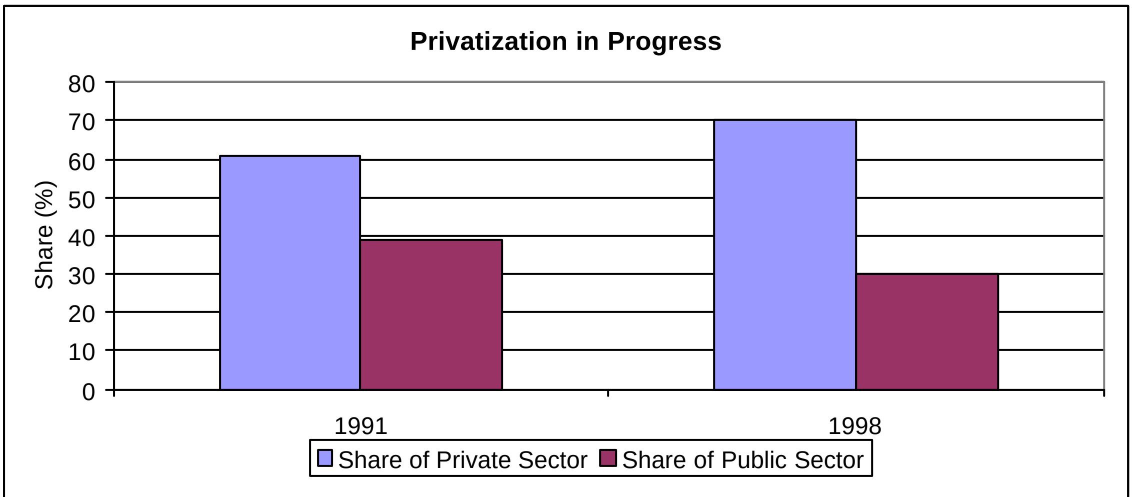
2.1.2 Characteristics of Economic Structure

(1) Characteristics of Economic Structure

Until the early 90s, the economy was led by state and characterized by the large public sector. While the price of crude oil was high, the state could lead the investment needed for growth. Recent economic performances show that the structural reform program is reducing the chronic problems in the economy, including the inefficiency caused by the public sector, budget deficit, trade deficit and unemployment.

The Figure 2.2.1 shows the progress of privatization. The Figure 2.2.2 shows the chronic deficit of trade balance although it is improving compared to the 80s. The Figure 2.2.3 shows that, although privatization is proceeding, the private shares of some sectors, including petroleum, electricity, Suez Canal, finance and insurance, are still less than half.

Figure 2.1.3 Privatization in Progress



Source: Ministry of Planning

Figure 2.1.4 Chronic Trade Deficit

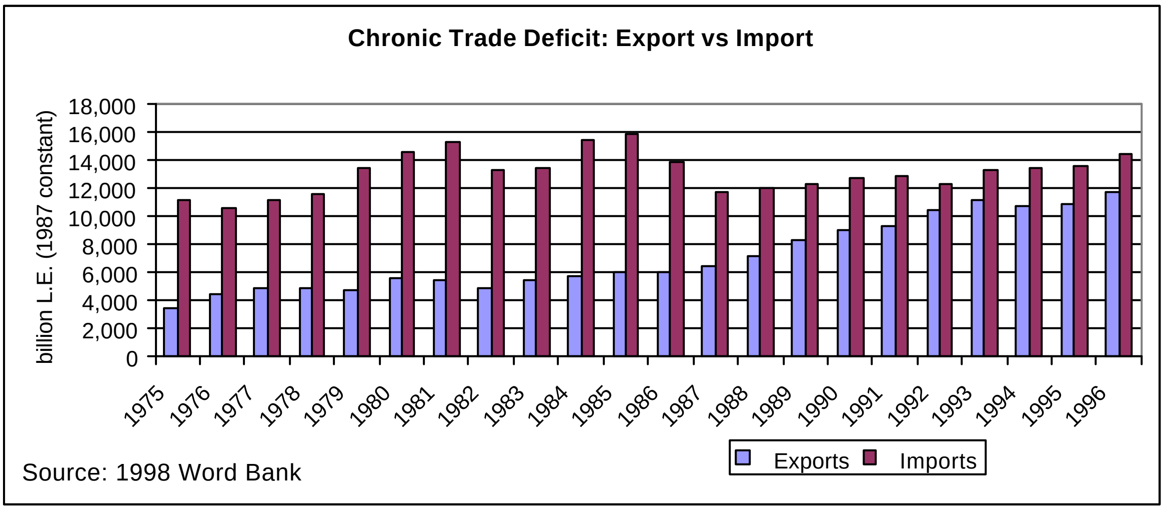
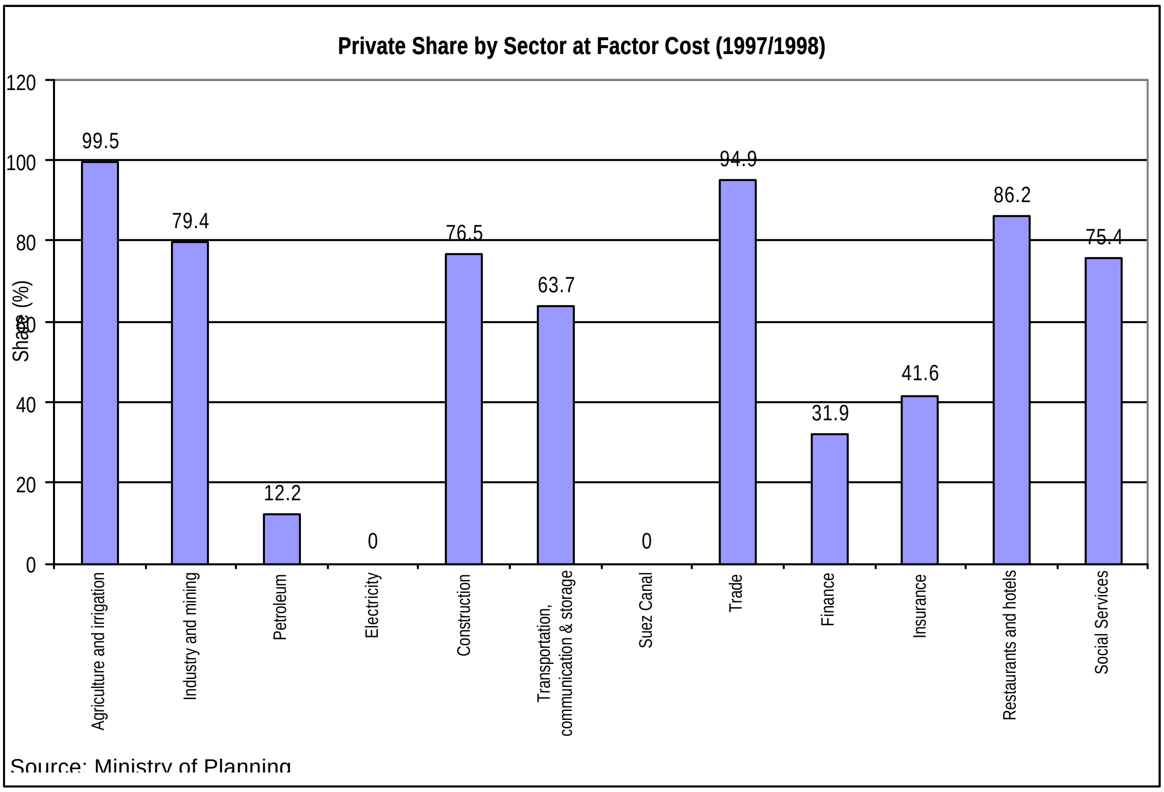


Figure 2.1.5 Private Share by Sector



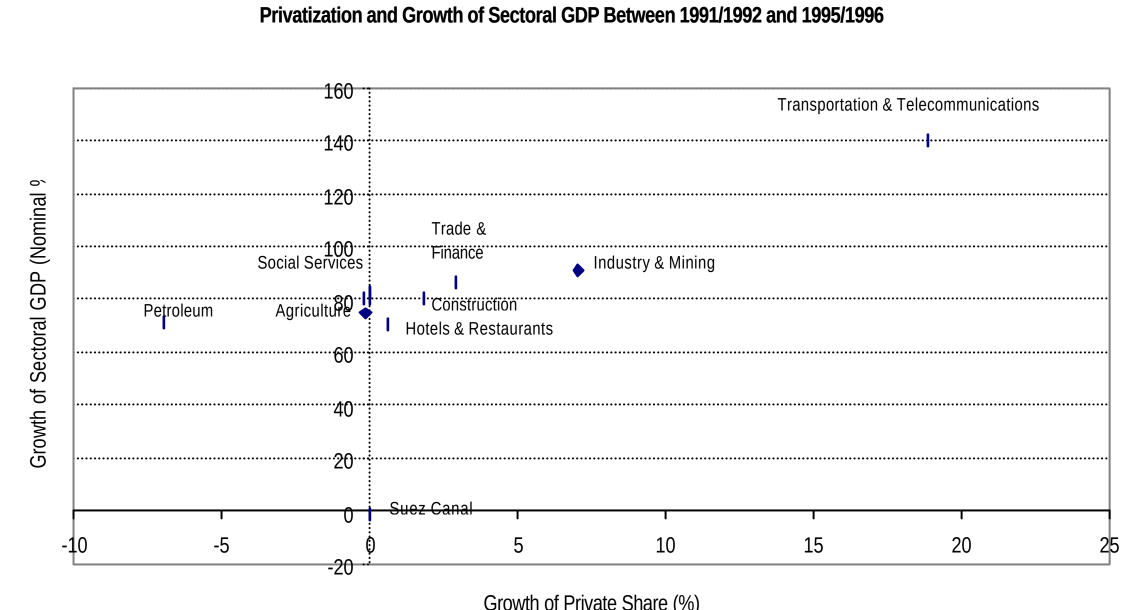
(2) Elements of Economic Reform

As such, the structure of Egyptian economy is currently in transition. The primary elements of such changes include 1) privatization, 2) exchange rate reform, 3) structural reform and 4) debt management reform.

1) Privatization

In 1993, 314 public sector enterprises were organized into 17 holding companies, which were permitted to sell, lease or liquidate company assets and sell government-owned shares. According to an estimate by the government, the state enterprise sector's book value amounts to LE 90 billion ($27 billion). What seems to push through the core of the reform is Egypt's commitment to privatization. As the next figure shows, the sector of faster privatization achieved faster growth.

Figure 2.1.6 Privatization and Growth of Sectoral GDP



Source: Minisry of Planning

2) Exchange Rate Policy

In November 1991, Egypt adopted a free market exchange system, subject only to the buying and selling intervention by the Central Bank. High interest rates and stable exchange rates have stimulated large capital inflows. To encourage foreign investment, the Parliament passed a bill in June 1996, amending the banking law to allow foreign ownership to exceed 49 percent in joint venture banks, thus encouraging greater competition. In July 1996, another bill eliminated the five-year repatriation restriction on sales proceeds of Egyptian real estate owned by foreigners residing outside Egypt.

3) Structural Policies

The Egyptian government deregulated all industrial prices except for pharmaceuticals, cigarettes, rationed sugar and rationed edible oil. It still subsidizes mass-consumption of bread. Prices of energy, transportation and water are still expected to remain administered. However, the price increases have brought domestic petroleum product prices to about 88 percent of international prices and electricity prices to about 77 percent of long-run marginal costs (Ministry of Planning).

Egypt instituted a general sales tax (GST) in May 1991, but the tax is currently applied to importers and manufacturers only. Fear of social unrest has made the government reluctant to develop the GST into a full value-added tax. A unified income tax has been adopted to reduce marginal tax rates, simplify the tax rate structure and to improve administration of tax policy.

4) Debt Management Policies

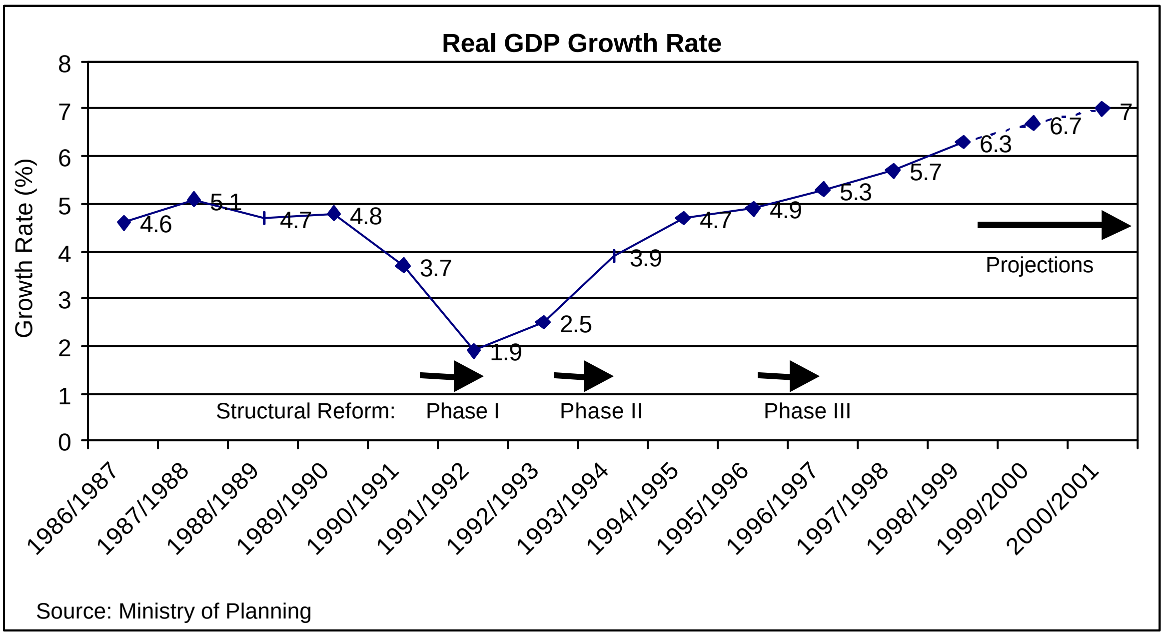
In early 1991, official creditors in the Paris Club agreed to reduce the current net value of Egypt's official debt by 50 percent. At about the same time, the United States relinquished $6.8 billion of high-interest military debt in appreciation of the Egyptian contribution to the Gulf War. As a result, Egypt's total outstanding medium-term and long-term debts have declined, and debt service payments have been reduced to around 10 percent from 46 percent of export earnings. The reduction in debt service bill has helped Egypt reduce the budget deficit dramatically, create macroeconomic stability and build a higher level of reserves.

These policies are based on four interconnected pillars that feed with one another to achieve the nation's huge potential--investment, savings, institutional reform and export promotion. In fact, there are scores of indicators that show improved economic performances. The inflation rate was brought down to 6.4% in 1996/97 from 21% in 1991/92. Foreign exchange reserves and the bank deposits increased. Moreover, the state budget deficit dropped to less than 1% of Gross National Product (GNP) in 1996/97 from 17% in 1990/91. Furthermore, Egypt's long-term and medium-term debts dramatically dropped by 50%.

2.1.3 Current Situation and Subjects for the Future

Omitting informal sectors that may account for 30%-50% of economic activities, Ministry of Planning reported a faster real GDP growth of 5.7% in 1997/98, up from 5.3% in 1996/97. (See next figure) The Egyptian economy is estimated to expand at 6.3 % in 1998/1999.

Figure 2.1.7 Real GDP Growth Rate and the Projections



This recent economic achievement was accomplished within the framework of an integrated, phased and gradual economic reform programs. As shown in the graph, its phase I started in 1991. Phase II started in 1993, when the real balance in financial and economic structures was achieved. Phase III of economic reform started in October 1996. Its objective was to increase growth rates and to reduce unemployment and inflation rates without losing foreign exchange reserves. It emphasized the stability and the expansion of structural reforms through privatization and liberalization of trade.

As one guideline to challenge these subjects of the future, the Egyptian Cabinet summarized the future strategy in its *Development Strategy Outline* of "Egypt & 21st Century." Its extraction was quoted here as follows.

＜**Development Strategy Outline**＞

(Extraction: Format modified from "Egypt & 21st Century")

The successful completion of the economic stabilization stage was the real breaking point for the Egyptian economy. It was inconceivable for the country to proceed towards an export-oriented economy, operating along free market rules, until a reasonable progress has been made in deregulating old administrative and legislative infrastructure, restructuring the economy and reforming macro-economic indicators under three consecutive five year plans from 1982 to 1997.

Without the necessary preparations already carried out over the last fifteen years, the ambitions, which have been, until the near past, mere wishful thinking could have come true.

1) Generate employment opportunities to accommodate new comers to the labour market.
2) Provide channels of communication and interaction between Egyptian and world economies.
3) Build partnership relationship based on mutual understanding and trust between the government and the private sector.
4) Provide an Egyptian product, compliant with international quality standards, and capable of penetrating non-traditional markets under severe competitive conditions.

It follow, therefore, that pre-requisites have been fully met for comprehensive development phased out in four successive 5-year plans covering a period of 20 years up to 2017. These plans seek to achieve a package of goals, through a physical and development strategy. This strategy is translated into an investment map for Egypt taking into consideration various economic, demographic, social and regulatory criteria. This map seeks to coordinate various elements of physical development by taking into account available and potential resources in the promising regions of Egypt, for optimum utilization. It also seeks to find elements of attraction to redistribute population in accordance with the expected growth elements in the new regions.

These objectives are as follows.

1) Extend the scope of development to the entire area of the country, explore its wealth and provide opportunities for settling millions of Egyptians outside the narrow valley, which accounts for maximum 5.5% of the total area of the country, thus raising the ratio of inhabited space to 25%. The next twenty years represent an important phase for such expansion. Areas rich in national resources are to be opened, and increasingly utilized, population is to be settled down at locations that will be integrated and interlinked in the long run.

2) Based on the national assets accumulated over years, raise growth rate from the annual average real growth rate prevailing during the last 15 years of approximately 4.8% to an annual average of approximately 6.8% over the fourth 5 year plan (1997-2002), then to an annual average of 7.6% over the following 5-year plans up to 2017.

3) Redouble GNP once each ten years, to reach in 2017 more than fourfold its present level, i.e. from approximately LE 257 billion ($US 76 billion) at present to LE 1,100 billion (about $US 324 billion) at the end of the 7th 5-year plan in 2017. Raise per capita share of GNP from its present level of about LE 4,270 to at least LE 13,750 in 2017.

4) Accelerated development allows trade deficit to be managed so that improvement will start from the fourth 5-year plan, reaching break-even point at the end of the fifth, scoring a remarkable surplus during the sixth, and a substantial surplus in the seventh, while achieving a current and gross surplus in the balance of payments throughout all coming plans.

5) Strive to develop a package of flexible economic, financial, and monetary policies, to accommodate changing conditions and bring inflation down to minimal possible levels, which should not exceed 5% per annum in spite of rising growth rate.
Endeavor to achieve a balanced general budget, by gradually bringing about a continuing and growing surplus, in the framework of an economic stability that provides the best climate for productive development, i.e. to expand production bases and services at growing rates, which will lead, in turn, to stable local currency rates against foreign currencies, taking into account interactive market forces.

6) Approximately 550,000 employment opportunities are planned to be generated in order to accommodate annual increase in population and detract from the balance of employment until it reaches zero point at the end of the fourth 5-year plan (1997-2002). With the employment of 97-98% of the workforce, unemployment will not be allowed to accumulate. In other words, manpower is expected to rise from its present level of 15.8 million to 26.8 million at the end of the seventh 5-year plan in 2017.

To realize these goals, an annual average investment of at least LE 100 billion is required over the next 20 years. At least 25% of GNP will be required to meet such volume of investments.

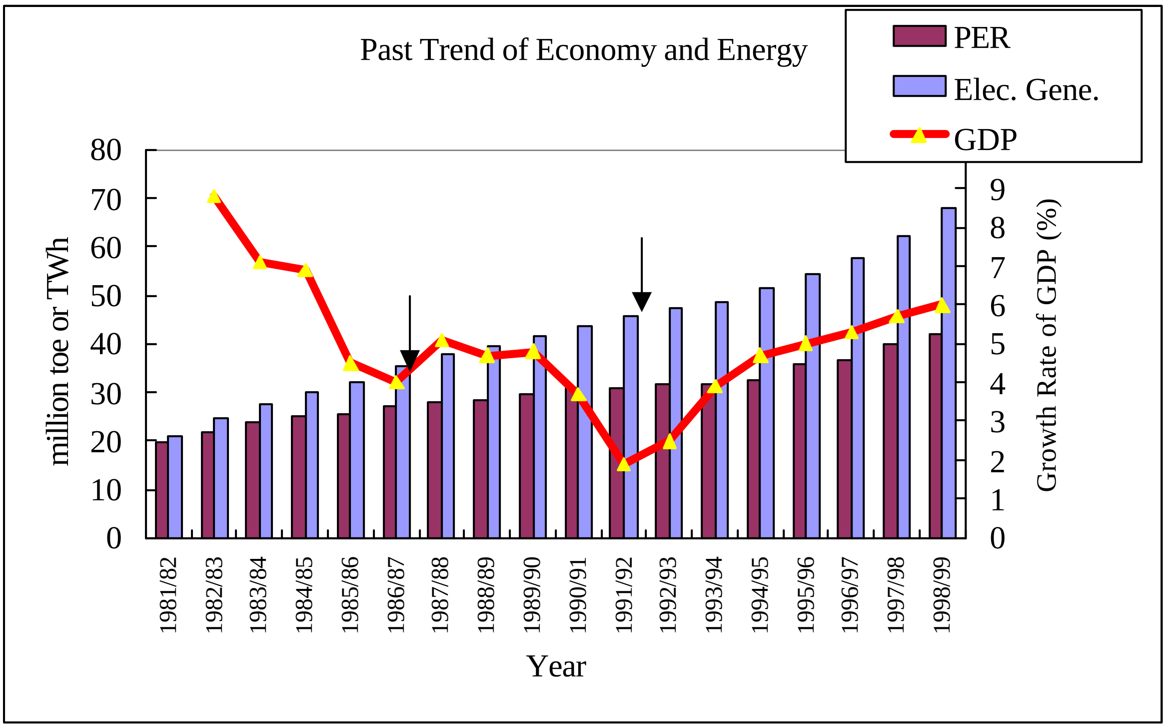
2.2 Turning Point of Economy and Energy Supply/Demand

2.2.1 Historical Trends of Economy and Energy

(1) GDP

Figure 2.2.1 shows historical trends of Egyptian economy and energy. In the figure, polygonal line means annual growth rate (%) of GDP and bar graphs mean primary energy requirement (PER, million toe) and electricity generation (Elec. Gene., TWh). As for the GDP trend, we can find two turning points, the first of which occurred in 1986/87 and the second in 1991/92, when Egypt promulgated ERSAP (Economic Reform and Structural Adjustment Program).

Figure 2.2.1 Historical Trend of Economy and Energy



(2) Energy Supply and Demand

Figure 2.2.2 shows annual growth rates (%) of primary energy requirement (PER), electric power generation (Elec. Gene.) and consumption (Elec. Cons.). The turning points, corresponding to GDP growth's change, seems to trail GDP trend by about two years. The points, in 1988/89 and 1993/94, are sometimes used as the beginning year of observation period for regression analysis of model building.

Table 2.2.1 shows average annual growth rates of GDP and energy supply/demand for the periods of 1981/82 - 1986/87, 1986/87 - 1991/92 and 1991/92 – 1998/99. Elasticity with respect to GDP is also shown in the Table. In general, the 1981/82 - 1986/87 period indicates the structure of over-consumption of energy, and the next 1986/87 - 1991/92 period was the adjustment period for energy conservation or energy efficiency. And from 1991/92, energy supply and demand structure moves toward reconstruction, especially in the electricity sector.

Figure 2.2.2 Annual Growth Rate of Primary Energy and Electricity Requirement

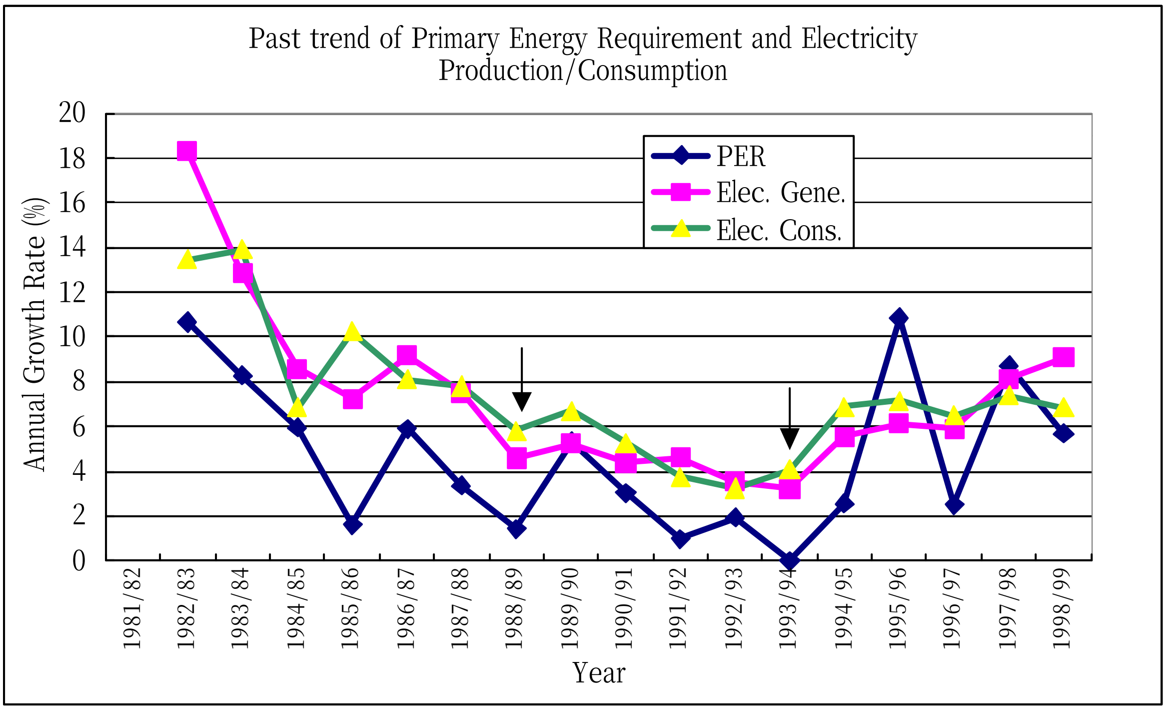


Table 2.2.1 GDP Growth Rate and Elasticity to GDP

	1981/82-86/87	1986/87-91/92	1991/91-98/99
Growth rate (%)			
GDP	6.24	4.03	4.72
Primary Energy Requirement (PER)	6.43	2.81	4.54
Final Energy Consumption (FEC)	7.21	2.30	4.63
Electricity Generation	11.15	5.26	5.91
Electricity Consumption	10.46	5.86	5.99
Elasticity to GDP			
Primary Energy Requirement (PER)	1.03	0.70	0.96
Final Energy Consumption (FEC)	1.15	0.57	0.98
Electricity Generation	1.79	1.30	1.25
Electricity Consumption	1.68	1.45	1.27

2.2.2 Domestic Energy Price

Before 1988/89, domestic energy prices had been kept constant and lower than supply costs because of the government subsidies. Then, the energy prices rose rapidly during 1988/89 – 1993/94 due to the new energy price policy that shifted to a market economy.

(1) Nominal Price

Figure 2.2.3 shows the trends of electricity prices in each sector. From the upper side, the polygonal lines show prices for the commercial sector, the government/public sector, the industrial sector, the agricultural sector and the residential sector. Price for the commercial sector was 4.56 PT/kWh in 1986/87 and multiplied by 6.3 times to 28.89 PT/kWh in 1993/94. During the same period, price for the industrial sector increased from 2.16 PT/kWh (1986/87) to 13.27 PT/kWh (1993/94), which is 6.1 times of 1986/87. The agricultural sector jumped from 2.25 PT/kWh to 11.46 PT/kWh (5.1 times) while the residential sector rose from 2.41 PT/kWh to 8.39 PT/kWh (3.5 times). The government/public sector also rose from 3.36 PT/kWh to 22.55 PT/kWh (6.7 times).

Figure 2.2.4 shows the trends of fuel prices. The polygonal lines show price of gasoline, kerosene, diesel oil, LPG, natural gas, fuel oil, from the top. Prices of kerosene and diesel oil and prices of natural gas and fuel oil follow a similar trend, respectively. Price of gasoline was 355 LE/toe in 1986/87 and increased to 1305 LE/toe in 1993/94, which is about 3.7 times. During the same period, price of kerosene jumped from 37.8 LE/toe to 504 LE/toe (13.3 times), diesel oil from 36 LE/toe to 504 LE/toe (14 times), fuel oil from 7.5 LE/toe to 130 LE/toe (17.3 times), LPG from 52 LE/toe to 200 LE/toe (3.8 times) and natural gas from 8.7 LE/toe to 152 LE/toe (17.5 times).

Figure 2.2.3 Historical Trend of Electricity Prices (Nominal)

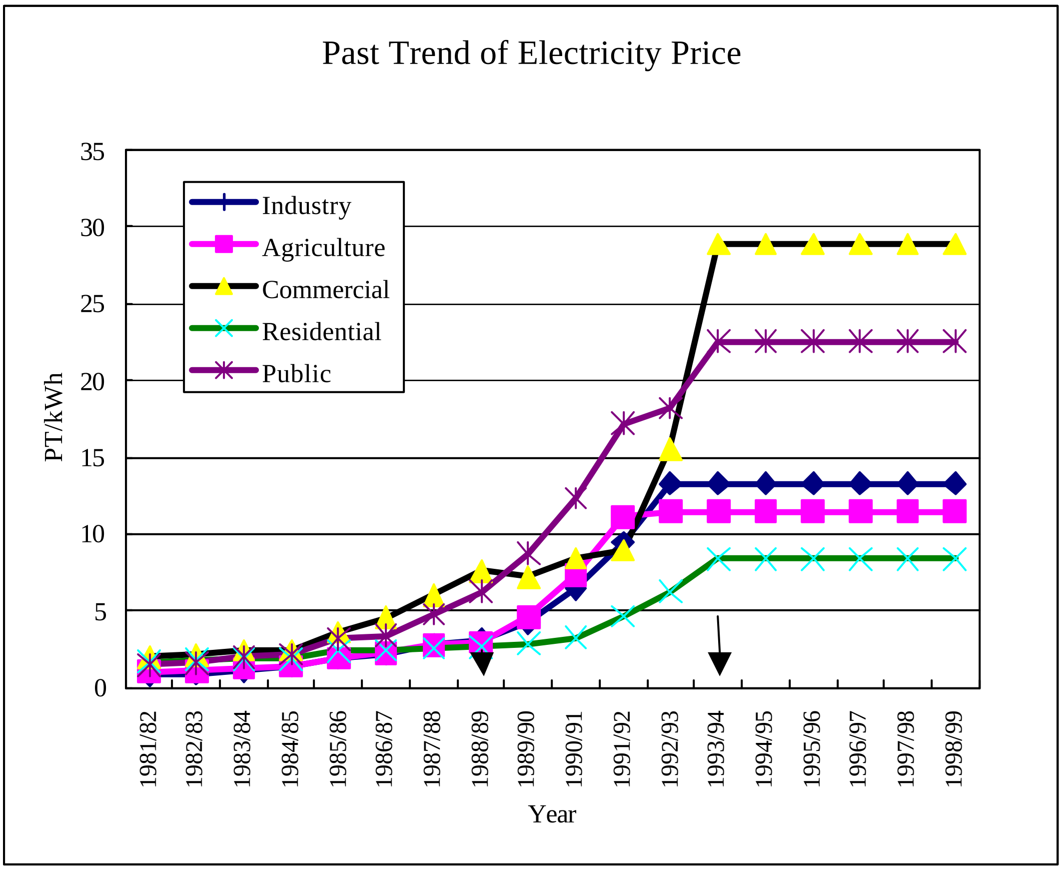
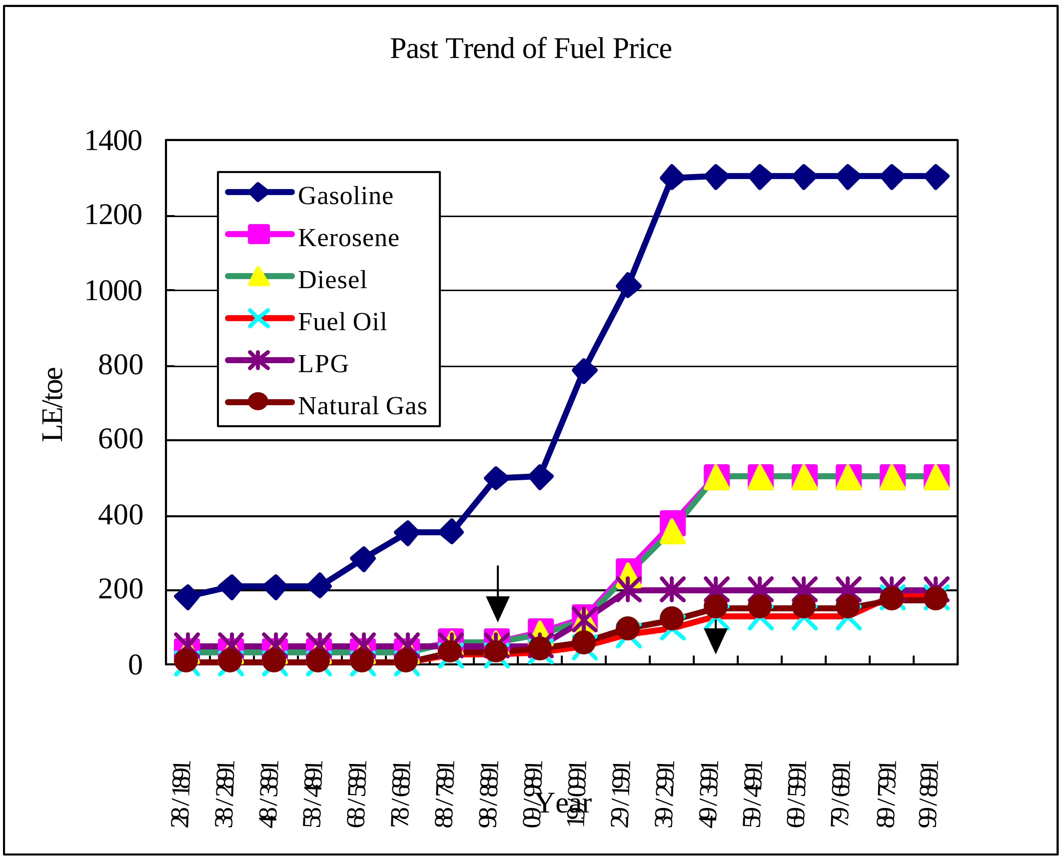


Figure 2.2.4 Historical Trend of Fuel Prices (Nominal)



(2) Real Price

While energy prices rose in the period of 1988/89–1993/94, the wholesales price index (WPI) increased 1.9 times, from 43.1 to 82.3, and the consumer price index (CPI) increased 2.1 times, from 37.1 to 77.2. Figure 2.2.5 shows trends of WPI and CPI (1996/97's value for both is 100). Both indicators have a similar tendency, with the growth rates of 17 % (WPI) and 16 % (CPI) during 1986/87–1993/94. During the period of 1993/94–1997/98, the annual average growth rates were 5 % (WPI) and 7 % (CPI) respectively. The relative prices (real price) of electricity and fuels are indicated in Figures 2.2.6 and 2.2.7.

