The Utilisation, Dissemination and Commercialisation of Renewable Energy Systems in Pacific Rim Countries.

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The main objective of this study is to survey the market prospects of non-conventional power-generating and transforming equipment in the Pacific Rim, a region where most of the newly industrialised and oil producing countries are found. The Asia and Pacific region is pioneering the application of, and trade in, non-conventional energy equipment. Partly because they have been at the forefront of developing both the technology and the markets for the products under review, and partly because of their potential as producers, users, traders, the following countries have been selected for study: Indonesia, the Philippines, Thailand, and Malaysia.

The technologies covered are: solar photovoltaic systems, small hydropower, wind energy, solar thermal, and biomass (fuelwood/charcoal, biogas digesters, and biomass gasifiers). In implementing an analysis of this nature, a multi-disciplinary approach must be undertaken. Therefore, this thesis not only examines the technical aspects but the social, political, economic, and environmental consequences of the utilisation and dissemination of renewable energy systems.

In order to discover the role that renewable energy systems play in each country, the overall energy context must be understood. Too often energy systems analysis and planning is done in an insular fashion, with conventional energy usage and planning accomplished separately from non-conventional energy systems. In many of the countries studied non-conventional/renewable energy has been handled by an alternate agency, generally one in charge of rural development, and as such, renewable energy systems in the Pacific Rim have not fared as well as they could have. This thesis argues that renewable energy must be incorporated into mainstream energy systems planning if the full market potential is to be reached.
I hereby declare that this thesis is based on my own research work and has been composed by myself.
Acknowledgements

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Abbreviations and Acronyms

Unless otherwise specified, all references to dollars ($) are to United States Dollars and all references to tons are metric tons.

The following abbreviations are used:

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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>IBRD</td>
<td>International Bank for Reconstruction and Development also know as the World Bank</td>
</tr>
<tr>
<td>ADB</td>
<td>Asian Development Bank</td>
</tr>
<tr>
<td>API</td>
<td>American Petroleum Institute</td>
</tr>
<tr>
<td>ASEAN</td>
<td>Association of South East Asian Nations</td>
</tr>
<tr>
<td>cct-km</td>
<td>circuit kilometers</td>
</tr>
<tr>
<td>CdTe</td>
<td>Cadmium telluride</td>
</tr>
<tr>
<td>CEM</td>
<td>Center for Educational Museums, Thailand</td>
</tr>
<tr>
<td>DOEA</td>
<td>Department of Agriculture Extension, Thailand</td>
</tr>
<tr>
<td>ECCT</td>
<td>Energy Conservation Center of Thailand</td>
</tr>
<tr>
<td>EGAT</td>
<td>Electricity Generating Authority of Thailand</td>
</tr>
<tr>
<td>FY</td>
<td>Fiscal Year</td>
</tr>
<tr>
<td>GaAs</td>
<td>Gallium Arsenide</td>
</tr>
<tr>
<td>GTZ</td>
<td>Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) GmbH</td>
</tr>
<tr>
<td>InP</td>
<td>Indium Phosphate</td>
</tr>
<tr>
<td>ITB</td>
<td>Institute of Technology, Bandung, Indonesia</td>
</tr>
<tr>
<td>KONEBA</td>
<td>PT. Konservasi Energi Abadi, Jakarta</td>
</tr>
<tr>
<td>LNG</td>
<td>natural gas</td>
</tr>
<tr>
<td>LPG</td>
<td>Liquefied Petroleum Gas</td>
</tr>
<tr>
<td>MEA</td>
<td>Metropolitan Electricity Authority, Thailand</td>
</tr>
<tr>
<td>MERALCO</td>
<td>Manila Electric Company, The Philippines</td>
</tr>
<tr>
<td>MOC</td>
<td>Ministry of Cooperatives, Jakarta</td>
</tr>
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<td>NEA</td>
<td>National Electrification Administration,</td>
</tr>
<tr>
<td>NPC</td>
<td>National Power Corporation, The Philippines</td>
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<td>OECD</td>
<td>Organisation for Economic Co-Operation and Development</td>
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<td>OEA</td>
<td>Office of Energy Affairs, The Philippines</td>
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<td>PEA</td>
<td>Provincial Electricity Authority, Thailand</td>
</tr>
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<td>PLN</td>
<td>National Electricity Board, Jakarta, Indonesia</td>
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<tr>
<td>PV/pv</td>
<td>Photovoltaic</td>
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<td>SEB</td>
<td>Sabah Electricity Board, Malaysia</td>
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<tr>
<td>SESCO</td>
<td>Sarawak Electricity Supply Corporation, Malaysia</td>
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<td>TEN</td>
<td>National Electricity Board, Malaysia</td>
</tr>
<tr>
<td>TISTR</td>
<td>Thailand Institute of Scientific and Technological Research</td>
</tr>
<tr>
<td>USAID</td>
<td>U.S. Agency for International Development The Philippines</td>
</tr>
<tr>
<td>WEC</td>
<td>World Energy Council</td>
</tr>
</tbody>
</table>

kgoe          | kilogram of oil equivalent |
kw            | kilowatt |
kw_e          | kilowatt electric |
kWh           | kilowatt hour |
kw_p          | kilowatt peak |
mboe  million barrels of oil equivalent
mtoe  million tons of oil equivalent
MW    megawatt
toe   ton of oil equivalent

Average Exchange rates for 1990

<table>
<thead>
<tr>
<th>Currency</th>
<th>Description</th>
<th>1 US$ =</th>
</tr>
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<tbody>
<tr>
<td>B</td>
<td>Thai Baht</td>
<td>B 25</td>
</tr>
<tr>
<td>MYR</td>
<td>Malaysian Ringgit</td>
<td>MYR 2.70</td>
</tr>
<tr>
<td>P</td>
<td>Filipino Peso</td>
<td>P 25</td>
</tr>
<tr>
<td>Rp</td>
<td>Indonesian rupiah</td>
<td>Rp 1,855</td>
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Definition of Terms

Non-Conventional energy, renewable energy, and traditional energy, are at times used interchangeably in this thesis. Depending on the country, technologies such as solar and small hydro have been considered as conventional energy technologies. Water power has been used in Thailand for over a hundred years, and solar thermal applications pre-date that. However, photovoltaic systems still are not mainstream enough to be considered as conventional energy systems. Biomass, in the form of charcoal and fuelwood, would fall in the dual categories of renewable energy and traditional energy. But for the purpose of this thesis, all terms will be used interchangeably as solar, biomass, small hydro and wind are not generally included in energy balances (which to the author makes them non-conventional), and are continuous or repetitive currents of energy occurring in the natural environment (this deems them renewable), and have been used by man in one form or another since the beginning of time (hence, traditional).

Small Hydro, unless otherwise stated, is defined as less that 1 MW and includes micro and mini hydro.

Rational Use of energy is defined as any action aiming at a rational consumption of energy in the final uses (for example, industrial, domestic, and commercial).
Chapter 1  INTRODUCTION

It is estimated that the world's energy consumption will rise by 50-75% in the next thirty years, and in the same period global population will increase by around three billion to over 7.8 billion, of which 6 billion will live in the third world. In the Asia and Pacific Region, the population is projected to reach 3.3 billion by the year 2000 [APDC, 1990].

In 1987, oil continued to play the most important role amongst the various energy sources with a share of 37% of the global energy consumption. As a result of the dramatic increase in oil supply, oil consumption has increased since 1983. With a figure of 26%, coal is the next most important energy source, followed by natural gas with 17% [WEC, 1989].

Together these fossil fuels account for three-quarters of the world's energy consumption. By comparison, hydroelectric power provides only 6% of our energy needs, and nuclear power only 5% [WEC, 1989]. In the developing countries oil comprises over half the energy consumption. Most of the approximately 100 oil importing developing countries are dependent on oil imports in order to fulfil more than three-quarters of their energy needs. Biomass also plays an important role as an energy source in
developing countries. Fuels based on wood and agricultural waste provide 35% of the energy requirement [WEC, 1989; Hall, 1991]. The expected enormous increase in demand will primarily be met by even greater use of fossil fuels (coal and lignite, gas and oil) but there are areas where renewable energy can play an important role.

In the Asian and Pacific region (see Fig.1), South East Asia is, as a whole, an energy surplus region with a variety of energy resources (coal, gas, hydro, geothermal and solar). The region also appears to have the potential for finding more oil and gas sufficient to ensure its energy security, given proper management and conservation.

However, it is suggested that South East Asia, as well as other countries in the Asia and Pacific region will, in the near future, become increasingly exposed to the uncertainties of the world energy market. The central problem is the rapid growth of energy demand, estimated at 14% per year, due to population growth, industrialisation, urbanisation and increased motor vehicle ownership. Since it is unlikely that these countries can, in the short-term, significantly alter the growth of the demand for oil or find sufficient regional sources of oil or oil-substitutes, the energy needs will become increasingly dependent on extra-regional supplies and other alternative energy sources.
Figure 1: Map of Asia and the Pacific
A further problem is the need to identify clean sources of energy to minimise the hazardous effects on the environment due to energy consumption using non-renewable fossil fuels. As discussed by Fisher [1990, p.4] and Goldemberg [1988, p.10], primary sources of usable energy, such as fossil fuels, release heat through the exothermic reaction of atmospheric oxygen with the carbon and hydrogen of fuel. The consequent release of carbon dioxide is an essential environmental problem of burning fossil fuels. Other atmospheric pollutants released by hydrocarbon combustion include carbon monoxide, nitrogen oxides, particulate matter, (e.g., soot and fly ash), volatile organic compounds, radionuclides and methane as well as various toxic substances (e.g., lead, cadmium, polycyclic aromatics, and dioxin). Some of these pollutants are greenhouse gases [Grubb, 1991] like carbon dioxide, methane, nitrogen oxide. Others such as sulphur dioxide and nitrogen oxide are dominant in acid precipitation [Grubb, 1991].

Despite the uneven distribution of energy resources and energy consumption in the Asia and the Pacific region, commonality of interest can be found in the study of non-conventional energy, energy management and conservation. The biggest users of non-conventional energy resources are the large rural populations, particularly when it comes to non-commercial usage of biomass resources. Biomass resources are also consumed in rural industries, such as
bagasse in sugar mills, and rich husk in rice mills for cogeneration of heat and electricity. Improvement of utilisation efficiencies could lead to conservation of other energy resources.

1.1 Objectives

The main objective of this study is to identify the market prospects of non-conventional power-generating and transforming equipment in the Pacific Rim. In addition to reviewing renewable energy supply possibilities which would stimulate economic growth and development, this study seeks to identify the alternatives which would promote the rational use of energy, or energy savings.

Investigation has concentrated on Asia and the Pacific, where most of the newly industrialized and oil producing developing countries are found. This region is pioneering the application of, and trade in, non-conventional energy equipment. Partly because they have been at the forefront of some of the region's efforts to develop both the technology and the markets for the products under review, and partly because of their potential as producers, users, and traders, the following countries have been selected for study: Indonesia, the Philippines, Malaysia, and Thailand.
1.2 Methodology

As this thesis involves a multi-disciplinary approach, many aspects of energy supply and demand must be investigated. These include:

** examining information about needs-orientated and resource-sparing energy supply in individual countries, the macro-economic situation and socioeconomic factors, relevant regional and national development planning measures, and national and regional energy policy (in particular plans for grid expansion and pricing policy).

** reviewing the national energy economies (requirements, demand, supply pattern), local income levels, and identifying the economic growth potential in the small scale industry sector, for crafts and agriculture which could be exploited through low cost energy.

** assessing the compatibility of the demand patterns of the possible target groups with the supply potential of the available renewable energy resources, and identifying possibilities for financing energy hardware investments.

** analysing the needs and market potential for particular renewable energy systems; identifying appropriate demonstration sites (in the region) and matching specific
technologies to the characteristics of specific sites; examining local innovations and modifications in renewable energy technologies and how the technology may be more suitably transferred; and examining the role of existing and prospective sponsors of technology transfer in the region.

localising resources for maintenance of energy systems and local production; ascertaining manpower skills and how they could be better developed for continued operation and management of the technology; and estimating the renewable energy potential in the following areas: Small-scale hydro, biomass, solar energy, and wind energy.

analysing the scope for energy savings in the crafts sector and in industry.

It is hoped that the final results will be used by the represented governments to promote indigenous and endogenous technological capacity and will assist in developing policy alternatives for aid agencies.

1.3 Technical Review

The technologies included in this study are: solar photovoltaic and solar thermal, wind, small hydro, and biomass energy systems.
1.3.1. Solar Photovoltaic systems

The fundamental conversion of light to electricity takes place via the photovoltaic effect, discovered by Edmund Becquerel in 1839, but not fully understood until the 1950s.

Light is absorbed in a solid by transfer of the photon energy into excitation of electrons (see Fig.2). If the electrons and holes generated by this photo-excitation are separated by an internal electric field and subsequently collected, then both a photovoltage and a photocurrent are produced. The photocurrent is a result of minority carrier transport and is thus a reverse current, whilst the photovoltage is positive. The device operates in the forth quadrant of the diode I/V diagram and is thus a power generator \[\text{[Hill, 1989]}\].

The photovoltaic (pv) effect was observed in silicon diodes in 1954, and solar cells made from silicon wafers are now a standard commercial product. Silicon is an indirect bandgap material and is not the optimum material for solar cells. Direct bandgap materials such as GaAs, InP or CdTe have energy gaps closer to the optimum 1.4 eV for absorption of terrestrial sunlight and should theoretically be more
efficient. Sunlight has a wide spectral range, so there are large inherent losses in conversion by a single bandgap and the maximum efficiency is about 28%. If the sunlight is absorbed by a cascade of materials of decreasing bandgaps in a multi-junction cell, then in principle over $\frac{2}{3}$ of the solar energy could be converted to electricity.

Single solar cells, usually 10 x 10 cm in area, generate
about 4 A at 0.5 V DC in full sunlight, i.e. at an irradiance of 1 kWm\(^{-2}\). To obtain a more useful output, cells are connected in series in a weather-proof module to give a maximum output of 4 A at 14-15 V DC. For higher power, modules are connected in series and/or parallel in an array to give the required output (see Fig. 3).

![Solar pv modules diagram]

**Fig. 3:** Solar pv modules used to power street lights. [Source: BP Solar]

Costs are usually quoted in terms of dollars per peak watt ($Wp^{-1}$), measured at a solar irradiance of 1000 Wm\(^{-2}\) (similar to Sahara Desert summer noon). The total cost of a pv system includes the module costs plus the cost of support structures, wiring, electronic control and conditioning.

These additional costs are usually lumped together as
balance-of-system costs, and are generally greater than the cost of the photovoltaic modules.

