9. THAILAND

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9.1. Introduction

In 1995, the United Nations Work Programme on Indicators of Sustainable Development (WPISD) developed a core set of indicators covering the various dimensions of sustainable development: environmental, social, economic and institutional. Several major studies on energy- and environment-related indicators complemented these efforts, including those of the Organisation for Economic Co-operation and Development (OECD), EUROSTAT, European Commission (EC), European Environment Agency (EEA), International Energy Agency (IEA), and the Division of Sustainable Development/United Nations Department of Economic and Social Affairs (UNDESA). The common objective of all these activities is to measure and monitor important changes and significant progress towards the achievement of sustainable development. None of them, however, focused on indicators for sustainable energy development (ISED). Thus, the International Atomic Energy Agency (IAEA) in cooperation with other international organizations developed a comprehensive set of indicators specifically addressing the energy sector with the following general objectives: (1) to supplement the general indicators of sustainable development (ISD) developed under the WPISD; and (2) to allow the use of ISED for making necessary modifications to the relevant databases and analytical tools and structuring assistance to member states in the formulation of their energy strategies in conformity with the objectives of sustainable development.[1]

The present study aims to apply the "Indicators for Sustainable Energy Development" (ISED) framework initiated by IAEA to Thailand. It assesses the sustainable energy development performance of Thailand focusing on energy conservation and efficiency policy. The main reasons for focusing on energy efficiency issues are the following:

- Thailand has been a good example in terms of energy conservation efficiency policy implementation.
- The policy was introduced in the early 1990s so programs are already in full-scale implementation, and the ISED concept can be applied to assess the effectiveness of the policy.
- Energy data are well established at the aggregate and sectoral level.
- It is expected that the analytical framework developed in this study can be applied to other countries.

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[1] IAEA, jointly with other international organizations, published in 2005 the methodology and guidelines for these indicators.

9.2. Overview of Thailand Energy Sector

9.2.1. Introduction

Thailand is located in Southeast Asia and has a land area of approximately 513,115 sq. km. The country is divided into six regions, with the northern and northeastern regions being the largest. Real GDP in 2000 was Baht 2,985 billion (constant 1988 prices). The population was about 62.4 million in 2000. Per capita GDP in 2000 reached Baht 78,783 (US$1,964). Energy consumption per capita in 2000 was 0.78 toe per person while electricity consumption per capita was 1,386.97 kWh per person (Table 9.1).

9.2.2. Overall energy balance

The overall structure of Thailand's energy supply and demand is summarized in the energy balance shown in Table 9.2. As shown, Thailand produces a lot of coal and petroleum but also imports significant quantities of these fossil fuels to meet domestic energy demand. Thus, for example, imported oil accounted for 60% of the total primary energy supply of petroleum in 2000.

TABLE 9.1: THAILAND BASIC ECONOMIC AND ENERGY INDICATORS

	1980	1985	1990	1995	2000
GDP (million Baht 1988 prices)	913,733	1,191,255	1,945,372	2,946,252	2,984,961
Population (millions)	46.72	51.68	55.84	59.40	62.39
GDP per capita (Baht)	19,558	23,051	34,838	49,599	47,841
Energy use per capita (toe/person)	0.32	0.36	0.55	0.77	0.78
Electricity use per capita (kWh/person)	279.18	384.26	682.28	1,173.70	1,386.97

Source: ADB, 2001; DEDP, Electric Power in Thailand 2000.

TABLE 9.2: THAILAND ENERGY BALANCE 2000, KTOE

Commodities Transaction	Coal	Petroleum	Petroleum products	Electricity	Renewable energy	Grand Total
Domestic Production	5,148	22,797		1,335	14,392	43,672
Imports	2,631	35,665	1,167	253	14	39,730
Exports		-509	-4,874	-17	-1	-5,401
Stock change/statistical difference	13	687	-613			87
TOTAL PRIMARY ENERGY SUPPLY	**7,792**	**58,640**	**-4,320**	**1,571**	**14,405**	**78,088**
Oil refining		-37,817	31,896			-5,921
NG processing plant		226	1,665			1,891
Power plant	-4,165	-14,015	-2,322	6,843	-385	-14,044
Hydro				-820		-820
Steam	-3,659	-2,270	-2,283	3,239		-4,973
Gas turbine		-392		98		-294
Combined cycle		-9,653	-15	3,462		-6,206
Diesel			-4	1		-3
Cogeneration	-506	-1,700	-20	865	-385	-1,746
Others				-2		-2
Other conversion			132		-4,888	-4,756
TOTAL TRANSFORMATION	**-4,165**	**-51,606**	**31,371**	**6,843**	**-5,273**	**-22,830**
Own uses		-3,883		-275		-4,158
Losses		-146		-647		-793
TOTAL FINAL ENERGY CONSUMPTION	**3,627**	**3,005**	**27,050**	**7,492**	**9,132**	**50,306**

Final non-energy uses		1,629	338			1,967
Final energy consumption	3,627	1,376	26,712	7,492	9,132	48,339
Agriculture			2,148	13		2,161
Mining			11	74		85
Manufacturing	3,627	1,374	4,136	3,346	4,258	16,741
Construction			149			149
Residential and commercial			1,621	4,056	4,874	10,551
Transportation - total		2	18,647	3		18,652
Road		2	14,873			14,875
Rail			95	3		98
Air			2,856			2,856
Waterway			823			823

Source: DEDP, Thailand Energy Situation, 2000.
Note: Others include geothermal, solar cell, and wind turbine.

Oil and coal accounted for 85% of total primary energy supply in 2000. The balance is accounted for by renewable hydroelectricity and biomass fuels.

On the demand side, petroleum products accounted for more than half of total final energy demand. The dominance of petroleum products is explained by the dominance of the transportation sector, representing 38% of total final energy demand in 2000. But final energy demand in the manufacturing and residential and commercial sectors followed very closely at 35% and 22%, respectively, of total final energy demand.

9.2.3. Indigenous energy production

Thailand is endowed with rich and diverse fossil and conventional energy resources (see

Table 9.3). Yet, traditional biomass resources dominated indigenous energy production and until 1998 accounted for the bulk of indigenous energy production. Since then, natural gas production, which was increasing at 25% per year between 1981 and 2000, has assumed this dominance and accounted for 40% of indigenous energy production in 2000 (See Figure 9.1 and Figure 9.2). Oil production was also growing by 25% per year during the same period, but accounted for 12% of indigenous energy production in 2000. The production of coal (or lignite) was also increasing by more than 18% per year until 1997, but began to decline through 2000, also contributing 12% like oil. Thailand also has huge hydropower potential. However, strong opposition against new large hydropower plants has slowed hydropower production to an average of less than 4% and its contribution to indigenous energy production reduced to 3% from a peak of 6%.

TABLE 9.3: THAILAND ENERGY RESERVES (AS OF DECEMBER 2000)

Energy resource	Proven reserves	Probable reserves	Possible reserves	Total
Lignite (million tons, Mt)				
Mae Moh province	1,227			1,227
Kra Bi province	112			112
Li province	1			1
Others	817			817
Hydro potential (MW)				
Indigenous				15,606
International*				11,328
Natural gas (billion cubic feet, BCF)				
Offshore	12,101	9,321	10,722	32,144
Onshore	604	278	679	1,561
Condensate (million barrels, Mbbl)				

Offshore	266	228	230	724
Oil shale (Mt)				
Tak province				18,600
Crude oil (Mbbl)				
Offshore	159	175	203	537
Onshore	90	38	31	159

*Potential power purchased from hydroelectricity produced in the Mekong and Salween Rivers.
Source: DEDP, Thailand Energy Situation 2000.

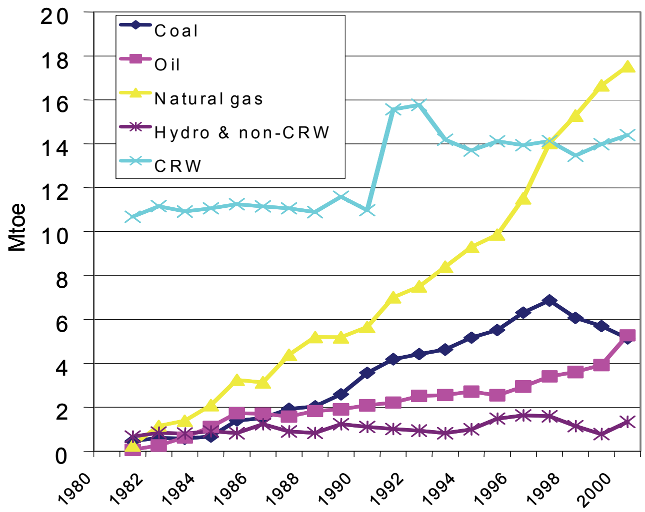

Figure 9.1: Indigenous Energy Production

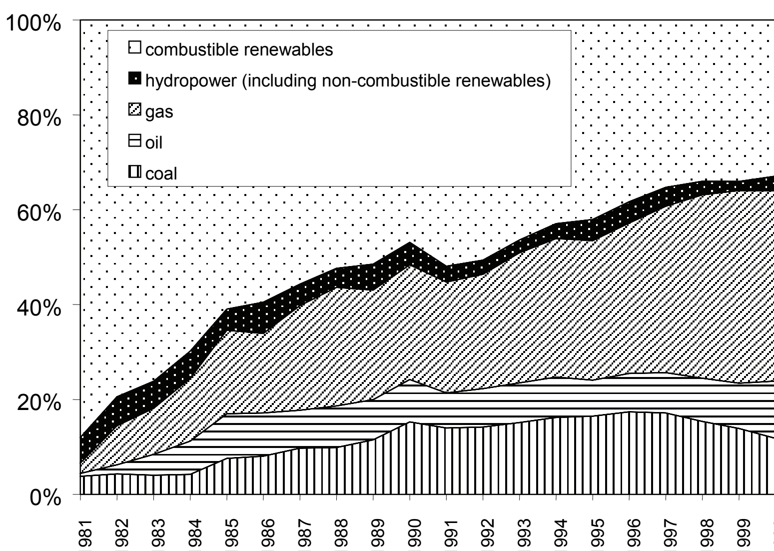

Figure 9.2: Indigenous Energy Mix

9.2.4. Energy import dependency and primary energy supply mix

Even with increasing domestic energy production, energy imports continue to be very significant. As shown in Figure 9.3, energy imports accounted for half of domestic energy supply in the late 1990s through 2000. Most of this, 85%, is oil. More than 70% of Thailand's oil imports come from the Middle East, mainly the United Arab Emirates (UAE), Oman, and Saudi Arabia (

Table 9.4). Its ASEAN neighbours, mainly Brunei and Malaysia, also supply oil to Thailand. In 2000, ASEAN contributed 22%, which was as large as that of UAE, to Thailand's oil imports.

Overall, oil (and condensate) accounted for half of the total primary energy supply mix in 2000, up from 35% in 1981(Figure 9.4). Meanwhile, the contribution of domestically produced natural gas continued to increase, from only 1% in 1981 to 25% in 2000.

Thailand also imports coal, which in 2000 accounted for one-third of coal's contribution in the primary energy supply mix.

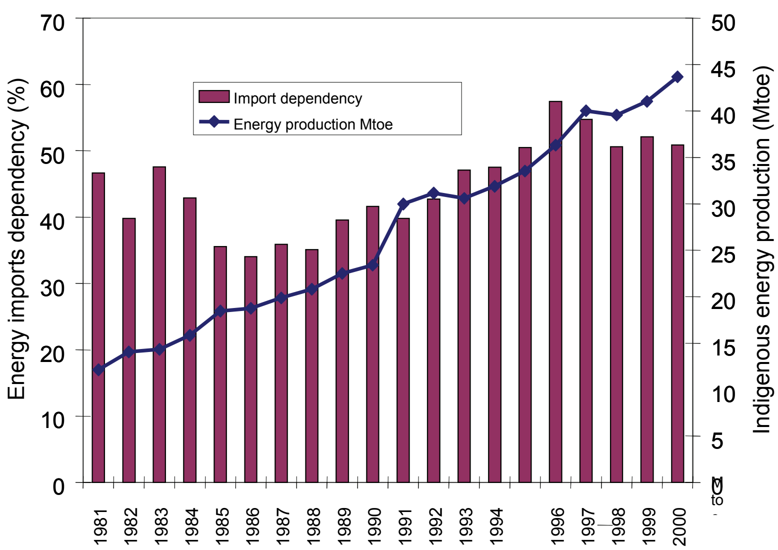

Figure 9.1: Energy Import Dependency vs. Total Energy Production

TABLE 9.4: CRUDE OIL IMPORTS, 2000 (MILLION LITERS)

Origin	Total
ASEAN	8,620
Asia-Pacific	1,235
Middle East	28,784
Africa	310
Europe	293
Total	39,242

Source: DEDP, Oil and Thailand 2000.

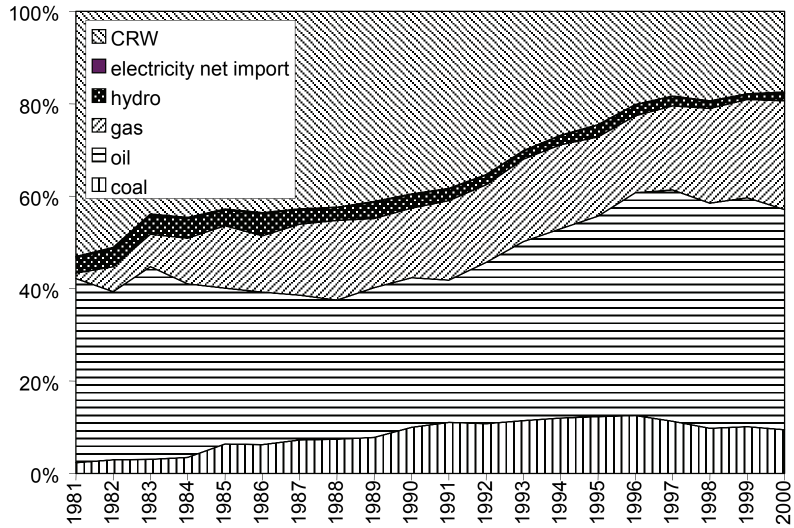

Figure 9.2: Primary Energy Supply Mix

9.2.5. Power generation mix

Natural gas, coal, and oil are the main fuels for power generation. Power generation from natural gas was increasing by 21% per year between 1981 and 2000 (Figure 9.5), when its share also increased from just 10% to 63% (Figure 9.6). The share of natural gas in total power generation actually decreased in the early 1990s when domestic production, although increasing, could not meet very high growth in electricity demand. Power generation from coal, which has been providing base load generation, was also increasing by 13%, but its share in the total generation mix remained at around 20% between 1985 and 2000. Oil remains an important fuel for power generation even with the close competition between natural gas and coal. Figure 9.6 also shows that oil began to be substituted by domestically produced natural gas from the early to late 1980s, but increased its contribution again in the early 1990s to meet high growth in electricity demand. With natural gas production recovering in the late 1990s, oil's contribution to total power generation dropped to less than 12% in 2000. In fact, actual energy generation from oil decreased from 1996, most likely due to the retirement of oil thermal plants during this period. Hydropower generation grew by 3.7% during this period but its share decreased from a high of 23% in 1982 to just 7% in 2000.

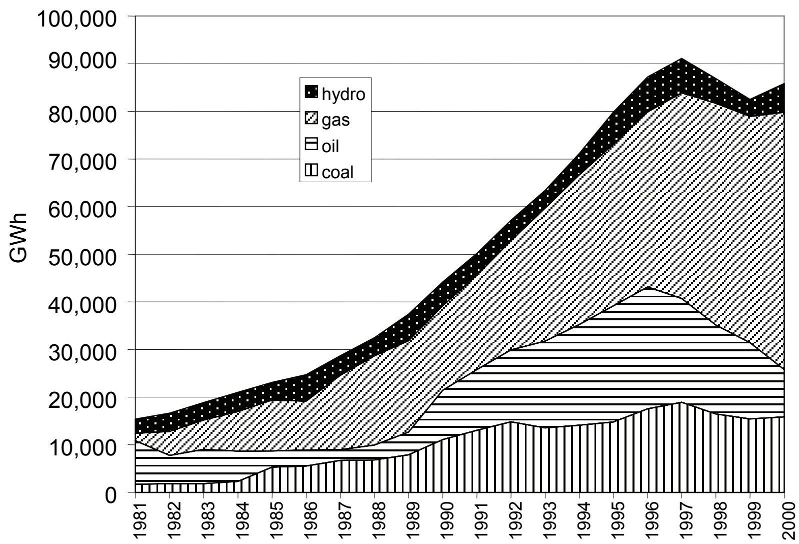

Figure 9.3: Growth in Power Generation

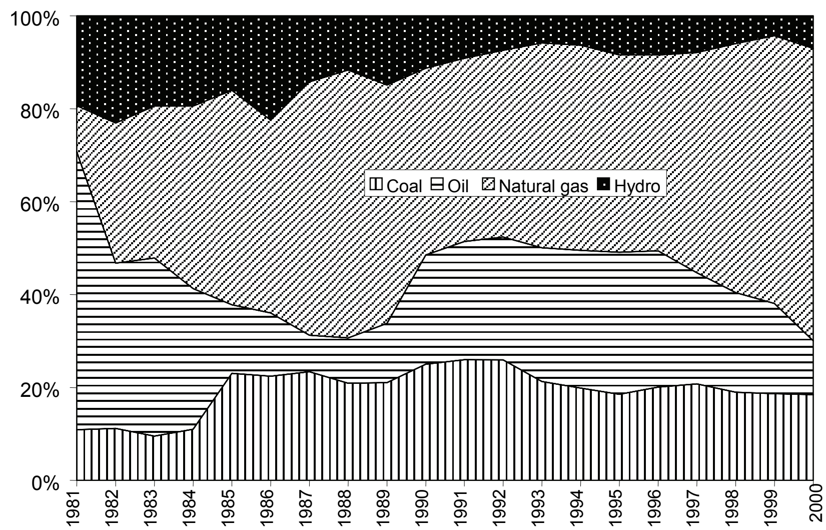

Figure 9.4: Power Generation Mix

9.2.6. Final energy demand

Petroleum dominates the final energy demand mix and dictates the growth of total final energy demand. It accounted for more than half of total final energy demand in 2000 and was increasing at 6.6% per year between 1981 and 2000 (Figure 9.7 and Figure 9.8). The reason for petroleum's dominance is the large and fast increasing energy demand from transport and manufacturing sectors, as well as the large and growing demand from the residential and commercial sectors (Figure 9.9). The transport and manufacturing sectors each grew by more than 7% during this period and each accounted for more than 30% of total final energy demand in 2000. Meanwhile, the residential and commercial sectors grew by slightly more than 3% but accounted for 22% of total final energy demand in 2000.

Electricity and coal also exhibited significant growth of 10% and 20%, respectively, during the period. The only difference is that the demand for coal tapered off during the financial crisis. Coal is used in industries, and the decrease in energy demand from industries during the crisis reduced as well the demand for coal. The demand for electricity, used in all sectors but to a relatively greater extent in the residential and commercial sector, was just slowed down by the crisis. Natural gas demand also recorded strong growth of 25% during this nearly 20-year period, when its use in the manufacturing sector expanded.