Figure 2.2.5 Historical Trend of WPI and CPI

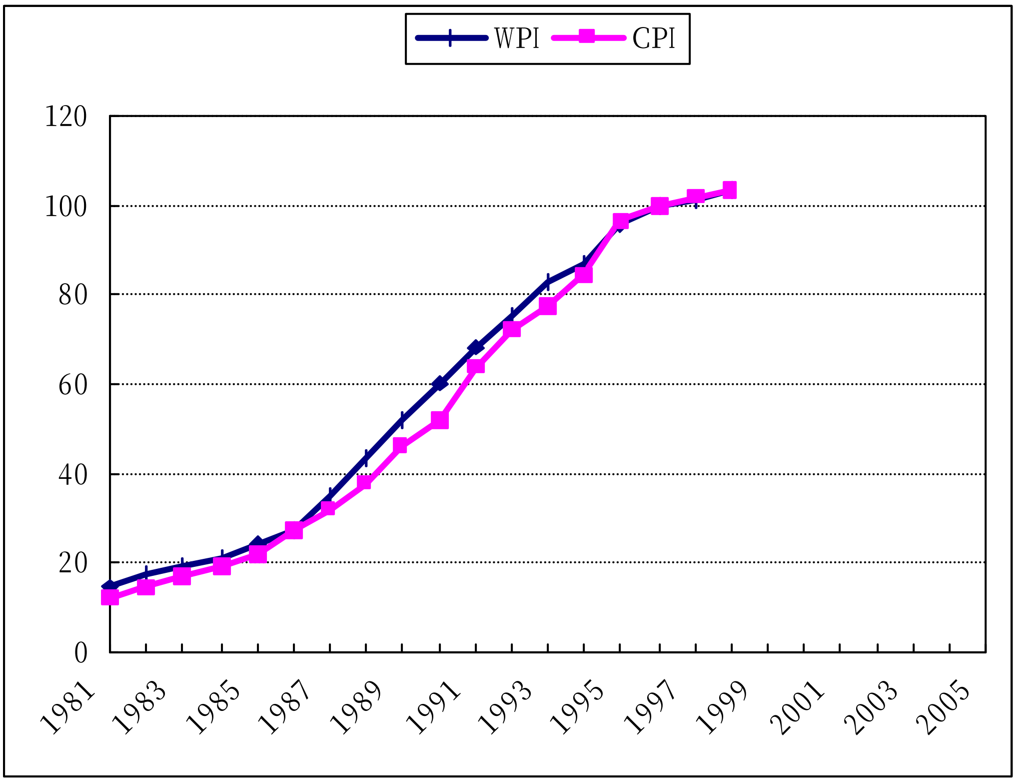


Figure 2.2.6 Historical Trend of Electricity Prices (Real)

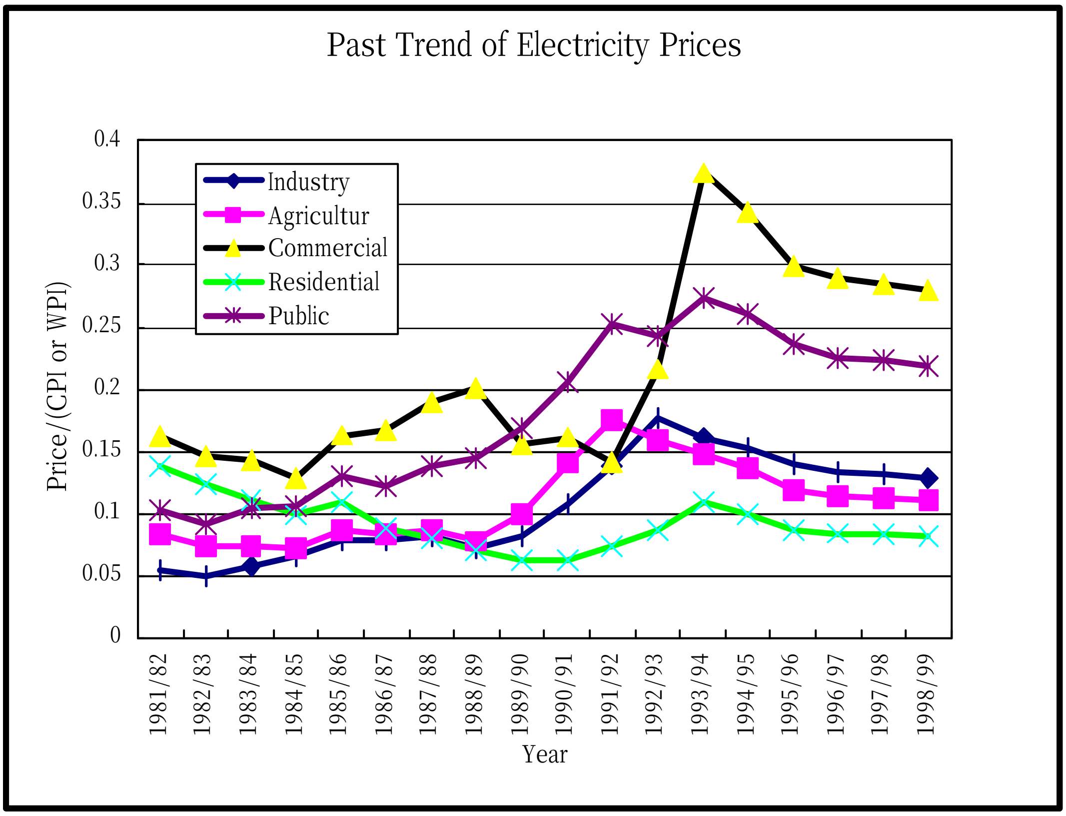
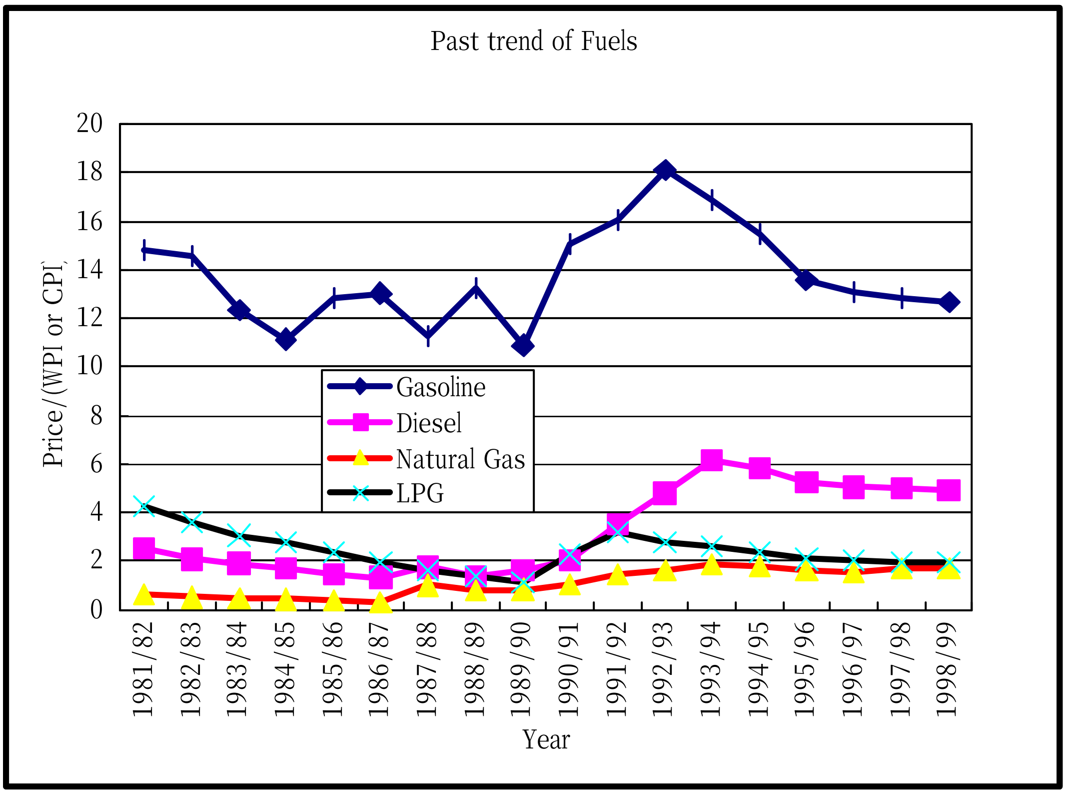


Figure 2.2.7 Historical Trend of Fuel Prices (Real)



2.2.3 Factor Analysis on Demand Contributor

(1) Factors behind the Increase of Energy Demand

We attempted to analyze the increase of primary energy requirement with three factors: 1) energy intensity per GDP, 2) GDP per capita, and 3) population. The energy intensity per GDP represents the energy volume required to produce a certain amount of added value. GDP per capita represents the economic level (not economic size). In general, decreasing tendency means an improvement of the energy efficiency or productivity. An increase in GDP per capita and population pushes up the energy demand. The formulas for analysis are as follows.

Fundamental Formula $E = I*G*P$ $(E = (E/GDP)*(GDP/P)*P)$

Where, E=Energy Consumption

I=E/GDP (Energy Intensity Factor)

G=GDP/capita (Economic Growth Factor)

P=Population (Population Growth Factor)

Equation for Factor Analysis

$$dE = dI*(E/I) + dG*(E/G) + dP*(E/P)$$

dE	Incremental Energy Consumption
dI*(E/I)	Increase/Decrease Factor due to Changes of Energy Intensity
dG*(E/G)	Increase factor due to Economic Growth
dP*(E/P)	Increase factor due to Population Growth

or $\triangle E = \triangle I*(E/I) + \triangle G*(E/G) + \triangle P*(E/P) + \text{Residual}$

or $\triangle E = \triangle I*G*P + I*\triangle G*P + I*G*\triangle P + \text{Residual}$

Figure 2.2.8 shows the historical trend of each factor's contribution. We cannot identify a rapid change in the Figure. However, the intensity factor has a tendency to decrease after 1994/95. Figure 2.2.9 shows the factors' contribution to primary energy requirement during each observation period--1981/81-1988/1989, 1988/89-1993/94 and 1993/4-1998/99. We can see the intensity improvement in the last period (latest five year) in the Figure. On the other hand, in the electric power sector, we can see the intensity improvement in each period as shown in Figure 2.2.10.

Figure 2.2.8 Factors behind the Increase of Primary Energy Requirement

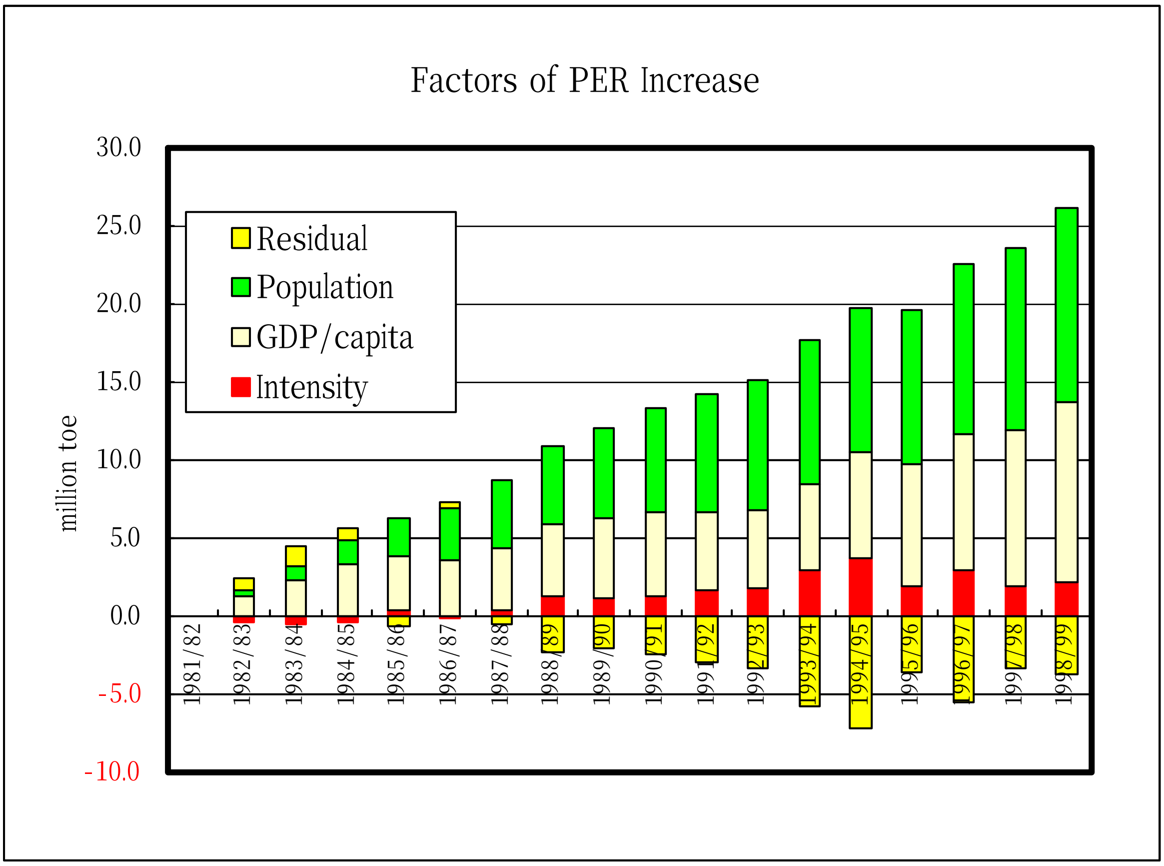


Figure 2.2.9 Factor's Contribution to Primary Energy Requirement by Period

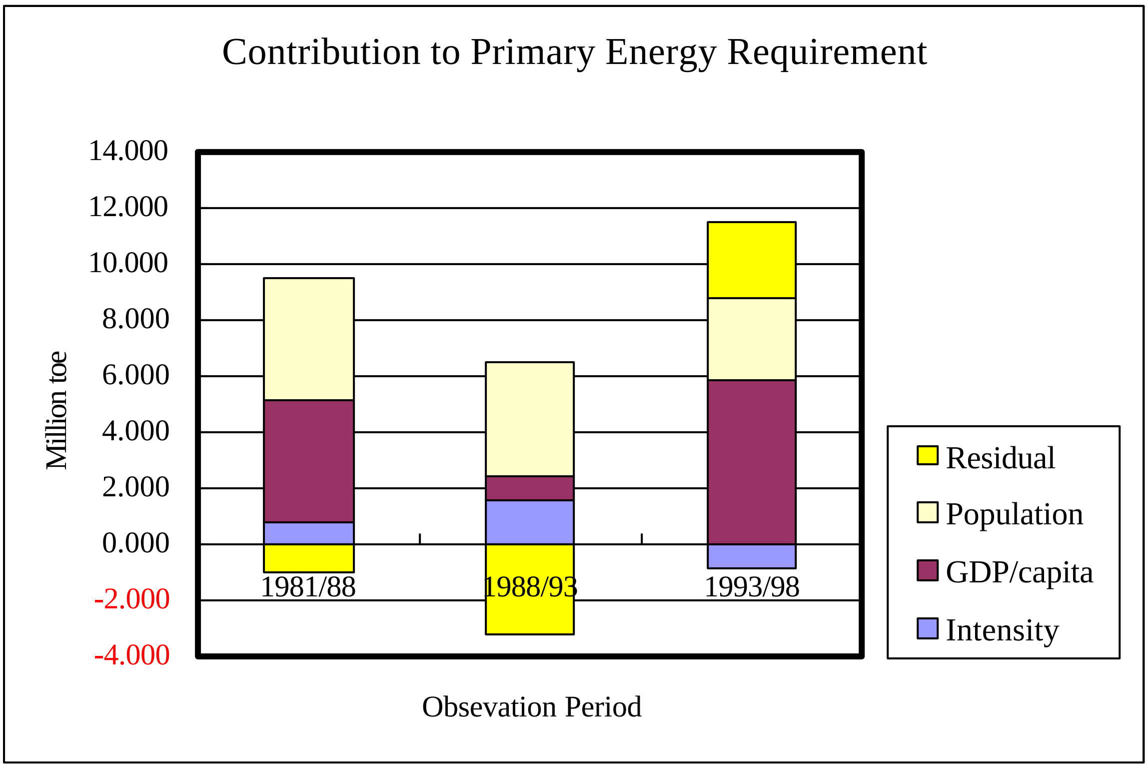
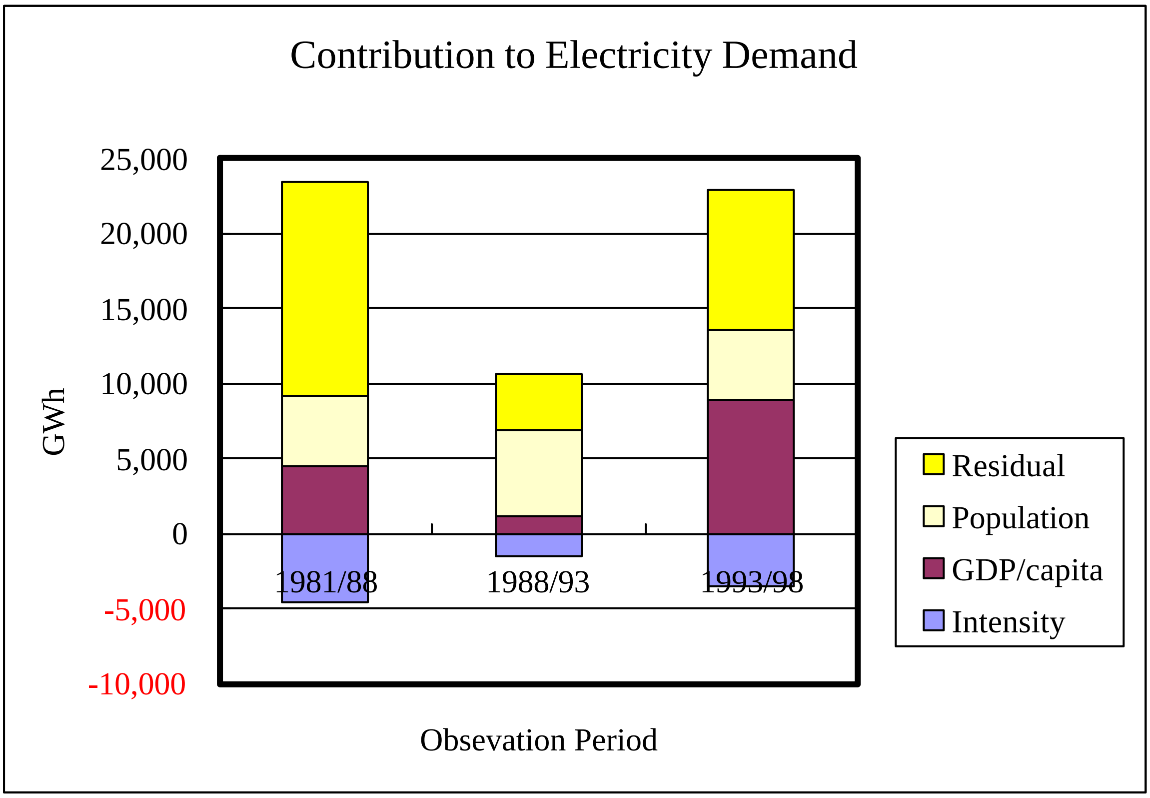


Figure 2.2.10 Factor's Contribution to Electricity Consumption



(2) Factor Analysis for Demand Structure Change

This analysis is to examine the factors that caused changes in energy consumption. We disaggregated this into three factors: 1) change in energy intensity in each industry (agriculture, manufacturing, transport, commercial, etc.), 2) change in industrial structure, and 3) change in economic activities. Formulas for analysis are as follows.

Fundamental Formula $E = I*S*G$

$\triangle E = \text{Sigma}(\triangle Ei)$

$= \text{Sigma}(\triangle Ii*Si*G) + \text{Sigma}(Ii*\triangle Si*G) + \text{Sigma}(Si*Ii*\triangle G) + \text{Residual}$

Where, Ei = Energy consumption of i-sector

$Ii = Ei / GDPi$ (Energy intensity of i-sector)

$Si = GDPi / GDP$ (Relative position of i-sector)

$G = GDP$ (Economic growth)

$\triangle E$ = Incremental energy consumption

$\triangle Ii*Si*G$ = Increase or decrease due to changes of intensity

$\triangle Si*Ii*G$ = Increase or decrease due to structure change

$\triangle G*Si*Ii$ = Increase factor due to economic growth

Figure 2.2.11 shows the historical trend of each factor's contribution. Drastic changes cannot be identified in the Figure. Basically, the increase in energy demand depended on the economic growth rates. However, the structural change boosted energy consumption recently (from 1994/95). This implies the shift to the energy consuming industry through industrial activities. As for the intensity factor, the value was decreased from 1990/91 to1993/94, increased by 1995/96 and began to decrease again in 1998/99.

Figure 2.2.12 shows the factors' contribution to the final energy consumption during the period of 1988/89 and 1998/99 (latest ten years) in each sector, classified into industry, agriculture, commercial, government/public and transportation. The Figure shows that the intensity change for improvement is identified in the industrial and commercial sectors. In the transportation sector, on the other hand, the structure change improved energy consumption, and the intensity change boosted the energy demand.

Figure 2.2.11 Factor's Contribution to Final Energy Consumption

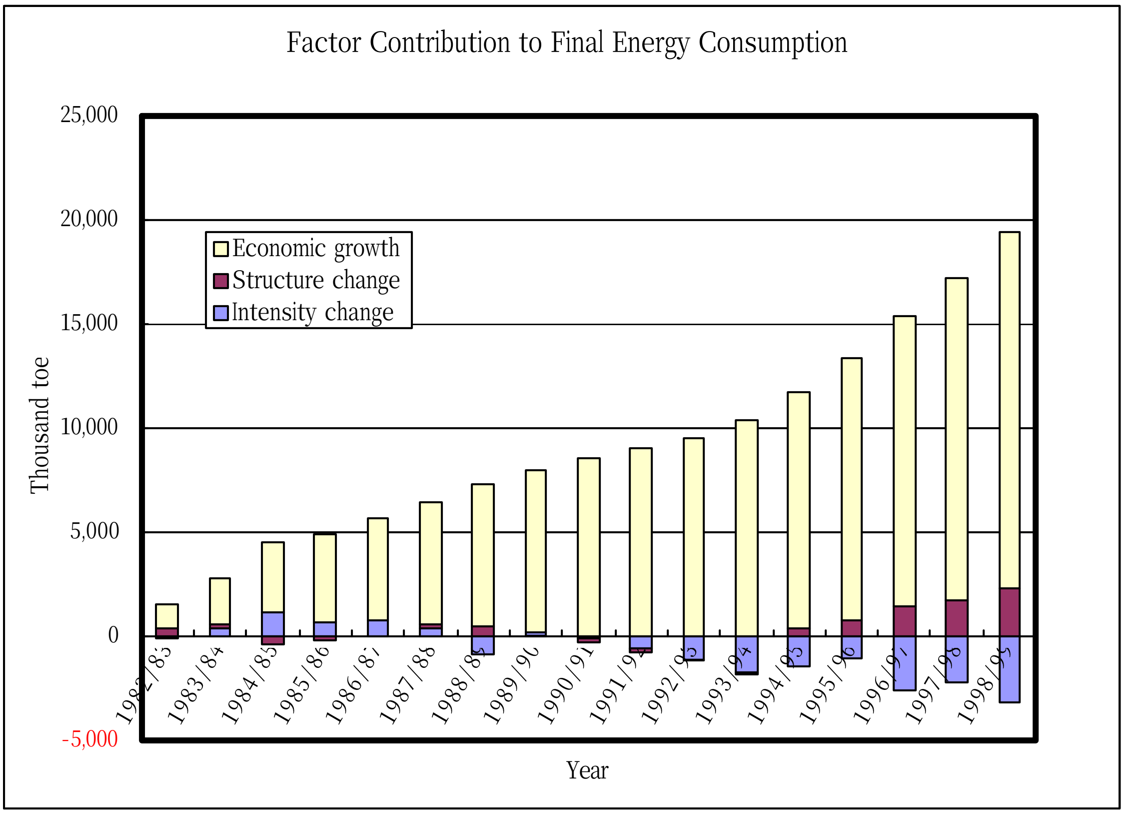
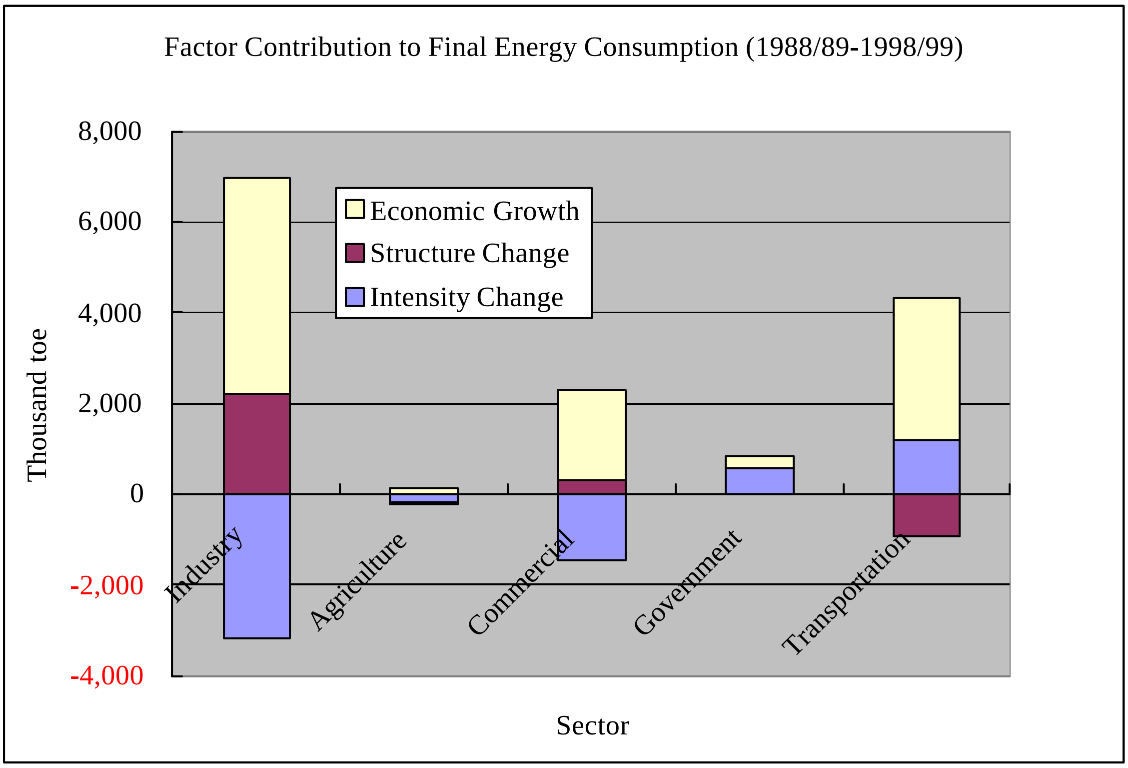


Figure 2.2.12 Factor's Contribution to Final Energy Consumption in each Sector



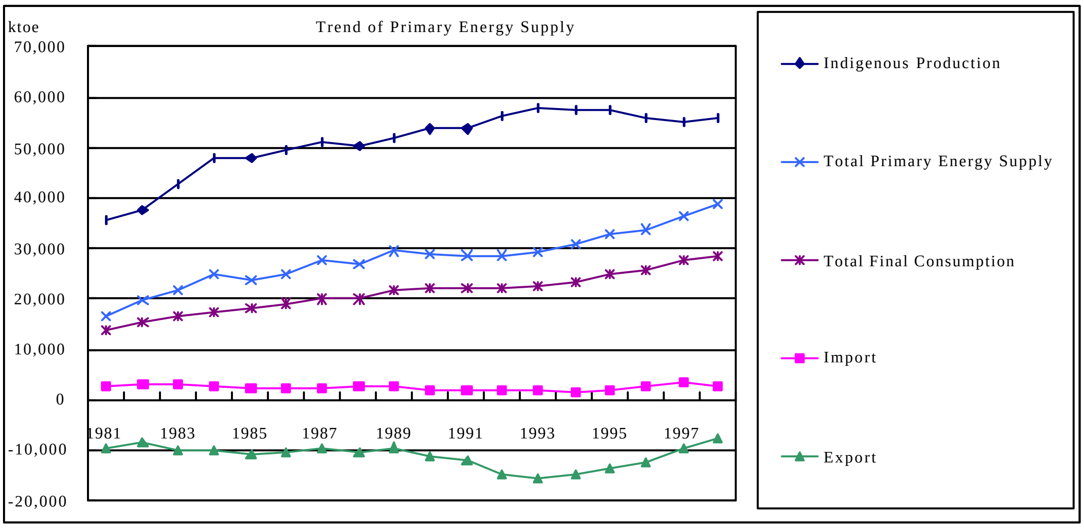
3. Outline of Energy Supply and Demand

This chapter is an outline of energy supply and demand in the context of energy flow of Egypt. First of all, primary energy production, oil and gas are explained, followed by the conversion sector, current situation of the refinery and electricity in Egypt. Finally, the final energy consumption of each sector is outlined.

3.1 Primary Energy Flow

Reserved crude oil and natural gas in Egypt are 3.5billion bbl and 31.5tcf, respectively, which covers most of the domestic energy consumption. Primary energy has been produced mainly in Suez Gulf area, added by the significant, recent discovery of natural gas and condensates in Nile Delta and Western Desert.

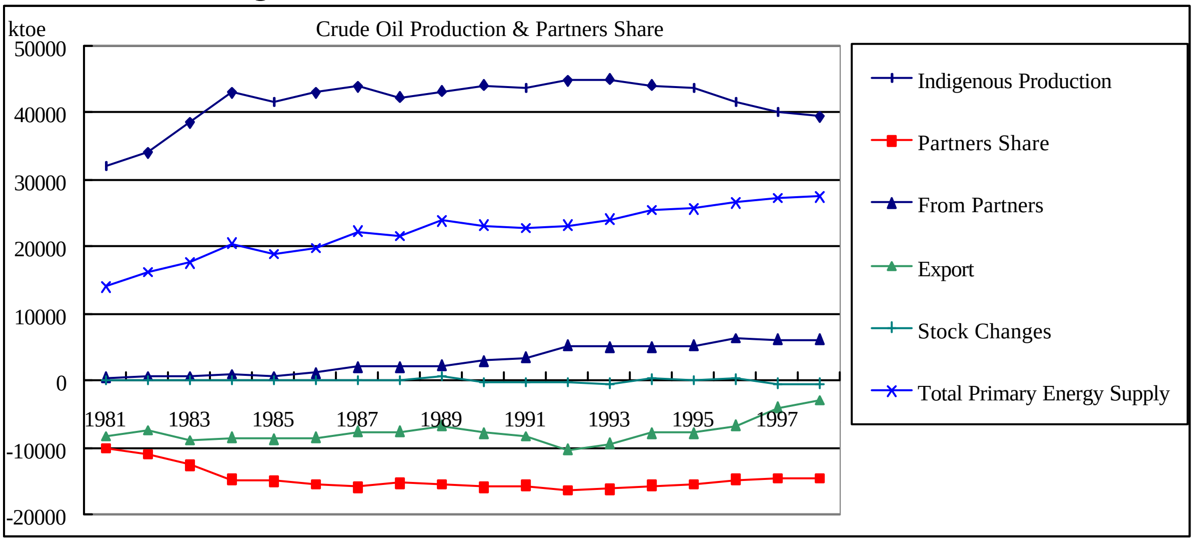
Figure 3.1.1 Historical Trend of Primary Energy Supply



Source: Prepared from OEP Annual Report "Energy in Egypt"

Figure 3.1.1 shows the trend of energy flow from indigenous production to total final consumption. This trend shows that indigenous production has been declining in recent years, but domestic energy consumption has been increasing. In contrast, the exportation of primary energy—crude oil—has increased in the last 4 years. Coking coal is imported, and other petroleum products, although in a small amount, are sometimes imported. Domestic supply of primary energy is currently 69% of primary energy production, 52% of which is transferred to final consumption via the conversion sector.

Figure3.1.2 Crude Oil Production and Partner's Share



Source: Prepared from OEP Annual Report "Energy in Egypt"

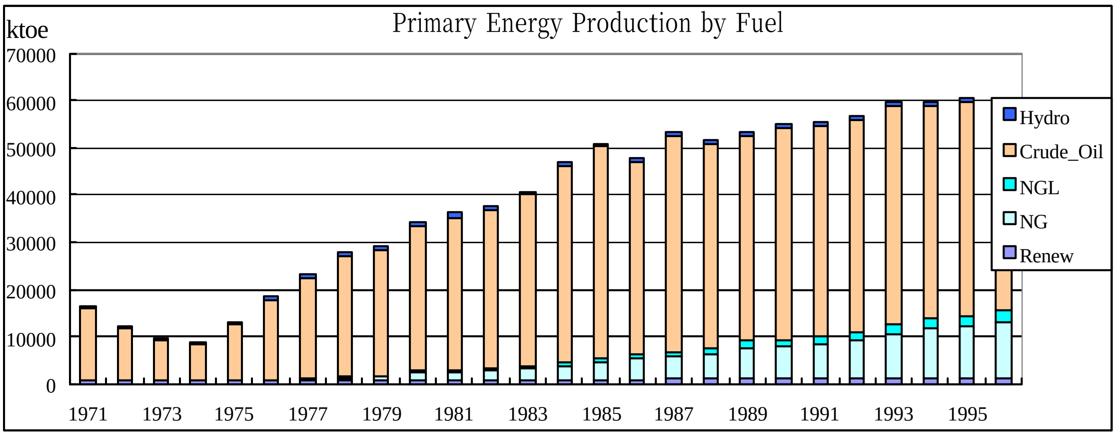
Primary energy production in Egypt has been mostly depending on foreign investments and technologies, dubbed "Partners". There are some contracts between Egypt and "Partners" on the development and operation of oil and gas fields. "Partners" can have some amount of field products based on the contracts. Egypt has to pay for the net expenses primarily with crude oil at the export price to "Partners", who is operating oil and gas fields. Then, Egypt buys crude oil and natural gas from "Partners" at the market price. Thus, Egypt can get all of the natural resources except for crude oil. "Partners" finally get some amount of crude oil in their hands. This is the current scheme of natural resources flow in Egypt.

