Chapter 12

Energy

12 ENERGY

I. INTRODUCTION

12.01 The energy sector plays a key role in the development and growth of the economy as the availability of adequate supplies of energy is a requisite to generate economic activities. During the Sixth Plan period, the energy sector provided an essential input for the rapidly expanding industrial sector and contributed significantly to government revenue as well as increased export earnings. The main objectives of the energy sector are ensuring adequate, secure and cost-effective supplies, utilizing the resources efficiently and minimizing its negative impacts on the environment. With overall energy demand increasing at 8.6 per cent per annum, amid supply constraints in the electricity subsector, the development of the energy sector received greater attention.

12.02 For the Seventh Plan period, concerted efforts will be taken to ensure that the development of energy resources will continue to contribute to the nation's economic growth and well-being. Measures will be directed towards the sustainable development of depletable resources as well as the continued diversification of energy sources. With electricity generation requirements of the country adequately met by the planting-up programme of the utilities and independent power producers (IPPs), the focus will be to expand and upgrade the transmission and distribution infrastructure.

12.03 Due to the long lead time for energy projects to come onstream, long-term planning will be emphasized. Efforts in improving the energy sector operations will be an on-going exercise with a view to promoting higher productivity and efficiency. In order to contribute towards sustaining and improving the competitive edge of the nation, the energy supply support system

and services will continually be upgraded in terms of quality, reliability and efficiency.

II. PROGRESS, 1991-95

12.04 During the Sixth Plan period, the focus of the sector was to ensure adequate and reliable supplies of energy as well as utilize the resources efficiently while taking cognizance of environmental considerations. The nation's strategic move to reduce dependence on oil as an energy resource resulted in the rapid development of environment-friendly natural gas. The period also witnessed the restructuring of the electricity supply sector with the licensing of seven IPPs to generate electricity. At the same time, initial efforts were taken to conserve the nation's energy resources through the development and promotion of efficient systems, processes, equipment and buildings.

Energy Demand

12.05 *Commercial Energy.* The final consumption of commercial energy grew at an average annual rate of 8.6 per cent during the period, in consonance with the rapid growth of the manufacturing and transport sectors, as shown in *Table 12-1*. The energy intensity of the economy increased from 6.96 gigajoules (GJ) or 0.166 tonnes of oil equivalent (toe) per thousand Ringgit of Gross Domestic Product (GDP) in 1990 to 7.07 GJ or 0.169 toe per thousand Ringgit of GDP in 1995. The per capita energy consumption increased by 6.6 per cent to 41.1 GJ or 0.98 toe in 1995. In terms of energy mix, there was a move from crude oil and petroleum products to alternative sources of energy as a result of the successful implementation of the four-fuel diversification policy. The final consumption of gas, coal and electricity grew at 17.8 per cent, 13.3 per cent and 12.8 per cent per annum, respectively.

12.06 The transport sector continued to be the largest energy consuming sector and accounted for 39.1 per cent of the total commercial energy demand in 1995, followed by the manufacturing sector at 35.7 per cent, as shown in *Table 12-2*. With total motorized vehicles growing at about 7.0 per cent per annum, energy demand in the transport sector grew at 8.1 per cent per annum during the period. Energy demand by the manufacturing sector increased at 9.7 per cent per annum due to the rapid growth in the value-added activities of the sector. The commercial and residential sectors accounted for slightly more than one-tenth of total energy demand.

TABLE 12-1

FINAL COMMERCIAL ENERGY[1] DEMAND BY SOURCE, 1990-2000

Source	*1990*		*1995*		*2000*		*Average Annual Growth Rate (%)*	
	PJ[2]	*%*	*PJ*	*%*	*PJ*	*%*	*6MP*	*7MP*
Petroleum Products	414.0	*74.9*	561.7	*67.1*	777.5	*60.8*	*6.3*	*6.7*
Natural Gas[3]	45.7	*8.3*	103.5	*12.4*	188.1	*14.7*	*17.8*	*12.7*
Electricity	71.8	*13.0*	131.4	*15.7*	221.8	*17.3*	*12.8*	*11.0*
Coal and Coke	21.5	*3.9*	40.1	*4.8*	92.0	*7.2*	*13.3*	*18.1*
Total	**553.0**	***100.0***	**836.7**	***100.0***	**1,279.4**	***100.0***	***8.6***	***8.9***
Per Capita Consumption (gigajoules)	29.9		41.1		56.1		*6.6*	*6.4*

Notes:

[1] Refers to the quantity of commercial energy delivered to final consumers but excludes gas, coal and fuel oil used in electricity generation.

[2] Joule is the unit of energy to establish the equivalent physical heat content of each energy form. One megajoule = 10^6 joules, one gigajoule (GJ) = 10^9 joules and one petajoule (PJ) = 10^{15} joules and one PJ = 0.0239 million tonnes of oil equivalent (mtoe). One toe = 7.6 barrels.

[3] Includes natural gas used as fuel and feedstock consumed by the non-electricity sector.

TABLE 12-2

FINAL COMMERCIAL ENERGY DEMAND BY SECTOR, 1990-2000

Sector	*1990*		*1995*		*2000*		*Average Annual Growth Rate (%)*	
	PJ	*%*	*PJ*	*%*	*PJ*	*%*	*6MP*	*7MP*
Agriculture & Forestry	32.8	*5.9*	52.7	*6.3*	63.4	*5.0*	*9.9*	*3.7*
Mining & Quarrying	25.7	*4.6*	34.4	*4.1*	50.0	*3.9*	*6.0*	*7.8*
Manufacturing	187.8	*34.0*	298.7	*35.7*	488.7	*38.2*	*9.7*	*10.3*
Transport	220.9	*39.9*	326.7	*39.1*	490.1	*38.3*	*8.1*	*8.4*
Commercial	23.9	*4.3*	34.7	*4.1*	53.3	*4.2*	*7.7*	*9.0*
Residential	43.4	*7.8*	51.5	*6.2*	64.4	*5.0*	*3.5*	*4.6*
Non-Energy	18.5	*3.3*	38.0	*4.5*	69.5	*5.4*	*15.5*	*12.8*
Total	**553.0**	***100.0***	**836.7**	***100.0***	**1,279.4**	***100.0***	***8.6***	***8.9***

Energy Supply

12.07 The supply of primary commercial energy increased at 13.1 per cent per annum during the Sixth Plan period, as shown in *Table 12-3*. The dependence on crude oil and petroleum products continued to decline indicating the success of the country's four-fuel diversification policy. The share of crude oil and petroleum products to the total energy supply decreased from 71.4 per cent in 1990 to 55.3 per cent in 1995, while that of natural gas increased from 15.7 per cent to 33.8 per cent during the same period. The increase in gas supply was mainly attributed to accelerated production activities by *Petroliam Nasional Berhad* (PETRONAS) and its production sharing contractors to meet the increasing demand for gas in the electricity and non-electricity sectors.

Crude Oil

12.08 *Reserves, Exploration and Production.* Malaysia's reserves of crude oil increased by about 41 per cent from 2.9 billion barrels to 4.1 billion barrels during the Plan period, as shown in *Chart 12-1*. This was primarily due to continued and successful offshore exploration activities.

TABLE 12-3

PRIMARY COMMERCIAL ENERGY SUPPLY[1] BY SOURCE, 1990-2000

Source	*1990*		*1995*		*2000*		*Average Annual Growth Rate (%)*	
	PJ	*%*	*PJ*	*%*	*PJ*	*%*	*6MP*	*7MP*
Crude Oil & Petroleum Products	520.2	*71.4*	746.1	*55.3*	943.2	*49.4*	*7.5*	*4.8*
Natural Gas[2]	114.4	*15.7*	456.4	*33.8*	793.9	*41.6*	*32.0*	*11.7*
Hydro	38.3	*5.3*	52.8	*3.9*	53.5	*2.8*	*6.6*	*0.3*
Coal and Coke	55.5	*7.6*	93.2	*7.0*	117.9	*6.2*	*10.9*	*4.8*
Total	**728.9**	***100.0***	**1,348.5**	***100.0***	**1,908.5**	***100.0***	***13.1***	*7.2*

Notes:

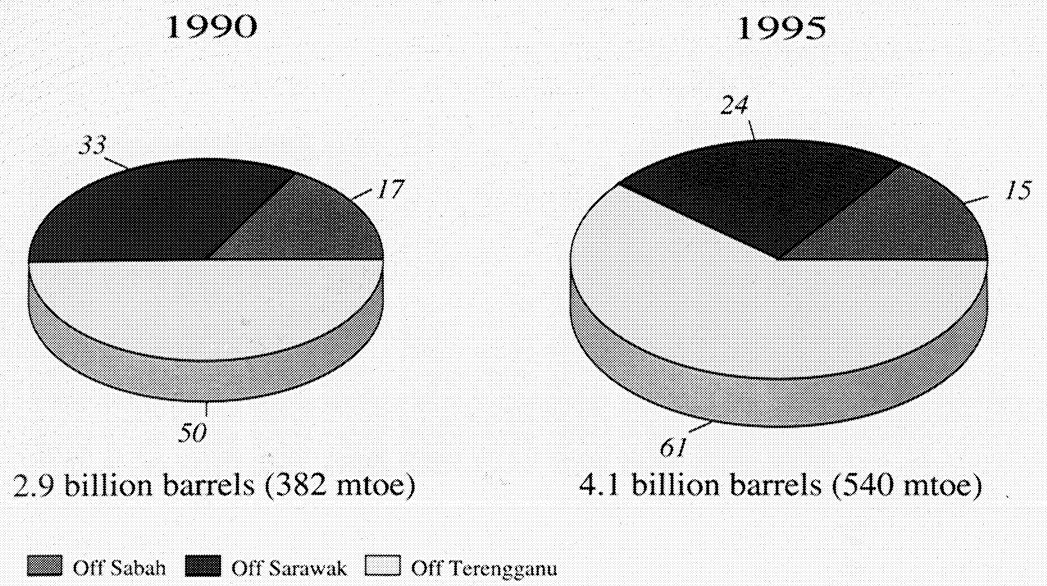
[1] Refers to the supply of commercial energy that has not undergone a transformation process to produce energy. Non-commercial energy such as biomass and solar have been excluded.

[2] Excludes flared gas, reinjected gas and exports of liquefied natural gas.

CHART 12-1

CRUDE OIL RESERVES, 1990 AND 1995

(%)



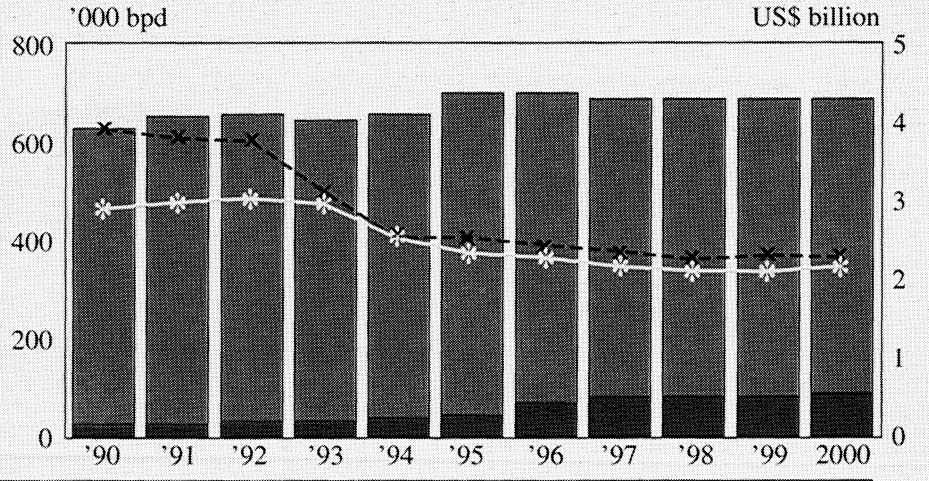
Note: One toe = 7.6 barrels

12.09 Prior to 1993, all exploration activities were undertaken in the continental shelves of the country. Exploration in deepwater areas was initiated in 1993 with the signing of two production sharing contracts (PSCs) which contained more attractive terms to encourage exploration in higher-risk areas. With the introduction of additional fiscal incentives, namely, the reduction of the export duty on crude oil from 25 per cent to 20 per cent as well as petroleum income tax from 45 per cent to 40 per cent, Malaysia was better placed to attract investment for petroleum exploration.

12.10 In line with the National Depletion Policy, which aims to prolong the producing life of crude oil reserves, production averaged about 631,000 barrels per day (bpd) during the Plan period. Production increased from 601,000 bpd in 1990 to 664,000 bpd in 1995, as shown in *Chart 12-2*. The higher than average production in 1995 was mainly attributable to the better production performance of existing fields. In addition, the production of condensate, a component of crude oil derived from natural gas streams, almost doubled from 22,000 bpd in 1990 to 42,000 bpd in 1995.

CHART 12-2

CRUDE OIL AND CONDENSATE[1] PRODUCTION, EXPORT VOLUME AND VALUE, 1990-2000



	'90	'91	'92	'93	'94	'95	'96	'97	'98	'99	2000
Crude Oil[2]	601	624	631	617	622	664	630	600	600	600	600
Condensate[2]	22	25	31	33	38	42	76	90	91	91	95
Export Volume[2]	463	466	476	459	408	399	374	368	339	339	339
Export Value[3] ×	3.940	3.708	3.591	3.111	2.557	2.680	2.457	2.417	2.227	2.351	2.227
Price[4]	24	21	21	19	16	17	18	18	19	20	20

Notes:
[1] A crude oil component derived from natural gas streams, comprising pentane and heavier hydrocarbons.
[2] In '000 bpd.
[3] In US$ billion.
[4] In US$.

12.11 *Utilization.* Domestic crude oil, which has low sulphur content and, therefore, considered to be of premium quality, was largely exported. Nevertheless, as shown in *Chart 12-2*, export volume as a proportion of total production declined during the Plan period, commensurate with the increased intake by local refineries.

12.12 During the Plan period, domestic crude oil refining capacity increased by 72 per cent to 356,000 bpd as a result of the coming onstream in 1994 of a 100,000 bpd-capacity PETRONAS refinery in Melaka and the expansion of existing refineries. The amount of oil refined locally subsequently increased by 45 per cent to about 121 million barrels, or approximately 16 million tonnes of oil in 1995.

12.13 With the increase in domestic crude oil refining capacity, the country moved towards self-sufficiency in the production of petroleum products such as fuel oil, diesel and petrol. Although the importation of several products continued, increasing at 6.1 per cent per annum from 5.4 million tonnes in 1990 to 7.3 million tonnes in 1994, it decreased markedly to 1.9 million tonnes in 1995. The total supply of petroleum products increased at 4.7 per cent per annum during the Plan period to 15.8 million tonnes in 1995.

12.14 *Price.* Retail prices of several petroleum products continued to be determined by the Automatic Pricing Mechanism (APM) which took into account costs, taxes and the prevailing ex-refinery product prices in Singapore. During the Plan period, prices of motor gasoline, diesel and liquefied petroleum gas (LPG) stabilized at around RM1.10 per litre, RM0.65 per litre and RM1.18 per kilogramme, respectively. Despite constantly fluctuating Singapore prices, domestic retail price stability was maintained by varying the taxes imposed on the products.

