GOVERNMENT OF THAILAND

IN CO-OPERATION WITH

THE ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC,
THE UNITED NATIONS DEVELOPMENT PROGRAMME AND
THE GOVERNMENT OF FRANCE

SECTORAL ENERGY DEMAND IN THAILAND

NOVEMBER 1989

REGIONAL ENERGY DEVELOPMENT PROGRAMME (RAS/86/136)

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This views and opinions expressed in this study are those of the authors and contributors who were associated with the implementation of the activity on sectoral energy demand studies conducted within the framework of the Regional Energy Development Programme (REDP) and do not necessarily reflect the views of the Government of Thailand or the United Nations or the Government of France.

PREFACE

Following the consent of the Government of Thailand to participate in the Regional Energy Development Programme (REDP) activity on sectoral energy demand studies implemented by the United Nations Economic and Social Commission for Asia and the Pacific (UN-ESCAP), the National Energy Administration (NEA) as the Government's representative had in consequence conducted this Study. This plan of action had been achieved through the assistance of the Asian Institute of Technology (AIT) Central Consultant's team, Dr. B. Chateau and Dr. B. Lapillonne and also with the continued guidance from the Senior Co-ordinator of REDP, Dr. Filino Harahap during the implementation of this Study.

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We hereby would like to express our sincere appreciation to the concerned personnel of UN-ESCAP, AIT and the agencies who have kindly assisted and provided necessary information related to this Study.

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TABLE OF CONTENTS

I. BACKGROUND OF THE PROJECT ---------- 1
A. Introduction ---------- 1
B. Methodology ---------- 1

II. OVERVIEW ---------- 2
A. Data Base ---------- 2
B. Economic Growth and Energy Consumption ------- 2

III. HOUSEHOLD AND TERTIARY ---------- 12
A. Data Base ---------- 12
B. Household ---------- 12
C. Tertiary ---------- 29

IV. INDUSTRY ---------- 36
A. Data Base and Definition ---------- 36
B. Pattern of Energy Consumption ---------- 36

V. TRANSPORTATION ---------- 46
A. Definition and Analytical Framework ---------- 46
B. Data Base ---------- 46
C. Pattern of Energy Consumption ---------- 49

VI. ENERGY CONSERVATION ---------- 72
A. Background ---------- 72
B. Assessment of Potentials in Energy Conservation and Past Performance ---------- 73
C. Barriers to Energy Conservation ---------- 82

VII. SUMMARY, CONCLUSIONS AND RECOMMENDATION ---------- 83
A. Summary and Conclusions ---------- 83
B. Recommendations ---------- 84

ABBREVIATIONS ---------- 87

GLOSSARY OF ENERGY RELATED TERMS ---------- 88

ANNEX ---------- 89
A. Household and Tertiary Annex ---------- 89
B. Inddustry Annex ---------- 90
C. Transport Annex ---------- 91

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I. BACKGROUND OF THE PROJECT

Introduction

Thailand is one of the eight countries participating in the Sectoral Energy Demand Studies under the Regional Energy Development Programme (REDP) of UNDP\ESCAP. The other countries taking part in this project are China, India, Indonesia, Malaysia, Maldives, Nepal, and the Republic of Korea.

The findings and recommendations in this project will provide useful inputs for national energy planning and management in each of the participating countries.

The Thai part of the project is under the responsibility of NEA with collaboration from the AIT central team in P-1.1. The project comes at an opportune time for Thailand since it aims to update and expand the analysis and scope of the related NEA's project Energy and Demand Forecast undertaken in 1986 with the support from CEC and recently completed in 1988.

The three major areas that need to be updated and expanded are

(1) data base in the sectors of household and tertiary, manufacturing, and transportation

(2) sectoral energy demand accounting

(3) energy conservation and substitution in the medium term

In addition to the three areas of studies, a section on the general overview of past macroeconomic performance of the Thai economy and its effect on energy consumption is presented which provides useful background for the sector analysis.

Methodology

Similar methodology employed in the NEA/CEC project is adopted in this study. The approach is to set up a rather descriptive framework which allows for an analysis of the energy consumption pattern so that a rational energy balance may be constructed by end uses, groups of consumers, and areas for each of the three sectors. The framework also includes an analysis of interactions between energy and important socioeconomic variables by using ratios and elasticity concepts.

II. OVERVIEW

This section presents a general overview of the macroeconomic performance during the fourth and fifth social and economic development plans. The emphasis is on macroeconomic growth and its correlation with the energy consumption.

Data Base

The energy and general socioeconomic data are collected and updated by NEA on a regular basis. Energy data are compiled from two main sources:

(1) directly from the suppliers such as oil companies, PTT, MEA, EGAT, and the other related government agencies.

(2) surveys of energy consumption by end uses undertaken by NEA and other agencies such as the NSO. Economic data are compiled from NESDB, BOT, and other related government agencies. The NSO is the major source of demographic data.

Economic Growth and Energy Consumption

Thailand experienced a rather rapid economic growth at the beginning of the fourth social and economic development plan (1977-1981). The growth rates in GDP of 9.9 percent and 10.4 percent per annum were recorded for 1977 and 1988 respectively (Table 1). As an open economy, Thailand's economic growth was adversely affected by the second energy crisis of 1979/1980 when the rate of increase in its GDP declined to 6.3 percent in 1981. Nevertheless, an average annual growth rate of 7.4 percent was achieved during the fourth plan

When compared with GDP, the corresponding energy consumption during the fourth plan increased at a slower rate. The average annual increase in energy consumption was only 2.9 percent. In fact, the amount of energy consumed declined in 1980 as a consequence of the second energy shock. Comparison between the GDP and energy consumption growth rates implies an average energy elasticity (arc elasticity) with respect to GDP of 0.40 between 1977 and 1981.

World wide recessions in the early 1980s continued to affect the macroeconomic performance of the economy during the fifth plan (1982-1986). The GDP increased at an average annual rate of 5.3 percent which is somewhat lower than the rate achieved during the fourth plan. However, falling international oil prices and world interest rates paved the way for the global economic recovery in 1986 and the Thai economy rebounded with a GDP growth rate of 8.4 percent in 1987 which almost doubled the previous year rate.

In contrast, energy consumption increased at an average annual rate of 4.6 percent during the fifth plan which is greater than the corresponding rate for the fourth plan. The average arc energy elasticity computed for the fifth plan increased to 0.88

TABLE 1 : COMPARISON OF FINAL ENERGY CONSUMPTION AND GDP, 1975-1987

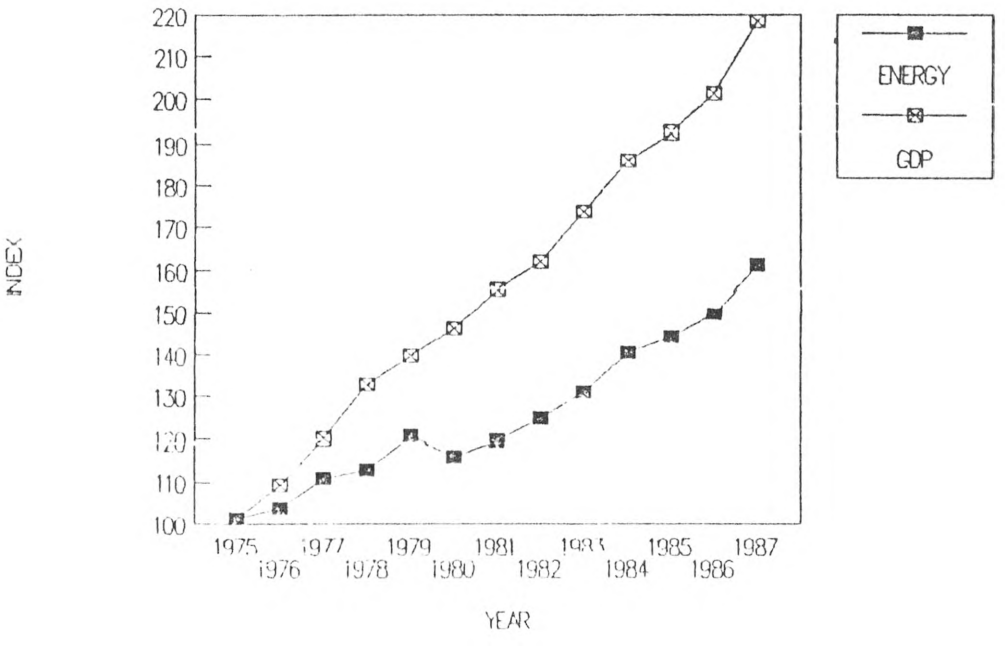
YEAR	ENERGY CONSUMPTION		GDP1972 PRICE		* ENERGY ELASTICITY	ENERGY CONSUMPTION INDEX	GDP INDEX
	TOTAL (KTOE)	GROWTH RATE (%)	TOTAL (MBHT)	GROWTH RATE (%)			
1975	12,995.00		204,428.00	4.85		100.00	100.00
1976	13,491.00	3.82	223,594.00	9.38	0.41	103.82	109.38
1977	14,432.00	6.98	245,727.00	9.90	0.70	111.06	120.20
1978	14,683.00	1.74	271,378.00	10.44	0.17	112.99	132.75
1979	15,706.00	6.97	285,797.00	5.31	1.31	120.86	139.80
1980	15,099.00	-3.86	299,472.00	4.78	-0.81	116.19	146.49
1981	15,551.00	2.99	318,439.00	6.33	0.47	119.67	155.77
1982	16,221.00	4.31	331,380.00	4.06	1.06	124.82	162.10
1983	17,022.00	4.94	355,408.00	7.25	0.68	130.99	173.85
1984	18,272.00	7.34	380,738.00	7.13	1.03	140.61	186.25
1985	18,783.00	2.80	394,113.00	3.51	0.80	144.54	192.79
1986	19,503.00	3.83	411,814.00	4.49	0.85	150.08	201.45
1987	20,970.00	7.52	446,361.00	8.39	0.90	161.37	218.35

* GROWTH RATE OF ENERGY / GROWTH RATE OF GDP

SOURCES : NEA, NESDB

FIGURE 1 : ENERGY AND GDP RELATIONSHIP

1975 - 1987



which is more than twice the fourth plan elasticity.

Figure 1 presents the relationship between energy consumption and GDP between 1975 and 1987. The increase in energy elasticity during the fifth plan may be attributed to changes in the structure of the economy as characterized by the growing importance of the energy intensive sectors.

Structural changes in the economy are evident from the shifts in relative importance between the nonenergy intensive and energy intensive sectors. The proportion of energy consumed by the sectors of transportation, manufacturing, household and tertiary in the total energy consumption increased from 85 percent in 1977 to 95 percent in 1987. During the same period, their contributions to the GDP increased from 56 percent to 59 percent.

The relative size of agriculture declined steadily during the period 1977 through 1987. The value added originating from agriculture in 1987 was 17 percent of the GDP compared with 22 percent for 1977. Agriculture is relatively less energy dependent as the total energy consumed in this sector was only 3.9 percent of the total energy consumption in 1987 compared with 6.9 percent for 1977(Tables 2 and 3).

TABLE 2 : GDP BY ECONOMIC SECTORS, 1975-1987

UNIT : M.BAHT IN 1972 PRICES

YEAR	AGRI	INDUSTRY	TRAN	COMM	TOTAL
1975	50,700	52,597	12,445	85,423	204,428
1976	53,764	61,351	13,205	91,610	223,594
1977	55,000	70,988	14,604	100,897	245,727
1978	61,856	78,809	15,717	110,122	271,378
1979	60,726	83,709	17,932	118,054	285,797
1980	61,770	86,379	20,045	125,370	299,472
1981	65,093	91,005	20,641	135,109	318,439
1982	67,082	93,102	22,711	140,937	331,380
1983	70,061	100,548	24,536	152,010	355,408
1984	73,977	109,044	27,074	161,620	380,738
1985	78,539	107,999	28,171	169,470	394,113
1986	78,725	115,167	30,191	176,569	411,814
1987	77,163	129,294	32,701	195,042	446,361

NOTE : AGRI = AGRICULTURE
TRAN = TRANSPORTATION
INDUSTRY = MINING + MANUFACTURE + CONSTRUCTION
COMM = HOUSEHOLD + TERTIARY SECTOR + PUBLIC ADMINISTRATION AND DEFENCE

SOURCE : COMPILED FROM NESDB

TABLE 3 : TOTAL ENERGY CONSUMPTION BY SECTOR, 1975-1987

UNIT : KTOE

YEAR	AGRI	INDUS	TRANS	HH&TERT	OTHERS	TOTAL
1975	837	3076	3074	5120	888	12995
1976	901	3666	3486	5195	222	13491
1977	980	4083	3058	5334	977	14432
1978	990	3717	3893	5378	705	14683
1979	1041	4698	4206	5375	386	15706
1980	1130	4208	4008	5395	358	15099
1981	1004	4489	4268	5402	388	15551
1982	1117	4913	4328	5502	361	16221
1983	1043	4727	5084	5622	546	17022
1984	1029	5116	5953	5760	414	18272
1985	841	5389	6342	6003	208	18783
1986	881	5420	6805	6171	226	19503
1987	835	5730	7863	6355	187	20970

NOTE : AGRI = AGRICULTURE
TRAN = TRANSPORTATION
INDUSTRY = MINING + MANUFACTURE + CONSTRUCTION
HH&TERT = HOUSEHOLD + TERTIARY SECTOR
OTHERS = PUBLIC ADMINISTRATION AND DEFENCE
RENEWABLE INCLUDED
SOURCE : NEA ENERGY STATISTICS SECTION

Changes in the distribution of energy consumption among the sectors of transportation, manufacturing, household and tertiary may also be observed during the fourth and fifth plans. At the beginning of the fourth plan, 37 percent of the total energy consumption may be allocated to household and tertiary, the second largest sector after manufacturing. Distributions of the remaining energy consumption were 28 percent for manufacturing and 21 percent for transportation(Table 4).

By the end of the fifth plan, transportation became the largest energy consumer as it consumed 37 percent of the total energy required in 1987 (renewable included). Energy consumption in manufacturing and household and tertiary were 27 percent and 30 percent of the total energy consumption respectively during the same period.

1. Sources of Energy

Energy sources in Thailand may be classified as solid fuels , petroleum products, natural gas, electricity, and renewable energy. Petroleum products are the only sources of fuel for the transportation sector. They also provide energy for the other sectors of manufacturing, agriculture, household and tertiary. Similar to the petroleum products, electricity is used

TABLE 4 : DISTRIBUTION OF TOTAL ENERGY CONSUMPTION BY SECTOR, 1975-1987

UNIT : PERCENT

YEAR	AGRI	INDUS	TRANS	HH&TERT	OTHERS	TOTAL
1975	6.4	23.7	23.7	39.4	6.8	100.0
1976	6.7	27.2	25.8	38.5	1.6	100.0
1977	6.8	28.3	21.2	37.0	6.8	100.0
1978	6.7	25.3	26.5	36.6	4.8	100.0
1979	6.6	29.9	26.8	34.2	2.5	100.0
1980	7.5	27.9	26.5	35.7	2.4	100.0
1981	6.5	28.9	27.4	34.7	2.5	100.0
1982	6.9	30.3	26.7	33.9	2.2	100.0
1983	6.1	27.8	29.9	33.0	3.2	100.0
1984	5.6	28.0	32.6	31.5	2.3	100.0
1985	4.5	28.7	33.8	32.0	1.1	100.0
1986	4.5	27.8	34.9	31.6	1.2	100.0
1987	4.0	27.3	37.5	30.3	0.9	100.0

NOTE : AGRI = AGRICULTURE
TRAN = TRANSPORTATION
INDUSTRY = MINING + MANUFACTURE + CONSTRUCTION
HH&TERT = HOUSEHOLD + TERTIARY SECTOR
OTHERS = PUBLIC ADMINISTRATION AND DEFENCE

SOURCE : NEA ENERGY STATISTICS SECTION

in all sectors for motive power and for lighting. At present, solid fuels and natural gas are used only in manufacturing. The renewable energy sources mostly used as fuels for household cooking and in some industries such as food manufacturing.

Petroleum products are the major sources of energy for Thailand. They supplied approximately 50 percent of the total energy requirements between 1975 and 1987 (Tables 5 and 6). The remaining 45 percent of the energy requirements during the mid 1970s were supplied from renewable energy, the other major source of energy in that period. Energy from other sources was negligible as they supplied only 5 percent of the total energy requirements.

From the late 1970s onwards, the uses of commercial energy became more widespread and they began to replace a proportion of energy supplied from renewables. As a result, the energy supplied from renewable sources declined relatively to 33 percent of the total energy mix in 1987. In contrast, increases in the demand for solid fuel and electricity may be observed during the same period. The proportion of electricity in the energy mix increased from 5 percent in 1975 to 10 percent in 1987. Similarly, the solid fuels share in the energy mix increased from

TABLE 5 : ENERGY CONSUMPTION BY ENERGY SOURCES, 1975-1987

UNIT : KTOE

YEAR	COAL AND LIGNITE	PETROLEUM	NATURAL GAS	ELECTRICITY	RENEWABLE ENERGY	TOTAL
1975	29	6,527	0	638	5,801	12,995
1976	57	6,638	0	735	6,061	13,491
1977	66	7,197	0	849	6,320	14,432
1978	82	7,656	0	969	5,976	14,683
1979	96	8,157	0	1,060	6,393	15,706
1980	114	7,913	0	1,121	5,951	15,099
1981	112	7,892	0	1,179	6,368	15,551
1982	256	7,834	0	1,281	6,850	16,221
1983	259	8,639	32	1,441	6,651	17,022
1984	301	9,342	194	1,583	6,852	18,272
1985	423	9,413	178	1,707	7,062	18,783
1986	464	10,018	87	1,878	7,056	19,503
1987	652	11,207	40	2,121	6,950	20,970

SOURCE : ENERGY STATISTICS SECTION, NEA

TABLE 6 : ENERGY CONSUMPTION BY ENERGY SOURCES, 1975-1987

UNIT : PERCENT

YEAR	COAL AND LIGNITE	PETROLEUM PRODUCTS	NATURAL GAS	ELECTRICITY	RENEWABLE ENERGY	TOTAL
1975	0.2	50.2	0.0	4.9	44.6	100.0
1976	0.4	49.2	0.0	5.4	44.9	100.0
1977	0.5	49.9	0.0	5.9	43.8	100.0
1978	0.6	52.1	0.0	6.6	40.7	100.0
1979	0.6	51.9	0.0	6.7	40.7	100.0
1980	0.8	52.4	0.0	7.4	39.4	100.0
1981	0.7	50.7	0.0	7.6	40.9	100.0
1982	1.6	48.3	0.0	7.9	42.2	100.0
1983	1.5	50.8	0.2	8.5	39.1	100.0
1984	1.6	51.1	1.1	8.7	37.5	100.0
1985	2.3	50.1	0.9	9.1	37.6	100.0
1986	2.4	51.4	0.4	9.6	36.2	100.0
1987	3.1	53.4	0.2	10.1	33.1	100.0

SOURCE : ENERGY STATISTICS SECTION, NEA

a low 0.2 percent to 3 percent during the same period.

A decline in the relative importance of renewable energy as an energy source is not unexpected as their supplies are becoming more difficult due to lack of adequate reforestration programs. Moreover, some of the renewable energy such as bagasse and paddy husk are by-products of the sugar milling and rice milling industries so that their supplies are constrained by the volume of the main outputs. In addition, renewables are bulky and are thus limited to local uses. In contrast, the supplies of modern energy are relatively more flexible and offer more conveniences.

Natural gas from the Gulf of Siam was first introduced in 1981 as a substitute for fuel oil in electricity generation. At present, the use of natural gas in other sectors such as manufacturing is still neglegible due to its unfavorable prices relative to the fuel oil prices. Its consumption in the future may be expected to increase as inputs for electricity generation and for the expanding petrochemical manufacturing.

2. Energy Intensity

Energy intensity is another indicator of the energy/economic relationship. Similar to the energy elasticity, it reflects the relationship between energy consumption and output as measured by value added . The difference in the two indicators is in the method of presentation. The elasticity concept shows the relationship in terms of a number without unit, whereas the energy intensity concept shows the ratio of actual energy consumption to value added .

There was a 20 percent reduction in the overall energy intensity from 59 TOE per million baht to 47 TOE per million baht between 1977 and 1987 (Table 7). When the energy intensity is considered by energy sources it is apparent that the economy is becoming more intensive in electricity and less intensive in renewable energy. In addition, a decline in the renewable energy intensity more than offset an increase in the electricity intensity during the same period. The pattern of energy intensity offers additional evidence for the substitution of electricity for renewable energy. The energy intensity of petroleum products was quite stable around 26 TOE per million baht during the mid 1970s and 1980s.

It should be pointed out that an increase or decrease in the energy intensity does not necessarily imply inefficient or efficient uses of energy since there may be rational substitutions between energy and other factors of production in accordance with their relative prices. As an example, there may be a rational shift from the labor intensive method of production to more automation caused by rising labor costs or problems which necessarily increase the electricity intensity. In addition, energy intensity variation may reflect structure changes in the economy.

TABLE 7 : ENERGY INTENSITY BY ENERGY SOURCES, 1975-1987

UNIT : TOE/MB

YEAR	ELEC	F+EL	F+EL+R	F	R
1975	3.1	35.2	63.6	32.1	28.4
1976	3.3	33.2	60.3	29.9	27.1
1977	3.5	33.0	58.7	29.6	25.7
1978	3.6	32.1	54.1	28.5	22.0
1979	3.7	32.6	55.0	28.9	22.7
1980	3.7	30.5	50.4	26.8	19.9
1981	3.7	28.8	48.8	25.1	20.0
1982	3.9	28.3	48.9	24.4	20.7
1983	4.0	29.2	47.9	25.1	18.7
1984	4.2	30.0	48.0	25.8	18.0
1985	4.3	29.7	47.7	25.4	17.9
1986	4.6	30.2	47.4	25.7	17.1
1987	4.7	31.4	47.0	26.7	15.6

NOTE : ELECT = ELECTRICITY
F = FOSSIL FUEL (SOLID FUELS, PETROLEUM, GAS)
R = RENEWABLE

SOURCE : COMPILED FROM NEA

Industry is the most intensive sector in the economy. Its energy intensity in 1977 was 58 TOE per million baht (Table 8).The industrial dependency on fossil fuel and renewable energy as the major sources of energy in 1977 was evident from the fossil fuel and renewable energy intensities of 27 and 25 TOE per million baht respectively. The intensities of these two energy sources represent 90 percent of the total industrial energy intensity in 1977. The electricity intensity in this year was only 6 TOE per million baht.

The industrial energy intensity declined steadily to 44 TOE per million baht in 1987. The sector was becoming less intensive in renewable energy which more than offset the increasing electricity intensity. The industrial energy intensity in renewable energy was 18 TOE per million baht in 1987 which is 28 percent less than it was in 1977. On the other hand, the electricity intensity increased by 25 percent to 7.5 TOE per million baht during the same period. It appears that electricity is replacing a proportion of the renewable energy in the manufacturing process.

Similar to the case of manufacturing, the household and tertiary sector is becoming more dependent on electricity relative to the renewable energy. The household and tertiary energy

TABLE 8 : ENERGY INTENSITY BY SECTORS, 1975-1987

UNIT : TOE/MB

YEAR	INDUSTRY			HOUSEHOLD AND TERTIARY			*TRANPORTATION
	ELECT	F+EL	F+EL+R	ELECT	F+EL	F+EL+R	TOTAL
1975	7.833	36.713	58.482	1.076	2.270	25.045	15.037
1976	7.693	35.827	59.755	1.140	2.692	23.234	15.591
1977	5.677	32.625	57.517	1.778	3.178	21.707	12.445
1978	5.710	28.715	47.165	1.879	3.154	19.817	14.345
1979	6.081	33.533	56.123	1.896	3.055	18.807	14.717
1980	6.367	31.883	48.716	1.870	2.999	18.015	13.384
1981	6.615	28.526	49.327	1.774	2.911	16.964	13.403
1982	6.767	27.475	52.770	1.925	3.039	16.603	13.061
1983	6.793	25.649	47.012	2.091	3.148	15.818	14.305
1984	6.823	26.054	46.917	2.159	3.107	15.129	15.635
1985	7.333	27.834	49.899	2.271	3.359	15.232	16.092
1986	7.520	26.344	47.062	2.409	3.645	14.985	16.524
1987	7.456	26.405	44.318	2.545	3.856	14.237	17.616

NOTE : INDUSTRY = MINING + CONSTRUCTION + MANUFACTURING
ELECT = ELECTRICITY
F+EL = FOSSIL FUEL + ELECTRICITY
F+EL+R = FOSSIL FUEL + ELECTRICITY + RENEWABLE ENERGY

* TRANSPORTATION SECTOR CONSUMES ONLY PETROLEUM PRODUCTS.

SOURCE : NEA

intensity also exhibited a declining trend during the same period. The total energy intensity of this sector was 14.2 TOE per million baht in 1987 which is 35 percent lower than the 1977 intensity. In contrast, the energy intensity for transportation increased by 50 percent between 1977 and 1987 or from 12 TOE per million baht in 1977 to 18 TOE per million baht in 1987.