As for crude oil, the production trend is shown in Figure 3.1.2. The shares of "Partners" have been stable even though the crude oil production has declined through the years. As a result, the exportation of crude oil by Egypt had to be rapidly declined in the last several years in order to satisfy the growing domestic demand of petroleum products in Egypt.

3.2 Energy Supply

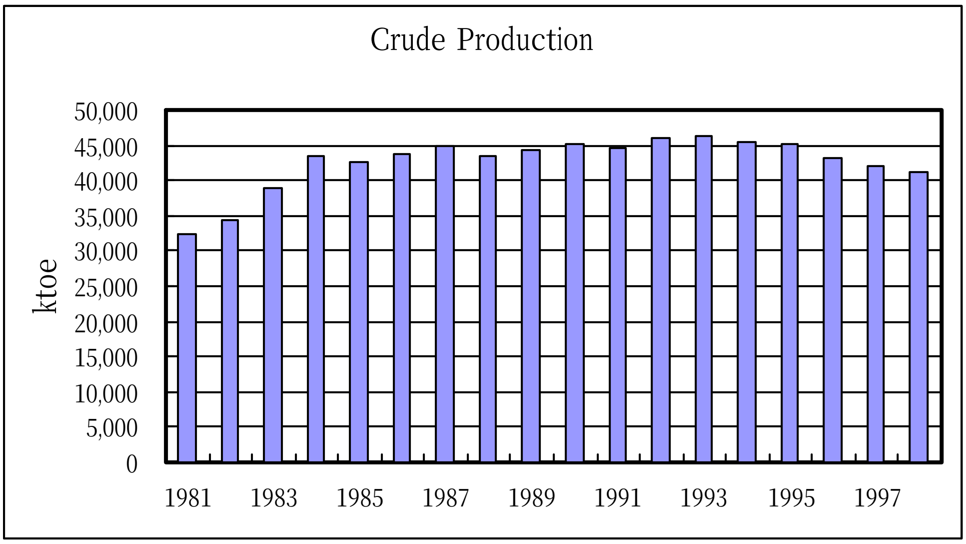
3.2.1 Primary Energy Production

Figure 3.2.1 Primary Energy Production by Fuel



Source: IEA, "Energy Balance and Statistics of Non-OECD Countries, 1997

Figure 3.2.2 Crude Production

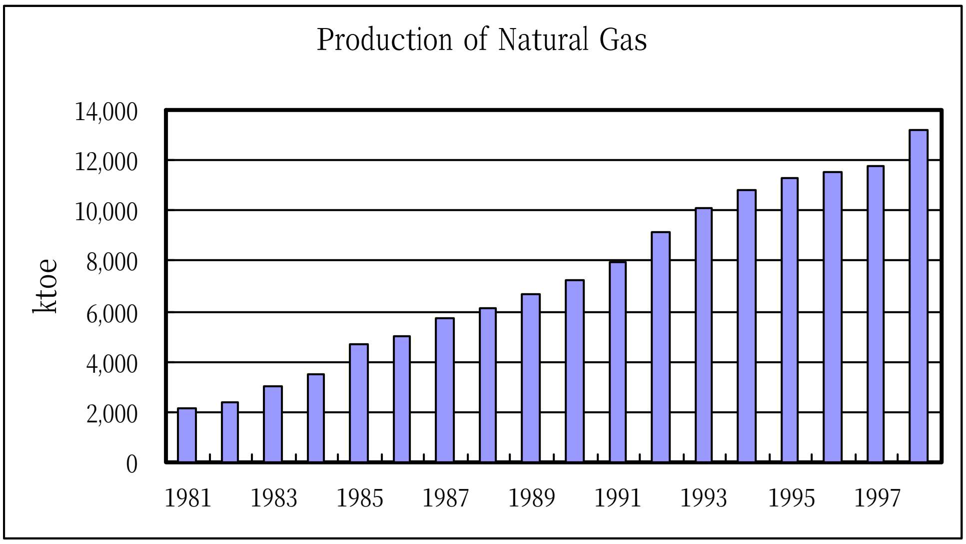


Source: Prepared from OEP Annual Report

Figure 3.2.1 shows the trend of primary energy production in Egypt. Crude oil has been the traditional primary energy production in Egypt. But Figure 3.2.2 shows that the production amount, which has been mainly contributed by Suez Gulf region, is gradually slowing down in recent years instead of investigating and developing to recover the crude production. The Western Desert, however, continues to make significant discoveries in the area, slowing the declining crude production in Egypt.

On the other hand, new gas fields have been discovered, and natural gas production has been increasing rapidly. Domestic natural gas consumption is growing under this new situation and lowers the domestic use of petroleum products. Nile Delta and the offshore area along the Mediterranean Coast, one of the world scale natural gas reservation, will be discovered for its geographical construction. Several big investments for discovering natural gas are now undergoing in these areas.

Figure 3.2.3 Natural Gas Production



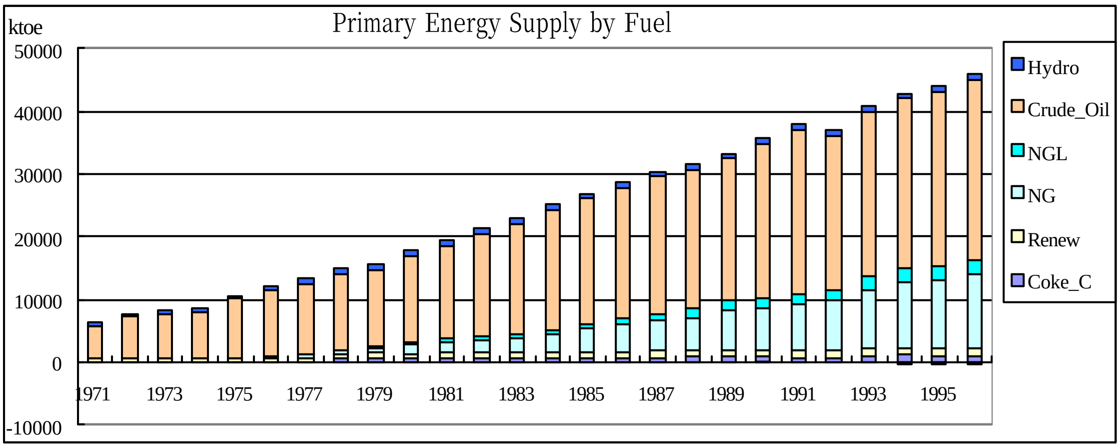
Source: Prepared from OEP Annual Report

The trend of natural gas production is shown in Figure 3.2.3. Big discovery of new gas field is continuing in Nile Delta and offshore areas, and some drilling has brought the largest yield in gas production. Commercial operation in those new gas fields to supply natural gas is expected in early 2000. Under this new situation, the Government of Egypt has a plan to transfer domestic energy supply from petroleum products to natural gas. It also has some strategic plan to build several gas transportation lines for natural gas export to neighboring countries. Egypt recently has reached the protocol agreement with Turkey to begin supplying LNG from Egypt by 2004.

Current proved reserve of crude is 3.5 billion bbl, and that of natural gas is 31.5Tcf (BP-Amoco Report 1999)

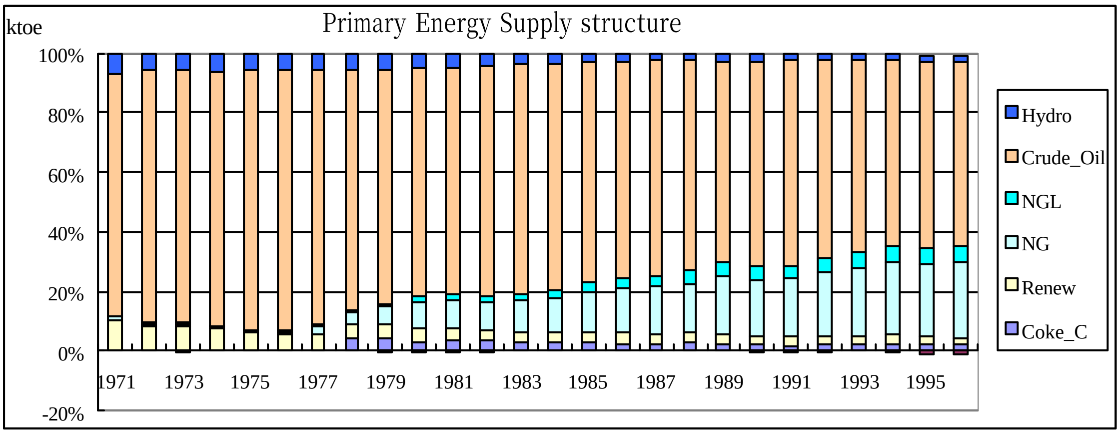
Figure 3.2.4 shows the trend of Total Primary Energy Supply (TPES) by fuel. TPES has been increasing constantly except in 1992. Its average annual growth rate is about 5% in the last 5 years. Major part of TPES is crude oil, with its share at 60.9% in 1998, followed by natural gas at 29.3%, NGL at 3.7%, coking coal at 3.0% and hydro at 2.9%.

Figure 3.2.4 Primary Energy Supply by Fuel



Source: IEA, "Energy Balance and Statistics of Non-OECD Countries, 1997"

Figure 3.2.5 Primary Energy Supply Structure by Fuel



Source: IEA, "Energy Balance and Statistics of Non-OECD Countries, 1997"

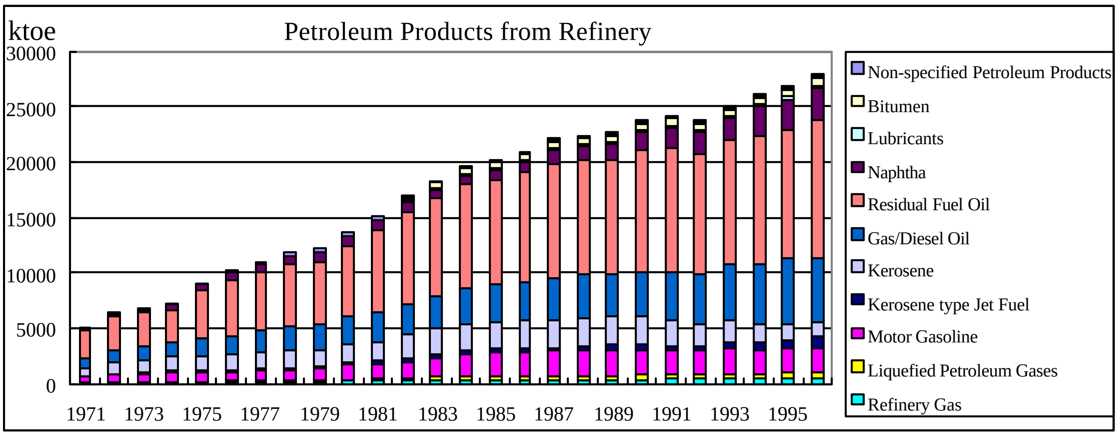
Natural gas and condensates production has made the major contribution to the growth of TPES during the latest decade while crude production has been stable or slightly decreasing.

The coal, of which a small amount is indigenously produced in Sinai Peninsula, is entirely exported to international markets. By contrast, Egypt imports Coking Coal to convert in Coke Oven.

3.2.2 Refinery Sector

All crude is refined in EGPC refineries, mainly for domestic supply. Some of fuel oil and base oil for lubricants are exported. Importation of petroleum products is currently very small.

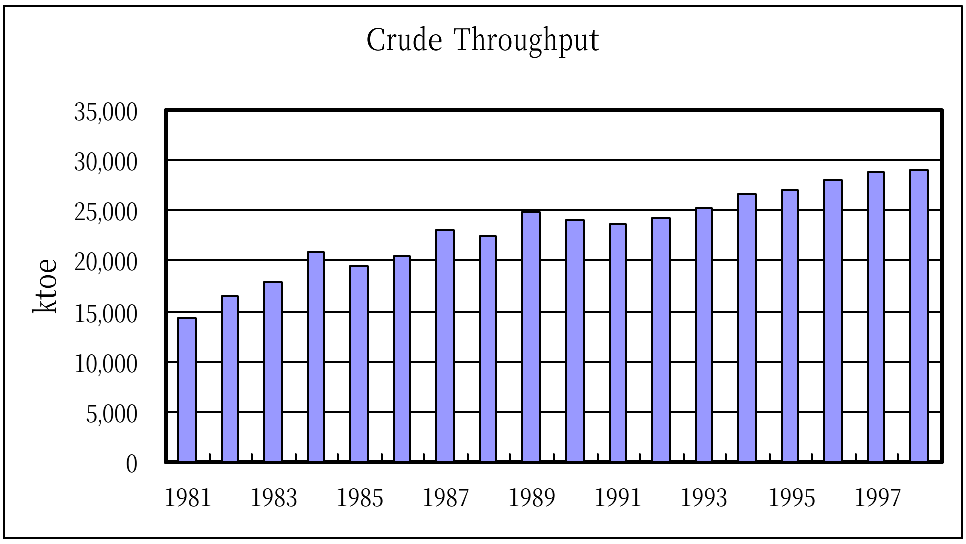
Figure 3.2.6 Petroleum Products from Refinery



Source: IEA, "Energy Balance and Statistics of Non-OECD Countries, 1997"

The total capacity of refineries in Egypt is 578,000bbl/d in 1998 as crude throughput. Figure 3.2.6 shows total refinery products, and Figure 3.2.7 shows the refinery crude throughput.

Figure 3.2.7 Crude Throughput



Source: Prepared from OEP Annual Report

There is an increasing tendency of lighter petroleum products, which have more value in the market. As a result, diesel oil production is increasing to meet the domestic demand while gasoline is stable and fuel oil is decreasing.

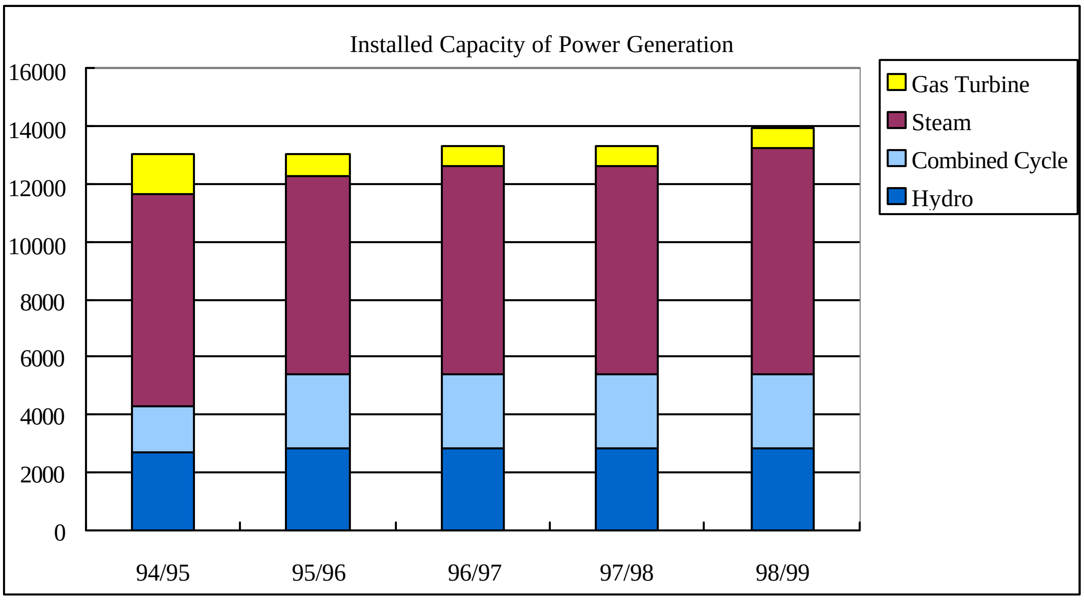
The largest refinery in Egypt is Mostord Refinery in Cairo, followed by El Nasr Suez Refinery and El Mex Refinery in Alexandria. The fourth largest is Ameria Refinery in Alexandria. Assiut Refinery has completed its expansion project, with the modernized capacity of 100,000bbl/d.

Egypt has a privatization plan for state-owned companies. However, all refineries are currently under EGPC and state-owned. Newly-built refineries shall be private companies to draw foreign investments in the new projects. For example, Midor's shareholders are EGPC (60%), Israeli companies (20%) and Egyptian private companies (20%). The new refinery has been under construction in Sidi Kerir, west of Alexandria.

3.2.3 Electricity Sector

According to EEA (Egyptian Electrical Authority) report in 1998/99, the current total of installed capacity of power generation is 13,935MW; thermal, 11,125MW; hydro, 2,810MW. Maximum generation in 1998 was 10,919MW, excluding independence generation. Annual load factor was comparatively high at 71.1%.

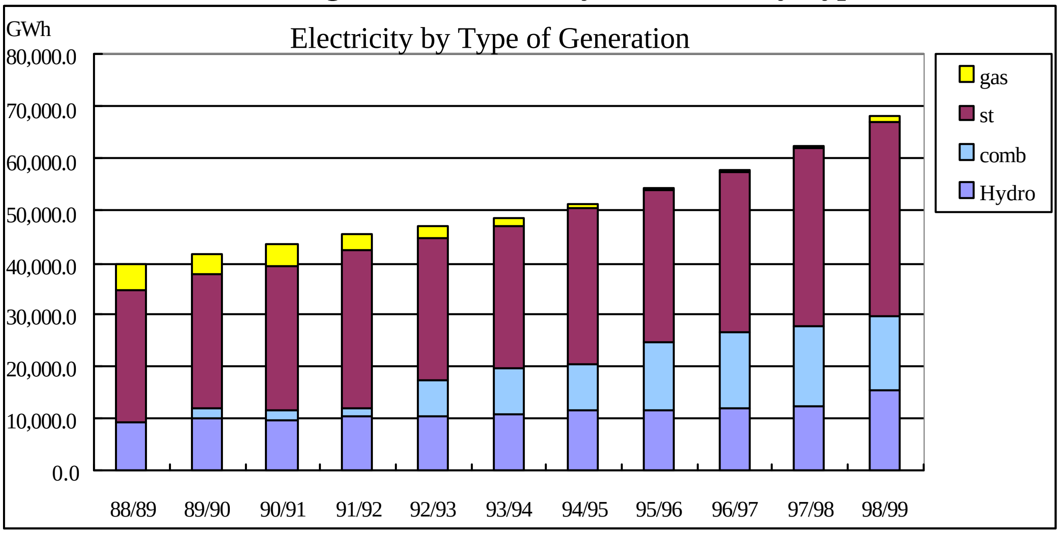
Figure 3.2.8 Installed Capacity of Power Generation



Source: Prepared from EEA Annual Report

Expansion of generation capacity mostly depends on increasing large-scale thermal generation, including re-powering of existing steam generation and open cycle gas turbine by introducing combined-cycle. Figure 3.2.8 shows this trend through the trend of installed capacity. Hydro generation is still stable because of Aswan High Dam, which was century-long project.

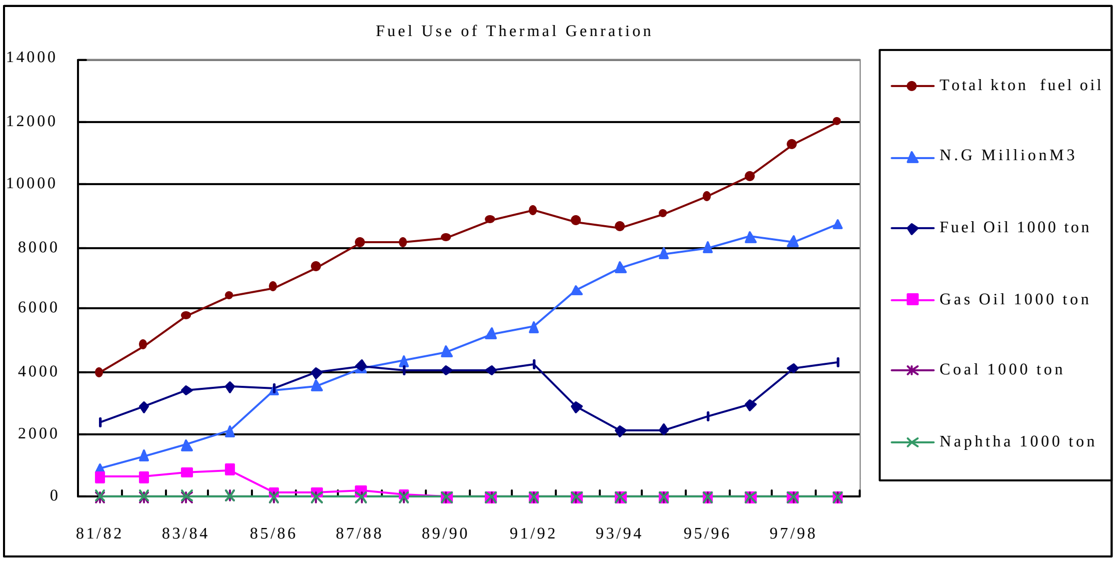
Figure 3.2.9 Electricity Generation by Type



Source: Prepared from EEA Annual Report

Increasing thermal generation output, especially through the use of natural gas, fills growing demand of electricity (Figure 3.2.9, Figure 3.2.10).

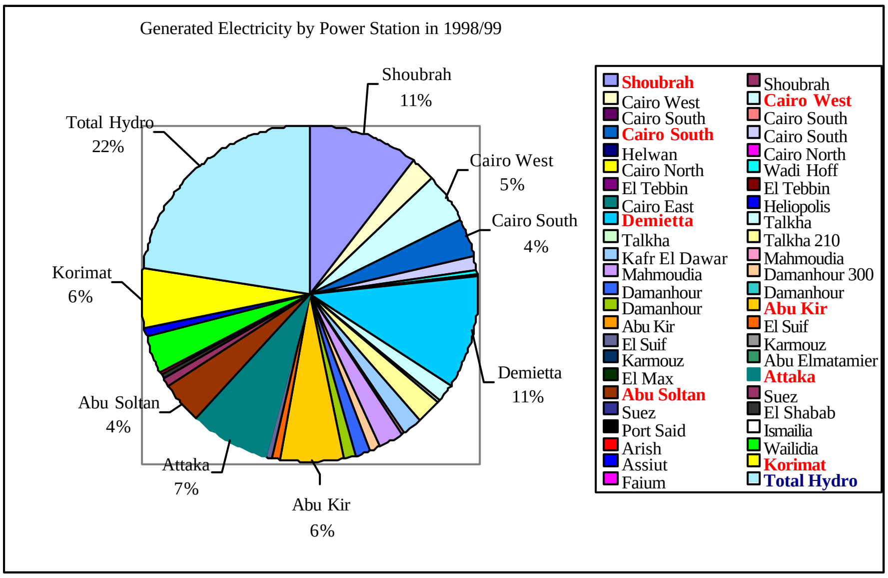
Figure 3.2.10 Fuel Consumption in Thermal Power Generation



Source: Prepared from EEA Annual Report

Figure 3.2.9 shows the trend of thermal generation by type. Combined cycle generation is the main part of incremental electricity generation by thermal. The fuels for thermal generation are gas and fuel oil, and the natural gas is expected to increase its share according to the policy. In Shoubrah power station, which JICA team visited, in Cairo, its preferred fuel is natural gas, complemented by fuel oil if natural gas supply is not enough.

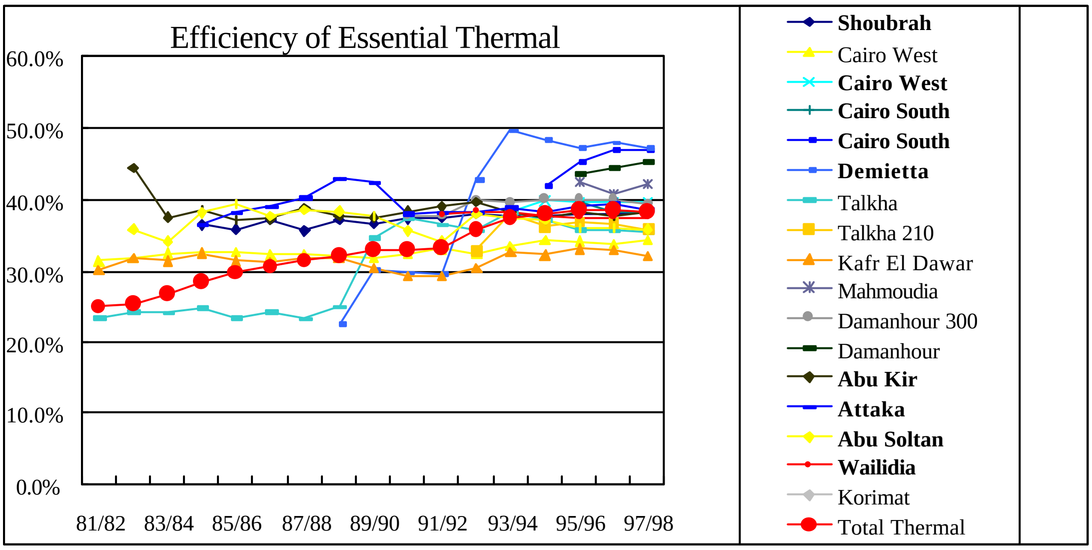
Figure 3.2.11 Generated Electricity by Thermal Power Station



Source: Prepared from EEA Annual Report

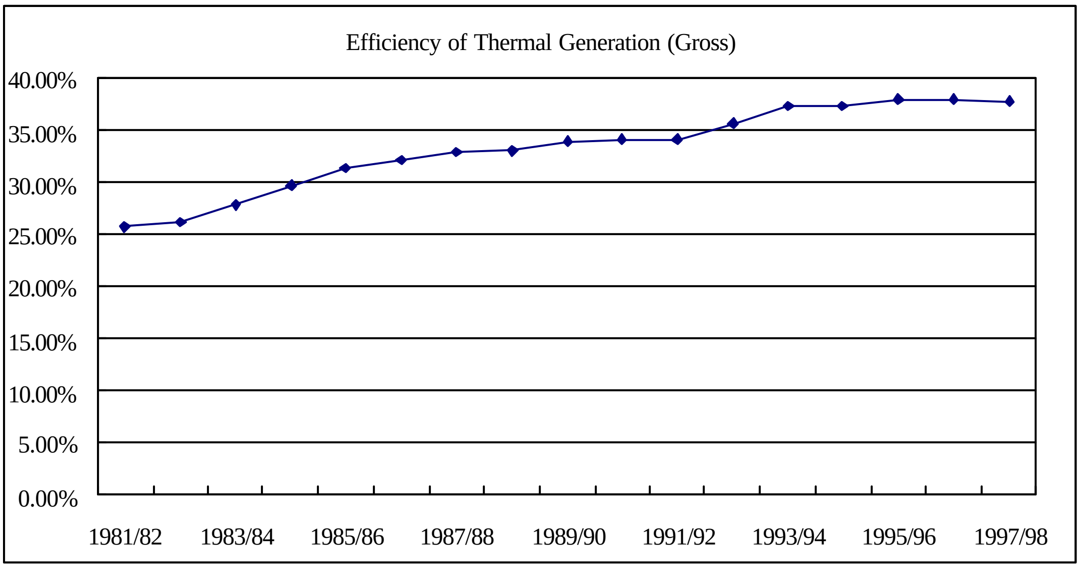
Figure 3.2.11 shows the generated electricity from all thermal power stations in Egypt. Main power stations are Damietta in Nile Delta, Shoubrah and Cairo West in Cairo, Abu Kir in Alexandria and Attaka and Abu Soltan in Suez. 60% of thermal generation and 50% of total electricity are generated by these 6 main power stations. The newest Kureimat (1,200MW) in the far south of Cairo has begun to send its generated power to grid.

Figure 3.2.12 Thermal Efficiency of Main Power Stations



Source: Prepared from EEA Annual Report

Figure 3.2.13 Average Efficiency of Thermal Power Generation



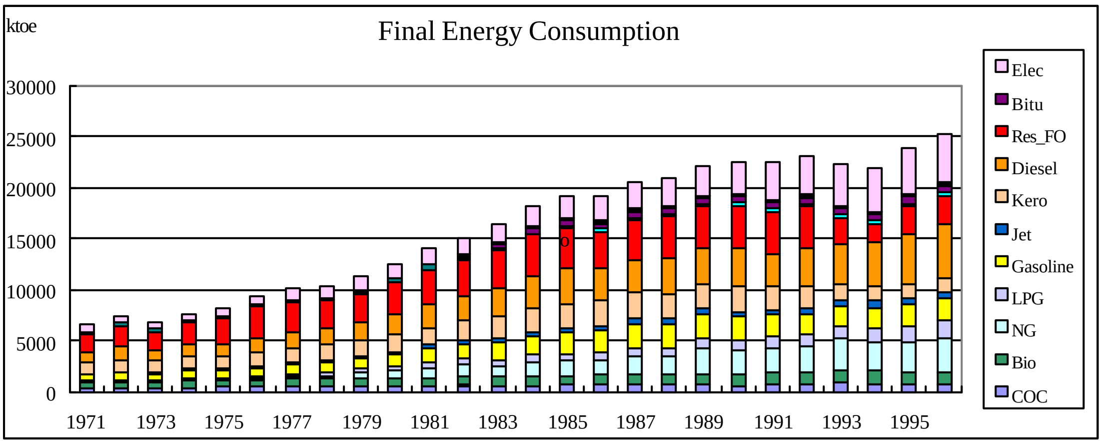
Source: Prepared from EEA Annual Report

Thermal efficiency of essential thermal stations is shown in Figure 3.2.12. The average value is slightly higher than that of estimation by designed condition. Figure 3.2.13 shows the average efficiency calculated from the OEP/JICA Database. It shows that the efficiency of thermal power in Egypt is comparatively high in recent year.

3.3 Final Energy Consumption

A brief analysis of the past trend of energy consumption shows that the growth of energy consumption slowed down slightly in the early 1990s. From the mid 1990s, the energy consumption began to grow again. The decline of the early 90s could attribute to the shock of economic reform toward the market-oriented economy. However, the decline from the shock has not been so drastic as the cases of the Eastern Europe and FSU countries. Egypt had the advantages of various sources of income, including oil exportation, Suez Canal and famous historical sites for tourism.

Figure 3.3.1 Final Energy Consumption by Fuel

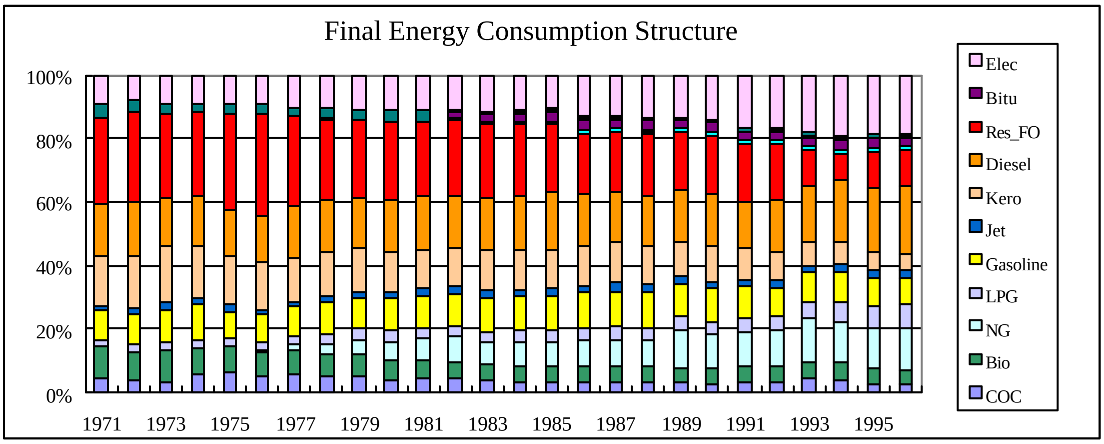


Source: IEA, "Energy Balance and Statistics of Non-OECD Countries, 1997

Figure 3.3.1 shows the energy consumption by fuel. Electricity, natural gas and LPG are growing in the total final energy consumption; fuel oil and kerosene are decreasing. Diesel oil and gasoline consumption shows rapid growth, in line with the growth of the transportation sector, which is caused by economic growth.

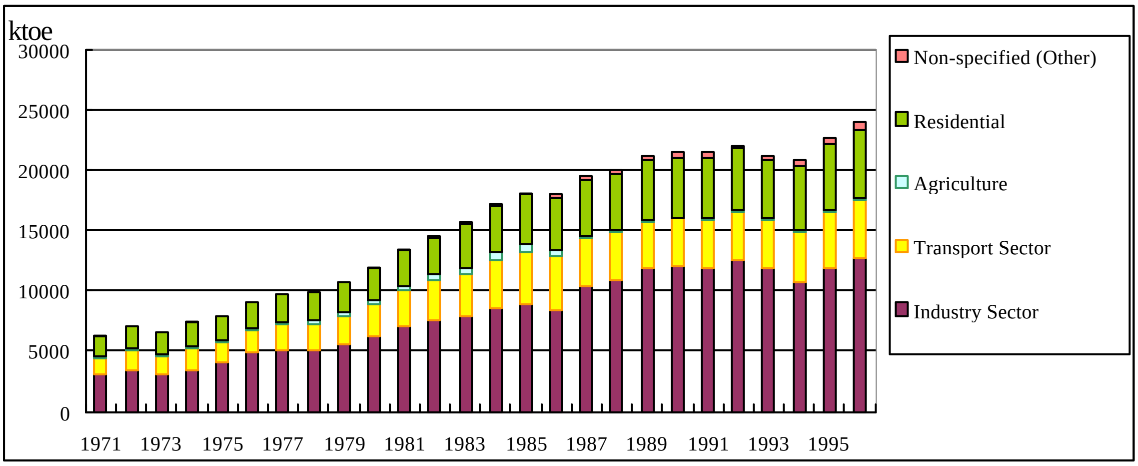
This trend is shown in Figure 3.3.2. This tendency is found clearly in the share of energy consumption by fuel. LPG consumption is the most rapid growth among all fuels. Its annual growth rate rose from 12% to 14% in recent years. LPG share of total energy consumption was 4.4% in 1990, but it became 8.4% in 1998. The next remarkable growth was diesel oil, at the annual growth rateof over 10%, and its share went up to 20.6% in 1990 and 24.8% in 1998. Electricity consumption grows continuously at the annual growth rate of 7% or higher; consumption share was 17.2% in 1998, just beyond diesel. Meanwhile, kerosene consumption has decreased recently although it was one of the most popular fuels in the past.