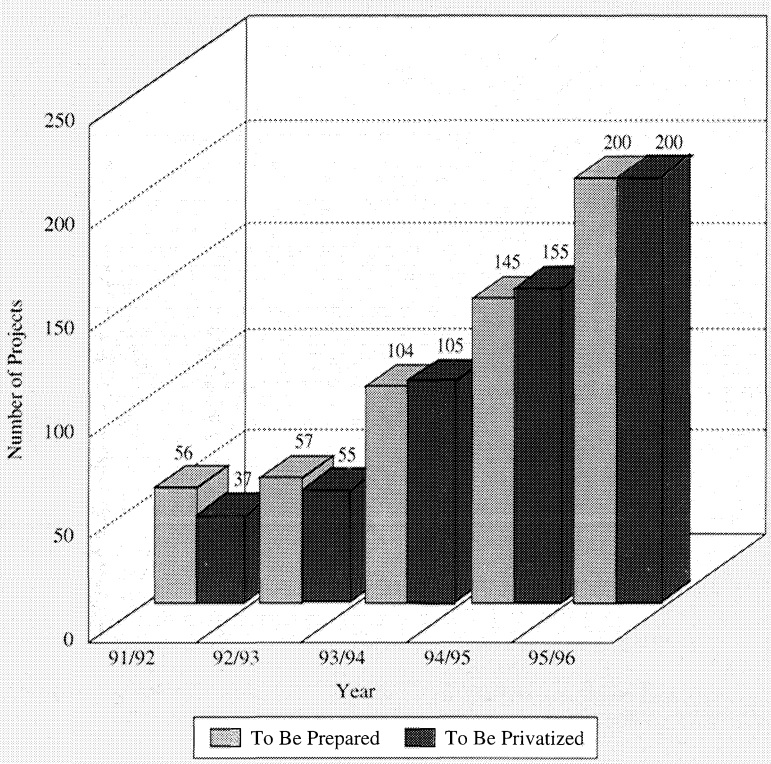
Natural Gas

12.15 *Reserves, Exploration and Production.* As a result of successful exploration activities, Malaysia's natural gas reserves increased to 85 trillion cubic feet (tcf) in 1995, as shown in *Chart 12-3.* Of this, 83 per cent was non-associated gas. The surge in demand for natural gas in the peninsula led to the development and commissioning of the Jerneh field in 1992, a non-associated gas field with a reserve of 3.4 tcf. The production of natural gas in the country almost doubled from 1,865 million standard cubic feet per day (mmscfd) in 1990 to 3,476 mmscfd in 1995, as shown in *Table 12-4.*

12.16 *Utilization.* The Plan saw a marked increase in the utilization of gas, particularly for electricity generation and export, as shown in *Chart 12-4.* Natural gas from offshore Terengganu was processed at the gas processing plants (GPPs), producing several components for use as fuel and feedstock. Methane, a component largely used as fuel, was transmitted through the Peninsular Gas Utilization (PGU) system to electricity generation plants in the east, south and west of the peninsula and also exported to Singapore, as shown in *Chart 12-5.* Other components, namely, ethane, propane and butane, were used as feedstock by several petrochemical industries producing, among others, methyl-tertiary-butyl-ether (MTBE), ethylene and propylene.

CHART 7-1

PRIVATIZATION ACTION PLANS, 1991-95

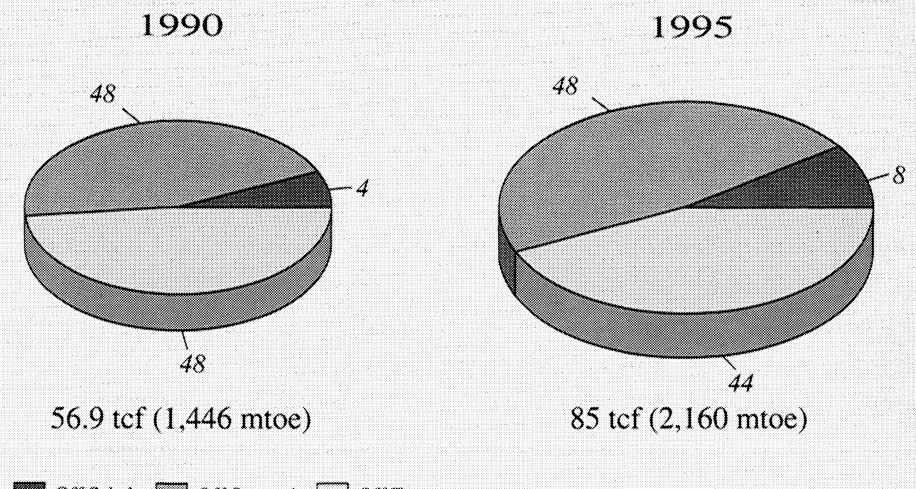


Projects Privatized

7.06 During the period, 204 projects were privatized, of which 56.4 per cent were Federal Government projects and 43.6 per cent State Governments projects. Of the total privatized projects, 138 represented existing projects and 66 new projects. There was a marked increase in the number of privatized projects, as shown in *Chart 7-2,* indicating the increased momentum in the implementation of the programme, particularly in the second half of the Plan period. The increase in the number of privatized projects was mainly attributed to the increased capacity and dynamism of the private sector to undertake projects as well as the various forms of support provided by the Government, such as soft loans, tax incentives and other concessionary terms, to selected projects. These forms of support were given especially for privatized projects with a high social component, such as sewerage, Light Rail Transit System (LRT) and roads with low traffic density, to ensure that these services were produced at affordable prices to the end-users after privatization.

CHART 12-3

NATURAL GAS RESERVES, 1990 AND 1995
(%)



Note:
One tcf = 25.41 mtoe
One toe = 7.6 barrels

TABLE 12-4

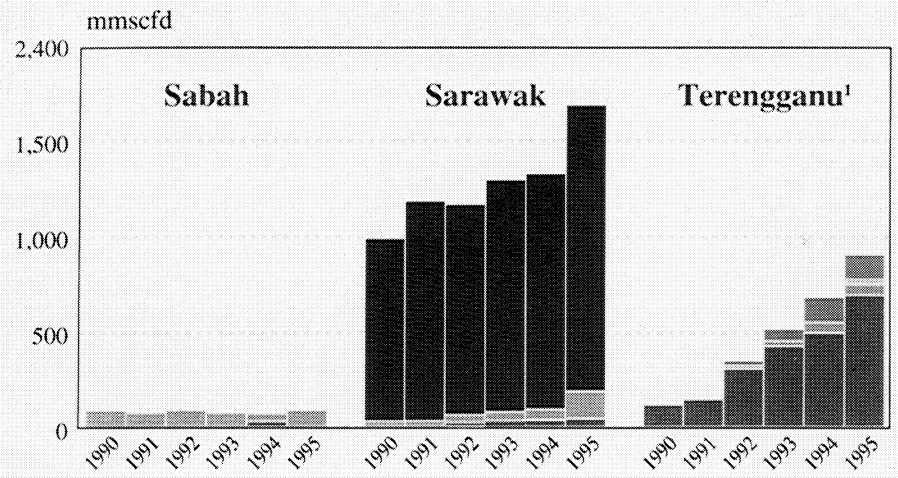
NATURAL GAS PRODUCTION[1], 1990-2000
(mmscfd)

Exploration Area	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Off Sabah	223	233	247	239	231	229	227	234	188	209	248
Off Sarawak	1,172	1,373	1,353	1,464	1,499	1,811	2,503	2,840	2,893	2,911	2,998
Off Terengganu	470	543	723	955	1,151	1,436	1,601	1,917	2,148	2,476	2,992
Malaysia	**1,865**	**2,149**	**2,323**	**2,658**	**2,881**	**3,476**	**4,331**	**4,991**	**5,229**	**5,596**	**6,238**

Note: [1] Total gas produced at wellhead

CHART 12-4

GAS UTILIZATION, 1990-95



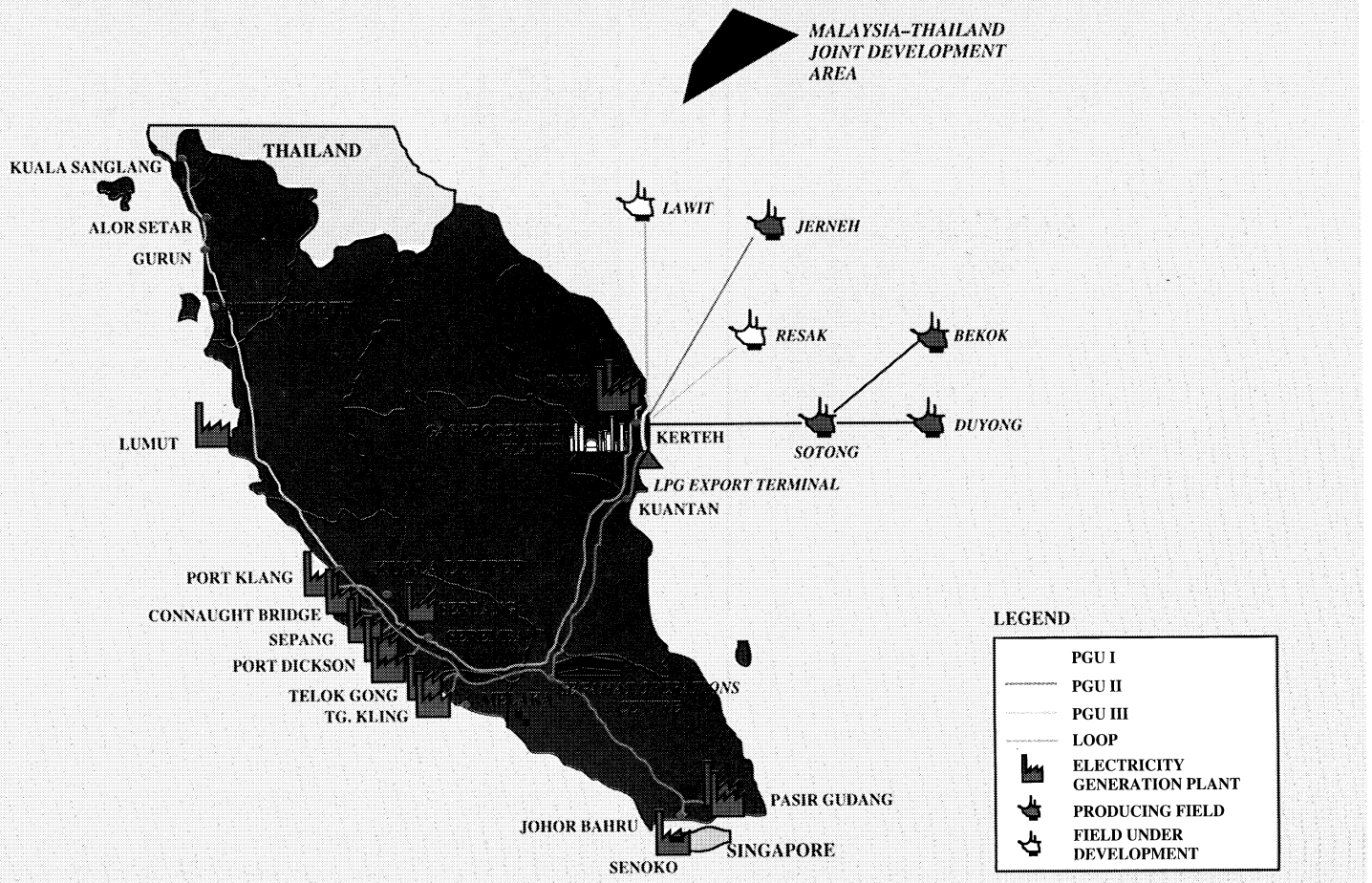
	Sabah						Sarawak						Terengganu[1]					
Elect. Generation	8	8	8	13	34	20	9	14	23	34	35	40	121	150	293	360	488	680
Industry	85	73	85	73	50	69	35	40	45	64	67	151	8	12	15	43	51	70
Reticulation	–	–	–	–	–	–	6	8	9	10	11	7	0	0	0	0	11	24
Export	–	–	–	–	–	–	–	–	–	–	–	–	0	0	43	127	151	150
LNG Feedstock	–	–	–	–	–	–	964	1,151	1,120	1,208	1,229	1,518	–	–	–	–	–	–
Total	**93**	**81**	**93**	**86**	**84**	**89**	**1,014**	**1,213**	**1,197**	**1,316**	**1,342**	**1,716**	**129**	**162**	**351**	**530**	**701**	**924**

Note: [1] Indicates only the methane produced by the GPPs. Other components are not included.

12.17 The bulk of the natural gas produced off the coast of Sabah continued to be utilized by the methanol and hot briquette iron plants as feedstock. Gas produced off Sarawak continued to be used to produce liquefied natural gas (LNG), the production of which increased from 6.5 million tonnes in 1990 to 11.9 million tonnes in 1995 for export to Japan and South Korea. While the natural gas used to produce LNG increased from 964 mmscfd in 1990 to 1,518 mmscfd in 1995, its share of total gas utilization decreased from 95 per cent to 88 per cent during the same period. This was due to the increased use of gas in electricity generation as well as the commissioning of the world's first commercial middle distillate synthesis (MDS) plant in 1993. Located in Bintulu, Sarawak, the plant utilizes 100 mmscfd of natural gas.

CHART 12-5

GAS SUPPLY PROJECTS, 1990-2000



12.18 To further diversify gas utilization in the country and encourage greater use of cleaner transportation fuels, gas was promoted as a fuel for vehicles. Under the natural gas for vehicles (NGV) promotion programme, the fuel was exempted from excise duty, making its retail price at the pump half that of premium petrol. In addition, the conversion kits that allowed petrol engines to use gas were exempted from import duty and sales tax. During the Plan period, six NGV stations were constructed in the Klang Valley and one in Miri, while 923 petrol-driven vehicles, mainly taxis, were converted to run on dual-fuel engines. Field trials of an imported bus running on NGV were conducted to test its feasibility in the domestic public transport system. The development of a prototype NGV car, a project spearheaded by PETRONAS, was launched in 1995.

12.19 Gas was reticulated to industries and commercial outlets as well as residential areas. Beginning in 1992, the reticulation of gas in the peninsula was undertaken by a gas utility company that laid a total of 162 kilometres of pipeline and supplied 24 mmscfd of gas, mostly to industries.

12.20 To ensure the sustainable development of gas resources, a long-term utilization limit of 2,000 mmscfd of processed gas was adopted for the peninsula in 1993. Of this, 1,300 mmscfd is reserved for electricity generation while the remainder is mainly for use as feedstock by petrochemical industries as well as for export to Singapore. Nevertheless, as shown in *Chart 12-4,* the rate of downstream utilization was below the overall 2,000 mmscfd limit during the Plan period.

12.21 *Price.* Gas supplied for electricity generation as well as reticulation in the peninsula was pegged to medium fuel oil (MFO) prices quoted in Singapore. Industries and other bulk users negotiated prices on a case-by-case basis. While the price of gas in Sabah was based on netback computations, that of LNG from Sarawak was linked to the price of a basket of crude oils imported for domestic consumption in Japan.

