# Mineral Resources and Green Accounting

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*Dr. Mingsarn Kaosa-ard*
*Vice President*

# *Introduction*

Thailand has been generously endowed by rich reserves and various types of natural resources, ranging from minerals, petroleum, forestry, fertile land and groundwater. With mineral resources in particular, including petroleum and groundwater, Thailand can be considered a naturally rich country. In the last year, more than 44 types of minerals were produced in Thailand. These minerals had a value of more than twenty billion baht; an amount which has steadily increased over the past decade. Approximately 90 percent of the mineral products are used to serve an increasing domestic demand, whereas the remaining 10 percent are exported. In terms of groundwater, recent economic development of Thailand has bought about increases in water requirements in industrial, commercial and domestic sectors, particularly in the Bangkok area and its vicinity. In order to serve such dramatic change in demand for water, groundwater is heavily pumped, resulting in increased and widespread land subsidence in some areas. Moreover, groundwater also plays an important role as an alternative source of water for industrial development and agricultural uses. It is still the only source of water supply for households in the Bangkok Metropolis Area and its vicinity where the public water pipeline is not available.

Petroleum is one of the major sources of energy in Thailand. Although Thailand can produce all types of petroleum, namely crude oil, natural gas and condensate, the country remains a petroleum importer as it requires more than 275 thousand barrels of oil equivalents each year (MMPDE) (as of December 1996). This requirement is growing at a tremendous and continuing rate, however, all responsible agencies are now attempting to reduce the dependency on imported petroleum.

# MINERAL

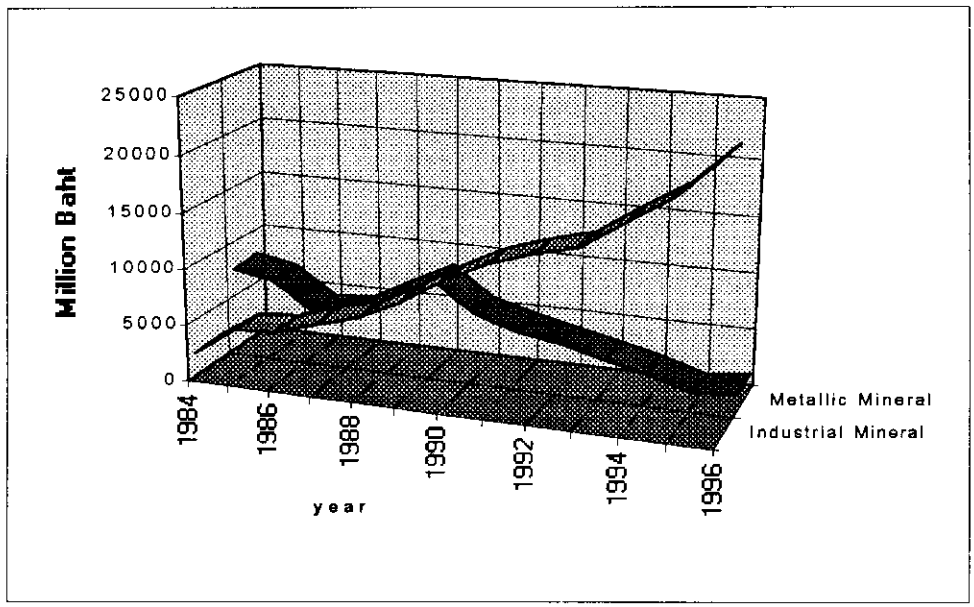
The mineral industry has made a considerable contribution to the dynamic economy of Thailand through taxation, royalties, employment in the rural areas etc. Its production accounted for more than 10 percent of the country's GDP in 1970. During the 1970's and early 1980's, the mineral sector was a major source of foreign exchange for Thailand. Mineral production, dominated by tin, was one of the countries top five exports. The share of exported minerals at the time was approximately 80 percent of total production. However, mineral production now accounts for less than 2 percent of GDP and its exports are negligible relative to the nation's total exports.

During the past two decades, the mineral sector in Thailand has experienced a structural change. There has been a marked decline in production of metallic minerals and a significant increase in the production of industrial minerals. As a result, after a long period of domination in this sector, the metallic minerals were replaced by the industrial minerals as the largest contributor to the sector, in terms of value, in 1986. The share of industrial minerals in over-all mineral production increased from 40 percent in 1985 to 94 percent in 1996. This dramatic shift in the composition of the mineral industry can be explained as follows.

***1. A Decrease in Production of Metallic Minerals :*** A sharp decline in tin price levels in all markets in late 1985, led to the bankruptcy of the International Tin Council's Buffer Stock Funds. As one of the largest tin exporting countries, tin production in Thailand sharply dropped from 5.29 billion baht in 1985 to 2.826 billion in 1986, and has continuously declined over time. It was in 1990 that Thailand, once a major tin exporter in the world, became a net tin importing country. Other metallic minerals such as lead and tungsten have shared the same unfortunate situation of their prices in the world market declining continuously. This decline has led to a decrease in their domestic production. On the other hand, as a consequence of depletion and reserve scarcity, the production of zinc also shows a decreasing trend in 1990's, though its world price has been relatively stable. This has forced Padeang Industry, the only zinc smelter in Thailand, to search for ore reserves in neighboring countries. The outlook for these metallic minerals in the near future is not quite as bright as it was in the past.

*2. An Increase in Demand for Industrial Minerals :* Between the mid 1980's and the early 1990's, the industrial minerals gained importance in the mineral sector. The total value of their production has increased at an average rate of 30 to 40 percent annually since the mid 1980 s, when their prices and production quantities began to show positive trends. This increase can be attributed to an impressive economic growth in the kingdom that in turn led to a high growth in some major industries, e.g. construction and energy. The average growth rates of these two industries were approximately 11.3 percent and 10 percent from the mid-1980's to the 1990's. Consequently, the demand for industrial minerals, which are used as raw materials in these sectors, increases. The largest growth rates of production in these minerals is found in lignite which is the most important source of energy in the country where gypsum and limestone came second and third, respectively. The dramatic increase in gypsum production is likely a response to an increase in demand for exports rather than a rise in domestic demand. The ratio of gypsum exports to its total production is 80 percent with Japan being the major importer of Thai gypsum. Gypsum is an unusual case and value of domestic consumption of all industrial minerals is nearly 90 percent of its overall production.

**Figure 1 The Production of Industrial and Metallic Minerals in Thailand**




*Source:* Department of Mineral Resources.

A significant increase in industrial mineral production has outweighed a decrease in metallic minerals, resulting in a steady growth in the overall production, from 11,324 million baht in 1985 to 19,857 baht in 1995 which represents an increase of an average rate of 7.5 percent annually.

Although the share of industrial minerals production, in terms of baht, first became larger than that of a metallic ones in 1986, the structural breaks in most individual major industrial minerals such as limestone, gypsum and lignite were likely observed in 1985. This can be explained as follows. The demand for exports of gypsum to Japan had sharply risen in 1985 at the rate of 15 percent, and at the same time, the completion of an electric generator installation of EGAT of unit 7-12 also caused a greater demand for lignite resulting in a more than doubling of production of lignite in that year. Instead of observing the structural break in 1985, it was not until a year later that the total production of industrial minerals, in terms of baht, surpassed that of metallic minerals. This may be due to their very low unit prices compared with metallic minerals. Additionally, the tin crisis had slight effect on the metallic mineral production, since it occurred late in that year.

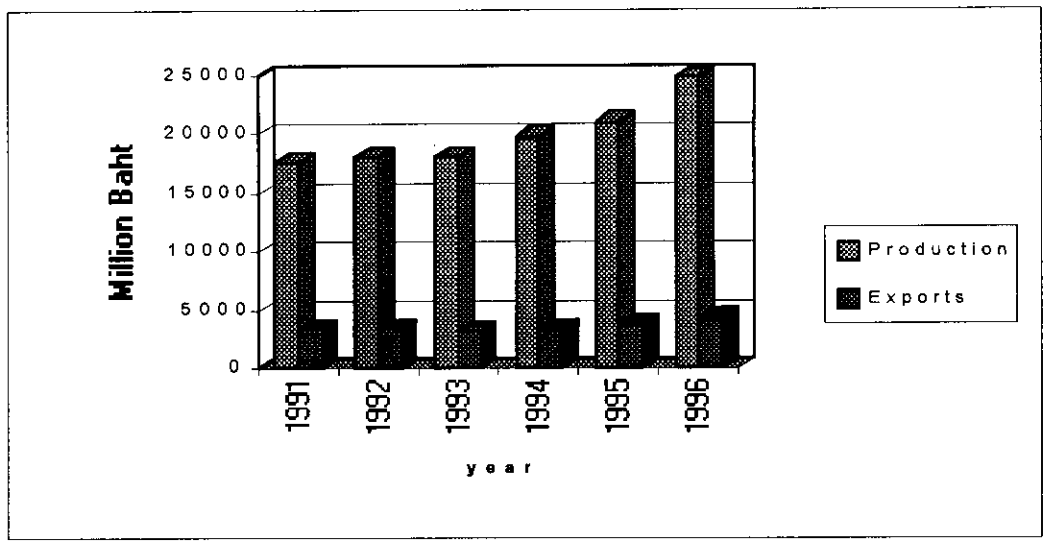
**Table 1 The Production of Minerals in Thailand between 1984-1995**

(unit: million baht)

| Year | Industrial Minerals | | Metallic Minerals | | Total Production |
|---|---|---|---|---|---|
| | Value | Ratio | Value | Ratio | |
| 1984 | 2,151 | 22.2 | 7,525 | 77.8 | 9,676 |
| 1985 | 4,566 | 40.3 | 6,757 | 59.7 | 11,323 |
| 1986 | 4,838 | 52.9 | 4,305 | 47.1 | 9,143 |
| 1987 | 5,942 | 57.1 | 4,470 | 42.9 | 10,412 |
| 1988 | 6,968 | 51.9 | 6,447 | 48.1 | 13,415 |
| 1989 | 8,755 | 50.8 | 8,488 | 49.2 | 17,243 |
| 1990 | 11,110 | 65.6 | 5,828 | 34.4 | 16,938 |
| 1991 | 12,861 | 73.1 | 4,732 | 26.9 | 17,593 |
| 1992 | 13,998 | 77.9 | 3,981 | 22.1 | 17,979 |
| 1993 | 15,023 | 83.4 | 2,995 | 16.6 | 18,018 |
| 1994 | 17,451 | 88.3 | 2,320 | 11.7 | 19,771 |
| 1995 | 19,832 | 94.6 | 1,143 | 5.5 | 20,975 |
| 1996 | 23,225 | 93.8 | 1,544 | 5.5 | 24,769 |

*Source:* Department of Mineral Resources.

**Figure 2 The Mineral Production and Exports of Thailand**




*Source:* Department of Mineral Resources.

**Minerals Potential and Reserves**

It seems to be an impossible mission to determine the exact amount of mineral reserves in the nation as it is cost prohibitive and reliability of data can not be assured. However, in an attempt to assess Thailand's mineral reserves, the government, through the Department of Mineral Resources, established the Mineral Resources Development Plan in 1984. The project was funded by the Asian Development Bank with partial financial assistance from the Canadian International Development Agencies (CIDA). The main activities in this project included an airborne geophysical survey, data interpretation and mapping. Completed in 1992, two years delayed from its original schedule, the project categorizes the country into 345 anomalous areas according to magnetic frequency and geological environment. These areas totally cover 74,900 sq. km. ranging in size from 3 sq. km. for the smallest one to 2,100 sq. km. for the largest one. However, as far as mineral commodity types are concerned, the potential areas can be divided into six areas, namely Base Metal, Epithermal Gold, Tin, Tungsten and Rare Minerals, Chromium and Nickel, Gemstone and Non-metallic Minerals.

Although the airborne geophysical surveys indicate a high potential for minerals in several areas throughout the country, ground follow-up investigations are needed to guarantee reliability of data for the possibility of further development. The database created by the project

will be available to all parties who enter into the bidding for survey and exploration licenses in the areas.

The figures of mineral reserves which are available today and are currently used for the purpose of resource management by governmental agencies are only preliminary figures based on present knowledge. These amounts are assessed for only some areas, and therefore might be changed as technologies become available to survey new areas more extensively. The reserves for some minerals are as follows (see table 2)

**Table 2 Mineral Reserves as of 1994**

(unit: million metric tons)

| Minerals | Reserves |
|---|---|
| 1. Tin | 0.4 (1-1,000 gm/Cu.m) |
| 2. Gypsum | 200 tons |
| 3. Feldspar | 11.8 tons |
| 4. Dolomite | 2,100 tons |
| 5. Antimony | 0.4 (Sb content) |
| 6. Kaolin | 250 |
| 7. Copper | 0.119 (Cu. content) |
| 8. Barite | 9 |
| 9. Pyrophyrite | 2 |
| 10. Iron | 27 (Fe content) |

*Source:* Department of Mineral Resources.