3. Per Capita Energy Consumption

The Thai population increased at an average annual rate of 2.1 percent during the fourth plan and 2.0 percent during the fifth plan. There were 54 million people in 1987 , eighty percent of which still lived in the rural areas.

Since the growth in population is slightly lower than the corresponding growth in the energy consumption during the fourth plan, the per capita energy consumption remained fairly stable at around 0.33 TOE per annum. Rapid increases in the energy consumption during the fifth plan raised the per capita energy consumption to 0.37 TOE in 1987. Part of this increase may be

TABLE 9 : ENERGY AND SELECTED ECONOMICS INDICATORS, 1975-1987

YEAR	TOTAL ENERGY CONSUMPTION (KTOE)	ELECTRICITY CONSUMPTION (KTOE)	GDP1972 PRICE (MBHT)	POPULATION (MILLION)	PER CAPITA		
					TOTAL ENERGY CONSUMPTION (TOE)	ELECTRICITY (TOE)	GDP (1972 PRICES)
1975	12,995	683	204,428	42.39	0.31	0.02	4,823
1976	13,491	735	223,594	43.21	0.31	0.02	5,175
1977	14,432	849	245,727	44.27	0.33	0.02	5,551
1978	14,683	969	271,378	45.22	0.32	0.02	6,001
1979	15,706	1,060	285,797	46.11	0.34	0.02	6,198
1980	15,099	1,121	299,472	46.96	0.32	0.02	6,377
1981	15,551	1,179	318,439	47.88	0.32	0.02	6,651
1982	16,221	1,281	331,380	48.85	0.33	0.03	6,784
1983	17,022	1,441	355,408	49.52	0.34	0.03	7,177
1984	18,272	1,583	380,738	50.58	0.36	0.03	7,527
1985	18,783	1,707	394,113	51.80	0.36	0.03	7,608
1986	19,503	1,878	411,814	52.97	0.37	0.04	7,774
1987	20,970	2,121	446,361	53.87	0.39	0.04	8,286

SOURCE : COMPILED BY NEA

attributed to an increase in the per capita electricity consumption from 0.02 TOE in 1977 to 0.04 TOE in 1987.

III. HOUSEHOLD AND TERTIARY

Data Base

The energy consumption data for household and tertiary are usually aggregrated into a single series. The aggregation is necessary since the available information and ambiguities in the sector definitions do not allow for easy disaggregration. Consider the case of electricity distribution by MEA and PEA to the tertiary customers classified by their building characteristics such as a shop house. The fact that many of these shop houses are also residences of the entrepreneurs make it difficult or impossible to separate the energy consumption of household from the tertiary group.

As in the case of electricity, the oil companies supply their petroleum products through intermediaries such as petrol stations before they are resold to final users. Such a marketing mechanism does not allow for an easy disaggregration of energy consumption for these two subgroups.

Fortunately, separate energy consumption data for household and tertiary may be compiled from a few available sources. The socioeconomic survey undertaken in 1985 and 1986 by the NSO are the sources of data for household energy consumption. Data on the tertiary energy consumption are compiled from the 1985 NEA/CEC study. Pattern of the tertiary energy consumption in 1986 may be studied by comparing the 1986 household energy consumption from the NSO survey with the aggregrate energy consumption of the two sectors from the national energy balance.

Household

1. Household Classifications and Analytical Framework

The framework employed in this section is to analyse the energy consumption by types of household, areas, income levels, and end uses.

Business and nonbusiness are the two types of households that are also classified by areas as urban and rural. The urban areas are defined as areas in Bangkok and its neighboring provinces of Samutprakarn and Nonthaburi. All the municipal and sanitary districts are also included in the urban areas. Rural areas are simply the remaining areas not classified as urban.

The income levels of households are classified as very low (less than 1,500 baht per month), low (from 1,501 to 4,000 baht per month), middle (from 4,001 to 10,000 baht per month), and high which exceeds 10,000 baht per month. (1$ = 25 Baht)

The end uses considered are categorised as household cooking, lighting, refrigerator, air conditioning, and others.

General Household Characteristics

(a) Distribution of Household by Areas

There were 7.9 million households in Thailand in 1976. Following the growth in population, the number of households increased at an average rate of 2.6 percent per annum to 102.2 millions in 1986 (Table 10). The higher growth in the number of households relative to population leads to a smaller household size which declined from 5.5 persons per household to 5.2 persons per household between 1976 and 1986.

The number of Bangkok households increased more rapidly than households in the other areas during the late 1970s. Between 1976 and 1981, the number of Bangkok households increased by 5.7 percent per annum compared with the rates of 2.8 percent observed for the rural and municipal households, and a decrease of 0.9 percent for households in the sanitary districts. The total number of urban households, however, increased at the rate of 2.2 percent per annum which is lower than the 2.8 percent rate of increase observed for the rural households.

The relative rates of growth in the number of urban and rural households began to change during the early and mid 1980s. There was a faster rate of increase in the number of urban households between 1981 and 1986. Switch in the growth rates was the most pronounced in 1986 when the number of urban households increased by 11.2 percent compared with 1.6 percent observed for the rural households. The ratio of the number of rural households to the number of urban households declined from 2.8 in 1976 to 2.6 in 1986. The switch in the relative growth rates between urban and rural households is not surprising considering the structural change towards more industrialisation and urbanisation discussed in the previous section which tends to induce a concentration of households in the urban areas.

(b) Distribution of Households by Types

Eighty percent of the households or 8.6 millions were nonbusiness household in 1986 (Table 11). The rural areas had a greater proportion of nonbusiness households : 89 percent compared with 73 percent for Bangkok, 58 percent for municipal, and 76 percent for the sanitary districts.

Trade, manufacturing, and services are the activities of business households (Table 12). The distributionly activities was 69 percent for trade, 20 percent for manufacturing, and 11 percent for services in 1986.

TABLE 10 : POPULATION, HOUSEHOLD AND HOUSEHOLD SIZES BY AREAS, 1976-1986

YEAR	POPULATION	NUMBER OF HOUSEHOLD	AVERAGE HOUSEHOLD SIZE	NUMBER OF HOUSEHOLD (THOUSAND)				
				URBAN				RURAL
	(MILLION)	(THOUSAND)		BANGKOK *	MUNICIPAL	SANITARY	TOTAL	
1976	43.2	7,903.0	5.5	646.0	552.9	896.3	2,095.2	5,807.8
1981	47.9	9,005.0	5.3	852.0	634.1	856.2	2,342.3	6,662.7
1985	51.8	9,813.0	5.3	939.5	655.9	950.6	2,546.0	7,267.0
1986	53.0	10,215.0	5.2	1,160.7	683.7	987.9	2,832.3	7,382.2
ANNUAL GROWTH RATE								
1976-1981	2.1	2.6		5.7	2.8	-0.9	2.2	2.8
1981-1986	2.0	2.6		2.5	4.4	2.6	3.9	2.2
GROWTH RATE								
1985-1986	2.2	4.1		23.5	4.2	3.9	11.2	1.6

* BANGKOK, NONTHABURI AND SAMUTPAKARN

SOURCE : COMPILED FROM NSO SOCIOECONOMIC SURVEY 1976, 1981, 1986 AND HOUSEHOLD ENERGY SURVEY 1985

3. Household Income Distribution

Household income is an important indicator of economic status and a determinant of energy demand. Wages, salary, bonus, net income from agricultural activities and other business activities, rent, interests, dividens, pensions, and others are the sources of household income.

The NSO socioeconomic survey shows a greater household income in the urban areas. Households in Bangkok were found to have the highest income of all the areas. Income of urban households, especially in Bangkok, were almost twice the income of rural households : close to 7,000 baht per month for Bangkok compared with an income of 2,680 for an average rural household in 1986 (Table 13). It should be noted that income of the rural households remained unchanged between 1981 and 1986 while the urban household income increased by 3.5 percent a year during the same period.

TABLE 11 : TYPES OF HOUSEHOLD BY AREAS, 1986

UNIT : THOUSANDS

TYPES OF HOUSEHOLD	URBAN				RURAL	TOTAL
	BKK	MUN	SAN	TOTAL		
BUSINESS HOUSEHOLD	311.9 (26.9)	288.1 (42.1)	235.8 (23.9)	835.8 (29.1)	792.1 (10.7)	1,627.9 (15.9)
NONBUSINESS HOUSEHOLD	848.8 (73.1)	395.6 (57.9)	752.1 (76.1)	1,996.5 (72.9)	6,590.0 (89.3)	8,586.5 (84.1)
TOTAL	1,160.7 (100)	683.7 (100)	987.9 (100)	2,832.2 (100)	7,382.2 (100)	10,214.4 (100)

FIGURES IN PARENTHESIS ARE PERCENTAGE

SOURCE : COMPILED FROM NSO SOCIOECONOMIC SURVEY, 1986

TABLE 12 : DITRIBUTION OF BUSINESS HOUSEHOLD BY ACTIVITIES, 1985-1986

UNIT : PERCENT

YEAR	TRADE	MANUFACTURE	SERVICES	TOTAL
1985	69.6	15.5	14.9	100
1986	69.1	20.2	10.7	100

SOURCE : COMPILED FROM HOUSEHOLD ENERGY SURVEY, 1985 AND SOCIOECONOMIC SURVEY, 1986

The distribution of households by income level was as folllows in 1980 : 34 percent very low income, 46 percent low income, 15 percent middle income, and 5 percent high income (Table 14). The share of very low and low income households was greatest in rural areas (50%) whereas Bangkok had the highest distribution of high income households (17%).

TABLE 13 : INCOME DISTRIBUTION OF HOUSEHOLD BY AREAS, 1976-1986

SOCIOECONOMIC DATA		1976	1981	1986
1.INCOME OF HOUSEHOLD : (BAHT/MONTH/HOUSEHOLD)	TOTAL	3,352	3,378 (0.15)	3,631 (1.4)
	BANGKOK	3,442	5,872 (11.3)	6,949 (3.4)
	MUNICIPAL	3,352	5,605 (10.8)	6,654 (3.5)
	SANITARY	2,211	3,385 (8.9)	4,018 (3.5)
	RURAL	1,482	2,680 (12.6)	2,680 (-)

FIGURES IN PARENTHESIS ARE GROWTH RATES

SOURCE : NSO SOCIOECONOMIC SURVEY, 1976, 1981, 1986

TABLE 14 : NUMBER OF HOUSEHOLD BY INCOME LEVELS, 1986

UNIT : THOUSAND

AREA	INCOME LEVEL				TOTAL
	VL	LO	MD	HI	
URBAN	361.4 (12.8)	1,063.6 (37.5)	1,054.4 (37.2)	352.8 (12.5)	2,832.2 (100)
BKK	63.6 (5.4)	389.1 (33.5)	514.3 (44.3)	193.6 (16.8)	1,160.7 (100)
MUN	54.4 (7.9)	226.5 (33.1)	292.2 (42.7)	110.5 (16.3)	683.7 (100)
SAN	243.3 (24.6)	447.9 (45.3)	247.9 (25.1)	48.7 (6.0)	987.9 (100)
RURAL	2,478.3 (33.6)	3,662.4 (49.6)	1,115.4 (15.1)	126.0 (1.7)	7,382.2 (100)
TOTAL	2,839.7 (27.8)	4,726.0 (46.3)	2,169.8 (21.2)	478.8 (4.7)	10,214.4 (100)

FIGURES IN PARENTHESIS ARE PERCENTAGE

VL = LESS THAN 1500 BAHT/MONTH
LOW = 1501 BAHT/MONTH TO 4000 BAHT/MONTH
MIDDLE = 4001 BAHT/MONTH TO 10,000 BAHT/MONTH
HIGH = MORE THAN 10,000 BAHT/MONTH

SOURCE : COMPILED FROM NSO SOCIOECONOMIC SURVEY 1986

Possession of Electrical Appliances

Electricity was first introduced to Thailand during the reign of Rama V in 1882. In order to satisfy the growing demand for electricity, MEA was established as a state enterprise under the supervision of the Interior Ministry in 1958 by the MEA Act. Its responsibility is to distribute electricity to consumers in Bangkok and the neighboring provinces of Nonthabuti and Samutprakarn.

Distribution of the remaining provinces is under the responsibility of PEA, also a state enterprise established in 1960 by the mergers of all the power provincial electricity organizations in the country. The responsibility of electricity generation is under EGAT, the other state enterprise established in 1960. EGAT sells its electricity to MEA, PEA, and a few direct customers.

TABLE 15 : ELECTRIFIED HOUSEHOLD BY ELECTRICITY DISTRIBUTION AUTHORITIES, 1981-1987

UNIT : PERCENT

YEAR	MEA	PEA	TOTAL
1981	77.3	35.7	41.4
1982	78.6	41.0	46.3
1983	80.6	42.5	47.4
1984	83.8	48.9	53.5
1985	83.5	52.6	56.7
1986	88.7	56.5	60.8
1987	87.8	59.7	63.5

SOURCE : NEA ELECTRIC POWER IN THAILAND (ANNUAL REPORT)

Only 41 percent of all households had access to electricity in 1981. As electricity became relatively more available, the households' access to this energy source also increased and by 1987, the power network was able to reach 64 percent of all households (Table 15). As expected, the access to electricity is more pronounced in the MEA areas. Nevertheless, the accelerated rural electrification program helps to increase the accessability to electricity in the rural areas. By 1987, 60 percent of the rural households were electrified compared with only 36 percent in 1981.

TABLE 16 : OWNERSHIP OF ELECTRICAL APPLIANCES BY TYPES AND HOUSEHOLD AREAS, 1976-1986

UNIT : PERCENT

YEAR	BANGKOK					MUNICIPAL				
	ELEPOT	TV	REFRI	AIR	WASH	ELEPOT	TV	REFRI	AIR	WASH
1976	21.0	53.3	25.6	3.8	0.2	20.1	37.2	23.1	1.6	0.1
1981	52.8	62.7	39.5	NA	NA	47.8	54.2	41.8	NA	NA
1986	75.5	80.2	56.5	7.4	4.5	73.1	73.5	59.3	2.6	6.0

TABLE 16 : OWNERSHIP OF ELECTRICAL APPLIANCES BY TYPES AND HOUSEHOLD AREAS, 1976-1986 (CONT.)

YEAR	SANITARY					RURAL				
	ELEPOT	TV	REFRI	AIR	WASH	ELEPOT	TV	REFRI	AIR	WASH
1976	5.6	12.5	8.1	0.5	-	0.5	4.0	0.6	0.0	-
1981	25.1	26.9	16.2	NA	NA	7.5	9.3	3.4	NA	NA
1986	46.5	51.4	29.2	0.5	1.4	25.4	51.3	10.6	0.2	0.2

ELEPOT = ELECTRIC RICE COOKER
REFRI = REFRIGERATOR
WASH = WASHING MACHINE
AIR = AIR CONDITIONER
TV = TELEVISION SET

SOURCES : 1976, 1981, 1986 FROM NSO SOCIOECONOMIC SURVEY

Increases in the accessability to electricity induce demand for the household electrical appliances. A greater proportion of all households were owning household electrical appliances such as television sets, electric rice cookers, refrigerators, washing machines, and airconditioners between 1976 and 1987. The proportion of households owning these elecrical appliances is greater in the urban areas.

Television sets were the most widely owned items by all types of households in 1976 (Table 16). They were owned by 53 percent of the Bangkok households and 4 percent of the rural households. Electric rice cookers and refrigerators are the other two accessible items for urban households and a few rural households. Only 0.5 percent of the rural households owned electric rice cookers in 1976. The use of washing machine is not popular in Thailand as it was used by less than 1 percent of the households in 1976.

Although television sets were still the most sought after items in 1986, the electric rice cookers and refrigerators became relatively more important, especially in the urban areas. The proportion of Bangkok households owning electric rice cookers increased from 21 percent in 1976 to 75 percent in 1987 compared with an increase from 0.5 percent to 25 percent for the rural households during the same period. Air conditioners are not as widely used as the other items as they were owned by only 7 percent of the Bangkok households and 0.2 percent of the rural households.

TABLE 17 : HOUSEHOLD OWNERSHIP FOR ELECTRIC APPLIANCES BY HOUSEHOLD AND INCOME LEVELS, 1986

UNIT : PERCENT

TYPE OF APPLIANCE	NONBUSINESS HOUSEHOLD				BUSINESS HOUSEHOLD				TOTAL HOUSEHOLD			
	VL	LOW	MD	HI	VL	LOW	MD	HI	VL	LOW	MD	HI
ELECT. POT	13	33	69	88	16	58	78	91	15	38	72	89
TV	15	37	74	92	2	61	85	97	17	41	77	94
REFRI.	3	11	47	84	8	35	68	91	5	15	54	87
AIR	-	-	12	50	-	-	16	53	-	-	13	51
WASH	-	-	1	11	-	-	2	14	-	-	1	12

VL = LESS THAN 1500 BAHT/MONTH
LOW = 1501 BAHT/MONTH TO 4000 BAHT/MONTH
MIDDLE = 4001 BAHT/MONTH TO 10,000 BAHT/MONTH
HIGH = MORE THAN 10,000 BAHT/MONTH

SOURCE : NSO SOCIOECONOMIC SURVEY 1986

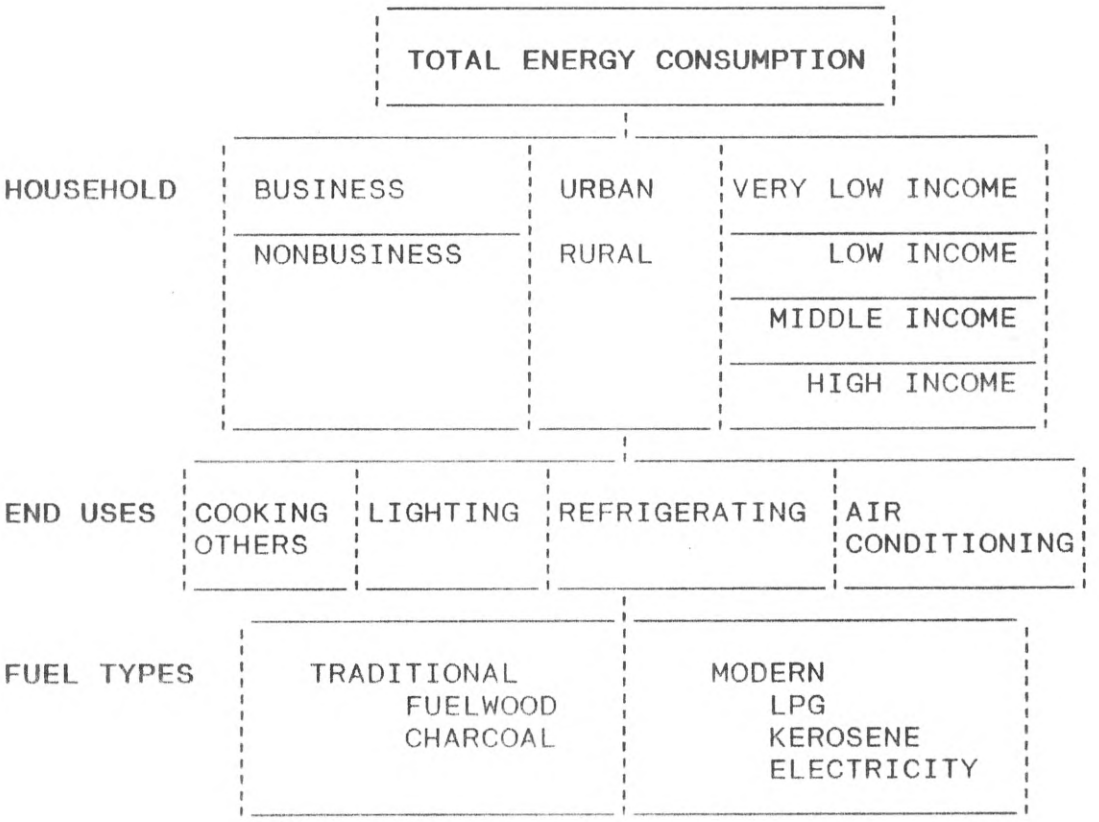
When the ownership of electrical appliances is analysed by income levels it is evident that the distribution of ownership is bias towards the higher income households (Table 17). Items such as air conditioners are owned by only the middle and high income households and are not, as yet, affordable by lower income households.

Pattern of Household Energy Consumption

The framework employed in the analysis of household energy consumption is summarized in Figure 2. The household energy balance by areas, household types, and income levels for 1986 are presented in Tables 18-20.

FIGURE 2

FRAMEWORK FOR HOUSEHOLD ENERGY CONSUMPTION ANALYSIS



(a) By Household Types and Areas

Households consumed a total of 2,829 KTOE in 1986. Sixty nine percent of the total household energy consumption may be allocated to the rural households. But on a per household basis, an average rural household consumed only 0.26 TOE per year compared with 0.31 TOE per year for an average urban household.

The nonbusiness households consumed more energy than the business households which is to be expected since they are a majority of all households (Table 21). Nevertheless, an average nonbusiness household consumed only 0.23 TOE per year which is less than half the amount of energy consumed by an average business household or 0.52 TOE per year in 1986 (Table 22).

(b) By Income Levels

The low income households were the largest energy consumers when they used 1,270 KTOE of energy or 45 percent of the total household energy consumption in 1986. The distributions of energy consumption for the other income levels were 29 percent for very low income, 27 percent for middle income, and 8 percent for high income households. When considered on a per household basis, an average high income household consumed 0.57 TOE of energy per year compared with 0.35 TOE for an average middle income household, 0.27 TOE for an average low income household, and 0.20 TOE for an average very low income household in the same year.

TABLE 18 : HOUSEHOLD ENERGY BALANCE BY AREAS, 1986

UNIT : KTOE

	URBAN				RURAL	TOTAL	SHARE OF RURAL
	BKK	MUN	SAN	TOTAL	VIL		(PERCENT)
A. BY END-USES	344	256	289	889	1,940	2,829	69
COOKING	150	152	217	519	1,602	2,121	75
LIGHTING	71	49	43	163	231	394	59
REFRIGERATING	50	31	17	98	38	136	28
AIR-CONDITIONING	31	2	0	33	1	34	4
OTHERS	41	21	13	76	67	143	47
B. BY TYPES OF FUEL	344	256	289	889	1,940	2,829	69
TRADITIONAL FUELS	71	106	189	366	1,536	1,902	81
FUEL WOOD	10	5	21	36	266	302	88
CHARCOAL	61	101	168	330	1,270	1,600	79
MODERN ENERGY	273	150	101	524	404	927	43
LPG	79	47	28	154	66	220	30
KEROSENE	1	4	8	13	114	127	90
ELECTRICITY	193	99	65	357	224	581	38

SOURCE : COMPILED FROM NSO SOCIOECONOMIC SURVEY 1986

TABLE 19 : HOUSEHOLD ENERGY BALANCE
BY HOUSEHOLD TYPES, 1986

UNIT : KTOE

	BUSINESS HOUSEHOLD	NON BUSINESS HOUSEHOLD	TOTAL	SHARE OF BUSINESS HOUSEHOLD (PERCENT)
A. BY END-USES	844	1,985	2,829	30
COOKING	444	1,677	2,121	21
LIGHTING	229	165	394	58
REFRIGERATING	81	56	136	59
AIR-CONDITIONING	21	13	34	61
OTHERS	69	74	143	48

TABLE 19 : HOUSEHOLD ENERGY BALANCE
BY HOUSEHOLD TYPES, 1986 (CONT.)

UNIT : KTOE

	BUSINESS HOUSEHOLD	NON BUSINESS HOUSEHOLD	TOTAL	SHARE OF BUSINESS HOUSEHOLD (PERCENT)
B.BY TYPES OF FUEL	844	1,985	2,829	30
TRADITIONAL FUELS	346	1,556	1,902	18
FUELWOOD	35	266	302	12
CHARCOAL	301	1,289	1,591	19
MODERN ENERGY	498	429	927	54
LPG	98	122	220	45
KEROSENE	95	32	127	75
ELECTRICITY	305	276	581	52

SOURCE : NSO SOCIOECONOMIC SURVEY, 1986

TABLE 20 : HOUSEHOLD ENERGY BALANCE BY INCOME LEVELS, 1986

UNIT : KTOE

	INCOME LEVEL				TOTAL
	VL	LO	MD	HI	
A. BY END-USES	554	1,270	752	252	2,829
COOKING	481	1,039	484	117	2,121
LIGHTING	59	165	146	24	394
REFRIGERATING	5	30	62	40	136
AIR-CONDITIONING	0	0	12	22	34
OTHERS	10	36	47	50	143
B.BY FUEL TYPES	554	1,270	752	252	2,829
TRADITIONAL FUELS	475	997	376	53	1,901
FUELWOOD	111	153	34	4	302
CHARCOAL	364	845	341	49	1,599
MODERN ENERGY	80	273	357	199	909
LPG	6	42	109	62	220
KEROSENE	32	59	31	5	127
ELECTRICITY	41	172	235	132	581

VL = LESS THAN 1500 BAHT/MONTH
LOW = 1501 BAHT/MONTH TO 4000 BAHT/MONTH
MD = 4001 BAHT/MONTH TO 10,000 BAHT/MONTH
HI = MORE THAN 10,000 BAHT/MONTH

SOURCE : NSO SOCIOECONOMIC SURVEY, 1986

(c) By End Uses

Household cooking is the major end-use for all households, with 75 percent of the total energy consumed by this sector in 1986. The remaining 12 percent of energy were used for lighting, 7 percent for refrigerating, 2 percent for air conditioning, and 4 percent for other activities. The high income households are the only group that used more energy for refrigerating than for lighting.