12.22 *Investment.* About RM19 billion was invested in the exploration and development of petroleum reserves during the Plan period. Of the total invested, about 16 per cent was expended on exploration and the balance on development and production activities. *PETRONAS Carigali,* the only Malaysia-owned production sharing contractor, accounted for 8.0 per cent of the total investment for exploration. Local participation was otherwise predominantly concentrated in the supply of materials and services, particularly after PETRONAS required contractors to procure inputs locally. In 1995, about 74 per cent of total value

of contracts awarded for upstream activities was granted to local companies, compared with 54 percent in 1990. Bumiputera companies accounted for 39 per cent of the total value of contracts awarded in 1995 compared with 36 per cent in 1990.

12.23 The participation of local companies in the supply of downstream goods increased substantially during the period. In 1990, of total contracts amounting to RM1.9 billion that were awarded by subsidiaries and associate companies of PETRONAS, only 15 per cent was given to local companies because they lacked the requisite technology, capital and know-how. By 1995, the share increased significantly to 92 per cent primarily as a result of the implementation of the procurement policy and vendor programme. Despite this credible achievement, the successful local contractors continued to import a substantial proportion of materials, technology and know-how required due to their unavailability in the domestic market.

12.24 The major gas project completed during the period was the RM3.3 billion PGU project undertaken by *PETRONAS Gas Berhad.* It involved the construction of the 730-kilometre PGU II pipeline and installation of three 250-mmscfd GPPs in Kerteh, Terengganu. PETRONAS also invested about RM3 billion on the construction of petrochemical plants producing resins such as ethylene and propylene for industries further downstream as well as RM2.2 billion on the crude oil refinery in Tangga Batu, Melaka.

12.25 While developing the local petroleum industry, PETRONAS ventured abroad taking advantage of its knowledge, expertise and strategic alliances towards becoming a fully-integrated multinational company. Its subsidiaries undertook petroleum exploration off the coasts of Myanmar, the People's Republic of China, the Philippines, Syria, Vietnam and Yemen. PETRONAS participated in downstream activities such as the marketing and distribution of petroleum products in Cambodia, India, the People's Republic of China, the Philippines, Seychelles, Thailand, Vietnam and Zimbabwe. It also acquired equity in the gas transmission and distribution industry in Argentina and Australia. Private sector companies followed suit, investing in the gas industry in Pakistan and developing an oil field in Uzbekhistan.

12.26 In 1992, the Malaysia-Thailand Joint Authority (MTJA) was established to explore and exploit the petroleum resources in the overlapping territory off the east coast of the peninsula, as shown in *Chart 12-5.* Under this unique arrangement, the Malaysian and Thai Governments equally share the costs and

benefits of the venture. PSCs were signed between the MTJA and three production sharing contractors in 1994, subsequent to which about RM132 million was spent on exploration in the joint development area (JDA).

Coal

12.27 During the Plan period, the National Mineral Policy was formulated to facilitate and expedite the expansion and diversification of the sector as well as to ensure the effective and efficient development and management of the country's mineral resources including coal. Currently, the total coal resources of the country stands at 982 million tonnes. Proven coal reserves as of 1995 totalled 175.5 million tonnes, of which 97.3 per cent is found in Sarawak and the rest in Sabah. Six exploration and mining licences were issued by the State Government of Sarawak and one exploration licence by the Sabah Government. About RM51 million was invested during the period for exploration and development. While cost of production was relatively competitive, the high cost of transportation, due to the relative inaccessibility of coal areas, constrained further mining activities. Notwithstanding this, production from existing mines more than doubled from 98,600 tonnes in 1990 to 200,000 tonnes in 1995.

12.28 In line with the four-fuel diversification policy, the use of local coal as an energy source was encouraged. Of the total produced in 1995, about 65 per cent was blended with imported coal for use at the Sultan Abdul Aziz Power station at Kapar, Selangor. While coal exports increased marginally from 26,000 tonnes in 1990 to 35,000 tonnes in 1995, domestic requirements continued to be largely met by imports which increased from 1.8 million tonnes in 1990 to 2.4 million tonnes in 1995. Apart from power generation, the other major user of coal was the cement industry.

Hydro

12.29 The estimated gross hydropower potential for the country was 29,000 megawatt (MW) at the end of the Plan period. Of this, 1,414 MW had been developed as of 1990, involving large plants such as the Kenyir Hydroelectric Project with a capacity of 400 MW and mini hydropower projects with capacities ranging from 100 kilowatt (kW) to 10 MW. About 69 per cent of the hydropower potential yet to be developed is found in Sarawak, 17.2 per cent in Sabah and 13.8 per cent in the peninsula. During the Plan period, an additional 70 MW of hydropower was commissioned by *Tenaga Nasional Berhad* (TNB) at Sungai Piah, Perak. Work on the construction of the 600 MW Pergau Hydroelectric

Project by TNB continued during the Plan period. Total electricity generated by hydropower increased from 4,001 gigawatthours (GWh) in 1990 to 4,424 GWh in 1995. However, the share of hydropower to total electricity generated declined from 17.6 per cent to 10.6 per cent during the same period.

Electricity

12.30 *Generation.* New capacities were installed by TNB, *Lembaga Letrik Sabah* (LLS), Sarawak Electricity Supply Corporation (SESCo) and IPPs to meet demand which grew at 12.8 per cent per annum during the Plan period. A total of 5,535 MW of new generating capacities was added to the TNB system, of which 33.5 per cent was commissioned on a fast-track basis in response to a major supply disruption that occurred in the peninsula in September 1992. Of these new capacities, 51 per cent was by TNB and the remainder by IPPs. The reserve margin of the TNB system declined from about 33 per cent in 1990 to 18 per cent in 1993 and subsequently increased to 61.1 per cent in 1995, as shown in *Table 12-5*.

TABLE 12-5

GENERATION CAPACITY, 1990-2000
(megawatts)

Year	*Generation by System*[1]	*Accumulated Installed Capacity*	*Peak Demand*	*Reserve Margin*[2] *(%)*
1990	TNB	4,576	3,447	*32.8*
	LLS	303	204	*48.5*
	SESCo	363	194	*87.1*
	Total	**5,242**	**3,845**	***36.3***
1995	TNB	10,111	6,276	*61.1*
	LLS	671	323	*107.7*
	SESCo	645	377	*71.1*
	Total	**11,427**	**6,976**	***63.8***
2000	TNB	13,548	10,448	*29.7*
	LLS	960	555	*73.0*
	SESCo	985	692	*42.3*
	Total	**15,493**	**11,695**	***32.5***

Notes:

[1] System refers to utilities and the respective IPPs.

[2] Reserve margin equals accumulated capacity minus peak demand divided by peak demand multiplied by 100.

12.31 The installed generating capacity of LLS rose by 17.2 per cent per annum from 303 MW in 1990 to 671 MW in 1995. The electricity supply system of LLS largely remained unintegrated during the period. While the west coast load centres in Sabah were linked via a high voltage transmission network, the east coast load centres were served by independent systems. As a whole, such a system did not allow the sharing of reserves and as a result a higher reserve margin was required. Peak demand for electricity in Sabah increased by 9.6 per cent per annum, from 204 MW to 323 MW during the same period. The reserve margin of LLS increased from 48.5 per cent in 1990 to 107.7 per cent in 1995. Steps were taken by the Government to increase capacity through projects undertaken by LLS and IPPs. LLS installed a 20 MW aeroderivative gas turbine unit each at Kota Kinabalu, Sandakan and Tawau. In addition, IPPs were given licences to install oil-powered generating plants of 50 MW at Melawa and 36 MW at Tawau.

12.32 SESCo's generating capacity was more than adequate to meet demand. The total installed capacity increased by 12.3 per cent per annum and the peak demand by 14.2 per cent per annum resulting in a reserve margin of 71.1 per cent in 1995. SESCo commissioned gas turbine plants in Bintulu, Kuching and Miri with a total capacity at 210 MW. In addition, a wholly-owned subsidiary of SESCo was licensed to install a 100 MW coal-fuelled generating plant at Sejingkat designed to utilize coal from Merit Pila and to be commissioned during the Seventh Plan period.

12.33 *Generation Mix.* In line with the four-fuel diversification policy, the use of gas for electricity generation in the country increased from 26.2 per cent in 1990 to 68.4 per cent in 1995, as shown in *Table 12-6.* The share of gas in the TNB supply system increased markedly from 27.1 per cent in 1990 to 70.3 per cent in 1995. The increase in gas utilization was accounted for by the commissioning of TNB's gas-based power plants in Connaught Bridge, Pasir Gudang, Port Klang, Serdang and Tanjong Kling as well as IPP plants in Paka, Pasir Gudang, Port Dickson, Sepang and Telok Gong during the period, as shown in *Chart 12-5.* The share of gas-generated electricity for SESCo increased substantially from 19 per cent in 1990 to 68.3 per cent in 1995, as a result of gas-based capacity additions at Bintulu and Miri. For LLS, the generation mix remained relatively unchanged during the Plan period. With these developments, there was an overall decline in the share of fuel oil from 41.9 per cent in 1990 to 11.2 per cent in 1995 and a corresponding increase in the share of gas.

TABLE 12-6

FUEL MIX IN ELECTRICITY GENERATION, 1990-2000

MALAYSIA

Year	Oil		Coal		Gas		Hydro		Others		Total	
	GWh	%	GWh	%	GWH	%	GWH	%	GWH	%	GWH	%
1990	9,532	41.9	3,146	13.8	5,967	26.2	4,061	17.8	62	0.3	**22,768**	**100.0**
1995	4,704	11.2	4,068	9.7	28,689	68.4	4,424	10.5	76	0.2	**41,961**	**100.0**
2000	4,667	6.7	11,427	16.5	48,029	69.2	5,204	7.5	89	0.1	**69,416**	**100.0**

TNB SYSTEM

Year	Oil		Coal		Gas		Hydro		Others		Total	
	GWh	%	GWh	%	GWH	%	GWH	%	GWH	%	GWH	%
1990	8,580	41.5	3,146	15.2	5,602	27.1	3,288	15.9	62	0.3	**20,679**	**100.0**
1995	3,510	9.2	4,068	10.7	26,786	70.3	3,651	9.6	76	0.2	**38,091**	**100.0**
2000	2,500	4.0	10,797	17.3	44,637	71.5	4,425	7.1	89	0.1	**62,448**	**100.0**

LLS SYSTEM

Year	Oil		Coal		Gas		Hydro		Others		Total	
	GWh	%	GWh	%	GWH	%	GWH	%	GWH	%	GWH	%
1990	585	54.1	0	0	173	16.0	323	29.9	0	0	**1,081**	**100.0**
1995	958	52.8	0	0	499	27.5	358	19.8	0	0	**1,815**	**100.0**
2000	2,001	66.3	0	0	657	21.8	360	11.9	0	0	**3,018**	**100.0**

SESCo SYSTEM

Year	Oil		Coal		Gas		Hydro		Others		Total	
	GWh	%	GWh	%	GWH	%	GWH	%	GWH	%	GWH	%
1990	367	36.4	0	0	192	19.0	450	44.6	0	0	**1,009**	**100.0**
1995	236	11.5	0	0	1,404	68.3	415	20.2	0	0	**2,055**	**100.0**
2000	166	4.2	630	16.0	2,735	69.2	419	10.6	0	0	**3,950**	**100.0**

12.34 *Transmission.* Along with the increase in the generating capacity, the transmission and distribution networks were expanded both to improve the coverage as well as enhance system reliability and stability. TNB's expansion of the transmission network involved the laying of 5,029 circuit-kilometres (cct-km) of high voltage lines ranging from 132 kilovolt (kV) to 275 kV lines, and the phasing out of 66 kV lines from 892 cct-km in 1990 to 274 cct-km in 1995, as shown in *Table 12-7.* In addition, TNB began implementation of a major 500 kV transmission project in 1995.

TABLE 12-7

TRANSMISSION NETWORK CAPACITY, 1990-2000
(circuit-kilometres)

Year	*Utility*	*500kV*	*275kV*	*132kV*	*66kV*
1990	TNB	0	3,596	6,107	892
	LLS	0	0	479	54
	SESCo	0	327	46	0
1995	TNB	0	4,881	9,851	274
	LLS	0	0	479	82
	SESCo	0	569	63	0
2000	TNB	1,112	5,493	11,594	0
	LLS	0	640	1,421	132
	SESCo	0	767	128	0

12.35 During the period, LLS completed the 33 kV Tuaran transmission system and initiated the construction of the 33 kV line from Patau-Patau to Sungai Berdaun and its associate substations. Among the transmission projects undertaken by SESCo were a 198-kilometre 275 kV transmission line linking Bintulu to Miri and a 56-kilometre 132 kV transmission line from Kemantan to Tanjung Manis in the Sarikei Division.

12.36 *Distribution.* The distribution network of the utilities comprises 33 kV, 22 kV, 11 kV and 0.415 kV lines. The TNB network, involving the top three capacities, increased from 25,765 cct-km to 44,276 cct-km during the Plan period, as shown in *Table 12-8.* The TNB system was reinforced by the addition of 8,753 substations. LLS expanded its distribution network of similar capacities from 2,850 cct-km in 1990 to 3,555 cct-km in 1995, and augmented the distribution capability by establishing 351 substations. For SESCo, the network increased by 1,351 cct-km. With the expansion in the distribution network, the three electric utilities were able to serve 1.37 million new customers.

TABLE 12-8

DISTRIBUTION NETWORK CAPACITY, 1990-2000
(circuit-kilometres)

Year	*Utility*	*33kV*[1]	*22kV*	*11kV*	*Total*
1990	TNB	2,656	1,845	21,264	**25,765**
	LLS	70	280	2,500	**2,850**
	SESCo	736	0	2,769	**3,505**
1995	TNB	3,647	2,432	38,197	**44,276**
	LLS	105	350	3,100	**3,555**
	SESCo	1,192	0	3,664	**4,856**
2000	TNB	5,286	3,162	68,755	**77,203**
	LLS	140	400	4,000	**4,540**
	SESCo	1,500	0	6,500	**8,000**

Note: [1] The 33kV line under LLS system is classified as a transmission line

12.37 *Rural Electrification.* By the end of the Plan period, 92 per cent of rural households in Malaysia were served with electricity, compared with 80 per cent in 1990, as shown in *Table 12-9*. Of total expenditure on rural electrification by the Federal Government, 87 per cent was for grid extention projects and the remainder for stand-alone projects involving the installation of diesel generators and solar-powered systems. In addition, TNB invested RM100 million in rural electrification projects in the peninsula.

TABLE 12-9

RURAL ELECTRIFICATION COVERAGE BY REGION, 1990-2000
(%)[1]

Region	*1990*	*1995*	*2000*
Peninsula	*91*	*99*	*100*
Sabah	*48*	*65*	*75*
Sarawak	*50*	*67*	*80*
Malaysia	***80***	***92***	***93***

Note: [1] Rural households served as a percentage of total rural households.

12.38 *Investment.* To meet the increasing demand, a total of RM25.1 billion was invested in the electricity sector by the utilities and IPPs to increase capacity and improve system reliability, as shown in *Table 12-10*, compared with RM15.4 billion targeted in the Sixth Plan. Of the total investment, 71.1 per cent was for generation, 13.9 per cent, transmission and 15 per cent, distribution. Investments in generation were for projects commissioned during the Sixth Plan period as well as those to be commissioned in the Seventh Plan period. Of the total capacity commissioned during the Sixth Plan period, TNB accounted for 45.6 per cent or 2,823 MW, LLS, 6.0 per cent or 368 MW, SESCo, 4.6 per cent or 282 MW and IPPs, 43.8 per cent or 2,712 MW. Foreign cost constituted about 75 per cent of the total investment.