Figure 3.3.2 Final Energy Consumption Structure by Fuel



Source: IEA, "Energy Balance and Statistics of Non-OECD Countries, 1997

Figure 3.3.3 Final Energy Consumption by Sector



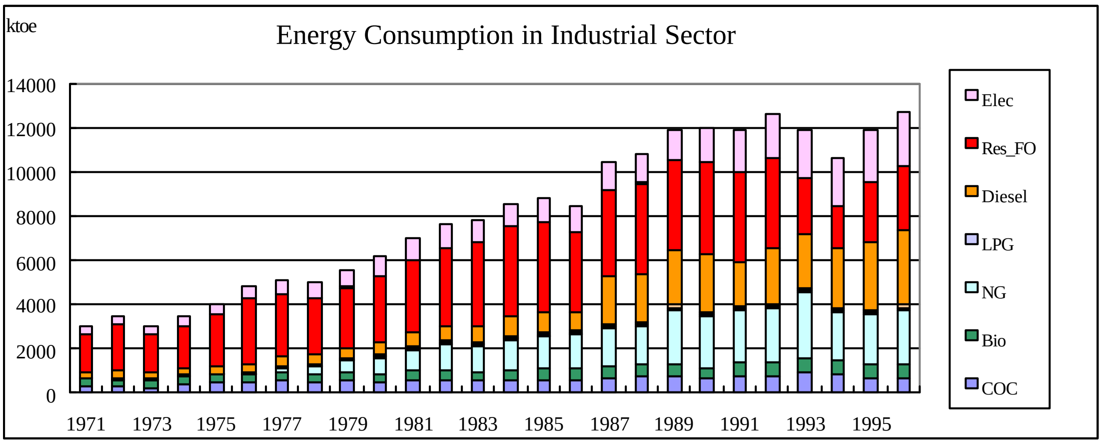
Source: IEA, "Energy Balance and Statistics of Non-OECD Countries, 1997

Egypt has a policy to change its domestic fuels from petroleum products to natural gas. Its main conversion target is the fuel for electricity, but it mostly depends on the development of infrastructure for natural gas supply system.

Figure 3.3.3 shows the trend of energy consumption by sector. The most energy intensive sector is the industrial sector, followed by the transportation sector and the residential sector. The annual growth of energy consumption in transportation is especially remarkable.

3.3.1 Industrial Sector

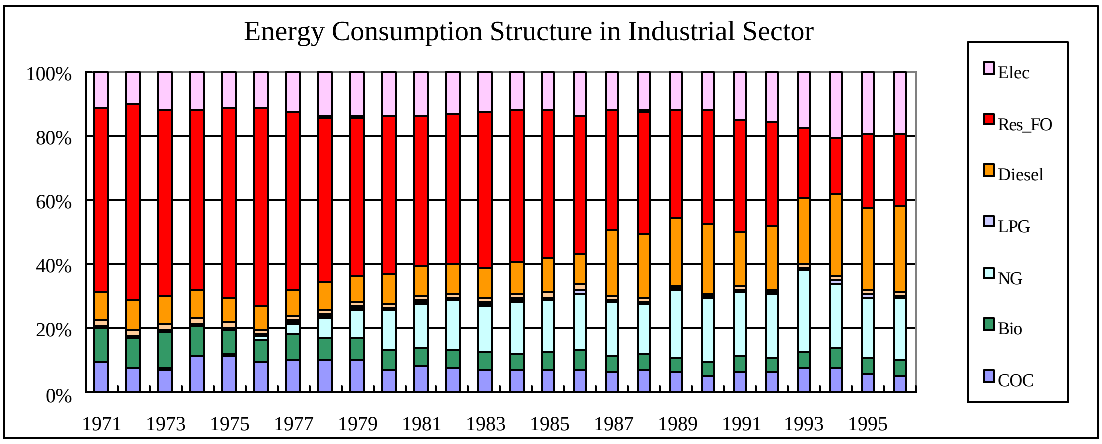
Figure 3.3.4 Energy Consumption in Industrial Sector



Source: IEA, "Energy Balance and Statistics of Non-OECD Countries, 1997"

Energy consumption in the industrial sector by fuel is shown in Figure 3.3.4. The energy consumption in the industrial sector is fluctuating a little in the early 1990s, when the economic reform started.

Figure 3.3.5 Energy Consumption Structure in Industrial Sector



Source: IEA, "Energy Balance and Statistics of Non-OECD Countries, 1997"

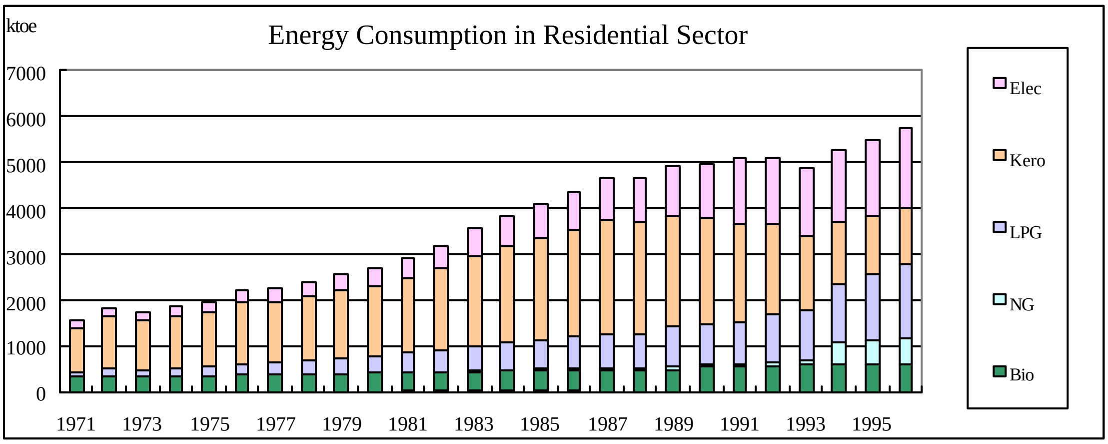
The consumption of electricity and diesel oil is increasing rapidly. However, fuel oil consumption is decreasing through the years. These changes in energy consumption in the industrial sector may be caused by the economic reform, from state-planned economy to market-oriented economy.

Figure 3.3.5 shows the energy consumption share of each fuel in the industrial sector.

3.3.2 Residential Sector

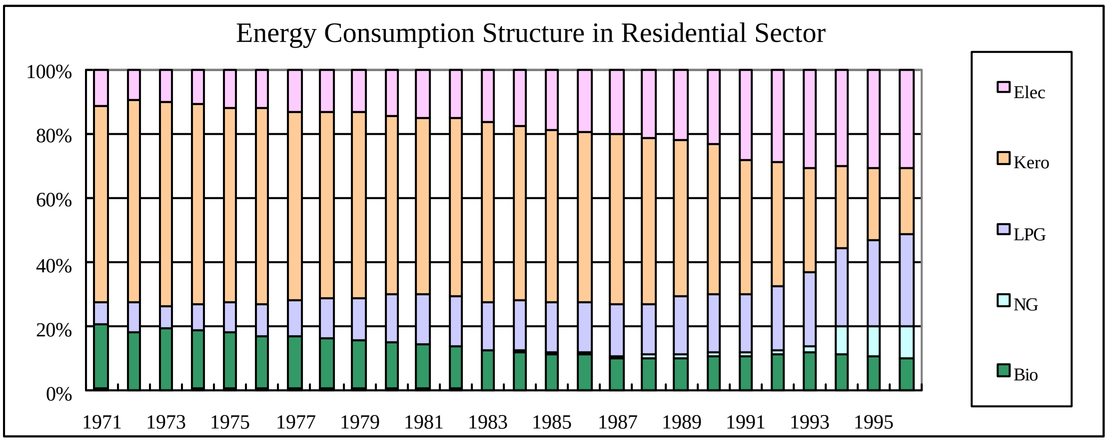
The annual growth rate of energy consumption in the residential sector has been comparatively higher than that of other sectors. This is shown in Figure 3.3.6 and Figure 3.3.7. An average annual growth was 6 – 8.5% in recent 4 years. LPG was the highest, with an annual growth rate of 13%. This means that the home use of LPG is widely spreading. It became 41.3% in the residential sector energy use in 1998. On the other hand, kerosene has decreased gradually. This means that the transfer from kerosene to LPG became popular in recent years. Electricity has the largest share of energy consumption in the residential sector. Its average annual growth rate is stable and continuously increasing at about 8%. The use of natural gas in the residential sector started its rapid growth since 1994. It shows that the national policy to promote natural gas achieved 5.8% of energy consumption by 1998, also helped by the discovery of large-scale gas fields in the recent decade.

Figure 3.3.6 Energy Consumption in Residential Sector



Source: IEA, "Energy Balance and Statistics of Non-OECD Countries, 1997"

Figure 3.3.7 Energy Consumption Structure in Residential Sector

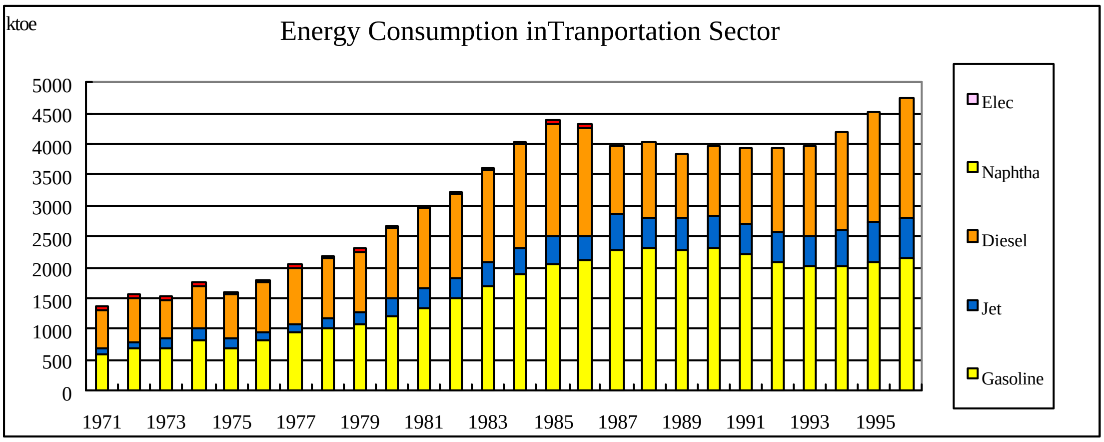


Source: IEA, "Energy Balance and Statistics of Non-OECD Countries, 1997"

3.3.3 Transportation Sector

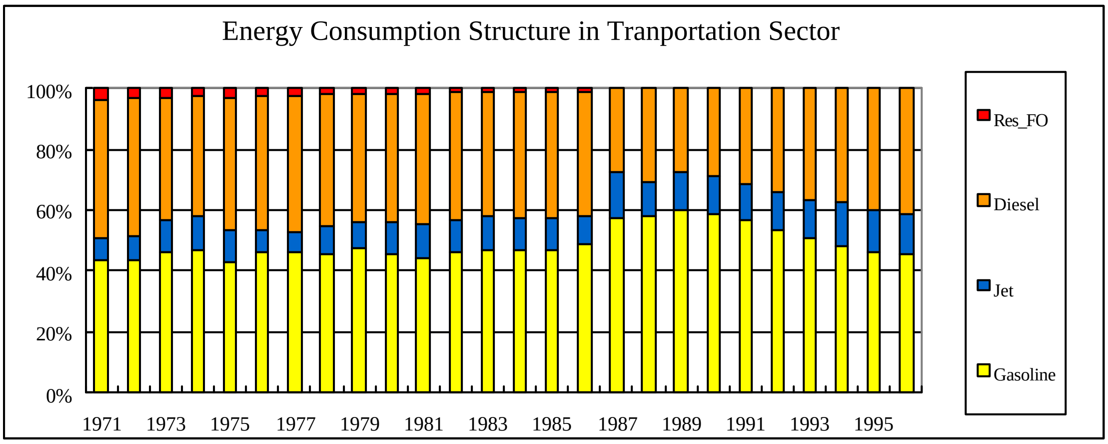
Some changes in the pattern of energy consumption in the transportation sector are shown in Figure 3.3.8, suggesting the impact of economic reform. Because of the economic growth in recent years, energy consumption is increasing at a fast rate. The share in the total final consumption (TFC) is also increasing, mainly due to the land transportation. And the annual growth rate of diesel use is high at an average of 10% per year in recent years. On the other hand, gasoline use is not increasing comparatively. Although it is Egypt's national policy to change the use of lead gasoline to unleaded gasoline, the change is very slow, and lead gasoline still mostly used.

Figure 3.3.8 Energy Consumption in Transformation Sector



Source: IEA, "Energy Balance and Statistics of Non-OECD Countries, 1997"

Figure 3.3.9 Energy Consumption Structure in Transportation Sector

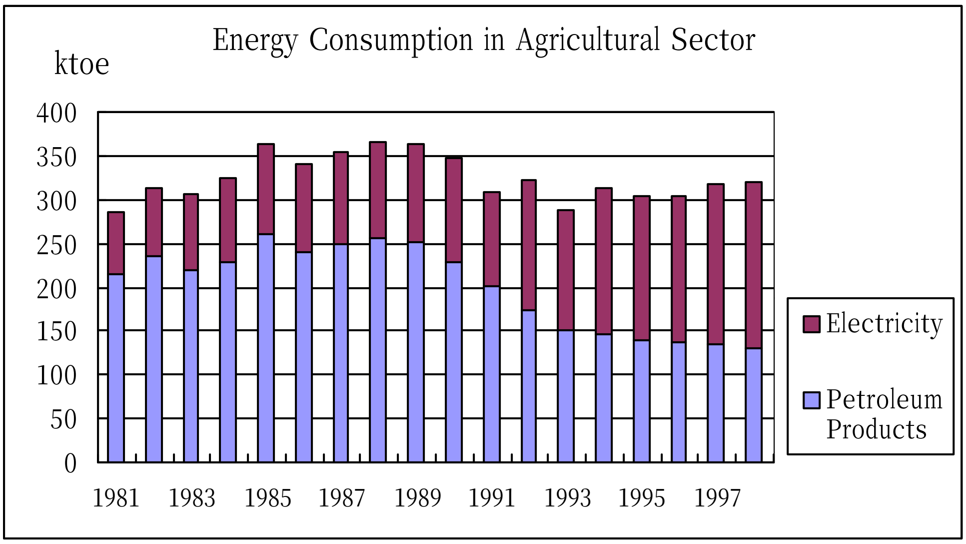


Source: IEA, "Energy Balance and Statistics of Non-OECD Countries, 1997"

3.3.4 Agricultural Sector

Agriculture is a traditional industry in Egypt. The agricultural field is spread in the Nile Delta. The database shows that the energy consumption in agriculture is slightly declining in recent years but electricity consumption is increasing.

Figure3.3.10 Energy Consumption in Agricultural Sector



Source: Prepared from OEP Annual Report

4. Tools for Energy-Economic Model Building

4.1 Econometric Simulation System

4.1.1 Macroeconomic Model: Basic Principles

A macro econometric model consists of equations, which represent the relationships between the variables in the system of national accounts and other key statistics. The parameters of the equations are empirically estimated based on time series and cross section data.

The macroeconomic model must be based on the macroeconomic principles although the actual applications of the principle may differ by the type of the economy. The primary parts of the models are (1) consumption, (2) investment, (3) export/import, and (4) wages and deflators. The followings are typical examples of these model formulations.

(1) Private Consumption

- Permanent income hypothesis

Household income is assumed to consist of permanent and transitory components, and consumption is to depend on the permanent component of income. A model based on the hypothesis can be written as

$$C = a + bY + gC_{-1}$$

"b" is the (short run) marginal propensity to consume. Since it becomes a steady state in the long run, all variables become stationary.

$$C = a + bY + gC \rightarrow C = (a+bY)/(1-g)$$

"b/(1-g)" is the long run marginal propensity to consume.

(2) Investment: Private Capital Formation

- Profit principle

It is widely observed that corporate investment in plants and equipment is closely correlated with corporate cash flow (depreciation allowance plus after-tax profits). The profit principle assumes that enterprises invest a certain portion of their cash flow in plants and equipment. Thus, a capital formation may be specified as

$$I = a + b(\text{cash flow})$$

- Accelerator principle

The accelerator principle presumes stable technological relationships between the level of output and capital stock required. That is,

$$K = bY$$

Because capital formation is equal to a net increase in capital stock plus replacement investment, letting d be a constant replacement ratio,

$$I=K_{+1} - K + dK$$

Defining Y^{e}_{+1} to be expected output in the next period,

$$I=K_{+1} - K + dK=b(Y^{e}_{+1} - Y) + dK=b(Y(Y/Y_{-1}) - Y) + dK$$

Where, Y(T/Y-1) represents an expected output level on the basis of a static expectation on the rate of growth.

(3) Exports and Imports

Both exports and imports are typically formulated as functions of real income and relative prices. Real income in an export equation could be the real world GDP, the world trade, or more appropriately, those of trading partners. In the case of import equation, the income factor is represented by home-country GDP or absorption (GDP + import, or identically consumption + investment + exports).

In export equations can be either

Export price (US$)/weighted average of wholesale prices of trading partners or
Export price (US$)/ weighted average of export prices of export competitors.

In import equation, the relative price factor can be

Import prices denominated in domestic currency / domestic wholesale prices

(4) Wages and Price Deflators

Wages are typically assumed to be determined by the Phillips curve relation, i.e.

$$\Delta w=f(U)$$

Where, Δw is the change in nominal wage rates and U, the unemployment rate. The Philips curve may be adjusted for inflation (increases in consumption deflator). Corporate income may also be included to reflect wage-paying capacity of enterprises.

Wholesale prices (or Alternatively, deflator of inventories of private enterprises) are determined based on the mark-up principle, in which profits of a certain proportion are added up to the costs (import prices and wage costs). Demand/supply conditions represented by e.g., the operating ratio or the GDP gap are possible explanatory variables. Because consumption deflator is more intensive in services than wholesale prices, wage rates have a larger weight in a consumption deflator function.

Investment deflators depend on material prices (hence, wholesale prices) and wages of construction workers.

Export deflator are based on domestic producer prices (wholesale prices) and the exchanges rate.

Import deflator is determined exogenously, taking into account oil and other primary commodity prices and the world inflation rate.

4.1.2 Econometric Methods

Econometric methods rely upon hypothesis testing of behavioral relationships as posited by economic theory as mentioned above, using statistical methods.

The econometric model contains an endogenous variable and a set of exogenous explanatory variables. Information on the dependent variable and the explanatory variables represents the observation set, and the parameters of the relationship are unknowns. The theory is based on the inclusion of a stochastic error term or the regression models, which differentiate this method from the deterministic technique like linear programming. The most popular regression model is to use the estimator called ordinary least square (OLS). OLS provides estimates of parameters by minimizing the sum of squares of the difference between the observed value of the endogenous variable and the linear relationship specified on the independent variables. The exact mathematical form of the relationship is usually not defined by economic theory; assumptions of linearity are norm. Therefore, the objective is to find the most appropriate functional form for the relationships. The modeling process involves the estimation of alternative relationships and then the reporting of the single equation that the analyst considers most appropriate.

EXAMPLE:
Equations in econometric models are classified into four categories.

i. Behavioral equations: describing behavior of economic entities such as consumption of households and investment of enterprises

ii. Technological equations: showing technological relationships between, e.g., capital and labor inputs and production capacity as in a neoclassical production function

iii. Institutional equations: incorporating institutional parameters such as tax rates

iv. Definitions: identifying definitional relationships between variables such as

GDE=final consumption +capital formation + exports + imports

The variables are distinguished by three types.

i. Endogenous variables: to be determined by the equations of a model (the number of endogenous variables is equal to that of equations)

ii. Exogenous variables: to be given from outside of a model, which include government expenditures, official discount rate, overseas variable, etc. (depending on the scope of the model)

iii. Predetermined endogenous variables: representing values of endogenous variables in preceding periods

For example, the following equations describe a simple macroeconomic model.

Equations:

i. $Y=C + I +G$ (definition)

ii. $C=a + bY$ (behavioral)

iii. $I=f + g(Y-Y_{-1}) + hI_{-1}$ (behavioral)

Variables:

i. Y: GDE (endogenous)

ii. Y_{-1}: GDE in previous period (predetermined endogenous)

iii. C: consumption (endogenous)

iv. I: capital formation (endogenous)

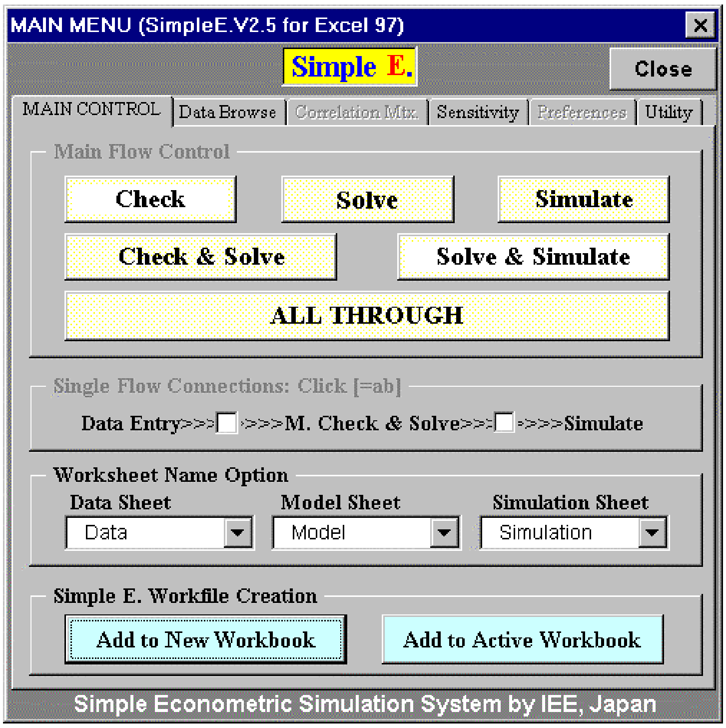
v. G: government expenditure (exogenous)

To test this model and to find the appropriate relationship, the econometric method can be applied to the behavioral equations of No. 2) and 3). Namely, regression analysis will be used to estimate and to see the statistical significance of the coefficients—a, b, f, g, and h.

4.1.3 Econometric Simulation Tool: *Simple E.*

The principal tool for the econometric simulation will be Simple E (Simple Econometric Simulation System by The Institute of Energy Economics, Japan). *Simple E.* is an Excel Add-In software, and it works with an *Excel* workbook file that includes three sheets—Data, Model and Simulation. *Simple E.* cannot work without these sheets, whereas inputs and outputs in these three sheets can be used without *Simple E.* From data input to simulation, as shown in Figure 4.1.1, main menu of Simple E, three processes -- 1) Model check, 2) Model Solve (Estimation of coefficients), and 3) Simulation-- are the main flows automated by *Simple E.*

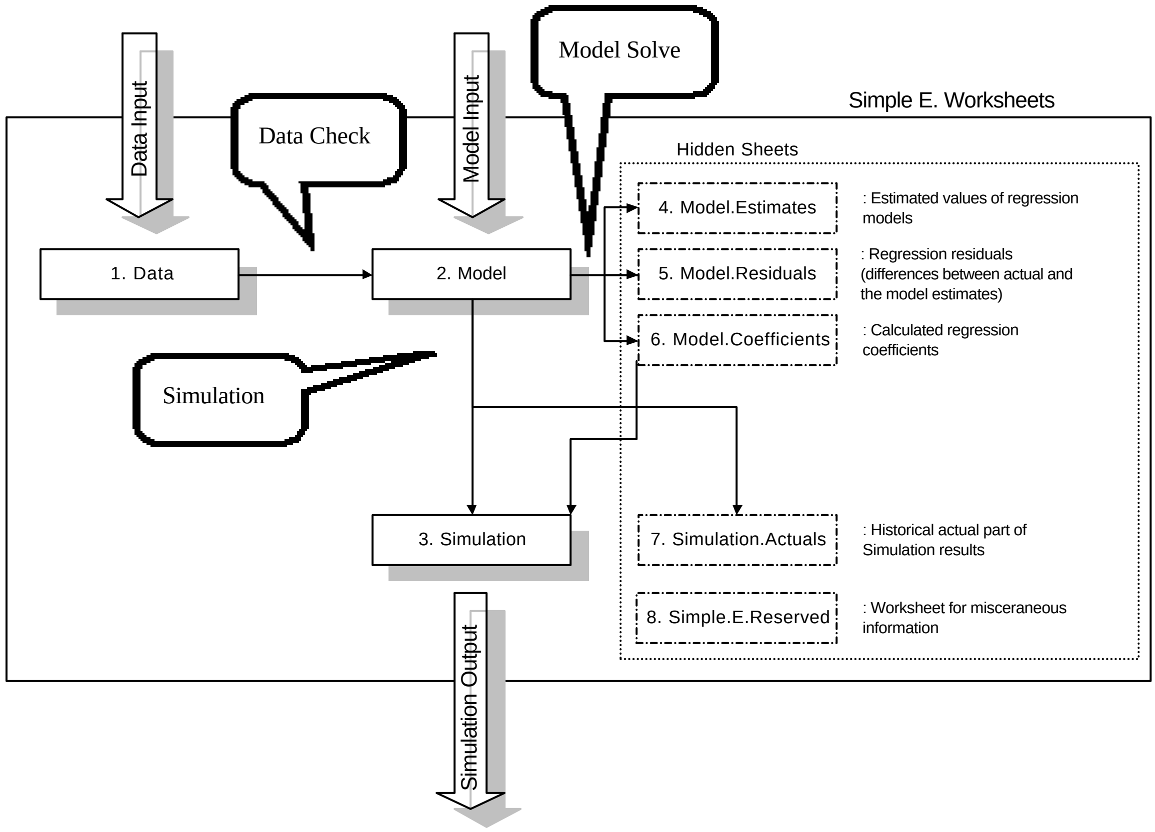
Figure 4.1.1 Main-Menu:



Each flow is processed in these specially designed worksheets. The next diagram shows the basic concept and the relationship of these processes with the worksheets of Simple E.

Figure 4.1.2 Conceptual Diagram:

Conceptual Diagram of Simple E. Worksheets



As shown in the above diagram, first, users have to prepare the necessary data and their idea of model specifications. Next, the users have to prepare the data in "Data" sheet and the model specifications in "Model" sheet. The rest of the tasks from model checking to simulation are the works of *Simple E*. "Model" will be solved in the hidden sheets "Model.Estimates", "Model.Residuals", and "Model.Coefficients." The summary results will be presented in "Model" sheet. The simulation results will be calculated in "Simulation" sheet. The actual part from the past will be set in the hidden sheet "Simulation.Actuals."

4.2 Linear Programming Method

4.2.1 Objective of Linear Programming Model (LP Model)

Linear programming method uses an objective function to maximize or minimize its target by finding feasible values of the related variables of the objective function. The values given to the variables are called optimal solution. An LP method will be applied to a supply planning model to obtain the optimum solution (maximum value or minimum value) in consideration with the following points.

1) In an energy supply planning model by an LP method, the variables should include such variables as energy production, import, sales volume, export, stock and so on.
2) In the model, constraints of the variables should include production capacity, import upper limit, demand, export upper limit, stock upper limit and so on.
3) In the model, the target of the objective function is generally the cost minimum or the profit maximum.

4.2.2 Structure of LP Model

The following is the procedure to formulate and define an objective function, variables and constraints to building up as LP model.

(1) Objective Function

The target of an objective function is the cost minimum or the profit maximum. The selection of the target depends on the objective of the model and the data availability. As is frequently the case, the supply planning model and the production planning model are built up in order to increase effectiveness of the organization concerned (Ex. Private company or Government organization). Therefore, the objective function is usually formulated to maximize the profit. However, if the organization such as that of infrastructure businesses does not have a clear benefit measurement, the target of the objective function is defined by the cost minimum. It is sometimes called "resource allocation model".

The difference in the objective function brings a different type of constraints in the model. For example, as shown in the following, the constraints of sales, stock and production are formulated differently for the cases of profit maximum and cost minimum.

Example 1: Cost minimum

Minimum sales ≦ Sales
Minimum stock ≦ Stock
Sales ≦ Production + Import

Namely, in case of the cost minimum target, minimum sales, minimum stock and minimum production are formulated as constraints in an LP model.

Example 2: Profit maximum

Demand $\geqq$ Sales

Maximum stock $\geqq$ Stock

Sales $\geqq$ Production + Import

In case of the profit maximum target, maximum demand, maximum stock, maximum supply are formulated as constraints in an LP model.

(2) Variables

Variables defined in LP method are unknown elements, which are determined internally. The values in the variables gradually converge from initial value 0 to optimal solutions in an LP model. Therefore, when an LP model is built up on MS-Excel sheet, variable cells do not accept any value or formula externally. If they are set externally, they will be reset with 0 when the model is started. Which items are set as variables in an LP model? It depends on the model builder's design. Generally, all items in an LP model can be set as variables. The following are examples of items, which are formulated as variables in an LP model.

Example 1: The LP model has initial stock as a variable. How can we fix the constant value of 1500 externally as the initial stock?

Minimum initial stock (1500) $\leqq$ Initial stock

Initial stock $\leqq$ Maximum initial stock (1500)

By setting the above constraints to the initial stock, the initial stock is uniquely determined to be 1500.

Example 2: Production of a by-product is 30% of the main product. How can we formulate the balance?

0.3 * Production variable of the main product

- production variable of the by-product = 0

By using the above formula for balance, the 30%-production of the main product will be the same as the production of the by-product.

Example 3: The model builder wants to assign all items of supply and demand balance as variables. How can we formulate the balance?

Initial stock + production + Import - Domestic demand - Export - Final stock = 0

If the items above are all set as variables, each variable should have constraints so that the LP could have a feasible solution. If some constraints are missed, the LP model could reach a wrong solution. Suppose that the import price is smaller than the production cost and the import volume does not have any constraints. Then the LP model presents the solution that the production is 0 and all demands are supplied by import. To keep from reaching such a solution, the items defined as variables usually should have constraints of the upper limit and the lower limit.

(3) Constraints

Constraints in an LP model can be classified into three categories. They are upper limit, lower limit and equation of balance between variables. The variables that have upper limit are sales constrained by the maximum demand, production constrained by the production capacity, stock constrained by the stock capability and import constrained by the maximum import. The variables with lower limitation are stock with the minimum stock, production with the minimum production and import with the minimum import. As already mentioned in Example 2, balance constraints are formulated by arithmetic expressions combined by equal signs or inequality signs. The values of variables with balance constraints are determined under the constraints of the specified balance.

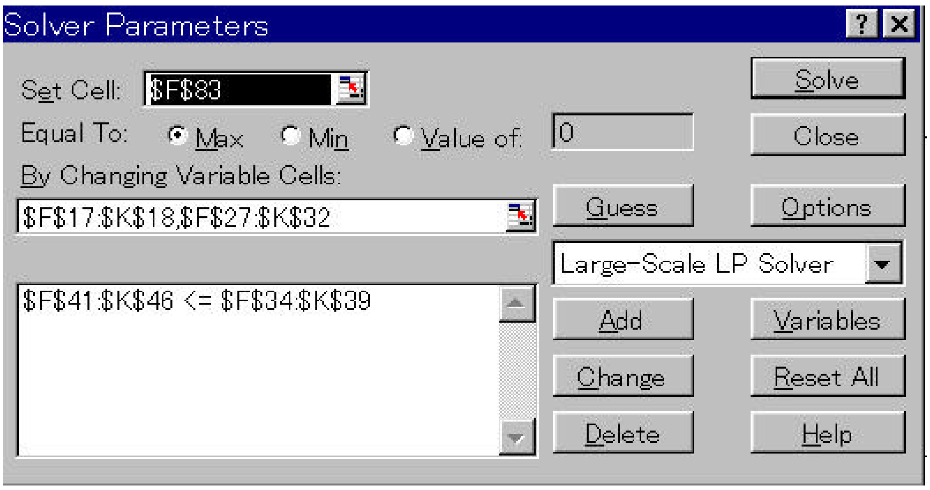
0.3 * Production of the main product - production of the by-product = 0
(Variable) (Variable)

Initial stock + production + Import - Domestic demand - Export - Final stock = 0

Generally, constraints in an LP model are formulated in line with the actual physical structure. Therefore, when constraints are put in an LP model, the constraints are defined in the real production as well as in the real trading. In some cases of many constraints in an LP model, however, the model could halt computation because it cannot reach a feasible solution within the constraints.

To build up and to solve an LP model, there are many software packages, like "Solver." The Figure 4.2.1 is an example of “Solver” menu to set the cells of an objective function, variables and constraints in an Excel worksheet. The upper box contains the cell address of the Objective function. The middle box contains the cell addresses of Variables. The lower box contains the formula of Constraints.

Figure 4.2.1 Solver Menu



4.2.3 Time Series Data in LP Model

In an LP model, the arrangement of time series data differs by the data type (monthly, quarterly, annual data). Generally, computer simulation models frequently use the time series data. Regarding the energy supply planning model, which will be developed in this project, the model has to be able to handle the time series data, such as annual data and quarterly data. Regarding this, the arrangement of the time series data becomes important for the handling of model building, utilization and model maintenance. If the model is small and simple, we can easily build the model by assigning each variable to one row, arranging time series data in column-wise. However, when we make a large, comprehensive model, we cannot easily build the model with using one-line cells for all items. In this case, it is better for the model that some of the items are arranged in column-wise cells. The contents of one year consist of several column cells. In other word, the LP matrix has several column cells in one year. Moreover, the values of annual or quarterly variables are independently computed by each period. Information in a period is carried over to the next period by stock variables.