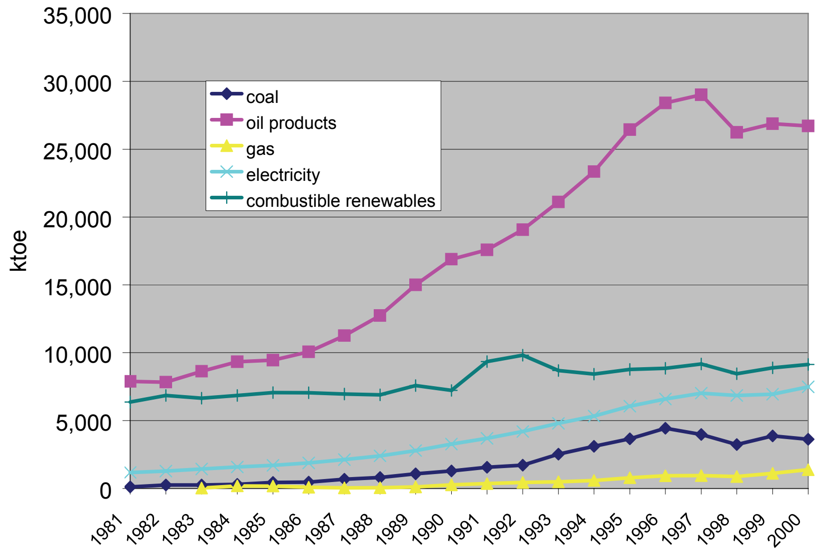

Figure 9.5: Final Energy Demand by Fuel

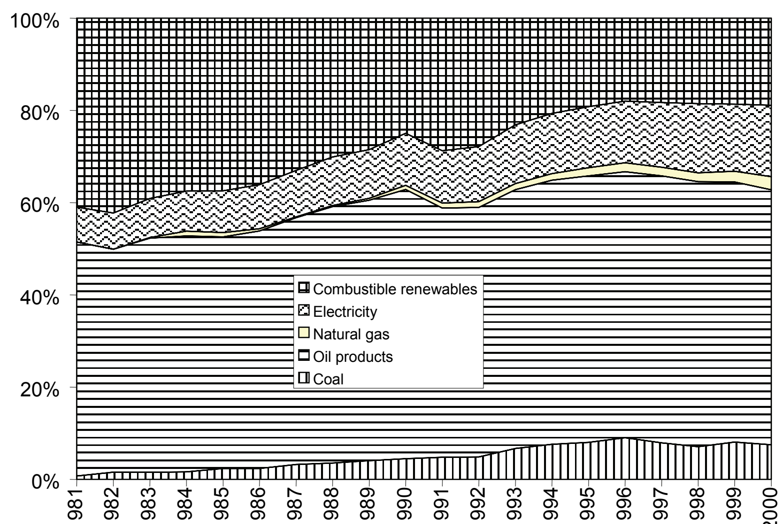

Figure 9.6: Final Energy Mix by Fuel

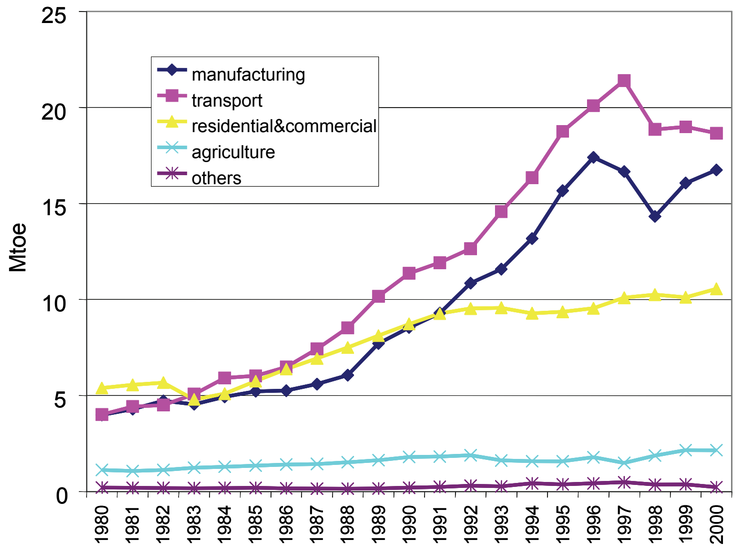

Figure 9.7: Final Energy Demand by Sector

9.3. Review of Energy Statistical Data Capability

9.3.1. Assessment of the available data in Thailand

9.3.1.1. Demographic and Socio-Economic Data

Various statistics on Thailand's demography and socio-economy are available at the National Statistical Office (NSO). The NSO is the main statistical information centre of the country, with provincial offices acting as information centres in the provinces. Data available at NSO are not only those produced by the office but also those data produced by other government agencies.

The NSO conducts various surveys and censuses in order to collect statistics. These surveys and censuses include (NSO website, 2002):

Population and Housing Census. Thailand's first national census was conducted in 1909 and afterwards censuses were carried out in 1919, 1929, and 1947. The Ministry of the Interior undertook the first five censuses. Since 1960, the National Statistical Office has been in charge of undertaking censuses every 10 years under the authorization of the 1952 Statistical Act (amended in 1965). In 1970 the first housing census was conducted simultaneously with the population census. The 1990 Population and Housing Census are the ninth population census and the third housing census, respectively, of Thailand. The main objective of the census is to quantify population demographic and socioeconomic characteristics as well as housing characteristics for the National Economic and Social Development Plan (NESDP).

Household Socio-Economic Survey. The first Household Socio-Economic Survey was conducted by the NSO in 1957, known as "The Household Expenditure Survey". This name was changed to Household Socio-Economic Survey in 1968 - 1969 and the survey has been conducted every five years. Due to the rapid economic expansion and the importance of the survey in order to set anti-poverty policy, the Ministerial Cabinet approved on September 8, 1987 that NSO carry out the survey every two years. The 2000 survey is the fifteenth survey of this kind.

Household Energy Consumption Survey. The NSO carried out the first two surveys of Household Energy Consumption in 1984 and 1985, following a request by the Office of the National Economic and Social Development Board (NESDB), at the same time as the Labour Force Survey. Since 1986, this survey has complemented the Household Socio-Economic Survey. The objective of the survey is to collect information on the quantity and household expenditures on fuel such as petroleum products (e.g., L.P.G. for cooking), electricity, charcoal and wood, etc. Since 1996, the data collection has focused only on expenditures for fuel, excluding information about quantities. The 2000 survey is the ninth survey of this kind.

The other surveys conducted by NSO are:

- Labour Force Survey to estimate the number and characteristics of the labour force in the country;
- Housing Survey to estimate areas of dwelling units;
- Survey of Population Change to measure changes in the population and other population characteristics; and the
- Construction Survey, started in 1999, to look into the size of various establishments in the country.

Time series statistics on demographic and socio-economic data for Thailand are also being published by international organizations such as the Asian Development Bank (ADB), the United Nations Organization (UN), and the World Bank (WB) on a regular basis.

9.3.1.2. Industrial Statistics

The NSO also conducts the following surveys to generate data and information on industries:

Industrial Census. The industrial census is conducted in order to collect basic industrial information (e.g., the number and characteristics of manufacturing establishments), for economic development planning, and for setting industrial policies at the macro and micro level. The second industrial census was conducted in 1997, and NSO plans to conduct the census every 10 years.

Manufacturing Industry Survey. The main objective of this survey is to collect basic industrial information, such as: number of establishments, number of persons engaged, number of employees, compensation, value of raw materials, parts and components purchased, sales value of goods produced and purchased for resale, and inventory and value of fixed assets.

Yet, the NSO census and survey do not include statistics on the production output of various industries of the country. The Office of Industrial Economics of Thailand produces a semi-annual report on industrial statistics (e.g., production, sales and sale values, etc.) but covers only a few industries. The publication of these statistics started only in the mid-1990s.

9.3.1.3. Energy and Environmental Statistics

The Department of Energy Development and Promotion[2] (DEDP) publishes three volumes of energy and environment statistics annually: *Power in Thailand*, *Oil and Thailand*, and *Thailand Energy Situation*. These statistical reports contain rich information on energy balances, energy production, energy consumption, energy imports and exports, energy prices, reserves, sectoral information, environmental statistics, and others.

These reports, however, do not give detailed information beyond the sectoral level. For example, energy use of cement, glass, and other non-metallic products industries are lumped together; energy consumption of road transport is not classified into passenger or freight but disaggregated by fuel and mode of transport such as road, rail, water and air.

Other sources of energy data in Thailand are the Energy Policy and Planning Office (EPPO) also now under the new Ministry of Energy, which regularly updates and prepares the national load forecast; the Electricity Generating Authority of Thailand (EGAT), which regularly publishes the national Power Development Plan (PDP); and the Provincial Electricity Authority (PEA). EGAT's and PEA's annual reports are also rich sources of power statistics.

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[2] DEDP is now under the new Ministry of Energy and since October 2002 has changed its name to Department of Alternative Energy Development and Efficiency (DEDE).

9.3.1.4. *Transport Statistics*

The Ministry of Transport and Communications (MOTC) provides annual data on transport statistics for all transport modes. Road statistics are essentially based on surveys carried out by the Department of Land Transport, focusing primarily on freight statistics. Vehicle stock data are also produced by MOTC, based upon the registration of motor vehicles covered under the Land Act of 1979. There are no data available on passenger-kilometres for road and urban transport.

For rail transport, the State Railway of Thailand (SRT) is the only rail operator and therefore the only source of information. Freight statistics are based on SRT's detailed records, while rail passenger statistics are based on records from ticket sales. For electrically driven mass rail transit such as the BTS (Bangkok Transit System), statistics are still not available at this writing as its operation began only in 2000.

Domestic water transport covers inland waterway transport running on rivers and canals, as well as coastal shipping[3]. In this sector, only freight transport statistics are being provided, as there are no available data on passenger transport. The main source of data for inland waterway transport is the Royal Irrigation Department, while statistics on coastal shipping come from the Department of Customs in coastal ports.

The main source for domestic air transport statistics is the Department of Aviation. Statistics covered include passenger and freight movements, origin-destination data, as well as statistics on the fleet of aircraft registered.

Surveys to gather information for statistics on distance travelled by passengers for road and water transport are not carried out in Thailand. Also, there are no pipeline transport statistics available in the country.

9.3.2. International Sources of Data on Thailand

In addition to local sources, socio-economic, industrial, energy, and environmental data on Thailand are also available from internationally published statistics. The Asian Development Bank (ADB) publishes annually the *Key Indicators of Developing Asian and Pacific Countries*, which is a time-series collection of macroeconomic statistics, including production statistics on energy intensive industries, for ADB developing member economies. The International Energy Agency (IEA) also publishes annually the *Energy Balances and Statistics* for OECD and non-OECD countries, as well as quarterly *Energy Prices and Taxes*. The United Nations also publishes air and rail transport statistics (except for road and water passenger transport).

9.3.3. Data development in relation to energy efficiency policy

The following data have been collected to derive the indicators related to energy efficiency:

- Energy prices (pre-tax prices and taxes) of unleaded gasoline octane 95 (ULG 95) and premium gasoline for transport, automotive diesel for commercial uses, heavy fuel oil and steam coal for industrial uses, LPG and kerosene for residential uses, and electricity prices for commercial, residential and industrial uses;
- Gross domestic product (GDP), and value added of economic sectors (manufacturing, transport, services/commercial, agriculture, and others);
- Value added of energy intensive industries such as basic metals, chemicals, non-metallic, pulp and paper and others;
- Freight transport activity by mode of transport;
- Total commercial area in square kilometres;

[3] Inland waterway transport is extended from the mouth of the Chao Praya River to along the coast of Eastern Sea Board.

- Total population, urban population/household population, urban and rural;
- Employment;
- Sectoral and sub-sectoral energy consumption, energy mix;
- Production of energy intensive industries (iron and steel, cement, pulp and paper only);
- Daily disposable income of poorest 20% household;
- Average disposable income of the population;
- Private consumption per capita spent on fuel and lighting of 20% poorest household;
- Average private consumption of population spent on fuel and lighting;
- Structure of households by mode of cooking fuel;
- Number of households with and without electricity;
- Quantities of green house gas and air pollutant emissions (such as CO_2, CO, NOX, CH_4, SO_2, SPM)
- Ambient concentration of pollutants in urban areas: CO, TSP (road side and ambient air quality).

9.3.4. Potential data parameters to be collected in the future

Many surveys are undertaken in the country periodically. However, they focus more on demography, expenditures, socio-economic classes, infrastructure, economic standing, and other more general information not related to energy.

End-use energy data are vital for understanding the real situation of the main economic sectors. In Thailand's case, little has been done in the past to collect energy end-use data. In fact, energy statistics published by various energy institutions tend to be aggregated in nature. Thus, there is a need to improve the energy data system by collecting more disaggregated or specific end-use energy data through frequent surveys to support future studies and for the development of the indicators for sustainable development.

9.4. Thailand's Energy Efficiency Policy and Programs

The main legislative provision in the field of energy efficiency and conservation in Thailand is the Energy Conservation Promotion Act B.E. 2535 (1992). This is where the government's energy efficiency policy is made explicit. The Act also serves as the foundation for all of the plans and programmes the government undertakes in order to promote energy conservation and efficiency in the country. The Thai government has undertaken two notable programmes since 1992 towards this end: i) energy conservation programs; and ii) demand side management programs.

9.4.1. The Energy Conservation Promotion Act 2535

The Energy Conservation Promotion Act, 2535 (1992) was enacted to mandate the production and use of energy efficiently and economically; and in parallel to this, to encourage the production and use of high-energy efficiency machineries and equipment. The Act targets three groups: (i) Designated Factories, (ii) Designated Buildings, and (iii) Producers or distributors of energy equipment and machinery. In order to facilitate energy conservation activities, the Act has made the following provisions:

<u>Energy conservation in plants</u>: Factories having a transformer of more than 1,000 kVA or an annual energy use exceeding 35 million Btu are required to conduct energy audits. The establishments have to appoint a full-time certified energy manager, keep records of energy use and submit those to the government, and submit an energy rationalization plan for review and approval. Non-compliance will

be met with penalties, e.g. by increasing tariffs. Factory owners are given three years to meet requirements.

Energy conservation in large buildings: Owners of designated buildings are required to appoint energy managers, conduct audits and keep records of energy use, and submit an energy plan for review and approval. A three-year time frame is given to owners to meet their efficiency requirements. A model energy code for new commercial and institutional buildings has been prepared.

Standards for appliance equipment and materials: The government has issued regulations concerning the minimum efficiency of equipment appliances, building materials and control systems.

Energy conservation promotion fund: The Act has made a provision of low-interest loans and grants for energy efficiency and renewable energy projects, as well as for research and development, demonstration, promotion and education.

9.4.2. The Energy Conservation Program (ENCON)

The Act gave birth to the Energy Conservation (ENCON) Program that is being implemented with the objective of promoting energy efficiency, energy conservation, sustainable use of natural resources, and protection of the environment. The lead agency for implementing this program is the Department of Energy Development and Promotion (DEDP) under the Ministry of Science, Technology and Environment (MOSTE).[4] The main tasks of the ENCON program include:

- Providing financial assistance and incentives for energy conservation, energy efficiency and renewable energy projects;
- Supporting demonstrations of energy conservation and renewable energy technologies;
- Supporting the promotion and dissemination of proven energy conservation and renewable energy technologies;
- Increasing research and development and training in energy conservation technology;
- Organizing public relations campaigns to promote energy conservation.

Under the ENCON program, the National Energy Policy Office (NEPO)[5] also supports voluntary activities for promoting wider application of renewable energy and its technologies. Such activities are supported with financial assistance and other incentives. The voluntary programs are mainly focused on the following:

- **Renewable Energy and Rural Industries Programs:** Biogas for power generation from livestock wastes in small and medium firms; biogas digesters among individual farmers; and landfill gas pilot projects.
- **Research and Development Programs:** This program aims at developing new or improving existing technologies, with support to small scale demonstration projects as well as information dissemination.
- **Industrial Liaison Program:** The purpose of this program is to enhance the capacity of the industrial sector to produce energy efficient and renewable energy equipment in Thailand.

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[4] DEDP is now the Department of Alternative Energy Development and Efficiency (DEDE) and has been moved to the new Ministry of Energy. The new Ministry of Energy started on 1 October 2002 along with the new Ministry of Science and Technology and Ministry of Environment and Natural Resources.

[5] Similarly, NEPO has been re-named EPPO or the Energy Planning and Policy Office, also under the new Ministry of Energy.

9.4.3. The Energy Conservation Promotion Fund (ENCON Fund)

One of the key policy aspects to promote energy conservation activities in Thailand is the establishment of the energy conservation fund (ENCON Fund) for providing financial support to various energy conservation activities. The fund called "the Conservation Fund" was created in 1992 in accordance with the Energy Conservation Promotion Act 2535 (1992) to promote energy conservation activities in factories and commercial/service buildings. The fund is sourced from the imposed levies on petroleum products. It is mainly used to provide either soft loans or grants for energy efficiency and renewable energy projects. This fund is also used for supporting research, development, demonstration, promotion and educational activities in the field of energy conservation and new and renewable energy. Additionally, funds also come from the government, the private sector, foreign governments and international organizations including the World Bank and the Asian Development Bank. Funds may be granted to individuals, businesses, non-government organizations and government agencies.

9.4.4. The Demand Side Management (DSM) Program

In parallel with the ENCON Program, the government through its three electric power utilities has also launched the demand-side management program (DSM). The first phase ran between 1993 and 1998, and the second phase covers the period 2002-2006.

9.4.4.1. DSM Program Phase 1

The government and the Electricity Generating Authority of Thailand (EGAT) implemented a Five-year DSM Master Plan beginning in 1993 to deal with a huge investment demand for electricity supply capacity expansion resulting from the rapid economic growth. The program had four main objectives:

- to educate, encourage (through incentives), and inform consumers about energy conservation;
- to stimulate manufacturers and importers to produce or import energy-saving and efficient appliances and equipment;
- to support and pursue energy efficiency and load management technologies; and
- to build sufficient institutional capability in the electricity sector and the energy-related private sector to deliver cost-effective energy services throughout the economy.

The program was started with a total budget of US$189 million, of which the Global Environmental Facilities (GEF) provided US$15.5 million, the Overseas Economic Cooperation Fund (OECF) of Japan granted US$25 million in concessional loans, and the remainder was sourced internally by the Electricity Generating Authority of Thailand (EGAT).

The Master Plan originally targeted a reduction of 238 MW peak demand, some 1,427 GWh of electricity generation, and 1.16 million tons of CO_2 emissions. The program achieved more than it had targeted. By 30 September 1998[6], the program resulted in reductions of 468 MW of peak demand, 2,194 GWh of electricity generation, and 1.64 million tons of CO_2 emissions. By September 2001, the overall program resulted in 651 MW peak demand cut and 3,665 GWh energy reductions.[7] This is why the DSM program in Thailand has been internationally regarded as extremely successful, and a model DSM program for developing countries.

The DSM Program Phase I consisted of six major sub-programs. These are the Residential Program, Commercial/Governmental Building Program, Industrial Sector Program, Load Management Program, Energy Conservation Attitude Promotion Program, and Program Monitoring and Evaluation. The first three programs focused on energy-efficient appliances, particularly lighting equipment, high-efficiency refrigerators and air-conditioners, and high-efficiency motors.

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[6] Due to implementation delays, the project had been extended and closed on June 30, 2000.

[7] Information on similar CO_2 reductions is not available.

Lighting

- Energy Efficient Fluorescent Lamp Program persuaded five local manufacturers to switch production from 40 W and 20 W fluorescent tubes (Fat Tube) to 36 W and 18 W (Thin Tube) instead;
- Lighting Retrofit Program in the Royal Project Foundation was a pilot program to persuade agriculturists to save energy utilized in their businesses;
- "Million Hearts Million Lights" Program encouraged consumers to use compact fluorescent lamps (CFL) instead of incandescent lamp bulbs;
- Street Lights Program was a pilot program to stimulate replacement of fluorescent tubes with high-pressure sodium vapour lamps;
- Energy Efficient Ballast Program created a market for energy efficient ballasts by stimulating manufacturers to produce them. The campaign was first focused on producing energy efficient ballast named 'Safety Ballast No. 5';
- Low-Income Fluorescent Program promoted the use of fluorescent tubes instead of incandescent lamp bulbs among low-income households.