Inspite of their smaller numbers, the urban households used more energy for refrigerating and air conditioning than the rural households which, reflects a large gap in the standard of living between these two groups. For example, urban households

TABLE 21 : ENERGY CONSUMPTION BY HOUSEHOLD TYPES AND BY AREAS, 1986

UNIT : KTOE

TYPES OF HOUSEHOLD	URBAN				RURAL	TOTAL
	BKK	MUN	SAN	TOTAL		
BUSINESS HOUSEHOLD	182.16	166.11	120.18	468.45	375.28	843.73
NONBUSINESS HOUSEHOLD	161.80	89.79	169.21	420.81	1,564.40	1,985.21
TOTAL	343.96	255.91	289.39	889.26	1,939.69	2,828.95

SOURCE : NSO SOCIOECONOMIC SURVEY 1986

consumed 98 KTOE and 33KTOE of energy for refrigerating and air conditioning respectively in 1986 compared with the coresponding amount of 38 KTOE and 1 KTOE for the rural households.

(c) By Fuel Types

Traditional fuels are the major sources of energy for the household sector. They supplied 67 percent of the total energy required by all households in 1986. The dependence on traditional fuels is more pronounced in the rural areas where they supplied 79 percent of the total rural household energy requirements compared with 41 percent for the urban areas. Similarly, the nonbusiness households depend more on traditional fuels than the business households. Traditional fuels accounted for 78 percent of the nonbusiness household energy balance compared with 41 percent for the business households.

Charcoal and fuelwood are the main traditional fuels used by all households. The use of charcoal is more widespread in all areas and it accounted for 84 percent of the total traditional energy consumed by all households in 1986.

Kerosene, LPG, and electricity are the modern or commercial energy that supplied the remaining 33 percent of the household energy requirements in 1986. Electricity is the most important source of modern energy for all households. The distributions of modern energy in 1986 were 63 percent electricity, 13 percent kerosene, and 24 percent LPG.

TABLE 22 : AVERAGE ENERGY CONSUMPTION BY HOUSEHOLD TYPES, 1986

UNIT : TOE/HH

TYPES OF HOUSEHOLD	URBAN				RURAL	TOTAL
	BKK	MUN	SAN	TOTAL		
BUSINESS HOUSEHOLD	0.58	0.58	0.51	0.56	0.47	0.52
NONBUSINESS HOUSEHOLD	0.19	0.23	0.22	0.21	0.24	0.23
TOTAL	0.30	0.37	0.29	0.31	0.26	0.28

SOURCE : NSO SOCIOECONOMIC SURVEY 1986

Rural households used relatively more kerosene for lighting than the urban households while the opposite is true for LPG. The share of kerosene in the modern energy mix was 28 percent for the rural households compared with only 7 percent for the urban households in 1986. In constrast, LPG share in the total modern energy was 29 percent for the urban households and 16 percent for the rural households.

The dependence on kerosene is also more prevalent for the nonbusiness and lower income households than for the business and higher income households. On the other hand, LPG was used more widely by the business and higher income households.

Electricity is virtually the only source of energy for refrigerating and air conditioning, whereas kerosene and electricity offer choices for lighting. Traditional fuels and LPG are the major choices for household cooking.

Charcoal was the most important source of fuel for household cooking in the Bangkok and municipal areas while the use of fuelwood was more widespread in the sanitary districts and rural areas in the 1970s (Table 23). However, the urban households became less dependent on charcoal as its share in the household energy mix decreased from 57 percent to 19 percent in Bangkok and from 61 percent to 31 percent in the municipal areas between 1976 and 1986.

TABLE 23 : ENERGY USED IN HOUSEHOLD COOKING BY AREAS, 1976-1986

UNIT : PERCENT

YEAR	BANGKOK					MUNICIPAL				
	LPG	CHAR	WOOD	OTHERS	NON	LPG	CHAR	WOOD	OTHERS	NON
1976	12.30	56.50	9.10	20.90	1.20	9.00	60.90	8.40	19.60	2.10
1981	24.90	38.10	12.90	14.00	10.10	20.70	47.30	12.20	14.20	5.60
1986	40.50	18.70	12.70	11.80	16.30	35.20	30.70	10.50	11.80	11.80

TABLE 23 : ENERGY USED IN HOUSEHOLD COOKING BY AREAS, 1976-1986 (CONT.)

UNIT : PERCENT

YEAR	SANITARY					RURAL				
	LPG	CHAR	WOOD	OTHERS	NON	LPG	CHAR	WOOD	OTHERS	NON
1976	1.80	51.50	32.20	13.90	0.60	0.30	38.40	49.00	12.20	0.10
1981	6.10	52.20	35.70	5.90	0.10	1.70	41.10	53.60	2.90	0.70
1986	14.40	42.90	34.80	4.30	3.60	5.50	47.40	43.30	2.70	1.10

OTHERS : KEROSENE, BIOGAS, PADDY HUSK, BAGASSE, ETC.
NON : NO COOKING

SOURCES : 1976, 1981, 1986 FROM NSO SOCIOECONOMIC SURVEY

During the same period, the urban households were depending more on LPG for cooking. The proportion of LPG in the energy mix increased from 12 percent to 41 percent in Bangkok and from 9 percent to 35 percent in the municipal areas. It appears that LPG is steadily replacing charcoal as a major source of energy for cooking in the urban areas.

The pattern of fuel uses is different for the rural areas where charcoal and fuelwood are still the dominant sources of energy for cooking. Although LPG became relatively more important as an energy source its proportion in the rural energy mix was only 6 percent in 1986 compared with 0.3 percent in 1976.

The use of LPG for cooking is more prevalent in the high income business households. The LPG dependence may be indicated by the proportion of households owning LPG stoves. The proportion in 1986 was 53 percent for high income business households in Bangkok and 17 percent for low income nonbusiness households in the same area (Table 24).

TABLE 24 : OWNERSHIP OF COOKING STOVE BY HOUSEHOLD TYPES AND AREAS, 1986

UNIT : PERCENT

LOCATION		BANGKOK		MUNICIPAL		SANITARY		RURAL	
TYPES OF HOUSEHOLD		NB	BH	NB	BH	NB	BH	NB	BH
INCOME	TYPES OF STOVE								
VERY LOW	FUEL WOOD	23.3	12.5	15.5	18.7	42.1	45.1	50.0	60.0
	CHARCOAL	13.4	50.0	29.1	41.7	39.7	43.6	39.6	27.5
	LPG	5.0	12.5	3.0	8.3	2.3	2.8	1.0	2.0
	NO STOVE	58.3	25.0	52.4	31.3	15.9	8.5	9.4	10.5
LOW	FUEL WOOD	17.3	7.8	16.3	6.3	28.4	23.5	34.1	36.3
	CHARCOAL	26.0	47.3	33.7	45.9	50.5	49.6	53.9	46.4
	LPG	10.2	17.1	9.0	19.0	3.3	10.1	2.0	3.0
	NO STOVE	46.5	27.8	41.0	28.8	17.8	16.8	10.0	14.3
MED	FUEL WOOD	8.4	2.0	4.0	3.5	10.9	11.4	17.5	20.4
	CHARCOAL	29.4	31.0	38.7	37.2	45.2	38.2	53.9	42.9
	LPG	26.2	39.6	21.3	29.2	18.2	30.0	8.0	21.4
	NO STOVE	36.0	27.4	36.0	30.1	25.7	19.4	15.7	15.3
HIGH	FUEL WOOD	-	-	-	-	8.3	-	15.5	7.1
	CHARCOAL	23.0	17.0	22.9	19.9	48.7	28.0	39.5	28.6
	LPG	50.0	53.0	43.4	46.3	25.0	44.0	19.1	28.6
	NO STOVE	27.0	30.0	33.7	33.8	18.0	28.0	25.9	35.7

NOTES : A) FUELWOOD : ALL HOUSEHOLDS THAT DECLARE TO HAVE A FUELWOOD STOVE
B) LPG : ALL HOUSEHOLDS THAT DECLARE TO HAVE AN LPG STOVE
C) NO STOVE : ALL HOUSEHOLDS THAT DECLARE TO HAVE NO STOVE
D) CHARCOAL : REMAINING HOUSEHOLDS

SOURCE : NSO SOCIO-ECONOMIC SURVEY, 1986

TABLE 25 : AVERAGE SPECIFIC ENERGY CONSUMPTION FOR HOUSEHOLD COOKING BY AREAS, 1986

UNIT: KGOE /MONTH/HH

LOCATION		BANGKOK		MUNICIPAL		SANITARY		RURAL	
TYPES OF HOUSEHOLD		NB	BH	NB	BH	NB	BH	NB	BH
INCOME & TYPES OF FUEL									
VERY LOW	FUEL WOOD	19.3	23.0	27.0	33.0	30.0 *	30.3 *	31.2	33.1 *
	CHARCOAL	9.0	14.0	23.0	18.1	29.2	26.5	30.0	27.1
	LPG	12.2	10.9	12.2	12.2	9.4	6.0	9.0	9.0
LOW	FUEL WOOD	23.4	21.0	29.8	30.0	30.0 *	30.3 *	31.2	33.1 *
	CHARCOAL	12.5	15.0	26.0	28.1	30.6	30.0	33.5	28.6
	LPG	12.3	13.5	12.2	15.3	12.2	11.7	12.2	9.0
MED	FUEL WOOD	0.0	0.0	25.8	28.0	30.0 *	30.3 *	31.2	33.1 *
	CHARCOAL	12.5	16.6	27.1	32.5	33.1	32.6	33.1	32.7
	LPG	13.6	16.6	12.2	15.8	13.6	15.8	12.2	12.4
HIGH	CHARCOAL	17.8	29.4	47.3	36.2	36.3	36.7	29.0	34.3
	LPG	15.9	19.3	15.9	20.8	15.9	20.8	14.8	17.0

* ESTIMATED CONSUMPTION
NB = NONBUSINESS HOUSEHOLD
BH = BUSINESS HOUSEHOLD
HH = HOUSEHOLD

SOURCE : COMPILED FROM NSO SOCIOECONOMIC SURVEY, 1986

It is observed that some of the households may not be preparing their own food since they do not own cooking stoves. This pattern is more pronounced for the very low income

nonbusiness households in the urban areas. The proportion in 1986 of very low income nonbusiness households with no cooking stove was 58 percent compared with 9.4 percent for the same type of households in the rural areas.

Average Specific Energy Consumption for Household (SEC)

The average SEC measured as KGOE per month per household is analysed for household cooking and for household electrical appliances.

(a) Household Cooking

Table 25 presents the SEC for household cooking by types of household, income levels, areas, and fuel types in 1986. Consistent with the foregoing analysis, the higher income households tend to have larger SEC for LPG than the lower income households. The gap in SEC is more pronounced for the business households in the sanitary districts where the SEC for LPG was 21 KGOE per month per household compared with 6 KGOE for the low income households. In contrast, the SEC for fuelwood tends to be higher for the lower income households in the rural areas.

(b) Household Electrical Appliances

Table 26 presents the SEC for household electrical appliances by household types, income levels, and areas in 1986. Ownerships of electrical appliances are classified by the number and types of the appliances as follows:

(1) less than or equal to two items
(2) at least three items but without refrigerators and air conditioners
(3) at least three items including refrigerators but without air conditioners
(4) at least three items including refrigerators and air conditioners

The urban households tend to have larger SEC than their rural counterparts. Assuming the same efficiency, the higher SEC implies a more intensive use of the electrical appliances. Higher SEC is also observed for the business households relative to the nonbusiness households. It should be noted that air conditioners are the highest energy consuming electrical appliances. The SEC of households with air conditioners more than doubles the SEC of households with no air conditioners.

Tertiary

Classification of Tertiary and Analytical Framework

Tertiary in this study means small and large business

TABLE 26 : AVERAGE SPECIFIC ENERGY CONSUMPTION FOR HOUSEHOLD ELECTRICAL APPLIANCES, 1986

UNIT: KWH/MONTH/HH

LOCATION		BANGKOK		MUNICIPAL		SANITARY		RURAL	
TYPES OF HOUSEHOLD		NB	BH	NB	BH	NB	BH	NB	BH
INCOME & HOUSEHOLD GROUP									
VERY LOW	<=2	25.76	50.00	22.61	47.86	15.81	26.28	9.95	21.56
	>=3	72.67	76.00	40.67	55.20	38.14	38.47	37.86	48.40
	REFRIG	92.70	128.80	83.63	75.88	64.16	71.50	64.28	70.00
LOW	<=2	42.45	55.42	38.46	50.39	23.52	35.09	13.72	31.86
	>=3	65.77	76.00	48.80	79.68	42.71	51.36	39.35	42.35
	REFRIG	107.19	124.88	81.91	101.74	71.64	85.33	72.45	86.00
MED	<=2	57.95	89.33	42.72	67.80	28.86	71.54	15.52	39.00
	>=3	76.60	107.72	64.97	77.00	54.23	71.63	51.99	72.00
	REFRIG	127.07	149.46	100.66	136.46	98.03	107.85	91.78	94.00
	AIR	526.99	548.47	322.60	172.27	0.00	0.00	0.00	0.00
HIGH	<=2	83.25	0.00	43.33	0.00	5.78	21.56	20.00	0.00
	>=3	106.47	172.22	88.38	113.88	64.30	72.00	60.00	64.00
	REFRIG	173.94	236.39	150.29	186.35	111.53	172.82	131.26	125.13
	AIR	858.60	973.25	314.60	259.20	0.00	0.00	0.00	0.00

SOURCE : COMPILED FROM NSO SOCIOECONOMIC SURVEY, 1986

as classified by MEA and PEA. The two electricity distribution authorities classify their business customers by the amount of their electricity consumption. The cut off point in the amount of electricity consumption between small and large businesses is 30 kw. In other words, any business using more than 30kw of electricity will be classified as a large business.

Some overlapping in the classification of business is observed in practice. For example, it is possible for a large residential customer with large electricity consumption to be classified as a small business customer which adds to the difficulties of separating the household from tertiary energy consumption.

The tertiary activities are classified as follows :

(1) Restaurants, hotels, and other lodgings
(2) Banking, insurance, and real estate
(3) Wholesale and retail trade
(4) Health, sanitary and social services
(5) Education and research services
(6) Recreational and cultural facilities
(7) Water works and supply
(8) Others (defense, public administration etc.)

The framework used in the analysis of tertiary energy consumption is presented in figure 3. The energy consumption is analysed by types of activities, areas, business sizes (small/large), and fuel types.

Pattern of Energy Consumption

Approximately 70 percent of the tertiary energy consumption may be allocated to electricity. The total tertiary electricity consumption was 27 percent of the total electricity consumption in 1986. The small business group used 3,442 GWH in 1988 compared with 2,995 GWH for the large business group (Table 27).

When considered by areas, the business group in MEA area, inspite of their smaller numbers, consumed more electricity than their counterparts in the PEA areas (Table 28). As an example, electricity consumption of PEA's large business customer increased from 239 GWH in 1980 to 698 GWH in 1988 compared with an

TABLE 27 : ELECTRICITY CONSUMPTION IN TERTIARY SECTOR, 1980-1988

UNIT : GWH

YEAR	SMALL BUSINESS	LARGE BUSINESS	TOTAL
1979/1980	1,596.1	1,319.2	2,915.4
1980/1981	1,665.1	1,275.7	2,940.9
1981/1982	1,782.8	1,400.3	3,183.1
1982/1983	2,075.3	1,695.3	3,770.5
1983/1984	2,263.2	1,875.8	4,138.9
1985/1985	2,471.9	2,141.6	4,613.5
1985/1986	2,618.0	2,316.7	4,934.7
1986/1987	2,981.0	2,554.8	5,535.7
1987/1988	3,442.2	2,954.6	6,396.8

SOURCE : LOAD FORECAST WORKING GROUP
(FISCAL YEAR : OCTOBER-SEPTEMBER)

FIGURE 3
FRAMEWORK FOR TERTIARY ENERGY CONSUMPTION ANALYSIS

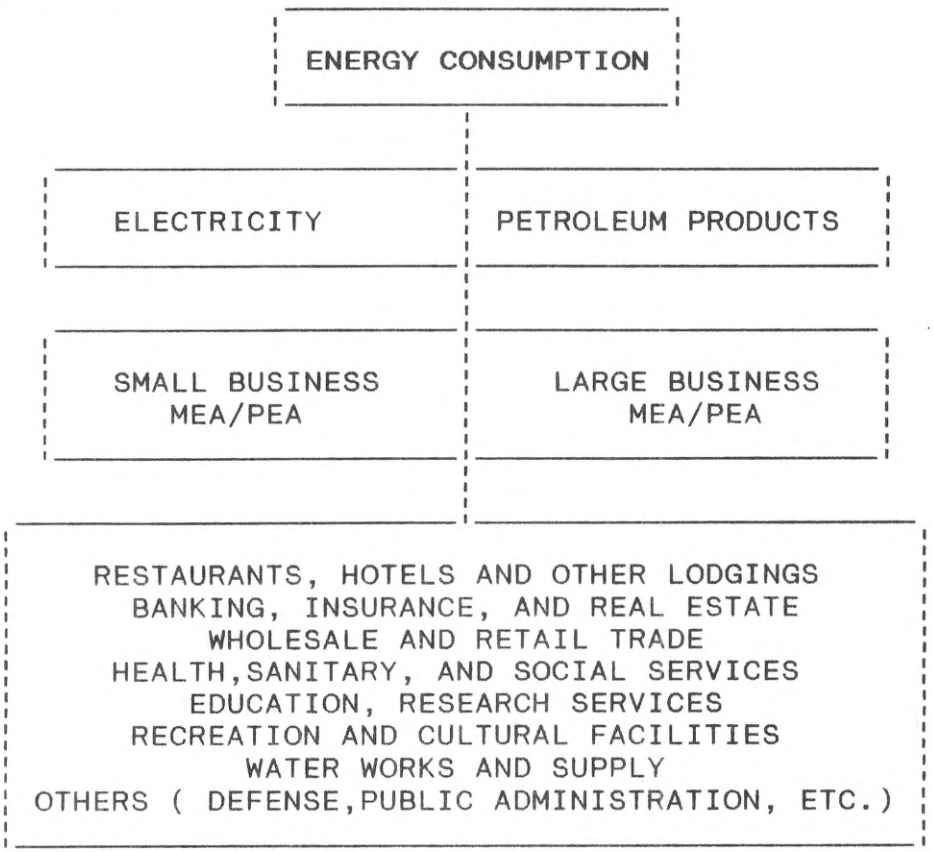


TABLE 28 : ELECTRICITY CONSUMPTION IN TERTIARY SECTOR BY DISTRIBUTION AUTHORITIES, 1980-1988

UNIT : GWH

YEAR	MEA		PEA	
	SMALL BUSINESS	LARGE BUSINESS	SMALL BUSINESS	LARGE BUSINESS
1980	1,069.3	1,079.5	526.9	239.7
1981	1,098.2	1,010.9	567.0	264.8
1982	1,153.6	1,105.4	629.2	294.9
1983	1,322.7	1,337.4	752.6	357.8
1984	1,392.2	1,460.5	871.0	415.3
1985	1,488.9	1,674.5	983.0	467.1
1986	1,529.9	1,804.0	1,088.1	512.7
1987	1,755.5	1,947.5	1,225.4	607.2
1988	1,946.1	2,255.9	1,496.1	698.7

SOURCE : LOAD FORECAST WORKING GROUP
(FISCAL YEAR : OCTOBER-SEPTEMBER)

increase from 1079 GWH to 1900 GWH for the MEA large business customers during the same period. However, the rate of increase in the business electricity consumption is greater in the PEA areas.

Wholesale and retail trade are the business activities that required more electricity than the other activities. The electricity requirements in these two activities were 2,745 GWH or 47 percent of the total tertiary electricity consumption in 1988. In the other extreme, recreation and cultural facilities required only 180 GWH or 3 percent of the total tertiary electricity consumption in the same year (Table 29).

Since the national balance always show the energy consumption of household and tertiary together, due to the unclarified data between these two subsectors. There the consumption are shown as a whole.

The energy consumption for household and tertiary in 1986 was 6,171 KTOE, which increased from 1985 about 2.8 percent. The percent share of energy consumption in these two years were similar the same. Traditional fuel was still the biggest part of energy consumption, followed by electricity and petroleum products remained the third.

TABLE 29 : COMMERCIAL ELECTRICITY CONSUMPTION BY BUSINESS TYPES, 1983-1986

UNIT : GWH

SUBSECTORS	1983 1/	1985 1/	1986 1/
1.RESTAURANT, HOTEL AND OTHER LODGINGS	661.1	775.1	851.9
2.BANKING INSURANCE AND REAL ESTATE	240.3	324.7	352.9
3.WHOLESALE & RETAIL TRADE	1,883.7	2,208.4	2,745.1
4.HEALTH,INSURANCE AND SOCIAL SERVICES	261.4	326.3	291.2
5.EDUCATION & RESEARCH SERVICES	180.6	224.8	209.3
6.RECREATIONAL AND CULTURAL FACITIES	170.8	188.6	180.3
7.WATER WORKS AND SUPPLY	346.8	334.6	362.2
8.OTHERS	785.3	961.6	854.9
TOTAL	4,530.0	5,344.1	5,847.8

NOTE : 1/ COMPILED BY NEA FROM MEA, PEA AND POF

SOURCES : COMPILED FROM EGAT, MEA, PEA, POF

TABLE 30 : ENERGY CONSUMPTION IN RESIDENTIAL COMMERCIAL SECTOR

UNIT : KTOE

YEAR	PETROLEUM PRODUCT	ELECTRICITY	TRADITIONAL FUEL	TOTAL
1985	429	895	4,432*/	5,756
1986	509	992	4,416*/	5,917

* _/ Not includes Paddy Husk

SOURCE : NEA, Energy Statistic Section.

IV. INDUSTRY

Data Base and Definition

Industry in this study means manufacturing which is classified according to the Thailand Standard Industrial Classification into the following 9 subgroups:

(1) TSIC 31: food, beverage and tobacco
(2) TSIC 32: textile
(3) TSIC 33: wood and furniture
(4) TSIC 34: paper
(5) TSIC 35: chemicals
(6) TSIC 36: non metallic minerals
(7) TSIC 37: basic metals
(8) TSIC 38: fabricated metals
(9) TSIC 39: others

The economic data in this section are from NESDB. In addition, the data on industrial energy consumption are compiled from the 1987 NEA/Chula survey of energy utilization in manufacturing.

Pattern of Energy Consumption

The General Overview

The pattern of energy consumption in manufacturing sector is dependent on the manufacturing structure and relative prices of the competing fuels. Table 31 presents the relative importance of the 9 manufacturing subgroups between 1970 and 1987. In the early 1970s, food and textile were the two largest manufacturing sectors when their value added were 36 percent and 21 percent respectively of the total manufacturing value added. The textile sector expanded more rapidly in the 1980s and became the largest manufacturing subgroup in 1987 when its value added was 29 percent of the manufacturing value added compared with 28 percent for the food sector.

Electricity, solid fuel, petroleum products, natural gas, and renewable fuels are the sources of energy for the manufacturing sector. The manufacturing sector consumed 4,083 KTOE of energy in 1977 of which 45 percent or 1,847 KTOE originated from petroleum products, 43 percent or 1,767 KTOE from the renewable fuels, 10 percent or 403 KTOE from electricty, and 2 percent or 66 KTOE from solid fuel (Tables 32 and 33).