Table 4.2.1 Sample Matrix with all Items in Line-wise Cells

Items	2000	2001	2003	2004	2005
Initial stock					
Production					
Import					
Export					
Final stock					
Balance	=0	=0	=0	=0	=0
Objective function	F(x,y,z)				

Table 4.2.2 Sample Matrix with some Items in Column-wise Cells

2000							2004			
Initial Stock	Produc-Tion	Import	Export	Stock	Balance	------------	Initial Stock	Produc-tion	Import	Export
Initial Stock	Produc-Tion	Import	Export	Stock	Balance		Initial Stock	Produc-tion	Import	Export
Initial Stock	Produc-Tion	Import	Export	Stock	Balance		Initial Stock	Produc-tion	Import	Export
Initial Stock	Produc-Tion	Import	Export	Stock	Balance		Initial Stock	Produc-tion	Import	Export
Initial Stock	Produc-Tion	Import	Export	Stock	Balance		Initial Stock	Produc-tion	Import	Export
Initial Stock	Produc-Tion	Import	Export	Stock	Balance		Initial Stock	Produc-tion	Import	Export
Initial Stock	Produc-Tion	Import	Export	Stock	Balance		Initial Stock	Produc-tion	Import	Export

4.2.4 Price and Cost

Price and cost data are required for all variables of a supply-planning LP model, which has a target of the profit maximum or the cost minimum. If prices and costs in the real market, such as production cost, import price, sales price and export price, exist, then we can use the market prices and market costs in the LP model. However, the book values of stock evaluation cost, own use consumption cost and trading cost in a factory are not officially published, such unpublished prices and cost should be estimated using published data of prices and costs.

Example 1: How can we estimate the price and cost of the domestic production?

Initial stock cost, final stock cost, own use consumption cost and trading cost in a factory are estimated using production costs.

Example 2: How can we estimate the price and cost of the products to be imported?

Initial stock cost, final stock cost, own use consumption cost and trading cost in a factory are estimated using import price.

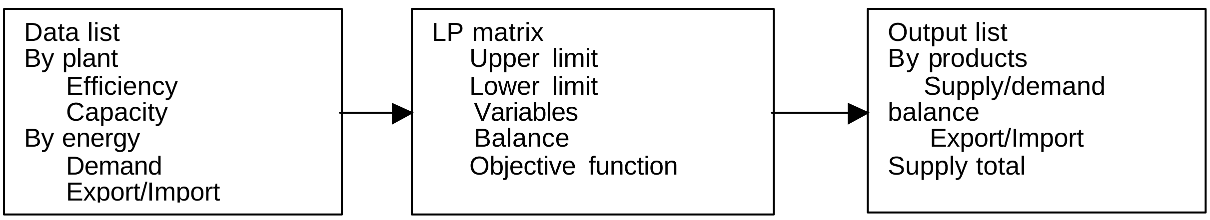
4.2.5 Efficiency (Yield)

Some types of efficiency rate are used in an LP model. These are efficiency rates to convert crude oil to petroleum products, coal to coke, crude oil to NGL and LPG and fossil energy to electric power. Such efficiency rates depend on individual plant. However, it is a common practice to apply the average of the efficiency rates to the national supply planning model. To calculate an accurate average efficiency rate is not easy. It could take a long time (sometimes 3 to 4years). For this, the initial stage of the supply planning model will not calculate the average efficiency rate but will assume it.

4.2.6 Input/Output Formation for Data

Upper limitation, lower limitation, balance condition and objective function are formulated and arranged encompassing the cells of LP variables (LP matrix). The arrangement should be clear and easy to handle and understand. For this purpose, the "data list," in which the data are arranged for easy input, is prepared in front of the LP matrix. Also, the "energy balance list," with which the results of an LP model can be easily examined, is prepared behind the LP matrix (see Figure 4.2.2).

Figure 4.2.2 Arrangement of Supply Planning Model



5. Macro Econometric/Energy Demand Forecasting Model

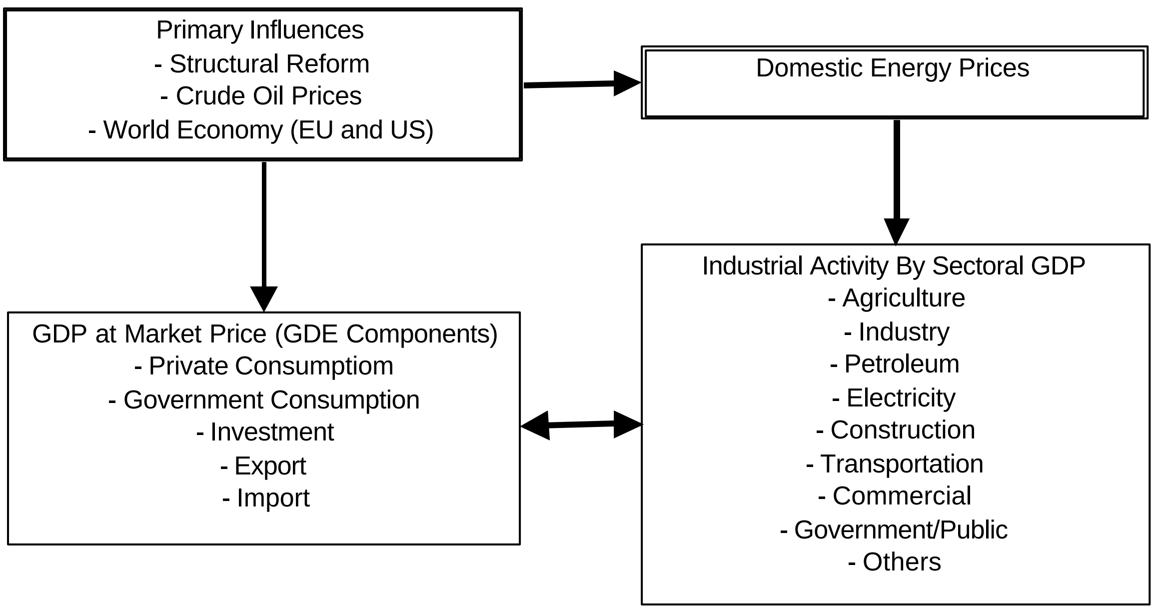
5.1 Macro-econometric Block

5.1.1 Purpose and the Basic Concept

The objective of macro-econometric model in this study is to address the relationships of ERSAP, international crude oil price, domestic energy price and major industrial activities.

The block diagram below shows the basic concept of the model. Here, the structural reform, crude oil price and world economy are the major determinant of domestic energy prices and the overall economic performance represented by GDP at market price. The industrial activities are represented by sectoral GDP. This sectoral GDP has the interrelationship with the overall GDP while its connection to domestic energy prices are expected to be direct.

Figure 5.1.1 Basic Concept



The idea is that the overall magnitude of GDP is a function of major external influences of structural reform, crude oil price and world economy. Because factors such as structural reform and world economy will influence overall economy from various aspects, they do not distinguish one specific sector, except for the case of crude oil, which has a direct link with the petroleum sector. Here, the influences from domestic parameters such as energy prices are indirect. On the other hand, industrial activities are not a direct function of such major determinants. The relationship is indirect through the overall performance of GDP and is directly related to variables like energy prices.

In this concept, the role of GDP at market price is to determine its overall magnitude principally in relation to these major determinants. The role of sectoral GDP is to determine its sectoral structure in relation to domestic factors such as energy prices. In an actual model, the sectoral share is redistributed to match the magnitude of the total GDP at a factor cost based on the total GDP at the market price.

5.1.2 Model Flow and the Components

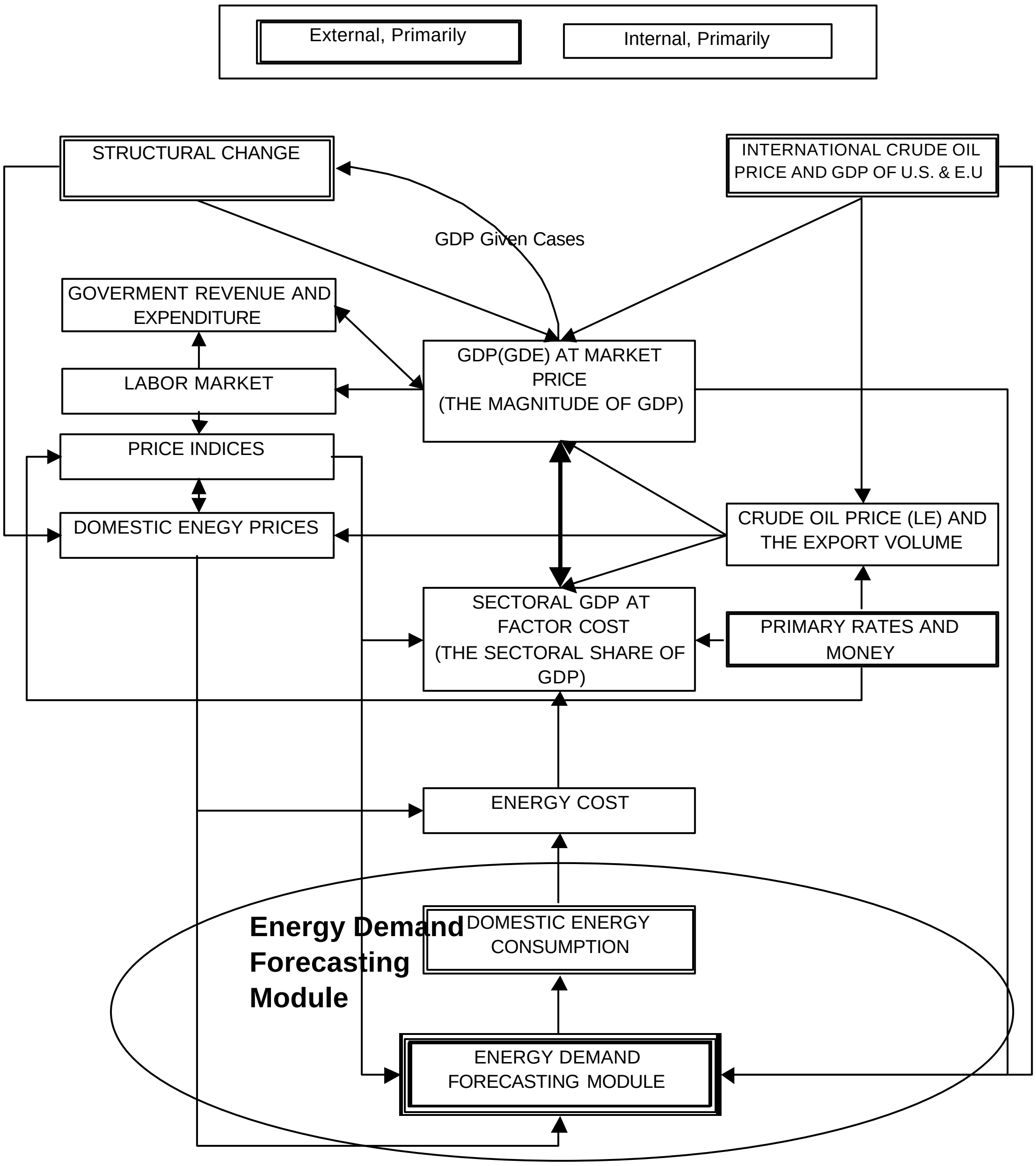
(1) Model Flow

Based on the above concept and the availability of macroeconomic data, the following 12 groups of variables are prepared.

1) Structural reform
2) International crude oil price and GDP of US & EU
3) GDP at market price
4) Sectoral GDP
5) Government revenue and expenditure
6) Labor market
7) Price indices
8) Domestic energy prices
9) Primary rates and money
10) Crude oil price in LE and the export volume
11) Energy cost
12) Energy consumption (Energy Demand Forecasting Module)

The flowchart of these groups is shown below. This flowchart provides us a blueprint for the specifications of the model. The specified relationship in arrows is the default model setting. Because of the transparent and adjustable nature of the model, all relationships can be modified based on the necessity. For example, the default setting of the GDP is endogenous. However, if it is necessary to make it external, the user can modify the link, for example, to make a structural change to external variables so that it gives the predetermined value for GDP.

Figure 5.1.2 Model Flow



(2) Model Components

1) Structural Reform

Structural reform cannot be represented by a single policy variable. Rather, it represents an aggregate change caused by many policies for market reform to improve the economic performance. These policies have been implemented since 1991 simultaneously and continuously. In this context, the most important characteristics of this factor are that it started in 1991 and is still continuing. In this regard, the variable of structural reform can be defined as a qualitative variable to distinguish pre-1991 and post-1991. In the model, the structural variable is defined to be 1 for pre-1991 and over 1.1 for post-1991.

As a default, structural reform is an exogenous variable.

2) International Crude Oil Price and GDP of US and EU

These are exogenous. Crude oil price is linked to export and petroleum sector GDP. GDP of the US and the EU are linked to export because the US and the EU are Egypt's major export destinations. The default setting is 6% annual growth (average growth rate between 1990-2000).

3) GDP at Market Price

As a default, GDP at the market price is internalized as a function of the above variables. It is defined as a sum of private consumption, government consumption, investment, export and import.

Private consumption is explained using its lagged variable, GDP minus tax revenue to represent the income level and structural reform. The impact of structural reform is expected to be negative because the structural reform promotes investment, which decreases consumption to increase the savings for investment.

Government consumption is explained by its lagged variable, total tax revenue and structural reform. The impact of structural reform is expected to be negative because it shrinks the public sector by promoting privatization.

Investment is a function of the sum of sectoral GDP, representing the economic performance of industrial actitivities, structural reform and interest rate. The impact of interest should be negative because less borrowing means more money for investment. Also, more deposit means more money in the saving for investment.

Export is explained by the GDP of the US and the EU. Also, the export values of crude oil, exchange rate and structural reform are related.

Import is explained by the GDP at factor cost to represent the industrial activity and exchange rate. The impact of exchange rate should be negative from the point of conventional trade theory.

4) Sectoral GDP

Sectoral GDP is internalized. The eight sectors are agriculture, industry, petroleum, electricity, construction, transportation, commercial, government and other. The GDP at factor cost is the sum of these sectoral GDP.

Each sectoral GDP is explained by its lagged variable, sectoral GDP total and the related energy cost or revenue. The impact of energy cost is expected to be negative. However, for the petroleum sector and the electricity sector, the related energy cost in other sectors is their revenues. Therefore the impacts should be positive.

5) Government Revenue and Expenditure

The government revenue is explained by income level using GDP and wage. Also related is the income of EGPC surplus. The expenditure is explained by the total revenue, wage and unemployment. It is understood that one of the most important role of the government is to keep the employment level as high as possible.

6) Labor Market

The variables of labor markets are population, labor force, unemployment rate and wage. Population is exogenous (2.1% growth as a default). Labor force is explained by population. Unemployment rate is explained by labor force to represent the labor supply pressure and GDP at factor cost to represent the labor demand pressure. Wage is explained by GDP per labor force to represent the labor productivity and the wholesale price index as a signal of labor demand for wage increase.

7) Price Indices

Price indices include wholesale price index, consumer price index and inflation rate. The wholesale price index is explained by wage to represent the labor cost, money supply and the exchange rate, which represents the cost of importing goods and services. Consumer price index was explained by wage to represent the pressure of cost increase, money supply and the average of the prices of petroleum products to represent the influence of energy prices.

8) Domestic Energy Prices

Domestic energy prices include electricity prices of industry, agriculture, commercial, residential and government as well as prices of petroleum products of gasoline, kerosene, diesel oil, diesel oil for transportation, LPG, natural gas and coal.

The electricity prices are determined politically. However, in the end, the price is expected to follow the cost increase. Also, they are subjected to structural reform. In this regard, especially the electricity price of industry is explained by its lagged variable, wholesale price index and structural reform. The other electricity prices are explained by the price of the industrial sector.

The prices of petroleum products are determined politically. However, in the end, the price is expected to follow the shadow market price, which is the international price. Also like other industry, the petroleum industry is under the pressure of cost increase and structural reform. In this regard, the gasoline price, as a representative of petroleum products, is explained by its lagged variable, crude oil price in LE, wholesale price index and structural reform. Other prices are explained by this gasoline price.

9) Primary Rates and Money

Primary rates include the Central Bank rate, lending rate, deposit rate, exchange rate and money supply. The Central Bank rate and the money supply are exogenous policy instruments. As a default, the central bank rate is assumed to be a function of last year's rate. Money supply is assumed to have the same growth rate of GDP. Lending rate and deposit rate are explained by the central bank rate, money supply and inflation. Exchange rate is explained, considering the purchasing power parity, by the real exchange rate or the ratio of the GDP deflator of the US and Egypt.

10) Crude Oil Price in LE and the Export Volume

Crude oil price in LE and the export volume are important to translate the $US value of crude oil export into the value of Egyptian domestic value. Crude oil price in LE is a simple calculation of crude oil price in $US multiplied by exchange rate (LE/$US). The export volume is an exogenous variable. As a default, it is defined as the continuation of the latest value.

11) Energy Cost

Energy cost variables are the major determinants of sectoral GDP as a cost factor. The electricity costs are calculated using their prices and the consumption estimates given by demand-forecasting module for the sectors of industry, agriculture, commercial, residential and government. The costs of petroleum products are calculated using their prices and the consumption estimates given by the demand-forecasting module for the sectors of agriculture, industry, residential/commercial and transportation.

12) Energy Consumption

Energy consumption by sector is an exogenous variable from the point of Macro-economic module. The estimates are given from the demand-forecasting module.

(3) The Dynamic Characteristics of the Model

The model is a partial equilibrium model. Also, the macroeconomic model in link with the demand forecasting model is simultaneous in nature. For example, the calculation of GDP requires the estimate of future energy consumption. The calculated GDP will be used for the calculation of future energy consumption in the demand-forecasting module. Then the calculation has to be reflected into the next iteration in the macro-economic module to re-calculate the GDP. The iteration will continue until the estimates converge.

There are four groups of such dynamic both-way links. They are 1) within the block of GDP at market price, 2) within sectoral GDP group, 3) between GDP at market price block vs. sectoral GDP block, and 4) sectoral GDP block vs. demand forecasting module.

5.2 Energy Demand Forecasting Block

5.2.1 Concept of Model Building

(1) Relationship between Macroeconomics and Energy Demand

In energy supply-demand forecasting, prices of primary energy such as crude oil and key energy carriers are the most important assumed values. As these values in the future are considered being uncertainty and/or massive fluctuation, it is popular to set some scenarios (plural cases). Fluctuations of crude oil prices, etc. not only have price effects that directly affect energy demand but also produce not-so-little impacts on the levels of economic/industrial activities, general commodity prices and secondary energy. It is crucially important to make these coherent and integrated direct/indirect ripple effects into the analysis.

In general, energy demand can be described as a function of income and price.

$$E = f(I, PE) \text{ - } (1)$$

Where, E: Energy Demand

I: Income (Production), + factor

PE: Energy Price, - factor

This means that increased income (production) level pushes energy demand up while increased price pushes it down. In this point, however, it must be taken into account that income is also a function of energy price with its impact being rather greater than price effect in Equation (1).

$$I = f(PE, Z) \text{ - } (2)$$

Where, Z: Other factors, in addition, Z = f (PE, …)

Hence, energy model's Equation (1) alone is insufficient for making an econometric analysis on relationship between energy price fluctuation and energy demand, and it is essential to grasp more comprehensive data including Equation (2). Furthermore, structural changes in income/production as well as those in production activity like heavier weight held by services and higher added-value-orientation form crucial factor to determine energy demand as well. Various secondary energy prices and crude oil price can never be independent of general commodity prices, either. Their relative prices pose essential factors in considering inter-energy competition.

(2) Characteristics of Energy Demand

1) Energy itself can never be counted as demand. Namely energy demand is always linked with other inputs to produce satisfactory services (derivative demand). An analysis focusing on use-by-use demand is important.

2) While serving as final goods directly in use at household, for instant, energy is concurrently consumed as intermediate goods to enable economic activity.

Energy intensity based approach

Energy consumption = Energy intensity * Output

3) Energy demand depends on stock levels of durable goods (energy-consuming appliances) and their utilization factor.

Stock based approach

Energy demand =	Technical coefficient *	Working ratio *	Capital stock
(Gasoline)	(Fuel consumption)	(km)	(No. of cars)

Ultimately, the factors described above can be taken as a function of price and income.

(3) Basic Idea for Model Building

The energy demand in each sector is classified into the electric power and non-electric power (fuels) that are estimated by regression analysis. As for fuel demand, two options are taken into consideration--estimation by regression of each fuel and one by use of the fuel source mix calculated by the introduction of the share function. General idea for energy demand forecasting model building can be expressed as follows.

$E = EL + F$

Where: Final Energy Demand Total $E = \sum Ei$

Electric Power Demand Total $EL = \sum ELi$

Fuel Demand Total $FU = \sum\sum FUij$

i: i sector (i industry)

j: j fuel (oil, coal, and gas, etc.)

Above equations show that the final energy consumption is the sum of power and fuels from the standpoint of energy sources and corresponds to the total demand of all sectors. The total electric power demand and the total fuel demand are obtained respectively by adding each demand sector. The separation of electric power and fuels is based on the assumption that significant substitution does not exist between electric power and other energy sources.

In regression analysis applied for the estimate of energy demand, energy intensity is used as much as possible. Electric power demand equation and fuel demand equation described below mean that the sectoral demand is a multiplication of the energy intensity and the economic activity level in each sector. In general, these intensities are estimated by regression analysis, and the indicators of economic activities are given exogenously from the macroeconomic model.

$ELi = ai*Yi$

$Fi = bi*Yi$

$ai = ELi / Yi.$ (ai: electricity intensity to activity level (Yi))
$bi = Fi / Yi$ (bi: fuel intensity to activity level (Yi))

In the case of using intensities, the energy demand is calculated by using the equation below.

$$E = \sum (ai*Yi) + \sum (bi*Yi)$$

In the case of using share function, the share of the individual energy source is distributed to petroleum products, gas, coal, etc. That is, model takes into consideration of the substitution and the competition of energies, and each share is explained by the relative prices between different energy products, for instance.

Fij (fuel j) $= Fi*Sij$
Where: Sij: Share of each energy source
$Sij = f (Peij / Pei)$
Pe: Energy price

Finally, the primary energy demand is calculated using the conversion factor. The conversion efficiency usually improves with technological improvements, especially with new equipments. The time trend and real energy prices become explanatory variables to represent the technological improvement.

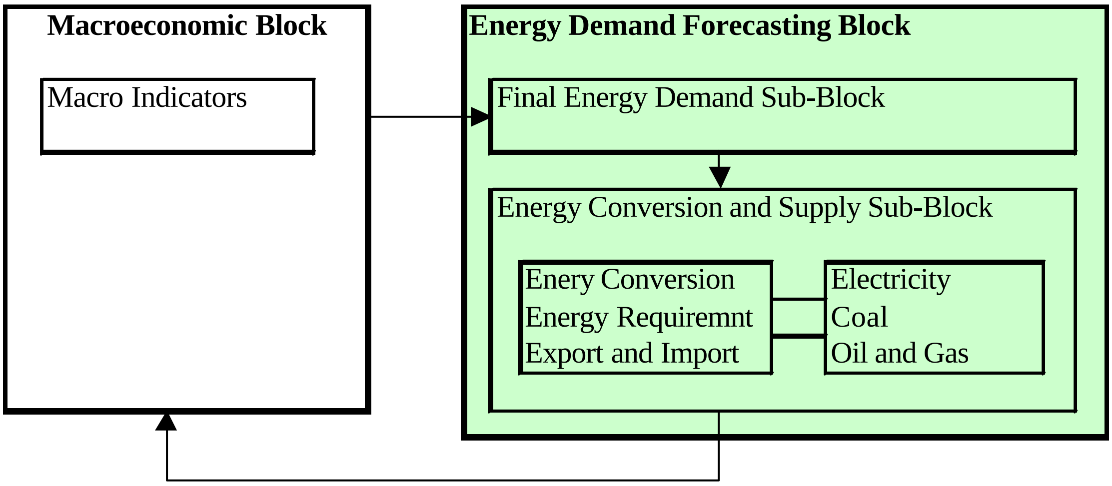
$$PER = EL/\alpha + Fj/\beta j$$

Where: PER: Primary Energy Requirement (demand)
α and βj : each conversion factor
$\alpha = f (T, Pe)$
$\beta = f (T, Pe)$
T: Time trend

5.2.2 Framework of Energy Demand Forecasting Block

An energy demand-forecasting model block consists of a final energy demand sub-block and an energy conversion and supply (energy requirement) sub-block, as shown in Figure 5.2.1. The model computes end-use energy demand in each of the final energy demand sectors, using economic indices obtained from the macro-economic model block. Taking into account of fuel inputs and conversion losses in the conversion sector such as electric power generation and oil refining, the primary energy requirement is estimated.

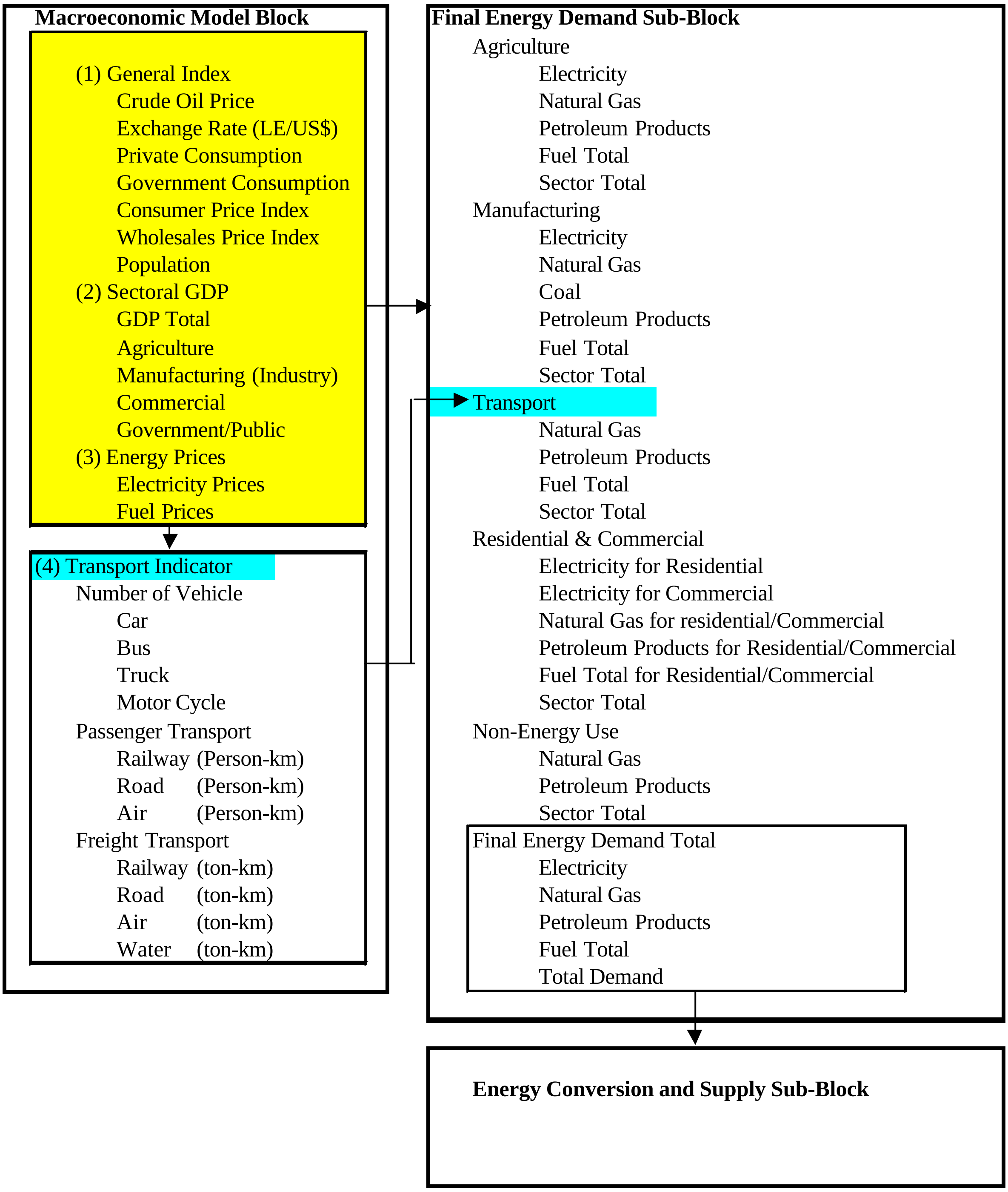
Figure 5.2.1 Schematic Diagram of Energy Demand Forecasting Block



(1) Final Energy Demand Sub-Block

Figure 5.2.2 shows the framework of final energy demand sub-block. Macro indicators consist of four items, which are, (1) general index, (2) sectoral GDP, (3) domestic energy prices and (4) transport indicators. In the energy demand forecasting sub-block, the first three items described above are treated as external valuables in order to simulate the impact of price and GDP growth. The final energy demand sub-block, comprising of each sector, creates structural equations by energy carrier, such as electricity, natural gas and petroleum products (kerosene, LPG, gasoline, diesel oil, fuel oil, etc.) and calculates the fuel total and the sector total. The demand function is estimated by regression analysis in each energy demand for agriculture, manufacturing, transportation, residential/commercial, government/public utilities (other) and non-energy sectors. The final energy demand total is obtained by adding the sector demand.

Figure 5.2.2 Framework of Final Energy Demand Sub-Block



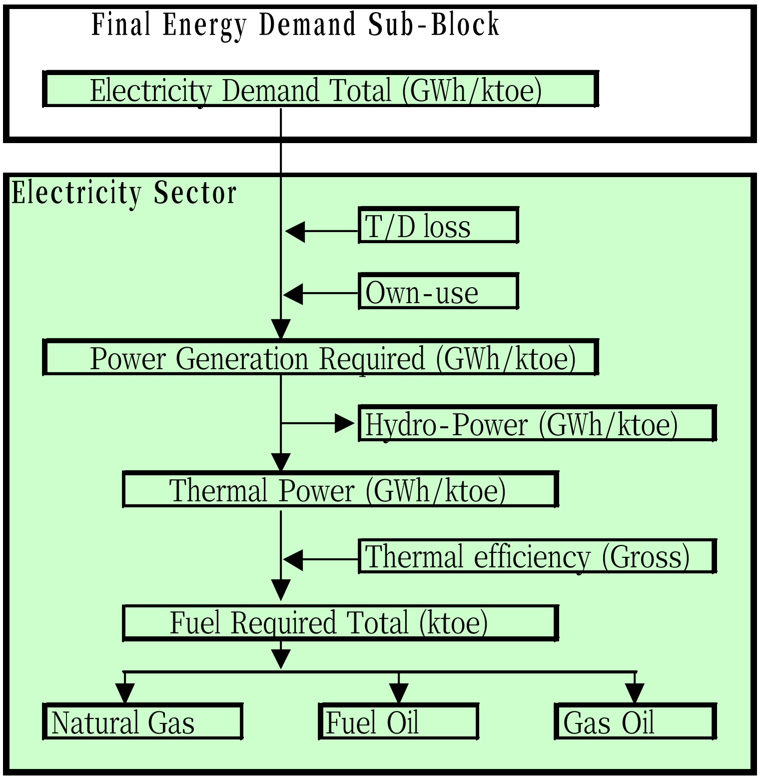
(2) Energy Conversion and Supply Sub-Block

The energy conversion and supply (energy requirement) sub-block consists of electricity sector, coal sector and oil/gas sector, including export and import.

1) Electricity Sector

Figure 5.2.3 shows the framework of the electricity sector. In this sector, the total electricity demand forecast is received from the final energy sub-block. Adding transmission /distribution (T/D) losses and own use (in plant use), the total electric power generation required is calculated. Thermal power generation is obtained by subtracting hydropower generation from the total. The total and each fuel demand are obtained by use of thermal efficiency and fuel share function. In this model, all variables are set as internal variables. From the technical point of view, the ratios of T/D loss and own use, hydropower generation and thermal efficiency can be input as external variables.

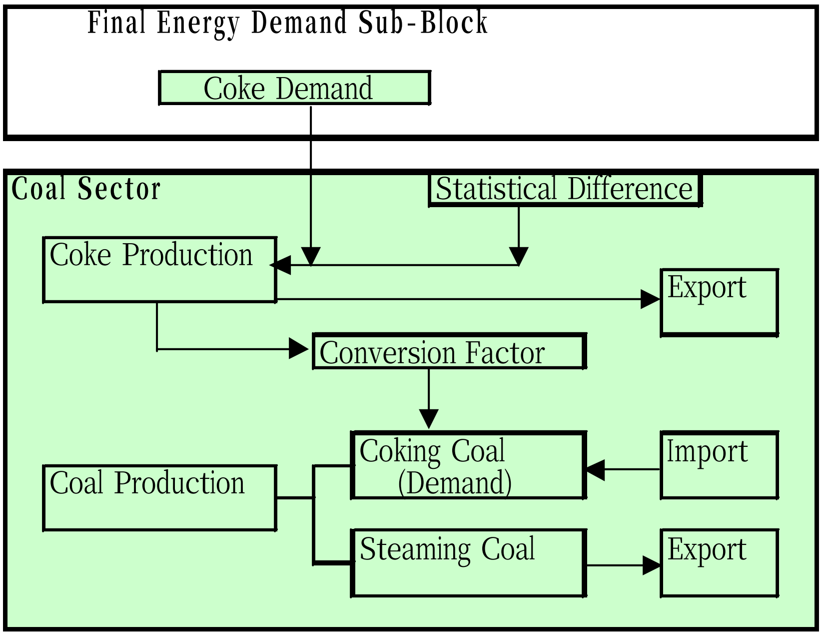
Figure 5.2.3 Framework of Electricity Sector



2) Coal Sector

Figure 5.2.4 shows the framework of the coal sector. In the coal sector as well, coke demand is received from the final energy demand sub-block. Main purpose of this sector is to obtain coking coal (metallurgical coal) demand. As for steaming coal (thermal coal), both production and consumption (or export) are a small amount at present. While all variables are treated as internal variables in this model, coke export, steaming coal export and conversion factor from coking coal to coke can be set intentionally as external variables. Coke produced is supplied to domestic market (industrial sector) and foreign market.