Refrigeration and air conditioning

- Energy Efficient Refrigerator Program persuaded the five manufacturers of refrigerators in the Thai market to have refrigerators tested for efficiency rating labelling;
- Energy Efficient Air-Conditioner Program persuaded local manufacturers and importers to have split-type air-conditioners tested for efficiency rating labelling and encouraged consumers to purchase high efficiency air-conditioners; all 55 air conditioner manufacturers joined the testing and labelling program and it is evident that consumers have been attracted by energy-efficient air-conditioners;
- Thermal Energy Storage promoted the utilization of thermal storage systems instead of central air-conditioning systems during peak demand periods;
- Appliance Testing Laboratory Program aimed at widening the testing of energy efficiency of refrigerators and air-conditioners in The Thai Industrial Standard Institute (TISI).

Energy efficient electric motors

- High Efficiency Motor Program encouraged motor manufacturers and importers to produce and import high efficiency motors and convince industrial entrepreneurs to utilize high efficiency motors. Since early 1996, EGAT has offered industrial customers a savings incentive of US$440 per peak kilowatt (kW) when they purchase energy-efficient motors.

Other programs

- Heat Pipe Program monitored implementation and cost studies of dehumidification heat pipes;
- Green Building Program stimulated both existing and new commercial buildings, offices, hotels, hospitals or department stores to utilize electricity in compliance with the Ministerial Regulations issued to complement Energy Conservation and Promotion Act 1992. To overcome the cost barrier to the installation of more energy-efficient equipment, EGAT provided building owners with an interest-free loan which was repaid over three to five years. By early 1996, owners of more than 180 large commercial buildings were participating;
- Energy Service Company (ESCO) provides current and modern technologies to enhance full-scale energy utilization in industry. The program is anticipated to prove to commercial and industrial entrepreneurs that ESCOs can improve the energy utilization in more efficient and cost-effective ways, and also bring confidence among new entrepreneurs on the importance of energy conservation activities;

- Attitude Creation Program created awareness of energy conservation and energy efficient utilization;
- Industrial Cost Reduction Program provided assistance and suggested energy efficient applications to industrial factories. Pre-capital investment was funded by the Energy Conservation Fund, and then repayment was made afterwards if appliance retrofitting was necessary;
- Low Efficiency Buy-Back Program transformed the operations and early retirement of low efficiency appliances utilized within the system, and also pressured manufacturers to produce only high efficiency appliances.

9.4.4.2. DSM Program Phase II (2002-2006)

The government has formulated another five-year (2002-2006) DSM Master Plan for the second phase of the DSM operation. DSM Phase II consists of 13 DSM programs targeting three major sectors of the economy, namely, residential, commercial, and industrial. Moreover, EGAT plans to build about 330 green learning rooms to create awareness of energy conservation in the curriculum.

Strategies for Phase II will include additional efforts, such as the promotion of energy efficiency and load management technologies in small and medium enterprise (SME) and the enhancement of standardization of energy use in corporations and the social sector. It will also build on successful approaches implemented during Phase I, such as market transformation, energy efficiency labelling, customer-oriented program design, public-private sector partnership (ESCOs), and attitude creation.

The total savings targeted for the Phase 2 DSM program is 632 MW peak demand and 2,508 GWh of energy. This will translate into a reduction of more than 1.85 million tons of CO_2 from accumulated energy savings at the end of 2006. According to EGAT, the program will cost Baht 2,155 million (i.e., Baht 1,700 million for the 13 DSM programs, and Baht 455 million for the attitude creation programs).

9.5. Implementation of ISED Framework

The conceptual framework of the present study follows ISED's model framework called Driving Force-State-Response (DSR), specifically fine-tuned for the energy sector. The DSR framework illustrates the interrelationship of the three principal pillars of development (i.e., economic, social, and environmental), as well as the institutional dimension so critical in the development of the energy system. The "Driving Force" indicators encompass human activities, processes and patterns that impact sustainable development, positively or negatively (UN, 1996). The "State" indicators refer to the state of sustainable energy development, while "Response" indicators highlight corrective policy actions affecting sustainability of the whole energy system. The environmental state of the energy system is the consequence of the driving forces coming from the economic and social dimensions of the energy system. The driving forces from the economic dimension also influence the social state of the energy system. The institutional dimension affects all three dimensions by means of laying out various policy options that affect the sustainability of the energy system.

Figure 9.8 illustrates the interrelationship of the four dimensions.

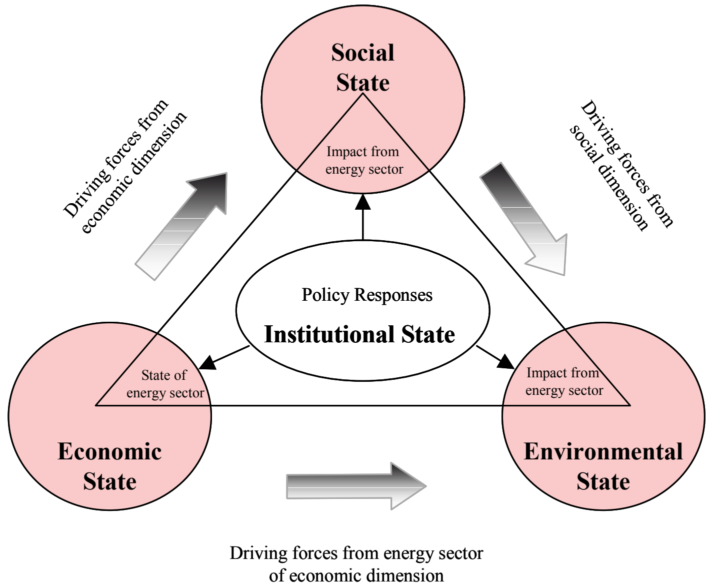

Figure 9.8: Interrelationship Among Sustainability Dimensions of the Energy Sector
Source: IAEA (2000)

9.5.1. Energy intensity as indicators in the economic dimension

The present study applies energy efficiency and conservation as "State" indicators of the economic dimension. Energy efficiency and conservation are measured through improvements in energy intensity, a measure of how much energy is used to perform a particular activity (e.g., production of output). It can be expressed both in monetary terms, in which energy consumption is denominated with monetary value of production, and in physical terms, when energy use is linked to physical output of production. The latter is usually called "specific consumption," to distinguish it from energy intensity that is usually expressed in monetary units.

At the highest levels of aggregation, two types of indicators are constructed: the national or aggregate energy intensity and sectoral energy intensities defined respectively as the total and sectoral energy consumption divided by gross domestic product or sectoral gross value added, and thus expressed in monetary terms as toe/Baht (see Figure 9.9). Due to the large level of aggregation, these broad indicators often include various structural and other effects. Thus, improvements in aggregate and sectoral energy intensities do not necessarily imply an increase in energy efficiency but could be a result of such factors as declining importance of energy intensive sectors (structural change) and non-energy related improvements. In turn, higher energy intensities also do not necessarily mean less efficient use of energy, as the structure of the economy might be moving towards more energy-intensive industries. There is a need, therefore, to decompose the energy intensity. Decomposition isolates the effect of changes in the economy's structure from the impact of real energy intensity. Real or pure energy intensity could be an explanatory indicator of energy efficiency, although efficiency improvements is not the main factor for reductions in energy intensity as the latter also could be attributed to changes in the fuel mix, changes in technology and operational changes. Several methods are used to decompose energy intensities. In this study, the *Divisia* method is used to decompose various effects on the aggregate energy intensity such as activity, structural and pure intensity effects.

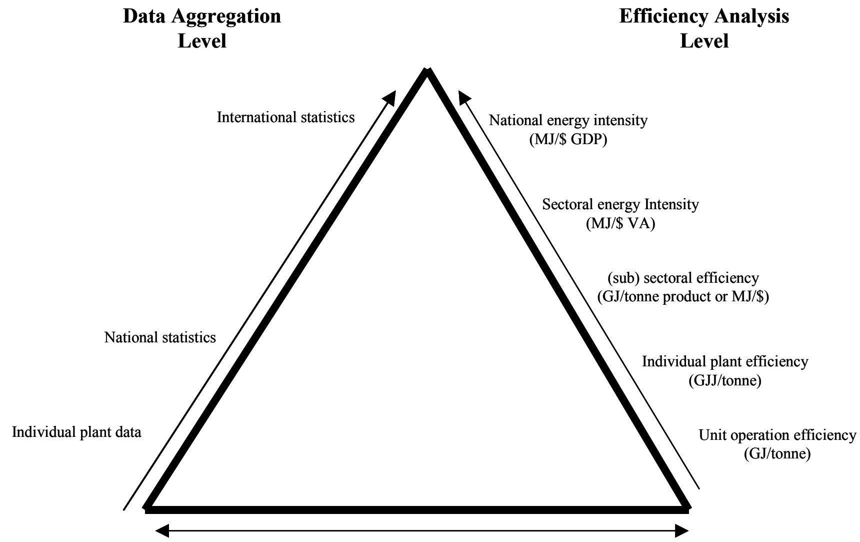

Figure 9.9: The Energy Efficiency Indicator Pyramid
Source: Phylipsen et al, 1998

At the lower level of aggregation, the number of indicators that can be constructed is increasing; thus, the influence of structural effects as well as other factors also declines. Few of the indicators at the lower level of aggregation include sub-sectoral efficiency measured from the ratio of energy consumption to a measure of human activity in physical terms (for example, toe/ton of product, for industry, kilogram of oil equivalent (kgoe)/billions of ton-kilometres for transport, etc.) and individual plant efficiency, or end-use efficiencies. These indicators are referred to as physical energy intensity, which are commonly called specific energy consumption (SEC) or unit energy consumption (Phylipsen et al, 1998). These physical energy efficiency indicators can reflect the effect of energy savings measures, for example, through the decrease of the SEC, leading to a greater understanding of the state of energy efficiency. In order to develop these physical energy efficiency indicators, substantial data are required. However, the accumulation of such data becomes increasingly more complex and costly as well.

Various driving forces influence changes in energy intensity. Mostly, these driving force indicators are economic and social in nature and affect the behaviour and preferences of energy consumers. For example, energy prices and taxes (as a government policy tool or an institutional response) affect the behaviour of energy consumers leading to either increases or decreases in energy intensity. The modal structure of transport can also influence energy intensity: the rapid growth of cars, which consumers prefer most, contributes to a more energy intensive transport system. Mass transport such as buses or trains are relatively more efficient compared to cars. The structure of the economy also influences energy intensity: a drive towards high value added and less energy intensive sectors reduces energy intensity. The government through its policy responses, therefore, has a major role in influencing these major driving forces that directly affect the behaviour of energy consumers as well as the structure of the economy leading to variations in energy intensity.

Moreover, there are other indicators affecting energy intensity, such as floor area per capita, freight and passenger activities, structure of manufacturing energy intensive industries, and others that are subsequently discussed in this study.

9.5.2. Indicators in the Social Dimension

Interrelationships between the state of energy efficiency and the state of social dimensions are also strong. For example, the heavy dependence on traditional energy in households and the share of households without electricity (state indicators under the social dimension) affect energy intensity: higher dependence over time on traditional energy would mean less improvement in energy intensity, as traditional fuels are less efficient than modern energies. Traditional fuels, for the case of Thailand, are fuelwood, charcoal, and paddy husk, while modern energies include LPG, electricity, and kerosene. With respect to lighting, households without access to electricity tend to use less efficient candles and kerosene lamps in lieu of more efficient electric lamps. These state indicators are, in fact, poverty-related—income dictates the type of energy households will use. Income therefore is the main driver that can influence households' preference of fuel as well as the type of technology. Moreover, income also affects the affordability of various energy fuels (i.e., LPG, kerosene, and KWh of electricity) used by the poorest households, as well as the degree of use of these fuels. These can be measured by the share of income spent on fuel and electricity to total private consumption expenditures in the poorest households.

9.5.3. Indicators in the environmental dimension

The state indicator under the environmental dimension seen as particularly relevant is the ambient concentration of pollutants,[8] since this is a major consequence of fuel use among various sectors (driving forces) of the economy:

- Transport vehicles emit pollutants. The amount of pollution released is chiefly related to the type of energy consumed, as well as the technology used. Yet there are other contributing factors as well, including the volume or stock of vehicles, the age of the fleet (also related to technology), and other technically-related factors such as the engine, tail types, etc.
- Industrial activities contribute to pollution. The burning of fuels either for thermal (to produce heat) or mechanical uses (to drive engines and motors) contribute to emissions. The type of technology, which also depends on the type of fuel used, is similarly of concern with regards to industrial pollution.
- Residential and commercial sectors contribute to increased pollution due to various activities (cooking, lighting, etc.), using certain types of energy as input and specific technologies in order to obtain various services.

Annex 9.1 summarizes the selected set of indicators in the ISED package, as well as a number of additional indicators employed, and other indicators relevant to energy efficiency. There are in fact numerous relevant indicators for explaining the state of energy efficiency; however, due to limited disaggregated data available, this study did not address them.

9.6. The Economic Dimension

9.6.1. Manufacturing sector energy intensity

The manufacturing sector accounted for about 35% of the total final energy consumption of the country in 2000. It also generated more than 36% of the country's total gross domestic product during the same period (Table 9.5).

[8] Rate of deforestation is also applicable as a state indicator but not covered by this study as there are no data available.

TABLE 9.5: STRUCTURE OF ENERGY CONSUMPTION AND GDP BY SECTOR

	Energy Consumption, 2000 (Ktoe)	Share (2000)	1980 GDP[1] in Million Baht	1980 GDP Share	2000 GDP[1] in Million Baht	2000 GDP Share
Manufacturing	16,741	34.6%	211,031	23.1%	1,085,104	36.4%
Transport	18,652	38.6%	65,669	7.2%	292,431	9.8%
Residential	7,433	15.4%				
Commercial	3,118	6.5%	403,714	44.2%	1,169,735	39.2%
Agriculture	2,161	4.5%	184,576	20.2%	298,060	9.9%
Others	234	0.5%	48,743	5.3%	139,631	4.7%
TOTAL	48,339	100%	913,733	100%	2,984,961	100%

1 At constant 1988 prices

Over the years, non-metallic manufacturing is by far the most energy intensive industry in Thailand (Figure 9.12). Although its energy intensity slightly declined from the 1980s through the early 1990s, it has remained since then at its highest level. In fact, its energy intensity rebounded in the following years, peaking in 1999. The basic metals industry became the second most energy intensive manufacturing sub-sector, beginning in 1989. Its energy intensity increased sharply until early 1992, dropped until 1995, and has climbed steadily since 1996. Fabricated metal manufacturing posted a smooth growth of energy intensity during the period 1986-1991, and beginning in 1993. Food manufacturing, on the other hand, registered a slight decrease in energy intensity between 1981 and 2000. Other manufacturing industries have maintained their average energy intensity since the 1980s.[9]

A different picture appears for final electricity intensity. The basic metallic industry and fabricated metal are the most electricity intensive manufacturing industries (Figure 9.13). These two industries present similarly increasing patterns from 1993 onwards. Non-metallic manufacturing remained stable over the years, except for a slight decline in 1992. Electricity intensity in wood manufacturing started to climb sharply beginning in 1998 from its past 10 year stable level. Paper and chemical manufacturing industries posted a slight decline in electricity intensity while other industries maintained almost constant electricity intensities over the last two decades.

Looking at the physical energy intensity of selected manufacturing sub-sectors, based on the limited available data, the glass industry, under the non-metallic manufacturing sub-sector, is the most energy intensive industry. Other industries such as cement, pulp and paper, iron and steel, chemicals and others have much lower intensities that have been stable over the years.

9.6.2. Transport Sector Energy Intensity

Transport is the most energy intensive economic sector in the country, and energy intensity, which is usually defined with respect to total GDP (APERC, 2002), had been on a rapid upward trend, growing at 2.75% per year, until the financial crisis in 1997-2000 (see Table 9.5 and Table 9.6).

For passenger transport, only data for rail transport are available. As shown in Table 9.6, the energy intensity of rail transport has not shown any general improvement over the years. Between 1981 and 1997, the average growth rate of energy intensity was inching up by about 0.5% per year. The energy intensity of rail passenger transport is estimated by dividing the total energy consumption of rail transport over the total rail passenger-kilometres.

For freight transport, freight energy intensity expressed as million toe per ton-kilometre cannot be determined as there are no available data to show energy consumption of freight transports.

[9] There are no available data in Thailand showing individual gross value added (GVA) of energy intensive industries. Thus, energy and electricity intensities in monetary terms were derived using GVA of aggregate sector. For example, non-metallic products include cement and glass industries.

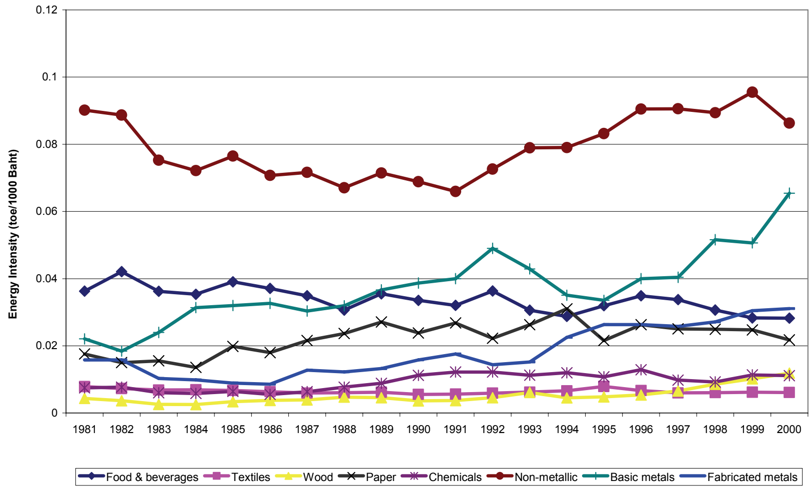

Figure 9.10: Energy Intensity of Manufacturing (toe/1,000 Baht at constant 1988 prices)

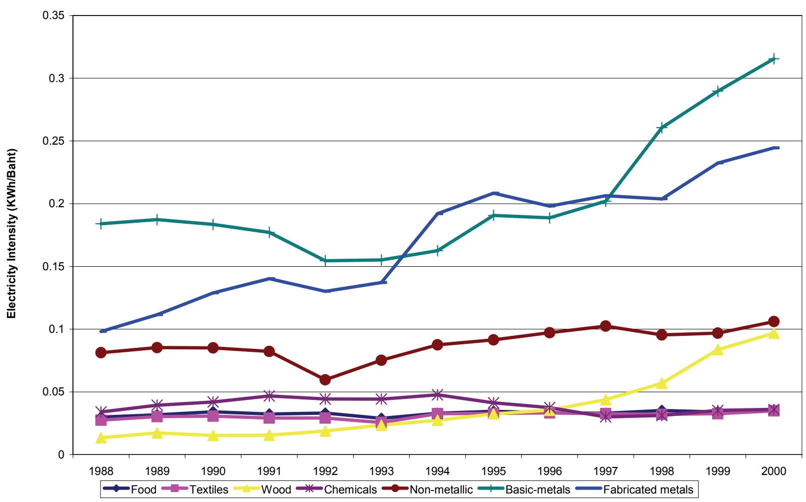

Figure 9.11: Electricity Intensity of Manufacturing (kWh/Bht at constant 1988 prices)

TABLE 9.6: ENERGY INTENSITY IN THE TRANSPORT SECTOR

Indicators	1982	1985	1988	1991	1994	1997	2000
Final energy intensity of transport (toe/1,000 Baht)	0.004	0.005	0.005	0.006	0.006	0.007	0.006
Rail Passenger travel energy intensity (mtoe/ pkm)	8.99	9.63	7.96	9.05	7.96	9.66	
Freight activity energy intensity (mtoe/ ton-km)	No data available						

9.6.2.1. Unit Consumption of Vehicles

The unit consumption of vehicles expressed as litres of fuel consumption required per 100-kilometer travel is a reliable measure of energy efficiency, in a technological sense. Although vehicles have a standard test value, the fuel efficiency can be influenced by the following parameters: for passenger cars, it depends on the speed, traffic and road condition, as well as drivers' behaviour; for freight vehicles, it depends on the type of service (load, average speed), the engine technology, and the external conditions (Guibet, 1999).