1.3.2 Solar Thermal Systems

Solar water heating systems may be grouped into two main categories: natural and forced circulation. These systems are usually referred to as gravity (natural circulation) and pumped (forced circulation) systems. They are distinguished by the manner in which the heat transfer fluid is circulated around the system. In natural circulation systems, sometimes referred to as thermosyphon flow solar water heaters, fluid circulation is caused by convection. No auxiliary power is required. On forced circulation systems, auxiliary power is required to operate the pumps circulating the fluid.

In either active or passive systems, direct and indirect arrangements arise. Direct systems are those in which water passes through the collectors. Indirect systems, are those in which a fluid other than water passes through the collectors. This fluid may or may not be water based, and such systems will out of necessity incorporate a heat exchanger, the primary working fluid being on one side and water on the other.
Direct, Natural Circulation

The thermosyphon flow system is the simplest and most widely used for domestic hot water supply. As shown in Fig. 4, it consists essentially of a solar energy collector plate connected to an insulated hot water storage tank by two lengths of metal piping. Solar rays falling onto the collector plate heat the water in the tubes of the panel. This hot water rises to the top of the storage tank where it is stored for use. The warmer water rises to the top of the tank with cooler water at the bottom. This cooler water at the bottom of the tank flows to replace the water in the collector plate. The process of natural circulation of water continues throughout the day as long as there is sunshine and the tank temperature is lower than the collector plate.

Some drawbacks of the system are:

(i) in cold countries there is danger of frost damage, although this can be overcome by having automatic drain-down valves.
Direct Natural Thermosyphon System

Draincocks and air vents are omitted

Dimension 'H' not less than 600 mm
(ii) In countries where the water is "hard", furring of the tubes can occur, thus degrading the thermal performance of the collector plate.

(iii) For thermosyphon action, the collector plate has to be installed at a position lower than the storage tank. In some houses this may not be possible.

(iv) The vertical distance between the collector plate and storage tank should be at least 1.3 m in order to minimise the cooling effect of reverse circulation. At night, when the temperature drops, the collector plate cools and acts as a radiator. Water circulation will reverse and hot water from the storage tank will lose its heat and cool down. The degree of cooling will depend upon this vertical separation distance between tank and collector plate.

Indirect, Natural Circulation

The indirect thermosyphon flow system is similar to the direct thermosyphon flow except that the former has incorporated a heat exchanger in the circuit. The advantages are:

(i) Anti-freeze and/or corrosion inhibitors can be used thus reducing the danger of frost damage.
(ii) Cheaper collector plates can be used, e.g. mild steel.

(iii) Furring is eliminated.

However, this system is more expensive due to the heat exchanger, and the thermal efficiency is less than the direct system.

**Indirect Natural Thermosyphon System**

Draincocks and air vents are omitted

Dimension 'H' not less than 600 mm

Sealed expansion tank

Flatplate solar collectors

Overflow

Cold water tank

Domestic hot water cylinder

Fig. 5 [Source: McVeigh, 1977]

**Direct, Forced Circulation**

This system incorporates a pump in the primary circuit.
When it is switched on, water is forced up through the collector plate. If the main supply tank is at a lower level than the collector plate, water will drain down to the hot water storage tank (unless a check valve is installed at pump outlet) thus eliminating frost damage. A temperature differential controller is used which senses the temperature of water after it leaves the collector panel and in the storage tank. The pump is switched on when the difference is greater than about \(3^\circ\) to \(5^\circ\) C and switched off when the difference is less than about \(0.5^\circ\) to \(1^\circ\) C.

Forced circulation systems are more expensive than natural circulation systems and are employed when:

(i) It is not possible to position the collector plate at a level lower than the storage tank.

(ii) Where a large number of collector plates are used, such as in commercial applications.

**Indirect, Forced Circulation**

This system is similar to the direct forced circulation system except that it incorporates a heat exchanger in the primary circuit. Anti-freeze and/or corrosion inhibitors are used in the solar circuit to eliminate frost damage and furring, and to enable cheap materials to be used for the
collector plate.

1.3.3. Small Hydroelectric Power

As shown in Fig. 6, a typical hydroelectric project includes a water diverting structure, such as a dam or canal, a conduit (penstock) to transport water to the turbine, turbine and governor, generator, control and switching apparatus, a power house to protect the equipment, transformers, and transmission lines to carry the generated power to the distribution centres.

Fig. 6: Typical hydroelectric plant.[Source: Dunn, 1986]
Hydraulic turbines are classified as either impulse or reaction turbines. The impulse turbine is represented by the Pelton-type water wheel. In an impulse turbine the water is discharged through one or more nozzles as one or more jets in free air which impinge upon the runner.

In reaction turbines, the entire flow from head water to tail water occurs in a closed penstock. Whereas with a Pelton wheel all available head is converted into kinetic energy, with a reaction turbine only part of the available head is converted to kinetic energy at the entrance to the runner.

![Schematic of a Pelton turbine (a) and a Turgo Impulse turbine.](https://via.placeholder.com/150)

Fig. 7 Schematic of a Pelton turbine (a) and a Turgo Impulse turbine. [Source: Dunn, 1986]

Reaction turbines are classified by two types: the Frances turbine and the propeller turbine. Propeller turbines are sub-divided into fixed blade and adjustable blade (Kaplan) types. Diagonal flow turbines have also been developed. In the Frances turbine, flow passes from the penstock to a
spiral case and then inwardly around the inside circumference through a series of pivoting gates to the runner. Water turbines are highly efficient devices with average efficiencies of more than 90% and peak efficiency of 97% [Parker, 1977].

Fig. 8 Schematic of a Cross-Flow turbine. [Source: Dunn, 1986]

The generator is normally located above the turbine except in plants having horizontal-flow turbines. Generator and turbine are connected either through a gear box, by a system of pulley wheels or directly, on a common shaft. Electrical
energy is carried by cables to the control and switching apparatus, and then to transformers from which it is transmitted over power lines to the load.

Hydroelectric developments may be classified as multi-purpose or single-purpose, as base load or peak load, as run-of-river or storage, or as high head or low head. A multi-purpose scheme is developed for a number of uses such as irrigation, flood control, power and silt removal. A base load system supplies power almost continually to satisfy the minimum constant power demand in a system whereas a peak load system generates power only during times of peak demand. A run-of-river project utilizes the flow passing the plant for hydro power but does not alter the flow rate to downstream. A storage project retains water so that river flow downstream may be regulated. Description of a project as high-head or low-head refers to the difference in water levels just upstream (head water) or downstream (tail water) of the plant. High head plants have heads over 30 m, while low head plants have heads of less than 30 m. The amount of head has a direct effect on the type of hydraulic turbine adopted. As a general rule, the Pelton turbine is designed for high-head sites, the Frances, Ossberger, Mitchell or Banki turbines for medium heads, and the Kaplan and other propeller type turbines for low-heads.

Electro-mechanical equipment for small hydro generating
systems cost between $1,000 and $5,000 per installed kilowatt. The unit cost rise rapidly as power ratings decrease and plants operating with low heads are more costly than those with high heads. The use of non-conventional technology for the civil construction and of locally produced equipment makes for lower unit costs than conventional technology and imported equipment. This advantage tends to be less significant as the power output rises [UN, 1983].

1.3.4 Biomass

Charcoal and Fuelwood - Direct Combustion

As early as 400,000 B.C., wood was used to kindle fire in the caves of Peking Man, making fuelwood the oldest form of renewable energy.

Direct combustion is not strictly a conversion process as the biomass itself is used for fuel. This is the traditional form of energy produced from biomass, and provides the main source of energy for more than half the world’s population [Hall, 1982]. The efficiency of a direct combustion system will depend on the moisture content of the biomass, the completeness of the combustion, and the efficiency with which heat is transferred to the site of heat use, such as the boiler tubes or a cooking pot.
The feedstock for direct combustion should be dry (>85% dry matter) [Kitani, 1989]. Damp feedstock may be burned, but combustion efficiency will be reduced as some of the energy produced will have to be used to evaporate the moisture, and combustion will be less complete. However, efficiency of combustion may not always be the primary consideration. In some situations, combustion may be used as a treatment process, for example for animal wastes, with energy production as a secondary output. Direct combustion may also make use of cheap feedstock such as wastes or residues to provide heat for processing of primary products. For example, the bagasse from sugar cane may be burned to provide heat for sugar or ethanol production.

The design of a combustion device will determine the completeness of combustion and efficiency of heat transfer. A wide selection of combustion devices is available, ranging from open fires and simple stoves to large scale fluidized-bed furnaces. Devices are available to handle most forms of biomass, although the preferred feedstock is a form of dry biomass such as wood. For some devices it may be necessary to process the feedstock (cut, chip, grind) before direct combustion. This enables automatic stoking, which can be an important selling point.

An important constraint on direct use of biomass as a fuel
is its low energy density, as compared to fossil fuels. The energy density of wood is 18 GJ per t compared to more than 30 GJ per t for coal [Kitani, 1989]. This restricts its use to near the point of production, or the fuel requires densification to reduce transport costs.

Another option is to convert the heat produced from the direct combustion of biomass to a more valuable form of energy such as electricity, either directly or by combined heat and power plants. Biomass has a low sulphur content, so co-combustion of biomass may be a means of reducing SO₂ emissions from power stations.

Charcoal is normally produced in permanent, commercial kilns (7-100 cubic metres), movable metal kilns or non-permanent earth mound kilns. Improvements in charcoal production efficiency through better kiln construction and firing techniques have been introduced since mid 1980’s. This has resulted in an increase in overall energy conversion efficiency of approximately 39% to 55-60% [De Lepeleire, 1981].

Of equal importance to charcoal production efficiency is stove efficiency. With improvement in design and construction, 25-100% increase in efficiency is obtainable; the 100% increase can be made with chimneyed rice husk stoves (5% efficiency before improvement and a 10%
efficiency after) whereas 25% increase can be obtained from technical advancements in charcoal bucket stoves.

Fig. 9: Traditional cookstoves. [Source: Hall, 1987]
Fig. 10: Improved cookstoves. [Source: Hall, 1987]
Briquetted fuels from sawdust and rice husk are used in direct combustion and are commercially produced by a few firms. The cost of briquetted fuels is higher than charcoal, but as wood becomes more scarce briquetted fuels may become economically competitive.

**Anaerobic Digestion - Biogas Digesters**

Biogas (a mixture of carbon dioxide and methane) may be produced from biomass under anaerobic conditions. Any form of wet biomass, such as green crop material or animal waste, may be used as feedstock. This process is sometimes used as a treatment for agricultural and industrial waste as it reduces the environmental pollutants. The feedstocks do not usually require pre-processing but maceration of plant materials may increase biogas yields. Biogas from some feedstocks may contain other gases such as hydrogen sulphide, which should be removed before the gas is used as a fuel.

The yield and quality of biogas produced from anaerobic digestion will depend on the type of feedstock, the digestion temperature, and the retention time.

Simple biogas plants have been developed which may be operated on a very small scale, and large numbers of such plants have been developed in India and China that run on
animal, human, and plant waste.

Figure 11: A typical biogas digester. [Source: van Buren, 1979]

**Biomass Gasification**

Biomass gasifiers (1-50kW mechanical capacity) have been developed to operate from rice husks, charcoal, fuelwood, coconut shell, corn cobs, and cassava stalk, for rural industrial heat production, electricity generation and water pumping.
Fig. 12: Biomass Downdraft Gasifier. [Source: Wilbur, 85]
The term gasification is used to describe a group of thermal conversion processes which yield mainly gases. A combustible gas, which can be used as fuel for an internal combustion engine, can be generated if biomass is burned with less air than is needed to achieve complete combustion. The gas, often called producer gas, consists of the components carbon monoxide, hydrogen, methane, carbon dioxide, water vapour and nitrogen. Technically, this can be achieved in a variety of ways. For fuelling small engines of up to 200-300 kW, the biomass fuel is supplied to the gasifier where combustion occurs and air is supplied at regulated levels. The hot gases are then passed through a fuel bed and this action produces the combustible gas.

If the gas contains more than a very small amount of dust and tar, then operational problems with the engine or excessive engine wear will occur. It is necessary either to clean the gas (which leads to disposal problems), or to try to generate a gas which has a low tar content.

Biomass is generally converted to gas in three stages: drying and pyrolysis, combustion, and reduction of the gases. The order of the stages are dependent on the type of gasifier. In the up-draught type, the tar is carried out with the gas from the gasifier. Unless a low tar fuel is used or the gas cleaned, gumming of the engine will occur.
In a down-draught type, the tar has to pass through the combustion and reduction zones. In a properly designed gasifier, this will lead to sufficient combustion and cracking of the tars to make the gas suitable for engine use.

A cross-draught gasifier runs best on charcoal due to the excessive build-up of tar in the gas if another fuel is used. For larger power stations, a gasifier where the fuel particles are kept in suspension by the air/gas flow (fluidized bed gasifier) is preferrable. The advantage of the fluidized bed gasifier is that it is compact and has the ability to maintain homogeneous gasification conditions. It requires a sophisticated control system and blowers to keep the bed fluidized which makes it expensive for small power needs. Fluidized bed gasifiers will probably not be economic for engines with a power output of less than 300 to 400 kW.

1.3.5 Wind

As there is very little wind energy utilized in the countries studied, this is a very brief discussion of the advantages and disadvantages of the types of wind power technologies currently being marketed.

There are two basic categories of wind energy machines: the
horizontal axis machines (HAM) and the vertical axis machines (VAM). The advantages of the HAM are:

** high aerodynamic efficiency,
** simplicity of design,
** high level of safety,
** comparative ease of speed control even during gales or hurricanes.

The disadvantages of the HAM are:

** the need for a tower,
** the cost and complexity increases with size and output of the electric generators,
** the need for orienting the rotor to wind direction,
** and the difficulty of installing and maintaining the heavy electric generators on top of the towers.

The advantages of the VAM are:

** easy installation of the rotor and electric generator,
** heavy equipment is at ground level thus making maintenance simpler,
** and independence of changes in the wind direction.

The disadvantages are that VAM’s suffer from a high level
prolonged vibration which shortens the lifespan of the bearings and reduces aerodynamic efficiency and that the rotational torque from the wind varies periodically within each cycle, and thus unwanted power occasionally appears at the output. Hence, most wind energy systems use HAM systems.

Fig. 13: VAM Wind Energy Systems. [Source: Cheremisinoff, 1978]
Upwind horizontal axis wind turbines may have a tilted rotor to increase tip clearance with tower.