TABLE 31 : DISTRIBUTION OF MANUFACTURING VALUE ADDED BY MANUFACTURING SUBGROUPS, 1970-1987

UNIT : PERCENT

YEAR	TSIC CODE									
	31	32	33	34	35	36	37	38	39	TOTAL
1970	37	21	6	3	12	4	3	14	1	100
1971	33	22	6	3	14	4	2	14	2	100
1972	31	23	5	3	15	4	2	15	2	100
1973	30	24	5	3	14	4	2	15	3	100
1974	32	23	5	3	13	4	2	15	2	100
1975	32	25	5	2	14	4	2	14	2	100
1976	33	24	5	3	13	4	2	15	3	100
1977	33	24	4	3	10	4	2	17	2	100
1978	31	24	4	3	12	4	2	17	3	100
1979	33	24	4	3	12	4	2	16	3	100
1980	30	25	3	3	12	4	2	16	3	100
1981	31	26	3	3	12	4	1	16	4	100
1982	32	26	3	3	12	4	1	16	4	100
1983	31	25	3	3	12	4	1	16	4	100
1984	32	25	3	3	11	4	1	16	4	100
1985	32	27	3	3	12	4	2	13	4	100
1986	31	28	3	3	12	4	2	13	5	100
1987	28	29	3	3	12	4	1	13	6	100

SOURCE : NESDB

TABLE 32 : PATTERN OF ENERGY CONSUMPTION IN MANUFACTURING SECTOR BY ENERGY SOURCES, 1977-1987

UNIT : KTOE

ITEMS	YEAR											AVERAGE ANNUAL RATE OF GROWTH	
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1980/83	1983/87
ELECTRICITY	403	450	509	550	602	630	683	744	792	866	964	7.63	9.00
COAL & LIGNITE (SOLID FOSSIL FUEL)	66	82	96	114	112	256	259	301	423	464	652	28.16	25.96
PETROLEUM PRODUCTS	1,847	1,731	2,019	1,877	1,686	1,487	1,420	1,416	1,414	1,441	1,598	-8.42	3.00
GAS	0	0	0	0	0	0	32	194	178	87	40		5.74
RENEWABLE ENERGY	1,767	1,454	1,891	1,454	1,893	2,355	2,148	2,275	2,383	2,386	2,316	3.24	1.90
TOTAL	4,083	3,717	4,515	3,995	4,293	4,728	4,542	4,930	5,190	5,244	5,570	0.15	5.23

CE : NEA

TABLE 33 : PATTERN OF ENERGY CONSUMPTION IN THE MANUFACTURING SECTOR BY ENERGY SOURCES, 1977-1987 (CONT.)

UNIT : PERCENT

ITEMS	YEAR										
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
- ELECTRICITY	10	12	11	14	14	13	15	15	15	16	17
- COAL & LIGNITE (SOLID FOSSIL FUEL)	2	2	2	3	3	5	6	6	8	9	12
- PETROLEUM PRODUCTS	45	47	45	47	39	31	31	29	27	27	29
- GAS	0	0	0	0	0	0	1	4	3	2	1
- RENEWABLE ENERGY	43	39	42	36	44	50	47	46	46	45	42
TOTAL	100	100	100	100	100	100	100	100	100	100	100

There tends to be a substitution of electricity for the petroleum products during the last decade when the proportion of electricity in the total energy mix increased to 17 percent compared with 29 percent for the petroleum products in 1987.

Solid fuel is another source of energy that finds increasing use in industrial applications in place of the petroleum products. Its proportion in the energy mix increased from 2 percent in 1977 to 12 percent in 1987.

The renewable fuels provide a steady supply of energy relative to other energy sources. Its proportion in the energy mix was rather stable at about 42 percent between 1977 and 1987.

Natural gas was introduced for industrial use in 1983 after it was first used as fuel for electricity generation in 1981. However, after the industrial consumption of natural gas reached a peak of 194 KTOE in 1984 its consumption declined steadily to 40 KTOE which is less than 1 percent of the total energy consumption of manufacturing in 1987. Decline in the industrial natural gas consumption is due to its unfavorable price relative to the fuel oil price.

Energy Consumption by Industrial Subgroups

(a) Food and Beverage

Food and beverage is the largest energy consumer of the manufacturing subgroups. It consumed 2,587 KTOE of energy or 55 percent of the total industrial energy consumption in 1982 (Table 34).The energy consumed by this subgroup increased by 0.9 percent per annum to 2,659 KTOE which is 48 percent of the industrial energy consumption in 1987. When compared with the growth in its value added of 4.3 percent, the elasticity was quite low at 0.21.

TABLE 34 : ENERGY CONSUMPTION IN MANUFACTURING SECTOR, 1982-1987

TSIC	1982	1983	1984	1985	1986	1987
31 FOOD & BEVERAGE	2,587	2,402	2,557	2,616	2,699	2,659
32 TEXTILE	373	392	421	416	450	502
33 WOOD & FURNITURE	47	34	39	51	53	67
34 PAPER	119	158	149	174	170	200
35 CHEMICALS	242	246	247	260	262	284
36 NON-METAL	942	891	986	1,137	1,066	1,246
37 BASIC-METAL	94	116	179	161	192	213
38 FEBRICATED METAL	85	70	67	63	68	83
39 OTHERS	239	238	285	312	284	316
MANUFACTURING SECTOR	4,728	4,547	4,930	5,190	5,244	5,570

SOURCE : NEA ENERGY STATISTICS SECTION

Renewable fuels are the most important sources of energy for food and beverage. Specifically, fuelwood, paddy husk, and bagasse are the major sources of energy which are by-products of the related industries. Due to their bulkiness, it is not economical to transport them to other areas so their uses are limited as fuels in the related production process. Thus, bagasse is used as fuel in sugar milling, paddy husk in rice milling, and fuelwood in the animal feeds production.

The consumption of renewable fuels in food and beverage alone accounted for 90 percent of the total renewable fuels consumed by the manufacturing sector in 1986 (Tables 35 and 36). Distribution of the the total energy consumed by sources were 79 percent renewable fuels, 12.8 percent petroleum products, and 6.2

percent electricity in the same year. Although petroleum products are not the major sources of energy for food and beverage, it is the second largest petroleum products consumer after the nonmetal subgroup. Similarly, it is also the second largest electricity consumer after the textile sector.

TABLE 35 : DISTRIBUTION OF ENERGY SOURCES BY MANUFACTURING GROUPS, 1986

INDUSTRY GROUP	PETROLEUM PRODUCTS		ELECTRICITY		SOLID FOSSIL FUEL		NATURAL GAS		RENEWABLE ENERGY		TOTAL	
	KTOE	%	KTOE	%	KTOE	%	KTOE	%	KTOE	%	KTOE	%
31 FOOD & BEVERAGE	345	24	166	19	52	11	0	0	2136	90	2699	52
32 TEXTILE	268	18	178	21	4	1	0	0	0	0	450	9
33 WOOD & FURNITURE	18	1	13	1	0	0	0	0	22	1	53	1
34 PAPER	114	8	28	3	28	6	0	0	0	0	170	3
35 CHEMICAL	63	4	102	12	17	4	0	0	80	3	262	5
36 NON-METAL	384	27	106	12	341	73	87	100	148	6	1066	20
37 BASIC METAL	99	7	80	9	13	3	0	0	0	0	192	4
38 FABLICATED METAL	11	1	57	7	0	0	0	0	0	0	68	1
39 OTHERS	139	10	136	16	9	2	0	0	0	0	284	5
TOTAL	1,441	100	866	100	464	100	87	100	2,386	100	5,244	100

SOURCE : NEA

Excluding renewable fuels, the food and beverage energy intensity declined slightly from 28 TOE per million baht in 1975 to 21 TOE per million baht in 1987 (Table 37). Decline in the overall energy intensity is caused by a decline in the petroleum product intensity from 24 TOE per million baht in 1975 to 14 TOE per million baht in 1987 which more than offset the increase in the electricity intensity from 5 to 7 TOE per million baht during the same period (Tables 38 and 39). The energy consumption in some of the major food industries are discussed below.

TABLE 36 : ENERGY CONSUMPTION IN INDUSTRY BY ENERGY SOURCES, 1986

INDUSTRY GROUP	PETROLEUM PRODUCTS %	ELECTRICITY %	SOLID FOSSIL FUEL %	NATURAL GAS %	RENEWABLE ENERGY %	TOTAL %
31 FOOD & BEVERAGE	13	6	2	0	79	100
32 TEXTILE	60	40	1	0	0	100
33 WOOD & FURNITURE	34	24	0	0	41	100
34 PAPER	67	16	16	0	0	100
35 CHEMICAL	24	39	6	0	30	100
36 NON-METAL	36	10	32	8	14	100
37 BASIC METAL	52	42	7	0	0	100
38 FABLICATED METAL	16	84	0	0	0	100
39 OTHERS	49	48	3	0	0	100
TOTAL	27	16	9	2	45	100

SOURCE : NEA

TABLE 37 : ENERGY INTENSITY IN MAIN MANUFACTURING SECTOR, 1975-1987

UNIT : TOE/MILLION BAHT

YEAR	TSIC CODE							
	31	32	34	35	36	37	38	3
1975	28	25	87	25	423	50	7	44
1976	25	29	84	30	340	62	9	43
1977	24	28	71	37	307	56	8	40
1978	24	24	60	27	293	53	7	36
1979	18	24	63	36	335	56	9	41
1980	17	24	55	29	321	68	6	38
1981	18	22	54	22	307	73	7	34
1982	19	20	48	20	315	102	8	33
1983	18	19	58	20	270	130	5	31
1984	18	20	52	19	253	180	5	32
1985	21	19	60	19	289	110	6	33
1986	20	18	57	16	272	129	6	31
1987	21	17	60	18	283	139	6	32

SOURCES : NEA & NESDB

TABLE 38 : FOSSIL FUEL INTENSITY IN MAIN MANUFACTURING SECTOR*, 1975-1987

UNIT : TOE/MILLION BAHT

YEAR	TSIC CODE						
	31	32	34	35	36	37	3
1975	23	16	73	17	394	24	34
1976	21	19	67	23	312	36	34
1977	20	18	56	30	281	32	32
1978	18	15	46	20	267	27	29
1979	13	15	50	29	305	30	33
1980	12	16	42	23	296	39	30
1981	13	14	42	16	280	41	25
1982	14	12	36	15	287	56	24
1983	13	11	39	10	242	76	22
1984	12	11	32	8	228	129	23
1985	15	10	47	9	259	72	24
1986	14	11	48	7	241	75	22
1987	14	10	51	9	252	81	23

* COAL , PETROLEUM PRODUCTS AND NATURAL GAS

SOURCE : NEA&NESDB

TABLE 39 : ELECTRICITY INTENSITY IN MAIN MANUFACTURING SECTOR, 1975-1987

UNIT : TOE/MILLION BAHT

YEAR	TSIC CODE						
	31	32	35	36	37	38	3
1975	5	9	7	29	26	2	10
1976	5	10	7	29	26	2	10
1977	4	9	7	25	24	2	7
1978	5	9	7	27	26	2	8
1979	6	9	7	29	26	3	8
1980	5	8	6	24	29	3	8
1981	5	8	6	27	32	3	9
1982	5	7	5	28	46	3	9
1983	6	8	10	27	54	3	9
1984	6	8	10	26	51	4	9
1985	6	8	10	30	38	4	9
1986	6	7	9	31	53	5	9
1987	6	7	10	30	58	5	10

SOURCES : NEA & NESDB

(i) Sugar Milling

The energy consumed in sugar milling accounted for 47 percent of the total energy consumption in food and beverage in 1986. Bagasse, the major energy source for sugar milling,supplied 96 percent of its total energy requirements in the same year. The remaining 4 percent of the energy requirements were supplied from petroleum products, solid fuel, and electricity.

Energy is used mainly in boilers to generate electricity and steam for process heat. The use of bagasse for paper manufacturing in the future may compete for the bagasse supply and may encourage the use of lignite in sugar milling. The extent that lignite will be used as fuel in the future depends upon its relative prices.

The energy intensity for sugar milling in 1986 was 536 TOE per million baht or, in terms of the physical unit, 0.51 TOE per ton ,which is similar to the 1987 NEA/Chula survey.

(ii) Rice Milling

Rice milling consumed 25 percent of the total energy requirements in food and beverage in 1986. As in the case of sugar milling, the renewable fuels supplied 85 percent of the total energy requirements in rice milling in 1986. Paddy husk is the major source of renewable energy which also includes fuelwood. The remaining energy requirements were supplied from fuel oil, diesel oil, and electricity. The choice of fuels depends upon the mill size and production process. Electricity and diesel were used mostly by small and medium mills for driving motors and lighting while the paddy husk and fuel oil were used for heat process by the larger mills.

The energy intensity for rice milling from the 1986 NEA was 0.359 TOE per ton compared with the NEA/Chula figure of 0.30 TOE per ton which is lower than the energy intensity for sugar milling.

(iii) Ice Production

The energy required for ice production was only 2.3 percent of the total energy consumption in food and beverage in 1986. Ninety eight percent of the total energy required by this industry were supplied from electricity, the major source of motive power. Diesel and fuel oil provided the remaining 2 percent. The energy intensity from the NEA/Chula survey was 0.0056 TOE per ton compared with 0.0028 TOE per ton for the world standard.

(b) Non Metallic Minerals

Although non metallic minerals is one of the smallest industry in terms of GDP contribution (only 3. 8 percent of the total manufacturing value added),it was the second largest energy consumer after the food and beverage industry in 1986. The nonmetal energy consumption increased from 20 percent of the

total industrial energy consumption in 1986 to 22 percent in 1987.

Petroleum products and solid fuel were the two major sources of energy for this industry in 1986, suppling 36 percent and 32 percent of the total energy requirements respectively in 1986.

Non metallic minerals is the most energy intensive industry. However, its energy intensity declined from 423 TOE per million baht in 1975 to 282 TOE per million baht in 1987.

Cement is the largest energy consumer in the non metallic minerals subgroup. The energy used in cement production were 72 percent of the total nonmetal energy consumption in 1986. Solid fuel is the major source of energy : it supplied 45 percent of the total energy requirements in cement production. The remaining energy requirements were supplied from petroleum products, natural gas, electricity, and renewable fuels. The cement energy intensity in 1986 was 0.70 TOE/Ton in term of physical Unit or 539 TOE per million baht of which 443 TOE per million baht may be allocated to solid fuel , 52 TOE per million baht to electricity, and 44 TOE per million baht to other sources.

(c) Textile

Textile is the third largest energy consumer after food and beverage, and non metallic minerals. The textile value added increased at the rate of 9.4 percent per annum compared with a 6.1 percent rate of increase in its energy consumption which implies an energy elasticity of 0.65 between 1982 and 1987.

Petroleum products and electricity are virtually the only sources of energy for textile. In 1986, the energy from petroleum products supplied 60 percent of the total textile energy requirements. The remaining energy requirements were supplied from electricity which accounted for 21 percent of the total industrial electricity consumption in the same year.

The textile energy intensity is slightly lower than the food and beverage energy intensity. The textile energy intensity declined from 25 TOE per million baht in 1975 to 17 TOE per million baht in 1987. The declining trend of the textile energy intensity is caused by declines in the petroleum products and electricity intensities.

(d) Others

Energy required by basic metal, chemicals, paper, wood and furniture, and other industries were 21 percent of the total manufacturing consumption in 1986. Renewable fuels were the major sources of energy for wood and furniture. The distributions of energy by sources in this industry were 51 percent renewable fuels, 28 percent electricity, and 21 percent petroleum products.

Petroleum products are the major sources of energy for

pulp and paper production. The energy distribution for this industry was 68 percent petroleum products, 16 percent solid fuel , and 16 percent electricity.

The chemical industry depended on electricity for 43 percent of its energy requirements in 1986. The remaining 27 percent of energy were supplied from petroleum products, 23 percent from renewable fuels, and 7 percent from solid fuel.

Petroleum products and electricity supplied 93 percent of the total energy requirements in the basic metal industry. The other remaining 7 percent of the energy were from solid fuel.

3. Determinants of Total Energy Intensity Variation

Declining trend in the manufacturing energy intensity discussed in the overview section may be further separated into the structural effect and the real energy intensity effect. The structural effect measures, ceteris paribus, the compositional changes in the value added of a given industry within a given time period. The structural effect is determined by many factors such as the changes in demand for the industrial product and the relative factor prices.

The real energy intensity effect measures, ceteris paribus, a direct change in the energy intensity which depends upon factors such as substitutions between different sources of energy and changes in the production technique. The total energy variation is simply the sum of structural effect and real energy intensity effect.

The structural and real energy intensity effect were computed for the manufacturing sector between 1982 and 1987 and the results are presented in Table 42. It is seen that the decline of 1.2 percent in the overall energy intensity between 1982 and 1987 may be separated into 6.4 percent of structural effect and -7.6 percent of real energy intensity effect. Most of the real energy intensity variation that more than offset the effect of strutural changes originated from petroleum products.

TABLE 40 : STRUCTURAL EFFECT AND REAL ENERGY INTENSITY EFFECT, 1982-1987

UNIT: PERCENT

EFFECTS	TOTAL ENERGY	FUEL	ELECTRICITY
STRUCTURAL	+6.4	+5.1	+9.7
REAL ENERGY INTENSITY	-7.6	-10.4	-0.01
TOTAL VARIATION	-1.2	-5.3	+9.69

V. TRANSPORTATION

A. Definition and Analytical Framework

Transportation in this section covers the tranportation of people and commodities by any motor driven mode. Waterways, air, and land are the modes of transportation in this study.

The framework used for the analysis of energy consumption in transportation is presented in Figure 4. The coverage of areas is divided into Bangkok and others which covers all the interurban transportation. The emphasis in this study is on road transportation which consumed approximately 80 percent of the total energy consumption in the transportation sector.

B. Data Base

1. Sources of Data

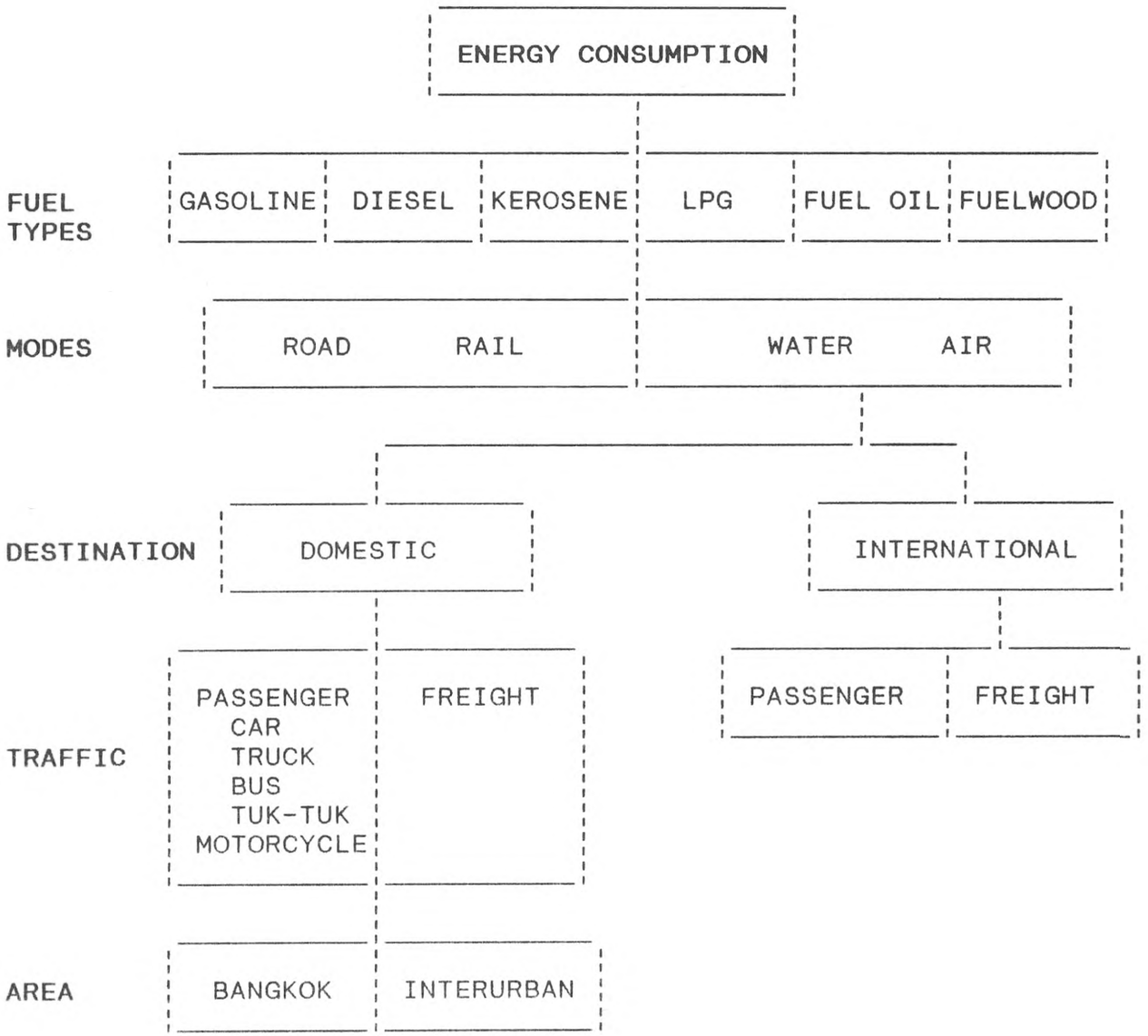
The NEA/CEC study is one source of data used in this section. Data from the survey on Energy Consumption of Vehicles in Road Transportation for 1985 undertaken by NEA and the Vehicle Fuel Use Survey for 1986 undertaken by NESDB/NEPO supplement the NEA/CEC data.

Additional data are collected and compiled from the LTD, PD, TMIS, BMTA, ETO, TCL, SRT, PTT, THAI, as well as from the following reports:

(1) Annual Transport Statistics, TMIS
(2) Study of Trucking Industy, KAMPSAX-DECCON (August, 1983)
(3) SRT Information Booklet
(4) Transport Planning Unit Project: Study of Energy Policy for the Transportation Sector, BCEOM (1982)
(5) Annual Reports: Oil and Thailand, Thailand Energy Situation, NEA
(6) Energy Use in Road Transport, CU (September, 1988)
(7) Transport Sector Review, MOC-GTZ (February, 1986)
(8) Metropolitan Bangkok Short Term Transport Review, NESDB-HFA

Data on the consumption of premium and regular gasoline, LPG, high and low speed diesel for land and part of water transport are from the sales of these fuels to inland petrol stations as well as petrol stations along the coast. The fuel consumption for part of the water transport includes fuels used by the fishing trawlers.

FIGURE 4
FRAMEWORK FOR ENERGY CONSUMPTION ANALYSIS IN TRANSPORTATION



The fuel oil and low speed diesel consumption for water transport are from the sales to shipping agencies which have international lines. Data on the consumption of jet fuels are from their sales to the domestic and international airlines.

Kerosene are used for motor cleaning and maintainance in the transportation sector and their consumption data are from the sales to all the transportation agencies.

Although some fuelwood were used as fuels for rail transportation, they were completely substituted by the commercial fuels after 1978. The fuelwood consumption data in rail transport are from the SRT.

2. Data Reconciliation and Constraints

There are some inconsistencies in the data from different sources caused by different definitions, levels of aggregation, and periods of coverage. Such inconsistencies are reconciled in the following area:

(a) Number of Registered Vehicles by Areas

Prior to 1979, all the vehicles were registered at the PD under the Motor Vehicle Act. Thereafter, the responsibility of registering of buses and trucks was transferred to the LTD. However, all the tractors, trailers, and private trucks with curb weight not exceeding 1,600 kg are still registered at the PD.

Only the total number of registered vehicles were collected by the PD on the fiscal year basis. The LTD data were collected on the calendar basis and the number of registered vehicles were disaggregrated by areas of Bangkok and others for only periods between 1980 and 1985. The PD series were adjusted to the calendar year basis on the assumption that there is no seasonality in the number of registered vehicles. The trend in the number of registered vehicles between 1980 and 1985 is the basis for their projections for 1986 and 1987.

(b) New Registrations

The data on newly registered vehicles were collected by the LTD for trucks and buses since 1983. The data prior to 1983 were collected by only the PD. However, examinations of the PD data shows that there were no new registrations in Bangkok which is contrary to the observed increase in the number of vehicles each year. A possible explanation is that owners of the vehicles observe in Bangkok choose to register their vehicles elsewhere.

Moreover, the "new registrations" recorded each year are simply the difference between the number of vehicles registered and the number of registrations that are not renewed in that year. There is thus no information on the age structure of vehicle , an important determinant of the vehicle fuel efficiency.

(c) Vehicle Classification

Since there are some differences in the classifications of vehicles between different sources of data, the following vehicle classifications are adopted in this study. Trucks and buses are classified according to their sizes and curb weight as follows:

Classifications	Weight
Small truck	Not exceeding 2,000 kg
Medium truck	Between 2,001 and 7,000 kg
Large truck	Over 7,000 kg
Small bus	Not exceeding 2,000 kg
Large bus	Over 2,000 kg

Passenger cars are grouped by the number of seats into two categories of up to 7 seats and exceeding 7 seats. Other vehicles include fire trucks, ambulances, tractors, business service vehicles. There are not disaggregrated by areas due to their negligible energy consumption.

C. Pattern of Energy Consumption

1. General Overview

The energy consumption in transportation increased from 2,354 KTOE in 1972 to 6805 KTOE in 1986 which is equivalent to an average annual increase of 8 percent per annum (Table 41). Gasoline and high speed diesel are the two major sources of energy for transportation. The energy from these two sources supplied almost 80 percent of the total energy requirements in this sector.

Diesel is more widely used than gasoline . Consumer's fuel choice depends upon their relative prices. In the mid 1970s, the observed pattern of energy consumption suggests a substitution of gasoline for high speed diesel. The proportion of diesel in the transport energy mix declined from 43 percent in 1972 to 41 percent in 1978 while the gasoline proportion increased from 36 percent to 41 percent during the same period.