**Gypsum:** The level of gypsum reserves has been widely disputed since the cabinet first launched its resolution on mineral conservation in early 1993. The intensive studies conducted by both private and government sectors showed different amounts of reserves. However, both sides agree on the figure of 200 million metric tons as of the beginning of 1994. The deposits are principally located in the Southern and lower-Northern parts of the nation; another potential area is in the province of Loei. Based on the domestic demand for gypsum, the reserve is expected to be exhausted within 25 years. Following the cabinet's resolution, the DMR has imposed an export restriction policy on gypsum in order to conserve it for industrial development, and set the minimum export price (FOB price) at $17 per metric ton at Thailand

port. These policies have been in force since January 1, 1996. The gypsum export quota was distributed to mining companies according to their past records of exports. Under this measure, the total exports of gypsum in 1996 will be reduced by 20 percent from those of the previous year. However, with the relaxeation of the export restriction policy during the late 1996, the total exports of gypsum was only 9 percent below the previous year's figure, in which an increasing price boosted up the total revenue from the gypsum exports by 10 percent.

**Tin:** Tin had been the main mineral produced and had rendered high foreign exchange for the country for over 100 years. Unfortunately, the tin crisis in 1985 caused the closure of over 50 percent of the tin mines in Thailand. Tin is mainly found in the offshore areas of Phuket-Phangnga-Takua Pas. Some deposits are found in the mountainous areas running from north to south along the west of the nation. The total amount of tin reserves is approximately 0.4 million metric tons of 0.1-1000 gram/$m^3$. The possibility of resuming the mining operation in the tin-industry is reliant on the world price for tin.

**Iron:** Only few deposits of iron were found in Thailand and most of them are relatively small. The extensive investigations were conducted at the deposits in Loei province where the largest possible reserves of iron are located. The study showed the amount of reserves to be around 30 million ton of 52 percent Fe. Other major deposits are Kanchanaburi and Lop Buri provinces where reserves of 4.8 million tons of 40 percent Fe and 7.6 million tons of 45 percent Fe were discovered. The total reserve of iron in the nation is estimated at 27 million tons.

**Gold**: The gold deposits are scattered around the country. Only the reserve in Toh Moh, Narathiwat province was found to be feasible to mine and develop. At present, the operation of this mine is slowing down due to the small amount of remaining reserve. The new gold occurrences of the country are found in the central-north and north-east; the provinces of Loei, Nong-Kai and U-Don Thani. Tung Kum Ltd. which is an exploration company has been exploring the area of Loei since 1991. According to most recent information, the company has claimed to discover the gold reserve of 2.08 million tons with Au content of 3.37 gm/ton in the area. It now has asked the DMR for permission to develop and mine this area. More reserves are expected to be found in the areas nearby.

**Copper:** The main and most well-known zinc deposit has been discovered at Mae Sot district of Tak province. The ore minerals from this deposit are dominantly hemimorphite in calcareous sandstone and dominantly smithsonite in limestone of the Triassic age. Cadmium was found to attach with zinc in this deposit. Padeang Industry Co. Ltd. has exploited this deposit since 1984 to supply its smelting plant nearby. By 1995, the reserves of 4.5 million tons of 24 percent Zn in this deposit were nearly exhausted, causing Padeang Co. Ltd. to seek for new zinc reserves from other sources to supply the plant.

**Potash:** The Potash reserves are scattered around the areas of north-east Thailand, however, the largest reserve was found in Chaiyaphom province. This reserve has been developed by the ASEAN Potash Mining Company Limited which is a joint venture project of all ASEAN member countries. The mining development processes are under way and are expected to provide a yield in 2001. The total reserves of Kalnalite (NaCl KCL $MgCL_2$ $6H_2O$) with 62 percent of $K_2O$ in this deposit is expected to be 540 million tons. The mine hopes that with the Box-Hole underground mining technology and capacity of 1.1 million tons a year, the productive life of this project would be 31.1 years on proven reserves, 45.5 years on probable reserves and another 29 years on possible reserves.

**Quarry:** Limestone with a $CaCO_3$ content more than 96 percent and whiteness over 70 percent is regarded as an industrial rock. This implies that the subsequent limestone quarrying operations will be subject to the mining Act. Previously, limestone mining for cement and related industries was the only activity treated under Mining Law. Until July 1996, quarrying operations for aggregates were regulated under a different act and another department. This policy was designed to force all operations towards more technically and environmentally efficient control as a rapidly increasing demand for this material is anticipated. The Department of Mineral Resources thus is the principal agency responsible for these quarrying operations.

### Legal System in Mining Sector in Thailand

All aspects of mineral activities in Thailand are governed by the Mineral Act (1976) and subsequent amendments. According to this act, all minerals, in principle, belong to the state and licenses are required for all stages of development, including both exploration and production.

However, besides the Mineral Act, there are others acts authorized by other agencies involving in the permission process of licenses of exploration and mining. They are

- the Improvement and Conservation of National Environmental Quality Act, B.E 2535 (1992), authorized by
- the Forestry Act, B.E 2484 (1941), authorized by the Department of Forestry, Ministry of Agriculture and Cooperation.
- the National Reserved Forest Act, B.E 2507 (1964), authorized by the Department of Forestry, Ministry of Agriculture and Cooperation.
- the Sub-district Council and Sub-district Organization Act, B.E 2537 (1994), authorized by Ministry of Interior.
- Cabinet's Resolution on the Military Reserve Area , authorized by Ministry of Defense.

**Exploration License**

According to the Mineral Law (B.E. 2510), one who wishes to do mineral exploration has to apply for exploration license from the DMR first. There are three types of exploration licenses.

1. the General Prospecting Licenses (GPL) gives non-exclusive right to the holder to undertake geochemical and geophysical exploration over designated area. This license is issued by the local Mineral Resources Office where the prospecting area located. It is valid for one year and is non-renewable.

2. an Exclusive Prospecting License (EPL) is also valid for maximum one year for onshore area and maximum two years for offshore, and also may be renewed. The license offers exclusive exploration rights over the license area in return for certain work and reporting obligations. However, this license does not offer surface or mining rights. Within 60 days of the EPL's issue date, the EPL holders have to carry out their exploration activities and the amount of work undertaken must not be unreasonably less than that expected for the particular mineral described in the EPL.

3. the Special Prospecting License (SPL) is designed to enable larger scale projects, which requires a substantial investment and special technical skill, to be undertaken. An SPL is valid for 3 years from the issued date. In the application process, the applicants has to specify, inter alias, the annual prospecting expenses during the valid period of EPL. If granted, the SPL holders have to begin the activity within 90 days of the date of issue and must file the report on prospecting operations to the DMR every 120 days. In the event of an economic mineral discovery, holders of exclusive and special prospecting licenses have first priority after the surface rights owner, of the subsequent issuing of mining rights.

**Mining License**

The applicants of Mining Licenses (concessions) are required to submit the detailed work plan, financial accreditation and an environmental impact assessment. Although the DMR would be likely to issue a mining license to the EPL or SPL holder rather than the owner of prospecting land, the applicants must seek surface land rights over the property, before the mining license can be issued. Moreover, if the prospecting land is in the area controlled by other agencies, the permission from those concerned agencies is required in the mining license application process, including the consent of the Sub-District Council of the area where the deposit is located, and an approval on the report of an environmental assessment by the National Environment Agency. The term of mining licenses varies according to the amount of mineral deposit discovered, the size of designated area and type of minerals described in the application request. It usually runs for a maximum of 25 years,

In 1996, the DMR has imposed a special fee on the exploration and mining license application process. Under this regulation, one who is granted a exploration or mining license has to pay government an extra fee on top of regular fees. This "special fee" is calculated on the expected value of mineral deposit, e.g. 0.1 percent of the expected total value of deposit over 50 million baht (given the current market price of the specified minerals).

**Taxation System**

Since the property right of all minerals belong to the state, one who exploits minerals has to pay a royalty to the government. Royalties on minerals in Thailand are assessed according to the Mineral Royalty Rate Act B.E. 2509 (1966), as amended in B.E. 2520 (1977) and in B.E.

2522 (1979). The current royalty system in principle can be considered as an ad-volaem tax, and most are collected based on the value of mineral production in the fixed rate manner, except in some major metallic minerals in which the progressive rate is applied. The quoted price of each mineral posted by the DMR will be used as the basis for royalty calculation. The current royalty rates of some major minerals are shown in Table 3.

**Table 3 The Royalty of Selected Minerals**

| Minerals | Royalty Rate (% as Quoted Price) |
|---|---|
| 1. Gypsum | 4 |
| 2. Limestone | 4 |
| 3. Lignite | 4 |
| 4. Potassium Feldspar | 2 |
| 5. Clay | 4 |
| 6. Kaolin (Ceramic Grade) | 4 |
| 7. Fluorite | 7 |
| 8. Granite, Marble | 4 |
| 9. Diatomite | 2 |
| 10. Iron ore | 4.5 |
| 11. Shale | 4 |
| 12. Barite (ungrounded) | 7 |
| 13. Barite (Chemical) | 2 |
| 14. Antimony ore | 10 |

*Source:* Department of Mineral Resources.

With regard to promotion and stimulation of investment, the Thai government has exercised its responsibilities through the Board of Investment (BOI). This agency grants investment privileges to projects that, amongst other criteria, use domestic resources, create employment opportunities, earn foreign exchange and locate and contribute to economic growth in areas outside Bangkok. The promotion schemes include a range of fiscal and non-fiscal incentives, tax incentives, permission both to use foreign nationals on promoted projects, remission of foreign currency and the provision of comprehensive business-related services to investors. Tax incentives depend on the geographic location of the project within Thailand. They include an exemption of corporate income tax for up to five to eight years, half rate for another five years, and exemption or reduction of import duties on machines for mining related

metallurgical projects. However, a mining licenses must be issued before BOI promotion benefits can be obtained.

**Minerals in the National Economic and Social Development Plan**

Minerals have played a vital role in the economic development process of Thailand through time, particularly in the development of the industrial sector. As appear in the NESDP, the development of the mineral sector was put as the front line objectives of the plan. The guidance and support from the government in this sector were set up in such a way that minerals could be used to facilitate the overall economy achieving the target growth. It is not surprising that the pattern of mineral production, particularly that of industrial minerals, would follow and is similar to the growth of economy with some a short lags.

In the early National Plan, the mineral sector received considerable attention from policy planners as the main source of foreign exchange, employment, and the raw materials needed for the economic development process. In the first two plans, between 1962 and 1966 and from 1967 to 1971, the government launched a number of investment incentives in the sector in order to expand the mineral production base for the nation. Tin was the main mineral as it contributed around 90 percent of the value of overall production in the sector. Together with the assistance of demand for exports, the mineral sector during these two plans grew at an impressive rate of 9.3 percent and 8.7 percent, respectively. Between 1972 and 1976, in the period of third national plan, the target growth of this sector was set at the rate of 6 percent, in response to the declining price of tin in the world market. The aims of this plan in the mineral sector were to promote an investment from the private sector in both surveying and production. However, unfortunate internal and external situations such as a recession in the global economy and domestic political turmoil caused a reduction in overall production and exports in the mineral sector. It was the first time that Thailand had experienced a decreasing rate in the main economic sector of the nation.

In the fourth national plan period, the readjustment in the economic structure after the global oil crisis helped the domestic mining industry bounce back from the slump. The demand for metallic minerals and metals in industrialized countries increased dramatically. Along with

this recovery, the country's economic expansion added to the demand for raw materials derived from minerals. These factors explain why mineral production recorded an extraordinary jump; from 6.852 billion baht in 1977 to nearly 14 billion baht in 1980 with the value of tin production accounting for 70 percent of this figure. During the fifth national plan, the government promoted the set up of a zinc refinery and lead smelter in the country in order to cut down on imports of these metals. The tin industry took a nose-dive due to a slow- down of its demand in western countries. Industrial minerals grew in importance as their values of production are firstly larger than metallic minerals, and most of them were produced to serve a growing domestic industries.

The problems of inefficient use of natural resources, the deterioration of reserves and land conflicts compelled the government to seek appropriate measures in managing natural resources. In the sixth national plan, the government set guidelines for developing natural resources and the environment as follows; (i) to improve efficiency in the use of each individual natural resource, (ii) to promote the participation of regional and local organizations in the process of natural resources development, (iii) to encourage complete integration and systematic planning for mineral uses and environment, and (iv) to promote conservation of environment and minerals for future use. As for the seventh national plan, the conservation of industrial minerals for domestic use, the conflict of land use and the assessment of mineral reserves in the country as a whole are the highlights of mineral development. The growth rate of this sector during this plan period (1992-1996) is expected to be 5 percent in which will contribute to GDP as 1.2 percent.

In the 8th NESDP, as the nation is now gearing towards the state of a newly industrialized country, the demand for minerals will increase significantly. However, it is imperative that minerals should be managed in the most appropriate manner in harmony with natural environment as the improvement of quality of life of people become a main objective of the plan and public's concern.

As for environmental concerns, the public has put a great deal of pressure on the government to control the environmental effects of the mining sector. The country's recent track record in environmental control for mining is impressive in relation to other sectors.