Orientation of rotor achieved through wind vane.
Chapter Bibliography

1. Additional information on solar pv systems can be found in:


2. Additional information on solar thermal systems can be found in:


3. Additional information on hydroelectric power generation can be found in:


4. Additional information on biomass energy can be found in:


5. Additional information on wind energy can be found in:


2.1 Energy Economy Asia and the Pacific

In 1987, primary commercial energy consumption (see Table 1) of selected countries\(^1\) totalled about one billion tons of oil equivalent (toe) [ADB, 1989]. In addition to commercial energy, the consumption of non-commercial energy is estimated at nearly 460 million toe, equivalent to about 45% of commercial energy requirements. Per capita commercial energy consumption is still extremely low at 0.4 toe, which is less than 7% of per capita energy consumption of OECD countries [IEA, 1987]. Total energy consumption per capita including noncommercial energy in the region amounted to about 0.6 toe, which is less than 10% of average per capita consumption of commercial energy in OECD countries [IEA, 1987]. Two countries, notably, the People’s Republic of China and India, accounted for more than 70% of total commercial energy consumed, while accounting for about 50% of regional GDP in 1987 [ADB, 1987].

2.2 Inter-temporal Trends

Since the first oil crisis of 1973, these countries\(^1\) have

\(^1\) Selected Countries: Bangladesh, Burma, People’s Republic of China, Hong Kong, Fiji, India, Indonesia, the Republic of Korea, Malaysia, Nepal, Pakistan, the Philippines, Sri Lanka, Taiwan, and Thailand.
experienced significant adjustments to changes in the international energy environment, whilst striving for continued economic growth. They have shown different

<table>
<thead>
<tr>
<th>Table 1: Primary Commercial Energy Consumption (Thousand standard toe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thailand</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1987</td>
</tr>
</tbody>
</table>

Total figures are adjusted for unavailable data
Source: Asian Development Bank

linkage effects of energy with economic growth. The region as a whole had experienced in the 1970's high energy cost with high energy consumption (an annual growth rate of 7.3%) against moderate economic growth of 5.3% on average. The region performed differently during the second oil shock period of 1979/80, experiencing low energy consumption (5.0%) against high economic growth of 6.7% [ADB, 1989].

However, with low energy cost after 1985, the region experienced again increased energy consumption (6.2%) with
an expanded economic growth of 7.5%. The movement of per capita energy consumption as a whole has shown similar changes over these periods. The per capita average energy consumption almost doubled to 408 koe in 1987 from 225 koe in 1973 [ADB, 1989].

2.2.1 Energy Intensity

Energy intensity is defined as the energy required to create a unit of product, valued in monetary units. It can be expressed, for example, in standard tons of oil equivalent per thousand U.S.$. The average values for the region is 0.82, but if China and India are excluded, the energy intensity average value is 0.45.

Table 2: Energy Intensity in Gross Domestic Product

<table>
<thead>
<tr>
<th>Source: Asian Development Bank, 1987</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>Bangladesh</td>
</tr>
<tr>
<td>China, People's Rep.</td>
</tr>
<tr>
<td>Fiji</td>
</tr>
<tr>
<td>Hong Kong</td>
</tr>
<tr>
<td>India</td>
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<tr>
<td>Indonesia</td>
</tr>
<tr>
<td>Korea, Rep. of</td>
</tr>
<tr>
<td>Malaysia</td>
</tr>
<tr>
<td>Pakistan</td>
</tr>
<tr>
<td>Philippines</td>
</tr>
<tr>
<td>Sri Lanka</td>
</tr>
<tr>
<td>Thailand</td>
</tr>
</tbody>
</table>

Standard ton of oil equivalent per thousand US$ at 1980 constant prices.
The Asian developing countries have taken considerable care to reduce their energy intensities in GDP. The commercial energy intensity of GDP had increased dramatically from 0.78 in 1973 to 0.87 in 1979. During the early 1980's, it had declined to 0.79 in 1984 [ADB, 1989]. Energy conservation measures activated by the region after 1973 helped to lower energy intensities after the second oil shock in 1979. However, the past low oil prices have changed the energy intensity in the region. In 1987, the energy intensity stood at 0.77 which was a slight decline from the 1984 value of 0.79. The regional energy intensity, exclusive of the People's Republic of China and India, had a dramatic increase to 0.47 in 1987 from 0.45 in 1984 [ADB, 1989]. This indicates that most countries in the region have experienced an increase in energy intensity since 1985 due to the past decline in oil prices (see Table 2).

2.2.2. Energy and Prices

Energy price adjustments in the region have preceded rises in general inflation. Whilst energy pricing policies vary greatly, almost all energy importing countries maintained high oil prices until 1987. Even energy exporting countries increased their oil prices considerably to regulate domestic demand for oil. The regional mean oil price increased, by three times the 1973 cost, in 1979, and nearly doubled again by 1986 [WEC, 1990]. Electricity prices also increased
dramatically although at a slower rate than oil prices. The increase in the prices of oil and electricity were more than double that of the overall inflation rates.

After 1987, most countries in the region decreased their oil and electricity prices in response to the low cost of imported energy. The regional average of the cost of oil decreased by about 33% of their 1986 level in 1987 [ADB,1989]. The downward adjustment of oil prices together with high economic growth has contributed to increased oil consumption since 1986.

2.3 Structural Changes in the Regional Energy Sector

2.3.1 Energy Diversification

The regional energy mix is coal dominant. Coal accounted for 59% of the commercial energy consumption in 1987. This high percentage is primarily due to high coal usage in the People's Republic of China (PRC) and India, two of the largest countries in the region. However, in the rest of the region exclusive of the PRC and India, oil dominated at 52% with coal only at 13% [WEC, 1990].

The most significant development in the energy sector has been structural adjustments through energy diversification, in response to the increases in oil price since 1973. Oil
dependence has decreased continuously: the reduction is now approximately 32% since 1973. Most countries have encouraged the substitution of coal and gas for oil. The development of nuclear, hydropower, and geothermal resources has also been encouraged by countries in the region. From the period of 1973 to 1987, the share of coal increased from nil to 66% in Hong Kong, from 0.2% to 8% in the Philippines, and from 2% to 11% in Thailand. The share of natural gas increased from almost nil in 1973 in Indonesia, Malaysia, and Thailand to 26%, 26% and 23%, respectively, in 1987. In Bangladesh, it increased from 34% to 62% during the same period. In the Republic of Korea, nuclear energy became a major source of commercial energy, amounting to 15% of primary energy in 1987. The development of hydropower has been noteworthy in Indonesia, Malaysia, Pakistan, and the Philippines. In the Philippines, growth of geothermal energy has been very impressive. However, changes in the total energy supply mix in the PRC and India had been moderate. From 1973 to 1987, the share of oil in energy supply declined slightly by approximately one percentage point to 17% in the PRC and 30% in India [ADB, 1989].

Another development in the energy sector has been an increase in the use of primary energy for electric power generation. The average share of electricity in primary energy consumption has systematically increased to 36% in 1987 from 25% in 1973. In low-income countries, rural
electrification programs have been vigorous whereas in high income countries there has been a shift towards greater use of electricity.

2.3.2 Sectorial Pattern of Final Consumption

The sectorial pattern of regional energy consumption did not change significantly over time despite the varying degrees of industrialisation and urbanisation.

The industrial sector in 1987 accounted for between 31% and 68% of domestic energy consumption, except for Bangladesh, Fiji, Hong Kong and Sri Lanka whose shares were below 30%. More than half the national energy was consumed by the industrial sector in the PRC and India. Even with the substantial increases in the GDP share of the industrial sector, the percentage of the industrial energy consumption in the region has not increased significantly. This is due to the high energy efficiency of the industrial sector compared to the other section like the residential sector. Some countries, such as the Republic of Korea and Thailand, have experienced only a moderate increase or even a decline in the share of industrial sector energy consumption against its increased share in GDP in the 1980’s.

Most countries experienced a comparatively high energy consumption in the transport sector with its share ranging
from 30% to 60%. A relatively low energy share (less than 20%) of the transport sector is exhibited in some countries like Bangladesh, the Republic of Korea, Taiwan, and with the lowest share of 6%, the PRC. If the PRC is excluded, the transport sector accounts for about 25% in the 1980’s.

The share of residential and commercial sectors in total energy consumption ranged between 10 and 20% in 1987, with an average share remaining constant at around 18% over the past. Nevertheless, higher sectorial allocations are experienced in some countries like Bangladesh, Hong Kong, Indonesia and the Republic of Korea, ranging from 23 to 38% in 1987.

Table 3: Energy Allocations per sector OECD countries (percentage share)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Percentage Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
<td>34%</td>
</tr>
<tr>
<td>Transport</td>
<td>31%</td>
</tr>
<tr>
<td>Agriculture</td>
<td>2%</td>
</tr>
<tr>
<td>Residential</td>
<td>19%</td>
</tr>
<tr>
<td>Commercial</td>
<td>11%</td>
</tr>
<tr>
<td>Non-energy</td>
<td>4%</td>
</tr>
</tbody>
</table>

Source: OECD, 1991
Table 4: Energy Allocations per Sector
(Average values for the Pacific Rim)

2.4 Energy Resources and Self-Reliance

2.4.1 Energy Reserves and Resources

Proved recoverable reserves in the region amounted to at least 30,000 million barrels of oil, and $5 \times 10^{12}$ cubic meters of natural gas. At 1987 rates of production, proved recoverable reserves of oil would last for more than 15 years and of natural gas for about 45 years. The proven coal reserves in place are at least 930 billion tons, which could last for more than 800 years at the 1987 production rate [ADB, 1989].
2.4.2 Energy Self-Reliance

Collectively, countries in the region are self-sufficient in energy (see Table 5). Indigenous production exceeded primary energy consumption by about 4% in 1979 and 1985 but almost balanced in 1987. Correspondingly, the aggregate energy balances have fluctuated from year to year.

Table 5: Self-Reliance in Commercial Energy Consumption (percentage share)

<table>
<thead>
<tr>
<th>Country</th>
<th>1979</th>
<th>1987</th>
</tr>
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<tbody>
<tr>
<td>Thailand</td>
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<tr>
<td>Indonesia</td>
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<tr>
<td>Malaysia</td>
<td></td>
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<tr>
<td>The Philippines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bangladesh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>China - PRC</td>
<td></td>
<td></td>
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<tr>
<td>Fiji</td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td></td>
<td></td>
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<tr>
<td>Korea - Rep.</td>
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<td></td>
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<tr>
<td>Sri Lanka</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taiwan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nepal</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Asian Development Bank

Note: Self-reliance in energy is defined as % share of indigenous production of energy to primary energy consumption.

Self-reliance in energy has become a major policy objective in almost all of the countries. In most energy importing
countries, vigorous development of indigenous energy resources combined with the use of energy efficient technologies has actively reduced their dependence on imported energy. Among energy exporting countries, Malaysia and Indonesia recorded indigenous energy production equivalent to more than 2.5 times the domestic consumption of 1987 but the production in Myanmar and the PRC only marginally exceeded total consumption. Malaysia has maintained an increased balance of energy production over domestic consumption, its production-consumption ratio was at 2.8 in 1987 against 1.2 in 1973 [TEN, 1989]. Indonesia, on the other hand, has experienced a decreasing trend, the comparable proportion being at 2.7 in 1987 against 6.3 in 1973 [PLN, 1989].

2.5 Energy Infrastructure

2.5.1 Electricity

The electrical energy infrastructure development has been the most significant undertaking. The electricity generating capacity of the power utilities has more than tripled from 70 GW in 1973 to over 234 GW in 1987, with the Republic of Korea, Indonesia, Pakistan, Malaysia and Thailand, increasing by more than 4 times.

The fuel mix of electricity generating plants has changed
due to the diversification policy. A significant shift to coal- and gas-fired thermal plants and gas-fired combined cycle power plants has occurred in order to reduce oil dependency. In the field of renewable energy, the capacity share of hydropower plants had decreased from 31% in 1973 to 27% in 1987, having been replaced by an increase in geothermal and nuclear power plants. After the Chernobyl incident, large scale hydropower has only made a slight comeback due to the growing environmental awareness of the populace [ADB, 1989].

2.5.2 Oil Refinery

In 1987, the region’s oil refining capacity totalled 6.4 million barrels per day (bpd), a significant increase from approximately 3.4 million bpd in 1973. Countries like the PRC, Indonesia, Taiwan, have more than doubled their refinery capacity since 1973. A moderate expansion was observed in Malaysia, Bangladesh, Sri Lanka and Thailand. For the region as a whole, refinery capacity was more than sufficient to meet their demand for petroleum products. In 1987, the refinery capacity was 15% higher than oil consumption.
2.5.3 Reliability of Power Supply

Despite the above scenario of energy self-reliance for the region, the power supplied to the industrial, residential and commercial sectors is far from reliable in most countries in the region. In order to combat this discrepancy many countries have encouraged their industrial sector to generate their own power supply. This can be actively used during working hours as in Indonesia or used as stand-by power as in the Philippines. As of 1990, the power generated by industries in Indonesia equalled that generated by the Perusahaan Umum Listrik Negara (the National Electric Authority). Although not as substantial as Indonesia, the Philippines also has strong back-up generating capacity.

The Government of Malaysia is encouraging private power generation to enhance reliability of supply, and the Thai Government has in the past performed quite a number of studies on the feasibility for Thailand (see Chapter 8).
Chapter 3 Indonesia

3.1 Energy Context

3.1.1 Consumption and Supply

Indonesia is an archipelagic country (see Fig. 15). The major islands are Java, Sumatra, Kalimantan, Sulawesi and Irian Jaya; the population is concentrated mainly on Java. Although the country has an abundant and well-diversified endowment of commercial energy sources, oil dominated energy consumption in the 1970s. Since the early 1980s, the Government has implemented a diversification strategy to correct this imbalance.

Table 6: Commercial Energy Consumption Indonesia (percentage share)

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Percentage Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>21.9</td>
</tr>
<tr>
<td>Hydropower</td>
<td>8.6</td>
</tr>
<tr>
<td>Oil</td>
<td>65.7</td>
</tr>
<tr>
<td>Coal</td>
<td>3.5</td>
</tr>
<tr>
<td>Geothermal</td>
<td>0.3</td>
</tr>
</tbody>
</table>

1986

Source: PLN, 1989
The share of oil in the commercial energy supply mix declined from 78.1% in Fiscal Year (FY) 80 to 65.7% in FY 86. Total commercial energy supplies for consumption within Indonesia increased from 27.4 mtoe to 33.8 mtoe during the same seven year period, at the rate of 3.6% per annum. The per capita consumption in FY 86 of about 0.2 mtoe was substantially below the levels of other ASEAN countries. Percentage share for FY86 can be found in Table 6 of commercial energy supplies [PLN, 1989]. Traditional noncommercial fuels such as fuelwood and agricultural wastes are estimated to meet almost half the total energy requirements in the country; their share is particularly high in the rural areas.