Notably, for cars, there was a trend for improved fuel efficiency using smaller size and less powerful cars after the oil crises. However, when energy prices moderated, consumer preferences shifted again towards bigger and more powerful vehicles, partially offsetting the previous improvements in fuel economy (IEA, 1997).

Cars

In Thailand, car sales are shifting towards larger and more fuel consuming vehicles such as luxury cars and sport utility vehicles (Bangkok Post, 1996). Despite severe traffic congestion problems, the relatively low prices of fuels and automobiles induce Thai customers to shift from small cars (i.e., below 1,600 cc), to medium ones (i.e., 1,600 cc and above) (TDRI, 1993). Hence, though it seems that vehicle efficiency has improved for certain cars in the past years, this structural change in the composition of the private car fleet has made it doubtful whether the overall fuel economy of the whole fleet has decreased significantly.

The correct assessment of the average fuel efficiency of the total car fleet is extremely difficult since a reliable figure can only be obtained by surveys. However, there are no surveys available for recent years in Thailand. The most recent survey of fuel consumption for cars was carried out by NEPO in 1991 for the preceding year. The outcome was a fuel consumption of 10 litres/100 kilometer gasoline for new cars and 11.5 litres/100 km for the whole fleet, taking into consideration its age structure (NEPO, 1992). A study by ONEB (1993) assumes that the fuel consumption under standard traffic conditions is 11 litres/100 km and 13 litres and 14 litres /100 km in the congested Bangkok Metropolitan Area (BMA) in 1991 and 1996. IIEC (1992) quotes data from the National Energy Administration, which revealed an even wider range for the fuel consumption level. For gasoline vehicles the fuel efficiency ranged from 7.1 to 14.3 litres/100 km, depending on the congestion level, while the consumption of diesel cars lies between 10.7 and 12.1 litres/100 km.

Buses

The fuel economy of urban buses is shown in the Table 9.7, based on the 1997 Survey of Bangkok Mass Transit Authority (BMTA)[10]. It is striking that air-conditioned buses consume almost 50% more fuel per 100 km than ordinary buses (without air-conditioning units). Even though there is no clear trend recognizable for the development of the individual unit consumption of ordinary and air-conditioned buses, the overall trend of the average unit consumption for the whole fleet is increasing, mainly due to a shift towards more fuel consuming air-conditioned buses (Table 9.7).

TABLE 9.7: EVOLUTION OF UNIT CONSUMPTION OF BUSES IN THAILAND

	1992	1993	1994	1995	1996
Ordinary bus [liter/ 100 km]	39.74	40.14	40.33	40.17	39.68
Air-cond. bus [liter/ 100 km]	62.91	59.43	57.49	60.54	62.57
Natural Gas Bus [m^3/ 100 km]	-	-	-	86.50	85.13
Weighted Average [liter/ 100 km]	42.43	43.66	43.93	44.71	45.51

Source: BMTA, 1997.

On the other hand, there are no recent data available concerning fuel consumption of buses outside the Bangkok Metropolitan Area. Based on NEPO statistics, average fuel consumption in 1992 for the non-Bangkok bus fleet was 37.5 l/100 km, indicating a larger proportion of ordinary buses than air-conditioned buses. For freight and other passenger vehicles, there are no available data on fuel efficiency in the country.

[10] The BMTA is directly operating BMTA-owned buses and, at the same time, responsible for supervising bus services from the private sector.

9.6.3. Service sector energy intensity

Changes in the overall service sector energy intensity over the past decade show three clear trends (Figure 9.14). It increased by more than 14% per year in 1989-1991, and then dropped steadily by more than 15% annually from 1991 to 1995. In 1998, however, energy intensity had jumped by more than 122% from its 1997 level, and then moderately increased in the following years.

A similar trend can be observed for the energy intensity by floor space, even though data are only up to 1995. This energy intensity measures the amount of energy consumed for every square meter of commercial floor area. It increased by 3.5% between 1989 and 1991, then decreased annually by 12% through 1995.

The declining service sector energy intensity from 1991 may be due to the comprehensive building codes and the introduction of building energy management services such as building improvement and energy audit programmes beginning in 1992. The large increase in service sector energy intensity from 1997 is most likely due to the financial crisis, when output or value added, from all economic sectors (except probably agriculture) was drastically reduced, but energy consumption did not follow at the same rate.

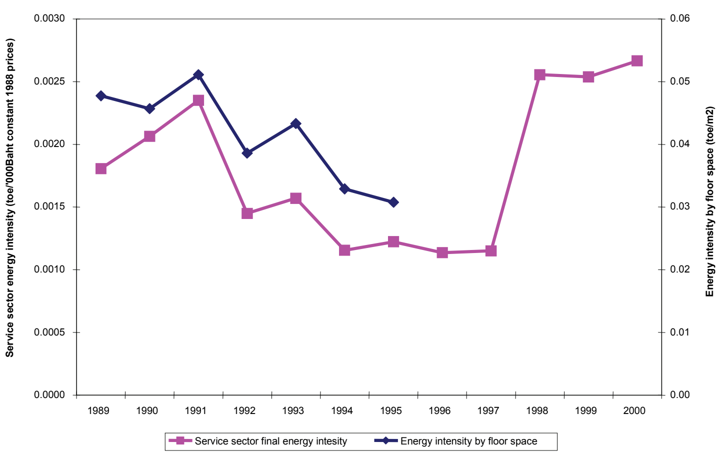

Figure 9.12: Service Sector Energy Intensity

The trend of electricity intensity in the service sector is rather different. Beginning in 1983 and continuing through 1998, total final electricity intensity (kWh/Baht at constant 1988 prices) and employee electricity intensity (kWh/employee) exhibited a robust growth in the exact same pattern, but at different rates—about 7% and 12%, respectively (Figure 9.15). The rapid increase indicated speedy development of office and commercial buildings, including the robust penetration of electrical office equipment (such as computers, faxes, photocopying machines, etc.) contributing to the growth in average unit consumption per employee. Electricity consumption in the commercial sector, however, slowed down starting in 1998, following the economic downturn which started in mid-1997.

9.6.4. Residential sector energy intensity

The evolution of residential sector electricity intensity expressed in terms of electricity consumption per household (kWh/hh) grew steadily in the past (Table 9.8). Two main factors explain this trend: an increase in the number of electrical appliances per household, and an increase in the utilization of existing appliances. The impact of the Asian financial crisis is evident with the decline of electricity consumption in 1999.

A different pattern can be observed for traditional fuel energy intensity (expressed in total traditional energy consumption per household). Over the years, consumption of traditional energy (including charcoal, paddy husk, and fuelwood) in the residential sector was declining at the rate of more than

9% per annum from 1990 to 1998. One of the reasons for the decline of traditional energy intensity is the shift to alternative fuels and technologies, for example from kerosene lighting to electric lamps, or from charcoal cooking stoves to LPG stoves. The shift to more modern fuels and technologies may be due to the increase in household income.

Modern energy intensity, on the other hand, remained stable over the years. Modern energies include kerosene and LPG (electricity was separated for a better grasp of the picture).

In sum, residential sector energy intensity has declined due to the shift to more efficient household equipment or technologies.

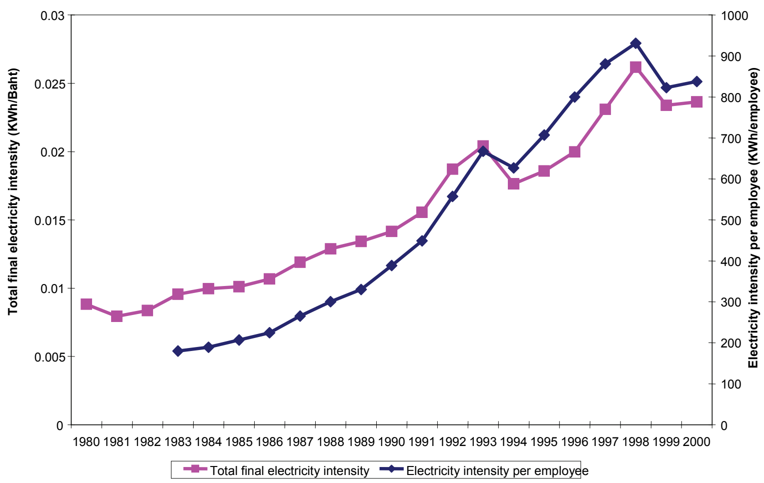

Figure 9.13: Electricity Intensity of Service Sector

TABLE 9.8: ENERGY INTENSITY IN THE RESIDENTIAL SECTOR

Indicators	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Residential sector energy intensity (Kgoe/hh)	675.5	690.5	668.9	639.2	593.5	569.1	533.2	526.5	557.4	461.5	446.2	450.0
Traditional energy intensity (Kgoe/hh)	48.5	49.3	45.9	43.4	40.0	37.2	33.1	31.5	30.8	22.9	23.2	22.9
Modern fuel per capita (Kgoe/hh)	13.1	13.0	13.7	13.6	11.7	11.8	11.7	12.2	15.3	13.1	11.8	12.0
Residential electricity intensity (KWh/hh)	702.6	800.2	856.0	805.9	894.8	921.2	994.9	1,046.0	1,140.1	1,187.5	1,122.7	1,179.1

Source of basic data: NSO and DEDP, various editions and issues
* hh means household
Note: Modern fuel excludes electricity.

9.6.5. Agriculture sector energy intensity

The evolution of the agriculture sector energy intensity showed an increasing trend until 1997 and a declining trend until 2000. Between 1989 and 1997, energy intensity grew annually by 12% on average, although sharp declines occurred in 1993 and 1995. Between 1997 and 2000 agriculture energy intensity fell by 19.1% per annum (Figure 9.16)

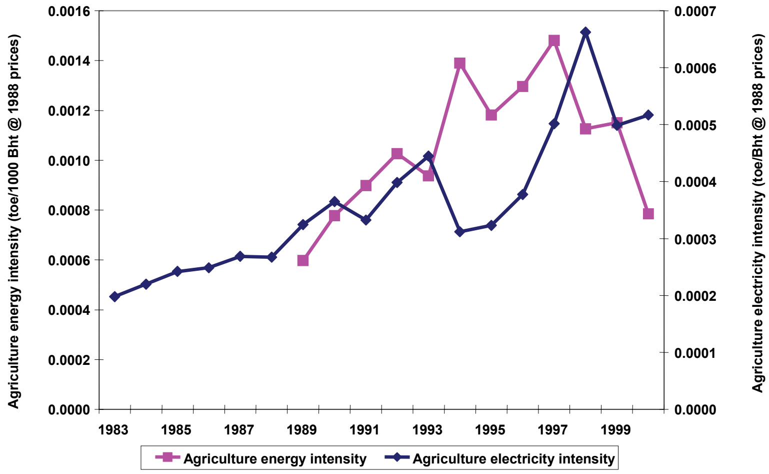

Figure 9.14: Agriculture Energy Intensity

Agriculture electricity intensity (expressed as total electricity consumption over the agriculture gross value added at constant 1988 prices) showed an overall sharply increasing trend between 1983 and 2000, except for two abrupt drops in 1994 and 1999 that were driven by the decrease in electricity consumption. In the decade to 1993, electricity intensity increased annually by more than 8%, despite a slight decrease in 1990-1991. Following a huge 30% drop in 1994, electricity intensity increased by around 21% per annum through 1998. By 1999, it dropped again by around 25%, before starting to rebound in 2000.

9.6.6. Aggregate energy intensity

Figure 9.17 shows the national aggregate as well as sectoral energy intensities for Thailand. Total final energy intensity is expressed as the ratio of total final energy consumption over total GDP while sectoral energy intensities are expressed as energy consumption of each economic sector over their corresponding gross value added (GVA).

Overall, aggregate and sectoral energy intensities remained fairly flat during the 12-year observation period through 2000. Only the transport sector energy intensity exhibited a significant decline, but only when approaching 2000.

The pattern of electricity intensity is rather different.[11] The electricity intensity of the commercial sector was increasing very fast at the rate of 5% per annum between 1980 and 2000, while those of the manufacturing and agriculture sectors remained rather constant. The trend of the aggregate (total final) electricity intensity follows that of the commercial sector (see Figure 9.16).

[11] Transport sector, particularly rail transit, only started to use electricity beginning in 2000.

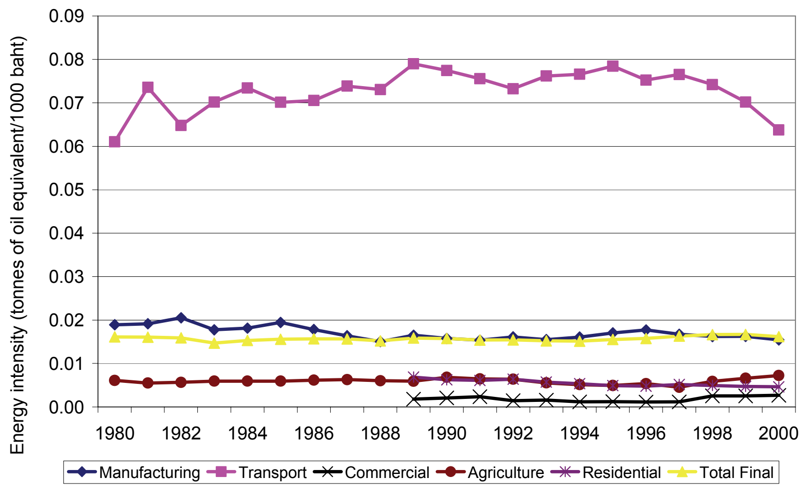

Figure 9.15: Total Final and Sectoral Energy Intensity (toe/1,000Baht constant 1988 prices)
Note: Residential energy intensity was calculated based on the total energy consumption of residential sector over total GDP at constant 1988 prices.

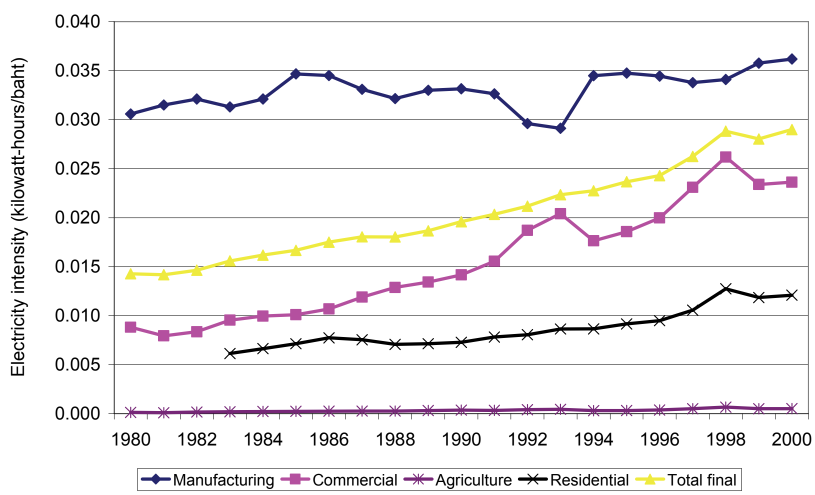

Figure 9.16: Total Final and Sectoral Electricity Intensity (kWh/Baht at constant 1988 prices)
Note: Residential electricity intensity was calculated using total GDP in constant prices.

9.6.7. Decomposition analysis of changes in aggregate energy intensities

Decomposition analysis is applied to the total or aggregate energy intensity to demonstrate the impact of structural changes on energy intensity and to separate the activity effect from structural and pure intensity effects. Activity effect refers to overall growth of the economy as measured by GDP; structural effect refers to changes in the structure of the economy, or the contributions of the main economic sectors; and pure energy intensity is the energy consumption to produce a certain value of output, or here expressed as toe per 1,000 Baht.

The structural effect measures variation in energy intensity brought about by changes in the structure of the economy. Some sectors require large amounts of energy to produce output. For example in the manufacturing sector, glass, cement, and iron and steel industries consume more energy than other industries to produce one unit of output. Other sectors, such as agriculture, are less energy intensive. A positive structural effect implies a structural shift to more energy intensive economic sectors like some manufacturing industries. It also means that the share of energy intensive sectors to GDP has increased compared to some base year. A negative structural effect indicates that the energy intensive sectors have decreased their share of GDP compared with that in the base year.

The pure energy intensity effect measures the improvement in energy efficiency, changes in technology, fuel mix changes, and other factors that are not related to activity or structure. A positive effect signifies a higher energy use per unit of GDP implying worsening energy efficiency, while a negative pure intensity effect indicates an improvement in energy use per unit of GDP.

Figure 9.19 shows the decomposition of changes in Thailand's aggregate energy consumption into activity, pure intensity and structural effects, and illustrates the advantages of disaggregating such components to isolate the main factors affecting the aggregate energy intensity.[12] The changes in energy use from year to year are depicted in the chart by the bars. The overall effect of these factors is captured by the changes in the aggregate energy intensity with respect to 1990 (1990=1.0) as shown by the intensity index represented by the curve.

The activity and structural effects held positive values all throughout the period, indicating the strong industrialization process of Thailand during this period and the shift of the economy towards more energy intensive sectors. In fact, during this period, the share of the manufacturing industry in GDP climbed sharply from 29% in 1990 to 36% in 2000. A closer examination of the structural changes in the manufacturing sector shows that the share of energy-intensive sectors increased from 20% to 27% in the same period. This is a typical pattern of energy use and efficiency for developing countries in the industrialization stage.

Pure intensity effect, on the other hand, maintained consistently negative values, indicating efficiency improvements with respect to the 1990 levels (the chosen base year) resulting from the very effective energy efficiency policies implemented by Thailand during the period. In fact, this effect explains, in part, the net 4% decline in aggregate energy intensity between 1990 and 1994. However, over the whole 1990-2000 period, the activity and structural effects dominated, leading to a net increase in aggregate energy intensity during this longer period.

9.6.8. Analysis of driving force indicators for energy efficiency under economic dimension

9.6.8.1. Population Growth, Urbanization and Employment

Thailand's total population was growing steadily at the rate of 1.4% per year in the last two decades and reached 62.4 million in 2000. Available data indicate that about 22% live in urban areas.

Metropolitan Bangkok, the national capital, is the most populous and most dense province of Thailand. It is estimated that Bangkok residents number more than 11 million (18% of total), equivalent to more than 7,000 persons per sq. km. In contrast, the largest and the second most populous province, Nakhon Ratchasima, has a population of less than three million (4.5% of total), or 130 persons per sq. km. Nonthaburi, the second most crowded province located 20 km north of Bangkok (also in the Central Region), is estimated to have a population density of 1,500 persons per sq. km.

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[12] The decomposition analysis is based on a Divisia Index approach. For more information on this approach, see APERC 2001; IAEA, et al., 2005, Annex 3; and Ang, B.W., 2004.