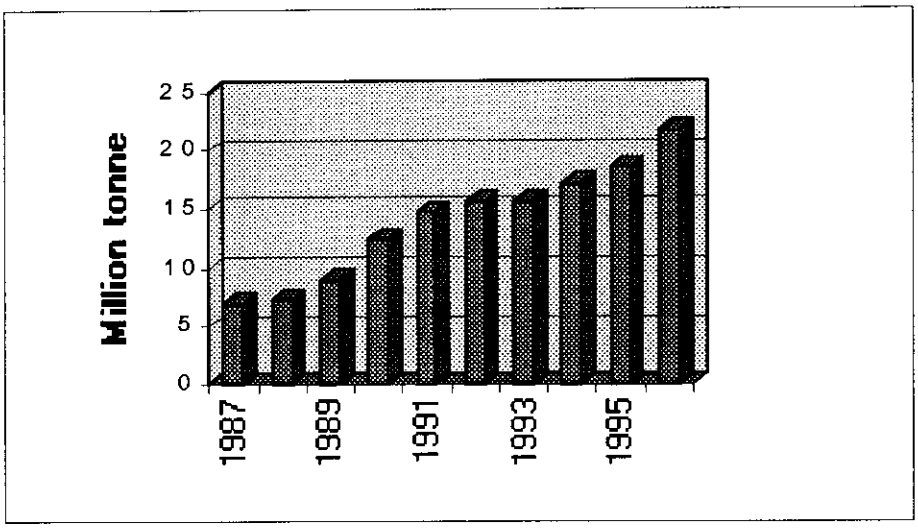
# COAL

For the past two decades, energy demand in Thailand has been growing as a result of the booming economy. Thailand's energy had been substantially fueled by imported oil, however, after the second oil crisis (1980), the Thai Government recognized the importance of the development of indigenous energy resources to reduce the dependency on imported fuel products. The Electricity Generating Authority of Thailand (EGAT), representing the major power generators, in co-operation with the National Energy Administration (NEA) and the Department of Mineral Resources (DMR) has conducted explorations to find domestic coal reserves. During the 1950's, the first exploration for coal reserve was launched in Mae Moh basin, Chiang Mai province, and the coal deposits were found to be low-quality lignite and subbituminous. During the exploration, 120 million tons of lignite deposit was assessed. Later, another exploration was conducted in Krabi province and found the same type of coal. Lignite deposits from the two reserves had proven sufficient for power generation. EGAT then established the first lignite mine in the Mae Moh area. At that time 45 million tons of lignite was produced to supply the power generator with capacity of 75 megawatts. A more detailed exploration was conducted and development was carried out on several mining fields. As of 1996, the total coal was approximately 2,300 million metric tons.

## Coal Production and Consumption

The Department of Mineral Resources (DMR) has so far issued 31 concessions to private sectors and state enterprise and 139 mining permits have been issued in 8 provinces. EGAT is the biggest agency known as the national power generator. About 20 percent of EGAT power generation is from lignite. Total lignite production has grown from 7 million tons in 1987 to 21 million tons in 1996. Approximately 75 percent of lignite production is from Mae Moh which is operated by EGAT. In 1996, Mae Moh produced 13.0 million metric tons of lignite which was mainly used for power generation.

**Figure 3 Thailand Lignite Production**




*Source:* Department of Mineral Resources, 1996.

**Table 4 Lignite Production from Different Reserves in Thailand**

(unit: million metric tons)

| Reserves | Mae Moh | Krabi | Li | Mae Tan | Mae Jam | Others |
|---|---|---|---|---|---|---|
| 1990 | 9.60 | 0.16 | 2.03 | 0.11 | 0.17 | 0.29 |
| 1991 | 11.50 | 0.24 | 2.39 | 0.09 | 0.19 | 0.29 |
| 1992 | 12.20 | 0.26 | 2.48 | 0.33 | 0.26 | 0.11 |
| 1993 | 11.20 | 0.22 | 2.92 | 0.69 | 0.45 | 0.13 |
| 1994 | 11.90 | 0.27 | 3.18 | 1.27 | 0.39 | 0.10 |
| 1995 | 13.20 | 0.14 | 2.90 | 1.67 | 0.39 | 0.12 |
| 1996 | 16.38 | - | 2.82 | 2.03 | 0.32 | 0.12 |

*Source:* Department of Mineral Resources, 1996.

EGAT's power generation proportion in 1994 was mainly composed of 44 percent from natural gas, 28 percent from imported oil, 20 percent from lignite, and 5 percent from hydro power. The energy generation from lignite provided a total of 14,065 million kWh. EGAT's fuel expenses for lignite accounted for 12 percent of the total fuel expenses or 4,474 million baht.

**Table 5 Lignite Production by Region**

(unit: tons)

| YEAR | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|
| Northern Region | | | | | |
| Chiang Mai | 261,259 | 450,172 | 392,622 | 388,913 | 31,2959 |
| Lampang | 12,541,479 | 11,910,132 | 13,172,374 | 14,896,650 | 18,180,537 |
| Lamphun | 2,475,292 | 2,923,548 | 3,176,079 | 2,903,140 | 2,824,370 |
| Tak | 73,450 | 85,717 | 92,091 | 85,802 | 67,627 |
| Others | - | - | - | - | 266,401 |
| Central Region | | | | | |
| Phetchaburi | - | - | - | - | 34,000 |
| Southern Region | | | | | |
| Krabi | 263,950 | 216,800 | 266,488 | 144,233 | - |
| Trang | 2,800 | 6,390 | - | - | - |
| **Total Production** | **15,618,230** | **15,592,759** | **17,099,654** | **18,418,738** | **21,685,894** |
| Value (Million Baht) | 7,809 | 7,796 | 8,549 | 9,209.4 | 10,842.9 |

*Source:* Department of Mineral Resources, 1997

According to the DMR, total lignite consumption rose from 13 million metric tons in 1990 to 20 million metric tons in 1995 and will increase to more than 30 million metric tons by the year 2000. The power sector represents approximately 65 percent of the total lignite consumption. Apart from the power sector, the cement industry is the major lignite user for nonpower usage accounting for 26 percent of the total consumption. The consumption from cement industry is expected to rise from 5.60 million metric tons in 1996 to 7 million metric ton by the year 2000. The other nonpower users of lignite are tobacco-curing and boiler-using industries which account for less than 1 percent of the total lignite consumption. For the nonpower sector, the two largest lignite producers are Ban Pu Coal Company and Lanna Lignite Company.

**Table 6 Types of Imported Coal, 1991 - 1995**

| | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|
| BRIQUETTES | | | | | |
| • Quantity (1,000 tons) | 0.064 | 0.198 | 3.055 | 0.05 | 0.05 |
| • Price (baht/KG.) | 7.766 | 0.811 | 0.387 | 10.38 | 8.25 |
| • Value (million baht) | 0.497 | 0.161 | 1.182 | 0.55 | 0.41 |
| ANTHRACITE | | | | | |
| • Quantity (1,000 tons) | 18.780 | 1.567 | 3.632 | 1.18 | 5.03 |
| • Price (baht/KG.) | 1.722 | 2.511 | 3.216 | 3.98 | 2.49 |
| • Value (million baht) | 32.330 | 3.936 | 11.680 | 4.68 | 12.55 |
| COAL SOLID FUELS FROM COAL | | | | | |
| • Quantity (1,000 tons) | 366.141 | 438.703 | 867.570 | 1408.15 | 2306.19 |
| • Price (baht/KG.) | 1.030 | 0.968 | 0.929 | 0.96 | 0.78 |
| • Value (million baht) | 377.028 | 424.744 | 805.850 | 1345.23 | 1793.78 |
| PEAT | | | | | |
| • Quantity (1,000 tons) | 0.005 | 0.000 | 0.000 | 0.000 | 0.1 |
| • Price (baht/KG.) | 13.343 | - | - | - | 5.54 |
| • Value (million baht) | 0.061 | 0.000 | 0.000 | 0.000 | 0.55 |
| COKE OF COAL | | | | | |
| • Quantity (1,000 tons) | 84.432 | 60.386 | 61.501 | 109.84 | 95.33 |
| • Price (baht/KG.) | 3.657 | 3.650 | 3.264 | 3.36 | 3.41 |
| • Value (million baht) | 308.747 | 220.388 | 200.709 | 368.59 | 324.79 |
| TOTAL | | | | | |
| • Quantity (1,000 tons) | 469.422 | 500.854 | 935.758 | 1519.21 | 2406.7 |
| • Price (baht/KG.) | 1.531 | 1.296 | 1.089 | 1.13 | 0.89 |
| • Price (USD/ton) | 60.085 | 50.902 | 43.000 | 44.95 | 35.47 |
| • Value (million baht) | 718.662 | 649.229 | 1019.422 | 1719.06 | 2123.11 |

*Source:* National Energy Administration, 1996.

**Box 1: A Case Study of Natural Resource Accounting of Coal in Thailand**

Thailand experienced a high growth rate since the mid 1980s. One result of this growth was heavy exploitation of the country's abundant natural resources. Coal is one of many resources which has been heavily extracted. Approximately 79 percent of coal is used to fuel the power sector, the rest being consumed by the non-power sector (i.e. the cement industry, paper mills, fiber factories, tobacco-curing and calcium oxide processing). The rate of coal production has been significantly increasing, as reported by the Department of Mineral Resources (DMR); 21 million tons were extracted in 1995 as compared to only 5 million tons in 1985.

The stock of coal will eventually be fully exhausted since it is a non-renewable resource. Moreover, non-renewable resources cannot be replaced, unlike man-made capital whose defects can be replaced utilizing new capital investment (e.g. a computer). Consequently, the new capital investment is included in the Capital Consumption Allowance (CCA), or Gross National Product (GNP) less Net National Product (NNP). Although NNP as an economic wealth indicator is more accurate than GNP, its estimation disregards environmental damage. In order to incorporate natural resource depletion into NNP, one needs to estimate the economic depreciation of coal. This depreciation is referred to as Hotelling's Rent (Hartwick 1995) and can be calculated by subtracting the marginal cost of one unit of extracted coal (MC) multiplied by the quantity (Q) from the price of coal (P). The result is an adjusted NNP, which equals the original NNP less Hotelling's Rent (HR):

$$HR = P - (MC \times Q)$$

The table below calculates an adjusted NNP that includes the depreciation of coal stocks for the period 1985-1995. The results illustrate that Hotelling's Rent increased from 5,888 million Baht in 1985 to 11,196 in 1995, mainly due to rising production rates for coal. The percentage of net adjustment (% NNP) was approximately 1 percent and less. The estimates indicate that policy-makers should re-invest the rent to compensate future generations for the current depletion of coal resources. The adjusted NNP is lower than the original NNP, meaning that the "free lunch" was eliminated.

For policy formulation that accounts for natural resource depletion, national "green" accounts should indicate how changes in the economy and the environment are linked (Pearce and Warford 1993). Additionally, resource pricing is also vital; the price of a resource should reflect its true cost. Otherwise, a price distortion could lead to the over-extraction of a limited resource, as well as mislead economic development policy. By estimating Hotelling's Rent and adjusting NNP accordingly, the real economic progress of the country is reflected in its national accounts. Furthermore, utilizing a fully adjusted NNP is vital in the formulation of sustainable economic development policies. A fully "adjusted for resource depletion," or adjusted NNP, would include all natural resources, both renewable and non-renewable, not only coal stocks (as is the case here).

| Year | NNP | Hotelling's Rent | Net Adjustment | Adjusted NNP in Baht. | % NNP |
|---|---|---|---|---|---|
| 1985 | 831,975 | 5,888 | 5,888 | 826,087 | 0.71 |
| 1986 | 879,915 | 6,001 | 6,214 | 873,701 | 0.71 |
| 1987 | 1,011,343 | 6,510 | 6,405 | 1,004,938 | 0.63 |
| 1988 | 1,198,771 | 7,531 | 6,467 | 1,192,304 | 0.54 |
| 1989 | 1,440,089 | 13,106 | 12,556 | 1,427,533 | 0.87 |
| 1990 | 1,681,522 | 18,207 | 21,485 | 1,660,037 | 1.28 |
| 1991 | 1,925,835 | 16,339 | 20,068 | 1,905,767 | 1.04 |
| 1992 | 2,160,037 | 10,016 | 8,885 | 2,151,152 | 0.41 |
| 1993 | 2,382,007 | 10,750 | 2,114 | 2,379,893 | 0.09 |
| 1994 | 2,768,500 | 11,503 | 2,542 | 2,765,958 | 0.09 |
| 1995 | 3,133,862 | 11,196 | 832 | 3,133,030 | 0.03 |

Lignite consumption during the past 5 years tended to be higher than the lignite production due to increasing demand for power generation and cement production. As a result, and because of the low quality of Thai coal, Thailand must import huge quantities of high quality coal each year from Indonesia, China, Australia, and Vietnam. The imported high quality coal is used for blending with low calorific domestic coal. In the first nine months of 1996, Thailand imported a total of 2.85 million tons of coal which had increased from that of the same period of the previous year by nearly 17 percent. The amount of imported coal consumed by the cement industry is expected to increase due to steady growth in the cement industry and the low quality of local coal. The high moisture and high ash content of local coal limits its potential usages. Moreover, the introduction of new power plants by EGAT's Independent Power Producers (IPP) will further increase demand for imported coal in the near future.