Figure 5.2.4 Framework of Coal Sector



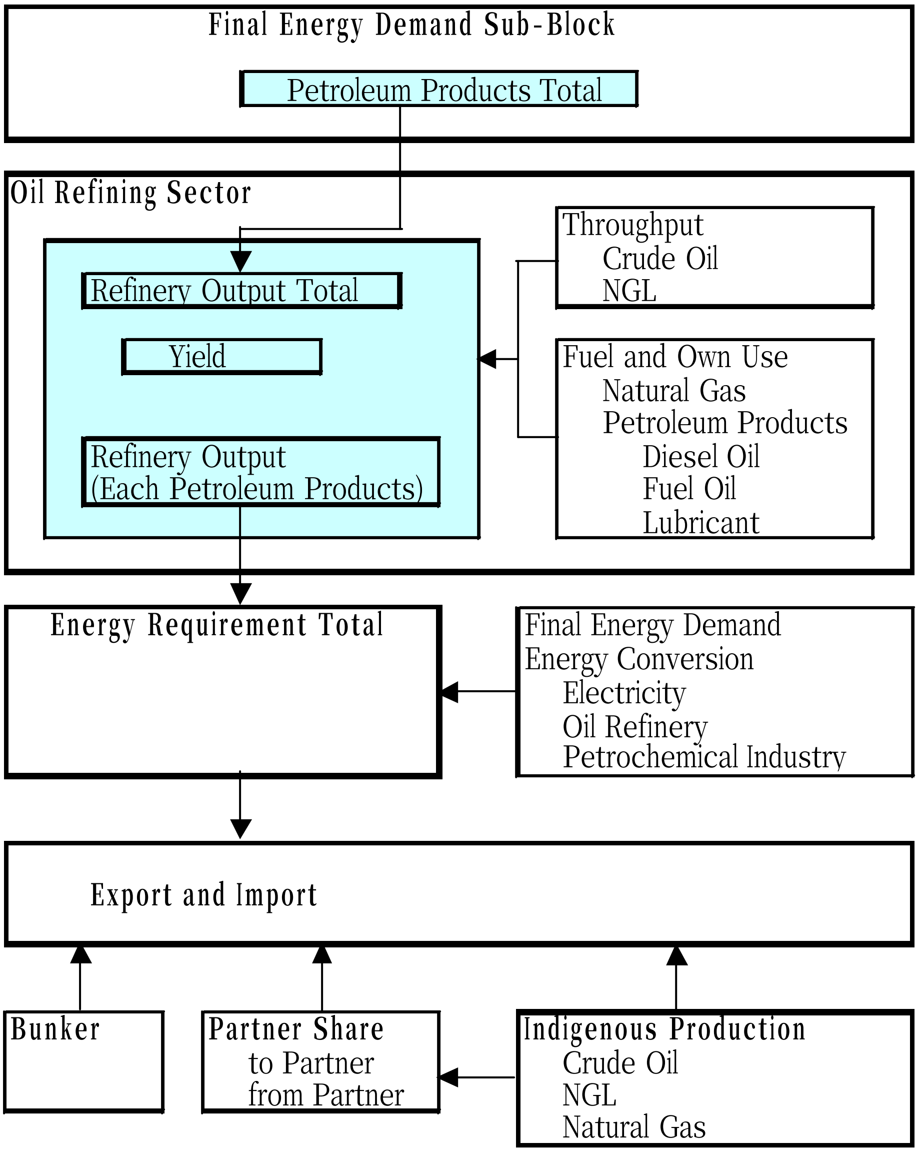
3) Oil and Gas Sector

Figure 5.2.5 shows the framework of the oil and gas sector. In this sector, oil refining plays an important role. Benchmark of oil refineries' operation is assumed to meet the domestic petroleum products' total demand, and the petroleum products total is received from the final energy demand sub-block. Firstly, refineries' products (output) total is forecast based on the past trend of refineries' products total and its domestic demand total. After the determination of the refineries' output, the required amount of throughput and fuel, etc. is forecast. Refineries' output of each petroleum product is obtained by use of yield of each product. Yield also can be input as external variables.

The model calculates the total energy requirement (total domestic demand) through the final energy demand sub-block, the conversion sector including electricity, oil refining, petrochemical industry and transfer (LPG), and the primary energy supply sector.

Indigenous production of natural gas and NGL are assumed to meet the total domestic demand in order to avoid mismatch between supply and demand (especially export/import) in this stage. Taking the indigenous production into consideration, partner share and bunker stock, export and import are calculated. Getting both natural gas and NGL in and out of partner is balanced. The in and out of crude oil from partner is calculated by the share function obtained from the past trend. Crude oil production is forecast by regression analysis and is balanced in terms of export and import. The balance of petroleum products is also taken into consideration in terms of in the export/import term.

Figure 5.2.5 Framework of Oil and Gas Sector



5.3 Simulation Results

In this section, simulation results by macroeconomic-energy demand forecasting model are described. Base year and target year of the model are F.Y.1998/99 and F.Y.2005/06 respectively. Although there are many scenarios to be considered, the following three kinds of energy price scenarios are set in this section.

1) Nominal price constant (low price scenario)
2) Real price constant (base price scenario)
3) Real price increase 10 % annually (high price scenario)

It can be said, from the standpoint of the demand side, that the low price scenario is demand high case and high price scenario is demand low case. Base case is the real price constant case. In this simulation, energy prices are classified as shown in Table 3.3.1.

Table 5.3.1 Classification of Energy Price

Electricity		Fuel	
Agriculture	PT/kWh	Gasoline	LE/toe
Industry	PT/kWh	Kerosene	LE/toe
Commercial	PT/kWh	Diesel for Boiler	LE/toe
Residential	PT/kWh	Diesel for Transportation	LE/toe
Government/Public	PT/kWh	Fuel Oil	LE/toe
		LPG	LE/toe
		Natural Gas	LE/toe
		Coking Coal	LE/toe

5.3.1 Summary of Simulation Results by Price Scenario

Table 5.3.2 shows the summary of results by price scenario described above. The annual growth rates (G.R) of primary energy requirement was 5.44%, 5.64% and 6.01% in each case of high price case, real price constant case and low price case, respectively. The GDP growth rates during the simulation term (1998/99-20005/06) are 5.77%, 5.74% and 5.68%, respectively. As the results, the elasticity of primary energy requirement with respect to GDP was 0.94, 0.98 and 1.06, respectively.

As for the final energy demand, the growth rates in each scenario were 5.04%, 5.27% and 5.71%, and their elasticity was 0.87, 0.92 and 1.01, respectively. In every case, natural gas demand will reach the highest growth rate of over eight percent. The demand of other energy sources, such as crude oil and petroleum products, will remain around four percent growth.

Table 5.3.2 Summary of Main Results by Scenario

		High Price Case		Real Price Constant		Low Price Case	
	1998/99 (ktoe)	G.R (%)	2005/06 (ktoe)	G.R (%)	2005/06 (ktoe)	G.R (%)	2005/06 (ktoe)
Energy Requirement Total	44,064	5.44	63,845	5.64	64,675	6.01	66,291
Primary Energy							
Coking Coal	1,360	2.04	1,567	2.44	1,610	2.96	1,669
Natural Gas	12,799	8.38	22,476	8.47	22,610	8.64	22,862
Crude Oil	27,400	3.79	35,547	4.10	36,294	4.70	37,800
NGL	1,671	3.79	2,168	4.10	2,213	4.70	2,305
Secondary Energy							
Petroleum Products	24,057	3.63	30,877	3.91	31,467	4.46	32,652
Electricity (Generation)	5,848	6.23	8,925	6.33	8,989	6.53	9,107
Final Energy Demand							
Agriculture	320	3.77	414	4.39	432	5.34	460
Industry	10,775	5.96	16,163	6.06	16,265	6.21	16,428
Transportation	9,113	4.08	12,058	4.49	12,394	5.37	13,145
Residential/Commercial	5,652	4.87	7,884	5.16	8,041	5.66	8,308
Government/Others	714	7.96	1,220	7.97	1,221	7.97	1,221
Non-Energy Use	1,923	3.66	2,474	3.66	2,474	3.66	2,474
Electricity (Demand)	4,868	6.48	7,555	6.59	7,609	6.79	7,710
Total	28,498	5.04	40,213	5.27	40,827	5.71	42,037
Elasticity to GDP							
Final Energy Demand		0.87		0.92		1.01	
Energy Requirement		0.94		0.98		1.06	
Electricity Demand		1.12		1.15		1.20	
Electricity Requirement		1.08		1.10		1.15	
Gross Domestic Product	268,341	5.77	397,500	5.74	396,544	5.68	395,071

Regarding the demand for petroleum products, the total growth rates were 3.6%, 3.9% and 4.5% in each price scenario. LPG is forecast to be the record growth rates of 6.8%, 7.3% and 8.2% in each scenario, followed by diesel oil (gas oil) of around 5.8% growth rate. Gasoline demand will fluctuate from 3.3% to 7.6% growth rates with the price scenario. From the results of this simulation, gasoline is the most sensitive to price. Kerosene demand is forecast to decrease rapidly around –10% as shown in Table 5.3.3.

Taking fuel switch policy from petroleum products to natural gas into consideration, its main target will be LPG and diesel oil from the view point of demand size, and LPG and gasoline from the view point of price policy. Fuel oil will be able to complement the short-term shortage of natural gas supply capacity.

Table 5.3.3 Forecasted Results of Main Petroleum Products

Petroleum Products		High Price Case		Real Price Constant		Low Price Case	
	1998/99 (ktoe)	G.R (%)	2005/06 (ktoe)	G.R (%)	2005/06 (ktoe)	G.R (%)	2005/06 (ktoe)
LPG	2,376	6.76	3,756	7.32	3,895	8.19	4,123
Gasoline	2,432	3.26	3,045	4.71	3,356	7.59	4,060
Jet Fuel	454	2.00	522	2.13	526	2.38	535
Kerosene	1,166	-11.04	514	-10.27	546	-9.11	598
Diesel	7,670	5.71	11,316	5.76	11,351	5.85	11,419
Fuel Oil	8,979	2.34	10,555	2.42	10,612	2.56	10,720
Lubricant	338	3.72	437	4.08	448	4.64	465
Bitumen	883	3.04	1,088	3.17	1,098	3.39	1,114
Petroleum Products Total	24,057	3.63	30,877	3.91	31,467	4.46	32,652

Forecast results in the power sector are shown in Table 5.3.4. Electricity demand is forecast to be around six percent growth rates, 6.5%, 6.6% and 6.8% in each price scenario, and the elasticity with respect to GDP will be expected to be 1.12, 1.15 and 1.20, respectively. The highest growth rates are recorded in the commercial sector, followed by the government/public, residential, and agricultural sectors.

Table 5.3.4 Forecasted Results in Power Sector

Electricity Sector		High Price Case		Real Price Constant		Low Price Case	
	1998/99	G.R	2005/06	G.R	2005/06	G.R	2005/06
	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)	(GWh)
Demand by Sector							
Agriculture	2,200	6.88	3,505	6.95	3,522	7.05	3,545
Industry	22,900	4.78	31,750	4.94	32,097	5.20	32,658
Residential	21,066	7.28	34,449	7.28	34,449	7.28	34,454
Commercial	2,134	9.23	3,959	10.20	4,213	12.25	4,792
Government/Others	8,300	7.96	14,190	7.97	14,201	7.97	14,202
Electricity Demand Total	5,604	6.48	8,698	6.59	8,760	6.79	8,876
Electricity Generation	68,000	6.23	103,776	6.33	104,518	6.53	105,900
Hydro-power	15,000	1.56	16,713	1.56	16,713	1.56	16,713
Thermal-power	53,000	7.35	87,063	7.48	87,804	7.72	89,187
Fuel Required							
Fuel Total	12,012	7.35	19,731	7.48	19,899	7.72	20,213
Petro. Products Total	4,337	4.16	5,770	4.29	5,819	4.52	5,910
Diesel Oil	129	-6.50	81	-6.50	81	-6.50	81
Fuel oil	4,208	4.40	5,689	4.53	5,738	4.77	5,830
Natural Gas	7,675	8.92	13,962	9.06	14,080	9.30	14,302

5.3.2 Simulation Results of Base Case

In this section, the simulation results of base case are described. Table 5.3.5 shows the summary of the base case.

Table 5.3.5 Summary of Simulation Results (Base Case)

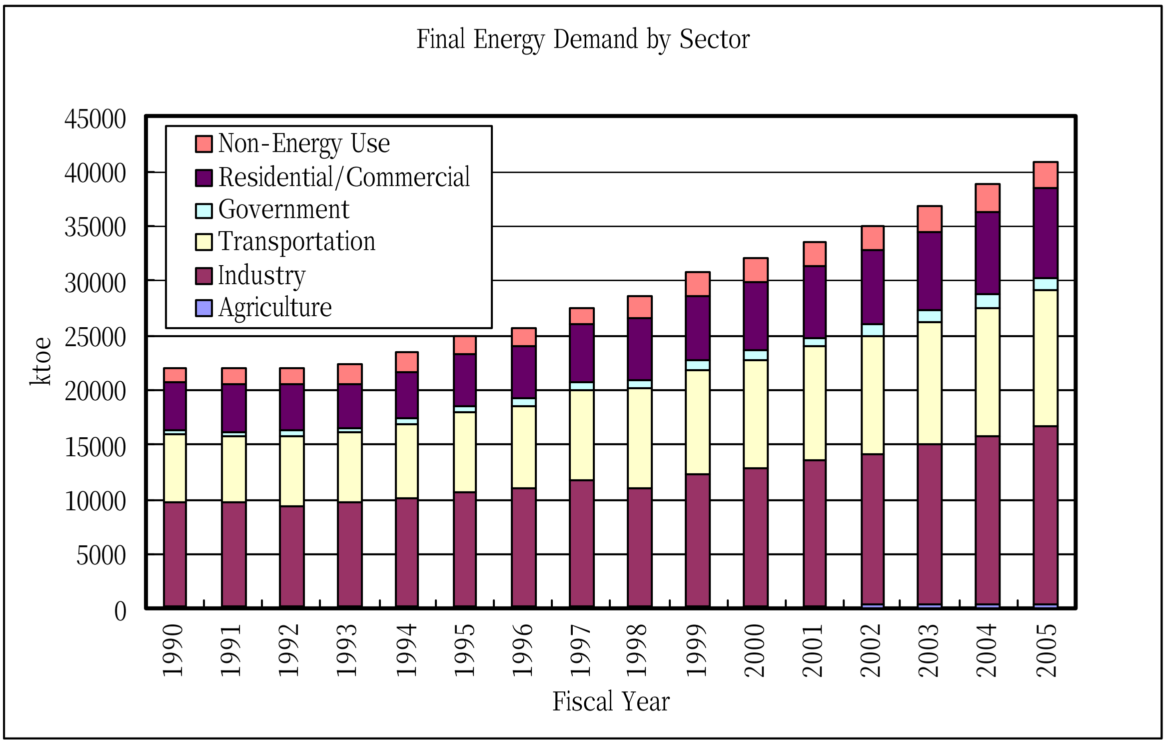
	1998 value (ktoe)	Forecast Growth Rate (%)	2005 Value (ktoe)
Final Energy Demand			
Agriculture	320	4.39	432
Industry	10,775	6.06	16,265
Transporatation	9,113	4.49	12,394
Residential/Commercial	5,652	5.16	8,041
Government/Others	714	7.97	1,221
Non-Energy Use	1,923	3.66	2,474
Electricity	4,868	6.59	7,609
Fuel Total	20,505	5.19	29,213
Final Demand Total	28,498	5.27	40,827
Energy Requirement for Domestic Use			
Primary Energy Requirement			
Coking Coal	1,360	2.44	1,610
Natural Gas	12,799	8.47	22,610
Crude Oil	27,400	4.10	36,294
NGL	1,671	4.10	2,213
Secondary Energy Requirement			
LPG	2,376	7.32	3,895
Gasoline	2,432	4.71	3,356
Jet	454	2.13	526
Kerosene	1,166	-10.27	546
Diesel	7,670	5.76	11,351
Fuel OIL	8,979	2.42	10,612
Naphtha	0	0.00	0
Lubricant	338	4.08	448
Bitumen	883	3.17	1,098
Petro. Coke	121	1.77	137
Non-specified	520	1.97	596
Petro. Total	24,057	3.91	31,467
Fuel Total	22,836	3.94	29,922
Electricity	5,848	6.33	8,989
Energy Requirement Total	44,064	5.64	64,675
GDP	268,341	5.74	396,544

(1) Final Energy Demand Sector

Figures 5.3.1 and 5.3.2 show the forecast results of the final energy demand by sector and by energy source. Figures 5.3.3(a) Table 5.3.3(b) show the forecast results of petroleum products and of the structure, respectively.

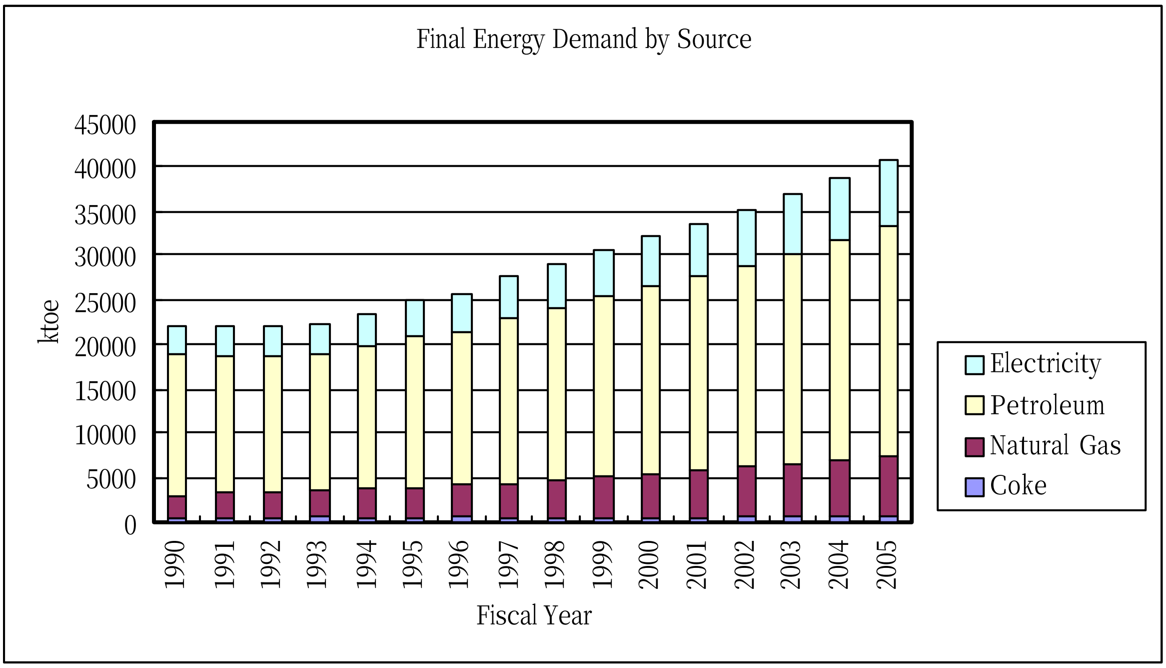
As shown in Figure 5.3.1, the major energy consuming sectors of the final energy are the industrial, transportation and residential sectors, which account for 90% of the total demand. The demand structure is little changed within the targeted year 2005/06. The share of the industrial sector will increase from 37.8% in 1998/99 to 39.8% in 2005/06.

Figure 5.3.1 Final Energy Demand by Sector



As for the final energy demand by energy source, the major source is petroleum products, the share of which decreases from 68% in 1998/99 to 63% in 2005/06, maintaining the share above 60%. On the other hand, natural gas increases the share from 15% (1998/99) to 17% (2005/06), and electricity increases the share from 17% (1998/99) to 19% (2005/06). In the past, electricity accounted for 12% in 1985/86, 14% in 1990/91 and 16% in 1995/96.

Figure 5.3.2 Final Energy Demand by Source



As seen in main petroleum products, diesel oil, LPG and gasoline demands have an increasing tendency (See Figure 5.3.3(a)). Each share of diesel oil, LPG and gasoline will expand a little bit. The share of fuel oil will shrink. Diesel oil will keep a large share in petroleum products demand, as shown in 5.3.3(b).

Figure 5.3.3(a) Main Petroleum Products Demand

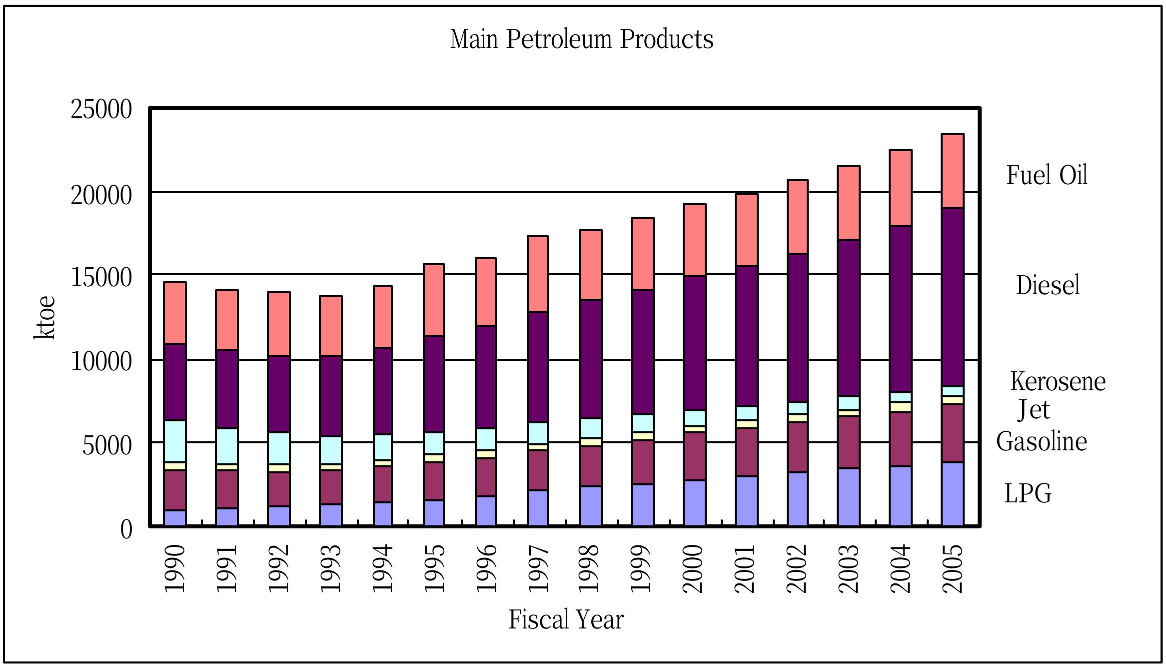
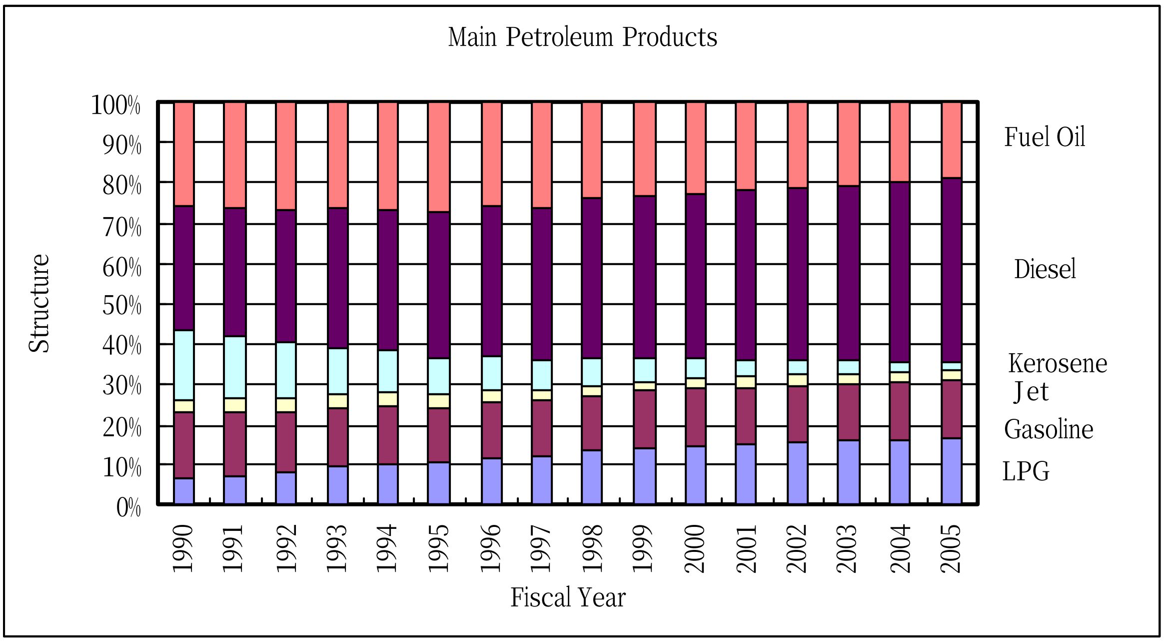


Figure 5.3.3(b) Demand Structure of Main Petroleum Products



1) Agricultural Sector

Energy demand for agriculture is forecast to be from 320 ktoe in 1998/99 to 432 ktoe in 2005/06 at an average growth rate of 4.4%. The energy demand accounts for only one percent of the total demand. Other than electricity, kerosene and some diesel oil are used as fuels in the agricultural sector. It is supposed that each energy carrier is used for irrigation.

Figures 5.3.4(a) and 5.3.4(b) show the forecast energy demand for agriculture and its demand structure. As shown in both figures, kerosene demand decreases rapidly, and electricity demand increases in place. This trend will continue beyond 2005/06.

The share of electricity was just under 40% in 1990/91 and about 70% in 1998/99. It is likely to rise above 80% in 2005/06, according to the simulation results (See Figure 5.3.4(b)). It is observed that kerosene will be substituted for electricity in a long run.

Figure 5.3.4(a) Energy Demand for Agricultural Sector

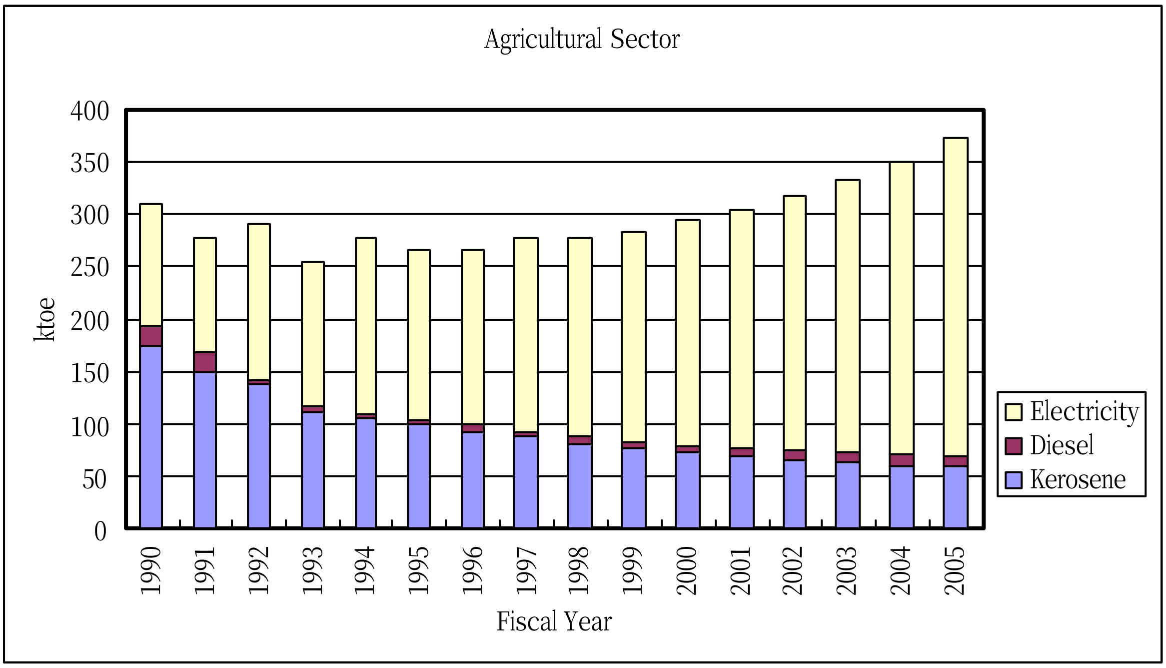
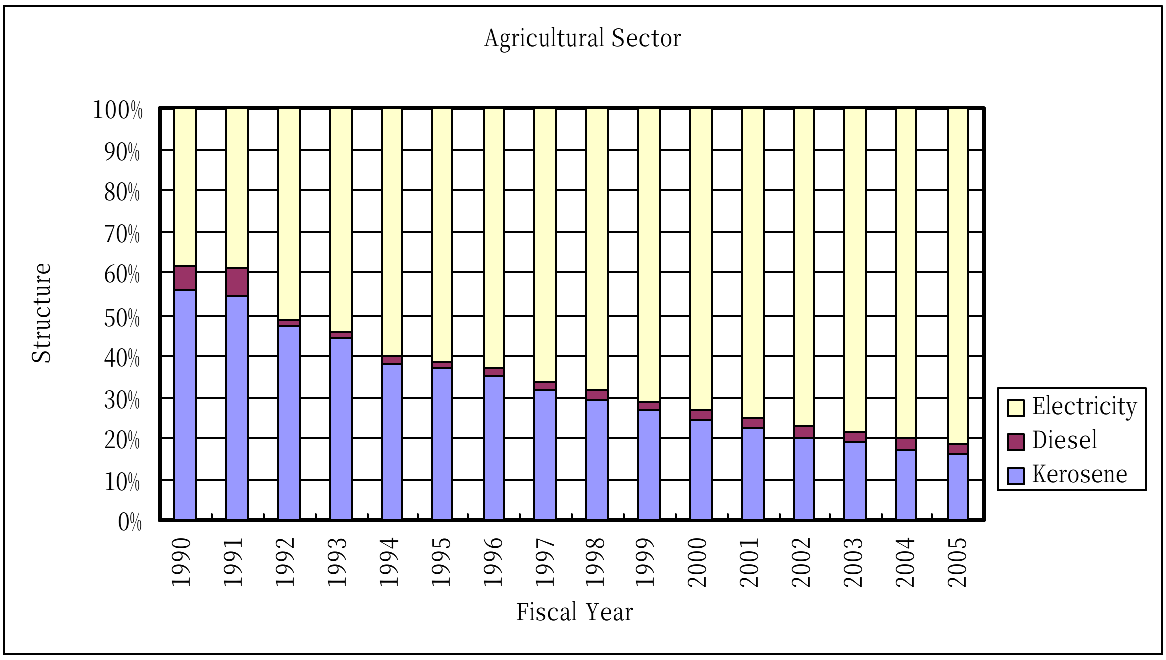


Figure 5.3.4(b) Energy Demand Structure in Agricultural Sector



2) Industrial (Manufacturing) Sector

Industrial sector is the biggest energy consumer. The energy demand will increase at an average growth rate of 6.1% per year, with 10,775 ktoe in 1998/99 to 16,265 ktoe in 2005/06. As the result, the share of energy demand for the industrial sector increases from 38% in 1998/99 to 40% in 2005/06.

Figure 5.3.5 shows the forecast demand by energy carrier, and Figure 5.3.6 shows petroleum products demand. Natural gas seems to be increasing the consumption and expanding the share. Petroleum products demand will also increase. However, the share will reduce. Electricity expands the share gradually.

As for petroleum products, fuel oil had been playing a main role in the past. However, the role of fuel oil will get smaller relatively. On the other hand, diesel oil demand is projected to grow and expand the share. LPG demand also increases although it is small in quantity (See Figure 5.3.6).

3) Transportation Sector

The transportation sector is a large energy consumer next to the industrial sector. Energy demand for transportation is likely to grow at an average growth rate of 4.45%, from 9,113 ktoe in 1998/99 to 12,394 ktoe in 2005/06. The share of the transportation sector in the total demand would remain slightly above 30%.

Figure 5.3.7 shows the forecast energy demand for the transportation sector by petroleum products. As shown in the figure, diesel oil demand is climbing, followed bygasoline demand. The growth rates of main fuels for transportation--Gasoline, jet (aviation fuel), diesel oil and fuel oil--are shown in the following Figure 5.3.6.

Table 5.3.6 Growth Rates of Fuels for Transportation

F.Y	1998	2005	G.R
	(ktoe)	(ktoe)	(%)
Gasolime	2,432	3,356	4.71
Jet	454	526	2.13
Diesel	5,242	7,337	4.92
Fuel Oil	717	810	1.75

As described earlier, gasoline, whose demand is largely dependent on price policy, fluctuates heavily by price. This trend is a result of the base case scenario (real price constant).