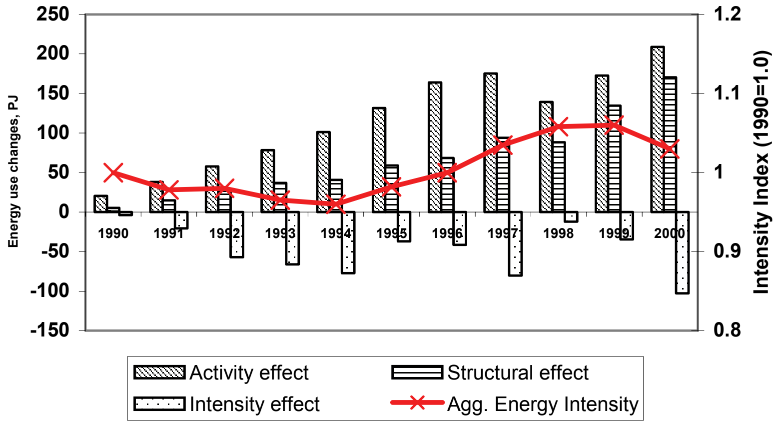

Figure 9.17: Decomposition of Aggregate Energy Intensity

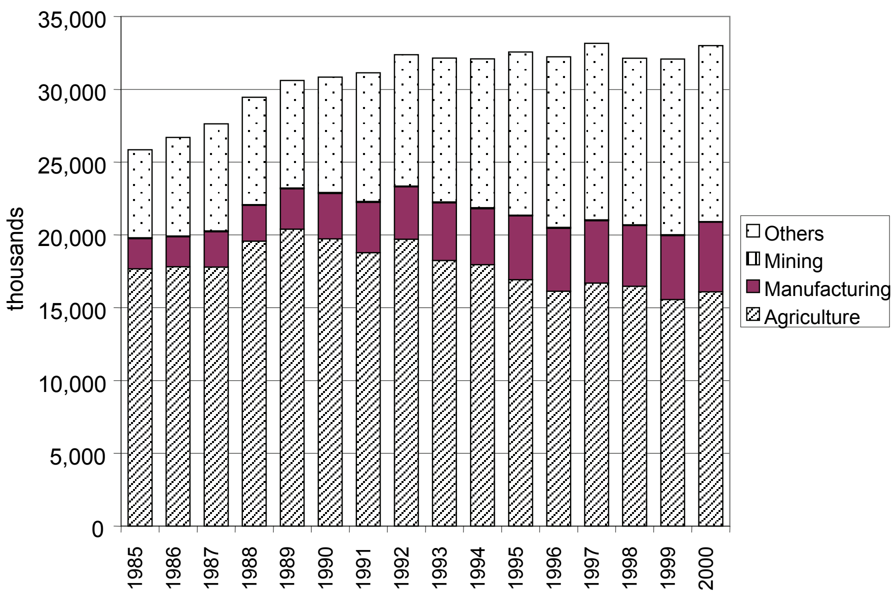

Figure 9.18: Structure of Employment

The economic boom in the late 1980s caused a rapid migration of the population from the provinces to Bangkok and nearby urban areas where industrial expansion was taking place. As a consequence, as shown in Figure 9.20, employment in the agriculture sector dropped to 49% (16.1 million) of those employed in 2000 from 68% (17.7 million) in 1985. On the other hand, those employed in the manufacturing sector increased by 2.7 million to 4.7 million in 2000, from 8% to 14.5% of those employed. The unemployment rate has been going down. Even though it deteriorated from a low of 1% to 3.4% in 1998 because of the financial crisis, it then improved to 1.8% in 2002 (see Figure 9.19).

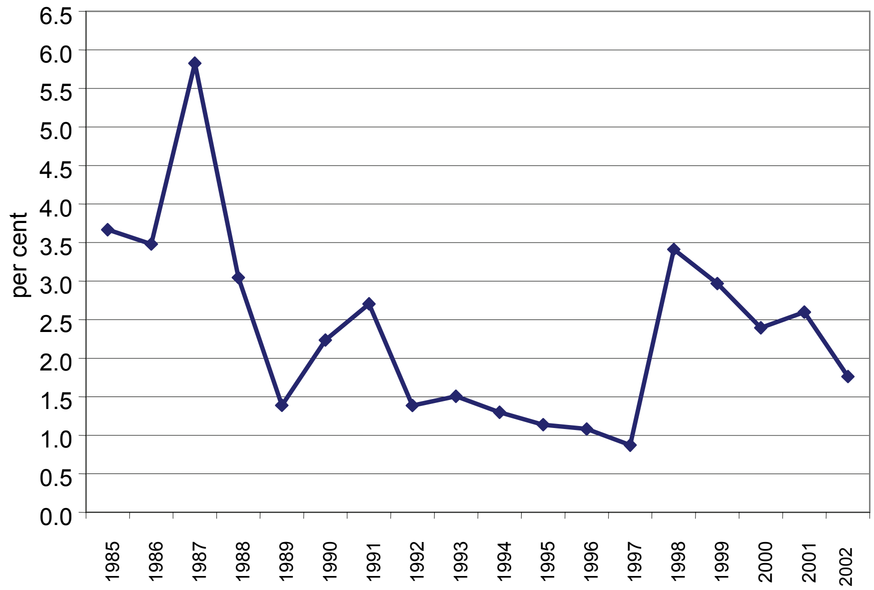

Figure 9.19: Unemployment Rate
Source of basic data: ADB, 2003.

9.6.8.2. Macroeconomic Structure and Performance

Thailand's economy experienced gradual but notable changes over the past two decades. The service sector has remained the largest contributor to the Thai economy, but its share decreased slightly from 45% in 1981 to 39% in 2000 (Figure 9.20). Manufacturing was catching up, with its share increasing from 23% in 1981 to 36% in 2000, more than any other sector. The manufacturing sector (primarily export-oriented industry) was at the forefront of Thailand's economic growth between 1985 and 1995, growth that was unprecedented in this part of the world and elsewhere. The 13.1% annual growth rate of the manufacturing sector during that period was responsible for the 9.5% annual GDP growth in the same period (Figure 9.23). The share of transport and communications also inched up from more than 7% in 1980 to almost 10% in 2000.

The growth in the manufacturing sector's contribution to GDP came at the expense of agriculture, whose share was halved from 20% to 10% between 1981 and 2000. Yet, the agriculture sector continues to provide inputs to food, beverages, and tobacco manufacturing that accounted for 16-19% of total manufacturing output during the pre-crisis years.

Having recovered from the financial crisis, Thailand expected its economy to grow by more than 8% in 2004[13], which is close to the average pre-crisis growth levels.

[13] 2004 GDP growth rate is 6.1%.

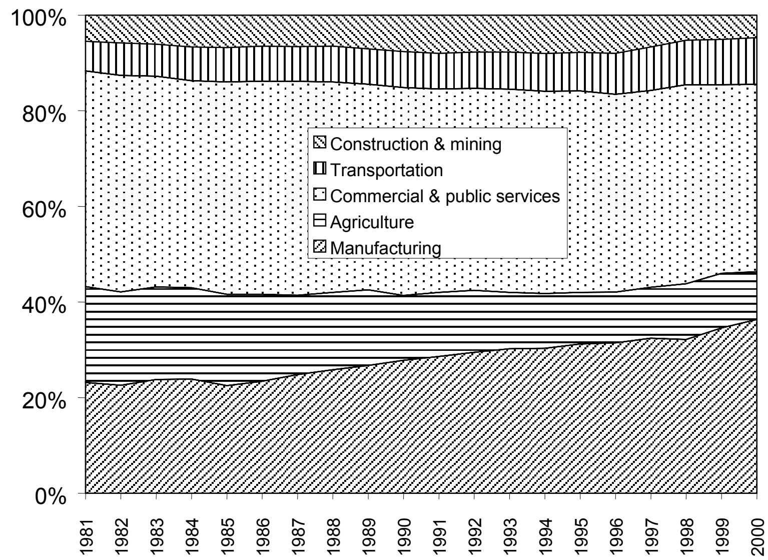

Figure 9.20: Sectoral Contribution to GDP

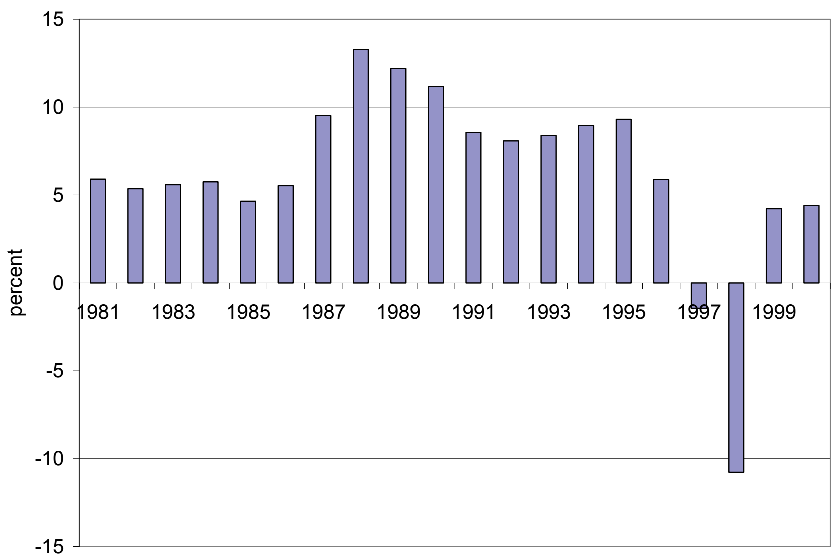

Figure 9.21: GDP Growth

9.6.8.3. Structure of Manufacturing Value Added of Energy Intensive Industries

Among the economic sectors, manufacturing plays an important role in the economy as it directly contributes to industrialization and creates linkages for the development of the other sectors (i.e., services and agriculture). To fully understand the patterns of energy consumption between energy and non-energy intensive manufacturing industries, it is also essential to identify the structure of the manufacturing industry.

In the manufacturing sector, the chemical industry remains the single biggest contributor to manufacturing value added. In fact, the industry's contribution to total manufacturing valued added increased from 15% in 1980 to 18% in 2000. The next biggest contributors after the chemical industry were non-metallic minerals, pulp and paper, and basic metals (iron and steel). Yet, more than 70% of the total value added of manufacturing came from other non-energy intensive industries (Figure 9.24).

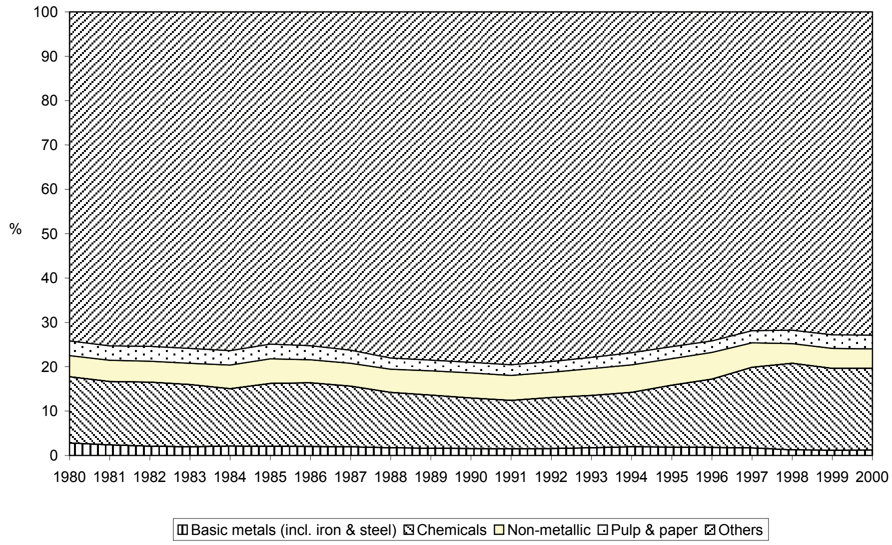

Figure 9.22: Structure of Manufacturing Value Added of Energy Intensive Industries

9.6.8.4. Energy Prices and Taxes[14]

Energy prices and taxes are essential policy tools to promote energy efficiency and conservation. For developed countries, energy prices can be used as a disincentive to increased energy consumption, while for the developing countries, there are concerns about energy affordability as well as incentives for energy conservation and efficiency improvement (IAEA/UN, 2002).

In Thailand, taxes were used as measures to promote energy efficiency and conservation. For example, a premium rate of about 0.04 Baht[15]/litre (adjusted from 0.01 beginning October 1998) is imposed on gasoline, diesel, kerosene and fuel oil. The revenues derived from the additional levies on petroleum products go to the Energy Conservation Promotion Fund (ENCON Fund) to support energy conservation projects in Thailand. Another example is the 5% tax reduction allowed on imported machines, materials, and equipment that can lead to the conservation of energy and protection of the environment.

Petroleum retail prices in Thailand generally increased annually between 1991[16] and 1999, from a low increasing annual rate of 0.26% for LPG cooking gas to a high of 6.47 % for heavy fuel oil (for industrial uses). (See Figure 9.25 to Figure 9.28) During the same period, taxes were highest for kerosene at 34% and lowest for heavy fuel oil at 16% of the total retail price. But, looking back during the late 1980s, the highest tax was levied on premium gasoline (95) reaching 52% in 1988 and from 42% to 50% in 1996 (Figure 9.25). The tax on premium gasoline was intended to discourage its use primarily due to concerns about the environment. Because of the government's drive to decrease pollution in the country, consumption of premium gasoline was actually discontinued after 1996. Unleaded gasoline (95), with competitive prices, was introduced in 1991 (Figure 9.26).

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[14] Petroleum prices used in this study are standard Bangkok retail prices. Retail price is the sum of the ex-refinery price (import price), excise and municipal taxes, the marketing margin, the Oil Fund contribution, the Energy Conservation Fund contribution, and value added tax (VAT). For this study, taxes include only ex-refinery excise taxes and municipal taxes, and for imported oil products, import duty is included. For electricity, electricity price is the average price charged to MEA and PEA customers. Prices exclude VAT. There are no available data for the complete structure of retail electricity prices (i.e., for the proportions of generation, transmission, and distribution costs).

[15] 1 Baht = 100 Satang; 1 US$ = ~43.5 Baht

[16] Beginning 19 August 1991, the oil market in Thailand was deregulated. The tax structure and several other regulations were revised with the aim of increasing competition in the domestic oil market.

The tax on kerosene was also very high in 1988, about 44% of the total retail price. It then began to decrease annually by more than 5%, dropping to as low as 22% by 2000 (Figure 9.25). The high tax levy for kerosene may be due also to the government's drive to discourage use of kerosene (especially in the residential sector), as its energy efficiency is very low. Kerosene is used for lighting and cooking in the residential sector, particularly in rural areas, and also for other uses in other sectors.

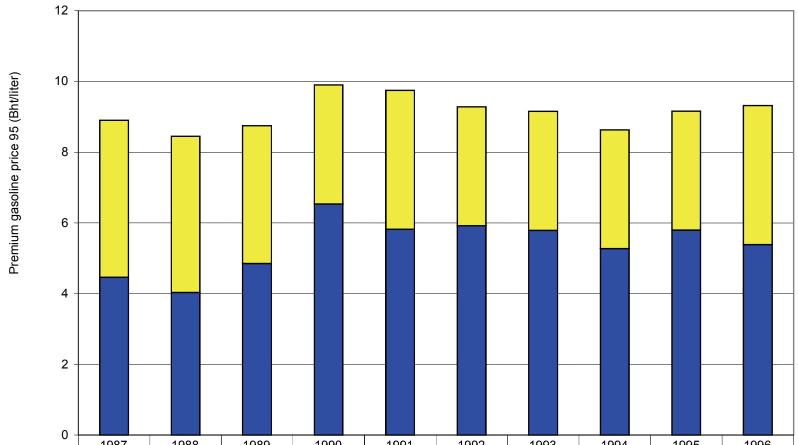
The annual average growth of the LPG retail price for cooking in the residential sector was only 0.3 % per annum between 1991 and 2000 (Figure 9.26). During the same period, pre-tax prices for the cooking gas also increased slightly by 1% per year, lowest among other petroleum prices such as heavy fuel oil (6.54%), ULG 95 (6.02%), kerosene (3.39%), and automotive diesel (2.94%). This was because LPG prices received a subsidy from the government at the rate of 1.40 Baht per kilogram. The government has deregulated the LPG market with the belief that energy use will be most effective and best adaptable to the changes in fuel prices without the price distortions caused by government subsidy. However, a certain level of subsidy is still maintained by the government at the present time for LPG prices[17], as it has a strong correlation with food prices that can affect the poor and become a political issue—and possibly fuel political uncertainty (Sajjakulnukit, 2001). Moreover, the low prices of LPG can encourage low-income households to shift to the more energy efficient cooking technologies.

Retail prices of heavy fuel oil for industrial uses also rose robustly at 6% per year between 1987 and 1999. The fast growth was induced mainly by the high taxes imposed for fuel oil. On the other hand, steam coal price for industrial uses is decreasing by more than 6% per year for the period 1980 to 1992 (recent data are not available).

Like the heavy fuel oil for industrial use, the retail prices of automotive diesel for commercial uses exhibited substantive growth of around 6% per annum (Figure 9.27). This growth, however, was brought about by increases in the pre-tax prices and not by taxes.

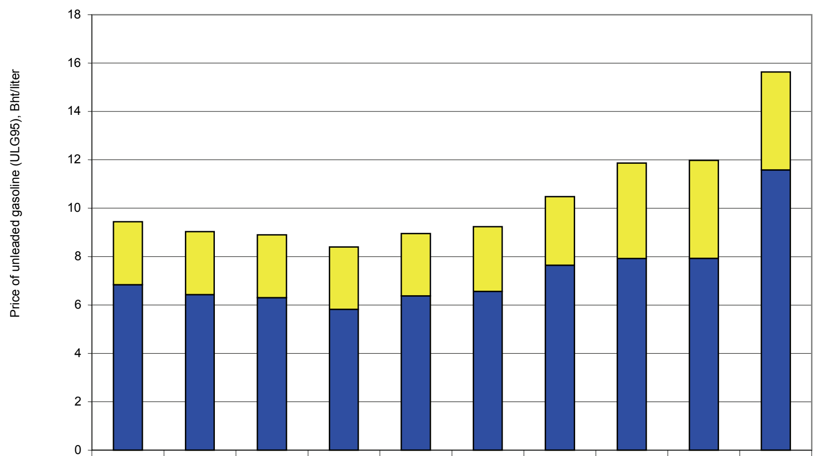
Meanwhile, average retail electricity prices in the country moved slowly up and down beginning in the early 1980s and continuing through the mid 1990s. The commercial sector maintained its highest prices from 1980 through 1993, but residential prices had a dramatic growth between 1994 and 2000, surpassing prices within the industrial and commercial sectors (Figure 9.28).

[17]The Thai government owed some two billion baht to the country's six oil refineries for selling LPG to the public at about 40% of its actual cost. The government controlled LPG prices at an artificially low level of about $125 per tonne, although the actual reference price on the world market had soared to $300 per tonne, resulting in oil refineries having to sell LPG to traders at $175 a tonne below cost. The heavy outflow from the Oil Fund amounted to nearly 1 billion baht a month. The Oil Fund, whose prime application is to subsidise local LPG prices, is sourced from levies imposed as part of the official pricing structure of oil products, especially petrol (Bangkok post 2000 Year-End Economic Review).