TABLE 12-10

INVESTMENTS BY UTILITIES AND IPPs IN ELECTRICITY SUPPLY INDUSTRY, 1990-95
(RM million)

Activities	*TNB*	*LLS*	*SESCo*	*IPP*	*Total*	*%*
Generation	7,654	273	353	8,303	**16,583**	*71.1*
Transmission	3,123	23	609	246	**4,001**	*13.9*
Distribution	4,305	35	154	0	**4,494**	*15.0*
Total	**15,082**	**331**	**1,116**	**8,549**	**25,078**	***100.00***
%	*60.1*	*1.3*	*4.5*	*34.1*	*100.0*	

12.39 *Efficiency and Productivity.* The unprecedented growth in demand for electricity, particularly in the peninsula, placed a strain on the TNB system resulting in supply interruptions in the early part of the Plan period. Measures were expeditiously instituted to enhance security and quality of supply through the expansion of the system generating capacity as well as the upgrading and expansion of its transmission and distribution networks. At the same time, efficiency improvements were recorded in several areas, as shown in *Table 12-11*. Demand pressures also strained the LLS system. Similar measures were undertaken resulting in appreciable improvements in supply security and quality. SESCo's efficiency and productivity improved satisfactorily during the period.

TABLE 12-11

PERFORMANCE INDICATORS OF ELECTRICITY SUPPLY SYSTEMS[1], 1990 AND 1995

Indicator	*1990*			*1995*		
	TNB	*SESCo*	*LLS*	*TNB*	*SESCo*	*LLS*
System Losses[2] (%)	*16.0*	*20.8*	*19.2*	*15.0*	*17.4*	*14.8*
Average Fuel Conversion Efficiency[3] (%)	*32.2*	*26.0*	*33.2*	*33.5*	*28.0*	*33.5*
kWh Sold per Employee[4] ('000)	753	444	390	1,420	838	648

Notes:

[1] Comprising utilities only

[2] Refers to generation, transmission and distribution losses and own use.

[3] Electrical energy generated in thermal power stations as a percentage of the amount of energy in primary fuel used.

[4] Refers to total electrical energy units sold divided by total number of employees.

12.40 *Price.* With the privatization of TNB, the price of electricity was regulated by the Department of Electricity and Gas Supply (JBEG) which took into account the costs and returns to the industry. The average tariff of the TNB system stabilized at around 18.7 sen per kilowatthour (kWh) during the period. Due to the higher cost of supply, average electricity tariffs of LLS and SESCo were correspondingly higher. While the LLS average tariff remained higher than that of TNB, it declined from 25.7 sen/kWh in 1990 to 24.6 sen/kWh in 1995, primarily due to the reduction in tariffs for Labuan in 1992, in line with the peninsula tariffs. SESCo's average tariff increased from 27.4 sen/kWh in 1990 to 28.2 sen/kWh in 1995.

Non-Conventional Energy

12.41 Malaysia is endowed with not only depletable energy resources but also non-conventional renewable resources such as biomass, solar and wind which are, however, relatively costly to harness. The utilization of these resources grew at 7.4 per cent per annum from 92.5 PJ in 1990 to 132.3 PJ in 1995. A large portion of these resources consisted of biomass, namely oil

palm waste and wood waste, used to produce steam for processing activities and also to generate electricity. During the period, a pilot wind-based plant with a capacity of 150 kW was installed on an island off Sabah. The Government also implemented 32 projects to generate electricity using solar technologies, benefitting about 800 rural households mainly in Sabah and Sarawak.

III. PROSPECTS, 1996-2000

12.42 The thrust of the Seventh Plan will continue to focus on ensuring adequate, secure and cost-effective supplies and utilizing the energy resources efficiently while minimizing the negative impacts to the environment. The security of supply objective will continue to be pursued through diversification of energy sources in line with the four-fuel diversification policy. The objectives of increasing efficiency in energy utilization as well as discouraging wasteful practices in energy usage will be further pursued. The import content of energy-related equipment and machinery will be reduced through increasing the production of locally-manufactured components for local utilization as well as export. Environmental considerations will continue to be taken into account in the efforts to harness and utilize energy resources.

Energy Demand

12.43 *Commercial Energy.* During the Seventh Plan period, the overall demand for commercial energy is expected to increase at 8.9 per cent per annum, from 836.7 PJ in 1995 to 1,279.4 PJ in the year 2000, while the energy intensity of the economy is anticipated to increase from 7.07 GJ or 0.169 toe per thousand Ringgit of GDP to 7.34 GJ or 0.175 toe per thousand Ringgit of GDP in the same period. This reflects the progression of the economy towards more energy-intensive industries as well as the rising affluence of the population. Per capita consumption is expected to increase at 6.4 per cent per annum, from 41.1 GJ in 1995 to 56.1 GJ in the year 2000, as shown in *Table 12-1.* While the share of *coal and coke* to total final commercial energy demand will remain small, the growth in their demand is expected to outpace that of other energy sources due to their increasing use in cement production. With the expansion of the gas supply infrastructure to the non-electricity sectors, comprising commercial, industrial and residential users, the growth in demand for *natural gas* is expected to increase by 12.7 per cent per annum.

12.44 *Electricity* demand is projected to grow at 11 per cent per annum, thereby increasing its share of total energy demand to 17.3 per cent in the year 2000. Per capita electricity consumption will correspondingly increase at a rate of 8.9 per cent per annum to about 2,800 kWh in the year 2000. In line with the fuel diversification policy, the share of *petroleum products* to total commercial energy demand is expected to decline to 61 per cent in the year 2000. Notwithstanding this, the demand for petroleum products is projected to grow at 6.7 per cent due to increasing demand particularly by motorized vehicles.

12.45 The transport sector will continue to be the leading energy-consuming sector in line with its anticipated rapid growth during the Seventh Plan period. A new source of energy demanded by this sector will be electricity, particularly with the introduction of electric-based transportation systems such as the Light Rail Transit and the *Keretapi Tanah Melayu Berhad* (KTMB) commuter train service. Energy demand by the sector is expected to grow at 8.4 per cent per annum and will account for 38.3 per cent of the total energy demand in the year 2000, as shown in *Table 12-2*. With the manufacturing sector's demand for commercial energy projected to grow at 10.3 per cent per annum, its share of total energy demand is expected to match that of the transport sector in the year 2000. As for the residential sector, energy demand will grow by 4.6 per cent per annum in line with increasing incomes.

Energy Supply

12.46 Security of energy supply will be ensured through a prudent fuel mix largely based on domestic resources. Towards this end, continued efforts will be made to create a conducive environment to encourage the exploration and production of depletable energy resources as well as harness the energy potential of renewable resources. The supply of primary commercial energy is expected to grow at 7.2 per cent per annum, as shown in *Table 12-3*.

Crude Oil

12.47 *Exploration and Production.* In the effort to increase Malaysia's crude oil reserves, exploration activities will continue, particularly in deepwater areas. In addition, a cost-efficient, integrated-development approach will be pursued in place of an individual field-development approach. PETRONAS will also continue to venture into upstream activities abroad to secure alternative sources of crude oil to supplement its domestic reserves. Production of crude oil will average about 606,000 bpd during the Seventh Plan period, while that of condensate is expected to be about 89,000 bpd.

12.48 *Utilization.* To maintain the presence of Malaysian crude oil as a benchmark in the international market, about 43 per cent of total volume produced will continue to be exported while the balance will be refined locally. The country will attain self-sufficiency in refining capacity with the commissioning of the second 100,000 bpd refinery in Tangga Batu, Melaka in 1997. Malaysia will then have a total of six refineries capable of refining 456,000 bpd where products in excess of local requirements will be exported. The construction of a multi-product pipeline from the Melaka and Port Dickson refineries to the KL International Airport, Sepang, and a bulk terminal within the locality of Sepang will ensure that petroleum products will be transported safely to this area. The upgrading of crude oil refining processes of existing refineries will enable the production of higher value-added products such as naphtha.

Natural Gas

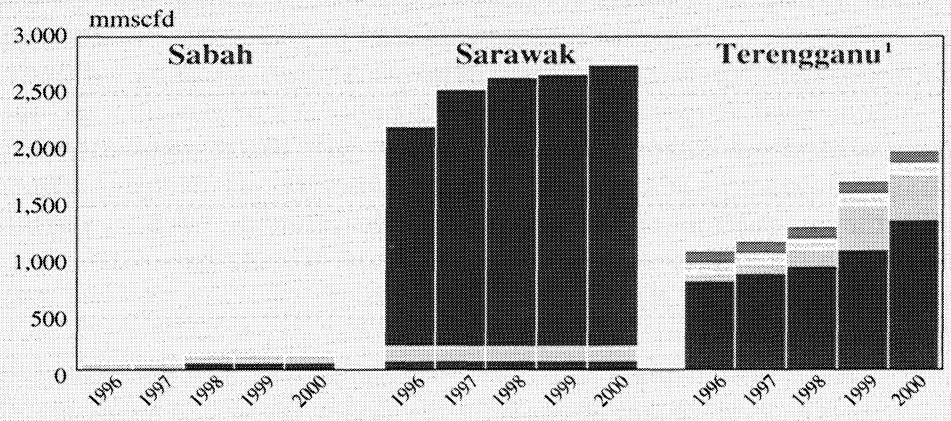
12.49 *Exploration and Production.* Measures will be continuously taken to encourage the development of gas fields by reviewing, when necessary, the fiscal and production sharing terms. Strategies, such as the exploration of deepwater areas and the integrated development of existing fields, will also be implemented to accelerate gas development and ensure adequate supply. Production of gas during the Plan period is expected to increase by 12.4 per cent per annum to 6,238 mmscfd in the year 2000. A possible new source of gas supply will be the JDA which is managed by the MTJA and is expected to begin production in 1999.

12.50 *Utilization.* Efforts will be made to ensure that the gas supplied will meet the needs of consumers, both in terms of quantity and quality. By the year 2000, about 1,300 mmscfd, or 65 per cent of the total methane produced in Terengganu, is expected to be used for electricity generation, as shown in *Chart 12-6*. The remaining 35 per cent will be exported to Singapore as well as used by domestic industries as fuel or feedstock. The other components of the processed gas will be used towards the expansion of the ethylene and propylene plants. PETRONAS will also set up an aromatics plant and a vinyl-chloride-monomer (VCM) plant in Kerteh, Terengganu, as well as a urea plant in Gurun, Kedah. Products from the petrochemical plants will benefit downstream industries, such as the plastics industries, in the move to fabricate higher value-added products.

12.51 While the main users of gas in Sabah will continue to be the methanol and hot-briquette iron plants, the Plan period will witness increasing gas utilization for electricity generation. In Sarawak, gas utilization will increase

CHART 12-6

GAS UTILIZATION, 1996-2000



	Sabah					Sarawak					Terengganu[1]				
Elect. Gen.	16	20	62	62	62	51	52	52	53	59	773	799	847	1,050	1,300
Industry	76	76	76	75	78	156	152	155	153	154	122	167	240	464	478
Reticulation	–	–	–	–	–	7	7	7	8	9	34	45	53	56	72
Export	–	–	–	–	–	–	–	–	–	–	150	150	150	150	150
LNG Feedstock	–	–	–	–	–	2,010	2,354	2,458	2,483	2,561	–	–	–	–	–
Total	**92**	**96**	**138**	**137**	**140**	**2,224**	**2,565**	**2,672**	**2,697**	**2,783**	**1,079**	**1,161**	**1,290**	**1,720**	**2,000**

Note: [1] Indicates only the methane produced by the GPPs. Other components are not included.

with the commencement of the third LNG plant which is expected to begin operations in the year 2000 with a production capacity of 6.8 million tonnes per annum. By the end of the Plan period, about 93 per cent of gas produced in Sarawak will be consumed by the LNG plants while the remaining portion will be piped to the petrochemical and electricity generation plants in Bintulu as well as to an electricity generation plant, households and commercial entities in Miri.

12.52 As for gas reticulation, about 250 kilometres of pipeline will be constructed largely in the Klang Valley to cater for industrial, commercial and residential consumers as well as NGV retailing stations. The reticulation industry will be governed by the Gas Supply Act, 1993 and the accompanying regulations, both of which are under the jurisdiction of the JBEG. The department's functions and responsibilities are principally to protect consumer interests by ensuring fair gas prices and enforcing safety standards and technical specifications.

12.53 *Investment.* About RM32 billion is expected to be invested in the upstream and downstream activities of the petroleum industry by PETRONAS, its production sharing contractors and joint-venture partners. Of this, about 52 per cent will be for exploration, development and production activities in Malaysian waters. In addition, the MTJA contractors are expected to invest about RM3 billion in the exploration and development of gas in the JDA.

12.54 A total of about RM15 billion will be expended by PETRONAS on downstream activities during the Plan period, with the major portion earmarked for gas-related activities. The capital expenditure includes about RM1.3 billion for the construction of the PGU III pipeline that begins from Meru, Selangor, extending northwards through Perak, Pulau Pinang and Kedah to Perlis, making gas available to these states by mid-1998. In addition, RM1.2 billion will be invested in the construction of a pipeline parallel to the section of PGU II that stretches from Kerteh to the Klang Valley via Segamat. The completion of this parallel line by 1998 will increase the gas transmission capacity to the Klang Valley, the area with the highest rate of gas utilization. About RM3.2 billion will be invested in the construction of two GPPs to further augment the gas processing capacity to over 2,000 mmscfd in 1999. PETRONAS is also expected to invest about RM4.4 billion in various petrochemical projects and RM4.9 billion in the second crude oil refinery in Tangga Batu, Melaka.

Coal

12.55 In line with efforts to pursue the fuel diversification policy within the context of least-cost planning, coal will play an increasingly important role during the Plan period. Exploration and assessment of coal resources will be stepped up by the Geological Survey Department and the private sector, particularly in Sabah and Sarawak. The development of known coal deposits is expected to be intensified in view of the high demand for coal in electricity generation and cement manufacture. About 90 per cent of the 5.5 million tonnes required annually by the country will be met by imports. With improvements in the infrastructure leading to coal deposits, the production of local coal is expected to increase further. Local coal production is expected to increase from 200,000 tonnes in 1995 to 510,000 tonnes by the year 2000, most of which will be used locally. Two coal-fired electricity generating plants will be commissioned during the Plan period, one by TNB at Klang, Selangor with a capacity of 1,000 MW that could also use gas, and another by a subsidiary of SESCo with a capacity of 100 MW at Sejingkat, Sarawak. In addition, coal will be increasingly used as fuel with the commissioning of four new cement plants. While the plant

in Kuching, Sarawak is expected to utilize domestic coal, the other cement plants in Gua Musang in Kelantan, Bahau in Negeri Sembilan and Bukit Sagu in Pahang are expected to be fuelled by imported coal.

12.56 With the implementation of the National Mineral Policy, the private sector is expected to play a key role in the development of coal resources in the country through greater involvement in exploration, development and production activities. However, due to the long lead time, the benefits of this private sector-led initiative will only be realized after the year 2000. Efforts will be made to increase the pool of expertise and improve know-how, especially in underground mining. Since most coal deposits are located in remote areas, the efficient transport, distribution and storage of this mineral will be given due consideration. Measures will be taken to ensure that the production and utilization of coal will meet environmental standards.