Indonesia is a net energy exporter. Exports of crude oil and refined products were over 35 mtoe in FY 86; exports of natural gas were about 20 mtoe. Marginal quantities of coal (about 0.4 mtoe) were also exported in 1987 [PLN, 1989].

Total final consumption of commercial energy in FY85, the most recent year for which data disaggregated by sector are available (see Table 7), was about 22.9 mtoe. Between FY 80 and FY85, the share of the industrial sector increased from 31% to 34% of commercial energy consumption, in line with the sector’s increase in the share of GDP from 12% to 14% [ADB, 1987]. The share of the transport sector remained unchanged while that of the other
Fig. 15: Map of Indonesia

sectors showed a gradual decline.
Table 7: Final Consumption of Commercial Energy in % share - Indonesia

![Pie chart showing consumption percentages]

Source: ADB, 1987

3.1.2 Reserves

Indonesia is richly endowed with all forms of energy resources. At its 1987 production level of about 60 million metric tons, the proven oil reserves of over 1.3 billion metric tons will be sufficient for more than twenty years. Further probable reserves range from 1.3 to 5.4 billion metric tons. Natural gas reserves are estimated at about 3.1 trillion cubic meters or about 2.7 billion mtoe. The bulk of the gas reserves are in non-associated form and can thus be developed independently of oil production.
However, these reserves are for the most part located far from the major population and industrial centres, i.e., the largest fields are in the South China Sea, East Kalimantan and in North Sumatra [PLN, 1989]. A major part of current gas production is being exported to Japan and the Republic of Korea in the form of liquified natural gas (LNG).

Table 8: Coal Reserves in Indonesia
Percentage Share

<table>
<thead>
<tr>
<th>Type</th>
<th>Percentage Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lignite/Brown</td>
<td>75</td>
</tr>
<tr>
<td>Bituminous</td>
<td>5</td>
</tr>
<tr>
<td>Sub-bituminous</td>
<td>20</td>
</tr>
</tbody>
</table>

Source: PLN, 1989

The country's coal reserves (see Table 8) are also large, estimated at 23 billion metric tons. Assuming an average thermal value of 5.3 kWh/kg, coal reserves represent about 10.3 billion mtoe. The bulk of these reserves are located in West and
South Sumatra, and along the coast of East and South Kalimantan. The FY86 production level was about 2.6 million metric tons; but increases in coal production are anticipated in the next few years. The country also has vast peat deposits, equal to about ten times the total coal deposits [PLN, 1989].

The total hydropower potential is estimated at 75,000 MW, capable of an annual energy generation of 400,000 GWh. However, the harnessing of this potential has been impeded by an incompatible geological distribution between hydropower resources and load centres. Java, which accounts for almost 80% electricity consumption has only about 5% of the country’s hydropower resources, while 59% of the resources are in Irian Jaya and Kalimantan, where electricity consumption is only about 3% of the country’s total. As a result, installed hydropower capacity at the end of FY86 was only about 2,000 MW, or less than 3% of the potential [ITB, 1990].

Indonesia is also one of the world’s largest geothermal areas. There are surface manifestations of geothermal energy on all islands except Kalimantan, but only a few sites have been investigated so far. According to Hertzmark, total geothermal potential has been estimated at about 10,000 MW with an annual energy generation capability of about 600,000 GWh. The geographical distribution is more favorable than that of
hydropower potential: 5,500 MW on Java, 1,400 MW on Sulawesi, 1,100 MW on Sumatra, and 2,000 MW on the other islands.

3.2 Energy Policy

In the 1970s and early 1980s, Indonesian energy policy was formulated in an atmosphere of high international oil prices. Petroleum products such as kerosene and diesel oil were subsidised as a means of sharing some of the profits from high export prices with the population and to stimulate productive enterprise. Kerosene was priced low to:

i) provide a substitute for fuelwood and thereby reduce deforestation, and;

ii) provide a reliable supply of fuel for the poor at affordable prices.

However, now the Government’s energy policy is determined by the overwhelming importance of oil and gas exports. About 61% and 55% of the total foreign exchange earnings came through energy exports in FY 85 and FY 86, respectively [ADB, 1989]. The major energy policy aims are to continue an active oil and gas exploration and development program, and to diversify the domestic energy consumption away from oil to increase the
exportable surplus. This diversification strategy, which began in the early 1980s, consists of developing indigenous natural gas, coal, hydropower, and geothermal resources, and adjusting domestic oil prices to encourage conservation.

The government is encouraging the use of LPG as a substitute for kerosene. A World Bank study estimated that by the year 2000, 20% of kerosene demand in Indonesia, currently 42 million barrels per year, will be substituted by LPG. Although the campaign is hampered by the limited LPG retail distribution network, LPG domestic consumption has increased fourfold since 1979. In 1987 alone, domestic sales increased 20%. However, the domestic market of 216,000 tons is still low compared to the market for kerosene. A 1986 study sponsored by MIGAS and the World Bank estimated domestic demand for LPG will reach 397,000 tons per annum by 1990. More recent government estimates place future domestic demand at 350,000 tons by FY 90 and 464,000 tons by FY93 [USAID-Jakarta, 1990].

As a number of ministries and government organisations are involved in the energy sector, the Government established a permanent inter-departmental Technical Committee on Energy (PTE) in 1976, which is responsible for preparing proposals for energy policies and plans, and monitoring their implementation. A cabinet-level inter-ministerial National Energy Coordination
Board (BAKOREN) reviews proposals made by PTE and issues directives on their execution to the ministries, state enterprises and other organisations concerned. The principal agency involved in the implementation of the Government's energy policy is the Ministry of Mines and Energy (MME). The MME coordinates activities in the energy sector and controls the state enterprises responsible for the various sub-sectors: Pertamina for oil, natural gas, and geothermal energy; P.N. Batubara and P.T. Bukit Asam for coal; and Perusahaan Umum Listrik Negara (PLN) for electricity.

3.2.1 Electric Power

Institutions and Structure

The electric power sub-sector is regulated by MME through the Directorate General of Electric Power and New Energy (DGEP). The electricity sub-sector in Indonesia comprises: (i) the Government-owned Perusahaan Umum Listrik Negara (PLN), the country's electric power utility; (ii) a large number of non-utility power plants installed and operated by private consumers for their own use; (iii) various small provincial, municipal and private franchises; (iv) electric cooperatives in rural areas; and (v) unregistered village-level utilities.
While DGEP is responsible for policy planning, franchise licensing and general supervision of the electricity sub-sector operations, PLN is in charge of the planning, construction and operation of power facilities, and of administering regulations on equipment standardization.

To increase the rate of rural electrification, the Ministry of Cooperatives (MOC) has been promoting the formation of rural electric cooperatives and is considering the establishment of an autonomous rural electrification agency. This agency would be responsible for formulating policies and plans, and for mobilising the necessary resources.

Supply System

As of March 31, 1988, PLN’s total installed capacity was 7,237 MW. The composition of which is shown in Table 9. Almost 70% of PLN’s generating capacity is located in Java. The PLN also purchased 90 MW of excess plant capacity from the Krakatau steam power plant in West Java, and 200 MW of plant capacity from the Asahan and Juanda hydropower stations in North Sumatra and West Java, respectively.
Owing to the Government's energy diversification program, the share of oil-fired generation has declined since FY83. Of PLN's total gross generation of 12,111 GWh (excluding purchases) in FY83 (see Table 10), heavy oil and diesel fuel were used to generate 9,020 GWh (74%).

In FY87, oil fired plants accounted for 11,070 GWh (51% of PLN's total generation of 21,559 GWh) while generation from coal and natural gas fired plants was 4,920 GWh (23%) and 393 GWh (2%) respectively. The remaining 5,176 GWh (24%) was from hydropower
Between FY76 and FY87, PLN's total installed capacity increased from 1,377 MW to 6,200 MW. Gross energy generation more than quadrupled in the same period to a level of over 21,559 GWh in FY87. Peak demand increased from 734 MW to 3,934 MW, at the rate of 16.5% per annum; and the reserve margin, i.e., the difference between the net system generating capability and system maximum load requirements, was maintained at levels of between 38% to 90% [PLN, 1989]. Despite the high reserve margins, PLN's power supply reliability has not met consumer expectations; many consumers install and operate private generation facilities for standby use.

Table 10: PLN's Gross Generation percentage share

<table>
<thead>
<tr>
<th>Source</th>
<th>Oil-fired plants</th>
<th>Coal-fired plants</th>
<th>Natural Gas</th>
<th>Hydro/Geothermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>51</td>
<td>23</td>
<td>2</td>
<td>24</td>
</tr>
</tbody>
</table>
A field survey conducted in 1985/86 [PLN, 1989] revealed that nearly 1,500 MW of standby generating units, consisting mostly of diesel sets, were in use by PLN consumers that year. An additional 2,000 MW of captive diesel generating facilities not owned by PLN consumers were also in use in March 1986. Installed capacity of standby (mostly diesel generator sets) facilities continues to grow, and exceeded 4,000 MW in March 1988. These data exclude installations smaller than 5 kW, for which no license is required.

In addition, there are several large power stations which are owned by entities (mostly large industrial plants) other than PLN. Those selling power to PLN include: (i) the Asahan hydropower station (603 MW) in North Sumatra, which is owned and operated by a joint venture company running an aluminium smelter; (ii) a steam power plant (400 MW) of the Krakatqu Steel Works in West Java; (iii) the Juanda hydropower plant (150 MW) of the Jatiluhur Authority in West Java; and (iv) the Larona hydropower plant (165 MW) of the INCO mining company in South Sulawesi.

The major load centre is Java, which has about 70% of PLN’s installed and purchase capacity. The 1985/86 survey showed that the capacity of captive and standby diesel generator facilities in Java is more than that in the rest of the country. However, total capacity of small captive diesel generators not owned by
PLN consumers is slightly higher outside of Java. These data indicate that the use of expensive diesel generators will not be eliminated until PLN is able to meet the power demand in all parts of the country - at a competitive cost and with high reliability.

**System Losses**

As a percentage of gross generation plus purchases, PLN’s total system losses (i.e. energy not available for sale) were estimated at 25.3% in FY 83 and FY 84, decreasing gradually to about 23.4% in FY87. Energy losses consist typically of 5% auxiliary consumption in power stations, 5% transmission losses and 15% distribution losses.

There are several reasons for the high level of losses, and for PLN’s relatively low operating efficiency. Only 19% of the population has access to electricity resulting in a low load density. Moreover, a high share of electricity sales is to low voltage residential consumers (about 37% whereas other figures for the region are less than 30%), which contributes to high distribution losses, and a reduction in the overall load factor due to the decrease in the average load carried by the electric utility when compared to the peak load. To an extent the country’s archipelagic character also contributes towards
increasing distribution and generation losses: PLN operates isolated power systems on all major islands outside Java (where there are almost 1,000 small power stations of an average size of 2.3 MW).

The relatively low load factor, coupled with a low load density and large transmission distances, leads to a light loading of transmission lines. In contrast, the loading of distribution lines is high, particularly in towns and cities, which results in a high level of distribution losses. Nevertheless, the high distribution losses are attributable only partly to technical factors. Other factors, such as inadequate metering and high levels of electricity theft [ADB, 1987], are also significant.

Capacity utilisation is relatively low, particularly for oil-fired plant, resulting in part from the high reserve margin in PLN's system. Some plants are old and not adequately maintained. Such factors also lead to high auxiliary consumption per kWh generated.

The Government gives high priority to improving PLN's operating efficiency. To formalise these efforts, an action plan was prepared by PLN for energy loss reduction, fuel consumption reduction, oil substitution, improved maintenance of power plants, rehabilitation of old power stations, power factor
correction, distribution system rehabilitation and upgrading, inspection of consumer premises, kWh meter calibration, and improved billing procedures. Since the introduction of this action plan in September 1986, significant improvements in PLN's generating efficiency have been achieved.

System Expansion

A ten-year energy sales projection prepared by PLN in December 1987 envisaged an average annual growth rate of 12.2%. According to this projection, the sales in Java are expected to grow at a rate of 11.8% per annum, to 35,364 GWh in FY96; and those in the other islands to 11,236 GWh, at a growth rate of 13.4% per annum.

In line with these projections, PLN adjusted its power development plan. The total installed capacity (including purchases), is expected to increase to 13,120 MW by March 1997. The resulting capacity growth rate of about 7% per annum (from FY86 to FY96) is considerably below that of the energy sales of 12.2%. This is attributable to the envisaged reduction of the reserve margin from 90% to 33%, and a decrease in energy losses from 24% to 18% - improvements expected from PLN's ongoing efficiency improvement action plan.

The plant mix is also expected to undergo major changes in the
planning period to FY96 - in line with the Government's diversification policy. The share of oil-based capacity is expected to decrease sharply from 63% in FY86 to 25% in FY96. With a share of 28% and 27%, respectively, coal-fired steam and hydropower plants will become the largest generating sources, particularly in Java. The rest of the capacity will be provided by gas-fired steam and gas turbine plants (17%) and geothermal plants (3%).

Electricity Market

Between FY74 and FY87, PLN’s energy sales increased seven times, from 2,444 GWh to 17,077 GWh. There were four periods with distinctly different growth patterns:

(i) FY74 to FY77, when the sales growth averaged about 13% per annum;

(ii) FY78 to FY82, when PLN’s load connection program was accelerated because of an improved supply capability, with the sales growth exceeding 20% per annum;

(iii) FY83 to FY84, when the average growth rate dropped to about 10% per annum because of a
general economic recession and relative slow down of new connections; and

(iv) FY85 to FY87 when the growth rate averaged about 16% per annum.

The energy sales growth during FY85 to FY87 has been attributable to a steady growth in the average consumption per consumer. The latter increased from 2,081 kWh in FY74 to 2,250 kWh in FY87, mainly as a result of the increased pace of the rural electrification program [PLN, 1989].

In FY87, Java accounted for about 80% of PLN's total sales. However, energy sales outside Java have increased slightly faster than in Java, at 17.4% compared to 15.8% in Java from FY74 to FY87.

The share of sales to various consumer categories in FY87 was as follows: 37% to residential consumers; 43% to industry, 11% to the public sector; and 9% to commercial establishments. Electricity sales to industrial consumers have grown most rapidly in the past five years, from 3,440 GWh in FY83 to 7,402 GWh in FY87, at a rate of 21.1% per annum. Sales to residential (low voltage) consumers increased at a substantially lower rate of 10.5% per annum, from 4,290 GWh to 6,390 GWh during the same
period. Nevertheless, the residential sector still accounts for more than one-third of PLN’s total sales, and contributes to the high distribution losses. This shows that one significant market for renewable energy technologies should be the industrial consumers as the actual and potential growth rate in energy demand is highest here. One can also conclude that the emphasis on residential consumers should be reduced.