The consumption pattern of these two substitutes switched in the late 1970s and 1980s as the proportion of diesel in the energy mix increased steadily to 54 percent in 1986 compared with 23 percent for gasoline in the same year. The rates of increase in the consumption of diesel and gasoline between 1972 and 1987 were 10 percent and 4 percent per annum respectively.

LPG, the other substitute for gasoline and diesel, was used as transport fuel since the second energy crisis in 1979 when the retail price of premium gasoline increased from 5.6 baht per liter in 1978 to 13.45 baht per liter in 1979 compared with the LPG price of 5.55 baht per liter. The use of LPG in transportation became more widespread as its share in the total energy mix increased from 1.1 percent in 1979 to 3.8 percent in 1985. However, the LPG proportion in the total energy mix declined to 2.9 percent in 1986. Nevertheless, the consumption of LPG increased at the rate of 22 percent per annum during the period 1979 through 1986.

The consumption of jet fuel depends upon the volume of air traffic for passengers and freight. The jet fuel consumption increased by 8 percent per annum between 1972 and 1986. Its proportion in the total energy mix was rather stable at around 18 percent.

The rate of increase of the consumption of fuel oil (bunker oil) was the highest of all fuel types, at 10 percent per annum. However, its consumption is relatively small as its share in the energy mix was less than 4 percent throughout the period between 1972 and 1986.

TABLE 41 : ENERGY CONSUMPTION IN TRANSPORTATION BY FUEL TYPES, 1972 - 1986

YEAR	LPG		KERO		PREMIUM GASOLINE		REGULAR GASOLINE		TOTAL GASOLINE	
	KTOE	%SHARE	KTOE	%SHARE	KTOE	%SHARE	KTOE	%SHARE	KTOE	%SHARE
1972	NA	0 %	27	1 %	0	0 %	0	0 %	851	36 %
73	NA	0 %	37	1 %	0	0 %	0	0 %	855	30 %
74	NA	0 %	29	1 %	0	0 %	0	0 %	1,021	33 %
75	NA	0 %	29	1 %	0	0 %	0	0 %	1,222	40 %
76	NA	0 %	23	1 %	0	0 %	0	0 %	1,364	39 %
77	NA	0 %	16	0 %	0	0 %	0	0 %	1,517	41 %
78	0	0 %	15	0 %	0	0 %	0	0 %	1,595	41 %
79	47	1 %	2	0 %	1,004	24 %	555	13 %	1,559	37 %
80	21	0 %	2	0 %	875	21 %	616	15 %	1,491	36 %
81	51	1 %	3	0 %	782	18 %	607	14 %	1,388	32 %
82	129	3 %	4	0 %	487	11 %	852	20 %	1,339	31 %
83	178	4 %	6	0 %	519	10 %	886	17 %	1,405	28 %
84	230	4 %	4	0 %	571	10 %	851	14 %	1,422	24 %
85	239	4 %	2	0 %	597	9 %	829	13 %	1,425	22 %
1986	194	3 %	1	0 %	656	10 %	902	13 %	1,557	23 %
AVERAGE ANNUAL GROWTH RATE										
	22		-18		-6		7		4	

TABLE 41 : ENERGY CONSUMPTION IN TRANSPORTATION BY FUEL TYPES, 1972 - 1986 (CONT.)

YEAR	TOTAL DIESEL		FUEL OIL		JET FUEL		TOTAL
	KTOE	%SHARE	KTOE	%SHARE	KTOE	%SHARE	(KTOE)
1972	1,021	43 %	63	3 %	393	17 %	2,354
73	1,186	41 %	58	2 %	721	25 %	2,858
74	1,341	44 %	78	3 %	583	19 %	3,052
75	1,075	35 %	65	2 %	682	22 %	3,073
76	1,378	39 %	23	1 %	699	20 %	3,486
77	1,500	41 %	25	1 %	624	17 %	3,682
78	1,612	41 %	28	1 %	642	16 %	3,893
79	1,820	43 %	68	2 %	711	17 %	4,207
80	1,675	41 %	151	4 %	772	19 %	4,111
81	1,920	45 %	148	3 %	757	18 %	4,268
82	1,799	42 %	173	4 %	884	20 %	4,329
83	2,335	46 %	225	4 %	934	18 %	5,083
84	3,085	52 %	228	4 %	986	17 %	5,955
85	3,499	55 %	164	3 %	1,012	16 %	6,341
1986	3,688	54 %	244	4 %	1,120	16 %	6,805
AVERAGE ANNUAL GROWTH RATE							
	10		10		8		8

GASOLINE = PG + RG

DIESEL = HSD + LSD

There is a marked difference in the consumption of kerosene between the 1970s and the 1980s. At the time of the first energy crisis in 1973, the kerosene consumption was 38 KTOE or 1.3 percent of the total energy consumption in transportation. After the late 1970s, the use of kerosene almost disappeared completely (1.5 KTOE in 1986).

2. Energy Consumption in Road Transport

(a) Motor Vehicle Fleet

Table 42 presents the total number of vehicles by types from 1973 to 1986. The total number of vehicles in the kingdom increased from 876,914 in 1972 to 3,642,070 in 1986 which is equivalent to an average annual increase of 12 percent during this period.

Motorcycles are the most widely used vehicles as their numbers accounted for 58 percent of the total vehicles in 1986. The number of motorcycles increased at the rate of 14 percent between 1973 and 1986, which is the highest rate of all the vehicle types.

The number of passenger cars and trucks accounted for 20 percent and 17 percent of the total number of vehicles respectively in 1986. The number of passenger cars increased at the rate of 9 percent per annum between 1973 and 1986 which is slightly lower than the corresponding rate of increase of 10 percent for trucks.

Small passenger cars with less than 7 seats are almost three times the number of large passenger cars. Similarly, small trucks are more widely used than large trucks. In contrast, small and large buses are equally used as there were about the same distributed number of large and small buses in 1986. Taxis are relatively small in numbers as the government imposed a quota of 9,000 taxis in Bangkok in 1976 which was later adjusted to 13,500.

A majority of passenger cars, taxis, motor tricycles or tuk-tuks were registered in Bangkok between 1973 and 1986. In constrast, more than half of the motorcycles, buses, and trucks were registered outside the Bangkok area during the same period (Table 43).

(b) Fuel Efficiency

Data on fuel efficiency were compiled from the NEA survey on energy consumption of road vehicles and the NEPO survey on vehicle fuel uses analysis after the vehicle classifications in the two survey were reconciled as mentioned above. The fuel efficiency by vehicle and fuel types in 1986 are presented in Table 44.

TABLE 42 : TOTAL NUMBER OF VEHICLES BY TYPES, 1973-1986

YEAR	VEHICLE TYPE						
	CAR			TAXI	BUS		
	CAR<7 C0001	CAR>7 C0002	CAR ALL C0003	C0004	SM BUS C0005	HEV BUS C0006	BUS ALL C0007
1973	191,275	38,541	229,816	19,816	NA	NA	20,755
1974	227,064	43,830	270,894	19,432	NA	NA	21,844
1975	224,635	57,095	281,730	16,581	NA	NA	22,173
1976	213,951	60,796	274,747	19,608	NA	NA	22,549
1977	228,870	72,648	301,519	20,786	NA	NA	25,981
1978	253,948	79,953	333,901	19,009	NA	NA	28,076
1979	272,841	90,775	363,616	19,001	NA	NA	31,024
1980	296,241	90,302	386,543	18,809	NA	NA	59,743
1981	321,336	102,249	423,585	18,419	NA	NA	63,373
1982	355,206	124,639	479,845	18,339	NA	NA	69,259
1983	387,859	149,465	537,325	18,055	35,288	35,254	70,542
1984	478,038	165,176	643,214	18,100	36,558	37,602	74,160
1985	518,950	185,697	704,647	19,328	36,836	39,320	76,156
1986	540,615	198,334	738,948	18,948	37,880	38,865	76,745
% AVG. GROWTH	8.32	13.43	9.40	-0.34	2.39	3.30	10.58

TABLE 42 : TOTAL NUMBER OF VEHICLES BY TYPES, 1973-1986 (CONT.)

YEAR	VEHICLE TYPE								
	TRUCK				MOT TRIC (2)	OTHER	SUB TOT	MOT CYCL	TOTAL
	SM TRUCK C0008	MED TRUCK C0009	HEV TRUCK C0010	TRUCK ALL C0011	C0012	C0013	C0014	C0015	C0016
1973	NA	NA	NA	179,152	NA	26,683	476,222	400,693	876,914
1974	NA	NA	NA	209,859	NA	28,192	550,220	442,374	992,594
1975	NA	NA	NA	238,012	NA	29,879	588,375	466,438	1,054,813
1976	NA	NA	NA	278,748	NA	30,234	625,885	491,245	1,117,130
1977	NA	NA	NA	339,110	NA	35,832	723,226	627,622	1,350,848
1978	NA	NA	NA	375,275	NA	44,567	800,828	730,372	1,531,199
1979	NA	NA	NA	413,459	NA	46,949	874,048	839,021	1,713,069
1980	NA	NA	NA	369,320	8,988	40,508	883,911	909,380	1,793,291
1981	NA	NA	NA	431,482	8,849	41,323	987,030	1,107,285	2,094,315
1982	NA	NA	NA	523,694	9,111	46,509	1,146,757	1,355,305	2,502,062
1983	409,206	95,011	50,425	554,642	10,768	48,449	1,239,780	1,656,610	2,896,390
1984	422,072	117,362	55,481	594,915	11,012	51,191	1,392,592	1,877,577	3,270,169
1985	426,159	124,365	60,687	611,211	11,290	53,984	1,476,615	1,883,897	3,360,512
1986	446,333	125,731	63,822	635,886	11,637	57,809	1,539,972	2,102,098	3,642,070
% AVG. GROWTH	2.94	9.79	8.17	10.24	5.63	6.13	9.45	13.60	11.58

(1) INCLUDING INTERURBAN TAXIS AND SERVICE CARS WITH LESS THAN 7 SEATS
(2) BETWEEN 1973-1979, MOTORTRICYCLES ARE INCLUDING IN "OTHER"

SOURCE : LAND TRANSPORT DEPARTMENT, POLICE DEPARTMENT AND ANNUAL TRANSPORT STATISTICS (TMIS), COMPILED BY NEA

A majority of small passenger cars, especially in Bangkok, depend on gasoline as fuel. Large passenger cars used more diesel than the small passenger cars. Nevertheless, the proportion of diesel in the fuel mix of large passenger cars was only 30 percent in 1986.

Diesel was used by a majority of small trucks and all of the medium and large trucks. It is interesting to note that all the Bangkok tuk-tuks used LPG while gasoline was the dominant fuel for the tuk-tuks in other areas.

The fuel efficiency of motorcycles was 27 km per liter in Bangkok and 32 km per liter for other areas. It may be generally observed that the fuel efficiencies are highest for vehicles with diesel engines and lowest for vehicles with LPG engines. The differences in fuel efficiencies between the gasoline run and LPG run vehicles ranged from 10 percent or 1 km per liter for small passenger cars in Bangkok to 20 percent or 2 km per liter for tuk-tuks outside Bangkok.

Fuel efficiencies were also found to be higher for vehicles outside Bangkok which is not unexpected considering the traffic congestion in the capital. The differences in the fuel efficiencies between the two areas ranged from 1 to 1.5 km per liter.

(c) Unit Energy Consumption Per Equivalent Vehicle

The unit energy consumption per equivalent vehicle is a measurement of the unit energy consumption for the whole stock of vehilces. The stock of each type of vehilce is express terms of a reference vehicle. By comparing the amount of energy consumption of a given type of vehicle with the equivalent amount of energy consumed by the reference vehicle.

Small passenger car with less than 7 seats is the reference vehicle for all gasoline and LPG powered vehicles. Medium and large truck is the reference vehicle for all the diesel powered vehicles. Table 45 presents the estimation results for the unit energy consumption per equivalent vehicle.

TABLE 43 : PERCENTAGE OF VEHICLE REGISTERED IN BANGKOK BY TYPES, 1973-1986

YEAR	VEHICLE TYPE						
	CAR			TAXI(1)	BUS		
	CAR<7 C0001	CAR>7 C0002	CAR ALL C0003	C0004	SM BUS C0005	HEV BUS C0006	BUS ALL C0007
1973	76 %	73 %	76 %	60 %	0 %	0 %	31 %
1974	79 %	70 %	77 %	61 %	0 %	0 %	29 %
1975	77 %	73 %	77 %	60 %	0 %	0 %	29 %
1976	75 %	74 %	75 %	70 %	0 %	0 %	26 %
1977	73 %	74 %	73 %	72 %	0 %	0 %	35 %
1978	73 %	73 %	73 %	73 %	0 %	0 %	38 %
1979	73 %	72 %	73 %	76 %	0 %	0 %	40 %
1980	73 %	83 %	75 %	78 %	0 %	0 %	16 %
1981	74 %	84 %	77 %	80 %	0 %	0 %	20 %
1982	74 %	82 %	76 %	79 %	0 %	0 %	22 %
1983	73 %	79 %	75 %	80 %	11 %	35 %	23 %
1984	77 %	75 %	77 %	81 %	11 %	32 %	22 %
1985	79 %	72 %	77 %	87 %	11 %	30 %	21 %
1986	80 %	70 %	77 %	89 %	8 %	31 %	20 %

TABLE 43 : PERCENTAGE OF VEHICLE REGISTERED IN BANGKOK BY TYPES, 1973-1986 (CONT.)

YEAR	VEHICLE TYPE								
	TRUCK				MOT TRIC (2)	OTHER	SUB TOT	MOT CYCL	TOTAL
	SM TRUCK C0008	MED TRUCK C0009	HEV TRUCK C0010	SUB TOTAL C0011	C0012	C0013	C0014	C0015	C0016
1973	0 %	0 %	0 %	25 %	0 %	53 %	53 %	18 %	37 %
1974	0 %	0 %	0 %	22 %	0 %	58 %	53 %	17 %	37 %
1975	0 %	0 %	0 %	19 %	0 %	53 %	50 %	18 %	36 %
1976	0 %	0 %	0 %	21 %	0 %	50 %	48 %	19 %	35 %
1977	0 %	0 %	0 %	20 %	0 %	49 %	46 %	18 %	33 %
1978	0 %	0 %	0 %	19 %	0 %	57 %	46 %	17 %	32 %
1979	0 %	0 %	0 %	20 %	0 %	58 %	46 %	16 %	31 %
1980	0 %	0 %	0 %	25 %	77 %	58 %	50 %	18 %	34 %
1981	0 %	0 %	0 %	22 %	78 %	57 %	49 %	23 %	35 %
1982	0 %	0 %	0 %	23 %	76 %	57 %	48 %	24 %	35 %
1983	22 %	25 %	13 %	22 %	68 %	55 %	48 %	23 %	33 %
1984	18 %	27 %	13 %	19 %	67 %	52 %	48 %	23 %	34 %
1985	21 %	27 %	13 %	21 %	66 %	59 %	50 %	24 %	35 %
1986	22 %	27 %	13 %	22 %	64 %	62 %	51 %	24 %	35 %

(1) INCLUDING INTERURBAN TAXIS AND SERVICE CARS WITH LESS THAN 7 SEATS
(2) BETWEEN 1973-1979, MOTORTRICYCLES ARE INCLUDING IN "OTHER"

SOURCE : LAND TRANSPORT DEPARTMENT, POLICE DEPARTMENT, ANNUAL TRANSPORT STATISTICS (TMIS), COMPLIED BY NEA

TABLE 44 : FUEL EFFICIENCY BY VEHICLE TYPES, FUEL TYPES AND AREAS, 1986

TYPE OF VEHICLE	AREA	FUEL SHARE			AVERAGE ANNUAL MILEAGE (KM)			SPECIFIC FUEL CONSUMPTION (KM/LT)		
		GASOLINE	HSD	LPG	GASOLINE	HSD	LPG	GASOLINE	HSD	LPG
MOTORCYCLES	BKK	100	0	0	18,000	0	0	27.0	0.0	0.0
	NON-BKK	100	0	0	8,000	0	0	32.0	0.0	0.0
		0								
MOTORTRICYCLES	BKK	0	0	100	0	0	70,000	0.0	0.0	12.0
	NON-BKK	83	0	17	30,000	0	30,000	12.0	0.0	10.0
CARS < 7 SEATS	BKK	90	7	3	16,500	26,000	23,000	10.0	10.5	9.0
	NON-BKK	85	12	3	16,500	26,000	23,000	11.0	11.5	10.0
CARS > 7 SEATS	BKK	65	30	5	21,000	31,000	24,000	9.5	10.0	8.5
	NON-BKK	65	30	5	21,000	31,000	24,000	10.5	11.0	9.0
TAXIS	BKK	5	0	95	82,000		82,000	10.0		9.0
	NON-BKK	8	87	5	65,000	65,000	65,000	11.0	11.5	9.5
SMALL BUSES	BKK	25	72	3	22,000	32,000	24,000	10.5	11.0	9.0
	NON-BKK	35	64	1	22,000	35,000	24,000	11.5	12.0	10.0
HEAVY BUSES	BMTA	0	100	0	0	75,000	0	0.0	2.5	0.0
	OTHERS	0	100	0	0	60,000	0	0.0	4.0	0.0
SMALL TRUCKS	BKK	25	72	3	22,000	32,000	24,000	10.5	11.0	9.0
	NON-BKK	35	64	1	22,000	35,000	24,000	11.5	12.0	10.0
MEDIUM TRUCKS	TOTAL	0	100	0	0	40,000	0	0.0	6.0	0.0
HEAVY TRUCKS	TOTAL	0	100	0	0	80,000	0	0.0	4.0	0.0
OTHERS	TOTAL	25	75	0	10,000	10,000	0	10.0	10.0	0.0

SOURCES : COMPILED FROM NEA AND NEPO

Assumption had to be made made to calculate the sectural account for 1986, ie. the consumption by fuel type and category of vehicle. Three sets of assumptions were considered :

Scenario 1

(i) gasoline and LPG are the only fuels used by small passenger cars

(ii) no quota is set for taxis and their numbers are adjusted accordingly between 1980 and 1986

(iii) The number of tuk-tuks are projected backwards to 1973

TABLE 45: COEFFICIENT USE TO MEASURE THE STOCK OF VEHICLES IN EQUIVALENT VEHICLE, (1986)

GASOLINE AND LPG POWERED VEHICLE	IN EQUIVALENT CAR*
TAXI	4.30
BUSES AND SMALL TRUCK	1.20
MOTORCYCLE	0.26
TUK-TUK	2.30
DIESEL POWERED VEHICLE	**IN EQUIVALENT TRUCK***
LARGE PASSENGER CAR, SMALL BUS AND TRUCK	0.26
LARGE BUS	1.51

* SMALL PASSENGER CAR WITH LESS THAN SEVEN SEATS IS THE REFERENCE VEHICLE FOR ALL GASOLINE AND LPG POWERED VEHICLES
MEDIUM AND LARGE TRUCK IS THE COMBINED REFERENCE VEHICLE FOR DIESEL POWERED VEHICLES

(iv) large passenger cars, small buses and trucks are grouped as light vehicles

(v) number of small buses are 50 percent of the total buses and small trucks are 60 percent of the total trucks between 1973 and 1986

(vi) proportion of gasoline in the fuel mix of light vehicle declined steadily from 80 percent in 1973 to 45 percent in 1986

Scenario 2

(i) -(v) same as scenario 1

(vi) proportion of gasoline in the fuel mix of light vehicle declined from 75 percent in 1973 to 45 percent in 1986

Scenario 3

(i)-(iv) same as scenario 1

(v) number of small buses are 50 percent of the total number of buses and small trucks are 70 percent of the total number of trucks

(vi) same as scenario 1

The actual energy consumption per vehicle are similar in magnitude under all scenarios and are observed to decline steadily by about 55 percent between 1973 and 1986. Only one estimate is given here that of scenario 1 (Table 46).

Declines in the energy consumption per vehicle in all three scenarios may be explained by increasing proportion of the low fuel consuming motorcycles. The energy consumed per unit of equivalent vehicle is higher than the corresponding actual energy consumption as expected and are also similar for all three scenarios.

The simulated increases in fuel efficiencies range from 38 percent under scenario 2 to 35 percent under scenario 3. The similar simulation results under the three scenarios implies that the fuel efficiencies are not sensitive to changes in the composition mix of gasoline powered vehicles.

TABLE 46 : ENERGY CONSUMPTION OF GASOLINE AND LPG VEHICLES, 1973-1986

YEAR	STOCK OF VEHICLES									
	CAR < 7 SEAT	TAXI		LIGHT VEHICLES(A)		MOTOR CYCLE		MOTOR TRICYCLE(C)	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
1973	191,275	19,816	85,209	125,128	150,154	400,693	104,180	5,500	12,650
1974	227,064	19,432	83,555	144,534	173,441	442,374	115,017	6,000	13,800
1975	224,635	16,581	71,298	164,571	197,485	466,438	121,274	6,500	14,950
1976	213,951	19,608	84,312	181,883	218,260	491,245	127,724	7,000	16,100
1977	228,870	20,786	89,379	213,937	256,724	627,622	163,182	7,500	17,250
1978	253,948	19,009	81,740	229,792	275,750	730,372	189,897	8,000	18,400
1979	272,841	19,001	81,703	248,149	297,779	839,021	218,145	8,250	18,975
1980	296,241	21,681	93,229	271,268	325,522	909,380	236,439	8,500	19,550
1981	321,336	22,312	95,939	288,507	346,208	1,107,285	287,894	8,849	20,353
1982	355,206	21,089	90,683	356,763	428,116	1,355,305	352,379	9,111	20,955
1983	387,859	20,276	87,186	368,255	441,906	1,656,610	430,719	10,768	24,766
1984	478,038	20,359	87,543	336,855	404,226	1,877,577	488,170	11,012	25,328
1985	518,950	21,890	94,126	311,372	373,646	1,883,897	489,813	11,290	25,968
1986	540,615	21,452	92,241	307,146	368,575	2,102,098	546,545	11,637	26,765

The simulation results for the diesel powered vehicles are also similar for all three scenarios (Tables 47). The decline in energy consumption per vehicle may be explained by the increase in the proportion of diesel powered vehicles. The increases in fuel efficiencies range from 12 percent under scenario 2 to 14 percent under scenario 1. As in the case of gasoline powered vehicles, the composition change in the proportional mix of diesel powered vehicles are not sensitive to their fuel efficiencies.

TABLE 46 : ENERGY CONSUMPTION OF GASOLINE AND LPG VEHICLES, 1973-1986 (CONT.)

YEAR	STOCK OF VEHICLES TOTAL (1)	STOCK OF VEHICLES TOTAL (2)	TOTAL SALES OF GAS/LPG KTOE	UNIT CONSUMPTION TOE/VEHICLE/YEAR (1)	UNIT CONSUMPTION TOE/VEHICLE/YEAR (2)	UNIT CONSUMPTION INDEX (1)	UNIT CONSUMPTION INDEX (2)
1973	742,412	543,467	1147	1.55	2.11	100	100
1974	839,404	612,878	1371	1.63	2.24	106	106
1975	878,725	629,642	1641	1.87	2.61	121	123
1976	913,686	660,346	1831	2.00	2.77	130	131
1977	1,098,715	755,405	2036	1.85	2.69	120	128
1978	1,241,121	819,735	2140	1.72	2.61	112	124
1979	1,387,262	889,443	2093	1.51	2.35	98	111
1980	1,507,071	970,981	2001	1.33	2.06	86	98
1981	1,748,289	1,071,731	1864	1.07	1.74	69	82
1982	2,097,473	1,247,338	1797	0.86	1.44	55	68
1983	2,443,768	1,372,435	1886	0.77	1.37	50	65
1984	2,723,841	1,483,305	1908	0.70	1.29	45	61
1985	2,747,398	1,502,502	1913	0.70	1.27	45	60
1986	2,982,946	1,574,741	2090	0.70	1.33	45	63

(A) LIGHT VEHICLES = CARS > 7 SEATS + SMALL BUSES (< 2000 KGS.) + PICKUPS (< 2000 KGS.)
NUMBER OF SMALL BUSES IS ASSUMED TO BE 50% OF TOTAL BUSES BETWEEN 1973 AND 1982
NUMBER OF PICKUPS IS ASSUMED TO BE 60% OF TOTAL TRUCKS BETWEEN 1973 AND 1982
NUMBER OF LIGHT VEHICLES USING GASOLINE IS ASSUMED TO BE 80% IN 1973 AND 45% IN 1986
(B) ALL CARS ARE ASSUMED TO RUN ON GASOLINE AND LPG
(C) NUMBER OF MOTORTRICYCLES IS RETRAPOLATED FROM 1980 TO 1973.
(1) ACTUAL FLEET
(2) STOCK EXPRESSED IN EQUIVALENT VEHICLE

(d) Interurban Transportation

The volume of interurban traffic in terms of vehicle-km (vkm) is presented in Table 48. The data only cover the traffic on royal and provincial highways which were estimated in the NEA/CEC study to be 94 percent of the total interurban traffic and do not include the remaining 6 percent of the traffic in the rural, municipal, and sanitary districts.