**Coal Exploration and Reserves**

The Department of Mineral Resources (DMR) has conducted an exploration to assess coal deposits and reserves in Thailand. The Coal Exploration and Assessment Project which the DMR undertook between 1988 to 1992 explored about 70 coal deposits and estimated 816.53 million tons of coal reserves. In explorations between 1992 and 1994 the DMR found six promising coal reserves. As of 1996, Thailand has 1,445 million tons of remaining lignite reserves with nearly 90 percent is in Mae Moh mine.

# GROUNDWATER

Groundwater is considered one of major sources of the country's water supply. In rural areas where the surface water is not available, groundwater is the source of day to day living water needs also used to support agricultural activities. In urban areas groundwater supplies the water needs of households and industries. Because of rapid urbanization, the Bangkok Metropolitan Area and its vicinity are confronted with a serious problem in water supply. The demand for water supply in this area has increased dramatically over time. An inadequate availability of surface water around the area has forced households situated outside the boundaries of the Metropolitan Waterworks Authority (MWA) water supply network, and MWA itself, to exploit the groundwater. Moreover, an expansion of industry around the Metropolitan area has escalated the demand for groundwater, resulting in its excessive pumping. This activity leads to a drastic decline of piezometric levels. The declining of artesian pressure has caused a land subsidence and contamination of the fresh groundwater by salt water intrusion and leakage of salty groundwater. In 1983, the measure on the Mitigation of Groundwater Crisis and Land Subsidence in the Bangkok Metropolis was introduced to control the groundwater pumpage in the Metropolitan area and its vicinity. The ultimate aim of this measure is to recover the piezometric levels in the three heavily used aquifers and to remedy the land subsidence problem in the area.

**Water Supply Requirement**

With the continued expansion of the Metropolitan area and its vicinity, statistics released by concerned agencies indicated that the water supply requirement for household, agricultural, and commercial and industrial uses in 1997 increased by 32 percent over the previous year. Recently, statistics published by the Department of Mineral Resources revealed that, water used in the Bangkok Metropolitan Area and its vicinity increased from 5.56 million $m^3$/day in 1996 to 5.9 million $m^3$/day in 1997. The commercial and industrial sector is still the major water user, accounting for 55 percent of the total consumption with households and agricultural sector came second and third, respectively. The major sources of water supply are surface water and

groundwater. It is estimated that the use of groundwater accounts for a quarter of the total water requirement in the areas. Although stricter measures have been imposed to limit and to curb down the number of ground water pumping wells in the area, especially in the land-subsidence critical areas, the use of groundwater in the private sector rose from 1.19 million $m^3$/day (April) in the last year to 1.46 million $m^3$/day in 1997 (April), increasing by 23 percent. At the same period, the number of groundwater pumping wells in the private sector increased over 50 percent, from 6,359 wells to 9,973 wells.

The major causes of an increase in groundwater utilization by commercial and industrial sector in the Bangkok Metropolitan and its surrounding areas are (i) lack of access to public pipe water supply, (ii) unreliable or insufficient piped water supply, and (iii) cheaper price of groundwater compared with that of piped water supply.

**Table 7 Groundwater Uses in the Bangkok Metropolitan and Its Vicinity**

Households Agri. Com + Ind. Gov. Agencies Total

| Province | No. of Well | mil. $m^3$/day | No. of Well | mil. $m^3$/day | No. of Well | mil. $m^3$/day | No. of Well | mil. $m^3$/day | mil. $m^3$/day |
|---|---|---|---|---|---|---|---|---|---|
| Bangkok | 684 | 0.154 | 31 | 0.003 | 630 | 0.178 | 29 | 0.067 | 0.403 |
| Samut Prakarn | 501 | 0.049 | 20 | 0.000* | 1,426 | 0.458 | 132 | 0.052 | 0.561 |
| Samut Sakorn | 333 | 0.036 | 12 | 0.004 | 946 | 0.229 | 268 | 0.033 | 0.304 |
| Nontaburi | 228 | 0.051 | 6 | 0.000* | 235 | 0.042 | 84 | 0.007 | 0.100 |
| Patumtani | 695 | 0.166 | 20 | 0.000* | 838 | 0.307 | 180 | 0.052 | 0.534 |
| Pra Nakorn Sri Ayuthaya | 257 | 0.039 | 21 | 0.001 | 370 | 0.137 | 909 | 0.091 | 0.259 |
| Nakorn Prathom | 130 | 0.259 | 23 | 0.001 | 441 | 0.112 | 314 | 0.023 | 0.162 |
| TOTAL | 2,828 | 0.512 | 133 | 9,924 | 4,886 | 1.464 | 1,962 | 0.336 | 2.323 |

*Source:* Department of Mineral Resources.

In 2010, the water supply requirement in the Metropolitan area is estimated to be 8.405 million $m^3$/day increasing from 5.32 million $m^3$/day in 1996. The water supply need in the industrial and commercial sector would be more than 50 percent of the total requirement where the domestic use would account for 37 percent. With the stricter measures imposed on the

ground water use, water supply from the groundwater will be relatively constant over the period. As a result, the proportion of groundwater in the total water supply will decline from 26 percent in 1996 to 17 percent in 2010. This proportion is expected to decline in 2008 when MWA will completely terminate its groundwater wells. Other alternative sources of water supply will be seriously considered, especially surface water, in order to serve an increasing demand. In MWA's Master Plan, surface water in Mae Kong river will be developed to cover demand in the eastern area of Bangkok by MWA's network. On the other hand, Provincial Waterworks Authority (PWA) will expand the water supply project in the north of Bangkok (Pathum Thani). The water supply requirement in commercial/industrial sector in 2010 are expected to be 4.579 million $m^3$/day whereas domestic use would be 3.08 million $m^3$/day.

**Table 8 Water Supply Requirement between 1997-2010**

(unit: million cubic metre per day)

| Year | Water Supply Requirement | | | Total Water Supply Requirement |
|---|---|---|---|---|
| | Domestic | Commercial & Industry | Agriculture | |
| 1997 | 2.072 | 3.271 | 0.524 | 5.867 |
| 1998 | 2.154 | 3.390 | 0.538 | 6.082 |
| 1999 | 2.235 | 3.484 | 0.588 | 6.307 |
| 2000 | 2.316 | 3.609 | 0.601 | 6.526 |
| 2001 | 2.398 | 3.702 | 0.643 | 6.743 |
| 2002 | 2.487 | 3.842 | 0.661 | 6.990 |
| 2003 | 2.568 | 3.932 | 0.709 | 7.209 |
| 2004 | 2.649 | 4.056 | 0.722 | 7.427 |
| 2005 | 2.730 | 4.177 | 0.738 | 7.645 |
| 2006 | 2.811 | 4.257 | 0.795 | 7.863 |
| 2007 | 2.894 | 4.367 | 0.819 | 8.080 |
| 2008 | 2.956 | 4.416 | 0.872 | 8.244 |
| 2009 | 3.018 | 4.497 | 0.890 | 8.405 |
| 2010 | 3.080 | 4.579 | 0.918 | 8.577 |

*Source:* Department of Mineral resources, Metropolitan Waterworks Authority, Ministry of Interior, Provincial Waterworks Authority, and Ministry of Health.

**Groundwater Level and Land Subsidence**

The problem of land subsidence in Bangkok was been first recognized in the early 1970s. Many previous studies were conducted to investigate and survey the level of land subsidence and the level of groundwater in the capital area. The results from those studies revealed that the land subsidence in Bangkok area accumulated between 1933 and 1987 was approximately 160 cm., where annual subsidence rates between 1988 and 1990 were between 2 and 5 cm per year varying by area and with the eastern suburbs suffering the most. The study conducted by JICA in 1995, using 1991 data, found that a subsidence rate of less than 2 cm/year is observed in most parts of Bangkok while a higher rate of subsidence of 2 to more than 5 cm/year was found in heavy industrial and bordering areas such as in Bang Phli and southwest of Samut Prakan.

The major cause of the land subsidence in Bangkok is a decline of groundwater level which is in turn caused by in excessive pumping of groundwater in the Bangkok Metropolis and its surrounding areas. An overheated economic growth and rapid expansion of industrial sectors during the mid-1980's and early 1990's combined with the inadequate capacity and network of water supply of MWA, led to a sharp increase in the demand for ground water use. As a result, groundwater which is an substitute source of water supply has been heavily withdrawn during the period, causing a decline of groundwater level at an average rate of 2-4 m/year. In the early 1990's, after the DMR implemented its tougher measure and policies towards managing ground water, under the Groundwater Act BE 2520, the land subsidence was lower and more stable than before. This is mainly due to a lower rate of declining groundwater levels in the Metropolitan area, resulting in a reduction of the rate of land subsidence from an average rate of 3 cm/year to 1.5 cm/year.

In order to prevent further land subsidence in the Metropolitan and its vicinity areas, the DMR has announced the land subsidence critical zone which is divided into 3 zones and has imposed new groundwater royalty (detail will be later discussed). With these new policies, the government expects to be able to control and curb down the growing demand for groundwater in the areas in which it would further cause a more severe problem of land subsidence. Under the implementation of land-subsidence critical zone policy, the utilization of groundwater in the first-critical zone was originally prohibited in 1997, but extended to 1998 in order to allow the

consumer to find other alternative sources of water supply. The use new groundwater wells in the second critical zone, where the water supply network of MWA is available, is not permitted. All permission of groundwater use in this zone will be withdrawn in 1999.

**Salt Water Intrusion**

Salt water intrusion in the aquifer of Bangkok has been observed since 1967 when many municipal wells in Thon Buri and areas in the southern part of Bangkok yielded brackish to salt water. Since then, more and more wells in these areas and on the west bank of the Choa Phraya River were abandoned. Now, many wells in central Bangkok which once yielded fresh water show an inferior water quality as it increases in hardness, contents of iron, manganese, sulfate, calcium, sodium, magnesium and dissolved solids. The major sources of groundwater quality degradation are believed to be the sea water and connate water entrapped under marine conditions in pore spaces of sediments at the time of their deposition. The sea water moves inland from all direction toward depressed areas of groundwater level. The studies conducted by the DMR showed that the rate of movement of saltwater in areas of large pumpage is rather greater than in areas of less pumpage. The rate of saltwater intrusion accelerated in areas when water levels are most drastically depressed by over pumpage particularly in the Phra Pradaeng, Nakorn Luang and Nonthaburi aquifers.

**Aquifers System in Bangkok Metropolitan Area**

The Lower Chao Phraya Basin covers 200 kilometers from the north to the south and 175 kilometers from the east to the west of the Bangkok area. It is a flood plain and delta of the Chao Phraya River. The principal aquifers in the areas, which are considered unconsolidated deposits of ground water, are in the upper 600 metres. They are divided into eight artesian aquifers, separated from each other by thick confining clays or sandy clay layers.

1. **Bangkok Aquifer**: This aquifer is divided into two-aquifers; an upper Bangkok aquifer and a lower Bangkok aquifer. The depth to the ground surface of these two aquifers are 16 to 30 metres and 30 to 50 metres respectively, where the topmost sediments are approximately 15 metres thick and known as Bangkok clay. The upper aquifer consists of fine brown sand on top and fine to coarse sand with gravel at bottom, where the lower one is located

in the level of grayish brown, fine to coarse sand with gravel and gray to yellowish brown clay layers.

2. **Phra Pradaeng Aquifer**: This aquifer is around 60 to 80 metres below the ground surface and ranges from 20 to 50 metres thick. It is separated from the Bangkok aquifer by 10 to 15 metres of confining brown to grayish brown clay. In the aquifer, coarse grained and whitish gray sand and gravel are found. The sediments were deposited under the fluviatile and shallow sea environments on an eroded surface of hard and compact clay.

3. **Nakorn Luang Aquifer**: This aquifer is 100 to 140 metres under the ground surface. It is separated from the Phra Pradaeng aquifer by a 3 to 10 metres of brown and compact clay. The sand and gravel found in this aquifer are generally moderately well sorted and whitish yellow to light brown. The Nakorn Luang aquifer has been known to provide a good quality of water, and it has now been heavily extracted which has caused a declining water level and a reduction in the quality of ground water in this aquifer.

4. **Nonthaburi Aquifer**: The Nonthaburi aquifer consists of sand and gravel with minor clay lenses. It is 170 to-200 metres below the ground surface and ranges from 20 to 70 metres thick. Similar to the Nakorn Luang aquifer, this aquifer is very permeable and provides good quality water. Due to lower water yield and poorer quality water in the Nakorn Luang aquifer, this aquifer has now been developed extensively even though the extraction cost is higher than that of the Nakorn Luang aquifer.