Hydro

12.57 Given that hydroelectricity generation is environment-friendly and to meet the objective of the four-fuel diversification policy, measures will be taken to promote the development of the country's hydropower resources. The Pergau Hydroelectric Project, which is expected to be commissioned in 1996, will increase the energy generated by hydro sources to 5,204 GWh by the year 2000 representing a share of 7.5 per cent in total electricity generation in the country.

12.58 The construction of the 2,400 MW Bakun Hydroelectric Project, which has excellent hydrological characteristics, is expected to begin during the Plan period and to be fully commissioned in the year 2003. The project comprises among others, a 205-metre high concrete-face rockfill dam and a 670-kilometre direct current transmission submarine link between Sarawak and the peninsula. The dam and the submarine cable will be the highest and longest in the world, respectively. The hydro plant of this project, which has a high load factor of approximately 80 per cent, will meet baseload requirements in the peninsula and Sarawak. It is expected to supply annually 12,850 GWh of electricity to the peninsula, and 875 GWh to the SESCo system or the equivalent of about 1,553 MW and 100 MW, respectively in terms of firm capacity. At a load factor of 80 per cent, this project will preempt the use of some 5.5 million tonnes of coal annually, valued at about RM560 million in 1995 prices. The completion of this hydro project will mark the beginning of the proposed integration of the electricity supply systems of the peninsula, Sabah and Sarawak.

12.59 Apart from the Bakun Hydroelectric Project, design work on the 165 MW Liwagu Hydroelectric Project in Sabah is expected to be completed during the Plan period. The project, which will serve as a peaking plant, is expected to be commissioned in the Eighth Malaysia Plan period. In addition, three mini hydropower projects with a total capacity of 950 kW will be undertaken at Pukak, Tagap and Tenompok in Sabah.

Electricity

12.60 The electricity requirements of the nation will be adequately met during the Seventh Plan period by the utilities as well as nine IPPs, five to serve the TNB system, and four the LLS system. Greater emphasis will be given by the utilities to the expansion and upgrading of transmission and distribution networks.

12.61 *Generation.* During the Plan period, an additional 4,066 MW of generation capacity will be commissioned by TNB, LLS, SESCo and the IPPs. The TNB system will be further strengthened by 3,437 MW, bringing the peninsula's total installed capacity to 13,548 MW in the year 2000, as shown in *Table 12-5*. The major projects will include a 1,300 MW gas-based plant owned by an IPP at Lumut in Perak, TNB's 1,000 MW coal-fired plant at Port Klang, Selangor, and the 600 MW hydroelectric plant at Pergau, Kelantan. With demand projected to grow at 11 per cent per annum, the reserve margin is expected to decline to 29.7 per cent in the year 2000.

12.62 The installed capacity of the LLS system will increase to about 960 MW in the year 2000. With peak demand increasing at 11.4 per cent per annum, the reserve margin is expected to be 73 per cent. Several IPP projects will be commissioned during the Plan period. These include a 120 MW gas-fuelled plant in Karambunai and three oil-fuelled plants in Melawa, Sandakan and Tawau with installed capacities of 50 MW, 60 MW and 36 MW, respectively. The 165 MW Liwagu Hydroelectric Project will begin construction during the period. The installed capacity of the SESCo system will increase to 985 MW in the year 2000 with the completion of two gas-fired plants and one coal-fired plant. This will result in a reserve margin of 42.3 per cent based on a peak demand of 692 MW. The high reserve margins for the LLS and SESCo systems are due to their unintegrated nature which does not permit the sharing of reserves.

12.63 *Generation Mix.* The fuel mix for electricity generation will be predominantly based on gas, accounting for 69.2 per cent of the mix in the year 2000, as shown in *Table 12-6.* Gas will continue to feature prominently in the generation mix of the TNB system, accounting for 71.5 per cent. The share of oil is expected to decline from 9.2 per cent in 1995 to 4.0 per cent in the year 2000, while that of coal will increase from 10.7 per cent to 17.3 per cent in the same period. For the LLS system, due to the limited availability of gas, oil will still be the main fuel comprising 66.3 per cent of its generation mix in the year 2000. The generation mix of the SESCo system in the year 2000 will constitute 69.2 per cent gas, 16 per cent coal, 10.6 per cent hydro and the rest, oil. During the Seventh Plan period, alternative sources of energy will be identified to ensure that the country will have a prudent fuel mix in the long term.

12.64 *Transmission.* Efforts will be made to improve and reinforce the country's transmission and distribution systems to enhance operational efficiency and system reliability. In the west coast of the peninsula, the National Grid will be further strengthened with the implementation of the 500 kV north-south transmission line. The first phase, comprising the Port Klang-Rawang-Lumut-Gurun sector and the Pasir Gudang-Yong Peng sector will be completed during the Plan period. In order to enhance and ensure the effectiveness of the Grid, the National Load Despatch Centre (NLDC) and the Regional Control Centres (RCCs) will be upgraded. This will help minimize interruptions and reduce transmission losses.

12.65 The LLS transmission system will be upgraded with the implementation of various projects, including the 132 kV Beaufort-Sipitang Interconnection, the Kota Belud-Kudat as well as the Simpudu-Kimanis links. SESCo will enhance the operations and reliability of its electricity transmission system with the integration of the Miri system through the installation of 198 kilometres of 275 kV transmission lines.

12.66 To promote greater cooperation in electricity supply among the ASEAN countries, the infrastructure for interchange of electricity within these countries will be further improved. Current interconnections with Thailand and Singapore are expected to be upgraded to 300 MW and 250 MW, respectively. These interconnections will form part of the ASEAN Grid in line with the objectives of regional cooperation.

12.67 *Distribution.* The TNB distribution system will be expanded and upgraded to ensure the smooth and reliable operation of the distribution network

focusing on high quality electricity supply such as voltage stability. Measures will be taken to monitor the supply system continuously through the establishment of regional and localized Supervisory Control and Data Acquisition Systems (SCADA) in the peninsula. To cater for the specific needs of industries that are sensitive to the quality of electricity supply such as the manufacture of wafers and microprocessors in the electronics industry, the current special quality monitoring units will be further upgraded. Measures will be implemented to enhance customer satisfaction via proactive planning, dialogue sessions, marketing efforts and use of the latest technologies. The distribution systems of LLS and SESCo will be further reinforced by the addition of 3,736 cct-km and 2,343 cct-km of 11 kV and 33 kV lines, respectively.

12.68 *Rural Electrification.* Rural electrification programmes under the Plan period will comprise grid extensions and the provision of stand-alone generators consisting of solar installations, micro- and mini-hydros as well as various hybrid systems. A total of RM469 million will be allocated by the Federal Government for rural electrification programmes which are expected to benefit about 137,000 rural households. In addition, TNB will continue to support these programmes in the peninsula in line with its corporate responsibilities. The States of Sabah and Sarawak will receive more than 75 per cent of the Federal Government allocation. By the end of the Plan period, electricity coverage in the rural areas is expected to increase to 93 per cent, as shown in *Table 12-9.*

12.69 *Investment.* In line with the objective of improving system stability and reliability, about RM34 billion is expected to be invested in the electricity supply systems in the peninsula, Sabah and Sarawak. This investment is to cater to the requirements during the Plan period and beyond. Of this total investment, about 43 per cent will be in generation activities, 35 per cent in transmission and 22 per cent in distribution. This investment will be undertaken both by the utilities and IPPs. The investment on the Bakun Hydroelectric Project is estimated to be RM6.7 billion during the Plan period.

12.70 *Improving Sector Operations.* The generation of electricity has been liberalized with the introduction of IPPs. In the peninsula, with the multiplicity of electricity generators, steps will be taken to make the grid system operator (GSO) independent. In addition to managing and enforcing the Malaysian Grid Code, the GSO is expected to plan the expansion of the transmission and generation networks as well as optimally operate the transmission system. The GSO is also expected to ensure the economic dispatch of electricity and maintain system integrity at all times.

Non-Conventional Energy

12.71 The consumption of non-conventional energy, the bulk of which constitutes biomass, is expected to decline from 132.3 PJ in 1995 to 124.2 PJ in the year 2000. This decline will be due to the increasing substitution of biomass with more efficient and cleaner fuels such as gas and electricity. However, the use of other forms of non-conventional energy such as solar, micro-hydros and hybrid systems are expected to increase in view of their economic and technical viability to supply energy in remote areas.

Productivity Improvements

12.72 In line with the productivity-driven growth thrust of the economy, efforts will be made to improve efficiency in the production of primary energy, conversion of primary energy into secondary energy, transmission of energy to final consumers and the utilization of energy by end users. In addition, efforts will be undertaken to promote the productive use of energy. Given that the country will continue to face labour shortages, capital intensity and automation will be promoted in production processes, thereby resulting in the greater use of electricity. As energy is one of the vital inputs in production processes, the efficient utilization of energy inputs will further enhance the competitiveness of Malaysian exports. In the long term, as demand for energy grows, the country is expected to become a net energy importer, thereby adversely affecting the balance of payments. On account of these factors, it is imperative that efficiency improvements be undertaken in the utilization of energy. Accordingly, appropriate measures will be undertaken.

Environmental Considerations

12.73 Environmental considerations will continue to be factored in energy planning and policy formulation with a view to reducing the negative impacts of harnessing and utilizing energy resources on the environment. The exploitation of hydro resources to generate electricity will be given increasing emphasis. The usage of natural gas, which is environment-friendly, will be promoted aggressively in the transport and manufacturing sectors to include utilization of gas by bus fleets and industries in place of polluting fuels. In this respect, environmental concerns will be taken into account in the formulation of a national transport fuel policy. In addition, electric-based urban public transport systems, which are emission-free, will be further expanded by the private sector with encouragement from the Government.

Research and Development

12.74 Greater emphasis will be given to research and development (R&D) activities aimed at the efficient harnessing and utilization of energy resources. To strengthen the institutional structure, consideration will be given to the establishment of an Energy Research Centre to coordinate R&D activities currently undertaken separately by various agencies. The Centre will rationalize and coordinate R&D activities of institutions such as universities and R&D subsidiaries of PETRONAS and TNB as well as collaborate with foreign research institutions.

IV. ALLOCATION

12.75 The development allocation and expenditures by both the Federal Government and Non-Financial Public Enterprises (NFPEs) for the Sixth and Seventh Plans are shown in *Table 12-12*. Of the total allocation amounting to RM43.3 billion for the development of energy programmes in the Seventh Plan period, 60.7 per cent will be for the development of the electricity sector and the balance for the petroleum sector.

TABLE 12-12

DEVELOPMENT ALLOCATION AND EXPENDITURE FOR ENERGY SECTOR PROGRAMMES, 1991-2000
(RM million)

Programme	*6MP Expenditure*			*7MP Allocation*		
	Federal Government	*NFPEs*[1]	*Total*	*Federal Government*	*NFPEs*	*Total*
Electricity Sector	**829.0**	**16,751.8**	**17,580.8**	**1,058.0**	**25,210.3**	**26,268.3**
Hydro	93.3	1,900.2	1,993.5	87.0	0.0	87.0
Thermal	199.5	6,107.2	6,306.7	209.0	9,940.6	10,149.6
Rural Electricity	499.2	100.0	599.2	468.5	50.0	518.5
Transmission & Distribution	36.7	8,190.4	8,227.1	288.5	14,890.3	15,178.8
Others	0.3	454.0	454.3	5.0	329.4	334.4
Oil & Gas Sector	**–**	**10,814.8**	**10,814.8**	**–**	**16,982.0**	**16,982.0**
Upstream	–	2,120.9	2,120.9	–	3,947.2	3,947.2
Downstream	–	5,488.0	5,488.0	–	6,523.2	6,523.2
Manufacturing	–	3,159.6	3,159.6	–	5,260.5	5,260.5
Others	–	46.3	46.3	–	1,251.1	1,251.1
Total	**829.0**	**27,566.6**	**28,395.6**	**1,058.0**	**42,192.3**	**43,250.3**

Note: [1] Refers to TNB, SESCo, LLS and PETRONAS.

V. CONCLUSION

12.76 The increase in demand for energy in the Sixth Plan period was attributed to the rapid growth of the economy, particularly in the manufacturing and transport sectors. This led to supply bottlenecks due to the long lead times required to bring in new supplies of energy. However, various measures were taken to ensure adequate and reliable supplies of energy including expanding electricity generation capacity by IPPs.

12.77 For the Seventh Plan period, the energy sector will continue to play an important role in the development and expansion of the other sectors of the economy. Concerted efforts will be made to increase productivity and efficiency of the energy sector to ensure that energy of the required quantity and quality will be supplied at reasonable prices. As in the past, environmental considerations will be factored in energy planning and development. Several programmes will be implemented to consolidate and strengthen the sector. These include upgrading the transmission and distribution networks in the electricity sector, promoting greater usage of gas in the non-power sector and enhancing the rural electrification programme.

Chapter 13

Science and Technology

13 SCIENCE AND TECHNOLOGY

I. INTRODUCTION

13.01 High priority will continue to be accorded to the promotion of science, research and technological innovation, as an essential part of the Government's development strategy to maintain high rates of growth and improve living standards. This is critical as science and technology (S&T) provides the means for economic advancement and enhances international competitiveness of the economy.

13.02 During the Sixth Plan period, considerable attention was given to effecting organizational, management and strategy changes in line with the efforts of the Government to increase technological capability and make public sector Research and Development (R&D) programmes more demand-oriented and relevant to industry. The private sector, on its part, contributed much more to the expansion of research activities and innovations, especially in the manufacturing sector, when compared with the Fifth Plan period.

13.03 Many of the new changes will be effected during the Seventh Plan, enabling S&T to make further contributions to productivity-driven growth and development as well as the shift into technology-intensive industries and services. Efforts to enhance productivity and the nation's competitiveness will involve stimulating the search for greater process and product innovation, diffusing technological change more rapidly within and across sectors, and accelerating complementary institutional and organizational changes.

II. PROGRESS, 1991-95

13.04 Amidst rapid and robust economic growth during the Sixth Plan period, considerable achievements were made in terms of S&T development within the

country. This was seen not only in terms of the size of R&D expenditure and magnitude of technology development activities but also in S&T policy and management initiatives.

S&T Policy

13.05 As stipulated in the Second Outline Perspective Plan (OPP2) and Sixth Plan, the goals of the national S&T policy are to ensure continuous scientific and technological developments that will support and sustain high rates of economic growth, accelerate overall industrial development and lay the foundation for the attainment of a scientific and technologically advanced society by the year 2020. Mindful that S&T activities are strongly influenced by increasing globalization and competition arising from new technologies and product development, the policy focus was to promote technological innovation, increase highly skilled technical and research manpower, push for greater productivity as well as better utilize and commercialize public sector S&T resources.