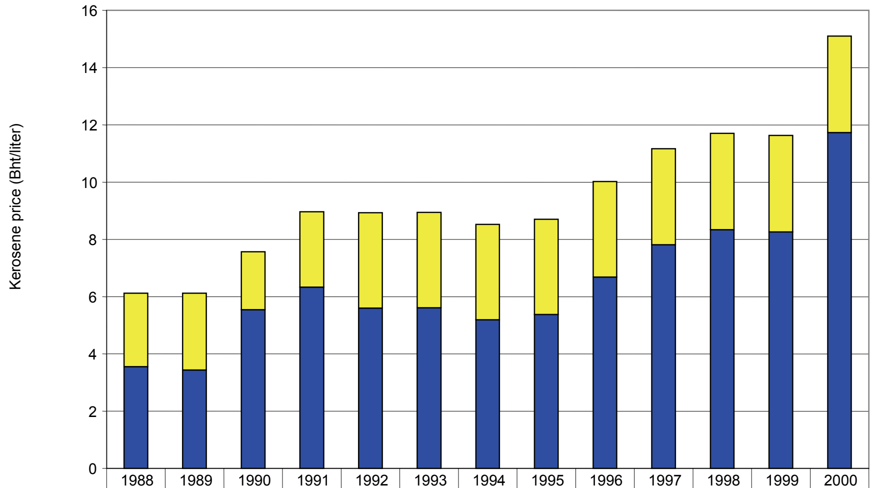
	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Tax	4.44	4.42	3.9	3.37	3.93	3.36	3.36	3.36	3.36	3.94
Pre tax	4.46	4.03	4.85	6.53	5.82	5.92	5.79	5.27	5.8	5.38

Figure 9.23: Retail Price and Tax for Premium Gasoline 95 (Transport Sector)



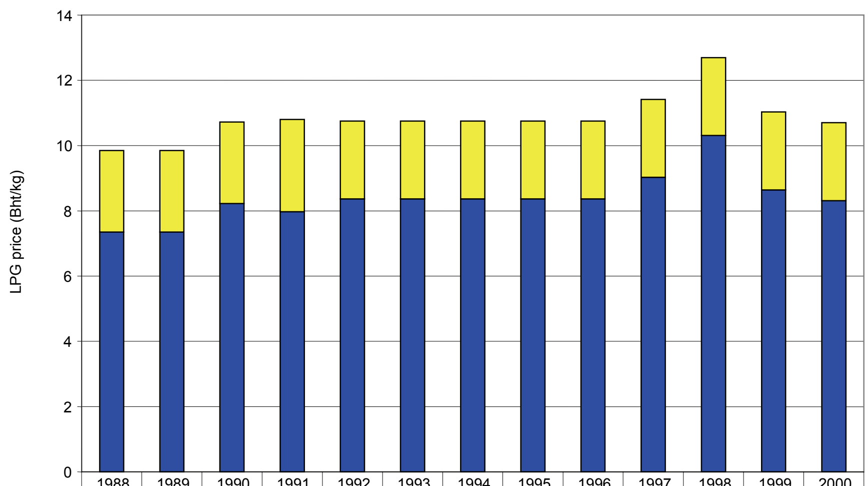
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Tax	2.6	2.6	2.6	2.58	2.58	2.68	2.84	3.94	4.0535	4.0535
Pre tax	6.84	6.43	6.3	5.82	6.37	6.56	7.64	7.92	7.9265	11.5765

Figure 9.24: Retail Price and Tax for Unleaded Gasoline 95 (Transport Sector)



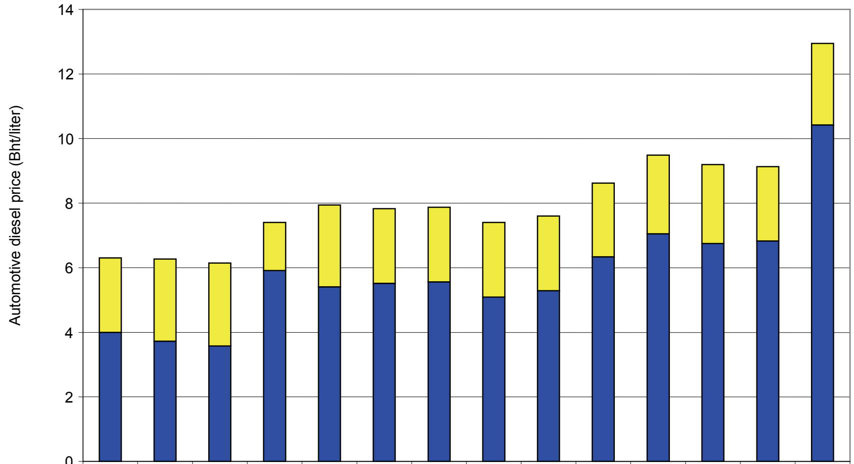
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Tax	2.56788	2.6815	2.025	2.63019	3.3325	3.3325	3.3325	3.3245	3.3325	3.35525	3.3655	3.3655	3.3655
Pre tax	3.55213	3.4385	5.545	6.32981	5.5975	5.6075	5.1875	5.3755	6.6875	7.81475	8.3345	8.2645	11.7345

Figure 9.25: Retail Price and Tax for Kerosene (Residential Sector)



	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Tax	2.5005	2.5005	2.5005	2.8275	2.3875	2.3875	2.3875	2.3874	2.3875	2.38745	2.392	2.38975	2.3875
Pre tax	7.3495	7.3495	8.2245	7.9725	8.3625	8.3625	8.3625	8.3626	8.3625	9.02255	10.308	8.64025	8.3125

Figure 9.26: Retail Price and Tax for LPG (Residential Sector)



	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Tax	2.3	2.54	2.57	1.49	2.53	2.31	2.31	2.31	2.31	2.28	2.44	2.44	2.3045	2.53
Pre tax	4	3.73	3.58	5.91	5.41	5.52	5.56	5.09	5.29	6.34	7.05	6.75	6.8255	10.42

Figure 9.27: Retail Price and Tax for Automotive Diesel (Commercial Sector)

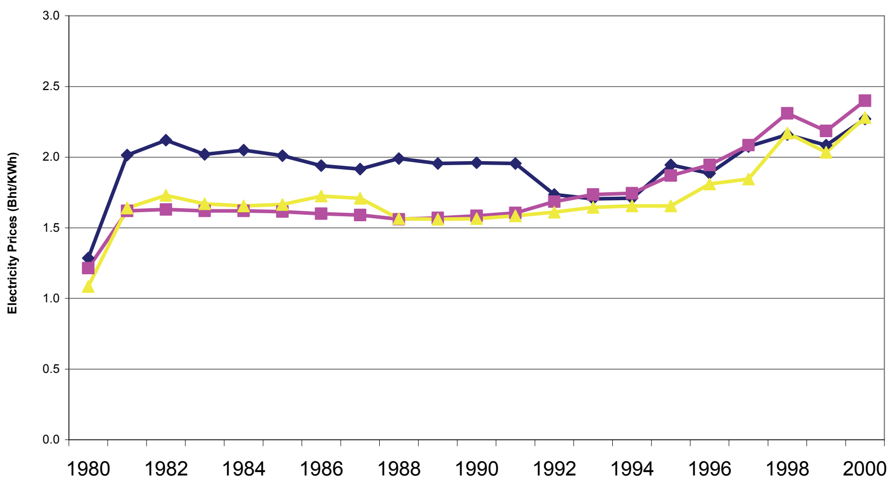


Figure 9.28: Sectoral Average Electricity Prices (Baht/kWh)

9.6.8.5. Car and Motorcycle Ownership

The actual size and composition of private vehicle stock such as cars and motorcycles has a big influence on the transport energy consumption level. Private cars, for example, are the most energy intensive mode of transport. An uncontrolled growth of cars causes traffic congestion and over-consumption of energy, as there are more vehicles required to move people than if large buses were used. Thus, policies that favour public or mass over motorized private transport vehicles can significantly reduce energy intensity levels.

The stock of cars increased tremendously as a result of increasing purchasing power that, in turn, was due to the rapid economic growth experienced by Thailand in the late 1980s to mid-1990s.[18] Indeed, the car ownership ratio more than quadrupled, from 126 persons per car in 1983 to 30 persons per car in 2000. This yielded a total vehicle car stock of around 2.3 million cars in 2000 (Table 9.9).

TABLE 9.9: CAR AND MOTORCYCLE OWNERSHIP (PERSONS PER STOCK)

	1983	1985	1990	1995	2000
Car ownership per capita (persons/car)	125.86	95.78	71.83	42.92	29.56
Motorcycle ownership per capita (persons/motorcycle)	28.81	28.29	11.69	6.38	4.52

Source: Vehicle stock - Ministry of Transport and Communications Annual Statistics Report 1990-2000; Population: ADB Key Indicators 2000

On the other hand, the stock of motorcycles in 2000 was almost seven times larger than the stock of cars, totalling 15.2 million in 2000 and translating to an ownership ratio of 4.5 persons per motorcycle. Further, the growth of motorcycles in Thailand also outperformed car growth rate between 1983 and 2000. The former grew by an average of more than 13% per annum, while the latter increased by 10% annually. Motorcycles are indeed very popular in Thailand; they are very affordable and can prevail over the usually heavy traffic. They are also used as taxis, and thus provide a source of livelihood for many low-income households in Bangkok.

The slowdown in the increase in vehicle stock in 1997-2000 may be due to the excise tax increase of 5 percent on *all* types of road vehicles in 1997 (*The Nation*, 1997), as well as to the financial crisis.

9.6.8.6. Modal Structure of Road Vehicle Stock

Transport energy consumption is linked to the corresponding dominant transport type. Hence, it is important to distinguish between vehicle types or mode of transport and whether these are used for passenger or goods transport, as the respective dynamics are very different. For passenger transport, it is also essential to categorize them by mode as the structure of the transport has a decisive influence on the level of energy consumption. For example, road and rail public transport are less energy intensive than cars.

The structure of vehicle stocks in Thailand showed that over the years, passenger vehicles continue to dominate Thailand's road transport system. Around 97% of the country's total vehicle stocks are passenger vehicles and only 3% are freight vehicles (Table 9.10). Among the country's passenger vehicle stocks, motorcycle vehicles have held an overwhelming proportion, averaging more than 70% of the total stocks. This gives an amount of 15.3 million motorcycles in year 2001 from just 1.7 million eighteen years ago, equivalent to an annual escalation rate of more than 13%. Vans and pick-ups followed well behind, accounting for 15.3% in 2001, up from 14% in 1983.[19] Meanwhile, the average share of sedan cars was around 12% and that of the bus fleet 3% of total road passenger transports (Figure 9.29).

In addition, it can be observed that there are changes in the structure of passenger transports. Stocks of motorcycles, vans and pick-ups increased at the expense of cars, buses and other passenger transports. The share of motorcycles increased from 62% in 1983 to around 70% in 2001, while vans and pick-ups grew slightly by 1.44 percentage points from a share of 13.8% during the same period.

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[18] One should add to these reasons the Thai's penchant for cars, as well as the easy financing terms to own a car.

[19] Note, however, that in Thailand, pick-ups are used for two purposes: for freight and passenger pick-ups. Passenger pick-ups, mainly called "Songthaew", are pick-ups modified in such a way that they allow for passenger transport instead of freight transport. These pick-up vehicles run on fixed routes where other means of public transport (i.e., buses) are insufficient or not available. However, they can also be hired directly like a shared taxi. This would obviously bring about a quite different usage pattern for the pick-up fleet. However, the national vehicle registration data do not differentiate between pick-ups for freight transport and pick-ups for passenger transport.

TABLE 9.10: SHARE OF PASSENGER AND FREIGHT VEHICLES (%)

	1983	1985	1990	1995	2000
Passenger cars	93.11	93.13	95.35	96.28	96.76
Freight vehicles	6.89	6.87	4.65	3.72	3.24

Source: Ministry of Transport and Communications Annual Statistics Report 1990-2000

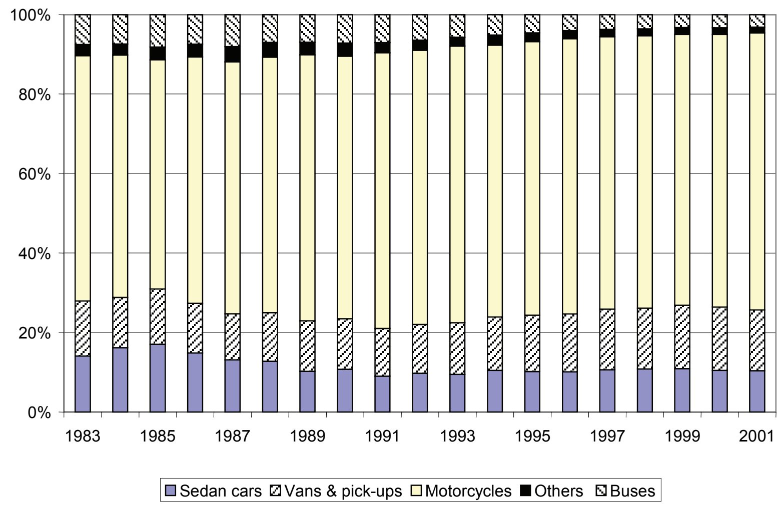

Figure 9.29: Modal Structure of Road Passenger Vehicles

Several mass rail transit system projects in Thailand are under construction or under implementation.[20] These projects are envisioned to form the basic core of a modern rapid transit network for the Bangkok Metropolitan Area. For example, the underground (subway) mass transit rail system has been formulated as four planned projects, eventually totalling 81 km: (1) the MRT Blue Line Hua Lamphong - Bang Sue, 20 km; (2) Blue Line North Extension: Red Line Bang Sue- Tha Phra , 13 km; (3) Blue Line South Extension: Brown Line Hua Lamphong - Bang Kae, 14 km; and (4) Orange Line Phase I Project, 35 km. The underground mass transit system is projected to service 400,000 commuters a day. The Blue Line had been initially planned to operate by December 2002 but was delayed due to technical and financial issues. It finally opened to the public on 3 July 2004. The Orange Line is now planned for the Bangkapi – Bang Bamru route totaling 24 km. Another line will extend from Bang Yai to Rat Burana, totalling 40 km. Thus, the currently operating Hua Lamphong – Bang Sue line will be extended by another 91 km, and this is planned over a period of six years.[21]

It is, therefore, expected that in the near future, once all the mass transit projects are completed, significant passenger diversions would take place. Some passengers will divert to rail transit, which will form the base load of the future mass transit systems. Riders are envisaged to pay a slightly higher fare for a premium service. However, it is not expected that the mass transit systems will completely eliminate the traffic congestion, as the majority of private car owners will probably continue to use their cars. [22] However, the diversion rate from private cars is expected to gradually rise as extensions of the mass transit system are brought on-line. Nevertheless, even with the full network of the mass transit systems in place, private car ownership will not significantly decline, as people would continue

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[20] In fact, seventeen major infrastructure projects, worth 313 billion baht, mostly highway and railway projects, have been suspended over the past two to three years because of national budget constraints (Bangkok Post, 2002).

[21] Source: Mass Rapid Transit Authority of Thailand as quoted in "Surveys start for subway extension," Bangkok Post, 2004.

[22] It has been estimated that the first opened line of the subway systems would not significantly improve traffic congestion in Bangkok.

to use cars occasionally for weekend or special trips. Moreover, people will continue to put a high social value on cars. Who would want to abandon the comfort, convenience, and status symbol of owning a car!

9.6.8.7. Freight Transport Activity

Freight activity is linked with the country's overall industrial production activity, and is thus associated with industrial gross value added. Increases in freight activity will also increase the level of transport energy consumption.

Thailand's freight transport activity rose 8% per year between 1992 and 1997 (Figure 9.30). The freight transported consisted mostly of agricultural products (46%) and non-metallic minerals (24%), with the remainder including chemicals, wood and other products. The principal vehicle used to transport these products is the truck, accounting for almost 89.4% of the country's total freight ton-km in 1997. Other products are transported through inland water (6.5%) and by train (more than 4%). Domestic airfreight contributed a very minimal portion (0.04%) of total freight ton-km (Figure 9.33).

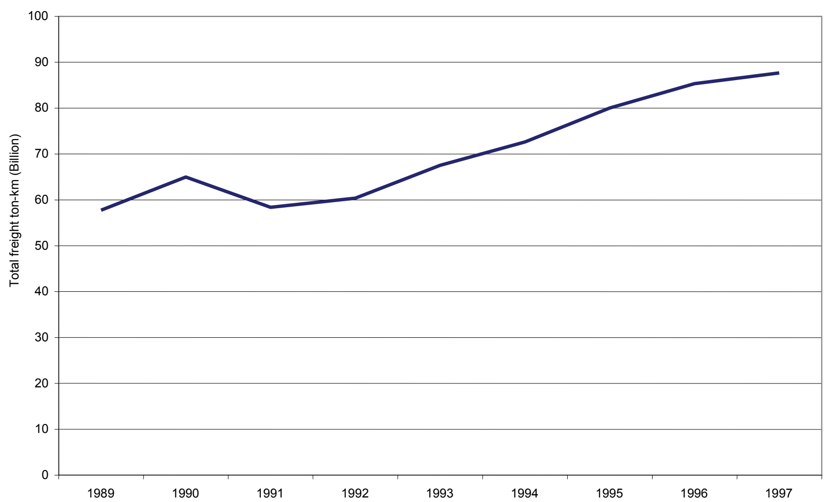

Figure 9.30: Freight Transport Activity

9.6.8.8. Floor Area per Capita

Service sector floor area per employee measures how many square meters each person utilizes. In this study, the floor area used refers to commercial building areas while the population refers to employee population. The only available data are 1985-1995. There are no available data for the residential sector.

The ratio of floor area to employee population in the service sector increased remarkably during the said period, from only 0.35 in 1985 to 1.5 in 1995 or by 15% growth rate per year (Figure 9.32).

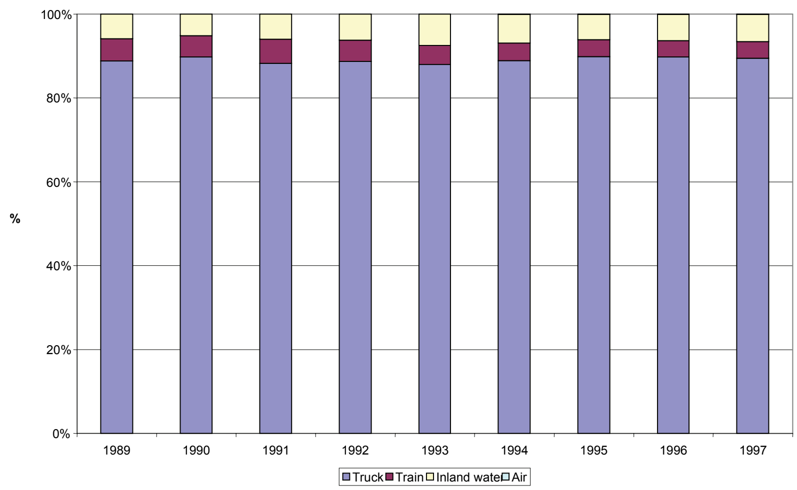

Figure 9.31: Modal Structure for Freight Transport Vehicles

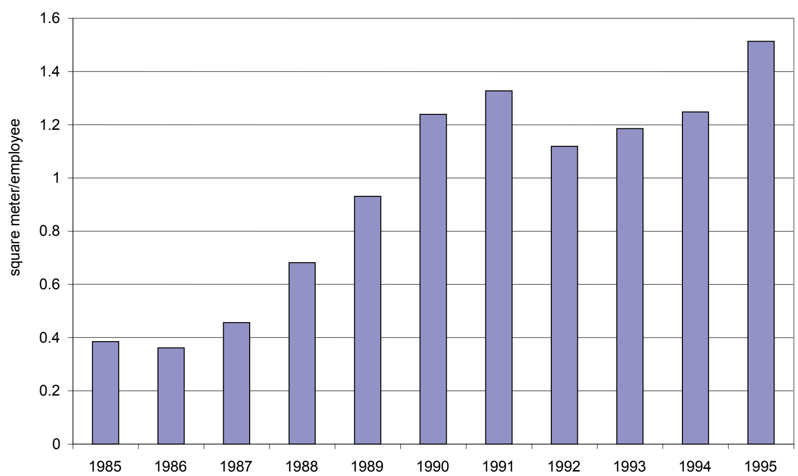

Figure 9.32: Floor Area per Capita

9.7. The Social Dimension

9.7.1. The state of social dimension

The state indicators under the social dimension contribute to the evolution of residential energy intensity. Consider the following facts for Thailand:

- Biomass is an essential energy commodity in the residential sector. Biomass use (mainly traditional fuels such as fuelwood and charcoal) accounts for a large portion of total residential energy consumption, amounting to 65.6% or around 5 Mtoe in 2000; and
- Around three million households in Thailand, based on DEDE (Department of Alternative Energy Development and Efficiency) statistics, had not been electrified as of 2000. These households continued to rely on traditional fuels for their energy needs, in particular heating for cooking that accounts for around 60% of end-use energy consumption in households.