3.3 Rural Electrification

According to PLN, 80% of Java is covered by the National grid. This differs from the World Bank figure of 60% and the USAID figure of less than 70% (this difference is due to the vague definition of what constitutes an electrified village, i.e. the percentage of units that have electric connections). Other islands have isolated grids which generally cover one town at a installed capacity of 300 kW to 1 MW. There are approximately 66,000 villages [USAID-Jakarta, 1990] and less than 30% of them are electrified.{Note: 1 village approximately averages 300 households, and out of this approximately 30 households would be covered in a rural electrification scheme in the definition used by USAID.}

About 80% of Indonesia’s population (some 26 million households) live in the rural areas. From a modest beginning of rural
electrification (RE) in the early 1970s, PLN reached almost 4 million consumers in nearly 16,800 villages by March 1988, thus serving about 15% of the rural population (compared with only 5% in 1984). Average monthly consumption per rural consumer was about 40 kWh in FY87 [Gianto, 1990].

Approximately 1,600 villages have formed nearly 350 rural electric cooperatives registered with MOC, over 95% of which purchase their power from PLN. Besides the villages supplied by PLN and the cooperatives, there are more than 9,000 villages with unregistered village level utilities [Gianto, 1990]. These utilities charge tariffs substantially higher than those of PLN, although they provide a lower level of service.

According to the Ministry of Cooperatives [Gianto, 1990], the Government’s RE target of 21% of the rural population by March 1994 is ambitious but achievable. The major operational responsibility for the RE program is assigned to PLN, as neither the rural electric cooperatives nor the village level utilities have the necessary technical and manpower resources.

3.4 Tariffs

As a result of four substantial tariff increases which were far above inflation, PLN’s average rate per KWh grew from about Rp 27
per kWh in FY79 to about Rp 98 per kWh in FY84. Since then, tariffs have declined marginally to about Rp 97, Rp 94 and Rp 93 in FY85, FY86, and FY87, respectively [PLN, 1989]. However, even the steep increases in the early 1980s were not quite sufficient to improve PLN’s financial position, as they were largely offset by sharply rising domestic oil prices (which had been subsidised by the Government).

For various social and economic reasons, the Government has not approved any tariff increases since March 1984. In fact, following the reduction of domestic oil prices in July 1986, the Government directed PLN to reduce the tariff to industrial consumers by about 6% [PLN, 1989].

There is a considerable degree of cross-subsidisation between commercial categories. Large residential consumers compensate for low tariffs of small residential consumers, while commercial consumers subsidise all other consumers. As the tariff schedule is uniform throughout Indonesia, it is clear that Java cross-subsidises all other regions.

3.5 Solar pv

The potential for solar energy appears high as the average daily radiation in Indonesia is around 4 kWh/m² [Parangtopo, 1982].
Indonesia has begun to develop and test solar energy systems under the frame of bilateral cooperation between the Indonesian government, the German Government and the BPP Technologi (which is the Agency for the Assessment and Application of Technology). In addition, several institutes and companies in Germany have established and launched a joint "Solar Village Indonesia" Project [Panggabean, 1990].

The project started in 1979 and comprises:

- two pilot villages with demonstration facilities (Picon and Citris in West Java).

- a technical programme which includes all the engineering activities required to support both villages, studies on social and economic acceptance, development of other promising technical systems and investigation of the possibility of future construction of solar pv systems in Indonesia.

In Picon, a 5.5 kWp pv plant was installed to supply electricity for an irrigation pump. The solar generator consisted of mono and polycrystalline modules operated at a voltage of 60 VDC. For driving the irrigation pump's a.c. motor a conventional inverter was used.
In November 1981, heavy rainfall caused a flood in the area of Picon damaging almost all electrical equipment. Therefore it was decided to modify the pv system, and the solar generator was rewired with a working voltage of 300 VDC. This was necessary since the new inverter required a higher input voltage to form a three-phase AC output voltage.

After a two year operational period, a drop in output of the solar generator was detected. This reduction was caused by the delamination of the encapsulating foil due to the high working voltage. The delamination foil separated the interconnectors from the cells, thus interrupting the electrical connection inside the module. This experience shows that this module type is not suitable for a high working voltage. The generator is now equipped with new polycrystalline modules and now powers a drinking water pumping system [Schwenke, 87].

In July 1982, a 25 kWp pv plant was installed at Citris to supply power for a reverse osmosis desalination plant and ice making plant. Additionally, it was meant to power the monitoring equipment for both plants and to provide lights and electricity for the field station.

Two solar generators consisting of a 220 VDC pv power system with a 1.2 kWp were installed. A 220 V battery with 600 Ah capacity
buffers the system and a 24 V battery with a 200 Ah capacity supplies the data processing and the control and monitoring system for both the desalination and ice making plants. Associated with the pv system is a diesel generator set to meet the energy requirement under unfavorable conditions. Since installation, no major problems have occurred.

Additionally three demonstration plants using photovoltaic cells have been set up by the Directorate General for Power with one unit in Lampung (south Sumatra) and two in Central Java. The Ministry of Cooperatives’ Rural Electrification Programme has initiated a solar pv cooperative which is located in Central Java. This cooperative has 19 units with each house containing two 10 W lights, and 1 socket for a radio or television, with an output of 120-140 Wh. The predecessor for this project was one implemented by the Ministry of Research in 1988, the data for which was evaluated by the Ministry of Cooperatives before beginning the Central Java project. This solar pv system makes use of Dutch technology through a bilateral agreement project.

There have been small-scale pv systems in very remote areas in Indonesia since 1981 (see Fig. 16). These were used to produce potable water, as well as for home lighting, and television. On the community level, pv systems were used for refrigeration and telecommunications.
President Suharto has decided to use solar pv to improve the standard of living for the rural populations. Applications for further development are: water pumping (shallow and deep well), television, radio, solar home systems, semi-decentralised systems (mini-grid), television repeater stations, telecommunications and navigation.

The class of pv pumping systems preferred are 3 kWp, 5 kWp, and 6 kWp which is best for deep water pumping.

Future plans for solar pv systems includes a Belgium government sponsored water pumping project that starts in 1991. This is under a bilateral agreement for energy development projects.

Fig. 16: Location of installed pv systems [Source: PLN, 89]
Solar pv Policy

The Indonesian government has gone on record as stating that pv systems should not be decommissioned after the grid has been extended to the village. They should instead be put to productive use [MOC, 1990] President Suharto has had presidential initiatives on the use of renewable energy, but there is a lack of implementation strategy, and very few incentives to use renewable energy.

Local Manufacture

Indonesian companies are looking at the local manufacture of inverters, and later at locally manufacturing pv modules. Presently, Solarex, Solar Indo, Arco Solar, BP Solar, TEG, Siemens, R&S, Keosara, Fuji and TUEV Rheinland have control of this market.

Future development of local manufacturing capabilities will be through joint ventures with one or several of the above companies. However, there are no immediate plans to start local manufacture. This is part of a long-term strategy.
Criteria

In choosing sites for new pv systems, the Indonesian government uses the following criteria: no grid extension must be planned for the next 5 -10 years, or the village electrification scheme must be located at least 10 km from the grid.

Solar Thermal

The most popular application of solar thermal collectors in Indonesia is for domestic hot water production. A test collector has been developed and installed in an experimental house in Jakarta since 1978. It consists of three flat plate collectors, each having an area of 0.8 m², and hot water storage of 200 litres. The circulation of the hot water is achieved through the thermosyphon method. The hot water taken from the storage tank varies from 50 to 70° C depending on the available insolation.

Such applications have now entered the market, both imported and locally manufactured. A survey made by a solar water heater company showed that approximately 4,000 m² collector area has been installed in Jakarta. Fig. 12 shows the number and collector area of solar water heaters installed in Jakarta.
Table 11

The users of solar water heaters can be classified as:

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households</td>
<td>90.0%</td>
</tr>
<tr>
<td>Hotel</td>
<td>7.0%</td>
</tr>
<tr>
<td>Hospitals</td>
<td>2.2%</td>
</tr>
<tr>
<td>Sports Centres</td>
<td>0.8%</td>
</tr>
</tbody>
</table>

Source: Budiono, 1987

Table 12: Number and Collector Area of Solar Water Heaters (SWH) Sold in Jakarta

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of SWH (unit)</th>
<th>Collector Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>1979</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>1980</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>1981</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>1982</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>1983</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>1984</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>1985</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>1986</td>
<td>1.8</td>
<td>1.8</td>
</tr>
</tbody>
</table>
3.6 Small Hydroelectric Systems

The organized construction of these plants was begun in 1968, and by 1984 it was planned to have completed 26,385 kW: 47 units with a capacity per unit of 20-4,000 kW, with 70% of the plants having locally manufactured turbines. In Indonesia, micro hydro plants are generally run-of-river.

According to a survey commissioned by Water Power and Dam Construction in 1990, Indonesia has an exploitable small hydro potential (units of 2 MW or less) of 1400 MWh/year. Currently in operation is 12,520 kW of small hydro capacity, with a further 7,818 kW under construction.

Along with the physical construction of plants, knowledge of the technology of generating equipment has developed, including selection of the type of turbine, generator, protection and control system; standardisation of turbine design; local manufacture, quality control, testing and development at the Hydropower Laboratory at Capayung; installation; on-site testing; and operation and maintenance.

In the development of turbines for government initiated micro-hydropower plants, priority is given to the Francis type,
followed by the Pelton and propeller types.

Presently, there are 19 micro hydro sites within the 30-50 kW range (two of which are non-functional)[ITB, 1990]. Most of these were implemented by NGO’s and use German designed cross-flow turbines (Banki) with some modifications in the design such as valve and turbine rotor adjustments, and the use of local materials.

There are also projects in cooperation with the Japanese International Cooperation Agency (JICA). These include hybrid systems utilizing pv and micro hydro and hybrid systems using pv and diesel. According to PLN, there is a small potential for micro-hydro to reduce the load on pv systems.

Micro hydro Policy

When the grid is extended, government policy is that the micro hydro be connected to the grid to reduce line losses and stabilise transmission.

This supports the policy to promote non-oil based energy for electricity generation, such as coal, LPG, hydro and solar.
3.7 Biogas

In Indonesia, biogas is generally used by industries for pollution abatement. However, small scale biogas digesters have been used by rural households. The technology that seems to work best is the Indian floating dome digester rather than the Chinese fixed dome [Kristoferson, 1986]. Local modification have been done to both designs, and digesters are in place in Java, Sumatra, Bali, Ache, North Sulawesi, and Maluka. The gas is used for cooking and lighting.

There are two sizes that are relatively popular: 4-8 m$^3$ family size which costs 600,000 Rp or US$300, and the 12-18 m$^3$ community size which costs approximately US$ 700 [ITB, 90]. The family sized digester is usually in the price range of the farmer with at least 6 -10 cows.

Slaughterhouse waste has been used for biogas digesters to provide hot water and electricity. This project was accomplished in cooperation with the German government. Two kinds of reactors were used: the liquid waste fixed bed reactor (2.8 m$^3$) which uses bamboo as a support material, and the solid waste Totalimix reactor which uses cow manure and feed gas (25 m$^3$) and has a Chemical Oxygen Demand (COD) inlet with 2,000 -3,000 PPM, produces 1.2 m$^3$ to 1.8 m$^3$ methane and has 70% degradation of
organic matter. Before the biogas technology was developed for this application, the effluent was directly discharged to the river.

These reactors work well. However, there are some minor problems with the mechanics and biology. The concentration of COD is generally not high enough which lowers the performance of the reactor. In theory, the degradation should be 70-80% but in practice has been as low as 50-60% [ITB, 1990].

A measure of the purity of water is the amount of organic matter in water, as reflected by the Biological Oxygen Demand (BOD) and COD counts. Clean water should have low BOD and COD (BOD: 1-3 parts per million). Methane fermentation can reduce BOD by 92%. The hydraulic retention time of the substrate also has a favourable effect on BOD reduction. If the substrate is held in the digester for longer periods, BOD reduction is higher [FAO, 86].

Future plans for biogas digesters include examining this technology for electricity generation. However, in spite of the considerable development in biogas technology, no significant increase has been apparent in the utilisation of agri-industrial waste for biogas production.
Biomass

As a tropical country the potential for biomass energy supply has been recognized for a long time. Precise data on the economics of biomass energy supply are not yet available. Fuelwood plantations were started in 1975 and since then promising figures have been obtained. On suitable soils, Caliandra species production ranges from 70 to 120 m$^3$ per hectare per year [UN, 1988] and would be suitable for fuelwood plantations due to its rapid growth. Other species are being evaluated although on a modest scale.

Saw dust briquettes have been used, but are not popular as people prefer fuelwood which is easier to gather. Distribution problems hinder the commercialisation of briquettes made with agri-industrial waste. However, pilot projects are being introduced to improve their market potential.

Improved cookstoves have been marketed, and although they perform at higher efficiency than the old cookstoves, they also have a higher initial capital investment. Generally, price is the first consideration, not efficiency. If the price is lowered, there is great potential for these cookstoves.

The Belgium government is currently carrying out a multi-lateral
cooperation project for wood energy in Bogor at the Forest Research Institute. Wood gasification projects have been sponsored by the Italians, Germans and Belgians, but this is only at the R&D phase. Rice husk gasifiers are being developed by the Agency for the Assessment and Application of Technology (BPPT). Both technologies are being developed for industrial lighting, and in association with the wood industry for such purposes as timber drying. Most of these projects are located in Jakarta, Sumatra, Ujung Pandan, S. Kalimantan, S. Sulawesi.

The Presidential Act on Wood Gasifiers 1988 [PLN, 1989] was passed to cut through the bureaucracy and to lessen the environmental impact of fossil fuel use and deforestation. Eighty percent of the rural population uses wood as a fuel. The government has encouraged a local private company, Cokro Brothers, to develop a gasifier that could be produced locally. This they are doing in cooperation with the Italian government. Partial funding (20%) for this is covered by a national grant with the remainder financed by the Italian government.

A market study is being done to look at the commercial potential for gasifiers. The government is promoting the industrial use of downdraft gasifiers, especially in areas outside Java. Initially 30 million Rp worth of downdraft gasifiers will be imported and an additional 6 million Rp worth (which is the pilot project
price) of gasifiers will be locally manufactured. Some local modifications in gasifier technology have been developed. For example, the high flow or plastic tube has been replaced with bamboo.

Wood Gasifiers for electricity generation use an adapted form of the Fritz-Werner and Embert Design which is a fixed bed downdraft which produces 40 kWe. This design can be found in Smapit, Kalimantan, and Pitchung near Jakarta. This project was implemented by the Directorate General for New Energy and has been in operation for ten years. Local modifications have included a gas cleaning system to avoid the discharge of phenol to the surrounding environment by providing a hotter system.