5. **Sam Khok Aquifer**: This aquifer is found in the layer of brown to yellow clay, coarse grained and fairly well sorted sand and gravel, located 240 to 290 metres below the ground surface. The ground water in this aquifer is of good quality in the north, east and southeast of Bangkok. However, it provides a less production capacity than the Nakhon Luang and Nonthaburi aquifers.

6. **Phayathai Aquifer**: Separated from the Sam Khok aquifer by 5 to 10 metres of a hard and compact clay bed, this 50 metre-thick aquifer lies in dirty brown, angular and medium sized sand and gravel layers. It yields a similar quality of ground water as that of the Sam Khok aquifer.

7. **Thon Buri Aquifer**: This aquifer consists of coarse grained, rounded and well sorted sand and gravel interbedded with a thin layer of clay. It underlies the Phayathai aquifer, separated from each other by a 50 metre-thick clay bed. At 350-400 metres below the ground surface, this aquifer provides a good quality of ground water in the north, east and southeast of Bangkok area.

8. **Pak Nam Aquifer**: It lies in white to gray and well sorted sand and gravel layer, at 420-500 metres from the ground surface.

**Legal Aspects**

During the 1970's, the problems of the land subsidence and the widespread decline of ground water levels became more serious as a result of uncontrolled and excessive pumping of groundwater in the area. To address the problem, the government enforced the Groundwater Act B.E. 2520 in July of 1978. The principle purpose of the Act is to provide the government authority to control the groundwater activities in order to prevent land subsidence. Under the Act, all groundwater activities i.e. exploitation, development, utilization and conservation are subject to the control and regulation of the government through the Department of Mineral Resources (DMR). Anyone wishing to engage in any of the above activities relating to groundwater must receive official permission from the DMR. An exception is that permits for drilling and groundwater use are not required for government organizations which are responsible for providing water for agricultural, domestic or industrial purposes. They are still under the Ministerial Regulations concerning drilling, well development or abandonment, controlled extraction of groundwater, public health and environmental protection.

Under the Groundwater Act BE. 2520, the official permits for groundwater activities are divided into 3 types.

1) A permit for drilling groundwater wells
2) A permit for groundwater use
3) A permit for disposing water into wells.

where the valid duration of each permit is set at 1 year for drilling, 10 years for groundwater use and 15 years for disposal.

The study on Groundwater in the Bangkok Area, jointly conducted by DMR and the Asia Institution of Technology (AIT), between 1978 and 1982 indicated a substantial increase of groundwater use in the future with predictions of possible resulting land subsidence in the area. In order to slow down the rate of land subsidence in the Bangkok Metropolis and its vicinity, the Cabinet issued a resolution on the Mitigation of Groundwater Crisis and Land Subsidence in March 1983. Under this resolution, the Bangkok Metropolitan Areas and three surrounding provinces (Nonthaburi, Pathum Thani and Samut Prakan later extended to cover Samut Song Kram and Nakon Pathom) were divided into three zones according to the degree of land subsidence crisis as follows.

Zone 1: covers the areas where the land subsidence rate is greater than 10 cm/yr. and/or groundwater level is declining rapidly.

Zone 2: covers the areas where the land subsidence rate is 5-10cm/yr. and/or groundwater level is declining rather rapidly.

Zone 3: cover the areas where the land subsidence rate is less than 5 cm/yr. and/or groundwater level is declining slowly.

The aim of the resolution is to reduce the groundwater pumpage in the critical zones.

According to this resolution, all government agencies were exempt. The Metropolitan water Authority (MWA) must phase out all public wells in Critical Zone 1 and 2 by the end of 1997, and must replace water sourced from groundwater with surface water. However, the phase-out-in-steps program of the MWA was extended to.

Most big cities and metropolises were coming under severe pressure to extend their urban water supply in order to provide this basic services to several million people who still had no access to a safe water supply and for commercial and industrial users whose demands are expanding with accelerated rate. With an inadequate and insufficient public piped water supply, groundwater seemed to be the best solution for users in these sectors. Not only did it provide a good quality and sufficient amount of water supply but with a cheaper price than that of piped water. This situation led to an overutilization of groundwater in urban areas, causing a severe

problem of land subsidence. As is known, land subsidence has brought tremendous economic loss and negative externalities in the way of social costs.

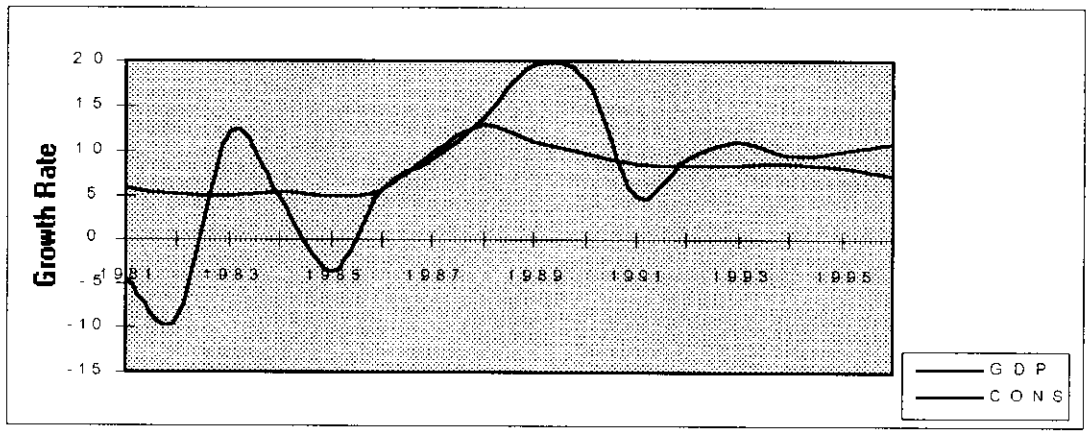
In order to restore the sustainable condition of groundwater, where its extraction rate and recharge rate are equal, the two possibilities are (i) to discourage groundwater use, and (ii) to improve the recharge rate. In the line of demand management, pricing policy seems to be the most popular and appropriate solution. To determine what price should be charged to users, externalities or social costs associated with groundwater use must be included so that the real cost of groundwater use is reflected in the price.

The costs associated with groundwater exploitation are comprised of capital investment, maintenance cost and royalties. For capital investment, fixed cost are is the most significant part of total cost. To recover the capital investment, users will be encouraged to overutilize groundwater. Thus, an increase in groundwater price, by use of a royalty, which is a variable cost, would cause a higher marginal cost, resulting in a reduction of quantity of groundwater extracted. If the proper amount of royalty is introduced, it could help to restore the sustainable condition of groundwater utilization.

# PETROLEUM

With Thailand's heavy dependence on imported petroleum, it is subject to oil crisis shocks. Although oil prices were high in 1990, during the 7th plan (1992-1996) they have been relatively low and stable since the end of the Persian Gulf conflict in January, 1991. Thailand's high growth (see Figure 4) and industrialization in the 1980's and early 1990's has been accompanied by the increasing energy demands associated with a transformation from an agrarian country to an NIC, and from a rural existence to a more urban based one.

**Figure 4 The Economic Growth and the Consumption of Petroleum**




*Source:* The National Energy Policy Office.

The 1986 world oil price slump can help to explain the high growth rates seen in Thailand during the late 1980's and the increased petroleum consumption required to fuel it. Increases in petroleum consumption were uninterrupted until the outbreak of the Gulf War and its associated price shock.

**Imports/Exports**

Thailand is not an especially rich country when it comes to petroleum resources and as such is heavily dependent on imports, leaving itself vulnerable to world oil price shocks. Given the geologically fragmented nature of Thai oil and gas fields, which mean extraction is

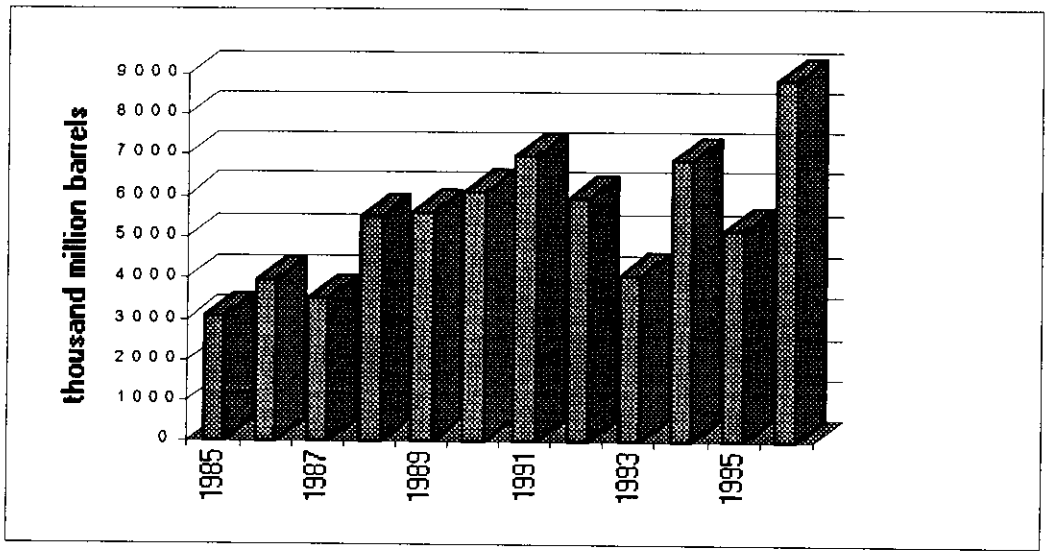
expensive, Thailand's energy needs are inexorably linked to imports, although recent "sliding scale" royalty schedules have helped make these small fields more attractive for investment.

### Crude Oil

Thailand currently *imports* both crude oil and petroleum products. Petroleum products include LPG, gasoline (premium, ULG, regular, ULR), aviation fuel, high and low speed diesel, and fuel oil. Through recent negotiations with Myanmar and Malaysia (JDA), natural gas will be imported starting in 1998. The discovery of natural gas in the Gulf of Thailand in the early 1980's and Thailand's interest in becoming less dependent on imported oil have led to a surge in natural gas development. Thailand *exports* petroleum products, condensate and a small amount of natural gasoline.

As for the volume of condensate exports, in 1996, their exports were valued at 4,320 million baht, increasing nearly double from that of a year earlier. All exports come from two sources, namely Erawan field of the UNOCAL and Bongkot field of the TOTAL. Together these fields combine for exports at a volume of 8,820 million barrels. Figure 5 shows the volumes of condensate exports for the last ten years.

**Figure 5 The Petroleum Exports of Thailand**




*Source:* The National Energy Policy Office.

## Petroleum Products

Thai imports of petroleum products in 1996, valued 32,344 million baht, were down 2 percent from 1995. The high-speed diesel held the largest proportion of imported petroleum products, at approximately 60 percent, and fuel oil came second. Around 80 percent of petroleum products were imported from ASEAN countries (Singapore, Indonesia and Malaysia). An additional 10 percent was imported from the Asia-Pacific Region (Japan, South Korea and China), with 5 percent from the Middle East, and the remainder represented by imports from the United States, Africa and Europe.

In 1996, Thailand exported 3,931 million litres of petroleum. Gasoline, both regular and premium, accounted for 1,237 million litres, followed by 1,065 million litres of high-speed diesel and 365 million litres of LPG.

The major progress with regards to environmental concerns in Thailand's petroleum industry is that the government adopted a policy to ban the use of leaded gasoline during 1996. This policy should make a marked decline the use of lead in petroleum products.

### Crude Oil

The value of imported crude oil was 121,161 million baht in 1996, increasing 70 percent from 1995 due both to increasing imported volume and world price changes. Crude oil imports have increased continually since 1988 to supply the expanding capacity of local refineries. The opening of two new refineries in 1996 means that dependence on imported oil will continue to be strong. However, imports of refined petroleum products may begin to decrease as domestic ones are substituted.

Thailand imported the bulk of its crude oil from the Middle East with 72 percent of the total volume imports coming from that area in 1996. ASEAN countries (Brunei, Indonesia and Malaysia) accounted for 22 percent, followed by 4 percent from the Asia-Pacific region (Australia and Papua New Guinea) and a negligible amount from Africa. The Thai importers resumed importing crude oil from non-OPEC countries, especially Oman, after the political situation in the region had been restored. This has led an increase in share of imported crude oil from the Middle East during the past five years.