There are two ways to improve energy efficiency in the households: (1) *fuel substitution*, which means, for example, moving away from less efficient biomass fuels to more efficient electric and LPG stoves for cooking (efficiency for fuelwood stoves ranges from 5% to 15% and for charcoal stoves from 20% to 27%) or switching from kerosene lighting to electric lamps; and (2) *improvement of equipment,* such as choosing more efficient cooking stoves or switching to more efficient lighting. For Thailand, there has been a shift toward the use of more efficient fuels in lieu of traditional fuels, as described in the following section. Further, the government has financially supported the improvement of cooking stoves. In fact, the efficiency of fuelwood stoves has improved to about 20% and charcoal stoves to about 34% as a result of these efforts (Sajjakulnukit, 2001).

9.7.2. Dependence on traditional energy

The information on the structure of household energy consumption is based upon socio-economic surveys published every two years by the National Statistical Office of Thailand. The survey focuses primarily on cooking methods used by various households in Thailand. This is because cooking is the dominant household energy activity.

TABLE 9.11 shows the country's household structure in terms of various types of cooking carriers. The figure shows that the relative importance of traditional cooking fuels among households has decreased substantially. In 1981, the percentage of households using traditional fuels for cooking was very high, at around 90% of total household population. By 2000, the share significantly dropped by more than half to 38.2%. Conversely, the share of households using modern fuels for cooking jumped from just around 10% in 1981 to 62% in 2000. Among households, the share of LPG stove users increased significantly over the years, from 6.6% in 1981 to around 58% in 2000. Where LPG is readily available or widespread and household income is also sufficient, the situation has encouraged the shift of households from wood or charcoal to LPG stoves. Aside from this, the government continues to subsidize LPG prices. A preference for more convenience has also contributed to the fuel switching.

Yet, the overall structure of energy consumption in the residential sector conveys a rather different message. Fuelwood and charcoal continue to dominate (Table 9.11). In 2000, these biomass fuels accounted for about 65% of the total energy consumption of the residential sector. The main reason behind this seemingly contradictory information is that in many rural areas of the country, biomass energy use in small household businesses and home-based livestock production (for example cooking animal feeds) is reported under total household energy use rather than under industrial or agriculture sectors.

TABLE 9.11: HOUSEHOLD STRUCTURE FOR COOKING (%)

% of Households	1981	1986	1988	1990	1992	1994	1996	1998	2000
Modern fuel	9.60	18.00	22.70	30.00	38.00	47.70	58.70	58.40	61.80
Kerosene	0.30	0.10	0.10	0.20	0.20	0.30	0.30	0.20	0.20
Gas	6.60	15.00	19.90	26.60	33.50	43.40	54.70	54.90	58.10
Electricity	2.70	2.90	2.70	3.20	4.30	4.00	3.70	3.30	3.50
Traditional fuels	90.40	82.00	77.30	70.00	62.00	52.30	41.30	41.60	38.20
Charcoal	41.90	43.70	38.10	34.30	29.80	25.70	19.10	19.50	15.30
Wood	43.90	34.00	34.00	31.20	27.80	21.50	17.10	16.80	17.90
Others	2.20	1.00	0.80	0.50	0.40	0.30	0.20	0.20	0.10

Source: NSO Household Socio-economic Survey (various editions)

9.7.3. Electricity Access

The majority of the households in Thailand is already electrified or has access to electricity. In 2000, of the total 16.25 million households in the country, about 13.19 million were electrified (Figure 9.33). In fact, the proportion of electrified households in the country has risen to 82% in 2000 from 68% in 1989. All of the villages in the country already have access to electricity supply, demonstrating the successful electrification program of the Thai government.

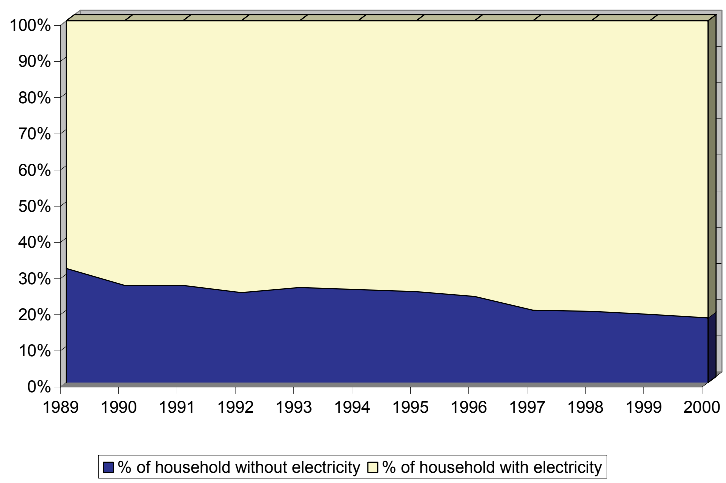

Figure 9.33: Share of Households With and Without Electricity in the Country
Source: DEDP, various issues

Focusing on the rural electrification program[23] in the country, between 1980 and 2000, some 430,000 households were being electrified every year, increasing the number of residential electricity connections from 1.85 million in 1980 to 10.44 million in 2000 (Figure 9.34). Households consuming less than 150 kWh dominate in the rural areas, but their share decreased from 89% in 1988 to 76% in 2000 (Figure 9.35).

[23] Rural areas or provincial areas mentioned here are those areas outside the Greater Bangkok Metropolitan Area.

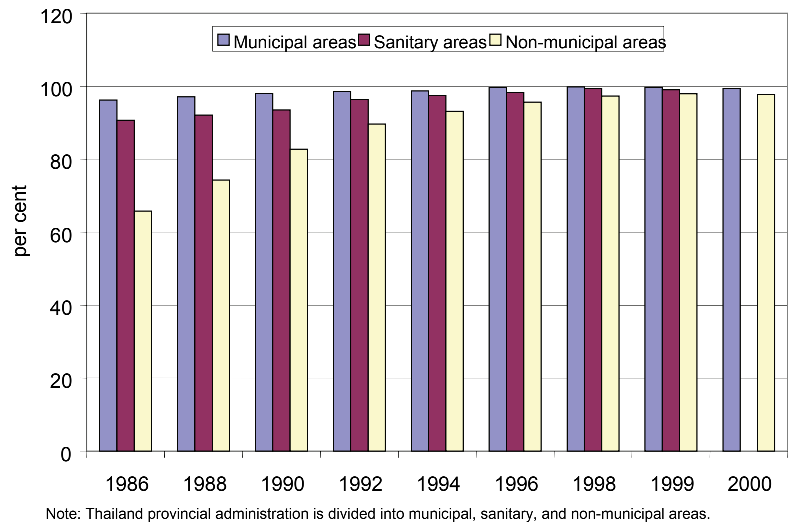

Figure 9.34: Electricity Access in Rural Areas
Note: In late 1990s, non-municipal areas and sanitary areas were combined together.
Source of basic data: NSO

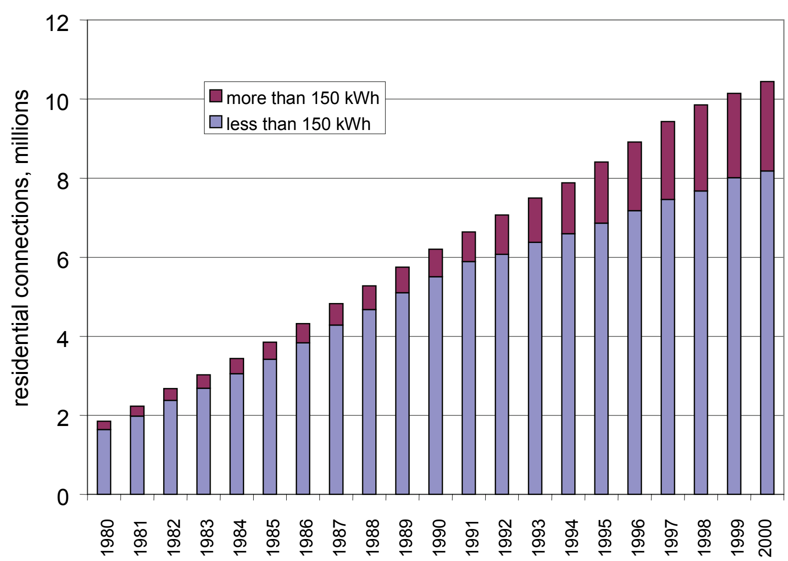

Figure 9.35: Growth in Residential Connections
Source of basic data: PEA

9.7.4. The driving forces under socio economic dimension

9.7.4.1. Daily Fuel Consumption per Capita of 20% Poorest Household Population

Daily consumption of electricity of the poorest 20% population (per household and per capita) in Thailand has been increasing over the years. Electricity consumption of households based on their daily disposable income and average prices of electricity increased by more than 6% per year from around 23 kWh/day/hh in 1986 to more than 43 kWh/day/hh in 1996 (Table 9.12). Similarly, daily electricity used per capita grew at the same rate of more than 6%, from 6.9 kWh/day/capita to almost 13 kWh/day/capita during the same period. However, beginning in mid-1997 to 2000, daily use of electricity per household and per capita began to decrease largely due to the financial crisis.

TABLE 9.12: DAILY CONSUMPTION OF FUELS OF THE POOREST 20% POPULATION PER HOUSEHOLD AND PER CAPITA

	1986	1988	1990	1992	1994	1996	1998	2000
Electricity KWh per hh	23.31	26.62	31.76	35.95	41.28	43.22	35.83	35.58
KWh per capita	6.89	7.55	8.30	11.16	12.13	12.81	12.46	11.21
LPG								
Gj/day/hh	0.20	0.21	0.24	0.28	0.34	0.39	0.33	0.40
Gj/day/capita	0.06	0.06	0.06	0.09	0.10	0.12	0.11	0.13
Kerosene								
Liters/day/hh		6.79	6.65	6.78	8.45	8.39	7.07	5.66
Liters/day/capita		1.92	1.74	2.11	2.49	2.49	2.46	1.78

Source: NSO Household Socio-economic Survey (various editions)

Daily use of LPG for heating and cooking for the poorest 20% population grew faster than electricity. From 1986 to 1996, consumption of LPG per household and per capita increased annually at the rate of around 7% (Table 9.12).

While the use of electricity and LPG by the 20% poorest population in the country has been growing in recent years, the trend for kerosene consumption has fluctuated. For example, between 1988 and 1990, daily consumption of kerosene of the poorest 20% household declined from 6.79 liters/day/hh to 6.65 liters/day/hh. Daily consumption of kerosene then began rising, but after 1994, it began to fall and continued falling through the year 2000 (Table 9.12). The decreased consumption of kerosene may have been brought about by the shift to other fuels (or technologies) by households belonging to the 20% poorest population in the country.

9.7.4.2. Fraction of Disposable Income/Private Consumption Spent on Fuel and Electricity

The share of disposable income paid for fuel and electricity by (a) the average population per capita, and (b) the poorest 20% population per capita were found to be in very close range over the years. Based upon available statistics, the ratio has been between 3.63% and 4.36% for average population, while for the group of poorest 20% population the share has been between 5.05% and 5.76% (Figure 9.38.

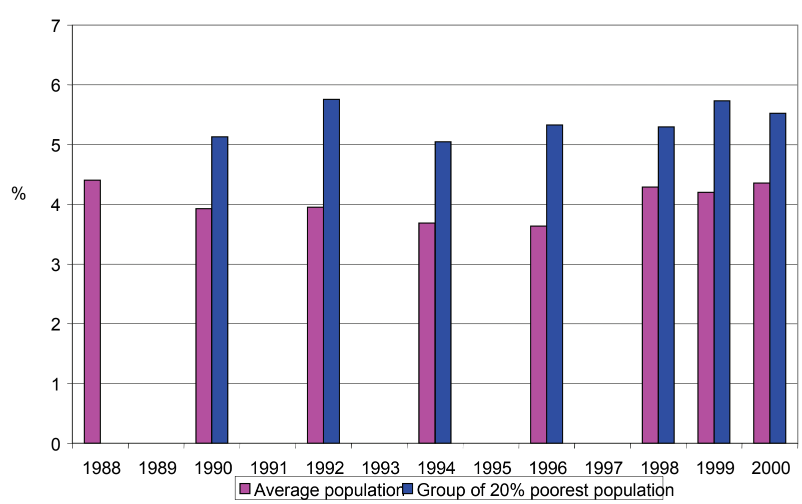

Figure 9.36: Fraction of Disposable Income Spent on Fuel and Electricity to Total Private Consumption

9.8. The Environmental Dimension

9.8.1. The state indicator: ambient concentration of pollutants in urban areas

Figure 9.39 shows that the concentration of carbon monoxide (CO), largely from vehicles, in the urban areas of Thailand has been kept around 1 part per million (ppm). On the other hand, the quantity of total suspended particulates matter (TSP), has changed rather erratically, but the overall trend has been going down. For example, measured in terms of roadside air quality, the TSP in Thailand's urban areas started from a high of 3.2 mg/m^3 in 1992 and went down to a low of 0.5 mg/m^3 in 2000. Meanwhile, the TSP measured in terms of ambient air quality also came down from 0.49 mg/m^3 to 0.34 mg/m^3 during the same period.

9.8.2. The driving forces

9.8.2.1. Quantities of Green House Gas Emissions

Carbon dioxide (CO_2) is the main contributor to the country's greenhouse gas (GHG) emissions. In 2000, its share of total GHG emissions stood at 96.1%, amounting to 81.6 million tons, even though its quantity has declined annually by almost 1% between 1990 and 2000. Among other pollutants, methane (CH_4) has grown substantially, registering an annual growth of more than 10% per annum. Its share is almost negligible, however, at about 0.1% of total emissions. The quantity of other pollutants such as carbon monoxide (CO), sulfur dioxide (SO_2), and nitrogen oxide (NOx) went down due to more stringent measures by the government (Table 9.13). Some of the measures include: requirements for installation of catalytic converters; fuel reformulation by limiting the content of some chemicals (e.g., benzene, aromatics and sulphur) by a certain percentage; emission standards for new vehicles using a national or international reference standard; an inspection and maintenance program and roadside inspection; traffic management and the reduction of vehicle kilometre travelled; and other measures such as use of cleaner alternative fuels, including LPG and natural gas.

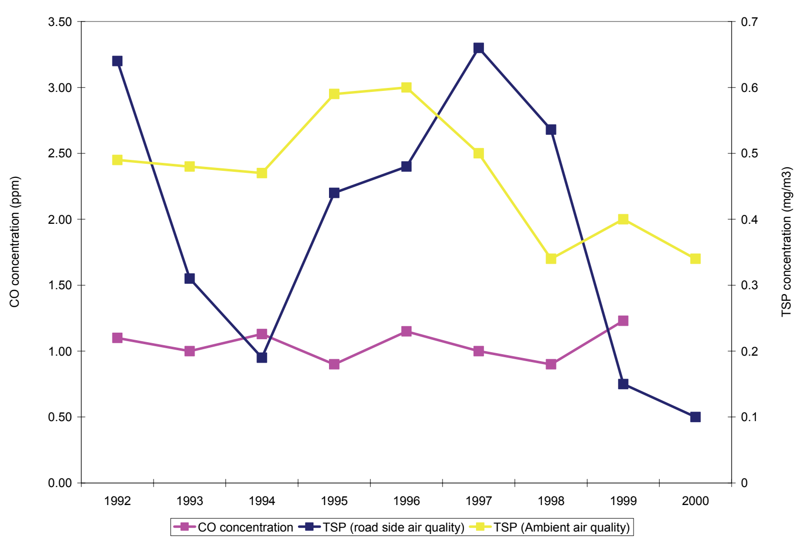

Figure 9.37: Ambient Concentration of Pollutants in Urban Areas

TABLE 9.13: ANNUAL GROWTH RATE OF POLLUTANTS BETWEEN 1990 AND 2000

Pollutants	Annual Growth Rate (%)
Carbon dioxide (CO_2)	-0.75
Carbon monoxide (CO)	-5.52
Nitrogen oxides (NOx)	-1.34
Methane (CH_4)	10.16
Sulfur dioxide (SO_2)	-3.70
Total Suspended Particulates matter (TSP)	4.62

The transport sector is responsible for more than half (57%) of total CO_2 emissions, or about 46 million tons in 2000 (Figure 9.38). Road transport is obviously the primary contributor, as it is the largest energy consumer among all modes of transport. Further, manufacturing contributed more than one third of total CO_2 emissions, while the remaining 5.3% came from the residential and commercial sectors.

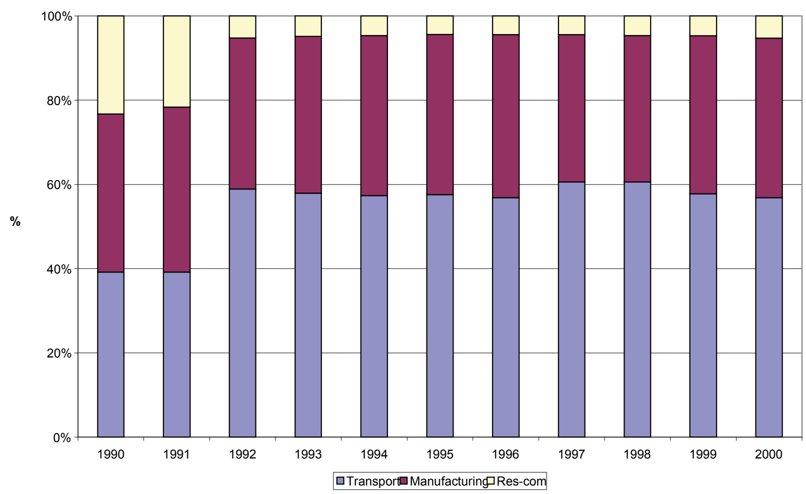

Figure 9.38: Sectoral Share to Total CO_2 Emissions

9.8.2.2. Carbon Dioxide Intensity

CO_2 emissions are directly linked with energy consumption in the various sectors of the economy. Any increase in energy consumption to produce an output will lead to higher emissions if fossil fuels are used. This is especially true for energy intensive industries that require more energy when production is expanded. Energy efficiency improvements are thus an important tool for mitigating greenhouse gas emissions.

Carbon dioxide intensity is the ratio of the sector's CO_2 emissions to its gross value-added or GDP. Figure 9.39 compares the evolution of carbon dioxide intensity in the transport, manufacturing, and combined residential and commercial sectors. It shows clearly the impact of the financial crisis on CO_2 intensity of the transport and manufacturing sectors. CO_2 intensity of the residential and commercial sectors continued to rise, even during the crisis period, despite a decline in the residential sector, because of the strong demand from the commercial sector. Notwithstanding, trends in CO_2 emissions remain strongly correlated with GDP or GVA, as with energy consumption.