3.8 Wind

In Indonesia, wind energy projects have not been successful due to severe turbine corrosion. In addition, there is a lack of wind for approximately 2-3 months per year [PLN, 1990]. However, wind energy had been used in the past for low power electricity generation on the North and South coast of Java.

LAPAN uses large scale wind energy in a hybrid energy system using anti-corrosion turbines. This technology is not heavily utilised and the future potential is doubtful.
3.9 Rational use of Energy (RUE)

The National Energy Conservation Committee, a governmental body, is to work on policy development and will issue guidelines on energy conservation. A private company, KONEBA, will be in charge of performing energy audits and will receive payment only from any energy savings generated. The Energy Research Lab, funded by the European Community, located in Surabaya also performs energy audits.

The biggest energy consuming sector is the industrial sector. Therefore, it has been the focus of energy conservation activities. The most energy intensive manufacturing industries are: fertilizers (which consumes over 8 million boe), cement (4 million boe), iron & steel (2 million boe), textiles (4 million boe), and plywood (1.7 million boe) [Widianto, 1990]. The potential savings, according to KONEBA, are seen in Table 5.

The potential energy savings are equivalent to 353,018 tons of oil per year or 17.93 million US$/year. However, it is not mandatory that industries follow the energy saving recommendations of KONEBA, so there is a failure to realise this potential.
Table 13: Potential Energy Savings in the Industrial Sectors

<table>
<thead>
<tr>
<th>Industry</th>
<th>Potential Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizers</td>
<td>15%</td>
</tr>
<tr>
<td>Textiles</td>
<td>10%</td>
</tr>
<tr>
<td>Cement</td>
<td>10%</td>
</tr>
<tr>
<td>Ceramics</td>
<td>15.5%</td>
</tr>
<tr>
<td>Iron &amp; Steel</td>
<td>20%</td>
</tr>
<tr>
<td>Tyres</td>
<td>10%</td>
</tr>
<tr>
<td>Tea</td>
<td>18%</td>
</tr>
<tr>
<td>Manufacturing Sector</td>
<td>25%</td>
</tr>
<tr>
<td>Glass</td>
<td>20%</td>
</tr>
<tr>
<td>Buildings</td>
<td>20%</td>
</tr>
</tbody>
</table>
Chapter 4  Malaysia

4.1 Energy Context

4.1.1 Consumption and Supply

Table 14 gives the primary supply of commercial energy. The average annual increase in primary supply of commercial energy in the period 1980 to 1989 was about 7.2%.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>.697</td>
<td>.771</td>
<td>1.308</td>
<td>4.605</td>
<td>4.444</td>
<td>4.525</td>
<td>4.607</td>
</tr>
<tr>
<td>Crude Oil</td>
<td>5.901</td>
<td>5.435</td>
<td>7.721</td>
<td>7.060</td>
<td>7.274</td>
<td>7.635</td>
<td>8.014</td>
</tr>
<tr>
<td>Petroleum Products</td>
<td>2.323</td>
<td>3.730</td>
<td>1.684</td>
<td>2.286</td>
<td>2.271</td>
<td>2.493</td>
<td>2.960</td>
</tr>
<tr>
<td>Coal and Coke</td>
<td>.053</td>
<td>.093</td>
<td>.270</td>
<td>.268</td>
<td>.327</td>
<td>.260</td>
<td>0.260</td>
</tr>
<tr>
<td>Hydropower</td>
<td>.383</td>
<td>.394</td>
<td>.913</td>
<td>1.070</td>
<td>1.212</td>
<td>1.288</td>
<td>1.368</td>
</tr>
<tr>
<td>Electricity</td>
<td>.007</td>
<td>.006</td>
<td>.007</td>
<td>0.0</td>
<td>-.002</td>
<td>-.006</td>
<td>0.0</td>
</tr>
<tr>
<td>Total</td>
<td>9.36</td>
<td>9.36</td>
<td>11.9</td>
<td>15.3</td>
<td>15.5</td>
<td>16.3</td>
<td>17.2</td>
</tr>
</tbody>
</table>

a/Source: National Energy Balances, Malaysia 1989 provisional
b/Net of flared gas, reinjection and LNG production

Malaysia is a net energy exporter. Table 15 shows the percentage share of indigenous commercial energy production in 1988 which was over 42.7 mtoe. Net exports accounted for 24.7 mtoe in 1988,
which represented a levelling-off in growth after significant increases averaging 24 per cent per annum over the period 1978 to 1987. This levelling of exports in 1988 was due to increases in domestic demand and to production cuts in support of OPEC's request to stabilise world oil market prices by reducing output. Net exports for 1988 largely comprised LNG (8.2 mtoe) and crude oil (20.6 mtoe) [NEB, 89].

Table 15: Indigenous Commercial Energy Production (percentage share)

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Percentage Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Oil</td>
<td>63</td>
</tr>
<tr>
<td>Coal and Coke</td>
<td>0.04</td>
</tr>
<tr>
<td>Hydropower</td>
<td>3</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>34</td>
</tr>
</tbody>
</table>

Source: NEB, 1989

The quantity of energy of all types delivered to final users is given in Table 16.
Demand for final commercial energy increased by 4.7% in 1988. The share of petroleum products in final energy demand which had been declining since 1980 increased in 1988. In 1988, the share of oil in final energy demand was 74.8% against 72.8% in 1987 and 86.9% in 1980 [NEB, 1989]. The decline had been due to the Government's fuel diversification strategy. The increase is thought to have been caused by cement plants reverting to cheaper fuel oil having previously used coal and coke.

<table>
<thead>
<tr>
<th>Table 16 - Final Energy Use by Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>(in mtoe)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>2.3</td>
<td>2.9</td>
<td>3.2</td>
<td>3.3</td>
<td>4.0</td>
<td>4.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Transport</td>
<td>2.0</td>
<td>2.4</td>
<td>2.8</td>
<td>3.3</td>
<td>3.7</td>
<td>3.9</td>
<td>4.3</td>
</tr>
<tr>
<td>Residential</td>
<td>.71</td>
<td>.83</td>
<td>.94</td>
<td>1.1</td>
<td>1.2</td>
<td>1.3</td>
<td>1.4</td>
</tr>
<tr>
<td>and commercial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-energy</td>
<td>.18</td>
<td>.27</td>
<td>.31</td>
<td>.31</td>
<td>.38</td>
<td>.36</td>
<td>.37</td>
</tr>
</tbody>
</table>

4.1.2 Reserves

Malaysia has substantial reserves of natural gas, oil and coal, as well as a large hydroelectric potential.

In terms of thermal equivalent, gas reserves are nearly four times that of the country's oil reserves, and over the past decade or so, known gas reserves have more than doubled. At the beginning of 1988, the total remaining recoverable reserves were estimated to be 1,500 million cubic metres [ADB, 87]. Gas reserves are located in three main areas: off-shore Peninsular Malaysia, off-shore Sarawak and off-shore Sabah. More than half of the total reserves are near the major consuming centres of Peninsular Malaysia. Over 80% is free (not-associated with oil reserves) gas, which lends flexibility in depletion decisions. There are good prospects for further gas discoveries, both near Peninsular Malaysia and Sarawak. The remaining recoverable oil reserves are estimated at 2.9 billion barrels (400 million mt) [ADB, 1987].

Potential coal reserves are estimated at 400 to 500 million metric tons [ADB, 1987]. The deposits are located mostly in Sarawak and are mainly lignite.

Economically exploitable hydropower potential in Peninsular
Malaysia is about 2,000 MW, most of which is expected to be developed by the year 2000. Hydropower potential in Sarawak is estimated at around 20,000 MW (87,000 GWh per annum) and a potential capacity of 5,000 MW has been indicated in Sabah [ADB, 87].

4.2 Energy Policy

The country's Fourth and Fifth Five Year Plans (1981-1985 and 1986-1990) recognised the need for the development of indigenous commercial energy resources to encourage socio-economic development. Besides developing indigenous gas and hydropower resources, objectives also include the use of locally available and imported coal to diversify the energy supply mix. Nuclear power has been considered, but is not now favored. Long-term energy objectives also include continued research on the development of non-conventional renewable energy forms, such as solar, biomass and agricultural by-products for power generation.

On the demand side, the Government is promoting energy conservation or the rational use of energy.
4.2.1 Electric Power

Institution and Structure

Electricity supply in Malaysia is principally the responsibility of two autonomous government owned public utilities and the newly privatized Tenaga Nasional Berhad (TEN). TEN is the largest of the utilities and is responsible for the generation, transmission, and distribution of electric power throughout Peninsular Malaysia, except in isolated areas. The States of Sabah and Sarawak in East Malaysia are supplied by the state-owned statutory authorities, Sabah Electricity Board (SEB) and Sarawak Electricity Supply Corporation (SESCO). Besides these utilities, several private licensees generate and supply power to isolated areas and mines.

The SEB and SESCO report to the Ministry of Energy, Telecommunication and Posts (METP) which is responsible for coordinating policy and planning for energy related matters. TEN reports to the newly formed Jabatan Bekalan Electrik (JBE), otherwise known as the Electricity Supply Department, which is a part of METP.
Supply System

Total installed generating capacity in Malaysia (excluding that by licensees), increased from about 3,105 MW in December 1983 to 5,183 MW in December 1987. Of this, about 4,530 MW (87.3%) belong to TEN, 336 MW (6.5%) to SESCO and 317 MW (6.2%) to SEB [ADB, 1987].

(a) TEN

TEN's installed capacity at the end of 1987 comprised 1,251 MW (27.6%) of hydroelectric. Steam turbine units accounted for 58.9%, gas turbine units for 8.5%, combined-cycle plants for 27.5% and diesel engines for 5.1%. TEN's total generation is shown in the following table.

Table 17: TEN's Total Generation percentage share

<table>
<thead>
<tr>
<th>Type of Power Plant</th>
<th>Percentage Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydropower</td>
<td>25.1</td>
</tr>
<tr>
<td>Oil-based thermal</td>
<td>55.9</td>
</tr>
<tr>
<td>Gas-fired plants</td>
<td>18.9</td>
</tr>
</tbody>
</table>

Source: NEB, 1988
An additional 23.1 GWh was purchased from privately operated generating units. Natural gas-based generation increased rapidly from 354 GWh in 1983 to 2,775 GWh in 1987, at a growth rate of 67% per annum [NEB, 1988]. Hydroelectric generation more than doubled during the same five-year period. These increases are in line with the Government's energy strategy of reducing dependence on oil, and developing non-oil indigenous energy sources. Additionally, TEN has power interchange arrangements with EGAT of Thailand.

(b) SESCO

The installed capacity increased from 197 MW in December 1983 to 336 MW in December 1987. Of this, nearly 110 MW was hydroelectric capacity, including a 108 MW (4x27MW) Batang Ai hydropower station commissioned in 1985. The remainder is comprised of gas turbine units but with the majority of the energy originating from diesel electric power plants which cater to the isolated areas. Total generation increased from about 513.4 GWh in 1983 to 760.8 GWh in 1987, at the rate of 10.3% per annum as shown in the Table 18 [ADB, 87].
In December 1987, SESCO’s transmission and subtransmission systems comprised 681 circuit-km of 275 kV and 33 kV lines.

(c) SEB

Installed capacity in the SEB system increased from about 216 MW in December 1983 to 317 MW in December 1987. A major addition was the 66MW (3x22MW) Tenom Pangi hydropower station commissioned in 1984; this is the only hydropower station operating in Sabah. Of the SEB’s remaining 251 MW capacity at the end of 1987, 30 MW was gas turbine units, and 221 MW diesel electric power plants.
The SEB’s total generation increased from 601.4 GWh in 1983 to 879.1 GWh in 1987, at the rate of about 10% per annum [ADB, 87].

**System losses**

(a) NEB

Auxiliary consumption (as a percentage of gross energy generation) in TEN’s power stations declined from 5.1% to 1983 to 4.1% in 1987, due largely to an increase in the share of hydroelectric generation. Transmission and distribution losses (as a percentage of net generation or units sent out) remained at around 11% during 1983 to 1987 and comprised about 10% technical losses (inadequate distribution) and 1% non-technical losses (theft). To reduce technical losses, a rearrangement of the low tension distribution network, reinforcement of the transmission system and installation of reactive power compensation equipment would be required [Rasidi, 1990].

(b) SESCO

In the SESCO system, auxiliary consumption plus transmission and distribution losses (as a percentage of gross generation) increased from about 13.2% in 1983 to about 19% in 1985, and remained at that level until 1987. Auxiliary consumption
declined from 4.3% to 2.8% during the same period [ADB, 87]. The increase in transmission and distribution losses is due largely to the extension of the grid to cover more rural and distant areas.

(c) SEB

Total losses in SEB system have been 22% or more during the 1983 to 1987. Financial losses are high, partly because of deficiencies in billing and collection procedures [ADB, 87].

System Expansion

(a) TEN

Due to a high economic growth in energy sales in 1987, TEN’s latest demand forecast has been revised upwards. Energy sales are projected to increase from 12,438 GWh in 1987 to 30,936 GWh in the year 2000, at the rate of 7.26% per annum; and peak demand to grow at the rate of 7.22% per annum [NEB, 89].

Based on this demand forecast, TEN’s capacity expansion program provides for a total installed capacity of 7,584 MW in the year 2000, comprising 1,890 MW of hydropower plants, and the rest thermal capacity [NEB, 89].
The quantity of gas-fired or oil-fired generation is difficult to project. If gas were to be available for power generation at competitive prices, then the planned trans-Peninsular Malaysia gas pipeline would be used and gas-fired power stations would become major consumers of gas.

(b) SESCO

The discovery of off-shore gas near Bintula in Sarawak has made gas an attractive resource for power generation. SESCO therefore plans to commission a 90MW combined cycle plant by 1992. According to the latest power development plan, SESCO’s capacity is expected to increase from 336.3 MW in 1987 to 593 MW in the year 2000. Major increases during this thirteen-year period are expected in gas-fired capacity, from 71 MW to 311 MW. [ADB, 87].

(c) SEB

The SEB’s installed capacity is planned to increase from 317 MW in 1987 to about 386 MW by 1995. The major addition to generating capacity is expected to be 50 MW of gas turbine capacity [ADB, 87].
Electricity Market

Electrical energy sales by the three utilities increased from 9,973 GWh in 1983 to 13,716 GWh in 1987. Although TEN's share of sales has declined somewhat in the past decade, from 1983 to 1987 its share was nearly 91% of the total sales by the three utilities [NEB, 89].

The TEN's electrical energy sales grew from 9,059 GWh in 1983 to 12,438 GWh in 1987, at an annual rate of 8.2%. The annual growth rate in energy sales between 1976 and 1980 had been higher at 11.6%, however during the 1981 to 1987 period it fell to 7.2% due in part to a slowing in Malaysia's economic growth [NEB, 89].