S&T Management

13.06 The S&T planning and implementation machinery in the public sector was strengthened and streamlined with a view to emplacing a more coordinated and effective approach towards enhancing national technological capability. Among the major measures was the establishment of the Cabinet Committee on S&T, under the chairmanship of the Prime Minister, to provide policy directions on S&T issues. The National Council for Scientific Research and Development (MPKSN), under the chairmanship of the Chief Secretary to the Government, was reconstituted and restructured during the early part of the review period. The MPKSN assumed the role and responsibility of coordination, and monitoring of research, science and technology activities through an interactive process among research institutions and universities as well as the private sector. In addition, the MPKSN supervised the management and implementation of the Intensification of Research in Priority Areas (IRPA) programme. It was also assisted by working groups assigned with the task of proposing specific measures to enhance capabilities in the key technologies of microelectronics, advanced materials, biotechnology, information technology (IT) and advanced manufacturing technology as well as energy and environmental-related technologies.

13.07 Several other measures to expand the institutional support structure for S&T were implemented. Apart from strengthening the existing R&D institutions

and agencies covering a wide range of research areas, a number of new centres and committees were established to increase technology-oriented activities in specific areas. These included the National Information Technology Council, the Biotechnology Directorate, the Academy of Sciences, the Malaysian Science and Technology Information Centre (MASTIC) and the Space Science Studies Centre as well as the Design Council Malaysia. Plans are also underway to set up the National Measurement Centre at the Technology Park Malaysia (TPM), Wilayah Persekutuan Kuala Lumpur and the Advanced Materials Research Centre at Kulim Hi-Tech Park (KHTP) in Kedah.

13.08 The Government promoted the adoption of a contract research system in public sector research institutions and universities. This was in line with the recommendation of the National Plan of Action on Industrial Technology Development, that public research organizations be transformed into contract research organizations to achieve the 65 per cent self-financing target by the year 2000. The establishment of a contract research system will require a significant change in the way R&D organizations are being managed. It would require comprehensive reevaluation of their management system, strategies, organizational structures and the way R&D activities are being selected and funded. In essence, the research institutions as well as the consultancy units in universities are to take on a commercial orientation. Guidelines were prepared to gradually steer research institutions towards this direction, and ensure that organizational infrastructure in public sector agencies undertaking R&D is in line with the demand and technological changes taking place in the economy.

13.09 As part of the national efforts to enhance the effectiveness and efficiency of public sector organizations, the Government initiated the corporatization of a number of research-related institutions. Currently, the Standards and Industrial Research Institute of Malaysia (SIRIM), Malaysian Institute of Microelectronics System (MIMOS) and TPM are undergoing corporatization to meet the R&D challenges required by the commercial world. With this restructuring, research organizations are expected to be better equipped to provide R&D services to the private sector and assist selected industries to undertake innovations as well as new product and process development.

13.10 In order to create a more conducive environment for private sector product innovation, the Government undertook measures to encourage greater involvement of industry in R&D activities. These included the provision of fiscal incentives, and infrastructure such as the TPM and KHTP, as well as promotion of collaborative efforts among the private sector, universities and research

institutions. The Malaysian Technology Development Corporation (MTDC) and Malaysian Industry–Government Group for High Technology (MIGHT), established to assist in public–private sector cooperation in industrial development, embarked on a number of proposals to initiate wider usage of emerging technologies. This was with the view to building competitiveness in industries such as telecommunications, automobiles, pharmaceuticals, healthcare and construction. The Working Committee on S&T under the auspices of the Malaysian Business Council (MBC) arranged a number of dialogues between the public and private sectors on the formulation of strategies for technological upgrading.

National R&D Expenditure

13.11 The findings of a R&D expenditure survey[1], conducted by the Government, indicated that a total of RM552 million was spent on research and development in 1992. This indicated that Malaysia's R&D efforts, as measured by R&D expenditure as a proportion to GNP was 0.4 per cent. This is considered low since at least one per cent of GNP is usually the accepted level at which R&D can begin to effectively support socio-economic development in a country. Generally, this reflected the need to increase national R&D expenditure in order to accelerate the building up of domestic R&D and technological capability in the country.

13.12 Notwithstanding the low level of R&D expenditure, it is recognized that expenditure on formal R&D cannot by itself be a measure of a country's capability to utilize technology for growth and development. It is significant to note that the country's high economic growth has been supported by other developments that have high technological content. This includes investment, infrastructure development and increases in labour and capital utilization, as well as total factor productivity (TFP). The TFP measures the residual contribution to growth, apart from contribution of labour and capital, and includes technical progress, management expertise, skills and entrepreneurship. Thus, the TFP contains significant elements of technology absorption and utilization. Of the 8.7 per cent growth in GDP during the period, the TFP contributed 2.5 per cent or 28.7 per cent of the expansion.

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[1] The survey, the first of its kind in the country, was undertaken with the aim to gauge the general level of national R&D expenditure.

13.13 Generally, increases in TFP growth are associated with increases in investment. In this regard, the substantial increase in investment, particularly foreign direct investment (FDI), has been the vehicle by which new technologies entered the production process. Sustained investment growth over the years had led to more rapid acquisition, absorption and diffusion of technology and innovation in the country. This was reflected in a recent study on Malaysia's competitiveness, in which the country ranked high in the level of investment and capacity to disseminate, absorb and utilize imported technology. However, the development and use of locally generated technologies in the production process, still lagged behind indicating the country's need to increase indigenous capability in developing new and improved technologies for industry.

13.14 Nonetheless, recognizing that formal R&D expenditure is an important performance indicator, the national 1992 R&D survey was undertaken to gauge the size and scope of research activities in the country. The survey showed that the public sector accounted for 55 per cent of R&D expenditure, and the private sector, 45 per cent. In terms of types of research, about half of the total expenditure was devoted mainly to applied research, and 38 per cent for developmental research. Strategic research accounted for 9.0 per cent, and pure basic research about 4.0 per cent of expenditure. From an economic perspective, general R&D efforts were concentrated in plant production, primary products, and animal production, followed by manufacturing. Public sector R&D had a strong focus in plant and animal production, with increasing research activities in information technology, computers and communications. Private sector R&D, on the other hand, was concentrated in the manufacturing area, particularly electronics and computer hardware, transportation and machinery, communications, as well as processed food products and beverages.

13.15 Of particular significance was the more than three-fold increase in private sector investment in R&D since the end of the Fifth Plan period. The private sector reported a total expenditure of RM246.4 million. Of this, RM67.8 million was spent on research personnel, RM57.6 million on other operating expenses and RM121 million on land, buildings and equipment. With nearly half of the total expenditure attributed to capital formation, this indicated the likelihood of an expansion of future R&D activities and industrial technology capability in the private sector. The survey, however, highlighted that most of the private sector expenditure on R&D was undertaken by foreign entities and the domestic component was still not significant.

13.16 The relatively higher R&D expenditure by industry reflected the favourable response of the private sector to incentives provided by the Government.

Incentive schemes included double deduction of expenditure incurred for R&D, five-year tax exemption for R&D companies, reduced import duties for research equipment, and investment tax allowance of up to 100 per cent of qualifying R&D related capital expenditure.

13.17 The small- and medium-scale industries (SMIs), generally dominated by domestic investors, continued to be plagued with problems such as low technology and poor production techniques and processes. Improvements were largely geared towards marginal adaptations to meet local needs while original design and development of new products were limited. This highlighted the need to strengthen domestic innovation, design and engineering capabilities.

Intensification of Research in Priority Areas

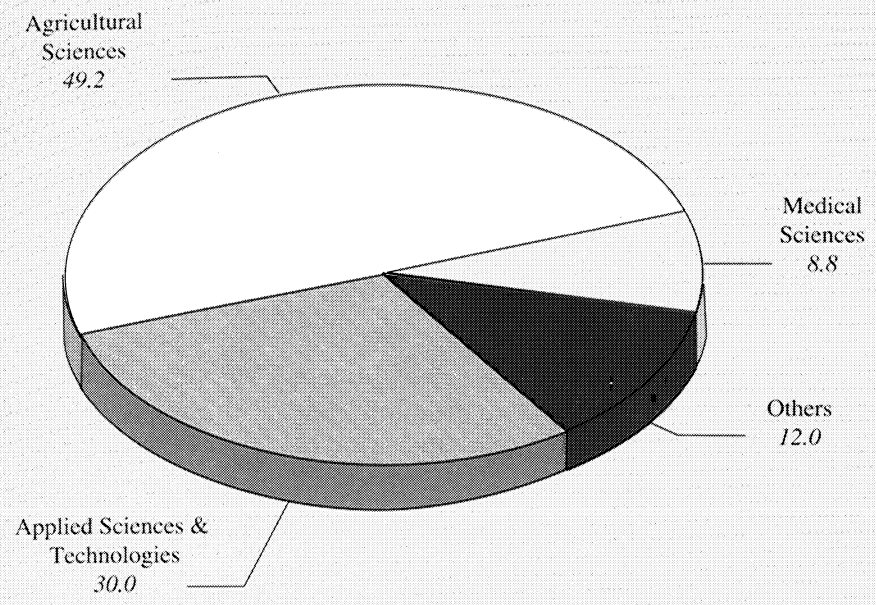
13.18 During the Sixth Plan period, the budgetary allocation for direct R&D in the public sector was RM629 million. This allocation covered R&D activities utilizing the IRPA funds and excluded related capital and operating expenditures. As shown in *Table 13-4*, a total of RM567.1 million or 90 per cent of the allocation was spent in major fields of research. Of the total expenditure, 49.2 per cent was in agricultural sciences, 30 per cent in applied sciences and technologies and 8.8 per cent in the medical sciences, as shown in *Chart 13-1*. The continuous predominance of research in agriculture, while reflecting the country's superiority in agricultural R&D, especially with regard to perennial crops, indicated the need to redirect resources towards downstream industrial R&D in order to generate potentially higher value-added commercial activities.

13.19 As a follow-up, an assessment[2] of the benefits and effectiveness of research funded under the IRPA programme was carried out, especially within the context of its contribution to income-generating activities. Findings of the evaluation showed significant improvements in the quality of technical outputs, covering developmental and applied areas, generating new knowledge, methods, techniques and applications at increasing efficiency and productivity. About 40 per cent of the projects generated technical results that gained national and international acclaim as these were considered major technical contributions generated by S&T activities. These new and improved S&T applications indicated the potential expansion of future downstream research activities for end-use product and process development. In addition, R&D in basic sciences augmented the build up of fundamental strengths required by research agencies and universities to handle core technologies such as biotechnology, advanced materials and microelectronics.

[2] The assessment covered a sample of 200 projects which represented about 10 per cent of total IRPA projects, 15 per cent of allocation and 14 institutions.

CHART 13-1

IRPA EXPENDITURE BY MAJOR FIELDS OF RESEARCH, 1991-95
(%)



Total: RM567.1 million

13.20 Notwithstanding the substantial technical progress achieved, the evaluation confirmed observations made of local R&D that it is generally not market-oriented. The IRPA projects were not always economically relevant and thus not exploited for commercial application. Of the 200 projects assessed, about a quarter had the potential to generate near-market product or process development outputs. Research outputs likely to have a significant business impact, as indicated by patents granted or pending, comprised 7.0 per cent of the total number of projects assessed. Linkages with industry were essentially informal, and joint or collaborative R&D was still negligible, thus reflecting the need to coordinate closely with the private sector to generate more R&D projects with commercial potential.

13.21 In preparation for the Seventh Plan, the IRPA mechanism was reviewed and improved upon. This was with a view to putting in place a more effective system for the utilization of resources directed particularly at increasing market-oriented R&D and technology development activities.

Technology Inflows

13.22 While the primary concern was to build and develop a stronger indigenous technological base, the transfer of technology from abroad continued to be important. During the Sixth Plan period, in line with the expanding investment in high value-added capital and technology-intensive industries, there was a concurrent rise in technology imports. The changing industrial structure had an influence on the growing demand for a wide range of technologies from abroad, particularly those used in new growth areas such as the automobile, oil and gas and aerospace industries. Even in the traditional electrical and electronic product category, demand was for high-order technologies required for intensive process and systems development.

13.23 The inflow of technology as indicated by the number of contractual agreements approved by the Government during the Sixth Plan, is shown in *Tables 13-1* and *13-2*. However, this indicator is reflective of only those agreements required under the Industrial Coordination Act (ICA), 1975, or the Promotion of Investment Act (PIA), 1986, or when specifically required under any Foreign Investment Committee (FIC) rulings.

13.24 Payment for technology acquisition from abroad registered a growth of 34 per cent during the period 1991-95, from about RM240 million in 1990 to an estimated RM1.0 billion in 1995, compared with 24 per cent during the Fifth Plan. These were royalties and fees mainly for procurement of franchises, use of international brand names and payment of licences for utilization of new and improved technology. The various payments, which are reflected as outflows in the services account of the balance of payments, indicated the relative importance of sourcing of technology from overseas. These royalties and fees, however, did not cover imports of technology embedded in machinery and equipment, as well as contract and professional charges by foreign personnel.

Standardization and Quality Assurance

13.25 In line with the national strategy to sustain and enhance the competitiveness of exports, the Government undertook measures to intensify the provision of technical services by relevant public sector agencies to assist the private sector in ensuring the quality of Malaysian goods and services for the international market. Due to the increasing demand for quality assurance schemes by major

TABLE 13-1

TECHNOLOGY INFLOWS BY INDUSTRY GROUP, 1990-95
(number)

Industry Group	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*6MP*
Electrical & Electronic Products	41	45	38	69	44	25	221
Chemical & Chemical Products (including Pharmaceutical)	24	21	19	20	12	17	89
Transport Equipment	18	16	28	25	21	9	99
Fabricated Metal Products	4	13	6	11	4	4	38
Food Manufacturing	4	6	2	11	2	2	23
Rubber & Rubber Products	8	10	8	5	4	3	30
Non-metallic Mineral Products	7	7	12	5	8	1	33
Basic Metal Products	4	7	2	5	4	0	18
Textiles & Wearing Apparel	7	6	7	3	1	1	18
Hotel & Tourist Complexes	3	8	1	5	0	0	14
Plastic & Plastic Products	5	6	6	11	3	6	32
Wood & Wood Products (including Furniture)	6	5	0	4	0	1	10
Paper & Paper Products, Printing & Publishing	4	4	2	3	1	4	14
Manufacture of Machinery	6	6	5	2	2	4	19
Beverages & Tobacco	10	3	1	4	2	1	11
Petroleum & Coal	0	0	1	1	19	1	22
Leather & Leather Goods	1	0	1	1	0	0	2
Miscellaneous	3	2	1	0	1	0	4
Total	**155**	**165**	**140**	**185**	**128**	**79**	**697**

Note: The total number of technology transfer agreements in specific years depends on the number of approved manufacturing licences, expected project implementation, as well as timing of submission and approval of the agreements.

TABLE 13-2

TECHNOLOGY INFLOWS BY TYPE OF AGREEMENT, 1990-95
(number)

Type of Agreement	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*6MP*
Joint Venture	15	11	7	7	3	3	31
Technical Assistance	72	93	80	85	55	36	349
Licences & Patents	17	28	14	44	32	20	138
Knowhow	12	10	21	23	11	4	69
Trade Mark	19	9	12	14	4	2	41
Management	5	6	2	2	1	1	12
Turnkey & Engineering	1	1	0	1	6	1	9
Services	6	4	4	9	5	5	27
Sales, Marketing/Distribution	5	0	0	0	0	1	1
Supply & Purchase	2	0	0	0	0	0	0
Others	1	3	0	0	11	6	20
Total	**155**	**165**	**140**	**185**	**128**	**79**	**697**

trading partners, local companies were encouraged to adopt and implement internationally accepted quality management systems. During the Sixth Plan period, more than 700 companies were successfully certified for ISO 9000 series of standards. In order to ensure international credibility of registration activities, the Malaysian Accreditation Council (MAC) was established to provide a system of recognition to bodies operating quality system registration and laboratory accreditation in Malaysia. The Government also took steps to facilitate participation in international standardization activities. In this regard, Malaysia became the secretariat to the Technical Committee on Rubber and Rubber Products and a participating member in a number of other technical committees of importance to the country.