Figure 5.3.5 Energy Demand for Industrial Sector

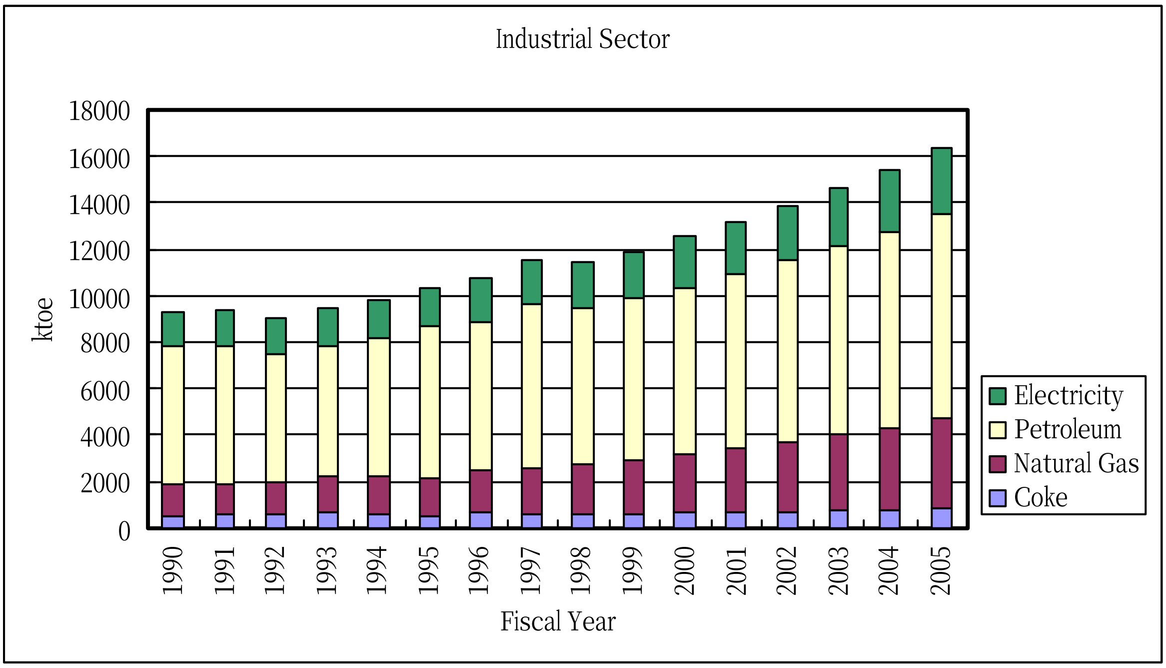


Figure 5.3.6 Petroleum Products Demand in Industrial Sector

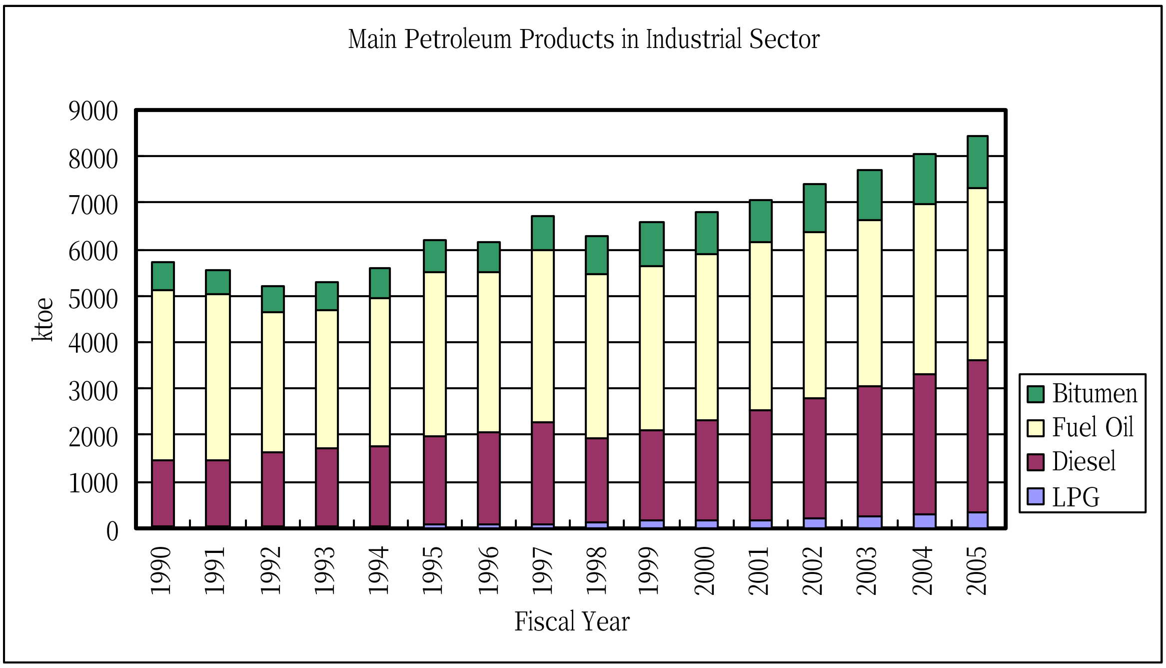
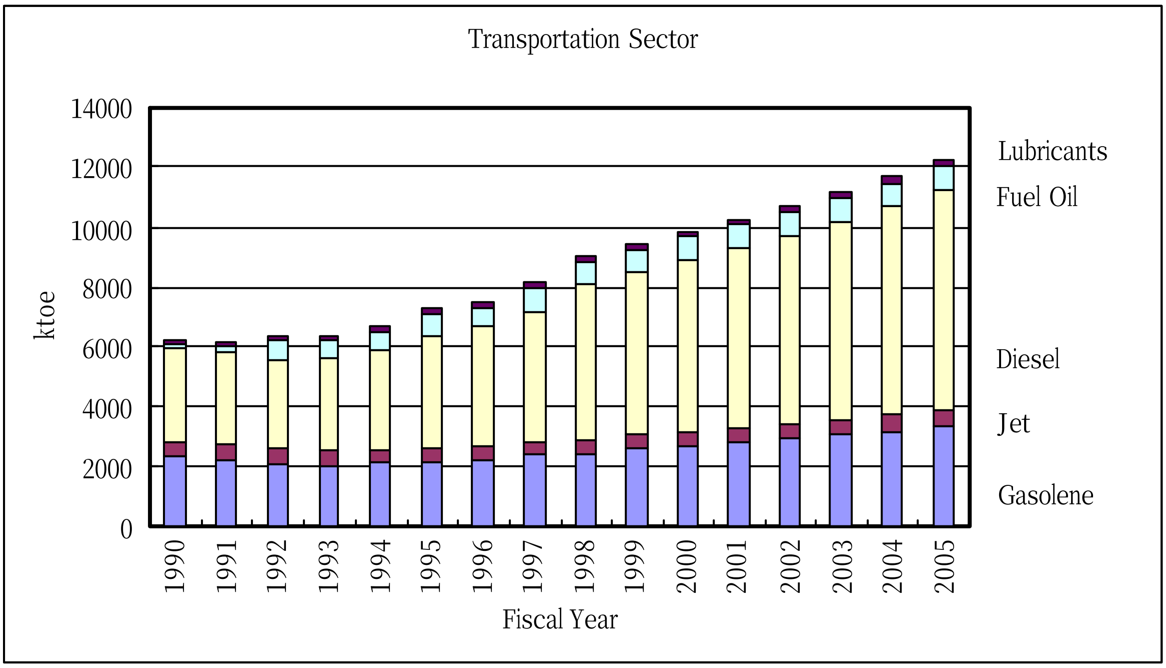


Figure 5.3.7 Energy Demand for Transportation Sector



4) Residential and Commercial Sector

The energy demand for residential/commercial sector grows at a pace of 5.2% growth rate, and the demand is expected to be 8,041 ktoe in 2005/06, up from 5,652 ktoe in 1998/99.

Figures 5.3.8(a) and 5.3.8(b) show the forecast demand and its structure. The residential and commercial sector is the third largest energy consumer and has its own unique demand structure. According to the simulation result, the demand for both LPG and electricity grows remarkably. Natural gas demand is also expected to rise. As a result, energy demand structure in the residential/commercial sector would clearly change. Kerosene, which took a large share in the past, loses the share. Electricity and LPG will take around 90% of the share of. It is estimated that natural gas use will expand, based on the investment for gas supply infrastructure.

Figure 5.3.8(a) Energy Demand for Residential and Commercial Sector

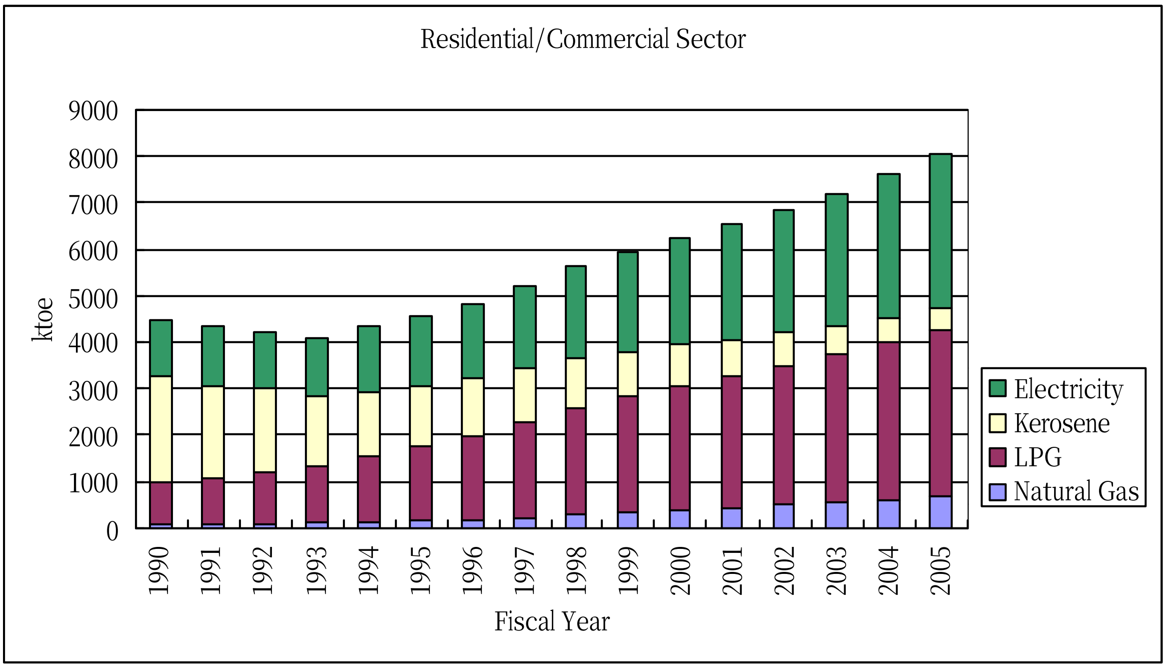
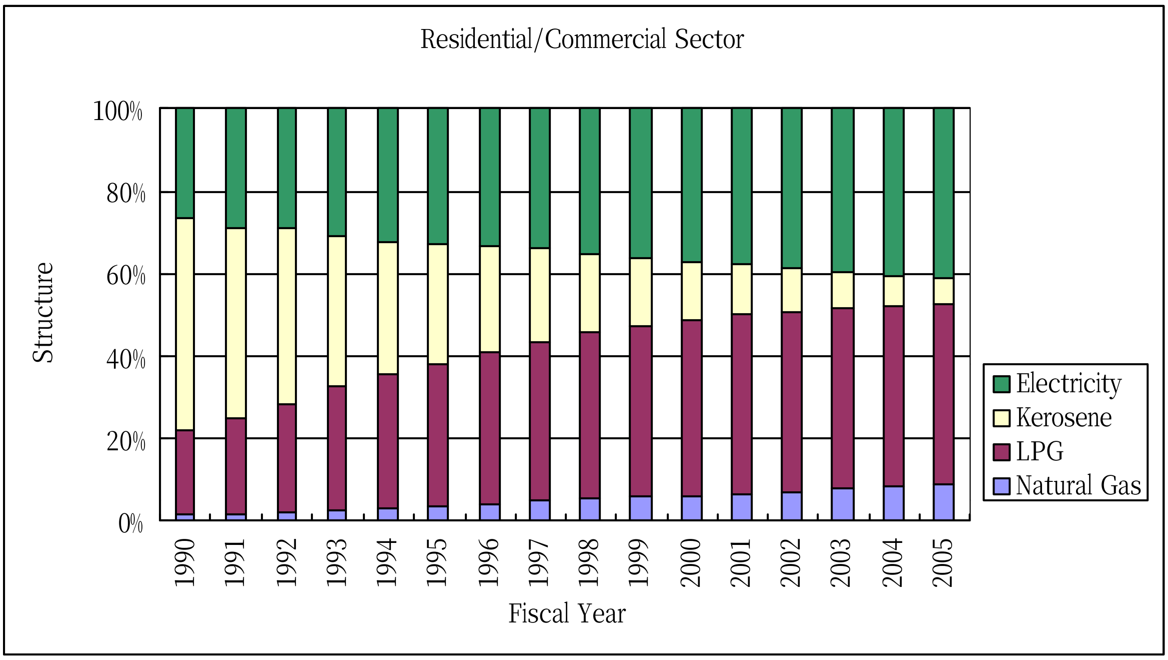


Figure 5.3.8(b) Energy Demand Structure of Residential and Commercial Sector



(2) Energy Conversion Sector

1) Electricity Sector

The electricity sector is a high growth sector and is expected to rise at a growth rate of 6.6%. Regarding the electricity demand by sector, demand for the industrial sector is likely to increase from 22,900 GWh in 1998/99 to 32,097 GWh (up 4.8% per year). Demand for the residential (household) sector is projected to climb from 21,006 GWh in 1998/99 to 34,449 GWh by 2005/06 (up 7.3% per year). The sector with the highest growth is the commercial sector, with the growth rate of 10.2%.

Figures 5.3.9(a) and 5.3.9(b) show the forecast demand by sector and the demand structure by sector. Presently, the biggest consumer of electricity is the industrial sector, followed by the residential. However, the demand for households will exceed the demand for industry by a remarkable growth in the residential and commercial sector.

As shown in Figure 5.3.9(b), the agricultural and government/public sectors will change slightly. The residential sector expands its share, and the industrial sector loses the share.

Figure 5.3.9(a) Electricity Demand by Sector

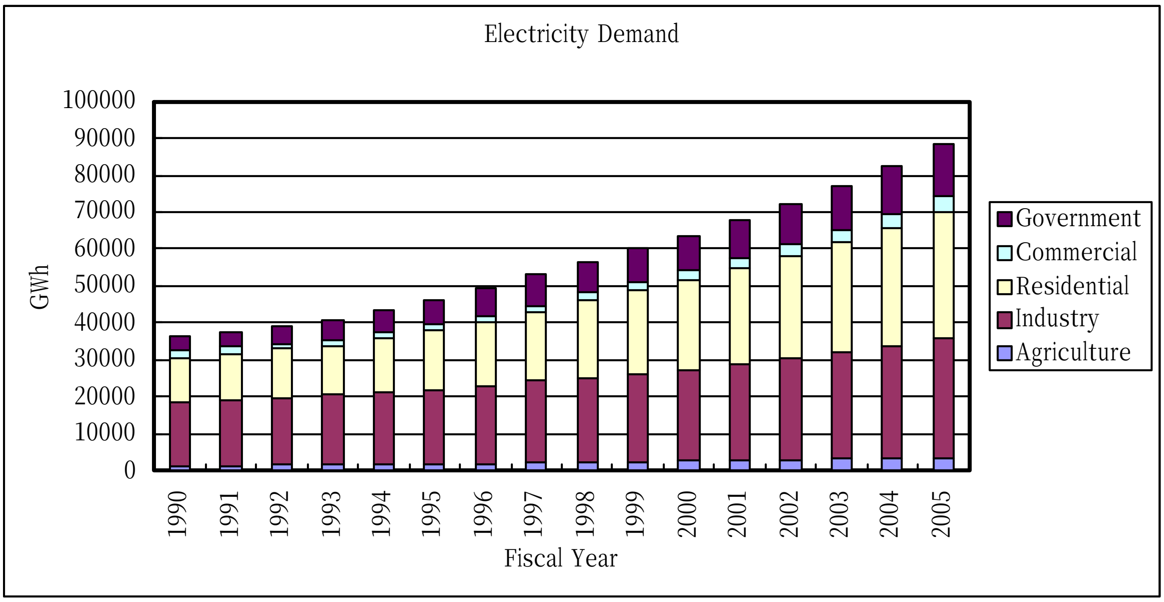
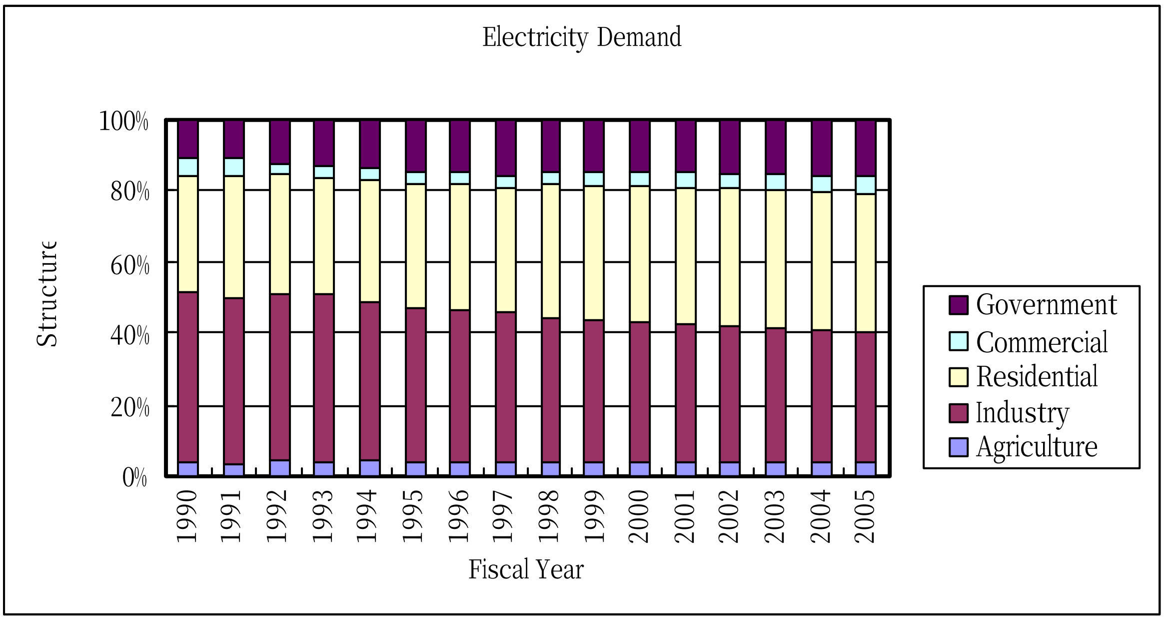
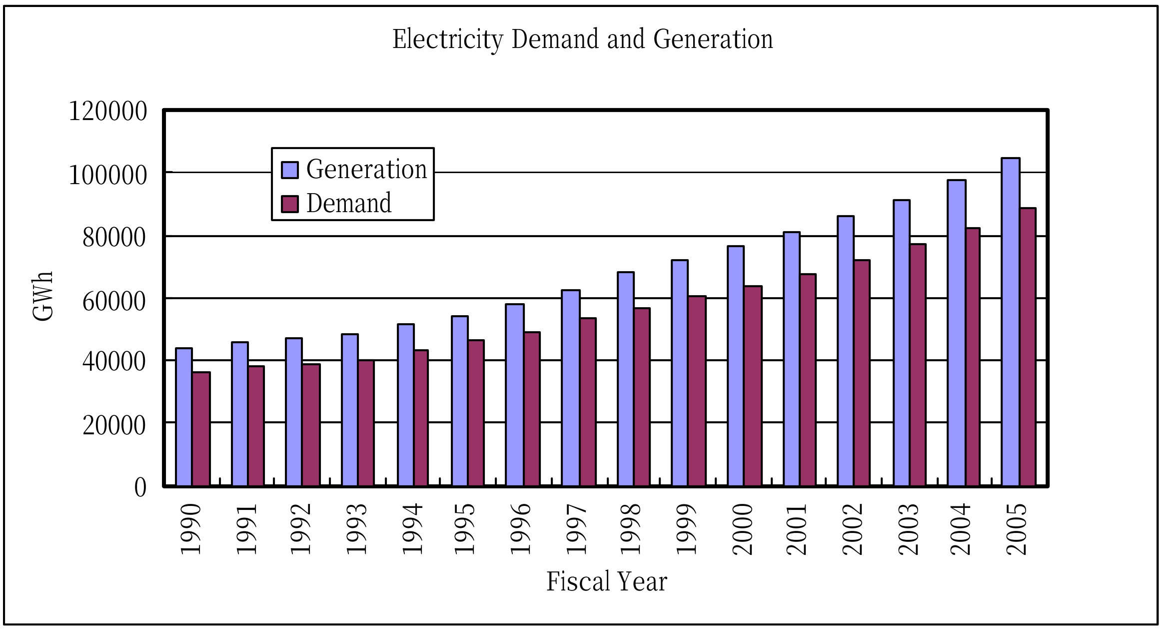


Figure 5.3.9(b) Electricity Demand Structure by Sector



The electric power generation, which recorded 68,000 GWh in 1998/99, is likely to reach 104,518 GWh by 2005/06 (See Table5.3.4). Figure 5.3.10 shows the forecast electricity demand and power generation. As for power source, the major incremental source would be the thermal power because the hydropower is assumed to grow by a small margin, based on the past trend.

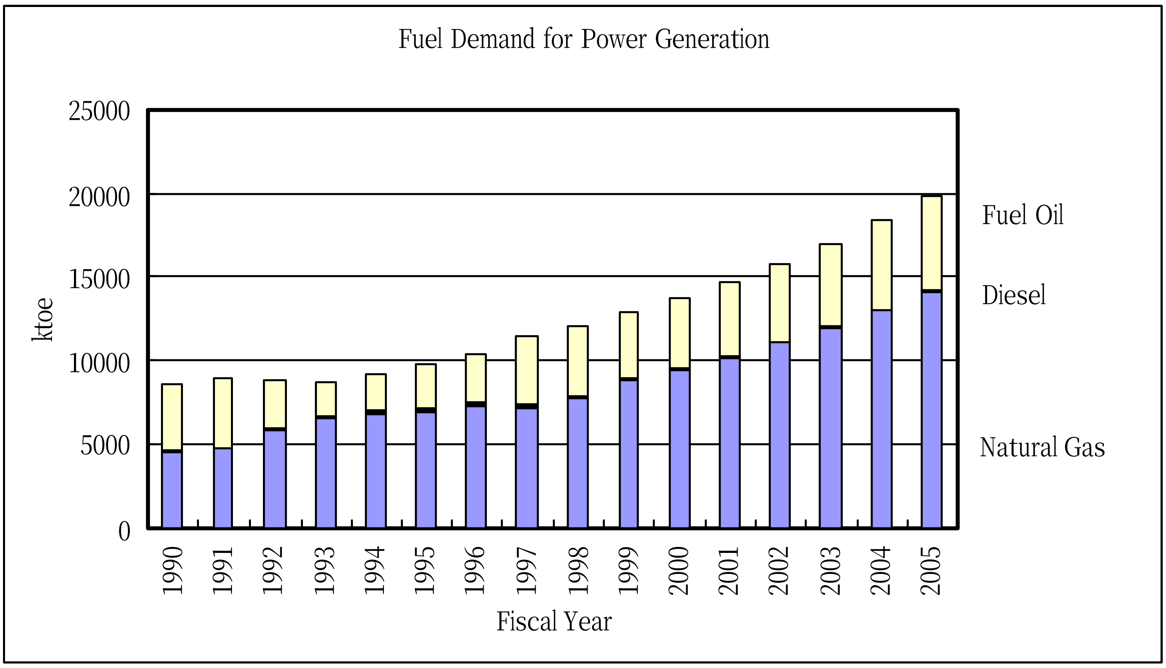
Figure 5.3.10 Electricity Demand and Power Generation



As for the fuel demand for thermal power generation, natural gas will show the highest growth , doubling the demand from 7,675 ktoe in 1998/99 to14,080 ktoe in 2005/06. Fuel oil demand is projected to increase from 4,208 ktoe in 1998/99 to 5,738 ktoe in 2005/05 (up 4.2% per year). Diesel oil demand continues to shrink.

Figure 5.3.11 shows the forecast fuel demand for thermal power generation. Natural gas maintains around 70% of the share. The share of fuel oil is just under 30%.

Figure 5.3.11 Fuel Demand for Power Generation



2) Oil Refinery Sector

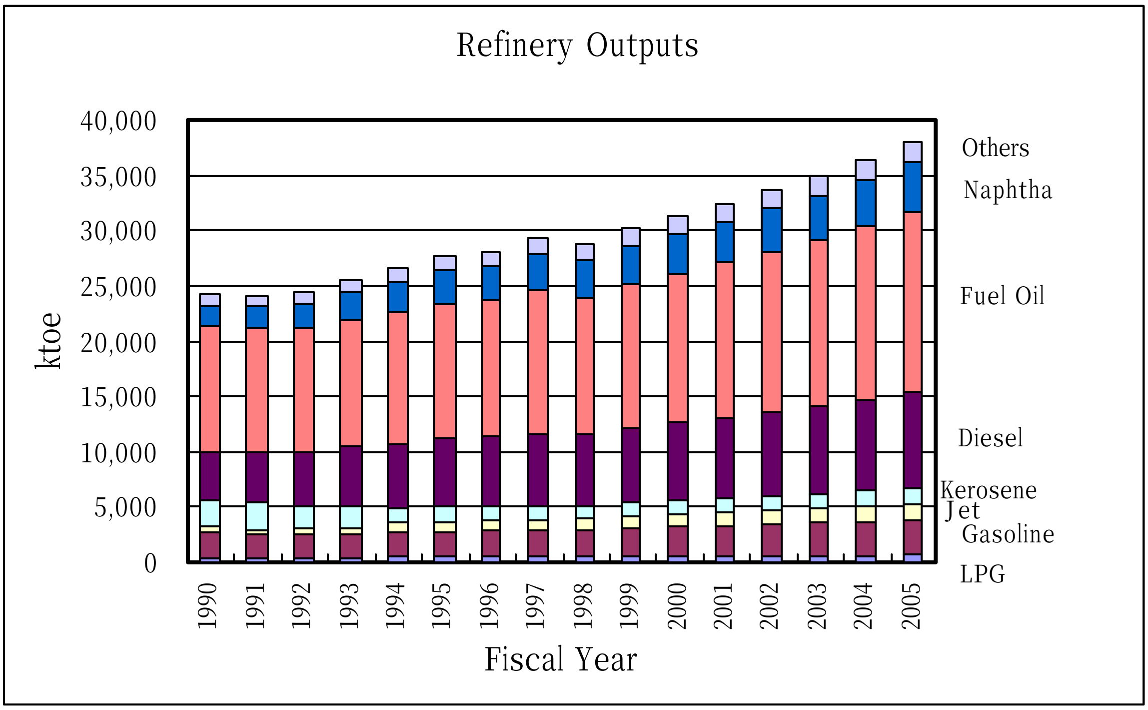
The production of petroleum products is projected under an assumption that the total production of petroleum products will meet the total domestic demand of petroleum products. As the production of each product depends on the yield of oil refineries, each product is not able to maintain the balance between the production and the domestic demand. In this simulation model, the balance is met through export and import after calculating the bunker stock.

Table 5.3.6 shows the forecast main petroleum products production, and Figure 5.3.11 shows the past trend and the forecast production. The total production of petroleum products is expected to increase at an annual average of 4.1%, from 28,745 ktoe in 1998/99 to 38,075 ktoe in 2005/06.

Table 5.3.7 Production of Petroleum Products

Fiscal Year	Actual			Forecasted			
	1990	1995	1998	1999	2001	2003	2005
LPG	384	507	491	515	554	597	650
Gasoline	2,358	2,232	2,432	2,552	2,746	2,962	3,222
Jet	441	920	1,020	1,070	1,151	1,242	1,351
Kerosene	2,447	1,378	1,164	1,221	1,314	1,418	1,542
Diesel	4,402	6,193	6,456	6,773	7,289	7,864	8,552
Fuel Oil	11,372	12,205	12,415	13,025	14,016	15,122	16,445
Naphtha	1,800	2,980	3,284	3,445	3,707	3,999	4,349
Non-Specified	115	170	176	185	199	215	234
Lubricants	206	223	259	271	292	315	342
Bitumen	636	707	927	973	1,047	1,129	1,228
Petro. Coke	90	117	121	127	137	148	161
Non-Specified	115	170	176	185	199	215	234
Petroleum Products Total	24,252	27,632	28,745	30,157	32,452	35,012	38,075

Figure 5.3.12 Production of Main Petroleum Products

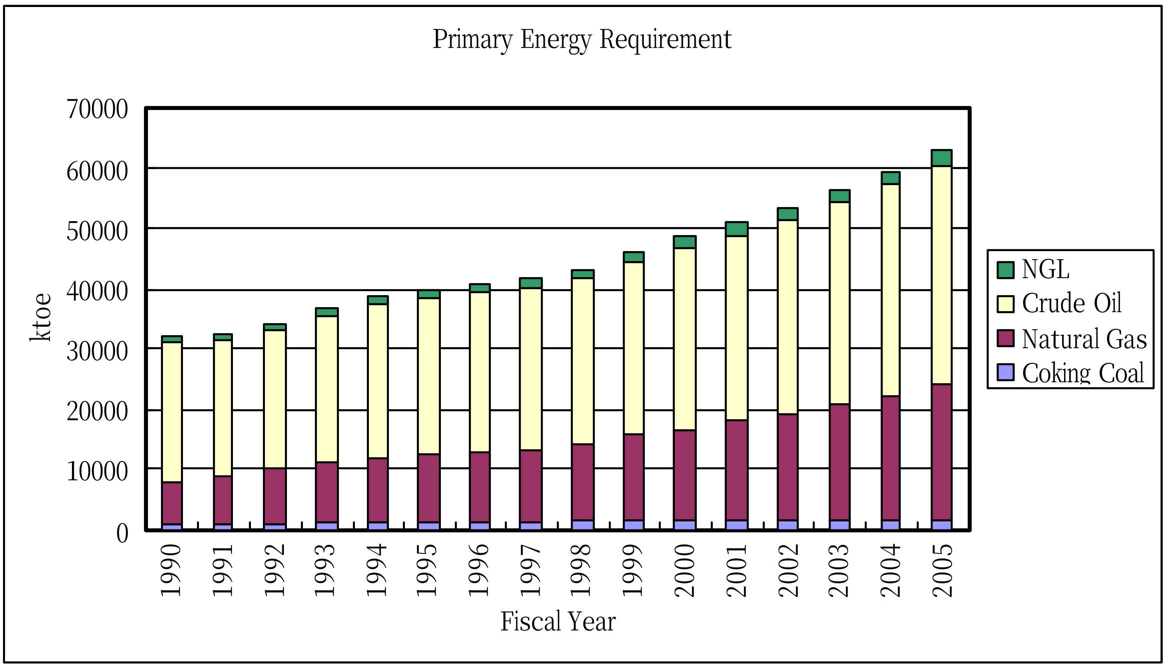


(3) Primary Energy Requirement

The primary energy requirement (total domestic supply) by energy carrier is shown in Figure 5.3.13. According to the simulation result, the primary energy requirement would grow at an average growth rate of 5.6%, from 44,064 ktoe in 1998/99 to 64,675 ktoe in 2005/06. The energy with the highest growth rate is natural gas, whose demand is likely to jump 1.7 times over the 1998/99 record of 12,799 ktoe to reach 22,610 ktoe by 2005/06, at an average growth rate of 8.6%. The growth of crude oil demand is projected to be 4.1%.

As a result, the share held by natural gas is expected to rise to 35% in 2005/06 from 29 % in 1998/99. On the other hand, the share of crude oil will fall to 56% from 62%.

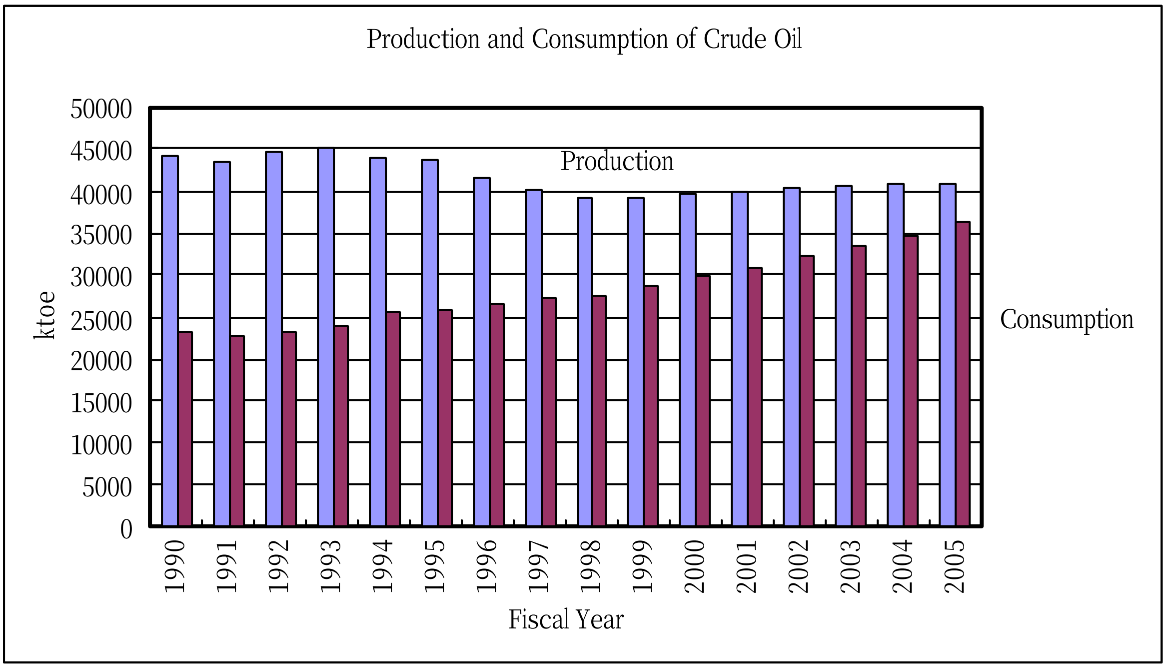
Figure 5.3.13 Primary Energy Requirement



In general, since the primary energy production is based on the national energy development plan, it is better to input such a supply plan in the model. In this simulation model, the supply of natural gas and NGL meets the domestic demand, and the production of crude oil is obtained by the regression analysis.

Figure 5.3.14 shows the forecast production and domestic consumption of crude oil. Although the production is leveled, the domestic crude oil demand for a stable energy supply will be increasing.

Figure5.3.14 Production and Consumption of Crude Oil



5.4 Applied Analyses: Macro-economic/Energy Demand Forecasting Model Simulation

As an integrated application, the macro-economic/energy demand forecasting model (macroeconomic-energy integrated model) was used for the analysis of ERSAP, crude oil price, domestic energy price, technology and energy substitution.

5.4.1 Reference Case

In Section 5.4, a reference case was prepared to represent a "Business As Usual" case to evaluate the sensitivity of various policy variables. Major assumptions and the results of major macroeconomic indicators and final energy demand for years 2000 and 2005 are shown in Table 5.4.1. The assumptions in this reference case are the same as those of the base case model in Section 5.3, except for the part of domestic energy prices, which are assumed to be constant in real term for the previously analyzed base case. This reference case assumes the domestic energy prices to be explained by the whole sale price index, crude oil price and the structural reform (ERSAP). Therefore, the simulation results of this reference case are slightly different from the base case (in terms of GDP of about 0.08 %). This reference case was needed because the domestic energy prices had to be internalized in relation to such variables as structural reform to discover the impacts of such policy issues as ERSAP.