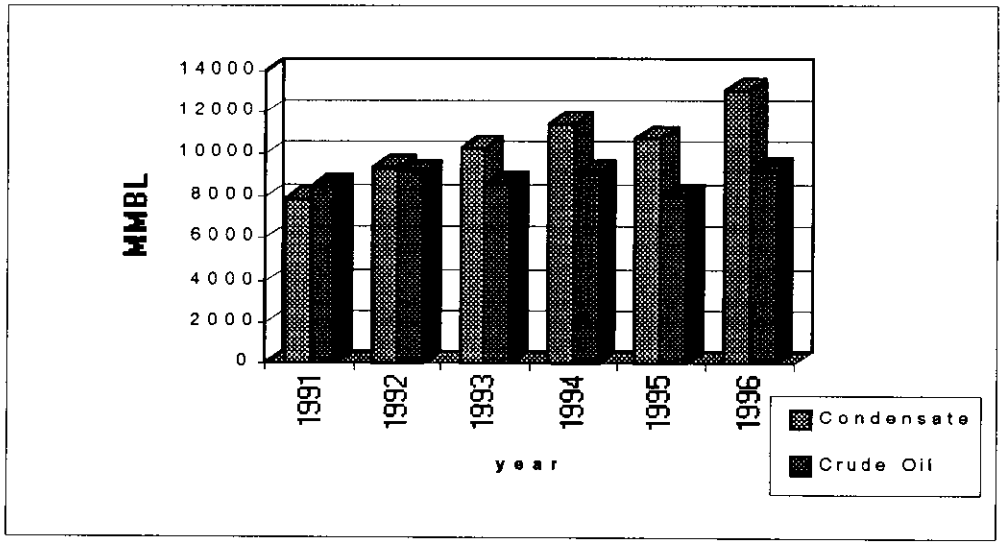
## Domestic Petroleum Production and Reserves

Domestic petroleum sources include crude oil, natural gas and condensates.

### Crude Oil

The domestic production of crude oil in terms of volume was 9.2 MMBL in 1996, increasing 12.2 percent from 8,700 MMBL in 1995. Based on reserve estimates by the DMR as of January 1997, proven reserves of crude oil are 115.3 MMBL, and possible and probable reserves are estimated at 242.42 MMBL. The largest production in 1996 came from Sirikit (onshore) at approximately 6.9 MMBL. The next largest well was Nang Nuan (offshore), which is considerably smaller at 1.7 MMBL.

**Figure 6 The Production of Crude Oil and Condensate in Thailand**




*Source:* Department of Mineral Resource.

### Condensate

The 1996 production volume was derived as follows (all offshore): 31 percent from Erawan; 26 percent from Satun; 11 percent from Funan; and 22 percent from Bongkot.

As of January 1997, proven reserves for condensates were 126 MMBL, where probable and possible reserves were estimated at 208 MMBL, significantly higher than the 1995 estimates, mainly due to the reestimation of reserves at JDA and Tantawan sites.

**Natural Gas**

The bulk of natural gas production, 88 percent in 1995, comes from offshore wells in the Gulf of Thailand. The highest producing area was Erawan, with 26 percent of total production and Bongkot, Erawan, Satun and Funan fields are second, third and fourth respectively. The production from these four major fields accounted for 72 percent of the 1996 total production. The new reserves of natural gas discovered at the JDA and Tantawan gas fields improved the proven reserves as of January 1997 to a total of 6.64 TCF, increasing from 4.6 TCF in January 1996, and probable plus possible reserves were 17.1 TCF, up more than 100% from that of the previous year.

All natural gas is carried by PTT pipelines to EGAT and industries. There were two Gas Separation Plants with a total capacity of 600 MMscfd and one small LPG separation unit, Palang Petch, at Sirikit in 1994. GSP I produced 79.4 BCF of methane, 280.9 KT of ethane, 143.3 KT of propane, 297.2 KT of LPG, 658 KB of NGL and 63.4 KT of $CO_2$, with it's capacity of 350 MMcfd. GSP II, with a capacity of 250 MMcfd produced 81.7 BCF of methane, 64.8 KT of ethane, 302.5 KT of LPG, and 402.8 KB of NGL. Additionally, the TSEPCO (Palang Petch) plant produced 102.2 KT of LPG.

At the end of 1994, there were 1,583 km of transmission pipeline in Thailand, with plans for 920 more to be built over the next four years. Seven of these are natural gas pipelines (4 offshore, 3 onshore) and two are oil product pipelines (both onshore). The gas pipeline network as of July 1997 will be extended from the Saraburi province to the Northeast provinces of Nakorn Ratchasima, Chaiyapum and Udon Thani, where the mega project of Petrochemical Comples will be established. The raw materials for industries in this complex will be supplied by what are possibly the world's largest deposits of potash and rock salt located near by.

As a part of a natural resource accounting project, research has been conducted by TDRI on the effect of depleting natural gas on Thailand's NNP and sustainability. An overview of this study shows in the Box below.

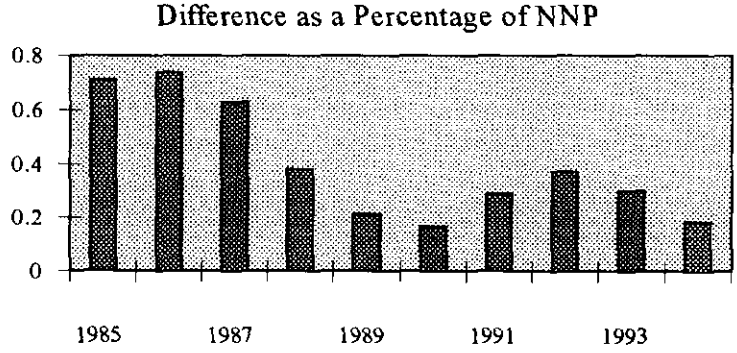
## *Box 2: Natural Resource Accounting: Natural Gas*

Thailand is a country rich in natural resources which have been exploited to help fuel its high growth rates. One such resource is natural gas, whose domestic production began in the early 1980's, spurred on by high world oil prices.

One issue which arises from this resource exploitation is that of national accounting. Currently, the difference between a country's Gross National Product (GNP) and Net National Product (NNP) is the Capital Consumption Allowance (CCA), an allowance made for depreciation of the capital stock. CCA is the investment in new capital needed to replace worn-out capital (e.g. one of last year's photocopiers finally died and needs replacing). In order for NNP to be an accurate measure of a countries welfare, a similar adjustment should be made for depletion of natural resources. However, a resource like natural gas differs from capital in the sense that it cannot be "replaced" or "kept intact" through investment. Therefore, the economy must invest some of the income flow generated by natural gas depletion into maintaining a sustainable level of consumption into the future.

By expanding our traditional definition of CCA to include natural resource consumption, we get a truer measure of an economy's well-being. When the depletion of a finite stock of natural gas in Thailand is included in NNP calculations, the new natural gas adjusted NNP is lower than what Thailand's national accounts currently maintain. That is, the unadjusted version gives an artificially high account and with it, a false sense of security.

The adjustment to NNP over the last ten years (1985-1994) was on average about 5.5 billion baht, or, as a percentage of NNP, generally under 1 percent and usually under 0.5 percent. This lower figure results because of the elimination the "free lunch" associated with using up the exhaustible resource, natural gas. The small magnitude of these numbers does *not* imply that the result can be ignored, but rather reflects the small size of the natural gas industry in Thailand (over the last five years, natural gas accounted for 0.8% of NNP).




By using the resource-adjusted version of NNP, we have started to account for natural resource depletion in the same way the national accounts take into consideration depreciation of capital. In measuring economic performance, trends of economic growth and setting guidelines for public policy, economists rely heavily on the aggregates in natural income accounts, since they provide the relationship between outputs of economic processes and economic inputs supporting these processes. By paying sufficient attention to natural resources, an adjusted NNP figure will better identify true income and provide more relevant economic signals for policy makers to use in judging the economy. Policy makers who may rely on natural resource revenue will become aware of the fact of limited resources and the need to invest more to sustain economic development.

Note however that the adjustment here is only for natural gas. All other natural resources have been excluded, and for a truly "adjusted-for-resource-depletion" NNP figure, all resources should be included. In addition to the study on natural gas, TDRI is undertaking studies on the coal and tree industries of Thailand.

## Refineries

In 1997, there are 5 refineries in Thailand. The largest, Thai Oil, with the capacity 210,000 barrels per day, is 49 percent PTT owned. Other key owners include Shell with 15 percent ownership, and Education & Public Welfare Foundation with 10 percent. The smallest refinery is Fang which is owned by the Defence Energy Department with a capacity of 1,000 barrels per day.

**Table 9 The Capacity of Refineries in Thailand**

| *Refineries* | *Capacity (Barrel per day)* |
|---|---|
| 1. Thai Oils Co. Ltd. | 210,000 |
| 2. Rayong Refinery Co. Ltd. | 145,000 |
| 3. Star Petroleum Refining Co. Ltd. | 130,000 |
| 4. ESSO (Thailand) Public Co. Ltd. | 154,000 |
| 5. Bangchak Petroleum Public Co. Ltd. | 120,000 |
| 6. Fang | 1,000 |

*Source:* Department of Mineral Resources.

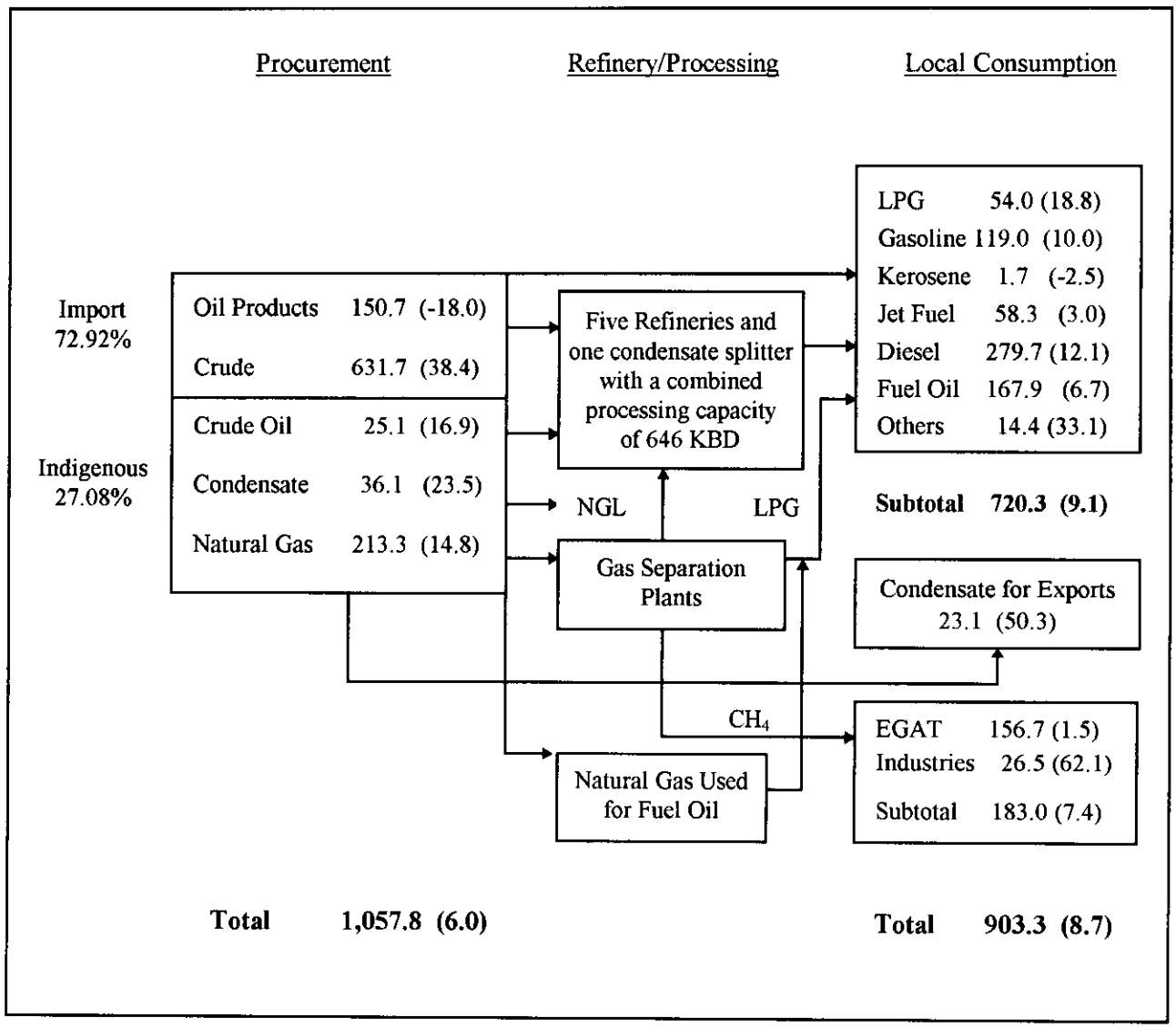
## Production Processes

Figure 7 provides an overview of Thailand's petroleum balance.[1] At the end of 1996, Thailand consumed all types of petroleum at the equivalent of 903.3 thousand barrels of oil. The total procurement was the equivalent of 1,057 thousand barrels of oil of which the indigenous petroleum accounted for 25 percent and the remaining 75 percent was comprised of imported petroleum including 60 percent crude oil.

[1] *Source:* PTIT Focus Statistics, 1996.

**Figure 7 An Overview of Thailand's Petroleum Balance**[2]

December 1996
Unit: 1,000 BPD Equivalent (KBDE)
Number in bracket indicates % change from 1995




[2] *Source:* Department of Mineral Resources, 1997.