TABLE 47 : ENERGY CONSUMPTION OF DIESEL VEHICLES,1973-1986

YEAR	STOCK OF VEHICLES								TOTAL SALE	UNIT CONSUMPTION TOE/VEHICLE/YEAR		UNIT CONSUMPTION INDEX	
	LIGHT VEHICLES(A)		HEAVY BUSSES		TRUCKS(B)		TOTAL						
	(1)	(2) 0.26	(1)	(2) 1.51	(1)	(2)	(1)	(2)	KTOE	(1)	(2)	(1)	(2)
1973	31282	8133	10378	15671	71661		113321	95465	1221	10,773	12,788	100	100
1974	36133	9395	10922	16492	83944		130999	109831	1380	10,536	12,566	98	98
1975	46417	12068	11087	16741	95205		152709	124015	1107	7,250	8,927	67	70
1976	57437	14934	11275	17025	111499		180211	143458	1419	7,873	9,891	73	77
1977	75167	19543	12990	19615	135644		223801	174802	1544	6,901	8,835	64	69
1978	89363	23234	14038	21197	150110		253511	194542	1660	6,547	8,531	61	67
1979	106349	27651	15648	23628	165383		287380	216662	1873	6,518	8,646	60	68
1980	127656	33191	31524	47601	177600		336780	258392	1724	5,119	6,672	48	52
1981	148625	38643	32379	48892	194400		375404	281935	1977	5,265	7,011	49	55
1982	175719	45687	32521	49107	158291		366531	253085	1853	5,054	7,320	47	57
1983	225705	58683	35254	53234	145436		406395	257353	2404	5,915	9,340	55	73
1984	286951	74607	37602	56779	172843		497396	304229	3176	6,386	10,440	59	82
1985	337320	87703	39320	59373	185052		561692	332128	3602	6,413	10,845	60	85
1986	375400	97604	38865	58686	189553		603818	345843	3797	6,288	10,979	58	86

(A) LIGHT VEHICLES = CARS > 7 SEATS + SMALL BUSES (< 2000 KGS.) + PICKUPS (< 2000 KGS.)
NUMBER OF SMALL BUSES IS ASSUMED TO BE 50% OF TOTAL BUSES BETWEEN 1973 AND 1982
NUMBER OF PICKUPS IS ASSUMED TO BE 60% OF TOTAL TRUCKS BETWEEN 1973 AND 1982
NUMBER OF LIGHT VEHICLES USING DIESEL IS ASSUMED TO BE 20% IN 1973 AND 55% IN 1986
(B) TRUCKS = MEDIUM AND HEAVY TRUCKS
(1) ACTUAL FLEET
(2) STOCK EXPRESSED IN EQUIVALENT VEHICLE

The interurban traffic increased from 18 billion vkm in 1978 to 28 billion vkm in 1987 which is equivalent to an average annual rate of increase of 5.4 percent during this period. Since this is lower than the 8.5 percent rate of increase in the number of total vehicles it implies a decline in the number of traffic per vehicle.

Passenger transportation accounted for 57 percent of the total interurban traffic or 10.4 billion vkm in 1978. The remaining 43 percent of the traffic were in freight. Traffic in the passenger transport increased at a rate of 4 percent per annum to 14.1 billion vkm or 51 percent of the total interurban traffic in 1986.The freight traffic increased at a faster rate of 7.1 percent per annum to 13.5 billion vkm or 49 percent of the total interurban traffic in the same year.

TABLE 48 : INTERURBAN ROAD TRAFFIC BY VEHICLE TYPES, 1978-1986

UNIT : 1000 MILLION VKM

VEHICLE TYPE	YEAR							ANNUAL GROWTH RATE
	1978	1981	1982	1983	1984	1985	1986	
CAR,TAXI	5.62	5.55	6.31	6.93	7.43	8.013	8.936	5.97
SMALL BUS	3.28	2.83	2.91	2.93	3.08	3.125	3.208	-0.28
HEAVY BUS	1.48	1.58	1.69	1.77	1.85	1.956	1.978	3.69
SUB TOTAL	10.38	9.96	10.91	11.63	12.36	13.094	14.122	3.92
SMALL TRUCK	3.64	4.36	4.78	5.5	6.3	6.953	7.417	9.31
MEDIUM TRUCK	2.45	2.43	2.61	2.77	3	3.081	3.23	3.52
HEAVY TRUCK	1.7	2.14	2.21	2.42	2.83	2.93	2.877	6.80
SUB TOTAL	7.79	8.93	9.6	10.69	12.13	12.964	13.524	7.14
TOTAL	18.17	18.89	20.51	22.32	24.49	26.058	27.646	5.39

SOURCE : ANNUAL TRANSPORT STATISTICS REPORT OF TRANSPORT MANAGEMENT IMFORMATION SYSTEM (TMIS), TRANSPORT AND COMMUNICATIONS ECONOMICS DIVISION, MINISTRY OF TRANSPORT AND COMMUNICATIONS

The traffic volume for passenger cars including taxis was the largest with 5.6 billion vkm or 31 percent of the total interurban transportation in 1978. Their traffic accounted for 54 percent of the total passenger traffic which includes the traffic by small and large buses in the same year. Sixty three percent of the passenger traffic in 1986 were by cars.

Small trucks have the second largest traffic with 3.6 billion vkm or 20 percent of the total interurban traffic in 1978. They accounted for 47 percent of the total freight traffic in the same year. The small truck traffic increased by 9.3 percent per annum to 7.4 billion vkm or 27 percent of the total interurban traffic in 1986. Fifty five percent of the total freight traffic in this year were transported by small trucks.

The interurban traffic trend between 1978 and 1986 shows a relative shift towards freight transportation by small trucks. Since a small truck is equivalent to 1.2 small passenger car, such a shift would, ceteris paribus, tend to raise the energy consumption per vehicle.

TABLE 49 : ENERGY CONSUMPTION IN RAIL TRANSPROTATION BY FUEL TYPES, 1960-1986

YEAR	CONSUMPTION / FY									
	FUEL WOOD			FUEL OIL			HSD			TOTAL
	1000 CUM	TOE	% SHARE	1000 LITR	TOE	% SHARE	1000 LITR	TOE	% SHARE	TOE
1960	949	215,507	94 %	3,450	3,248	1 %	12,430	10,714	5 %	229,469
1965	673	152,830	79 %	10,246	9,645	5 %	36,097	31,115	16 %	193,590
1970	563	127,851	66 %	16,881	15,891	8 %	58,412	50,350	26 %	194,091
1971	570	129,440	63 %	25,596	24,095	12 %	59,427	51,225	25 %	204,760
1972	491	111,500	57 %	35,489	33,407	17 %	59,835	51,577	26 %	196,484
1973	438	99,465	54 %	35,379	33,304	18 %	58,272	50,229	27 %	182,998
1974	354	80,389	45 %	52,563	49,480	27 %	57,847	49,863	28 %	179,732
1975	300	68,126	45 %	25,148	23,673	16 %	69,658	60,044	39 %	151,843
1976	82	18,621	21 %	1,405	1,323	1 %	81,671	70,399	78 %	90,343
1977	9	2,044	3 %	30	28	0 %	89,762	77,373	97 %	79,445
1978	1	227	0 %	0	0	0 %	90,570	78,070	100 %	78,297
1979	0	0	0 %	1,044	983	1 %	94,649	81,586	99 %	82,568
1980	0	0	0 %	2,504	2,357	3 %	98,432	84,846	97 %	87,204
1981	0	0	0 %	1,482	1,395	2 %	98,892	85,243	98 %	86,638
1982	0	0	0 %	66	62	0 %	96,952	83,571	100 %	83,633
1983	0	0	0 %	0	0	0 %	98,848	85,205	100 %	85,205
1984	0	0	0 %	0	0	0 %	105,920	91,301	100 %	91,301
1985	0	0	0 %	0	0	0 %	100,205	86,375	100 %	86,375
1986	0	0	0 %	31	29	0 %	99,656	85,901	100 %	85,931

REMARK : (1) FUEL WOOD 10^6 KG = 378.48 TOE
1 CU.M. OF SOLID WOOD = 600 KG
(2) FUEL OIL 10^6 LITRE = 941.24 KG
(3) HSD 10^6 LITRE = 861.98 TOE

3. Energy Consumption in Rail Transport

(a) Sources of Energy in Rail Transport

Prior to 1979, fuelwood, fuel oil and high speed diesel were the sources of fuels for the rail transport (Table 49). In the early 1960s, fuelwood was the dominant source of energy when it supplied 94 percent of the total energy required by rail transport in 1960. Thereafter, the amount of fuelwood consumed declined steadily from 215 KTOE in 1960 to 0.2 KTOE in 1978. From 1979 onwards, fuelwood was no longer used.

High speed diesel is the major substitute for fuelwood in rail transportation. As the rail technology shifts towards the use of diesel trains, the use of high speed diesel became more widespread and its share in the total energy consumption increased from 5 percent in 1960 to almost 100 percent in 1986.

Fuel oil was also used increasingly since 1960 and its consumption in 1974 was equal to the diesel consumption. But from 1974 onwards, the use of fuel oil declined steadily when all the steam engines were replaced by diesel trains. Only 29 TOE of fuel oil was used in rail transport in 1986.

(b) Energy consumption for Passenger and Freight Transport

Table 50 presents the energy consumption for passenger and freight transports in terms of Gross Ton Kilometer Hauled (GTKH). In the computation of GTKH, it is assumed that an average passenger weighs 65 kg, an average passenger car weighs 28.92 tons and an average freight car weighs 10.28 tons. In the early 1960s, the freight traffic was 60 percent of the total rail traffic. The distribution of rail traffic began to shift steadily towards passenger transport which increased to 62 percent of the total rail traffic in 1986.

TABLE 50 : ENERGY CONSUMPTION IN RAIL TRANSPORTATION BY TRAFFIC TYPES, 1960-1986

YEAR	RAIL WAY ENERGY CONSUMPTION (TOE) (1)	AVAIL SEAT KM RAIL/P (MSEAT-KM) (2)	PKM RAIL/P (MPKM) (3)	PASS. CAR KM. RAIL/P (1000 KM.) (4)	NET TON KM RAIL/P (MTKM) (5) (A)	TRAIN TKM RAIL/P (MTKM) (6) (B)	GROSS TKM RAIL/P (MGTKH) (7) =(5)+(6)
1960	229,469	4043	2,353	65,217	153	1,886	2,039
1965	193,590	5324	2,847	85,867	185	2,483	2,668
1970	194,091	8045	4,113	129,758	267	3,753	4,020
1971	204,760	8448	4,260	136,254	277	3,940	4,217
1972	196,484	8450	4,412	136,291	287	3,942	4,228
1973	182,997	8574	4,696	138,286	305	3,999	4,304
1974	179,732	8811	5,376	142,118	349	4,110	4,459
1975	151,843	9347	5,640	150,759	367	4,360	4,727
1976	90,343	9873	5,352	159,237	348	4,605	4,953
1977	79,445	10210	5,649	164,675	367	4,762	5,130
1978	78,297	11004	6,039	177,483	392	5,133	5,525
1979	82,568	11731	7,029	189,215	457	5,472	5,929
1980	87,203	12713	8,861	204,762	576	5,922	6,498
1981	86,638	13336	9,483	213,453	616	6,173	6,789
1982	83,633	13350	9,231	216,523	600	6,262	6,862
1983	85,205	13345	9,699	217,204	630	6,282	6,912
1984	91,301	13478	9,643	201,751	627	5,835	6,461
1985	86,375	12492	9,140	207,091	594	5,989	6,583
1986	85,931	12863	9,274	305,518	603	8,836	9,438

TABLE 50 : ENERGY CONSUMPTION IN RAIL TRANSPORTATION BY TRAFFIC TYPES, 1960-1986 (CONT.)

YEAR	AVAIL TKM RAIL/F (MTKM) (8)	LOAD TKM RAIL/F (MTKM) (9) (C)	FREIGHT CAR KM RAIL/F (1000 KM.) (10)	TRAIN TKM RAIL/F (MTKM) (11) (D)	GROSS TKM RAIL/F (MGTKH) (12) =(9)+(11)	TOTAL GROSS TKM (MGTKH) (13) =(7)+(12)	PERCENTAGE RAIL/P (14)	PERCENTAGE RAIL/F (15)
1960	3625	1,147	206,891	2,127	3,274	5,313	38	62
1965	4386	1,534	250,371	2,574	4,108	6,776	39	61
1970	6458	2,209	368,604	3,789	5,998	10,018	40	60
1971	6421	2,304	366,495	3,768	6,072	10,289	41	59
1972	6561	2,242	374,495	3,850	6,092	10,320	41	59
1973	5941	2,070	339,114	3,486	5,556	9,861	44	56
1974	5653	2,296	322,650	3,317	5,613	10,072	44	56
1975	5933	2,353	338,638	3,481	5,834	10,561	45	55
1976	5624	2,505	321,006	3,300	5,805	10,758	46	54
1977	5474	2,912	312,465	3,212	6,124	11,254	46	54
1978	5997	2,651	342,292	3,519	6,170	11,695	47	53
1979	6184	2,747	352,940	3,628	6,375	12,304	48	52
1980	6259	2,805	357,269	3,673	6,478	12,975	50	50
1981	6220	2,601	355,045	3,650	6,251	13,040	52	48
1982	6594	2,421	325,018	3,341	5,762	12,624	54	46
1983	5476	2,413	312,583	3,213	5,626	12,538	55	45
1984	5732	2,618	327,148	3,363	5,981	12,443	52	48
1985	5854	2,718	334,139	3,435	6,153	12,736	52	48
1986	5353	2,583	305,518	3,141	5,724	15,162	62	38

Up to 1980, more energy was used for freight than for passenger transportation. The energy requirements for freight traffic increased from 88 KTOE in 1960 to 141 KTOE in 1986. As the volume of passenger traffic became relatively larger, the gap in the energy consumption between these two traffic types became smaller. From 1980 onwards, more energy were required for transporting passengers than for freights. Inspite of the increase in the traffic volumes of both types of transport, less energy was used and only 53 KTOE and 32 KTOE were used in the transport of passenger and freight respectively in 1986.

Declines in the energy requirements for rail transport are reflected more clearly by its Specific Energy Consumption (SEC) in term of energy per unit of traffic. The SEC in terms of either GOE per seat-kilometer, or GOE per passenger-kilometer (PK), or GOE per GTKH declined drastically between 1960 and 1981. As an example, the SEC for passenger and freight traffic declined from 43 GOE per GTKH in 1960 to 6 GOE per GTKH in 1980.

TABLE 50 : ENERGY CONSUMPTION IN RAIL TRANSPORTATION BY TRAFFIC TYPES, 1960-1986 (CONT.)

YEAR	ENERGY CONSUMPTION		SEC		SEC		SEC	
	RAIL/P (TOE) (16)=(1) X(14)/100	RAIL/F (TOE) (17)=(1) X(15)/100	RAIL/P (GOE/AVAIL-SEAT KM (18)	RAIL/F (GOE/AVAIL-TON KM (19)	RAIL/P (GOE/PKM) (20)	RAIL/F (GOE/TKM) (21)	RAIL/P (GOE/GTKH) (22)	RAIL/F (GOE/GTKH) (23)
1960	88,068	141,401	22	39	37	123	43	43
1965	76,232	117,358	14	27	27	76	29	29
1970	77,882	116,209	10	18	19	53	19	19
1971	83,930	120,830	10	19	20	52	20	20
1972	80,503	115,981	9	18	18	52	19	19
1973	79,885	103,113	9	17	17	50	19	19
1974	79,576	100,156	9	18	15	44	18	18
1975	67,959	83,884	7	14	12	36	14	14
1976	41,594	48,748	4	9	8	19	8	8
1977	36,212	43,233	4	8	6	15	7	7
1978	36,991	41,305	3	7	6	16	7	7
1979	39,787	42,781	3	7	6	16	7	7
1980	43,669	43,535	3	7	5	15	7	7
1981	45,108	41,530	3	7	5	16	7	7
1982	45,459	38,174	3	6	5	16	7	7
1983	46,971	38,234	3	7	5	16	7	7
1984	47,413	43,888	3	8	5	17	7	7
1985	44,646	41,728	4	7	5	15	7	7
1986	53,492	32,439	4	6	6	13	6	6

(A) NET TON KM IS A RESULT OF PASS-KM MULTIPLIED BY 0.065 TON (AVERAGE WEIGHTS/PASSENGER)
(B) TRAIN TKM IS A RESULT OF PASS.CAR-KM MULTIPLIED BY 28.92 TONS (AVERAGE WEIGHT FOR PASS.CAR)
(C) CARLOAD ONLY (SRT SOURCE)
(D) TRAIN TKM IS A RESULT OF FREIGHT CAR-KM. MULTIPLIED BY 10.28 TONS (AVERAGE WEIGHT FOR FREIGHT CAR)

ALL ASSUMPTION IN (A) (B) AND (D) ARE FROM THE TRANSPORT PLANNING UNIT PROJECTION : STUDY OF ENERGY POLICIES FOR THE TRANSPORT SECTOR. BCEOM , 1982

Changes in the energy consumption may be separated into a quantity effect reflecting the effect of traffic increase, and a unit consumption effect. They are two effect defined as

$$QE_{T/T+a} = (Q_{T+a} - Q_T)SEC_T$$

$$UCE_{T/T+a} = (SEC_{T+a} - SEC_T)Q_{T+a}$$

where $QE_{T/T+a}$ = quantity effect between period T and T+a
$UCE_{T/T+a}$ = unit consumption effect between period T and T+a

The total variation is the sum of the quantity effect and the unit consumption effect. The two effects were computed from Table 50 and the results are presented in Table 51. It is seen that the decline in the energy consumed by rail transport between 1960 and 1986 were the results of the negative unit consumption effect which more than offset the positive quantity effect i.e. by the increase in rail traffic.

TABLE 51 : DECOMPOSITION OF THE TOTAL VARIATION OF ENERGY CONSUMPTION OF RAIL TRANSPORT IN TO UNIT CONSUMPTION AND QUANTITY EFFECTS, 1960-1986

UNIT : KTOE

	PASSENGER TRAFFIC	FREIGHT TRAFFIC	TOTAL TRAFFIC
QUANTITY EFFECT	319.6	105.8	425.4
UNIT CONSUMPTION EFFECT	(354.2)	(214.7)	(568.9)
TOTAL EFFECT	(34.6)	(109.0)	(143.5)

4. Air Transport

The total jet fuel consumption increased by 10.4 percent per annum or from 711 KTOE in 1979 to 1,120 KTOE in 1986 (Table 52). International airlines are the major customers as they purchased about 86 percent of the total jet fuel sales in the country in 1979. Proportion of the jet fuel purchase by the international airlines in the total sales declined steadily to 72 percent in 1986.

In contrast, THAI began to purchase relatively more jet fuel in Thailand during the same period as the proportion of its purchase in the total jet fuel sale increased from 12 percent in 1979 to 25 percent in 1986. The proportion of its domestic purchase in the total purchase increased from 29 percent in 1979 to 43 percent in 1986 (Table 53). The average elasticity with respect to passenger between 1972 and 1986 is 0.78.

TABLE 52 : SALE OF JET FUEL FOR AVIATION IN THAILAND, 1979-1986

	1979		1980		1986	
	KTOE	PERCENT	KTOE	PERCENT	KTOE	PERCENT
TOTAL JET FUEL SALE	711	100	772	100	1,119	100
THAI AIRWAYS	20	3	22	3	39	3
THAI INTERNATIONAL	2	11	112	14	278	25
INTERNATIONAL AIRLINES	609	86	638	83	802	72

(a) Domestic Aviation

Table 54 presents the energy consumption and SEC for domestic aviation. The jet fuel consumption in domestic aviation increased at the rate of 10.4 percent per annum or from 20 KTOE to 39 KTOE between 1979 and 1986. The growth rates of the aviation traffic and energy consumption are summarized in Tables 55.

The faster rate of increase in the traffic volume relative to the energy consumption results in decreases in the SEC which range from 3.1 percent in terms of GOE per PK to 6 percent in terms of GOE per ATK. It may be shown that the increase of 19.5 KTOE in the jet fuel consumption may be separated into 35.6 KTOE due to the traffic increase (quantity effect) and -16.1 KTOE due to a decrease in SEC (unit consumption effect).

(b) International Aviation

Table 56 presents the energy consumption and SEC for international aviation. Similar to the case of domestic aviation, the rate of increase in the volume of air traffic is faster than the rate of increase in the jet fuel consumption which also implies an energy elasticity lower than 1 (Table 54). The total increase in the jet fuel consumption of 363 KTOE between 1979 and 1986 may be decomposed into 441 KTOE of quantity effect and -78 KTOE of unit consumption effect.

TABLE 53 : JET FUEL CONSUMPTION IN DOMESTIC AVIATION BY SOURCES OF PURCHASE, 1979-1986

SOURCR OF PURCHASE	1979		1980		1986	
	KTOE	PERCENT	KTOE	PERCENT	KTOE	PERCENT
DOMESTIC	82	29	112	30	279	43
ABROAD	205	71	261	70	371	57
TOTAL	287	100	373	100	650	100

TABLE 54 : ENERGY CONSUMPTION AND SEC FOR DOMESTIC AVIATION, 1976-1986

YEAR	JET OIL CONSUMPTION		FREIGHT	AVAIL SEAT KM	NO.PERSON	PKM	CABIN FACTOR	AVAIL TKM	TOTAL TKM	LOAD FACTOR
	(M.LT)	(KTOE)	(HOUR)	(MSEAT--KM)	(K.PERSON)	(MPKM)	(%)	(MTKM)	(MTKM)	(%)
1976		0.0	16504	231	319	166.3	72.1	21	12	57.1
1977		0.0	18002	247	352	183.1	74.0	22	13	57.9
1978		0.0	14509	307	414	223.2	72.6	31	17.7	57.5
1979	23.8	19.5	16054	366	530	286.0	78.2	37	22.4	60.5
1980	27.0	22.1	12731	466	608	333.9	71.6	50	26.2	52.1
1981	33.4	27.3	12175	568	683	381.0	67.1	63	29.8	47.6
1982	35.2	28.8	12427	606	759	418.3	69.0	67	32.6	48.8
1983	38.4	31.4	16205	691	911	496.6	71.7	76	38.8	51.2
1984	47.2	38.6	17576	851	1121	607.5	71.4	94	53.8	57.2
1985	49.4	40.4	22811	998	1261	678.1	68.0	105	59.9	57.3
1986	47.7	39.0	23471	1047	1334	713.8	68.2	114	63.4	55.4

5. Water Transportation

Information on water transport are not as readily available as for the other transportation modes. There is no data on energy consumption for water transport and the only available information is the volume of water traffic for coastal shippings and inland waterways.

TABLE 54 : ENERGY CONSUMPTION AND SEC FOR DOMESTIC AVIATION, 1976-1986 (CONT.)

YEAR	SEC			
	(GOE/AVAIL-SEAT KM)	(GOE/PKM)	(GOE/AVAIL-TKM)	(GOE/TKM)
1976	0	0	0	0
1977	0	0	0	0
1978	0	0	0	0
1979	53	68	526	869
1980	47	66	441	842
1981	48	72	433	916
1982	47	69	429	883
1983	45	63	413	809
1984	45	63	410	717
1985	40	60	385	674
1986	37	55	342	615

(A) THERE IS NO DATA FOR FUEL CONSUMPTION FROM THE YEAR 1976 TO 1978.
DATA BETWEEN YEAR 1979 - 1980 ARE FROM BCEOM'S STUDY.
(B) LOAD FACTOR = PKM / SEAT KM.
(C) TOTAL TKM = PASSENGERS + MAIL + CARGOES
(D) LOAD FACTOR = TKM / TON KM.

TABLE 55: GROWTH RATES OF ENERGY CONSUMPTION, TRAFFIC, AND SEC IN DOMESTIC AND INTERNATION AVIATION,1979-1986

UNIT: PERCENT

	INTERNATIONAL	DOMESTIC
JET FUEL CONSUMPTION	12.4	10.4
FLIGHT HOURS	9.4	5.6
TRAFFIC		
PASSENGER	10.4	14.1
PKM	13.5	14.0
TKM	14.2	16.0
SEC		
GOE/ASK	-1.5	-5.0
GOE/PKM	-0.9	-3.1
GOE/ATK	-0.2	-6.0
GOE/TKM	-0.2	-4.8

TABLE 56 : ENERGY CONSUMPTION AND SEC FOR INTERNATIONAL AVIATION, 1976-1986

YEAR	JET OIL CONSUMPTION (M.LT)	JET OIL CONSUMPTION (KTOE)	FREIGHT (HOUR)	AVAIL SEAT KM (MSEAT-KM)	NO.PERSON (K.PERSON)	PKM (MPKM)	CABIN FACTOR (%)	AVAIL TKM (MTKM)	TOTAL TKM (MTKM)	LOAD FACTOR (%)
1976	0	0.0	33158	4992	1316	3025	60.6	609	361	59.2
1977	0	0.0	33358	5168	1321	3095	59.9	633	377	59.6
1978	0	0.0	34478	5877	1282	3782	64.4	749	480	64
1979	351	286.9	38265	6483	1554	4252	65.6	866	559	64.6
1980	456	372.7	45479	8718	1845	5514	63.3	1159	734	63.4
1981	556.4	454.8	50157	11299	2186	6904	61.1	1446	888	61.4
1982	624.5	510.5	55826	12903	2403	7928	61.4	1659	1034	62.4
1983	658.6	538.3	58618	13609	2506	8461	62.2	1761	1100	62.5
1984	688.9	563.1	60578	13806	2635	8813	63.8	1823	1195	65.6
1985	745.6	609.5	64630	14776	2924	9835	66.6	1973	1323	67
1986	794.9	649.8	71893	16310	3112	10317	63.3	2244	1419	63.2

TABLE 56 : ENERGY CONSUMPTION AND SEC FOR INTERNATIONAL AVIATION, 1976-1986 (CONT.)