Table 5.4.1 Reference Case: Major Assumptions and Macroeconomic Indicators

Reference Case Major Assumptions

Structural Reform	Before 1991: 1 1991 and after: 1.1 plus 0.001 each Year
Crude Oil Price	6% Growth
GDP of US and EU	4% and 2% Growth
Money Supply	Growth at the same rate of GDP
Central Bank Rate	12% Constant
Population	2.1% Growth

Macro Economic Indicators

Name		2000	2005	Growth Rate %
Private Consumption	mil. 1996/1997 LE	231170	299181	5.29
Government Consumption	mil. 1996/1997 LE	30732	40454	5.65
Investment	mil. 1996/1997 LE	82513	120425	7.85
Export	mil. 1996/1997 LE	56730	69435	4.12
Import	mil. 1996/1997 LE	81421	108425	5.90
Electricity Price (Industry)	PT/kWh	14.19	19.33	6.38
Price of Petroleum Products (Gasoline)	LE/toe	1630.40	2786.91	11.32
GDP	mil. 1996/1997 LE	298999	393777	5.66
Agriculture	mil. 1996/1997 LE	48888	60448	4.34
Industry	mil. 1996/1997 LE	59958	85780	7.43
Petroleum	mil. 1996/1997 LE	16612	18739	2.44
Electricity	mil. 1996/1997 LE	5494	7401	6.14
Construction	mil. 1996/1997 LE	18653	28943	9.18
Transportation	mil. 1996/1997 LE	19987	25076	4.64
Commercial	mil. 1996/1997 LE	69908	93621	6.02
Gov./Pub.	mil. 1996/1997 LE	24627	32875	5.95
Others	mil. 1996/1997 LE	34871	40894	3.24
Unemployment	%	7.45	6.21	-3.58
CPI	%	119.75	162.29	6.27

Table 5.4.2 Reference Case: Final Energy Demand

Final Energ Demand

Sector	2000	2005	Growth Rate %
Agriculture	(ktoe)	(ktoe)	
Kerosene	67.07	25.14	-17.82
Diesel	7.25	9.95	6.54
Petroleum	120.11	90.29	-5.55
Lubricants	45.79	55.20	3.81
Fuel Oil	74.32	35.08	-13.94
Natural Gas	0.00	0.00	
Elec	214.85	300.94	6.97
Total	334.95	391.23	3.15
Industry			
Steam Coal	0.00	0.00	0.00
Coke	670.55	842.31	4.67
Natural Gas	2511.28	3831.63	8.82
LPG	163.66	340.07	15.75
Kerosene	3.07	2.66	-2.79
Diesel	2109.97	3095.08	7.96
Fuel Oil	3555.20	3668.52	0.63
Naphtha	0.00	0.00	0.00
Lubricants	100.37	119.49	3.55
Bitumen	913.60	1065.54	3.12
Petro Coke	0.00	0.00	0.00
Non Specified	282.61	300.63	1.24
Petroleum	7128.47	8591.99	3.81
Fuel	9296.32	12080.90	5.38
Natural Gas	2511.28	3831.63	
Elec	2144.37	2763.89	5.21
Total	12454.66	16029.82	5.18
Transportation			
Gasolime	2646.35	2665.20	0.14
Jet	473.63	516.45	1.75
Diesel	5724.48	7266.67	4.89
Fuel Oil	747.01	809.85	1.63
Lubricants	194.18	231.60	3.59
Non Specified	94.22	116.76	4.38
Petroleum	9879.89	11606.54	3.27
Natural Gas	0.00	0.00	
Total	9879.89	11606.54	3.27

Sector	2000	2005	Growth Rate
Residential/Commercial		(ktoe)	
LPG	2589.97	3215.12	4.42
Kerosene	863.12	441.35	-12.55
Diesel	0.00	0.00	0.00
Petroleum	3453.09	3656.48	1.15
Natural Gas	393.55	709.01	12.49
Elec	2314.93	3301.19	7.36
Res Elec	2088.93	2939.53	7.07
Comm Elec	226.00	361.65	9.86
Total	6161.57	7666.67	4.47
Total Final Consumption			
Steam Coal	0.00	0.00	0.00
Coke	670.55	842.31	4.67
Crude Oil	0.00	0.00	0.00
NGL	0.00	0.00	0.00
LPG	2753.62	3555.20	5.24
Gasolime	2646.35	2665.20	0.14
Jet	473.63	516.45	1.75
Kerosene	933.25	469.15	-12.85
Diesel	7841.70	10371.70	5.75
Fuel Oil	4302.20	4478.37	0.81
Naphtha	0.00	0.00	0.00
Non Specified	541.98	595.55	1.90
Lubricants	340.35	406.30	3.61
Bitumen	913.60	1065.54	3.12
Petro Coke	126.43	137.18	1.65
Petroleum	20873.13	24260.64	3.05
Natural Gas	4808.30	6699.19	6.86
Fuel Total	22902.98	27856.41	3.99
Elec	5489.35	7598.51	6.72
Total	31841.33	39400.66	4.35

5.4.2 Impact of ERSAP Measures

(1) ERSAP Measures

The major policies selected here are the exchange rate stabilization, privatization and price restructuring of the energy sector.

1) Exchange Rate Policy

In November 1991, Egypt adopted a free market exchange system, subject only to the Central Bank's buying and selling intervention. High interest rates and stable exchange rates have stimulated a large inflow of capital. To encourage foreign investment, the Parliament passed a bill in June 1996, amending the banking law to allow foreign ownership in joint venture banks to exceed 49 percent, thus encouraging greater competition. In July 1996, another bill eliminated the five-year repatriation restriction on Egyptian real estate sales proceeds owned by foreigners residing outside Egypt.

One of the most important impacts of this policy could be an increase in investments.

2) Privatization

In 1993, 314 public sector enterprises were organized into 17 holding companies, which are permitted to sell, lease or liquidate company assets and to sell government-owned shares. According to a government estimate, the book value of the state enterprise sector amounts to LE 90 billion ($27 billion). At the core of the reform was Egypt's commitment to privatization, and it seems to be moving forward.

The direct impact of this reduction in the public sector enterprises is the reduction in government consumption.

3) Structural Policies

The Egyptian government freed all industrial prices except for pharmaceuticals, cigarettes, rationed sugar and rationed edible oil. It still subsidizes mass-consumption of bread. Also, energy, transportation and water prices are expected to remain controlled. However, the price increases have brought domestic petroleum product prices to about 88 percent of international prices and electricity prices to about 77 percent of long-run marginal costs (Ministry of Planning).

The impacts of energy price rises are simulated separately later.

(2) Simulation Results

1) Macroeconomic Impacts

The variable of structural reform was increased by one percent in 2000--and in 2000 only. The impacts on major economic indicators and energy consumption are listed in Table 5.4.3. Direct impact means an impact not thorough other variables. Short-term equilibrium means the result of the same year after simultaneous calculation with indirect influences in the consideration. The midterm-equilibrium is the result in 2005, five years from now.

The impact on GDP is 0.87% in short-term and 0.68% in mid-term. The relatively low increase in private consumption as a direct impact (0.16%) implies that the increase in savings would be much higher and will be shown in investment. It can be attributed to the policies for stable monetary and exchange rate. The increase of private consumption in equilibrium is the effect of the increase in income. In this regard, the positive impacts on investments are primarily attributed to the stabilization policy, represented by the exchange rate policy. The result is a very high value of 1.65%, especially in short-term. However, in the mid-term, the impacts are fading. The impact on government consumption, as one of the results of privatization, is about –0.34% in short-term. But in the mid-term, the government consumption began to rise again. The rise in values in the mid-term, except export, can be attributed to the rise in GDP, which can lead all other factors to improve.

Table 5.4.3 Impacts of 1% Increase in Structural Reform on Major Economic Indicators (%)

Name	Direct Impact	Short-term Equilibrium	Mid-term Equilibrium
Private Consumption	0.16	0.77	0.64
Government Consumption	-0.34	-0.34	0.81
Investment	1.70	1.65	0.88
Export	0.46	0.80	0.44
Import	n/a	0.90	0.70
Electricity Price (Industry)	2.46	2.46	0.76
Price of Petroleum Products (Gasoline)	0.45	0.45	0.66
GDP	n/a	0.87	0.68
Agriculture	n/a	0.71	0.54
Industry	n/a	0.73	0.64
Petroleum	n/a	0.81	0.42
Electricity	n/a	0.68	0.25
Construction	n/a	0.67	0.51
Transportation	n/a	0.92	0.77
Commercial	n/a	1.17	0.94
Gov./Pub.	n/a	1.02	0.92
Others	n/a	0.73	0.41
Unemployment	n/a	-3.02	-2.36
CPI	n/a	1.42	0.845

Looking into the setoral GDP, the structural reform does not contribute to the energy sector (petroleum & electricity) as much as other sectors. The largest short-term impact is on the commercial sector (1.17% in short term).

2) Impacts on Energy Consumption

The total final consumption increases 0.4% in short-term and 0.57% in mid-term. The impacts on energy consumption are mostly positive because of the increase in the total GDP. In the short-term, the negative values of natural gas and government electricity in residential/commercial category are notable. Natural gas, however, increases significantly in the mid-term.

Table 5.4.4 Impacts of 1% Increase in Structural Reform on Energy Consumption (%)

Sector	2000	2005	Sector	2000	2005
Agriculture	(ktoe)	(ktoe)	**Residential/Commercial**		(ktoe)
Kerosene	0.32	0.64	LPG	0.36	0.39
Diesel	0.00	0.00	Kerosene	0.36	0.39
Petroleum	0.39	0.61	Diesel	N/A	N/A
Lubricants	0.55	0.68	Petroleum	0.36	0.39
Fuel Oil	0.30	0.54	Natural Gas	-0.86	1.50
Natural Gas	N/A	N/A	Elec	1.12	0.90
Elec	1.15	0.81	Res Elec	1.09	0.81
Total	0.86	0.75	Comm Elec	1.46	1.55
			Total	0.56	0.70
Industry					
Steam Coal	N/A	N/A			
Coke	0.08	0.07			
Natural Gas	0.32	0.68	**Total Final Consumption**		
LPG	1.72	1.40	Steam Coal	N/A	N/A
Kerosene	0.00	0.00	Coke	0.08	0.07
Diesel	1.10	0.73	Crude Oil	N/A	N/A
Fuel Oil	0.00	0.00	NGL	N/A	N/A
Naphtha	N/A	N/A	LPG	0.44	0.48
Lubricants	0.47	0.41	Gasolime	1.40	1.22
Bitumen	-0.12	0.56	Jet	0.16	0.15
Petro Coke	N/A	N/A	Kerosene	0.36	0.41
Non Specified	0.00	0.00	Diesel	0.54	0.65
Petroleum	0.36	0.40	Fuel Oil	0.00	0.00
Fuel	0.38	0.45	Naphtha	N/A	N/A
Natural Gas	0.32	0.68	Non Specified	0.00	0.00
Elec	0.05	0.32	Lubricants	0.36	0.54
Total	0.29	0.44	Bitumen	-0.12	0.56
			Petro Coke	0.00	0.00
Transportation			Petroleum	0.46	0.54
Gasolime	1.40	1.22	Natural Gas	0.10	0.55
Jet	0.16	0.15	Fuel Total	0.45	0.58
Diesel	0.33	0.62	Elec	0.44	0.72
Fuel Oil	0.00	0.00	Total	0.40	0.57
Lubricants	0.25	0.57			
Non Specified	0.00	0.00			
Petroleum	0.59	0.71			
Natural Gas	N/A	N/A			
Total	0.59	0.71			

5.4.3 Impact of Changes in Crude Oil Price

The variable of crude oil price was increased by one percent in 2000--and in 2000 only. The impacts on major economic indicators and energy consumption are listed in Table 5.4.5.

(1) Macroeconomic Impacts

Crude oil is linked directly to variables of export, price of petroleum products and petroleum sector GDP. The direct impacts on these variables are clear. The total GDP increase is 0.0027% in the short-term and 0.0125% in the mid-term. The overall impact in the short-term is small (around 0.03/0.05%). By contrast, the mid-term impacts fluctuate (around -0.007/0.13%). This means that the impact of crude oil price change have a time lag.

Table 5.4.5 Impacts of 1% Increase in Crude Oil Price on Major Economic Indicators (%)

Name	Direct Impact	Short-term Equilibrium	Mid-term Equilibrium
Private Consumption	n/a	0.0027	0.0125
Government Consumption	n/a	0.0000	0.0274
Investment	n/a	-0.0002	0.0153
Export	0.0079	0.0167	0.0105
Import	n/a	0.0040	0.0144
Electricity Price (Industry)	n/a	0.0000	0.0110
Price of Petroleum Products (Gasoline)	0.3400	0.3400	0.5060
GDP	n/a	0.0039	0.0139
Agriculture	n/a	0.0032	0.0087
Industry	n/a	0.0035	0.0050
Petroleum	0.0117	0.0030	0.1310
Electricity	n/a	0.0029	-0.0006
Construction	n/a	0.0032	-0.0011
Transportation	n/a	0.0041	0.0135
Commercial	n/a	0.0053	0.0175
Gov./Pub.	n/a	0.0045	0.0155
Others	n/a	0.0031	-0.0072
Unemployment	n/a	-0.0135	-0.0485
CPI	n/a	0.00369	0.0161

(2) Impacts on Energy Consumption

The total final consumption increases 0.001% in the short-term and 0.04% in the mid-term. In the short-term, the impacts are mostly negligible. In the mid-term, however, the reduction in kerosene and fuel oil in the agricultural sector is distinguishable from others. In the mid-term, the total consumption becomes negative. This means that the price effect exceeds the income effect with time for the case of crude oil price increase.

Table 5.4.6 Impacts of 1% Increase in Crude Oil Price on Energy Consumption (%)

Sector	2000	2005	Sector	2000	2005
Agriculture	(ktoe)	(ktoe)	**Residential/Commercial**		(ktoe)
Kerosene	0.001	-0.994	LPG	0.002	-0.121
Diesel	0.000	0.000	Kerosene	0.002	-0.121
Petroleum	0.002	-0.474	Diesel	N/A	N/A
Lubricants	0.002	-0.103	Petroleum	0.002	-0.121
Fuel Oil	0.001	-0.830	Natural Gas	0.000	0.051
Natural Gas	N/A	N/A	Elec	0.006	0.018
Elec	0.006	0.013	Res Elec	0.005	0.017
Total	0.004	-0.125	Comm Elec	0.010	0.030
			Total	0.003	-0.048
Industry					
Steam Coal	N/A	N/A			
Coke	-0.048	-0.039			
Natural Gas	0.002	0.004	**Total Final Consumption**		
LPG	0.008	-0.069	Steam Coal	N/A	N/A
Kerosene	0.000	0.000	Coke	-0.048	-0.039
Diesel	0.004	-0.050	Crude Oil	N/A	N/A
Fuel Oil	0.000	0.000	NGL	N/A	N/A
Naphtha	N/A	N/A	LPG	0.002	-0.116
Lubricants	0.002	-0.049	Gasolime	0.006	-0.309
Bitumen	0.000	-0.026	Jet	0.001	-0.023
Petro Coke	N/A	N/A	Kerosene	0.001	-0.205
Non Specified	0.000	0.000	Diesel	0.002	-0.014
Petroleum	0.001	-0.025	Fuel Oil	0.000	0.000
Fuel	-0.002	-0.017	Naphtha	N/A	N/A
Natural Gas	0.002	0.004	Non Specified	0.000	0.000
Elec	0.000	0.002	Lubricants	0.002	-0.076
Total	-0.001	-0.014	Bitumen	0.000	-0.026
			Petro Coke	0.000	0.000
Transportation			Petroleum	0.002	-0.070
Gasolime	0.006	-0.309	Natural Gas	0.001	0.007
Jet	0.001	-0.023	Fuel Total	0.001	-0.058
Diesel	0.001	0.002	Elec	0.003	0.015
Fuel Oil	0.000	0.000	Total	0.001	-0.040
Lubricants	0.001	-0.084			
Non Specified	0.000	0.000			
Petroleum	0.003	-0.083			
Natural Gas	N/A	N/A			
Total	0.003	-0.083			

5.4.5 Impact of Changes in Domestic Energy Prices

The simulation results have two cases--electricity and petroleum products.

(1) Electricity Prices

The variables of electricity prices were increased by one percent in 2000--and in 2000 only. The impacts on major economic indicators and energy consumption are listed in Table 5.4.7.

1) Macroeconomic Impacts

The impacts on GDP are –0.017%(direct), -0.0014(short-term) and –0.0001(mid-term). Except for the direct and the short-term of the energy sector (sectors of petroleum and electricity), impacts are negative or zero. However, the magnitude of the negative impacts is small and is fading with time. Then, in the mid-term, the impacts may be negligible (less than 0.003%).

The implication of these results in terms of ERSAP is that the price control policy on electricity would not work well in view of the economic performance at a current level. However, the current level of electric price is not high enough to cause a clear negative impact on economy.

Table 5.4.7 Impacts of 1% Increase in Electricity Prices on Major Economic Indicators (%)

Name	Direct Impact	Short-term Equilibrium	Mid-term Equilibrium
Private Consumption	n/a	-0.0010	0.0001
Government Consumption	n/a	0.0000	0.0006
Investment	n/a	-0.0016	0.0001
Export	n/a	-0.0036	0.0001
Import	n/a	-0.0014	0.0002
Electricity Price (Industry)	1.0000	1.0000	0.0000
Price of Petroleum Products (Gasoline)	n/a	0.0000	0.0000
GDP	-0.0147	-0.0014	0.0001
Agriculture	-0.0125	0.0000	-0.0005
Industry	-0.0303	-0.0188	0.0006
Petroleum	0.0000	0.0183	0.0027
Electricity	0.0058	0.0168	-0.0010
Construction	-0.0301	-0.0173	-0.0010
Transportation	0.0000	0.0102	-0.0011
Commercial	-0.0188	-0.0022	-0.0007
Gov./Pub.	-0.0048	0.0070	-0.0007
Others	0.0000	0.0122	0.0033
Unemployment	n/a	0.0048	-0.0005
CPI	n/a	0.2420	0.0001

2) Impacts on Energy Consumption

The impacts of electricity price increase on energy consumption are as small as those on macro economy. The total final consumption increases 0.0081% in the short-term and 0.0027% in the mid-term. The increase in the final energy consumption in the short-term would be a result of the substitution from electricity to other energy like kerosene in agriculture and diesel in industry.

Table 5.4.8 Impacts of 1% Increase in Electricity Prices on Energy Consumption (%)

Sector	2000	2005	Sector	2000	2005
Agriculture	(ktoe)	(ktoe)	**Residential/Commercial**		(ktoe)
Kerosene	0.0801	0.0459	LPG	0.0335	0.0004
Diesel	0.0000	0.0000	Kerosene	0.0335	0.0004
Petroleum	0.0571	0.0197	Diesel	N/A	N/A
Lubricants	0.0285	0.0002	Petroleum	0.0335	0.0004
Fuel Oil	0.0732	0.0384	Natural Gas	0.0000	0.0011
Natural Gas	N/A	N/A	Elec	-0.0476	0.0000
Elec	-0.0403	-0.0007	Res Elec	-0.0184	0.0002
Total	-0.0031	0.0051	Comm Elec	-0.3180	-0.0011
			Total	0.0018	0.0003
Industry					
Steam Coal	N/A	N/A			
Coke	-0.0001	0.0000			
Natural Gas	-0.0084	0.0002	**Total Final Consumption**		
LPG	-0.0009	0.0014	Steam Coal	N/A	N/A
Kerosene	0.0000	0.0000	Coke	-0.0001	0.0000
Diesel	0.1100	0.0007	Crude Oil	N/A	N/A
Fuel Oil	0.0000	0.0000	NGL	N/A	N/A
Naphtha	N/A	N/A	LPG	0.0315	0.0005
Lubricants	0.0147	0.0004	Gasolime	0.0323	0.0383
Bitumen	0.0205	0.0004	Jet	0.0021	0.0015
Petro Coke	N/A	N/A	Kerosene	0.0371	0.0048
Non Specified	0.0000	0.0000	Diesel	0.0306	0.0002
Petroleum	0.0359	0.0004	Fuel Oil	0.0000	0.0000
Fuel	0.0232	0.0003	Naphtha	N/A	N/A
Natural Gas	-0.0084	0.0002	Non Specified	0.0000	0.0000
Elec	-0.0161	-0.0083	Lubricants	0.0224	0.0004
Total	0.0162	-0.0012	Bitumen	0.0205	0.0004
			Petro Coke	0.0000	0.0000
Transportation			Petroleum	0.0229	0.0052
Gasolime	0.0323	0.0383	Natural Gas	-0.0044	0.0002
Jet	0.0021	0.0015	Fuel Total	0.0189	0.0046
Diesel	0.0006	-0.0001	Elec	-0.0373	-0.0029
Fuel Oil	0.0000	0.0000	Total	0.0081	0.0027
Lubricants	0.0249	0.0004			
Non Specified	0.0000	0.0000			
Petroleum	0.0099	0.0101			
Natural Gas	N/A	N/A			
Total	0.0099	0.0101			

(2) Petroleum Products Prices

The variables of petroleum product prices were increased by one percent in 2000--and in 2000 only. The impacts on major economic indicators and energy consumption and energy consumption are listed in Table 5.4.9.

1) Macroeconomic Impacts

The impacts on GDP are -0.01%(direct), 0.0023(short-term) and 0.054(mid-term). The increase in prices of petroleum products contributes to the GDP, especially in the mid term. From the point of ERSAP, the price liberalization or the price increase of petroleum products will contribute to the overall performance of the economy. In the short-term, however, it will cause some pain for the sectors of transportation and electricity. Interestingly, the gain in the petroleum sector in the mid-term becomes negative, probably because the price increases of petroleum products would promote energy conservation in the mid/long-terms.

Table 5.4.9 Impacts of 1% Increase in Petroleum Product Prices on Major Economic Indicators (%)

Name	Direct Impact	Short-term Equilibrium	Mid-term Equilibrium
Private Consumption	n/a	0.0016	0.0051
Government Consumption	n/a	0.0000	0.0056
Investment	n/a	-0.0001	0.0072
Export	n/a	0.0099	0.0035
Import	n/a	0.0024	0.0055
Electricity Price (Industry)	n/a	0.0000	0.0062
Price of Petroleum Products (Gasoline)	1.00	1.0000	0.0083
GDP	-0.01	0.0023	0.0054
Agriculture	0.00	0.0060	0.0035
Industry	-0.02	-0.0065	0.0048
Petroleum	0.20	0.1930	-0.0190
Electricity	-0.01	-0.0055	0.0014
Construction	-0.03	-0.0224	0.0048
Transportation	-0.09	-0.0703	0.0122
Commercial	-0.02	-0.0112	0.0072
Gov./Pub.	-0.01	0.0034	0.0069
Others	0.00	0.0073	0.0114
Unemployment	n/a	-0.0080	-0.0187
CPI	n/a	0.0022	0.0068

2) Impacts on Energy Consumption

The total final consumption decreases by 0.0448% in the short-term and 0.0153% in the mid-term. Considering the macro-economic impact, these reductions could be the result of price effect, and the effect seems to be larger in the short-term. This effect and the increase in electricity, which could be the result of the substitution from petroleum products, are getting smaller in the mid-term. In the mid-term, the reduction of gasoline consumption and the increase of natural gas, LPG and diesel are a distinctive result in this simulation.

Table 5.4.10 Impacts of 1% Increase in Petroleum Product Prices on Energy Consumption (%)

Sector	2000	2005	Sector	2000	2005
Agriculture	(ktoe)	(ktoe)	**Residential/Commercial**		(ktoe)
Kerosene	-0.3300	-0.3180	LPG	-0.1390	-0.0020
Diesel	0.0000	0.0000	Kerosene	-0.1390	-0.0020
Petroleum	-0.2340	-0.1380	Diesel	N/A	N/A
Lubricants	-0.1130	-0.0046	Petroleum	-0.1390	-0.0020
Fuel Oil	-0.3010	-0.2650	Natural Gas	0.0000	0.0104
Natural Gas	N/A	N/A	Elec	0.0010	0.0071
Elec	0.0103	0.0052	Res Elec	0.0030	0.0065
Total	-0.0830	-0.0353	Comm Elec	-0.0172	0.0119
			Total	-0.0790	0.0029
Industry					
Steam Coal	N/A	N/A			
Coke	0.0002	0.0006			
Natural Gas	-0.0029	0.0036	**Total Final Consumption**		
LPG	-0.1760	0.0101	Steam Coal	N/A	N/A
Kerosene	0.0000	0.0000	Coke	0.0002	0.0006
Diesel	-0.1390	0.0052	Crude Oil	N/A	N/A
Fuel Oil	0.0000	0.0000	NGL	N/A	N/A
Naphtha	N/A	N/A	LPG	-0.1410	-0.0008
Lubricants	-0.1030	0.0028	Gasolime	-0.1380	-0.2170
Bitumen	-0.0843	0.0036	Jet	-0.0243	-0.0082
Petro Coke	N/A	N/A	Kerosene	-0.1530	-0.0326
Non Specified	0.0000	0.0000	Diesel	-0.0469	0.0042
Petroleum	-0.0583	0.0028	Fuel Oil	0.0000	0.0000
Fuel	-0.0362	0.0028	Naphtha	N/A	N/A
Natural Gas	-0.0029	0.0036	Non Specified	0.0000	0.0000
Elec	-0.0006	0.0012	Lubricants	-0.1070	-0.0010
Total	-0.0342	0.0026	Bitumen	-0.0843	0.0036
			Petro Coke	0.0000	0.0000
Transportation			Petroleum	-0.0677	-0.0268
Gasolime	-0.1380	-0.2170	Natural Gas	-0.0015	0.0032
Jet	-0.0243	-0.0082	Fuel Total	-0.0572	-0.0229
Diesel	-0.0121	0.0038	Elec	0.0006	0.0050
Fuel Oil	0.0000	0.0000	Total	-0.0448	-0.0153
Lubricants	-0.1070	-0.0021			
Non Specified	0.0000	0.0000			
Petroleum	-0.0486	-0.0555			
Natural Gas	N/A	N/A			
Total	-0.0486	-0.0555			

5.4.6 Impact of Technology: Case of Energy Cost Savings

As an example of the analysis of technological advances, a case of technological advances for energy cost savings was simulated. Energy cost is calculated by multiplying the price of energy and the consumption. Therefore, if energy price is given, the energy cost can be reduced by reducing the consumption. One way to reduce energy conservation is shifting the production line a less-energy-intensive one. Another way is energy conservation. These could be achieved by, for example, production process improvements and thermal efficiency improvements of a power plant.

To hypothesize cost saving technology, the model is modified so that the energy cost is reduced by one percent from the reference case. Because the technology is expected to be effective for the successive years from the starting year in this example, the cost savings are applied not only to the year 2000 but also to the years thereafter. At the same time, the model of investment is modified by adding the benefits, which match the cost savings, in line with the investment model of the reference case.

If the energy cost is reduced by a politically-intentded price reduction, it is simply a transfer of value from one sector to another sector that accompanies an economic inefficiency. By contrast, the energy cost savings by reducing the consumption, through technological advancement, accompany the increase in added-value for the whole economy. In this simulation, this newly generated value from the cost savings is hypothesized to be entirely put into the investment.

Tables 5.4.11 and 5.4.12 show the simulation results of this modified model.

1) Macroeconomic Impacts

As for the sectoral GDP, the direct impacts are fundamentally the same as the case of reduced energy consumption. Therefore, the decrease in the petroleum sector is distinguishable. The difference is the increase of the investment in the GDP components.

The impact on GDP is 0.006% (direct)、0.03% (short-term) and 1.09%(mid-term). Here, it shows that the longer the time span is, the larger the gain is. The accumulation of benefit with time is characteristic of technology. The sectoral differences are that the gain is large for sectors of transportation, commercial, and public while the gain of energy sectors is relatively small. The energy sector is not a consumer but rather a supplier. Therefore, the gain in the energy sector is not a result of the technology but of the gain in GDP.

Table 5.4.11 Impacts of 1% Energy Cost Cut on Major Economic Indicators (%)

Name	Direct Impact	Short-term Equilibrium	Mid-term Equilibrium
Private Consumption	n/a	0.021	0.895
Government Consumption	n/a	0.000	0.454
Investment	0.080	0.080	2.090
Export	n/a	0.012	0.612
Import	n/a	0.031	1.120
Electricity Price (Industry)	n/a	0.000	0.384
Price of Petroleum Products (Gasoline)	n/a	0.000	0.385
GDP	0.006	0.030	1.090
Agriculture	0.002	0.023	0.860
Industry	0.016	0.042	0.946
Petroleum	-0.204	0.009	0.784
Electricity	0.014	0.002	0.670
Construction	0.033	0.040	0.842
Transportation	0.085	0.018	1.220
Commercial	0.023	0.045	1.530
Gov./Pub.	0.005	0.025	1.340
Others	0.000	0.010	0.828
Unemployment	n/a	-0.105	-3.800
CPI	n/a	0.029	1.110

2) Impacts on Energy Consumption

In this modified model for technological progress, the technological advancement is supposed to reduce the consumption of energy without additional costs. Therefore, providing other variables equally, the energy consumption of the modified model should be 99% of the reference model. The result, however, shows more than 99%. This increase is caused by the income effect, starting from the increase in investment. From the above analysis, the energy consumption of the transportation sector is expected to advance the most. Actually, the simulation result here shows significant increases in agriculture's electricity, industry's LPG, Transportation's gasoline and residential/commercial's electricity. The total increase in gasoline exceeds the technological energy savings by the magnitude of 0.65% in the mid-term.

Table 5.4.12 Impacts of 1% Energy Cost Cut on Energy Consumption (%)

Sector	2000	2005	Sector	2000	2005
Agriculture	(ktoe)	(ktoe)	**Residential/Commercial**		(ktoe)
Kerosene	-0.9905	-0.1820	LPG	-0.9882	-0.4240
Diesel	-1.0000	-1.0000	Kerosene	-0.9882	-0.4240
Petroleum	-0.9882	-0.2380	Diesel	N/A	N/A
Lubricants	-0.9827	-0.1550	Petroleum	-0.9882	-0.4240
Fuel Oil	-0.9913	-0.3170	Natural Gas	-1.0000	-0.1520
Natural Gas	N/A	N/A	Elec	-0.9562	0.4800
Elec	-0.9601	0.3200	Res Elec	-0.9606	0.3200
Total	-0.9709	0.1600	Comm Elec	-0.9154	1.7700
			Total	-0.9772	-0.0230
Industry					
Steam Coal	N/A	N/A			
Coke	-0.9973	-0.9053			
Natural Gas	-0.9811	-0.3970	**Total Final Consumption**		
LPG	-0.9043	1.1500	Steam Coal	N/A	N/A
Kerosene	-1.0000	-1.0000	Coke	-0.9973	-0.9053
Diesel	-0.9514	0.0600	Crude Oil	N/A	N/A
Fuel Oil	-1.0000	-1.0000	NGL	N/A	N/A
Naphtha	N/A	N/A	LPG	-0.9833	-0.2770
Lubricants	-0.9756	-0.3490	Gasolime	-0.9520	0.6500
Bitumen	-0.9976	-0.6280	Jet	-0.9942	-0.7620
Petro Coke	N/A	N/A	Kerosene	-0.9884	-0.4040
Non Specified	-1.0000	-1.0000	Diesel	-0.9792	-0.2450
Petroleum	-0.9824	-0.4710	Fuel Oil	-1.0000	-1.0000
Fuel	-0.9817	-0.4650	Naphtha	N/A	N/A
Natural Gas	-0.9811	-0.3970	Non Specified	-1.0000	-1.0000
Elec	-0.9953	-0.7850	Lubricants	-0.9858	-0.4040
Total	-0.9852	-0.5290	Bitumen	-0.9976	-0.6280
			Petro Coke	-1.0000	-1.0000
Transportation			Petroleum	-0.9827	-0.3240
Gasolime	-0.9520	0.6500	Natural Gas	-0.9901	-0.5660
Jet	-0.9942	-0.7620	Fuel Total	-0.9824	-0.3270
Diesel	-0.9898	-0.3770	Elec	-0.9779	-0.1200
Fuel Oil	-1.0000	-1.0000	Total	-0.9833	-0.3380
Lubricants	-0.9917	-0.4910			
Non Specified	-1.0000	-1.0000			
Petroleum	-0.9803	-0.1710			
Natural Gas	N/A	N/A			
Total	-0.9803	-0.1710			

5.4.7 Energy Substitution: Cross Price Elasticity

Cross price elasticity is an indicator of substitution potential by price control. Generally, the cross price elasticity is calculated as a coefficient of double-log regression model, based on the historical data of prices of substitute products and their demands. However, in a developing economy like Egypt, where the governmental control over the market is strong, it is difficult to determine the cross price elasticity econometrically. The statistical results of the regression model with actual data were not econometrically meaningful.

However, when macroeconomic and energy demand integrated model is considered as a substitute for the real world, the issue of energy substitution can be approached as a simulation application of the system of the integrated model. Namely, the values of price elasticity and cross price elasticity are calculated as results of model simulation here, not as coefficients of regression models of historical data. In other words, the cross price elasticity of energy type B for the consumption of energy type A is calculated as a percentage change of A, when the price of B is changed by 1% in the integrated simulation. The fundamental difference of the elasticity of a simulated result from the elasticity as a regression model coefficient is that a simulation gives the value as a final result of influences of the price changes on the whole economy, whereas a regression model coefficient is a value when other explanatory variables are assumed to be constant. In this regard, the coefficient from the simulation is more realistic than that of the regression coefficient.

1) Electricity and Petroleum Products

Table 5.4.13 shows the simulation results of the price elasticity of electricity in general and petroleum products in general and the cross price elasticity between them. The price elasticity as a simulation result is quite small—minus 0.0331 and minus 0.0717, respectively, for electricity petroleum products. This means that the impact of price changes on the market is limited and implies that the price has not reached the real market level. Therefore, not surprisingly, the cross price elasticity is almost negligible—0.0000722 and 0.0249. This implies that the price control is not an efficient way to change the consumption of the substitute.

Table 5.4.13 Price Elasticity and Cross Price Elasticity
(Electricity vs Petroleum Products)

Price Change 1%	Consumption Change of Electricity in %	Consumption Change of Petroleum Products in %
Electricity	-0.0331	0.0249
Petroleum Products	0.0000722	-0.0717

2) Cross Price Elasticity of Natural Gas Substitutes for the Consumption of Natural Gas

The consumption changes of natural gas are simulated by changing 1% in the price of natural gas substitutes. All of the results, which are in Table 5.4.14, are negligible. Some energy types show negative sign, which means complements, not substitute. These results indicate that, assuming energy prices will continue to stay below the shadow market price level, it is better to rely the promotion of natural gas on not price control but on other measures as expansion of natural gas supply network

Table 5.4.14 Cross Price Elasticity (Natural Gas vs Other Fuels)

Price Change 1% in	Consumption Change of Natural Gas in %
Electricity All	-0.00271
Petroleum All	-0.00243
Gasoline	-0.00026
Kerosene	0.000201
Diesel	-0.00202
Diesel for Transportation	-1.4E-05
Fuel Oil	-0.00083
LPG	0.00043
NG	9.53E-13

As an integrated application, the macroeconomic-energy integrated model was used for the analysis of ERSAP, crude oil price, domestic energy price, technology and energy substitution. The result shows that the impacts of ERSAP and the potential of energy saving technology are quite large. The impact of 1% change in crude oil price in a year on GDP in the mid-term is only 0.014%. However, it could have the force to increase the GDP by 1.4 % in the mid-term if the crude oil price temporarily doubled for one year. As for the domestic energy prices, the impact of electricity price is negligible while the impact of the price rise of petroleum products is slightly positive for GDP. The simulation results of cross price elasticity show that they are mostly negligible. It means that the price control of a fuel is not an efficient policy as a measure to control the consumption of its substitute.