## Consumption

### Petroleum Product Consumption

During the past decade, the Transportation sector was the largest consumer of petroleum products in Thailand and is also expected to remain a major petroleum product consumer through the year 2000. Interestingly, Thailand is the only country in this region where transportation is the highest consumer of energy - Korea, India, Indonesia and China all have the industrial sector as the highest. In the 1980's, the growth of gasoline consumption was much higher than the growth in the number of passenger cars. This reflects an inefficient use of petroleum in this sector. A shift in consumer preferences from small cars to luxurious ones, and the heavy traffic congestion in Bangkok are responsible for this inefficiency.

Within the manufacturing sector, in 1996 non-metal was the largest sector for energy consumption at more than 25% percent, followed by the food and beverage sector.

As for natural gas, its consumption grew considerably during the period from 1985 to 1996 due to its emergence as a domestically available energy source. The primary sector over this entire period for natural gas consumption is electricity generation. In 1996, this sector accounted for approximately 90 percent of natural gas consumption. Industry (petrochemical, cement, and others) accounted for 8 percent and transportation accounted for the remaining amount.

The Electricity Generating Authority of Thailand which is the state enterprise responsible for the development of supply of electricity in Thailand has been the sole major petroleum consumer for many years. In 1996, the largest shares of fuel used in generating electricity were Lignite, Natural Gas and Fuel oil, respectively. Considering the trend of fuel consumption in this sector, it was found that during the past decade, the use of Diesel oil and Lignite showed the highest growth rate, whereas fuel oil had a declining rate.

## Exploration and Development

Open acreage with potential of petroleum deposits will be divided into exploration blocks for the application of exploration and production rights. International invitations to bid

will be announced and data packages be will be prepared and available for applicants to study prior to the submission of the bids. There bids must be received within a specific time period of approximately 90 days following the announcement.

Individual oil companies or joint ventures which wish to apply for the concessions must submit background information including a corporate profile, as well as evidence of financial strength and petroleum exploration and production capability. Qualified oil companies will be selected, their proposed exploration program for each exploration period (which is the major feature for bid assessment) considered, and any special advantages offered by the companies compared.

The bidders with the exploration program most suitable for the geological condition of the block will be selected as concessionaires. Only those proposed exploration programs restricted to seismic surveys during the first three years of the exploration period will be accepted for the areas too risky for a drilling commitment.

**Contract**

The petroleum contract between the government and private sector will be consist of two distinct components, namely exploration and production. Normally, the exploration contract lasts for three years with the possibility of a three year extension, and production contracts run for 20 years with ten year extensions. The production period will be start immediately at the end of the exploration period. However, if commercial reserves are discovered, the production area will be delineated and production can start right regardless of whether the contract for the exploration period has expired. In this case, 12.5 percent of the original exploration area can be reserved for further exploration for an additional five years at the end of the exploration period.

**Fiscal Terms**

The "Petroleum Act" and "Petroleum Tax Act" of Thailand are responsible for legal and tax implications of petroleum business in the country. Petroleum royalties are levied on the volume of all types of petroleum sold or disposed of during each month. For the purposes of determining the volume of petroleum to be taxed, it is assumed that quantity of heating value of

ten million BTU's of natural gas is equivalent to ten barrels of petroleum. The structure of the petroleum royalty is a sliding scale with the rate corresponding to the revenue from petroleum sold or disposal of as follows.

**Table 10 Petroleum Royalty Schedule in Thailand**

| *The volume of all types of petroleum sold or disposal of during the month* | *% of the value* |
|---|---|
| 0-60 | 5.00 |
| 60-150 | 6.15 |
| 150-300 | 10.00 |
| 300-600 | 12.50 |
| > 600 | 15.00 |

*Source:* Department of Mineral Resources.

Other taxes associated with petroleum business such as the Petroleum Income Tax and the Supplemental Tax are noteworthy. The Petroleum Income Tax is levied on the net profit of the company and there is no provision for cost deduction. Its applicable rate is presently 50 percent. The Supplemental Tax, called Special Remuneratory Benefit (SRB), is an extra tax taken from windfall profit and is used only if:

- all capital costs (plus special a reduction) are recovered, and
- annual revenues become drastically high compared to the investment (i.e. unusual high oil prices)

Both the petroleum royalty and SRB paid can be treated as tax deductible expenses for the firm.

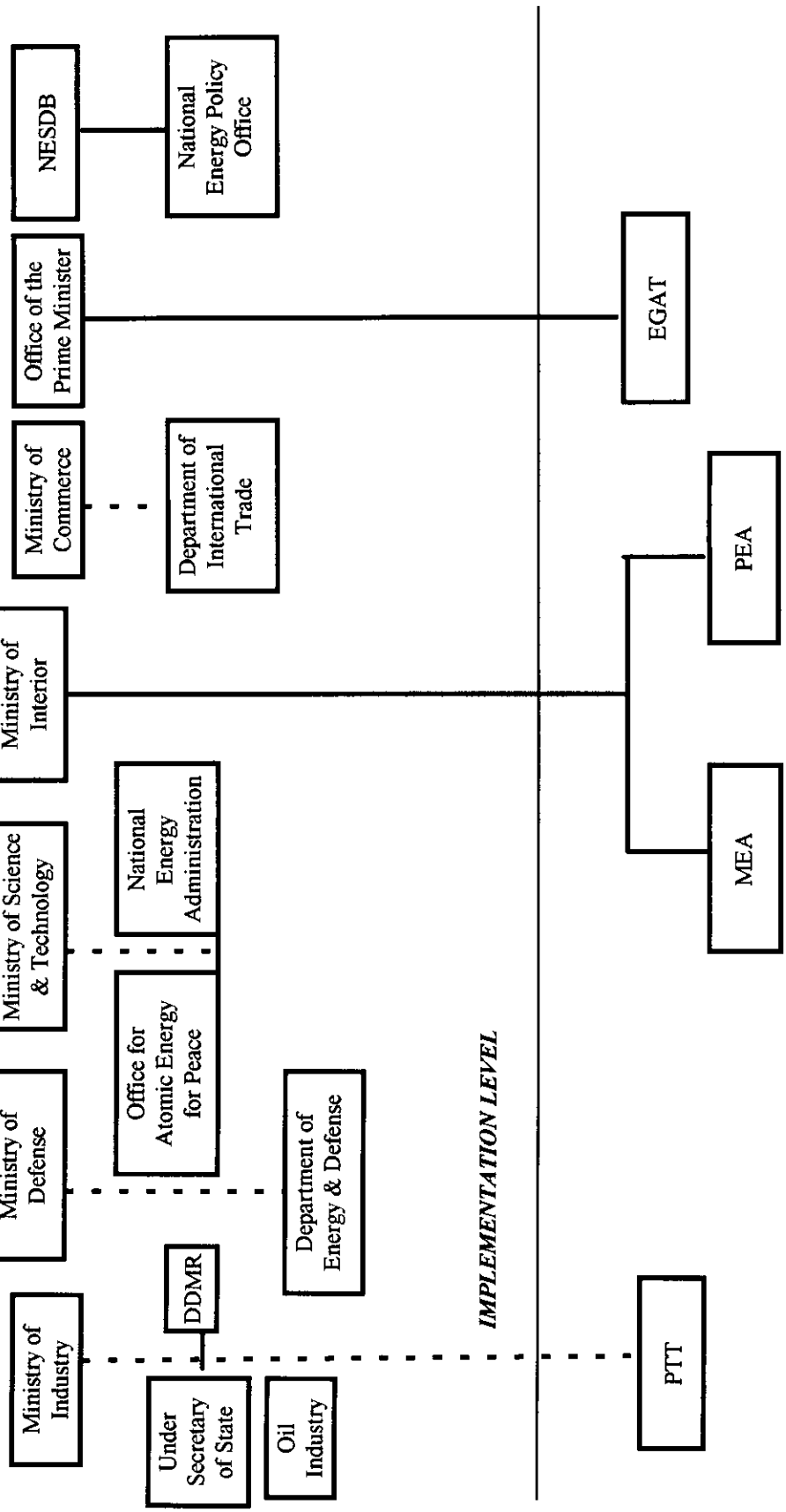
Total royalty payments in 1994 were 2,332.88 million baht from the production of natural gas, 586.32 million baht from condensate, and 480.77 million baht from crude oil. Cumulative royalty payments at the end of 1994 were 16.93 billion baht for natural gas, 5.06 billion baht for condensate and 5.20 billion baht for crude oil.

An overview of the key agencies of the energy industry and their functions appears in Table 11, whereas the Governmental structure appears in Figure 8 below.

**Table 11 Key Agencies and Their Functions in Petroleum Industry in Thailand**

| Organization | Role |
|---|---|
| Petroleum Authority of Thailand (PTT) | Empowered to handle all industrial and commercial aspects of the petroleum business |
| National Economic and Social Development Board (NESDB) | The government's main economic planning agency - develops five year plans |
| Department of Mineral Resources(DMR) | Responsible for the surveying of energy resources, and issuing licenses for exploration and development |
| Electricity Generating Authority of Thailand (EGAT), Metropolitan Electricity Authority (MEA) and Provincial Electricity Authority (PEA) | The three government state enterprises responsible for the generation and distribution of electricity |
| National Energy Policy Committee (NEPC) | Committee chaired by the Prime Minister acting as the supreme policy-making body for energy matters |
| Ministry of Industry (MOI) | In the Petroleum Industry Division, deals with future production plans, expansion, investment, distribution and the acquisition of domestic refineries and handles contracts signed by private refineries and the Ministry. |
| National Energy Administration (NEA) | Involved in the research and development of various energy forms with the main objective of improving energy utilization efficiency. |
| Ministry of Finance | Authorized to issue laws and regulations concerning rates, method of calculation and administration of taxes on petroleum products domestically produced or imported. |
| Ministry of Defence | Petroleum related issues that concern national security. |
| Ministry of Interior | Under the Oil Storage Act (1931), is empowered to issue licenses for oil storage and the sale of petroleum products and to examine oil storage areas for safety. |
| Ministry of Commerce | Has the authority under the Fuel Oil Act to control and ensure that a firm engaged in retail oil business in complying to the Act. |
| National Energy Policy Office (NEPO) | Established by the NEPC and acts as the energy policy planning coordinator |

**Figure 8 The Government Structure in Petroleum Management**



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# *Appendices*

## APPENDIX I Demand and Supply for natural Gas, 1995-2011

| | Demand for Natural Gas (MMSCFD)[1] | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
| **DEMAND** | | | | | | | | | | | | | | | | | |
| ***FEEDSTOCK*** | **133** | **150** | **175** | **175** | **345** | **345** | **345** | **345** | **345** | **345** | **345** | **345** | **345** | **345** | **345** | **345** | **345** |
| GSP1 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 105 | 105 |
| GSP2 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| GSP3 | 0 | 10 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| GSP4 | 3 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| NPC3 | 0 | 0 | 0 | 0 | 170 | 170 | 170 | 170 | 170 | 170 | 170 | 170 | 170 | 170 | 170 | 170 | 170 |
| ***INDUSTRY*** | **63** | **113** | **136** | **142** | **151** | **154** | **167** | **197** | **237** | **287** | **292** | **292** | **292** | **292** | **292** | **292** | **292** |
| ***Cogen/SPP*** | **37** | **143** | **211** | **211** | **211** | **211** | **211** | **211** | **211** | **211** | **211** | **211** | **211** | **211** | **211** | **211** | **211** |
| NPC | 17 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Thai Cogen | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| COCO | 13 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 | 66 |
| Bangpakong | 0 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Ind. Power | 0 | 0 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Thai Oil | 0 | 10 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 |
| Thai Melon | 0 | 0 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Alfatech | 0 | 0 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Fertilizer | 0 | 0 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| ***EGCO*** | **187** | **283** | **283** | **283** | **283** | **279** | **279** | **279** | **279** | **279** | **272** | **272** | **272** | **272** | **272** | **261** | **261** |
| ***IPP*** | **0** | **0** | **0** | **41** | **75** | **135** | **179** | **197** | **199** | **167** | **170** | **167** | **185** | **193** | **192** | **200** | **200** |
| ***EGAT*** | **673** | **673** | **501** | **516** | **787** | **1227** | **1387** | **1427** | **1429** | **1382** | **1457** | **1450** | **1452** | **1413** | **1259** | **1149** | **1031** |
| **TOTAL** | **1093** | **1190** | **1321** | **1639** | **2292** | **2511** | **2608** | **2658** | **2653** | **2746** | **2740** | **2739** | **2733** | **2726** | **2571** | **2458** | **2340** |

[1] *Source:* EGAT's PDP (1995-2011).