S&T Manpower

13.26 Despite efforts in the development of high level and specialized skills, particularly scientific and technological manpower, disparities still continued to exist between the type and number of manpower produced and that required by the nation. In particular, the expansion in R&D manpower, a crucial element in our effort towards technological advancement, did not keep pace with the increasing demand for highly trained, knowledge-based scientific, engineering and technical personnel.

13.27 An analysis of the output of graduates from local public tertiary institutions for the period 1985-95, revealed the continued predominance of arts in comparison with science and technical graduates, as shown in *Table 13-3*. Arts graduates during the Fifth and Sixth Plan periods made up the majority of graduates, that is, 53 per cent and 62 per cent, respectively. In comparison, science graduates accounted for 33 per cent and 25 per cent for the two Plan periods, respectively, indicating a decline in the share of total output, over the ten-year period. The output of technical graduates, on the other hand, remained at about 14 per cent for both periods. This means that by the end of the Sixth Plan period, local public institutions produced many more arts graduates compared with science and technical graduates, a trend that does not augur well for the establishment of a strong technological base.

13.28 The relatively lower share of output of science graduates, though supplemented by Malaysians trained overseas, had affected the number of qualified personnel available for R&D activities. The current number of full and part-time researchers and scientists is estimated to be at 8,300. This gives a ratio of 400 per million population which is considered low compared with the ratios ranging from 1,000 per million to 1,500 per million population found in some Newly Industrializing Economies (NIEs), when they were at Malaysia's current level of economic development. The total number of support staff including sub-professionals and technicians was estimated at 12,450. The public sector represented the largest source of R&D manpower in the country, a substantial portion of whom were engaged in applied or developmental research. The proportion of R&D personnel in market-oriented research, however, was limited, thus the consequent low impact of R&D on industry. The pool of R&D personnel in the private sector was too small to stimulate significant indigenous market-driven research.

TABLE 13-3

OUTPUT OF DEGREE COURSES[1], 1986-2000
(number)

Course	5MP		6MP		7MP[2]	
	Number	*%*	*Number*	*%*	*Number*	*%*
Arts & Humanities including Economics, Business & Law	27,780	*53*	49,018	*62*	82,123	*57*
Science including Medicine, Agricultural Sciences, Pure Sciences & Others	17,510	*33*	19,642	*25*	40,077	*28*
Technical, Engineering, Architecture, Surveying & Others	7,550	*14*	10,508	*13*	21,953	*15*
Total	**52,840**	***100***	**79,168**	***100***	**144,153**	***100***

Notes:

[1] Output for First Degree, Masters, Ph.D. and post-degree diploma

[2] Estimate

13.29 In view of the need to expand the R&D human resource base, the Government reviewed the training programmes for public sector R&D personnel. Apart from strengthening the existing programmes, the Industrial Technology Development and Management Programme was launched to provide advanced training to R&D personnel from a number of research agencies and universities. This programme increased opportunities for post-graduate and post-doctoral training, especially in areas of new technologies and industrial research. Besides increasing the number of scholarships at the degree level in R&D priority areas, specific training in specialized technical areas was also made available. The programme trained a total of 1,617 personnel from 17 research institutions and universities, at both degree and non-degree levels. Research institutes and universities also used financial resources under the programme to employ short-term S&T experts and consultants from overseas to provide in-house training to their personnel.

13.30 In 1994, the Government initiated a programme to bring back Malaysian scientists and engineers working overseas as well as allow local research institutions and universities to employ foreign R&D personnel, where necessary.

The purpose of this programme is to fill the gaps for specific expertise required by public research institutions, universities and the private sector, with the aim to accelerate the rate of technology transfer and upgrade indigenous R&D capabilities. However, at this juncture, it is premature to evaluate the impact and potential contribution of the programme.

Commercialization of Research and Technology

13.31 While public sector R&D activities contributed significantly to technical improvements, the progress on the commercialization of such output was limited. This was largely attributed to problems related to lack of industry-relevant R&D projects and finance to fund the various stages of commercialization from the laboratory to the market place. To date, from the RM1 billion allocated under the IRPA mechanism during the Fifth and Sixth Malaysia Plans, a total of 2,000 R&D projects was completed. Of this, about 240 projects were identified as potential candidates for commercialization.

13.32 The R&D projects for potential commercial exploitation were at various stages of implementation. Research institutes such as the Malaysian Agriculture Research and Development Institute (MARDI), Malaysian Institute for Nuclear Technology Research (MINT), Palm Oil Research Institute of Malaysia (PORIM), Rubber Research Institute of Malaysia (RRIM), and SIRIM as well as the universities had more than 150 projects under investigation, while another 55 were in the advanced stage of being commercialized. The MTDC received more than 100 proposals for potential commercialization from public sector research agencies. Of these, 18 were successfully commercialized and the rest are under further scrutiny. Apart from this, the MTDC invested in 28 technology-based companies with a total investment of RM54.6 million, in the areas of advanced manufacturing, biotechnology, electronics, information technology and precision manufacturing. MIGHT initiated activities to promote public-private sector collaboration in new technologies with potential business and investment opportunities, especially in the telecommunications, advanced materials and aerospace industries.

S&T Awareness, Promotion and Popularization

13.33 Activities aimed at promoting greater interest, awareness and understanding of S&T, and its role in national development were organized at various levels throughout the Sixth Plan period. These activities for scientists, students and

members of the public included scientific conferences and exhibitions, S&T excellence achievement awards, educational visits and workshops, and environmental programmes. As part of the promotional activities, students were encouraged to participate actively in science essay competitions, science fiction writings, science quizzes, inventor competitions as well as computer software and graphic development activities. The media, largely television and newspapers, provided reasonable S&T coverage considering the time and space available. The National Planetarium, opened to the public in 1994, provided innovative ways of appreciating the sciences. The new National Science Centre (NSC), now in the final stages of its development, incorporated elaborate theme based hands-on exhibits and events in order to popularize and promote S&T, especially among school children. A number of these exhibits were sponsored by private companies.

13.34 The National S&T Awareness Survey 1994, was a first attempt to gauge the level of S&T awareness among Malaysians as well as the impact of S&T promotional activities undertaken by various organizations in the country. The survey showed that there was generally a high level of interest in S&T among the general public, adolescents between the ages of 15 to 20 years and children aged 12 to 14 years. Malaysians recognized the critical contribution of S&T towards growth and development of the economy, and especially in the achievement of the goals of Vision 2020. However, in terms of career preference, a career in business and economics featured relatively high on the list of all students in general. The survey provided a useful basis for planning school curriculum and instituting measures to encourage greater student interest in S&T through special incentive schemes. This will be with a view to formulating more effective strategies to promote S&T as a career choice of the future and, more importantly, to increase the pool of S&T personnel in the country. In addition, the survey indicated that the media, NSC and the National Planetarium should be used more extensively as important channels for raising the general S&T interest and awareness levels.

III. PROSPECTS, 1996-2000

13.35 It is recognized that Malaysia must keep abreast with rapid advances in new technologies and move into intensive application of the emerging new generation of technologies in order to promote innovation-oriented industries and services, as they are the growth areas of the future. In line with this, the Government will continue to place high priority on innovation-driven and technology-led industrial development. The goal is to contribute much more to

long-term sustainable growth, development and competitiveness of the economy. The primary source of technology will continue to be foreign enterprises, which will serve as a base to enhance Malaysia's participation in high level technology-intensive industrial activities and services.

The Thrust for S&T Development

13.36 The thrust for S&T development under the Seventh Plan will be to meet the objectives of productivity-driven growth and competitiveness. The development of Malaysia in the long-term, *inter alia*, will depend on the increased use of technology, knowledge and skills to enhance industrial competence and productivity, as well as improve standards of living. Greater emphasis will be placed on increasing indigenous innovation capability, and accelerating the strategic development of industrial technology. The focus will be to provide an enabling environment for technology development, with greater complementarity and proper balance between the supply and demand side initiatives for technology upgrading. Emphasis will, therefore, be given not only to the enhancing of technology infrastructure but also to the strengthening of demand for, and capacity to use, technology at the firm level. This will be done mainly through:-

- *implementing appropriate policy and institutional reforms to strengthen the S&T planning and management system;*
- *optimizing the utilization of skills and capital by promoting adaptation and application of new and improved technologies, undertaking more commercially-oriented R&D and increasing capability to innovate, design and market domestic technologies;*
- *increasing investments in R&D as well as scientific and technological education and training with a view to developing a critical mass of scientists, engineers and researchers, fostering creativity and innovativeness in the young, and raising the general S&T interest and awareness levels;*
- *building domestic technological capability in new enabling technologies that will yield higher economic returns. Among others, this will include enhancing the practice of technology management and the preparation of a national technology map to identify long-term technology development targets;*
- *fostering stronger cooperation in R&D and technology development amongst and between industry, universities and research institutes;*

- *promoting greater private sector participation in the acquisition, development and transfer of new and specialized technologies;*
- *providing an enabling environment for MNCs and local conglomerates to invest, expand and diversify into new high-technology industries with greater local content and linkages;*
- *undertaking special programmes to augment technological capability among the SMIs;*
- *providing strategic linkages and joint ventures through international cooperation in S&T; and*
- *nurturing domestic innovations and inventions in the context of the changing international environment for technology transfer.*

13.37 In order to build upon present growth trends and productivity gains in the economy, a critical thrust will be to focus upon improvements in the TFP. Concurrent and complementary developments must take place in the various sources of TFP in order for it to have a spread effect on the economy as a whole, and in particular, industry. This implies that the public and private sectors must find ways to optimize the utilization of the potential of labour and capital by improving the quality of capital, workforce and work systems. Thus, issues pertaining to education and training, technical progress, entrepreneurship development, application of new and improved technologies, more commercially-oriented R&D and increased capability to innovate, will be important areas to focus upon.

13.38 The efficiency and applicability of R&D will be increased by reorientating such activities towards economic needs. In this regard, increased efforts will be made to sensitize public sector R&D to meeting market needs and generating economic spin-offs. While basic research will continue to be supported, greater emphasis will be accorded to ensuring more effective and productive utilization of resources earmarked for R&D activities. This will also include the promotion of co-financing and joint public-private sector cooperation in the commercialization of research results as well as technology upgrading and development. For this purpose, appropriate policy and institutional reforms at strengthening S&T planning and management will be undertaken. Apart from this, business and consultancy units within research institutions and universities will be restructured to take on a commercial stance and promote their R&D services, particularly to the private sector.

13.39 In line with the anticipated demand for scientific and technological manpower during the Seventh Plan period and beyond, a long range scientific and technological human resource development policy to enhance technology capability will be formulated. This is to ensure availability of a critical mass of higher level S&T related manpower needed by industry, especially to master core technologies in order to get a clear competitive edge, to undertake and sustain industrial R&D as well as generate indigenous technology.

13.40 In order to ensure sustained and competitive industrial technology development, the private sector must assume a more significant role in technology acquisition, transfer and commercialization. In line with this, industry will be encouraged to specialize in new and promising technologies in the form of niche strategies. This is part of the move towards the establishment of technologically-sophisticated industries producing better quality and competitive products to meet new demands. Domestic firms, particularly the larger enterprises, will be encouraged to set up their own R&D and innovation systems.

13.41 The scope of technology development will encompass the strategy to exploit more fully the competence-building potential of international technology transfer. In this regard, the larger local firms are expected to play a significant role. By importing the requisite technology, they are potential vehicles for building indigenous R&D capabilities and undertaking higher risk projects. This role is expected to be boosted by a system of improved incentives and risk-sharing ventures in key technologies.

13.42 For the medium- and long-term, the strategic focus will be on building up a strong competence in growth-generating technologies, especially in the field of advanced materials, IT and microelectronics, advanced manufacturing technology, biotechnology, as well as energy and environmental-related technologies. These targeted technologies are expected to spawn new growth areas in industry. In this regard, it will be important to develop centres of excellence, with sufficient resources to undertake future R&D activities in these advanced technology areas.

13.43 Priority will be accorded to extending financial and technical assistance to existing SMIs and, more importantly, to promote the growth of new technology-based start-up companies. Technical services provided by various government agencies to enhance the performance of SMIs in the economy, will be further expanded and strengthened.

Programmes

R&D in Priority Areas

13.44 The country will support R&D and technology that will promote growth, enhance industrial efficiency, productivity and competitiveness, generate home-grown technology with own brands of goods and services and improve quality of life. Within this context, the recently redesigned IRPA mechanism will ensure that national R&D resources are invested in areas that can reap the most benefits. This will be effected through better coordination, as well as more stringent assessment and selection of R&D activities. A prominent feature will be the management of the IRPA funding by a single entity to ensure optimum utilization of research resources. Another new component will be the establishment of an efficient mechanism to monitor the performance of on-going projects, as well as appraise and formulate new projects for the future.

13.45 In the allocation and utilization of resources for R&D, a new evaluation process will be introduced whereby research agencies and universities are subject to a competitive bidding process. Research institutions and universities will be allowed to bid for funding of projects that cut across socio-economic objectives and major fields of research. This is essentially aimed at allocating funds to the best proposals and reducing excessive overlaps and duplication of research activities and wastage of resources. In the process of evaluating and selecting research project proposals, greater emphasis will be placed on ensuring, where possible, that the potential output of the project will be required by specific clients, whether Government or industry.

13.46 A national approach towards accelerating the development of strategic technologies will be adopted in view of the high risks and high costs associated with investments in such areas. Specific research institutions, singly or jointly with industry partners, will be provided with resources to develop targeted areas of industrial technology to promote specific sectors such as microelectronics, advanced materials and aerospace. Priority will also be accorded to the development of innovative, but simple and practical, technologies that will contribute towards improving the quality of life of Malaysians taking into account, among others, the lifestyles of the local population and the environmental and climatic conditions. The development of such national R&D projects will involve multi-disciplinary and multi-institutional research teams, including participation from the private sector.

13.47 In order to enhance R&D and technology development, international cooperation in selected S&T areas will be further strengthened. Cooperation arrangements will be expanded to increase exchange of technological information, as well as joint development of industrial technology and training in specific areas of S&T. This will include mutually beneficial activities such as exchange of technical information on fundamental and applied research, as well as exchange of researchers and scientists in specific technologies.