(a) TEN

Of TEN's total energy sales in 1987, over 42% were to industrial consumers, 33% to commercial consumers, 21% to residential consumers and the balance (less than 4%) to mining consumers and for public lighting. From 1977 to 1987, sales to the residential sector grew at the rate of 13.5% per annum, while sales to industrial and commercial consumers grew at 8.6% and 9.2% per annum respectively. Sales to other sectors, however, declined by 7.5% per annum during the same period. The high growth in residential consumption was largely due to the vigorous rural
electrification program undertaken by TEN (at that time known as the National Electricity Board of Malaysia - NEB). On the other hand, sales to other sectors declined due to a decrease in mining activity, as primary commodity prices in the international market continued to remain low.

(b) SESCO

Sales made by SESCO increased from 445.5 GWh to 616.4 GWh during 1983 to 1987. In 1987, the commercial sector accounted for about 47.5% of SESCO's total sales, the residential sector for 31.9%, the industrial sector for 14%, and other consumers for 6.6% [ADB, 87].

(c) SEB

The SEB's total energy sales increased from 468.1 GWh in 1983 to 661.6 GWh in 1987, at the rate of 9% per annum [ADB, 87].

4.3 Rural Electrification

The country's Fourth and the Fifth Five-Year Plans emphasised the implementation of rural electrification (RE) programs to improve socio-economic conditions in the rural areas. During the Fourth Five-Year Plan, RE programs benefitted about 449,400 additional
households in Malaysia: 387,200 (86%) in Peninsular Malaysia, 37,700 (8%) in Sarawak and 24,500 (6%) in Sabah. By the end of 1985, about 68% of the rural population had access to electricity, compared to 48% in 1980. By December 1987, over 85% of rural households in Peninsular Malaysia, and 21% in Sabah, had electricity service connections. The total number of households electrified in Malaysia (both East and West) was 749,627 and the total number of villages electrified were 10,599 for the period 1986 to 1987. For Sarawak, it is anticipated that nearly 49% of the rural population will be covered by RE programs by the end of the Fifth Plan in 1990 [ADB, 87].

4.4 Tariffs

(a) TEN

TEN's consumers are classified into twelve categories. Both TEN and the Government review the tariffs every six months, and if necessary adjust them accordingly, taking into account fuel prices as well as TEN's financial performance. The latest adjustment in TEN's tariff structure was introduced in September 1985 and consisted of the following:
(i) introducing time-of-day rates for certain medium voltage commercial and high voltage industrial consumers;

(ii) suppressing the increasing kWh blocks in low and medium voltage non-residential rates: only residential consumers are now subject to increasing block tariffs;

(iii) adjusting relative prices for various consumer categories; and

(iv) introducing a new voltage category for customers directly connected to the transmission line.

Because of a substantial decrease in fuel oil prices, in March 1986, TEN reduced electricity charges to hotels, textile and mining consumers, by way of discounts ranging from 10% to 20% of total charges. However, there is a fuel cost variation charge (FCVC) in the tariff schedule. Further downward revisions in NEB's tariff rates also occurred, and its average revenue per kWh sales declined from M$0.20 in 1986 to M$0.18 in 1987.
(b) SESCO

The most recent major reform to SESCO's tariffs was introduced in 1978. This reform accomplished the following:

(i) abolished tariff differentials related to the type of use in the residential sector;

(ii) re-grouped the previous sub-groups of commercial consumers into a single tariff;

(iii) re-grouped water works and industrial tariffs;

(iv) introduced high voltage commercial and industrial tariffs; and

(v) reintroduced a fuel cost variation charge (FCVC) as the basis for adjusting tariff levels.

After 1978, SESCO's tariffs were revised largely under the effects of FCVC. In March 1986, a 10% discount was offered to licensed hotels and industrial consumers. SESCO's average revenue per kWh sales declined from M$0.2976 in 1985 to M$0.2798
SESCO's tariff structure differentiates by region. Rates for small and remote load centres are M$0.03/kWh higher than rates for the major load centres [ADB, 87]. This brings additional income to finance rural electrification programs.

(c) SEB

SEB's tariffs were revised in April 1986. The revisions included:

(i) reducing customer classifications from nine to six by eliminating tariff differentials based on type of use in the commercial sector;

(ii) introducing a two-part tariff for commercial consumers of more than 500 kW;

(iii) raising the lower limit of the industrial two-part tariff to 500 kW; and

(iv) incorporating the prevailing FCVC into the tariff.
The SEB's average revenue per kWh sold declined from M$0.2941 in 1984 to M$0.2611 in 1987 [ADB, 87].

4.5 Solar Energy

In Malaysia, local conditions favour the use of solar energy (pv and thermal) as an alternative energy source. The country is located between 1°N and 7°N of the Equator with daily temperatures ranging from 20°C to 35°C. The average daily total solar radiation recorded over various sites in Malaysia by the meteorological offices is about 4.5 kWh/m² [BP Solar, 1990].

At least 90% of solar energy projects are implemented by the public sector. The private sector is hesitant to use solar energy, as they consider the capital cost to be high compared to other developed energy sources available. Existing and potential end-users are uncertain of the reliability and cost effectiveness of using pv, as the market is still in its infancy. Currently STM (Telecoms Malaysia) and the Marine Department are the biggest users of pv systems, and it would appear they are convinced of its viability by the fact that they have annual contracts for purchasing pv systems. TEN, SESCO, and SEB, apart from the planning and operation of bulk electricity supply, are also entrusted to provide small-scale dispersed pv electrical energy systems for rural electrification.
The Standards and Industrial Research Institute of Malaysia (SIRIM) does studies on special request projects utilising renewable energy, and has a few on-going projects in the fields of solar energy, biogas and fluidised waste combustion. SIRIM is the technical counterpart of the ASEAN/Australia Sub-Committee on Non-Conventional Energy Research, and as such does research with the Universiti Sains Malaysia, The Universiti of Malaya, and the Universiti Kebangsaan Malaya. The Japanese Government is instrumental in the field of technical cooperation. Most of the solar energy projects undertaken by the above organisations have been funded by the Japanese Government.

SIRIM is currently researching only three applications of solar energy: solar heating, solar street lighting and solar water pumping for agricultural use. Solar energy studies at SIRIM are very limited due to the following perceptions.

1. It has a high initial capital investment and,

2. The panels and solar batteries must be imported which increases the cost.

In addition to solar pv systems for rural electrification, there is an interest in solar powered highway lighting, signalling, and
warning lights, and also the use of solar energy to power cameras to photograph speeding violators and errant drivers. This is being studied and developed by the private sector in conjunction with multi-national organisations [Mat Khair, 1990]. The Malaysian Highway authority has utilised solar energy for hazard lighting on the North-South Highway, but these were quickly vandalised. These systems were redesigned by Shell to contain a portable solar power system in one light post, however it is doubtful that these will become commercial in Peninsular Malaysia due to the very good infrastructure and the 80%-90% coverage by the national grid [Chang, 1991]. Street lights powered by solar energy are not economically competitive compared to those powered by conventional means.

Solar powered telephones have also been developed and are being utilised by the Ministry of Energy, Post and Telecommunication and Syarikat Telekom Malaysia (STM) Berhad. It is reported that STM is probably the biggest user of pv systems in Malaysia [NST, 90]. In addition to rural telecommunications systems such as solar powered radio phones and time divided multi-access cellular phones, they are also applying pv systems to microwave repeater stations. There are a few islands utilising solar power for rural electrification located off the east coast of West Malaysia. Pulau Aur, has approximately 60 homes that utilise solar energy for lighting; the system is shortly to be upgraded
to include water pumping and the electrification of additional homes.

There is interest on the part of government officials to look into the use of solar photovoltaic energy, but only if it is competitive with conventional power supplies, not only in economic terms but in the time it takes to implement a project. A diesel generator can be sized, manufactured and on-line in a matter of weeks, and in places where rural electrification is a sensitive political issue this can mean the difference as to whether solar pv systems are used or not.

However, in the present five year plan, one hundred million ringgit has been set aside to provide rural electricity, most of which is likely to be spent on solar pv systems.

4.5.1 Solar-Powered Water Pumping Systems

Malaysia’s first ever solar powered water supply was launched in 1984 in Perlis. The plant can generate power to pump 36.4 litres of water per-minute from a 60 metres deep well. Water from the plant is now being supplied direct to a school, a mosque and a clinic, with the excess water being stored in a 72,000 litre capacity tank. The electrical components which were used in the plant were designed and tested locally. The plant is running
very well, and continuing economic and performance evaluation of the system is being carried out by the Public Works Department.

4.5.2 Solar Thermal Usage

The dominant application of solar thermal energy is for hot water production. In this field, there are ten viable local companies: two of which, SolarMate and SolarHart, locally manufacture systems that are more economical than the formerly imported systems. Customer financing is available so the technology is affordable; however, the main consumers are still the middle-income families. There has been an excellent consumer awareness program that has been developed by SOLCO, a local company that produces solar hot water heaters.

Many local property developers have included solar hot water heaters in the design of new residential homes. The price of the home is only slightly more expensive than those without and the fact that the system will provide "free hot water" is a big selling point.

Other applications that have been studied are: sterilisation of soil for greenhouses and other botanical/agricultural applications, sterilisation of air for medical equipment, and
heating of water for swimming pools.

4.6 Small Hydro

The Mini Hydro Department of NEB was formed in late 1979 as a unit involved in the development of mini-hydro power projects in Peninsular Malaysia with the following objectives:

1. To give a 24 hour supply of electricity to isolated rural areas where there is no electricity supply.

2. To replace diesel stations in rural areas with a view to providing a 24-hour supply.

3. To stabilise the voltage in areas where large fluctuation can occur.

By 1989, the department has initiated 41 projects, of which 25 projects are operating very satisfactorily, 2 pilot projects are experiencing technical problems and the others are at various stages of implementation. The generation from these stations totalled 17.6 GWh per annum.

Currently, there remain very few mini hydro sites that meet the initial criteria [Rashidi, 1990]. Therefore, the department is
venturing into the field of small hydro, of which there are very few in Malaysia. A total of 16 potential small hydro sites with capacities ranging from 2 MW to 20 MW has been identified. The total capacity of the 15 sites is estimated to be about 163 MW, with an annual generation of about 550 GWh [Rashidi, 1990]. Financing for these projects still has not been approved, but investors are being sought under a BOT or BOO scheme.

Currently, there are 3 small hydro systems (1000-5000 kW) which are used to support the national grid both to improve stability and also as a backup in the event of line outages. Most applications are high head, costing typically US$400/kW [TEN, 1991] compared to low head sites which cost US$2,000/kW.

4.7 Biomass

Wood is used mainly by rural communities for cooking and heating purposes. Biomass constitutes less than 5% of total energy consumption [MEPT, 1982] although amounts of agricultural waste produced each year are substantial. The energy available from oil palm shell and fibre is estimated to be an equivalent of 11,600 barrels of oil per day. In 1989, 1 million tonnes of charcoal was produced [MEPT, 1990].

Biomass energy is used extensively in industry. Five million
tonnes of wood per year are used in the tobacco curing industry alone. The Palm Oil Estates make use of palm oil trees for direct combustion, and the heat is used in the refinery, and for drying rubber products and ceramics which are subsidiaries or joint ventures of the palm oil industry. Dendrothermal generation (the utilisation of wood to produce electricity) is rarely used.

Palm oil fibre and shell is used as a fuel for steam turbines, for the production of electricity. Excess electricity could then be sold to the grid.

There are two private companies producing charcoal from palm oil shell and fibre. In Malaysia there is no real need to commercialise the technology for use in the palm oil industry. The amount of energy needed to process one ton of FFB (fresh fruit bunch) is only 16-20 kWh and 10-60 tons are processed a day. As biomass, contributes only 5% of the total energy consumption, the future market for palm oil shell charcoal is negligible.

Some research has been done on the use of palm oil as a substitute for diesel fuel. This is done by converting palm oil into methyl esters. In order for this method to be commercial the price of petrol must be over US$40 per barrel [Selvam, 1991].
Most methyl esters are used as a feedstock rather than a fuel. However, in field trials no problems were reported by drivers. Engine performance was similar to that run on diesel fuel. Final inspection of critical components such as pistons, rings, liners, bearings, etc, showed normal wear and tear. Problems encountered included excessive fuel dilution of the engine oil, but this was due to improper high pressure pipe joints which was subsequently rectified [Palm Diesel Exhaustive Field Trial, 1989].

Wood gasification is being studied to see how feasible it would be for the palm oil industry.

**Biogas - Malaysia**

Table 20 shows the livestock census for five categories of livestock. It is estimated that the total biogas available per year in West Malaysia from this sector is about 570,000 barrels of oil equivalent.

From an environmental and social viewpoint piggery waste stands out as the most problematic of all livestock waste. It is in this sector that biogas technology could be introduced to fulfill the dual role of treatment and utilisation. Except for a few small-scale biogas plants in the State of Kedah, Kelantan, Selangor and Penang, utilisation of biogas derived from animal
wastes in Malaysia is minimal. This is mainly due to the availability of inexpensive and highly subsidised alternative fuels.

<table>
<thead>
<tr>
<th>Period</th>
<th>Buffaloes</th>
<th>Oxen</th>
<th>Sheep</th>
<th>Goats</th>
<th>Pigs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1967</td>
<td>238,000</td>
<td>286,000</td>
<td>37,000</td>
<td>308,000</td>
<td>601,001</td>
</tr>
<tr>
<td>1968</td>
<td>227,000</td>
<td>286,000</td>
<td>36,000</td>
<td>321,000</td>
<td>692,000</td>
</tr>
<tr>
<td>1969</td>
<td>225,000</td>
<td>300,000</td>
<td>39,000</td>
<td>320,000</td>
<td>678,000</td>
</tr>
<tr>
<td>1970</td>
<td>233,000</td>
<td>301,000</td>
<td>38,000</td>
<td>333,000</td>
<td>725,000</td>
</tr>
<tr>
<td>1971</td>
<td>215,000</td>
<td>317,000</td>
<td>37,000</td>
<td>322,000</td>
<td>742,000</td>
</tr>
<tr>
<td>1972</td>
<td>205,000</td>
<td>330,000</td>
<td>40,000</td>
<td>310,000</td>
<td>733,000</td>
</tr>
<tr>
<td>1973</td>
<td>201,000</td>
<td>334,000</td>
<td>41,000</td>
<td>304,000</td>
<td>745,000</td>
</tr>
<tr>
<td>1974</td>
<td>204,000</td>
<td>363,000</td>
<td>43,000</td>
<td>310,000</td>
<td>790,000</td>
</tr>
<tr>
<td>1975</td>
<td>213,000</td>
<td>380,000</td>
<td>45,000</td>
<td>329,000</td>
<td>1157,000</td>
</tr>
<tr>
<td>1976</td>
<td>212,000</td>
<td>412,000</td>
<td>47,000</td>
<td>332,000</td>
<td>1308,000</td>
</tr>
<tr>
<td>1977</td>
<td>211,000</td>
<td>428,000</td>
<td>52,000</td>
<td>332,000</td>
<td>1186,000</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>217,000</td>
<td>340,000</td>
<td>41,000</td>
<td>320,000</td>
<td>851,000</td>
</tr>
</tbody>
</table>

SOURCE: Department of Statistics, 1979
Table 20: Livestock Census

An agro-waste of significance which has the best potential for biogas generation is palm oil mill effluent (POME) generated by the Malaysian palm oil industry. Malaysia is the world’s largest producer of palm oil in the world, accounting for some 40% of the total. In 1977, West Malaysia alone produced 1.47 million tons of crude palm oil. This amount is expected to rise at an annual increase of 10%.
In 1977, some 4.4 million tonnes of POME were discharged into water courses, estuaries or the sea. POME is characterised by its high BOD and low liquid content posing serious environmental problems to the country. Regulations for the control of this discharge are provided for under the Environmental Quality Act of 1974. This gives the much needed impetus to the palm oil industry to utilise this technology for the treatment of the mill effluent. Studies have indicated that biogas of about 130,000 barrels of oil equivalent could be obtained through anaerobic digestion of the palm oil mill effluent.