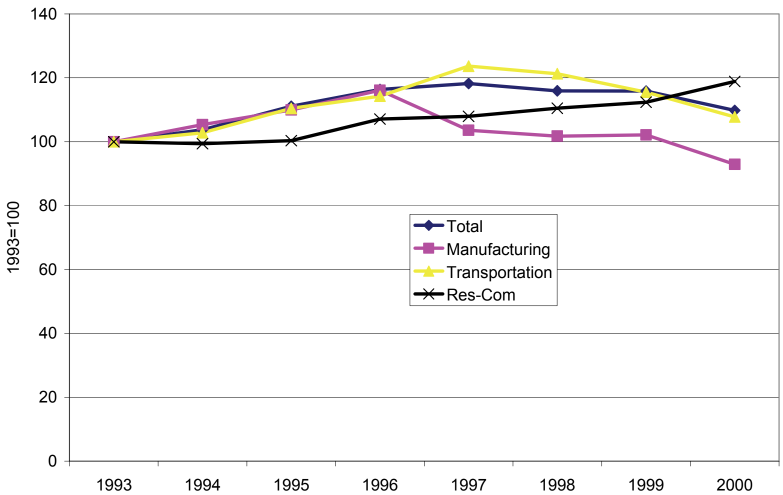

Figure 9.39: Trends in Sectoral CO_2 Intensity

9.9. Policy Response: Strategic Plan for Energy Efficiency

Thailand has targeted a reduction in the country's energy elasticity from the current 1.4:1 to 1:1 by 2007 and consequently a reduction in national energy expenditures by 3.1 trillion baht (77.5 million USD) in 2007-2017.[24] In order to achieve this target, energy efficiency measures have been established for the transport and industrial sectors which combined contributed 73% of final energy demand in 2000.

In Thailand, almost 80% of energy consumption in the transport sector is accounted for by land transportation, of which 78.6% is road transport and the remaining by rail (see Table 9.14). With the growing number of cars each year, passengers using mass transportation in Bangkok and its vicinities decreased from 1,224 million in 1997 to 938 million in 2001. The number of passengers using inter-province buses also dropped from 12.6 million in 1997 to 10.8 million in 2001. Similarly, train passenger numbers dropped from 64.9 million to 56.7 million in the same period. Thus, measures to promote energy efficiency in the transport sector focus on the development of the mass transportation system, including:

- Switching the mode of transport, for both passengers and freight, from cars and light trucks (pick-ups) to the rail system. In Bangkok and its vicinities, the rail system and other forms of mass transport will be developed. In the provinces, investment will be made in dual-rail tracks.
- Developing efficient networks of multimodal transport. Towards this end, the networks of the transportation system (both land and waterway) and the nationwide depot system will be improved, including oil transport via the oil pipeline networks.
- Promoting the use of energy efficient vehicles.
- Using the town and country planning system in determining goods transport routes.
- Introducing tax or fiscal measures to induce energy conservation in the transportation sector.

[24] EPPO, 2003.

TABLE 9.14: ENERGY DEMAND IN THE TRANSPORT SECTOR

Transport mode	Energy demand (ktoe)	Share(%)
Land	14,743	79.1
Road	14,638	78.6
Rail	105	0.5
Water	851	4.6
Domestic	57	0.3
Overseas	794	4.3
Air	3,038	16.3
Domestic	307	1.6
Overseas	2,731	14.7

Source: EPPO, 2003.

Sources of capital for such measures include investments from the private sector, the public sector and various energy funds (e.g., the Oil Fund, the Energy Conservation Promotion Fund, etc.).

The Ministry of Transport, the Ministry of Finance, the Ministry of Energy and the Office of the National Economic and Social Development Board (NESDB) will jointly study and accelerate joint ventures in the integration of the rail system, coastal navigation and the logistics networks, together with efficient town and country planning. The same agencies will also jointly review the transportation infrastructure, with to the intention of increasing energy efficiency within the sector.

The following measures will be implemented for the industrial sector:

- The Ministry of Industry, the Ministry of Finance, the Ministry of Energy, the National Competitiveness Committee (NCC) and the NESDB will jointly determine measures and accelerate industrial structure reform to enhance the competitive edge of the country. They will also review the investment promotion policy, attaching greater importance to energy aspects and economic value.
- The Ministry of Finance will devise tax measures to promote energy conservation in factories and goods transportation. Consideration will be given to exemptions of juridical body income tax for the profits gained from auditable energy savings. Interested industries can submit a petition for tax exemptions and apply for energy conservation plan development on a voluntary basis.
- The Ministry of Industry and the Ministry of Energy are to jointly speed up the implementation of the following:
    - enforcement of the Minimum Energy Performance Standards (MEPS) for electrical appliances and energy-efficiency labeling for cars;
    - establishment of the Energy Conservation Certification for factories; and
    - promotion of energy production systems with efficient combined use of energy, such as co-generation systems in the industrial estates and district heating/cooling systems.

9.10. Summary and Conclusions

The Indicators for Sustainable Energy Development (ISED) have proven to be a useful framework for analyzing the performance of the energy sector in Thailand, in particular with respect to energy efficiency and conservation. It does so in all three dimensions of sustainable development. The framework identifies the main driving variables, the interrelationships among economic and social state indicators and their consequences on the state of the environment, and finally the institutional response that serves as the main denominator affecting all three dimensions. Nonetheless, a few additional indicators were also derived in this study to analyze the state of energy efficiency within the country.

This section summarizes the progress of Thailand towards sustainable development in the economic, social, and environmental dimensions, as well the contributions and performance of the energy sector using ISED and a few derived indicators. The summary uses a radar diagram to track the movement of indicators between 1990, the chosen base year just before the implementation of the national Energy Conservation Program, and 2000, when most recent data are available. For this purpose, all indicators have been indexed with respect to their 1990 values.

Economic Dimension. The main indicator used in the study to measure economic sustainability was energy intensity.

Figure 9.42 indicates that energy consumption -- particularly in the transport, agriculture, and commercial sectors -- continues to increase faster than the respective sectoral gross value-added. An examination of these trends shows that the results were nevertheless affected by the financial crisis, which had caused total energy consumption to drop between 1997 and 1999, before recovering in 2000. The financial crisis, however, barely affected energy use in the commercial sector, which actually increased in 1998–2000. Energy consumption in the residential sector did not recover by 2000 — thus energy intensity for the sector has declined.

Figure 9.43 shows the other indicators that were used to measure sustainability in the economic dimension. The higher values in 2000 compared to their values in 1990 indicate economic growth and industrialisation. The higher income and electricity consumption per capita and the significant improvement in car ownership point to an increase in the economic status of the Thai people and to higher purchasing power. The higher electricity consumption implies greater affordability and accessibility. Similarly, the higher contribution of manufacturing value-added to GDP points to industrialisation. However, the higher energy consumption because of increased income and higher share of energy-intensive manufacturing industries because of industrialization imply increasing emissions that must be mitigated in order for growth and industrialization to be sustainable.

Social Dimension. The selected indicators shown in Figure 9.44 point to significant progress towards social sustainability. The figure shows that the proportions of households relying on traditional fuels and those without access to electricity have declined. These two parallel indicators also indicate increased access to modern energy services and complement the higher electricity consumption per capita noted above. Figure 9.44 also includes indicators to show the change in the social status of the poorest 20% of the population in Thailand. Similarly, the selected indicators point to improvement in the latter's access to modern energy services.

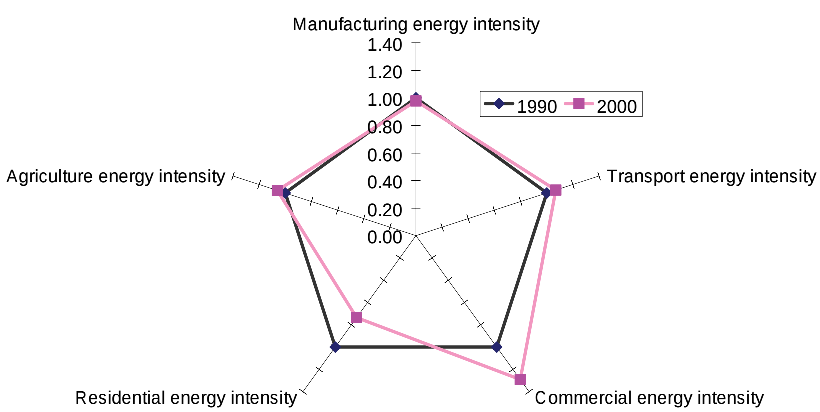

Figure 9.40: Progress Towards Energy Efficiency (Indexed to 1990 base year)

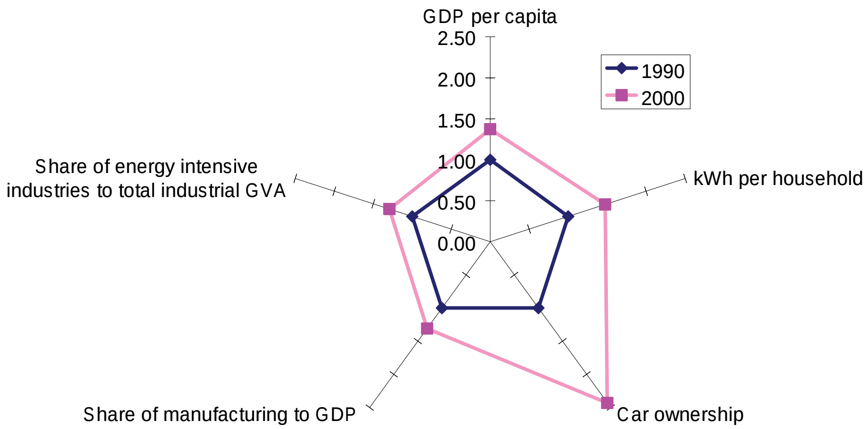

Figure 9.41: Progress Towards Economic Sustainability (Indexed to 1990 base year)

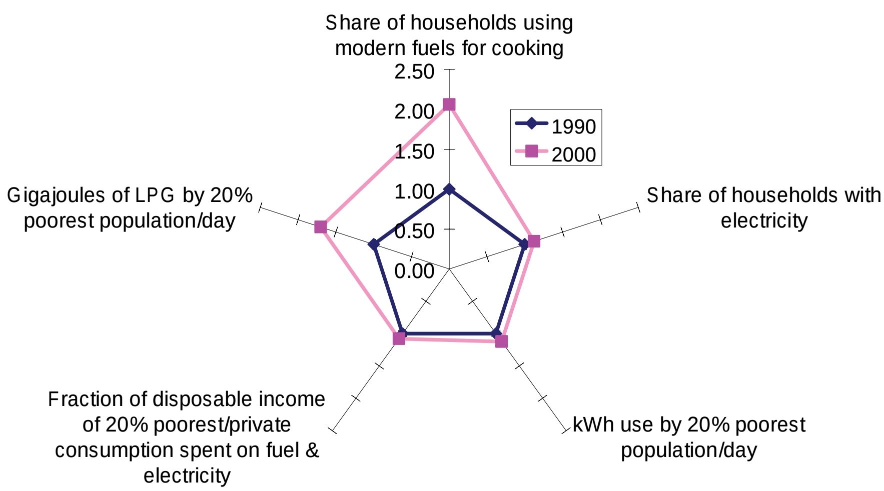

Figure 9.42: Progress Towards Social Sustainability (Indexed to 1990 base year)

Environmental Dimension. Figure 9.43 indicates increasing CO2 emissions even during the period of the financial crisis, particularly for the transport and residential–commercial sectors. Moreover, this is also true for the manufacturing sector even if its CO2 intensity dropped from 1993 to 2000. The reason for this is that the growth in CO2 emissions of manufacturing (4.4% per year) was lower than the growth in its gross value-added during this period (5.5%).

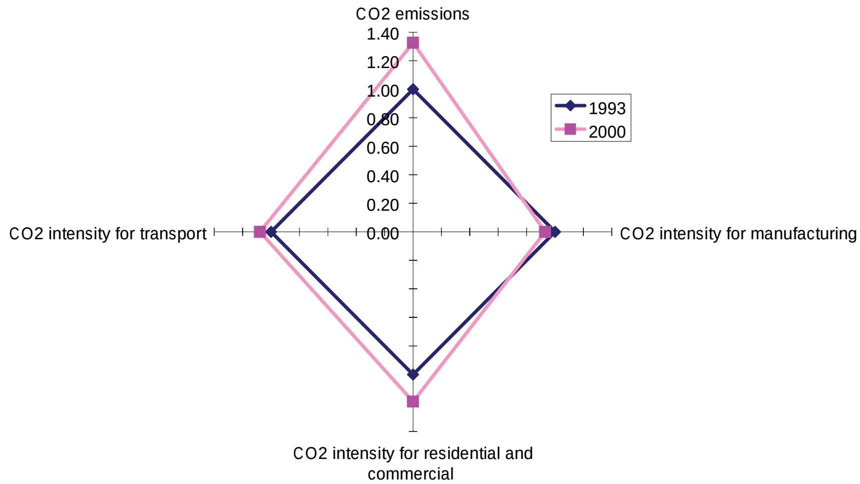

Figure 9.43: Progress Towards Environmental Sustainability (indexed to 1990 base year)
Note: Base year for residential and commercial CO_2 intensity is 1992.

Overall Assessment. Figure 9.44 attempts to integrate the analyses presented above. Aggregate energy intensity remained fairly stable, as the increasing energy intensities in the transport and commercial sectors were compensated by decreasing energy intensity in the residential sector and stable energy intensity in the manufacturing sector. The reductions in energy use during the financial crisis did cause reductions in environmental emissions, in particular CO2 emissions, but emissions quickly rebounded in 2000 along with growth in energy consumption. This demonstrates that environmental impacts are closely linked to energy consumption, as well as to economic activity.

Yet, despite the distortions caused by the financial crisis in the environmental and energy efficiency performance of Thailand, significant achievements can be noted in the economic and social dimensions. The financial crisis notwithstanding, the last two decades saw significant improvements in per capita and household incomes and access to and affordability of modern energy services, especially for the poorest segments of the population.

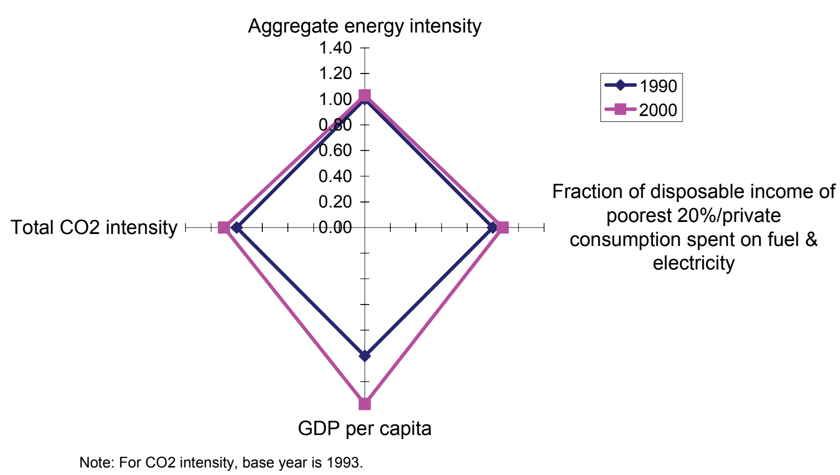

Figure 9.44: Progress Towards Sustainable Energy Development

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Annex 9.1: Summary of Indicators Used to Analyze State of Energy Efficiency

Structure of GDP value added (manufacturing, transportation, service, agriculture)
Structure of manufacturing value added of energy-intensive industry (but not disaggregated fully)
Modal structure of road vehicle stock (by passenger and freight transport)
Car ownership
Motorcycle ownership
Floor area per capita
Energy price and taxes by sector (industry, transport, residential and commercial)
Energy mix by sector (manufacturing, transport, service, residential, agriculture)
Aggregate energy intensity (total final energy consumption per GDP)
Decomposition of aggregate energy intensity

Sectoral energy intensity (manufacturing, transport, service, residential) in monetary terms
Manufacturing sub-sectoral final energy and electricity intensity (in monetary and physical terms)
Rail passenger energy intensity
Freight energy intensity
Unit consumption of vehicles
Service sector energy/electricity intensity (by floor space and per employee)
Residential energy intensity (by type of fuel and per household)
Agriculture energy intensity
Energy mix in the residential sector
Ratio of households using traditional and commercial fuels
Ratio of daily disposable income of poorest 20% household to price of: -electricity -main fuel used for heating and cooking -kerosene used for lighting
Fraction of disposable income/private consumption per capita spent on fuel and electricity -Average population -Group of 20% poorest population
Fraction of households: -heavily dependent on non-commercial energy -without electricity
Quantities of air pollutant emissions
Industrial carbon dioxide intensity by industrial VA
Transportation carbon dioxide intensity by total GDP
Services carbon dioxide intensity by services GDP
Residential carbon dioxide intensity per capita
Ambient concentration of pollutants in urban areas
Relevant Indicators But Not Available
Distance traveled per capita by passenger (total, urban public)
Fully disaggregated manufacturing value added by selected energy intensive industry
Energy intensity for passenger travel (kgoe/pkm)
Space heating (kgoe/m2 of floor area)
Passenger travel (kWh/pkm) –applicable for Thailand beginning 2000
Final energy intensity of production for energy intensive industries (the study covered very few)

Note: Indicators in **bold** are additional indicators or ones derived during the study, but which do not form part of the original set of ISED.

Annex 9.2: Sources of Statistical Data and Acronyms

STATISTICS	SOURCE
Ambient concentration of pollutants in urban areas	MOSTE, Pollution Control Department, ADB, Suksod, J.
Average disposable income spent on fuel and electricity	NSO
Daily disposable income of poorest 20% household	NSO
Disposable income of 20% poorest household spent on fuel and electricity	NSO
Electrified households	DEDP
Employment population	NSO
Energy consumption (total, sectoral, by type of fuel)	DEDP, IEA statistics
Energy prices	DEDP
Floor area for commercial sector	ERI
Freight transport activity (ton-kilometer by mode of transport)	MTC, UN Statistics

Gross domestic product in constant 1988 prices	
Indirect within energy sector	NSO
Non-electrified households	DEDP
Number of households using modern fuel (by type of cooking mode)	NSO
Number of households using traditional fuel (by type of cooking mode)	NSO
Population	ADB indicators, NSO
Production for selected manufacturing industry	OIE
Quantities of green house gas emissions (by type)	DEDP
Rail passenger -kilometer	UN Statistics
Stock of vehicles	MTC
Total disposable income	NSO
Total number of households	NSO
Unit consumption of buses	BMTA
Unit consumption of cars	NEPO, ONEB, IIEC
Urban and rural population	NSO, DOLA
Value added of economic sectors (in constant 1988 prices)	ADB indicators, Bank of Thailand, NESDB
Volume of production by manufacturing subsector	UN Statistics, ADB indicators, APERC

Acronyms

MTC	Ministry of Transportation and Communication
ADB	Asian Development Bank
NSO	National Statistical Office
IIEC	Institute of Energy Conservation
ONEB	Office of the National Environment Board
UN	United Nations
NESDB	National Economic and Social Development Board
APERC	Asia Pacific Energy Research Centre
BMTA	Bangkok Mass Transit Authority
ERI	Energy Research Institute
IEA	International Energy Agency
MOSTE	Ministry of Science, Technology and Environment
OIE	Office of Industrial Economics
DOLA	Department of Local Administration
DEDP	Department of Energy Development and Promotion