Strategic Technologies and Emerging Industries

13.48 In order to support the implementation of the technology-based industrial strategies, several advanced technologies are being promoted. Development in these areas, both domestically and internationally, are expected to create new investment opportunities for the economy as a whole, and in particular industry. The core technologies, *inter alia*, are as follows:

a. information technology and communications
   - high performance computing
   - networking
   - communications
   - digital imaging
   - multimedia
   - high definition display
   - high density storage
   - software
   - simulation and modelling

b. microelectronics
   - sensor technology
   - semiconductor materials and microelectronics circuits
   - optoelectronics
   - avionics
   - advanced semiconductor devices

c. biotechnology and life sciences
   - biotechnology materials and processes
   - medical devices and diagnostics
   - medical technology

d. advanced manufacturing technology
   - flexible computer integrated manufacturing
   - machine intelligence and robotics
   - micro and nano fabrication
   - systems management technology

e. advanced materials
   - composites
   - ceramics
   - semiconductor materials, microelectronics circuits and photonic materials
   - materials synthesis and processing
   - superconductors
   - high performance metals and alloy

f. environment and energy-related
   - green materials
   - agro-based waste
   - renewable energy
   - portable energy
   - pollution minimization, remediations and waste management

These advanced technologies will have a significant impact not only on new industries but also on established industries, where production processes and demand patterns are expected to alter radically.

13.49 In identifying these broad-based technologies for development, the aim is to develop competence in a selected number of areas to enable industries to upgrade by fully exploiting the latest advances in technology. Towards this end, a more detailed technology development strategy will be formulated. As an initial step, a national competency mapping study will be undertaken to, among others, reexamine and identify technology needs of the country in the context of the nation's development policy, and provide specific strategies for the future expansion of selected technology areas.

13.50 As part of the long term technology-based industrial strategy, Malaysia has begun to move into some of the abovementioned areas. However, it will be necessary to accelerate the process of building up the development pre-requisites especially in terms of adequate S&T infrastructure, related manpower and domestic R&D. In its efforts to upgrade its technological capabilities, Malaysia will continue to rely, to a large extent, on multinational companies which have vast global networks in research and technology-based projects, including modern manufacturing plants, systems and related services. This will provide the impetus and inputs as well as expertise to the learning process by domestic industry.

13.51 To promote the development of these high-technology content industries, a number of measures will be implemented to attract investment and other resources to these areas. The Government will finetune the package of incentives and assistance currently available for high-technology industries. Among others, risk-sharing investment projects between Government and industry will be promoted in order to reduce the high risks associated with such ventures. Special efforts will be made to identify opportunities to assist the private sector to establish smart partnerships and strategic alliances overseas to enable local industry to gain access to new technologies, services and markets, and be cost competitive in a global environment. In addition, the Government will review current mechanisms for the acquisition, dissemination and transfer of technology with a view to strengthening these mechanisms, thereby fostering the development of higher technology and value-added activities.

Commercialization of Research and Technology

13.52 As part of the efforts to accelerate technology development in the country, the Government will mount a comprehensive strategy for the commercialization of indigenous R&D. Concerted efforts will be taken to develop and commercially exploit the large pool of untapped research findings in public sector research agencies and universities. This is with the view to ensuring that Malaysia can reap the full commercial benefits of local research, consequently creating new investment opportunities.

13.53 For this purpose, at the institutional level the organizational, legal and administrative framework will be revamped. Among others, the commercial and investment units of research institutes and universities will be restructured, and gradually corporatized. It is appropriate at this juncture for research agencies and universities to play a major role in identifying and marketing intellectual property with commercial potential, and proposing new ways of sharing intellectual

property rights with inventors and researchers. In order to attract more people into research activities, added incentives will be promoted to ensure that R&D personnel, especially those who contribute to successful commercialized ventures, are appropriately rewarded, including offer of share options in subsidiaries of corporatized research institutes or companies they serve.

13.54 At the national level, a mechanism for effective coordination and management of R&D commercialization activities will be established. In this regard, the MTDC has been identified to undertake this role. The private sector will be encouraged to participate in such activities through joint ventures and establishment of collaborative R&D programmes with research agencies.

13.55 Technical assistance and financial resources are often required at many stages of the commercialization process in view of the associated high risks and long gestation period. For this purpose, a special fund will be established to finance, in particular, the market phase of the commercialization process. This fund is expected to assist the MTDC and business units in universities and research institutes to intensify the development and marketing of local technologies.

Strategies for Private Sector Investment in R&D

13.56 Technology efforts by the private sector will continue to be supported by the Government in several ways. Greater private sector R&D will be directly promoted through a number of incentives, the provision of infrastructure and other forms of assistance. Incentives will be expanded to cover new areas such as acquisition of technology, commercialization of research results from local agencies, transfer of technology, and development of human capital related to research.

13.57 In addition to fiscal incentives, the Government will consider direct financial grants and long-term low interest loans to enterprises that participate in development and commercial applications of new technologies, especially in strategic industries. The larger enterprises are expected to play a major role in working towards the development of high-technology content industries which can produce own brands of internationally competitive goods and services. It is anticipated that the bigger corporations will, among others, contribute significantly to the advancement of industrial technology capabilities in areas such as precision engineering, advanced manufacturing knowhow, process-product interfacing and product design. The SMIs, which have different technical needs from the large conglomerates, are expected to be further assisted by

special technology development programmes. For this purpose, an initial budget of RM100 million will be allocated, and priority accorded to the build up of local technology capability through technology absorption, modification and adaptation, particularly in the development of improved as well as innovative products, processes and services.

13.58 In order to propagate the expansion of technology-based enterprises, the Government will continue to provide direct equity financing to, and nurture, early stage technology projects as they evolve through the various stages of technology innovation from incubation and commercialization, to market entry and expansion. Apart from this, the Government will consider the setting up of a third securities board to provide for the listing of technology-oriented companies seeking to source investible funds. In addition, technology-based private sector companies will be encouraged to forge linkages with overseas investors in specific areas such as telecommunications, aerospace and pharmaceuticals as well as medical and chemical products. These are areas which can create specialized usages in a wide range of industries and as such provide immense investment opportunities.

13.59 The Government will continue to invest in a large way in technology infrastructure to support the development of industrial technological capabilities. The expansion of TPM will provide facilities not only for small technology start-up companies but also for large enterprises undertaking product development and manufacturing process engineering. The TPM will house major public sector research institutes such as MIMOS, and the National Measurement Centre. The KHTP in Kedah, Composite Technology City, Melaka as well as the Subang Industrial Aerospace Park and Avionics Park, in Selangor, will play an important role in building the country's high technology base. These parks are expected to house corporate, academic and Government tenants specializing in R&D activities related to electronics, telecommunications, new materials and biotechnology. This approach will create the requisite synergy among industry, universities and the public sector in upgrading and augmenting technology capability. The proposed Techno-Centre within KHTP is anticipated to provide specialized R&D support services such as information exchange and networking, training and technical consultancies, as well as linkages with major international high-technology hubs. In addition, the Natural Resource Park in Sarawak and the Science Parks in Pulau Pinang and Johor are expected to generate extensive innovation and R&D activities, particularly in the fields of plant biotechnology, microelectronics and communications, respectively. The private sector will also be encouraged to set up business parks that focus on R&D activities.

13.60 Increased efforts will be undertaken to strengthen and institutionalize the currently informal R&D collaboration among universities, research agencies and industry. The gradual institutionalization of the contract research system within research agencies and universities as well as the partial or total corporatization of selected research institutes will facilitate greater utilization of their R&D services by the private sector. These developments will provide for greater synergy and linkage between industrial demand for technology and more advanced R&D, and contribute towards research syndication among the public and private sectors.

S&T Manpower

13.61 An area of major concern in S&T manpower development will be to ensure that expansion and improvements in education and training will effectively increase technological capabilities in strategic areas. In this respect, allocations amounting to more than RM1.6 billion will be made to universities and institutes of higher learning to produce the type of high-level S&T manpower required by the economy, especially for R&D, and technology management and development activities. Emphasis will be given to ensure adequate output of graduates in science and engineering fields which is anticipated to expand by more than two-fold during the Seventh Plan period, as shown in *Table 13-3*. The supply of S&T manpower is expected to be supplemented by increases of local science and engineering graduates trained abroad, as well as the employment of foreign scientists, technologists and researchers, where relevant.

13.62 Given the need to build up technological capability, greater emphasis will be placed on the teaching and learning of basic sciences and the provision of technical-oriented instruction at the primary, secondary and tertiary levels of education. Improvements and adjustments to the requisite curricula will be made to keep abreast with the expansion of knowledge, knowhow and applications especially in the mathematical, scientific and technological fields. Increased resources, in terms of manpower and improved facilities, will be made available to schools and institutions of higher learning to strengthen the teaching and learning of science and related subjects.

13.63 In order to ensure that research institutes and universities continue to be an important source of technology experts and R&D specialists, existing education and training programmes such as in-service training, off-campus schemes and distance learning will be further strengthened. In addition, a new

S&T human resource fund, with an initial allocation of RM300 million, will be established to build up capability in targeted technologies on a continuous basis so as to augment efforts to improve industrial competitiveness and growth. The fund will provide scholarships particularly at the post-graduate and post-doctoral levels as well as fellowships for graduate research and advanced studies, both locally and abroad. In addition, on-the-job and in-house training, as well as formal training will be provided to high- and middle-level technical manpower to support R&D activities. These measures will form part of the efforts to make available the requisite S&T manpower, as well as increase the national target of R&D personnel to 1,000 per million population by the year 2000.

13.64 Notwithstanding the above measures, a long-term S&T manpower development strategy will be pursued to systematically enlarge the pool of technology-oriented manpower, and replace the loss of such manpower due to retirement and emigration. For this purpose, a study has been commissioned to, among others, undertake an assessment of the country's scientific and technological manpower needs and prepare a long-term S&T human resource development plan.

Improving Standardization and Quality Assurance

13.65 The rapid advancement in technology and consequent regulatory changes, in both the domestic and international economies, make it necessary for the country to continuously review and upgrade the standards and quality assurance infrastructure and services which include standards development, metrology and measurements, as well as testing and quality assurance. This will be with the aim to enhance domestic capability in meeting standardization requirements in traditional areas related to the protection of health and safety as well as keep abreast with new developments. The latter, in particular, includes new international regulations pertaining to large-scale electronic products manufacture, environmental management and labelling systems, and the development of standards for the services industry as well as domestic regulations catering for automotive safety and emission control. At the same time, expansion in international trade and reduction of trade barriers will make it necessary for the country to increase active participation in international standards and systems development activities in order to ensure, among others, that national needs are protected.

Intellectual Property Protection

13.66 As a result of the scope and intensity of the obligations contained in the Agreement on Trade-Related Intellectual Property Rights (TRIPs), globally there will be stronger application of provisions that relate to protection of key technology transfer instruments such as patents, trade marks, copyrights, technical knowhow and industrial designs. This has implications on the extent to which technology transfer from abroad can take place and, more importantly, the need to accelerate the development and commercialization of indigenous technology. In this regard, relevant agencies will continually monitor and study the changes in the international environment for technology transfer, with the aim to take early measures to lessen any adverse impact on the economy.

13.67 Special emphasis will be accorded to creating a favourable climate to nurture domestic innovations and inventions, and promote commercialization of potential technologies. R&D incentives, which are expected to be further improved, will provide for a more conducive environment to increase private sector spending on technological advancement. Another important aspect will be to expedite the implementation of an intellectual property policy and guidelines for universities and research institutions, as these agencies are major sources of potential technologies for industry. Other measures will include the establishment of public-private sector technology partnerships with the view to adopting and diffusing new technologies as well as providing venture capital for downstream commercialization and patenting activities.

13.68 The Government will continue to strengthen and expand the requisite infrastructure for the development and management of intellectual property rights. Increased efforts will be made to monitor changes on the international front, review existing intellectual property legislations, formulate new legislations and adopt appropriate judicial, administrative and enforcement measures. The major thrust will be to stimulate development of home-grown technologies and, where necessary, to fulfil commitments under the TRIPs Agreement.

Increasing S&T Awareness

13.69 In line with current momentum to promote technology-led development, S&T awareness activities will be further expanded and diversified. This will be with a view to increasing public understanding of the role and importance

of S&T in development as well as encouraging students to take up S&T related careers. Apart from public sector agencies, the mass media, non-governmental organizations, private companies and professional groups are expected to contribute substantially to these activities.

13.70 Aside from existing promotional activities, new programmes and projects initiated by the NSC and the National Planetarium are anticipated to play a significant role in enhancing interest in S&T. The NSC will contain the largest display of interactive exhibits in the country, where students and members of the public can acquire some hands-on knowledge on S&T related principles and concepts. It aims at making S&T more appealing to students of all ages and academic abilities. In addition, a number of galleries will contain technology-oriented exhibits to expose visitors to historical and new developments in areas such as aeronautics, computers and IT, automobiles, telecommunications, and oil and gas. These exhibits will also incorporate local discoveries and developments.

13.71 During the Seventh Plan period, the NSC and the National Planetarium will be involved in many new promotional programmes. These will also provide opportunities for private sector participation in exhibit development by way of innovating, designing and constructing exhibits connected with the formal education system. Some of the new activities will include mobile S&T exhibitions, design and production of interactive exhibits and exhibitions for schools and the general public, and science support services, such as science kits, especially for primary school pupils and teachers.

Coordination and Management of S&T Strategies and Programmes

13.72 As the country seeks to accelerate technological innovation to generate greater economic growth, productivity and competitiveness, the Government will place increasing emphasis on the coordination of S&T strategies and programmes. In this regard, the role of MPKSN will be enhanced in order to effect a more integrated approach towards S&T development. Better integration of S&T policies with economic and other policies will be essentially aimed at harmonizing activities across sectors and institutions, as well as synthesizing the needs of the academia, research agencies and the private sector.

IV. ALLOCATION

13.73 The Federal Government development allocation and estimated expenditure for the period 1991-95 and the allocation for the period 1996-2000, are as shown in *Table 13-4*. The Government will increase direct R&D funding to RM1 billion, while approximately RM2.0 billion will be provided for related infrastructure facilities and services. Increasing emphasis will be accorded to making R&D more relevant to industry by accelerating the institutionalization of a contract research system within research agencies and universities, thus ensuring greater utilization of research services by the industry. In order to get better returns on investment in R&D activities, a sizeable budgetary allocation will be for the commercialization of research output. In essence, priority will be given to S&T related projects that will build up competence in enabling technologies, in line with the need to adapt, modify and diffuse technology advances for economic development.

TABLE 13-4

DEVELOPMENT ALLOCATION FOR SCIENCE AND TECHNOLOGY, 1991-2000
(RM million)

Programme	*6MP*		*7MP*
	Allocation	*Expenditure*	*Allocation*
Direct R&D	629.0	567.1	1,000.0
Technology Development for SMIs	—	—	100.0
Technology Acquisition	—	—	100.0
Commercialization of Technology	—	—	100.0
S&T Infrastructure and Development	807.7	629.2	1,749.0
Total	**1,436.7**	**1,196.3**	**3,049.0**

V. CONCLUSION

13.74 During the Sixth Plan period, the S&T policy directions emphasized improvements related to the institutional and organizational infrastructure required to promote market-oriented R&D, and contribute to the development of capital and technology-intensive industries and services. For the Seventh Plan, the thrust of S&T will be to move rapidly from absorptive and assimilative to original design and more complex development work, as the country moves into more demanding high-technology areas, and access to new technologies becomes more difficult. In an increasingly competitive global environment, where technology has become the focus of new opportunities for investment and growth, the emphasis will be to fully exploit and utilize existing technologies, improve upon imported technologies, as well as generate indigenous technology.