YEAR	SEC (GOE/AVAIL-SEAT KM)	SEC (GOE/PKM)	SEC (GOE/AVAIL-TKM)	SEC (GOE/TKM)
1976	0.00	0.00	0.00	0.00
1977	0.00	0.00	0.00	0.00
1978	0.00	0.00	0.00	0.00
1979	44.26	67.48	331.30	513.25
1980	42.75	67.60	321.60	507.81
1981	40.25	65.88	314.52	512.16
1982	39.56	64.39	307.70	493.68
1983	39.56	63.63	305.70	489.40
1984	40.79	63.90	308.89	471.22
1985	41.25	61.97	308.90	460.66
1986	39.84	62.98	289.55	457.89

(A) THERE IS NO AVAILABLE DATA FOR FUEL CONSUMPTION FROM THE YEAR 1976 TO 1978.
DATA BETWEEN 1979 - 1980 ARE FROM BCECOM'S STUDY.
(B) CABIN FACTOR = PKM / ASK
(C) TOTAL TKM = PASSENGERS + MAIL + CARGOES
(D) LOAD FACTOR = TKM / ATK

The major cargoes in coastal shippings are petroleum products that constituted between 70 to 85 percent of the total coastal shipping cargoes. It is likely that the traffic data for inland waterways prior to 1986 are inconsistent due to problems of double counting. Earth, sand, and gravel were the major inland waterways cargoes in 1986. They accounted for about 80 percent of the total inland waterways cargoes in the same year.

6. Energy Balance in Transportation

The energy consumption in road and rail transports discussed above are the major parts of the energy balance of the transportation sector. Some assumptions are made in order to complete the balance with the energy consumed by the other modes of transportation.

The aviation traffic is disaggregrated into domestic and international traffic. Energy consumed by THAI represents the domestic energy consumption and the remaining jet fuel are allocated to international traffic.

Similarly, water transport is disaggregrated into domestic and international traffic. All the low speed diesel and fuel oil used is allocated to international water transportation. The domestic water transport which covers all the inland waterways and coastal shippings is assumed to consume only high speed diesel. Its consumption is the difference between the total high speed diesel consumption and the high speed diesel consumption in road and rail transports.

Table 52 presents the energy balance for transportation in 1986. The balance shows a total energy consumption of 6,817 KTOE which compares closely to the NEA national aggregate of 6,805 KTOE in the same year.

Energy used for domestic transportation accounted for 80 percent of the total energy consumption in this sector. Road transportation consumed 96 percent of the total energy required by domestic transportation. The remaining 1.5 percent are allocated to rail, 0.7 percent to air, and 1.8 percent to water transportation.

The international transport accounted for the remaining 20 percent of the total energy consumption in this sector. Seventy nine percent of the total energy consumed in international transport is used for air transportation. The remaining 21 percent may be allocated to water transportation.

High speed diesel supplied 67 percent of the total energy requirements in domestic transportation. The remaining 29 percent were supplied from gasoline, 3 percent from LPG, and 1 percent from jet fuel.

TABLE 52 : ENERGY BALANCE IN TRANSPORTATION BY FUEL TYPES AND MODES, 1986

MODE OF TRANSPORT	PETROLEUM PRODUCTS CONSUMPTION (KTOE)							TOTAL
	LPG	GASOLINE	AVIATION	KEROSENE	HSD	LSD	FUEL OIL	
DOMESTIC TRANSPORT	174.78	1,589.52	39.00	0.00	3,646.55	0.00	0.00	5,449.85
PRIVATE PASSENGER TRANSPORT	42.94	1,335.56	0.00	0.00	244.74	0.00	0.00	1,623.24
MOTORCYCLE		548.17						548.17
CARS *	42.94	787.39			244.74			1,075.07
PUBLIC PASSENGER TRANSPORT	121.69	41.75	39.00	0.00	712.40	0.00	0.00	914.84
TRICYCLE	28.58	6.54						35.12
TAXI	92.42	5.89			8.84			107.15
SMALL BUS	0.69	18.55			61.58			80.82
BMTA BUS					97.21			97.21
OTHER BUS					453.91			453.91
OTHERS		10.77			37.37			48.14
RAIL					53.49			53.49
AIR			39.00					39.00
FREIGHT TRANSPORT	10.15	212.21	0.00	0.00	2,689.41	0.00	0.00	2,911.77
LIGHT TRUCK	10.15	212.21			737.07			959.43
MEDIUM TRUCK					722.52			722.52
HEAVY TRUCK					1,100.27			1,100.27
RAIL					32.44			32.44
WATERWAYS & COASTAL					97.11			97.11
INTERNATIONAL TRANSPORT	0.00	0.00	1,080.59	0.00	0.00	41.75	244.31	1,366.65
AIR			1,080.59					1,080.59
SEA						41.75	244.31	286.06
TOTAL	174.78	1589.52	1119.59	0	3646.55	41.75	244.31	6,816.50

* SMALL AND LARGE PASSENGER CARS

In contrast, the aviation or jet fuel supplied 79 percent of the total energy requirements in international transportation. The remaining 18 percent of the energy requirements were supplied from fuel oil and 3 percent from low speed diesel.

VI. ENERGY CONSERVATION

A. Background

Energy conservation may be considered as an indigenous source of energy. A successful and economical program in energy conservation has the same effect on the economy as the development of indigenous energy resources in alleviating pressure on the balance of payments by substituting for the energy imports.

The importance and potential of energy conservation is in reflected its inclusion in the fifth and sixth social and economic development plans. The plans called for more efficient use of energy, especially in transport, industry, commercial buildings, and food preparation .

Ceiling for the growth of energy demand was set at 3.7 percent per annum against an anticipated GDP growth rate of 5 percent per year during the sixth plan. Annual savings of 390 million liters of crude oil equivalent are the target to be achieved by improving the energy efficiencies in transportation and buildings.

The following strategies for conserving energy were included in the sixth plan

(1) Set up the Energy Conservation Center of Thailand with the responsibility of promoting energy conservation within both the public and private sectors. Its role is to provide advice on energy conservation issues, training for energy related personnel, and to conduct energy audits.

(2) Provide low interest loans for energy conservation projects through financial institutions such as the IFCT.

(3) Speed up the process of approving reductions in duties on the imports of energy saving equipment.

(4) Supplement the public relations efforts to create public awareness of energy conservation through educational at programs schools, universities, and other educational institutes.

(5) Enact a new law on energy conservation in industries and commercial buildings

(6) Modify the Building Code such that the concepts of energy conservation are included in building design.

(7) Study and update information on energy conservation policies and measures in other countries for the possibility of adopting it in Thailand.

(8) Promote the transfer of technology in energy conservation and improve the coordination between public and private sectors.

B. Assessment of Potential of Energy Conservation and Past Performance

In accord with the energy conservation strategies mentioned above, the Energy Conservation Center has been established under the umbrella of the Federation of Thai Industries and is under the supervision of NEA.

Studies on the practical methods of conserving energy have been undertaken on a regular basis by NEA. Potential of energy conservation was assessed and guidelines laid down for lighting, cooling, uses of electrical appliances, and cooking in household and tertiary sector, and industrial production.

The potential of energy conservation may be considered from two aspects. The economical replacements of an existing equipment by a more energy efficient one is one of the aspect of conserving energy. The other aspect which involves considerable public relations effort is to eliminate waste in energy usage such as leaving an unneeded air conditioner on. Only the first aspect of energy conservation is considered in this study.

1. Household and Tertiary Sectors

(a) Lighting

Results from the study show that, for the same lighting intensity, a change-over from 40 watts and 20 watts fluorescent light bulbs to high efficiency bulbs of 36 watts and 18 watts respectively will yield a 10 percent savings in energy. The energy used for lighting from kerosene lamps, which are still used in the rural areas, can be saved up to 17 percent by increasing the efficiency of the bulbs.

(b) Cooling

Appropriate use of air conditioners could result in large savings of electricity. The installation of window blinds and external roller blinds are found to reduce the amount of electricity required for air conditioning by 9.2 percent and 10.1 percent respectively. The use of an electric thermostat in an air conditioned room with old air conditioners can lower electricity consumption by about 5 percent. In addition, a 15.5 percent saving in electricity consumption for air conditioning may be realized by switching from general to high efficiency air conditioners.

Refrigerators with no self defrosting mechanism and moisture protector require 17.5 percent less electricity than the refrigerators with these two options.

(c) Cooking

Energy conservation potential in cooking depends upon the choices of stoves. There are two general types of cooking stoves, an iron fabricaed stove and a general household stove. The average efficiency of an iron fabricated stove is 37.5 percent but this could be raised to between 40 to 55 percent.

The potential energy conservation from improving efficiency of the iron fabricated stove may be estimated from Total energy conservation = Number of stoves*utilization rate per household*increase in efficiency where increase in efficiencieny = 1 - previous efficiency/improved efficiency

Efficiency of the general household stoves may be improved by 21 to 29 percent for the charcoal stove, and from 12.6 percent to 25 percent for the fuelwood stove.

(d) Other Household Electrical Appliances

The other electrical appliances included in the energy conservation study are television sets, vacuum cleaners, and irons. It is found that that the television sets without remote control devices can reduce electricity consumption by 20 percent. Energy may also be conserved by emptying the vacuum cleaners every time before use. A change in the ironing habit from daily ironing to once every three days can also conserve electricity. The total potentials for energy conservation from improved efficiencies of the relevant equipments are assessed by energy types and presented in Table 53.

(e) Commercial Buildings

The potentials for energy conservation were assessed for small and large commercial buildings. Small buildings are distinguisted from large buildings by the amount of their power consumption. Any commercial building with less than 30 kw of power demand is listed as a small building whereas a large building uses more than 30 kw of electricity. The potentials of energy conservation were assessed for 7,203 large buildings and 199,014 small buildings and the results are presented in Table 54.

2. Industry

(a) Assessment of Energy Conservation Potentials

A survey was conducted during the fifth social and economic development plan for 296 industrial factories to evaluate their potential for energy conservation. The factories were classified as large, medium, or small with the distribution of 60 percent, 25 percent, and 15 percent respectively. The survey shows that it is potentially possible to conserve energy up to 95 MLOE or 82 KTOE per annum from the total energy consumption of about 1 MTOE with an investment of 466 million baht.

TABLE 53 : ASSESSMENT OF POTENTIALS FOR ENERGY CONSERVATION FOR HOUSEHOLDS BY ENERGY TYPES, 1986

ENERGY TYPES	ENERGY CONSERVATION POTENTIAL (Per Year)
PETROLEUM PRODUCTS	22.82 MILLION LITERS OF CRUDE OIL EQUIVALENT
ELECTRICITY	143.49 GWH AND 7,109 MW
FUELWOOD	231.04 MKG
CHARCOAL	361.08 MKG

TABLE 54 : POTENTIALS OF ENERGY CONSERVATION IN COMMERCIAL BUILDINGS, 1986

UNIT : GWH/YEAR

TYPES OF ACTIVITY	ENERGY SAVED		
	SMALL BUILDING	LARGE BUILDING	TOTAL
COOLING	220.21	153.58	373.79
LIGHTING	174.02	366.67	540.69
OTHERS	0.09	1.03	1.12
TOTAL	394.32	521.28	915.60

SOURCE : NEA, ENERGY CONSERVATION STUDY, 1986

Incentives were provided in the form of import tax exemption totalling 98 million baht for 37 types of energy conservation equipment valued at 444 million baht for 30 industrial factories. Low interest loans were also provided to five demonstration factories in the sectors of food and beverage, paper, and basic metal. Four of these factories had completed their investment for energy conservation that are worth 3.2 million baht.

Training on energy conservation was provided by the government for 487 person. The private sector also conducted training programs for approximately 2,500 persons. The total budget allocated to energy conservation in industry was 16.8 million baht .

In 1987, the first year of the sixth plan, a survey of energy conservation potential was conducted for 1,102 factories. Import tax exemptions of 27 million baht were granted for 23 items of energy conservation equipment valued at 124 million baht. Low interest loans were provided to three demostration factories of which two had completed their investments of 2.5 million baht. Training on energy consumption was conducted by NEA for 772 persons and by private organizations for 835 persons. A budget of 5.6 million was allocated for the energy conservation program in that year.

(b) Energy Conservation Potential Identified

The potential for energy conservation in industry is based on the difference between the energy intensity of a given industry and the corresponding world standard (Tables 55 and 56). It is evident that the energy intensities of Thai factories are somewhat higher than corresponding world standards. The difference in the energy intensity help to emphsize the importance of energy audits in factories which will provide useful guidelines for setting up a rational energy conservation program.

Even though energy audits were conducted for a wide range of factories, the data are far from complete due to poor reporting system in the factories and the reluctance to reveal the true nature of their production and energy consumption for fear of tax reprisals and loss of competitive edge.

(i) Electricity

The potential for electricity conservation in factories was assessed at 472 GWH and 108 MW from an investment of 1,198 million baht in 1987 (Table 57). The payback periods of such an investment varies from less than half a year to 5 years and the cost of energy conservation ranges from 0.052 baht per KWH to 0.96 baht per KWH which is less than the production cost of electricity.

TABLE 55 : SPECIFIC ENERGY CONSUMPTION, 1986

UNIT:TOE/MBHT

TSIC	FOSSIL FUEL	ELECTRICITY	RENEWABLE ENERGY	GRAND TOTAL
3113,4	43.191	6.016	0	49.207
3116	27.069	14.089	236.7402	277.899
3118	18.536	1.519	516.3841	536.439
31212	2.756	152.012	0	154.768
3122	3.040	3.091	61.56035	67.692
3211	24.363	14.877	0	39.241
#33	7.395	5.343	13.22045	25.959
341	93.113	14.322	0	107.434
3511	62.057	88.171	0	150.228
355	14.516	11.627	33.77623	59.919
361	158.644	19.708	81.57865	259.931
362	171.076	23.101	0	194.177
3692	443.426	52.317	43.56586	539.308
371	124.410	62.850	0	187.260
#38	0.974	4.808	0	5.782
#39	31.390	29.042	0	60.432

SOURCE : NEA, ENERGY STATISTIC SECTION

Large factories have relatively higher conservation potential with savings of 293 GWH and 67 MW compared with 109 GWH and 25 MW for the medium-sized factories and 70 GWH and 16 MW for small factories (Table 58). Eighty two percent of the total electricity conservation investment were made by large factories, 11 percent by medium-sized factories and 7 percent by small factories.

The potential for electricity conservation were also assessed for 1991 and 1993 when the electricity demand, as forecast by the Load Forecast Working Group, July 1988, will be 18,327 GWH and 21,610 GWH respectively. The potential savings of 765 GWH and 902 GWH are anticipated from investments of 1939 and 2286 million baht in 1991 and 1993 respectively.

For the remaining 3 years in the sixth plan or from 1989 to 1991, the target for electricity conservation was originally set at 299 GWH and 68 MW or about 89 KTOE from investments of 338 million baht.

TABLE 56 : POTENTIALS IN ENERGY CONSERVATION FOR SELECTED INDUSTRIES

TSIC	TYPE OF INDUSTRY	SPECIFIC ENERGY CONSUMPTION (TOE/TON)		POTENTIAL SAVING
		WORLD REFERENCE(1)	NEA&CHULA1986(2)	%
3113,4	CANNED FOOD	0.033	0.075	56.16%
3116	RICE MILL	0.017	0.030	42.95%
3118	SUGAR	0.274	0.288	5.05%
3121	ICE	0.028	0.006	-
3122	ANIMAL FEED	0.012	0.086	85.40%
3141	TOBACCO CURING	0.065	1.236	94.73%
3211	SPINNING/WEAVING FINISHING TEXTILE	1.555	NA	-
3311	SAW MILLS	0.100	NA	-
3411	PULP&PAPER	0.363	NA	-
3513	PLASTICS/RASINS	0.102	NA	-
3551	TYRE&RUBBER	0.401	NA	-
3610	CERAMICS	0.413	0.099	-
3620	GLASS	0.214	0.553	61.31%
3692	CEMENT	0.106	0.070	-
3711	IRON&STEEL	0.141	0.063	-

CONVERSION FACTOR 1 TOE = 10.093 GCAL

SOURCES : (1) NEA, CONSERVATION NEWS, OCTOBER 1987
(2) CHULALONGKORN UNIVERSITY & NEA ENERGY CONSUMPTION IN INDUSTRIAL SECTOR, MAR 1987

Due to time and resource constraints, not all of the planned 8,000 factories will be surveyed and only 834 factories which express interests in the conservation program will be selected. The target for electricity conservation which is determined by the size of investment, payback period, ability for better house keeping, improvement in the production process, and changes in relevant equipments, is modified to 111 GWH and 23 MW or about 33 KTOE with an investment of 109 million baht.

(ii) Petroleum Products

The potentials for conservation of energy from petroleum products in 1987 are presented in Table 59. The assessed potentials are 194 MLOE for the conservation project with less than 5 year payback period and 175 MLOE with payback period of less than 2 years. The target for the remaining three years in the sixth plan was set at 76 MLOE or about 22 KTOE between 1989 and 1991.

TABLE 57 : ASSESSMENT OF POTENTIALS IN ELECTRICITY CONSERVATION, 1987

PAYBACK PERIOD (NUMBER OF YEARS)	SAVINGS IN POWER CONSUMPTION		INVESTMENT			
	GWH/YEAR	MW	TOTAL (MILLION BAHT)	BATH/KWH	ANNUITIES*	
					MILLION BAHT	BAHT/KWH
< 0.5	155	35	26	727	8	0.05
> 0.5 - 1	61	14	75	5,319	24	0.39
> 1 _ 2	45	10	106	10,258	37	0.83
SUBTOTAL	261	60	206	3,460	70	0.27
> 2 - 3	34	8	111	14,357	32	0.94
> 3 - 5	177	40	880	21,753	169	0.95
TOTAL	472	108	1,198	11,102	271	0.57

* 12 PERCENT OPPORTUNITY COST

(c) Energy Conservation in Major Industries

(i) Sugar

There is not much incentive to conserve energy in sugar mills as the millers do not have to purchase bagasse, the major energy source for sugar milling, which is the by-products of sugar milling. However, there will be more incentive to conserve energy if sales of electricity generated from the bagasse are permitted and there are demand for the bagasse from industries such as paper production.

Boilers are the major equipments that utilize energy to produce steam and electricity for process heat. Improvement in the boiler efficiency is the key to energy conservation in this industry as its efficiency is only 50 percent at present. The low

TABLE 58 : ASSESSMENT OF POTENTIALS IN ELECTRICITY CONSERVATION BY FACTORY SIZES, 1987

FACTORY SIZE	SAVINGS IN POWER CONSUMPTION		PERCENTAGE OF TOTAL SAVINGS	INVESTMENT		PERCENTAGE OF TOTAL INVESTMENT
	GWH/YEAR	MW		MILLION BAHT	BAHT/KW	
SMALL	70	16	14.8	87	5,386	7.3
MEDIUM	109	25	23.2	126	5,030	10.5
LARGE	293	67	62.0	985	14,712	82.2
TOTAL	472	171	100.0	1,198	11,101	100.0

TABLE 59 : POTENTIALS IN PETROLEUM PRODUCTS CONSERVATION IN INDUSTRY BY PAYBACK PERIODS, 1987

UNIT: MLOE/YEAR

STEPS IN CONSERVATION	PAYBACK PERIOD	
	NOT MORE THAN 5 YEAR	LESS THAN 2 YEAR
HOUSE KEEPING	82	81
ADJUSTMENT IN PRODUCTION PROCESS	65	54
CHANGES IN EQUIPMENT	46	40
TOTAL	194	175

boiler efficiency is caused by high moisture content in the bagasse which induces loss of latent heat from evaporation. The boiler efficiency may be improved to 80 percent and, in addition, 30 percent reduction in the bagasse volume is possible by drying the bagasse to reduce its moisture content from 50 percent to 10 percent.

(ii) Textile

The energy conservation potential in textile industry depend upon the degree of integration in the process of spinning, weaving or knitting, and finishing. A study by JICA shows that savings of between 11 and 12 percent in electricity and 8 percent in fuels are possible from better house keeping and from adjustments in some aspects of the production process.

Generally, there are energy losses in steam generation, distribution, and dyeing process in the finishing plant. Energy savings of up to 35 percent may be realized from the recycling of waste heat from dyeing and 25 percent from the drying and lowering of exhausted air volume.

In the long run, energy may be conserved in textile by employing better equipment for dyeing, printing and change-over from a conventional spinning mill to an advanced and integrated spinning and weaving mill. These adjustments can save up to 20 percent of energy.

(iii) Paper

Energy may be conserved mainly in the paper drying process where steam from the boiler generates the required heat. Steps for energy conservation includes the appropriate design of boiler;adjustment of parts of the steam generation and distribution process such as burners, pipes, recycling of condensate; better house keeping on heat control and insulation of the steam pipes.

Technological progress in the production process appears to be slow for this industry, and there are relatively little investment for energy conservation. Nevertheless, the steps for energy conservation mentioned above are capable of conserving up to 17 percent of energy.

(iv) Ceramics

The potential for energy conservation in this industry is in the ceramic firing process. Up to 50 percent of energy savings may be realized by replacing the traditional two firing tunnel kilns by a single firing roller kiln. Such replacements will affect other production phase and improve the overall production efficiency.

Generally, there are no investments on new production equipment but some adjustments have been made to control the firing time. In addition, some energy conservation steps such as insulating the tunnel kiln and replacing the muffle tunnel kiln by direct fired tunnel kiln, and the substitution of gas for fuel oil have been taken. However, lack of good house keeping practice such as the prevention of air leak into the kiln, was observed. Nevertheless, savings of at least 22 percent in fuels and 1 percent in electricity can be anticipated from the above mentioned

adjustments.

(v) Glass

Most of the energy required by this industry is used in glass melting. The potential for energy conservation thus lie in the melting process. Since glass melter have short life-times, it is possible to consider the investments in modern melter and experimenting in the adjustments of melting process which can result in energy savings of up to 40 percent.

The main difficulty in experimenting with the melting process is the continous nature of the process which does not allow for the necessary interruption. It is estimated that 4 percent of savings in fuels and 2 percent in electricity may be realized in this industry.

(vi) Cement

Most of the energy required in this industry is used for firing cement. The cost of energy depends upon the choice of fuels which is determined by their relative prices. Whatever the fuel choice, less use of clinker by adopting a new formula for better control of raw materials or by changing their components may produce between 10 and 20 percent of savings in energy.

Most of the large factories already have good house keeping and are now adjusting their major equipment to further conserve energy. This phase of the energy conservation yields a lower rate of return on investment than the house keeping phase.

C. Barriers to Energy Conservation

The barriers to energy conservation efforts may be classified as technical, economic, financial, and institutional. Lack of suitable measuring instruments, energy saving equipment, and technical expertise in this area are technical barriers to the conservation efforts.

Distorted domestic energy prices and the small proportion of energy cost in the total production cost are the economic barriers to energy conservation. Recent adjustments in the power tariff structure to better reflect the economic cost of power generation, transmission and distribution, and a plan to deregulate petroleum products prices will remove some of the economic barriers to energy conservation.

Lack of adequate financial incentives in the form of tax credit or reliefs and funds are among the financial barriers to energy conservation that require more attention. Institutional barriers which are characterized by the absence of energy consumption standards and targets, and lack of awareness of the conservation issue are the most important barriers to a successful energy conservation program.

VII. SUMMARY, CONCLUSIONS AND RECOMMENDATION

A. Summary and Conclusions

Thailand has been experiencing periods of rapid economic growth during the fourth and fifth social and economic development plan. Although energy consumption increased at a relatively faster rate during the fifth plan, the average energy elasticity with respect to GDP is still inelastic. The energy inelasticity leads to decline in the energy intensity in all of the energy intensive sectors of industry, household and tertiary, and transportation.

Due to the different definition of "output" measurement in transportation, its energy intensity in terms of energy per value added increased throughout the last decade. However, the transportation energy intensity in terms of energy per unit of equivalent vehicle which is the more relevant output measurement for transportation exhibits a declining trend during the same period.