(Continued)

| Supply of Natural Gas (MMSCFD)[2] | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
| **SUPPLY** | | | | | | | | | | | | | | | | | |
| *OFFSHORE* | | | | | | | | | | | | | | | | | |
| Unocal #1-3 | 740 | 742 | 873 | 902 | 740 | 740 | 740 | 740 | 740 | 740 | 740 | 740 | 740 | 740 | 740 | 732 | 719 |
| Bongkot | 250 | 350 | 350 | 425 | 650 | 650 | 650 | 650 | 650 | 650 | 650 | 650 | 650 | 650 | 500 | 400 | 300 |
| Maersk | | | | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Unocal #4 | | | | | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| **Sub-Total** | **990** | **1092** | **1223** | **1427** | **1690** | **1690** | **1690** | **1690** | **1690** | **1690** | **1690** | **1690** | **1690** | **1690** | **1690** | **1690** | **1690** |
| *ONSHORE* | | | | | | | | | | | | | | | | | |
| Nampong | 65 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 55 | 51 | 48 | 45 | 41 | 38 | 35 | 32 |
| Sirikit | 38 | 38 | 38 | 37 | 34 | 36 | 33 | 33 | 28 | 26 | 24 | 26 | 23 | 20 | 18 | 16 | 14 |
| **Sub-Total** | **103** | **98** | **98** | **97** | **94** | **96** | **93** | **93** | **88** | **81** | **75** | **74** | **68** | **61** | **56** | **51** | **46** |
| **Domestic Total** | **1093** | **1190** | **1321** | **1524** | **1784** | **1876** | **1873** | **1873** | **1778** | **1771** | **1765** | **1764** | **1758** | **1751** | **1596** | **1483** | **1365** |
| *IMPORT* | | | | | | | | | | | | | | | | | |
| Yanada | | | | 115 | 408 | 525 | 525 | 525 | 525 | 525 | 525 | 525 | 525 | 525 | 525 | 525 | 525 |
| Yetagun | | | | | 100 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| JDA | | | | | | | 100 | 150 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 |
| | | | | | | | | | | | | | | | | | |
| **TOTAL SUPPLY** | **1093** | **1190** | **1321** | **1639** | **2292** | **2511** | **2608** | **2658** | **2653** | **2746** | **2740** | **2739** | **2733** | **2726** | **2571** | **2458** | **2340** |

[2] *Source:* EGAT's PDP (1995-2011).

## APPENDIX II Consumption of Total Petroleum Products by Economic Sector: 1985-1994

*(unit: million litres)*

| | 1985 | % | 1986 | % | 1987 | % | 1988 | % | 1989 | % | 1990 | % | 1991 | % | 1992 | % | 1993 | % | 1994 | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture | 1576.4 | **12.69** | 1634.2 | **12.44** | 1675.2 | **11.74** | 1769.4 | **10.84** | 1904.9 | **9.81** | 2093.2 | **9.09** | 2120.9 | **8.65** | 2198.6 | **8.18** | 1872.9 | **6.20** | 1826.8 | **5.44** |
| Mining | 84.6 | **0.68** | 57.5 | **0.44** | 56.3 | **0.39** | 55.4 | **0.34** | 63.5 | **0.33** | 64.6 | **0.28** | 60.5 | **0.25** | 48.4 | **0.18** | 48.7 | **0.16** | 41.7 | **0.12** |
| Manufacturing | 1583.9 | **12.75** | 1611.9 | **12.27** | 1771.9 | **12.42** | 1966.4 | **12.04** | 2344.6 | **12.07** | 2779.8 | **12.07** | 2966.7 | **12.10** | 3596.3 | **13.38** | 3997.1 | **13.24** | 4313.5 | **12.85** |
| Electricity | 911.6 | **7.34** | 880.6 | **6.71** | 585.9 | **4.11** | 838.4 | **5.14** | 1245.5 | **6.41** | 2697.3 | **11.71** | 3228.4 | **13.16** | 3793.3 | **14.11** | 4613.6 | **15.28** | 5267.6 | **15.70** |
| Construction | 142.9 | **1.15** | 140.9 | **1.07** | 127.6 | **0.89** | 112.1 | **0.69** | 125.2 | **0.64** | 168 | **0.73** | 221.6 | **0.90** | 253.2 | **0.94** | 206.4 | **0.68** | 386.4 | **1.15** |
| Residential & Commercial | 705 | **5.67** | 842.2 | **6.41** | 964.3 | **6.76** | 1196.6 | **7.33** | 1386.4 | **7.14** | 1429.3 | **6.20** | 1431 | **5.83** | 1566 | **5.83** | 1730.1 | **5.73** | 1865.8 | **5.56** |
| Transportation | 7419.9 | **59.72** | 7965.4 | **60.65** | 9090.5 | **63.70** | 0387.2 | **63.63** | 2357.6 | **63.62** | 3807.6 | **59.93** | 4496.6 | **59.11** | 5423.9 | **57.38** | 17731 | **58.71** | 9855.5 | **59.17** |
| Total | 2424.3 | **100.00** | 3132.7 | **100.00** | 4271.7 | **100.00** | 6325.5 | **100.00** | 9424.7 | **100.00** | 3039.8 | **100.00** | 4525.7 | **100.00** | 6879.7 | **100.00** | 0199.8 | **100.00** | 3557.3 | **100.00** |

## APPENDIX III (a)[3]

| | Ex-ref (avg) | Tax* | Oil Fund | Con sv. Fund | Whole-sale | VAT | WS & VAT | Mkting margin | VAT | Retail Price |
|---|---|---|---|---|---|---|---|---|---|---|
| **UGP 97R;UNL** | 3.9071 | 2.5850 | 0.1300 | 0.0700 | 6.6921 | 0.4684 | 7.1605 | 1.5415 | 0.1079 | 8.81 |
| **ULG 98R;UNL** | 3.9222 | 2.5850 | 0.1300 | 0.0700 | 6.7072 | 0.4695 | 7.1767 | 1.4330 | 0.1003 | 8.71 |
| **ULH 97R;UNL** | 3.8690 | 2.5850 | 0.1300 | 0.0700 | 6.6540 | 0.4658 | 7.1198 | 1.4862 | 0.1040 | 8.71 |
| **ULG 92R:UNL** | 3.3576 | 2.5850 | 0.1300 | 0.0700 | 6.1426 | 0.4300 | 6.5726 | 1.5116 | 0.1058 | 8.19 |
| **Kerosene** | 4.8591 | 3.3000 | 0.0300 | 0.0700 | 8.2591 | 0.5781 | 8.8372 | 1.0400 | 0.0728 | 9.95 |
| **H-Diesel (0.25%S)** | 4.7613 | 2.2000 | 0.1700 | 0.0700 | 7.2013 | 0.5041 | 7.7054 | 0.7707 | 0.0539 | 8.53 |
| **L-Diesel** | 4.5118 | 2.3100 | 0.1300 | 0.0700 | 7.0218 | 0.4915 | 7.5133 | 0.6978 | 0.0488 | 8.26 |
| **Fuel 600 2%S** | 3.0527 | 0.7165 | 0.0300 | 0.0700 | 3.8692 | 0.2708 | 4.1400 | 0.8130 | 0.0569 | 5.01 |
| **Fuel 1500** | 2.6106 | 0.6819 | 0.0300 | 0.0700 | 3.3925 | 0.2375 | 3.6300 | 0.9159 | 0.0641 | 4.61 |
| **Fuel 1500 2%S** | 2.8442 | 0.6819 | 0.0300 | 0.0700 | 3.6261 | 0.2538 | 3.8799 | 0.8505 | 0.0595 | 4.79 |
| **Fue2000** | 2.5539 | 0.6545 | 0.0300 | 0.0700 | 3.3084 | 0.2316 | 3.5400 | - | - | - |
| **Fuel 2500** | 2.4988 | 0.6441 | 0.0300 | 0.0700 | 3.2429 | 0.2270 | 3.4699 | 1.1309 | 0.0792 | 4.68 |
| **Fuel** | 2.5006 | 0.6330 | 0.0300 | 0.0700 | 3.2336 | 0.2264 | 3.4600 | - | - | - |
| **LPG-large (B/KG)** | 6.0313 | 2.3870 | -0.7282 | - | 7.6901 | 0.5383 | 8.2284 | 2.3566 | 0.1650 | 10.75 |
| **LPG-small (B/KG)** | 6.0313 | 2.3870 | -0.7282 | - | 7.6901 | 0.5383 | 8.2284 | 2.3566 | 0.1650 | 10.75 |
| **LPG-cars (B/KG)** | 6.0313 | 2.3870 | -0.7282 | - | 7.6901 | 0.5383 | 8.2284 | 1.3843 | 0.0969 | 9.71 |

* *Excise tax and Municipal tax.*

## APPENDIX III (b)[3]

| | Ex-ref (avg) | Tax** | Oil Fund | Con sv. Fund | Whole-sale | VAT | WS & VAT | Mkting margin | VAT | Retail Price |
|---|---|---|---|---|---|---|---|---|---|---|
| **UGP 97R;UNL** | 3.5338 | 2.6500 | 0.1300 | 0.0700 | 6.3838 | 0.4469 | 6.8307 | 1.8498 | 0.1295 | 8.81 |
| **ULG 98R;UNL** | 3.7940 | 2.6500 | 0.1300 | 0.0700 | 6.6440 | 0.4651 | 7.1091 | 1.4962 | 0.1047 | 8.71 |
| **ULH 97R;UNL** | 3.5338 | 2.6500 | 0.1300 | 0.0700 | 6.3838 | 0.4469 | 6.8307 | 1.7564 | 0.1229 | 8.71 |
| **ULG 92R:UNL** | 3.3395 | 2.6500 | 0.1300 | 0.0700 | 6.1895 | 0.4333 | 6.6228 | 1.4647 | 0.1025 | 8.19 |
| **Kerosene** | 4.7326 | 3.3650 | 0.0300 | 0.0700 | 8.1976 | 0.5738 | 8.7714 | 1.1015 | 0.0771 | 9.95 |
| **H-Diesel (0.25%S)** | 4.8295 | 2.2650 | 0.1700 | 0.0700 | 7.3345 | 0.5134 | 7.8479 | 0.6375 | 0.0446 | 8.53 |
| **L-Diesel** | 4.4706 | 2.3750 | 0.1300 | 0.0700 | 7.0456 | 0.4932 | 7.5388 | 0.6740 | 0.0472 | 8.26 |
| **Fuel 600** | 3.0122 | 0.7265 | 0.0300 | 0.0700 | 3.8387 | 0.2687 | 4.1074 | - | - | - |
| **Fuel 600 2%S** | 3.0732 | 0.7265 | 0.0300 | 0.0700 | 3.8997 | 0.2730 | 4.1727 | 0.7825 | 0.0548 | 5.01 |
| **Fuel 1500** | 2.7944 | 0.6919 | 0.0300 | 0.0700 | 3.5863 | 0.2510 | 3.8373 | 0.7221 | 0.0505 | 4.61 |
| **Fuel 1500 2%S** | 2.8626 | 0.6919 | 0.0300 | 0.0700 | 3.6545 | 0.2558 | 3.9103 | 0.8221 | 0.0575 | 4.79 |
| **Fue2000** | 2.7386 | 0.0664 | 0.0300 | 0.0700 | 3.5031 | 0.2452 | 3.7483 | - | - | - |
| **Fuel 2500** | 2.6814 | 0.6541 | 0.0300 | 0.0700 | 3.4355 | 0.2405 | 3.6760 | 0.9383 | 0.0657 | 4.68 |
| **Fuel** | 2.6814 | 0.6430 | 0.0300 | 0.0700 | 3.4244 | 0.2397 | 3.6641 | - | - | - |
| **LPG-large (B/KG)** | 6.0313 | 2.3380 | -0.7292 | - | 7.6901 | 0.5383 | 8.2284 | 2.3566 | 0.1650 | 10.75 |
| **LPG-small (B/KG)** | 6.0313 | 2.3380 | -0.7292 | - | 7.6901 | 0.5383 | 8.2284 | 2.3566 | 0.1650 | 10.75 |
| **LPG-cars (B/KG)** | 6.0313 | 2.3380 | -0.7292 | - | 7.6901 | 0.5383 | 8.2284 | 1.3848 | 0.0969 | 9.71 |

** *Excise tax and Municipal tax + Import duty.*

[3] NEPO 2539 Annual Report in Thai, Table 15.

## APPENDIX IV

| TYPE | March, 1996 |
|---|---|
| **CONDENSATE** | |
| Sales Price (baht/bbl) | |
| Local Avg | 433.17 |
| Export | 444.30 |
| Value (million baht) | 256.22 |
| **CRUDE OIL** | |
| Sales Price (baht/bbl) | |
| Sirikit | 432.12 |
| Nang Nuan | 446.44 |
| Kamphaeng Saen & U Thong | 434.70 |
| Bung Ya & Bung Muan | 438.98 |
| Wichian Buri | 354.03 |
| Value (million baht) | 335.90 |
| **NATURAL GAS** | |
| Sales Price (baht/mmbtu) | |
| Bongkot | 60.23 |
| Erawan | 43.76 |
| Baanpot | 52.52 |
| South Satun | 52.52 |
| Satun | 53.90 |
| Platong + Kaphong | 53.90 |
| Funan | 53.90 |
| Jakrawan | 53.90 |
| Surat | 53.90 |
| Gowin | 53.90 |
| Sirikit | 36.70 |
| Nam Phong | 53.23 |
| Value (million baht) | 1753.47 |

*Source:* DMR.