Changes in the pattern of energy consumption in Thailand as reflected by the changes in energy mix may be observed during the mid 1970s and the 1980s. The economy is depending more on commercial or modern fuels relative to the traditional sources of energy. At the macro level, petroleum products provide a steady source of energy which supplies between 45 to 50 percent of the total energy demand in the country.

Since the early 1970s, solid fossil and electricity became relatively more important as their shares in the total energy mix increased steadily throughout the last decade. In contrast, a decline in the share of renewable fuels in the total energy mix may be observed during the same period.

At the sectoral level, the process of industrialization and urbanization increased the demand for electricity which is quite pronounced in the household sector, especially in the urban areas. Petroleum products such as LPG began to replace the traditional fuels in cooking, the major activity in the household sector. The tertiary energy consumption pattern also shows an increasing use of electricity compared to the petroleum products.

The industrial demand for electricity and solid fossil showed an increasing trend during the last decade compared to the demand for petroleum products and renewable fuels. However, traditional fuels are still important sources of energy for some industries such as sugar milling and rice milling where bagasse and paddy husk are the respective by-products and thus are convenient and inexpensive sources of fuels. Nevertheless, the use of these renewable fuels elsewhere are constrained by the output of sugar and rice and high transportation cost due to their bulkiness.

Unlike the other two sectors, petroleum products are the only source of energy for the transportation sector. Gasoline and diesel are the two major fuels and close subtitutes. The substitution between these two fuels depend upon their relative prices and the cost of engine conversion. In the mid 1970s, the use of gasoline increased more proportion than diesel but this pattern was reversed in the 1980s. LPG is another fuel that was used increasingly after 1979 especially by taxis and tuk-tuks.

Eighty percent of the energy consumed in transportation is for domestic transportation . Ninety percent of the energy used for domestic transportation is for road transportation. The interurban traffic tends to shift towards the freight traffic relative to passenger traffic which will increase the per vehicle energy consumption in the future. International transportation consumed 20 percent of the energy required by this sector of which 79 percent was used for air transportation.

From the pattern of energy consumption observed during the past decade, it would appear that the consumption of electricity and solid fossil will continue to increase relative to the renewable fuels especialy in the household and industrial sectors. Petroleum products are likely to remain a stable source of energy in the transportation sector.

The importance of energy conservation has been realized since the fifth social and economic development plan. Studies by NEA have shown potentials for energy conservation in households, commercial buildings, and industry. Although some progress has been made, the lack of personnel , expertise, fiscal and monetary measures to promote energy conservation, and distortions in the energy prices are among the major barriers to a successful and economical energy conservation program.

B. Recommendations

The pattern of energy consumption observed during the last decade has shown increasing use of indigenous energy sources in the form of electricity and solid fossil which is consistent with the energy policy in the sixth plan. As the uses of the indigenous sources of energy increase in the future, the issue of their pricings become a more relevant issue that needs to be reviewed. The recent adjustment in the power tariff structure and the present plan to deregulate oil prices are moves in the right direction to provide appropriate economic signals to consumers.

The methodology employed in this study depends on the concept of ratios and elasticity which provide a general picture of the energy consumption pattern. Further studies on the price responses and factors that affect the fuel choices of consumers at a more micro level in each sector would provide more useful inputs for energy planning and management.

The major constraints in this study are the inconsistencies in the data from different sources and data unavailability in some areas especially in water transportation.

1. Household and Tertiary

Inconsistencies in the data on household energy consumption stems from the different method of data collection and in the survey objectives of different agencies. It should be feasible for the responsible agencies such as NEA and NSO to cooperate in the survey design such that common objectives of the survey can be shared as much as possible. Such a cooperation would tend to reduce the total survey cost and avoid unnecessary waste of overlapping and repetitive survey.

At present, there is not much information on the pattern of energy consumption, especially in petroleum products, in the commercial buildings, one of the targets for energy conservation. The only available information came from spot interviews from the commercial building survey and audits undertaken by NEA. A periodic household survey every 2 or 3 years will provide information on the pattern of energy consumption and strengthen the data base and capability of energy planning.

2. Industry

As in the case of household and tertiary sector, a periodic survey every 3 to 5 years on energy consumption in factories at the 3-5 digit level are needed to supply information on the changing pattern of energy consumption and intensities.

Energy audits are also important for a successful energy conservation program and should be conducted on a regular basis. A visit to the audited factory after 6 months to 2 years should be made to evaluate the progress and to assess the needs for further assistance in the energy conservation measures.

In addition, a periodic seminar on energy conservation issues for the executive managers will strengthen the awareness of the importance of energy conservation.

3. Transportation

Since different agencies such as the PD and LTD have different methods of data collection and definitions, the coordination between these agencies would improve the consistencies in the data such as fuel efficiencies, volume of traffic, vehicle classifications, as well as the cost effectiveness of data collection.

The possibility of assigning one agency such as the LTD to the task of registering all types of vehicles should be considered as this will help remove the inconsistencies and overlappings in the data collection.

Data on the vehicle age structure should be collected by the LTD as this will strengthen the data base used for projecting the energy demand in transportation.

The study of energy consumption pattern is also needed at a more micro level such as household uses of vehicles. Such information will provide useful insight for energy planning in this sector.

The greatest deficiency energy data is in water transportation. A survey of energy consumption in water transportation will fill the information gap in this area.

ABBREVIATIONS

AIT	-	Asian Institute of Technology
BMTA	-	Bangkok Mass Transit Authority
CEC	-	Commission of European Community
CU	-	Chulalongkorn University
EGAT	-	Electricity Generating Authority of Thailand
ETOT	-	Express Transportation Organization of Thailand
GTZ	-	German Agency for Technical Cooperation
IFCT	-	Industrial Finance Corporation of Thailand
LTD	-	Land Transport Department
MEA	-	Metropolitan Electricity Authority
MOC	-	Ministry of Communications
NEA	-	National Energy Administration
NEPO	-	National Energy Policy Office
PEA	-	Provincial Electricity Authority
PD	-	Police Department
PTT	-	Petroleum Authority of Thailand
REDP	-	Regional Energy Development Programme
SRT	-	State Railway of Thailand
TCL	-	Transport Company Limited
TMIS	-	Transport Management Information System
THAI	-	Thai Airways International
TSIC	-	Thailand Standard Industrial Classification

MEASURES

ASK	-	Available seat kilometer
TKM	-	Ton kilometer
ATK	-	Available ton kilometer
GTKH	-	Gross ton kilometers hauled
PK	-	Passenger kilometer
VKM	-	Vehicle kilometer
TOE	-	Tons of crude oil equivalent
KTOE	-	1,000 TOE
GOE	-	Grams of crude oil equivalent
KGOE	-	Kilograms of crude oil equivalent
W	-	Watt, unit of real (active) power
KW	-	1,000 W
MW	-	1,000 KW
WH	-	Watthour, unit of energy
KWH	-	1,000 WH
GWH	-	1,000,000 KWH

GLOSSARY OF ENERGY RELATED TERMS

Energy Elasticity with Respect to GDP	-	A percentage change in energy consumption brought about by a one percentage change in GDP
Arc Energy Elasticity	-	Average energy elasticity for a given period
GDP	-	Gross domestic product, a measure of domestic final output
Fossil Fuels	-	Fuels derived from plant matter laid down during prehistoric times
Solid Fuels	-	Fossil fuels that are solid such as coal and lignite
Renewable Energy	-	Source of energy that can be renewed at a rate comparable to the rate at which it is being used to produce useful energy. Fuelwood, charcoal, and bagasse are examples of the renewable energy
Energy Intensity	-	A ratio of energy consumption to output measured as value added or physical unit
Specific Energy Consumption (SEC)	-	Energy intensity for a specific activity
Cabin Factor	-	Ratio of PK to ASK
Load Factor	-	Ratio of Total TKM to ATK

ANNEX

A. Household and Tertiary Annex

The greater Bangkok Metropolitan Area : BKK

Includes the changwats Bangkok metropolis, Nonthaburi, Pathumthani and Samutprakarn.

Municiple Area

A municipal area is a legal unit established by the Royal Decree of the 1953 Municipal Act. There are three categories of municipal areas : Nakhon (city), Muang (town) and Tambon (commune).

A tambon municipality is established wherever it is deemed appropriate.

A muang municipality is established in each area where the administrative seat of the provincial government is located of where the population is at least 10,000 persons, with an average density of not less than 3,000 persons per square kilometer. The sources of tax revenue must also ve sufficient for the execution of municipal affairs as stipulated in the 1953 Municipality Act.

A Nakhon municipality is established in areas where the population, is least 50,000 persons, with an average density of not less than 3,000 persons per square kilometer. Tax revenues must also be sufficient for the execution of municipal affairs as stipilated in the 1953 Municipality Act.

Sanitary District

A sanitary district is established by the Ministry of Interior under the provisions of the Sanitary District Act of 1952. Under the provisions of the Municipality Act, any sanitary district may be established as a municipal area.

Non Business Household

A non business household is defined as any house used for only habitation by a household.

Business Household

A business household is defined as the use of living quarters and promises for business purposes, i.e. for manufacturing, trade and service uses, as well as for habitation.

B. Industry Sector Annex

TABLE I1 : ENERGY CONSUMPTION IN MANUFACTURING SECTOR IN 1987

INDUSTRY GROUP	PETROLEUM PRODUCTS	ELECTRICITY	SOLID FUEL	NATURAL GAS	RENEWABLE ENERGY	TOTAL
	%	%	%	%	%	%
31 FOOD & BEVERAGE	21%	19%	11%	0%	89%	48%
32 TEXTILE	19%	21%	1%	0%	0%	9%
33 WOOD & FURNITURE	1%	1%	0%	0%	1%	1%
34 PAPER	7%	3%	10%	0%	0%	4%
35 CHEMICAL	5%	12%	3%	0%	3%	5%
36 NON-METAL	29%	12%	72%	100%	7%	22%
37 BASIC METAL	6%	9%	3%	0%	0%	4%
38 FABLICATED METAL	1%	7%	0%	0%	0%	1%
39 OTHERS	10%	16%	1%	0%	0%	6%
TOTAL	100%	100%	100%	100%	100%	100%

SOURCE: NEA

TABLE I2 : ENERGY CONSUMPTION IN MANUFACTURING SECTOR IN 1987

INDUSTRY GROUP	PETROLEUM PRODUCTS	ELECTRICITY	SOLID FUEL	NATURAL GAS	RENEWABLE ENERGY	TOTAL
	%	%	%	%	%	%
31 FOOD & BEVERAGE	13%	7%	3%	0%	78%	100%
32 TEXTILE	60%	39%	1%	0%	0%	100%
33 WOOD & FURNITURE	31%	21%	0%	0%	48%	100%
34 PAPER	53%	16%	32%	0%	0%	100%
35 CHEMICAL	30%	40%	7%	0%	23%	100%
36 NON-METAL	38%	9%	37%	3%	12%	100%
37 BASIC METAL	48%	42%	10%	0%	0%	100%
38 FABLICATED METAL	23%	77%	0%	0%	0%	100%
39 OTHERS	50%	48%	3%	0%	0%	100%
TOTAL	29%	17%	12%	1%	42%	100%

SOURCE: NEA

C. Transport Sector Annex

TABLE T1 : SIMULATION RESULTS OF ENERGY CONSUMPTION
BY GASOLINE AND LPG VEHICLES UNDER SCENARIO 2, 1973-1986

YEAR	STOCK OF VEHICLES								
	CAR < 7 SEAT	TAXI		LIGHT VEHICLES(A)		MOTOR CYCLE		MOTOR TRICYCLE(C)	
	(1)(2)(B)	(1)	(2) 4.3	(1)	(2) 1.2	(1)	(2) 0.26	(1)	(2) 2.3
1973	191,275	19,816	85,209	117,307	140,769	400,693	104,180	5,500	12,650
1974	227,064	19,432	83,555	133,694	160,432	442,374	115,017	6,000	13,800
1975	224,635	16,581	71,298	154,022	184,826	466,438	121,274	6,500	14,950
1976	213,951	19,608	84,312	172,310	206,772	491,245	127,724	7,000	16,100
1977	228,870	20,786	89,379	205,264	246,317	627,622	163,182	7,500	17,250
1978	253,948	19,009	81,740	223,409	268,090	730,372	189,897	8,000	18,400
1979	272,841	19,001	81,703	244,604	293,524	839,021	218,145	8,250	18,975
1980	296,241	21,681	93,229	263,290	315,948	909,380	236,439	8,500	19,550
1981	321,336	22,312	95,939	288,507	346,209	1,107,285	287,894	8,849	20,353
1982	355,206	21,089	90,683	356,763	428,115	1,355,305	352,379	9,111	20,955
1983	387,859	20,276	87,186	368,255	441,906	1,656,610	430,719	10,768	24,766
1984	478,038	20,359	87,543	336,855	404,226	1,877,577	488,170	11,012	25,328
1985	518,950	21,890	94,126	311,372	373,647	1,883,897	489,813	11,290	25,968
1986	540,615	21,452	92,241	307,146	368,575	2,102,098	546,545	11,637	26,765

TABLE T2 : SIMULATION RESULTS OF ENERGY CONSUMPTION BY GASOLINE AND LPG VEHICLES UNDER SCENARIO 2, 1973-1986 (CONT.)

YEAR	STOCK OF VEHICLES TOTAL (1)	STOCK OF VEHICLES TOTAL (2)	TOTAL SALES OF GAS/LPG KTOE	UNIT CONSUMPTION TOE/VEHICLE/YEAR (1)	UNIT CONSUMPTION TOE/VEHICLE/YEAR (2)	UNIT CONSUMPTION INDEX (1)	UNIT CONSUMPTION INDEX (2)
1973	734,591	534,082	1,147	1.56	2.15	100	100
1974	828,563	599,869	1,371	1.65	2.28	106	106
1975	868,175	616,983	1,641	1.89	2.66	121	124
1976	904,113	648,859	1,831	2.02	2.82	130	131
1977	1,090,042	744,997	2,036	1.87	2.73	120	127
1978	1,234,738	812,075	2,140	1.73	2.64	111	123
1979	1,383,716	885,189	2,093	1.51	2.36	97	110
1980	1,499,093	961,407	2,001	1.33	2.08	85	97
1981	1,748,289	1,071,732	1,864	1.07	1.74	68	81
1982	2,097,473	1,247,338	1,797	0.86	1.44	55	67
1983	2,443,768	1,372,435	1,886	0.77	1.37	49	64
1984	2,723,841	1,483,305	1,908	0.70	1.29	45	60
1985	2,747,398	1,502,503	1,913	0.70	1.27	45	59
1986	2,982,946	1,574,741	2,090	0.70	1.33	45	62

(A) LIGHT VEHICLES = CARS > 7 SEATS + SMALL BUSES (< 2000 KGS.) + PICKUPS (< 2000 KGS.)
NUMBER OF SMALL BUSES IS ASSUMED TO BE 50% OF TOTAL BUSES BETWEEN 1973 AND 1982
NUMBER OF PICKUPS IS ASSUMED TO BE 60% OF TOTAL TRUCKS BETWEEN 1973 AND 1982
NUMBER OF LIGHT VEHICLES USING GASOLINE IS ASSUMED TO BE 75% IN 1973 AND 45% IN 1986

(B) ALL CARS ARE ASSUMED TO RUN ON GASOLINE AND LPG

(C) NUMBER OF MOTORTRICYCLES IS RETRAPOLATED FROM 1980 TO 1973.

(1) ACTUAL FLEET

(2) STOCK EXPRESSED IN EQUIVALENT VEHICLE

TABLE T3 : SIMULATION RESULTS OF ENERGY CONSUMPTION
BY GASOLINE AND LPG VEHICLES UNDER SCENARIO 3, 1973-1986

YEAR	STOCK OF VEHICLES								
	CAR < 7 SEAT	TAXI		LIGHT VEHICLES(A)		MOTOR CYCLE		MOTOR TRICYCLE(C)	
	(1)(2)(B)	(1)	(2) 4.3	(1)	(2) 1.2	(1)	(2) 0.26	(1)	(2) 2.3
1973	191,275	19,816	85,209	139,460	167,352	400,693	104,180	5,500	12,650
1974	227,064	19,432	83,555	161,322	193,586	442,374	115,017	6,000	13,800
1975	224,635	16,581	71,298	183,136	219,763	466,438	121,274	6,500	14,950
1976	213,951	19,608	84,312	203,068	243,682	491,245	127,724	7,000	16,100
1977	228,870	20,786	89,379	239,031	286,837	627,622	163,182	7,500	17,250
1978	253,948	19,009	81,740	256,812	308,174	730,372	189,897	8,000	18,400
1979	272,841	19,001	81,703	277,091	332,509	839,021	218,145	8,250	18,975
1980	296,241	21,681	93,229	301,460	361,752	909,380	236,439	8,500	19,550
1981	321,336	22,312	95,939	320,583	384,700	1,107,285	287,894	8,849	20,353
1982	355,206	21,089	90,683	356,763	428,116	1,355,305	352,379	9,111	20,955
1983	387,859	20,276	87,186	368,255	441,906	1,656,610	430,719	10,768	24,766
1984	478,038	20,359	87,543	336,855	404,226	1,877,577	488,170	11,012	25,328
1985	518,950	21,890	94,126	311,372	373,646	1,883,897	489,813	11,290	25,968
1986	540,615	21,452	92,241	307,146	368,575	2,102,098	546,545	11,637	26,765

TABLE T4 : SIMULATION RESULTS OF ENERGY CONSUMPTION BY GASOLINE AND LPG VEHICLES UNDER SCENARIO 3, 1973-1986 (CONT.)

YEAR	STOCK OF VEHICLES TOTAL (1)	STOCK OF VEHICLES TOTAL (2)	TOTAL SALES OF GAS/LPG KTOE	UNIT CONSUMPTION TOE/VEHICLE/YEAR (1)	UNIT CONSUMPTION TOE/VEHICLE/YEAR (2)	UNIT CONSUMPTION INDEX (1)	UNIT CONSUMPTION INDEX (2)
1973	756,744	560,666	1,147	1.52	2.05	100	100
1974	856,192	633,023	1,371	1.60	2.17	106	106
1975	897,290	651,920	1,641	1.83	2.52	121	123
1976	934,871	685,768	1,831	1.96	2.67	129	130
1977	1,123,809	785,518	2,036	1.81	2.59	119	127
1978	1,268,141	852,159	2,140	1.69	2.51	111	123
1979	1,416,204	924,174	2,093	1.48	2.26	97	111
1980	1,537,263	1,007,211	2,001	1.30	1.99	86	97
1981	1,780,365	1,110,223	1,864	1.05	1.68	69	82
1982	2,097,473	1,247,338	1,797	0.86	1.44	56	70
1983	2,443,768	1,372,435	1,886	0.77	1.37	51	67
1984	2,723,841	1,483,305	1,908	0.70	1.29	46	63
1985	2,747,398	1,502,502	1,913	0.70	1.27	46	62
1986	2,982,946	1,574,741	2,090	0.70	1.33	46	65

(A) LIGHT VEHICLES = CARS > 7 SEATS + SMALL BUSES (< 2000 KGS.)
+ PICKUPS (< 2000 KGS.)
NUMBER OF SMALL BUSES IS ASSUMED TO BE 50% OF TOTAL BUSES BETWEEN 1973 AND 1982
NUMBER OF PICKUPS IS ASSUMED TO BE 70% OF TOTAL TRUCKS BETWEEN 1973 AND 1982
NUMBER OF LIGHT VEHICLES USING GASOLINE IS ASSUMED TO BE 80% IN 1973 AND 45% IN 1986

(B) ALL CARS ARE ASSUMED TO RUN ON GASOLINE AND LPG

(C) NUMBER OF MOTORTRICYCLES IS RETRAPORATED FROM 1980 TO 1973.

(1) ACTUAL FLEET

(2) STOCK EXPRESSED IN EQUIVALENT VEHICLE

TABLE T5 : ENERGY CONSUMPTION OF DIESEL VEHICLES UNDER SCENARINO 2, 1973-1986

YEAR	STOCK OF VEHICLES								TOTAL SALE	UNIT CONSUMPTION TOE/VEHICLE/YEAR		UNIT CONSUMPTION INDEX	
	LIGHT VEHICLES(A)		HEAVY BUSSES		TRUCKS(B)		TOTAL						
	(1)	(2) 0.26	(1)	(2) 1.51	(1)	(2)	(1)	(2)	KTOE	(1)	(2)	(1)	(2)
1973	39102	10167	10378	15671	71661		121141	97498	1221	10,079	12,523	100	100
1974	46973	12213	10922	16492	83944		141839	112649	1380	9,729	12,250	97	98
1975	56967	14811	11087	16741	95205		163259	126758	1107	6,781	8,733	67	70
1976	67009	17422	11275	17025	111499		189783	145947	1419	7,477	9,723	74	78
1977	83840	21798	12990	19615	135644		232474	177057	1544	6,642	8,720	66	70
1978	95747	24894	14038	21197	150110		259895	196202	1660	6,387	8,461	63	68
1979	109894	28572	15648	23628	165383		290925	217584	1873	6,438	8,608	64	69
1980	135634	35265	31524	47601	177600		344758	260466	1724	5,001	6,619	50	53
1981	148625	38643	32379	48892	194400		375404	281935	1977	5,266	7,012	52	56
1982	175719	45687	32521	49107	158291		366531	253085	1853	5,056	7,322	50	58
1983	225705	58683	35254	53234	145436		406395	257353	2404	5,915	9,341	59	75
1984	286951	74607	37602	56779	172843		497396	304229	3176	6,385	10,439	63	83
1985	337320	87703	39320	59373	185052		561692	332128	3602	6,413	10,845	64	87
1986	375400	97604	38865	58686	189553		603818	345843	3797	6,288	10,979	62	88

(A) LIGHT VEHICLES = CARS > 7 SEATS + SMALL BUSES (< 2000 KGS.) + PICKUPS (< 2000 KGS.)
NUMBER OF SMALL BUSES IS ASSUMED TO BE 50% OF TOTAL BUSES BETWEEN 1973 AND 1982
NUMBER OF PICKUPS IS ASSUMED TO BE 60% OF TOTAL TRUCKS BETWEEN 1973 AND 1982
NUMBER OF LIGHT VEHICLES USING DIESEL IS ASSUMED TO BE 25% IN 1973 AND 55% IN 1986

(B) TRUCKS = MEAMS MEDIUM AND HEAVY TRUCKS

(1) ACTUAL FLEET

(2) STOCK EXPRESSED IN EQUIVALENT VEHICLE

TABLE T6 : ENERGY CONSUMPTION OF DIESEL VEHICLES UNDER SCENARINO 3, 1973-1986

YEAR	STOCK OF VEHICLES						TOTAL SALE	UNIT CONSUMPTION TOE/VEHICLE/YEAR		UNIT CONSUMPTION INDEX	
	LIGHT VEHICLES(A)		HEAVY BUSSES		TRUCKS(B)	TOTAL					
	(1)	(2) 0.26	(1)	(2) 1.51	(1) (2)	(1)	(2)	KTOE	(1)	(2)	(1)	(2)
1973	34865	9065	10378	15671	71661	116904	96397	1221	10,444	12,666	100	100
1974	40331	10486	10922	16492	83944	135197	110922	1380	10,207	12,441	98	98
1975	51654	13430	11087	16741	95205	157946	125376	1107	7,009	8,829	67	70
1976	64127	16673	11275	17025	111499	186901	145197	1419	7,592	9,773	73	77
1977	83984	21836	12990	19615	135644	232618	177095	1544	6,637	8,718	64	69
1978	99871	25966	14038	21197	150110	264019	197274	1660	6,287	8,415	60	66
1979	118753	30876	15648	23628	165383	299784	219887	1873	6,248	8,518	60	67
1980	141864	36885	31524	47601	177600	350988	262086	1724	4,912	6,578	47	52
1981	165149	42939	32379	48892	194400	391928	286231	1977	5,044	6,907	48	55
1982	175719	45687	32521	49107	158291	366531	253085	1853	5,056	7,322	48	58
1983	225705	58683	35254	53234	145436	406395	257353	2404	5,915	9,341	57	74
1984	286951	74607	37602	56779	172843	497396	304229	3176	6,385	10,439	61	82
1985	337320	87703	39320	59373	185052	561692	332128	3602	6,413	10,845	61	86
1986	375400	97604	38865	58686	189553	603818	345843	3797	6,288	10,979	60	87

(A) LIGHT VEHICLES = CARS > 7 SEATS + SMALL BUSES (< 2000 KGS.) + PICKUPS (< 2000 KGS.)
NUMBER OF SMALL BUSES IS ASSUMED TO BE 50% OF TOTAL BUSES BETWEEN 1973 AND 1982
NUMBER OF PICKUPS IS ASSUMED TO BE 70% OF TOTAL TRUCKS BETWEEN 1973 AND 1982
NUMBER OF LIGHT VEHICLES USING DIESEL IS ASSUMED TO BE 20% IN 1973 ,55% IN 1986

(B) TRUCKS = MEDIUM AND HEAVY TRUCKS

(1) ACTUAL FLEET

(2) STOCK EXPRESSED IN EQUIVALENT TRUCK.