Several plantation groups are currently working on anaerobic digestion of the POME to meet national environmental discharge standards. The system is designed for a 20 ton mill (20 t FFB/hour for 20 hours/day). Based on 0.6 tons effluent/tons FFB processed, the total cost of the system excluding land cost is about M$600,000 inclusive of 3 digesters, 2 acid ponds, 1 cooling pond, 1 aerobic pond, 2 aerators, pumps, pipelines fencing, etc. The cost of the three digesters is approximately M$250,000.

It has been estimated that a 60 FFB tonnes/hour mill will generate about 12,000 m³ of gas/day, which when used as a fuel for reciprocating gas engine coupled to an alternator, would generate about 770 kWh of electricity.
4.8 Wind

At present, the use of wind turbines in Malaysia is negligible. The potential of wind systems for rural areas in Malaysia could be a viable option for mechanical energy applications such as water pumping, and to produce low power electricity in rural areas on the East coast of West Malaysia and in some areas of Sabah and Sarawak. Such a system would have to be cyclone resistant. Natural resource data would have to be developed before these projects could be considered, thus delaying any implementation for at least five years while this information is compiled and analysed.

4.9 Rational Use of Energy

Energy conservation activities in Malaysia started in 1983. Many government agencies and the private sector were involved in promoting and implementing energy conservation activities, but they were poorly coordinated. In 1984, three Japanese experts and four Malaysian counterparts completed the energy diagnosis of nine different factories. The studies were funded by the United Nations Industrial Development Organization (UNIDO). Unfortunately, no follow-up action has been taken.
A programme on screening the energy use in industry was formulated by SIRIM in 1985. Questionnaires were circulated to approximately 40 selected industries in the establishment of an Energy Consumption Reference. Since the questionnaires requested very detailed information on energy use and production, the return rate was low (10%) [SIRIM, 90].

The establishment of an Energy Consumption Reference was continued by the Ministry of Energy, Telecommunications and Post in 1986. A simple questionnaire was circulated to approximately 200 factories and the return rate was better (40%).

Currently a few R&D programmes exist on energy conservation in the industrial sector. The most notable is in the palm oil processing and petroleum industries, carried out at the University of Malaya and the Technical University of Malaysia.

Apart from these there are also institutions related to particular industries, such as the Rubber Research Institute of Malaysia, the Palm Oil Research Institute of Malaysia, National Electricity Board (NEB), and SIRIM, which carries out programmes according to the needs of the industry. A study is being done by National Electricity Board to quantify the effect of an energy conservation programme on the use of fuels (oil, gas, electricity) at the national level in terms of avoided cost and
revenue to justify such a programme.

The NEB has to evaluate in economic terms the revenue generated from greater use of electricity to the costs incurred to generate more electricity in terms of building new power plants. A few years ago when plant capacity was low the NEB was encouraging conservation/efficiency but this is not the case now as Malaysia has a capacity surplus. In the private sector, most of the major companies have already invested in energy savings measures in the past five years.
Chapter 5 Philippines

5.1 Energy Context

5.1.1 Consumption and Supply

Between 1979 and 1985, commercial energy supplies and requirements in the Philippines declined from 12.3 mtoe to about 10.9 mtoe, then rose marginally in 1986 and substantially in 1987. Total commercial energy supplies were about 12.4 mtoe in 1987 [ADB, 87].

Several factors are responsible for this trend, including low GDP growth in the early 1980's and a decline in real GDP in the 1984-1986 period. The impact of the Government's demand management measures, and increased use of non-conventional energy sources, particularly agricultural waste and bagasse, also contributed to a decline in commercial energy requirements. It is estimated that about 2.2 mtoe of agricultural waste and bagasse supplies were available in 1987 [OEA, 89].

Indigenous commercial energy supplies increased from less than 0.5 mtoe in 1973 to 3.3 mtoe in 1987. Besides the production of indigenous coal, geothermal and hydroelectric energy, modest amounts of oil have been produced since 1979. As a result of the latter, dependence on imported oil
Fig. 20: Map of the Philippines
declined from 95% of the total commercial energy requirements in 1973, to about 72.5% in 1987. The 1987 commercial energy supply mix is shown in table 20. In addition, 1.1 mtoe of geothermal energy, 1.3 mtoe of hydropower, and 2.9 mtoe of fossil fuels were used for power generation in 1987 [OEA, 89].

Table 20: Commercial energy supply mix percentage share

| Source: OEA, 1989 |

Available data on final commercial energy consumption shows that industry continues to be the major energy consuming sector (see table 21).
Table 21: Final Commercial Energy Consumption (percentage share by sector)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
<td>44.2</td>
</tr>
<tr>
<td>Transport</td>
<td>35.8</td>
</tr>
<tr>
<td>Other Sectors</td>
<td>4.9</td>
</tr>
<tr>
<td>Res./Commercial</td>
<td>14.8</td>
</tr>
</tbody>
</table>

Source: OEA, 1989

5.1.2 Reserves

The Philippines' indigenous energy resource base is diverse. A 1983 estimate puts proven oil reserves at 2.2 million metric tons and natural gas reserves at 0.323 mtoe [OEA, 89]. After a promising beginning in oil production in 1979, output declined, but, since the Gulf War of early 1991, production is expected to increase. Due to the government's financial crisis and political instability, further exploration and development of oil and gas fields is expected.
Of the approximately ten known coal bearing regions, those of commercial interest are at Cebu, Polullo-Bataan, Surigao, and Zamboanga del Sur. Proven reserves of lignite, sub-bituminous coal and hard coal are estimated at about 369 million metric tons. Prospects for developing some coal fields are considered promising, although only limited activity has occurred in recent years. Indigenous coal production has not met demand, partly because the quality of coal produced (low BTU, high ash) differs considerably from that in demand (high BTU, low ash). In 1987, imported coal (about 0.62 million metric tons) accounted for about 30% of the total coal consumption.

The Philippines has extensive reserves of geothermal energy, and about 900 MW of geothermal power has been developed so far. Due to the archipelagic character of the country, and mismatch between demand for power and geothermal availability on various islands, existing geothermal capacity is not used fully. This is particularly true of the existing 234 MW capacity in the Visayas region. It is expected that under-utilisation will persist for a few more years, although the interconnection of Negros and Panay and the planned interconnection of Negros and Cebu will increase the market for geothermal energy. Commitment to the development of large geothermal resources in Leyte, where at least 800 MW can be readily developed for providing electric power to the Luzon market, is now lacking as it requires
underwater cables and long overhead transmission lines, and due to security reasons may compromise the reliability of power supplies to the Metro Manila region.

Of the known hydropower potential in the country of about 10,000 MW, less than 2,150 MW was developed by 1987 [OEA, 89]. However, increased development of the country’s hydropower resources is expected to maintain the Government’s policy of developing indigenous energy sources.

5.2 Energy Policy

Imported oil still accounts for a major share of commercial energy requirements (71% in 1987). As dependence on oil increases the country’s vulnerability to oil price fluctuations in the international market, the Government adopted an energy policy aimed at reducing oil imports. The strategy is based on two objectives:

(i) changing the structure and level of energy supply and demand to make the country less dependent on imported fuels and external conditions; and

(ii) developing an institutional framework for more effective management of energy demand and supply.

The first objective is being pursued by the development of
indigenous energy resources such as coal, oil, hydropower and geothermal energy, as well as non-conventional sources. The sources of oil imports are also being diversified. In 1973, more than 90% of the country's oil imports were obtained from three countries in the Middle East. Since then, supply agreements have been negotiated with the People's Republic of China, Malaysia, Indonesia and other countries. More than ten countries supplied oil to the Philippines in 1987.

In addition, the Government also regulates demand, partly to moderate the economy's import dependence, as well as to lessen the adverse impact on the balance of payments. As a percentage of foreign exchange earnings through commodity exports, the energy import bill declined from 40% in 1983 to 22% in 1987. The main instrument for moderating energy demand was the pricing policy (until the fuel price increase and rollback in September 1987, the Government passed on to the consumers all increases in energy costs). At the same time, programs for encouraging energy conservation and fuel substitution (through public education and financial incentives) were also introduced.
5.2.4 Electric Power

Institutions and Structure

(a) National Power Corporation (NPC)

NPC, formerly under the jurisdiction of the Ministry of Energy (MOE), was placed under the office of the President in April 1986. NPC is a non-profit corporation, and in 1972, was given total responsibility for the construction and eventual operation of all power generation facilities in the country, as well as for the establishment of island power grids. In July 1987, NPC's exclusive generation rights were withdrawn. At the end of 1987, NPC operated 5,788 MW, or 89% of the total installed generating capacity [Heruela, 91]. Electricity distribution is the responsibility of private utilities and electric power cooperatives.

(b) MERALCO

The Manila Electric Company (MERALCO) is the largest distribution utility in the country, and holds the franchise for power distribution in the metropolitan area. Between 1983 and 1987, with the government-initiated takeover of a number of cooperatives, MERALCO's franchise area doubled. It now covers nine cities and 96 municipalities within a
radius of about 60 km [Heruela, 91]

(c) Others

Other major private utilities operating on various islands in the Philippines are:

(i) the Angeles Electric Corporation, San Fernando Electric Light and Power Company, and the Philippines Power Development Company in the Luzon region; and

(ii) the Visayan Electric Company, and the Panay Electric Company in the Visayan region; and

(iii) the Davao Electric Light and Power Company, and the Cagayan Electric Power and Light Company in the Mindanao region.

Power distribution in the rest of the country is undertaken by smaller private and municipal utilities, and by 118 electric power cooperatives.

(d) NEA

The National Energy Administration (NEA) is responsible for the rural electrification program. It oversees the establishment of electric power cooperatives and provides
them with both technical and financial assistance. The 118 cooperatives established so far includes many small systems previously operated by private and municipal power utilities. The NEA is responsible to the Department of Environment and Natural Resources.

(e) OEA

The Office of Energy Affairs (OEA), which was created in June 1986, was assigned primary responsibility for the formulation, planning, monitoring, implementation and coordination of policies and programs in the field of energy, including the power sub-sector.

Supply System

The total installed generating capacity in the country at the end of 1987 was about 6,477 MW, 89% of which was owned by NPC. Of NPC’s installed capacity of 5,788 MW, 4,111.2 MW was in Luzon, 600.5 MW in Visayas and 1,076.2 MW in Mindanao. The grids on the various islands of the three regions (Luzon, Visayas and Mindanao) are not interconnected, thus the installed generating capacity in these regions is an indication of the relative size of the power market in each region [ADB, 87].
The NPC’s total installed generating capacity (see table 22) registered a growth rate of 3.7% per annum. During 1987, no generating capacity was added to the NPC systems. In December 1987, NPC’s capacity consisted of 2,365 MW (40.9%) of oil-fired capacity, 2,124 MW (36.7%) of hydropower capacity, 894 MW (15.4%) of geothermal plants and 405 MW (7%) of coal-fired thermal plants [ADB, 87].

Table 22: NPC’s Installed Generating Capacity (percentage share in 1987)

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>40.9</td>
</tr>
<tr>
<td>Hydropower</td>
<td>36.7</td>
</tr>
<tr>
<td>Coal</td>
<td>7</td>
</tr>
<tr>
<td>Geothermal</td>
<td>15.4</td>
</tr>
</tbody>
</table>

Source: ADB, 1989

MERALCO and most electric cooperatives, as well as large electric consumers, purchase most of their power requirements from NPC. Although NPC did not add to generating capacity in 1987, NPC’s energy generation
increased by nearly 9% in that year, from 19,263 GWh in 1986 to 20,995 GWh in 1987. The operations by regions of NPC, MERALCO and electric power cooperatives in 1987 are summarised in the table below [ADB, 87].

Table 23: Generation and Sales, by Region (GWh)

<table>
<thead>
<tr>
<th></th>
<th>Luzon</th>
<th>Visayas</th>
<th>Mindanao</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NPC</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-generation</td>
<td>16,008</td>
<td>1,688</td>
<td>3,262</td>
<td>20,958</td>
</tr>
<tr>
<td>-sales</td>
<td>14,688</td>
<td>1,488</td>
<td>3,116</td>
<td>19,292</td>
</tr>
<tr>
<td>[system losses]</td>
<td>8.2%</td>
<td>11.8%</td>
<td>4.5%</td>
<td>7.9%</td>
</tr>
<tr>
<td><strong>MERALCO</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-generation</td>
<td>260</td>
<td></td>
<td></td>
<td>260</td>
</tr>
<tr>
<td>-purchases</td>
<td>11,367</td>
<td></td>
<td></td>
<td>11,367</td>
</tr>
<tr>
<td>-sales</td>
<td>8,828</td>
<td></td>
<td></td>
<td>8,828</td>
</tr>
<tr>
<td>[system losses]</td>
<td>24.1%</td>
<td></td>
<td></td>
<td>24.1%</td>
</tr>
<tr>
<td><strong>Electric Power Cooperatives</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-generation</td>
<td>58.7</td>
<td>20.4</td>
<td>6.2</td>
<td>85.3</td>
</tr>
<tr>
<td>-purchases</td>
<td>1,321</td>
<td>577</td>
<td>867</td>
<td>2,765</td>
</tr>
<tr>
<td>-sales</td>
<td>937</td>
<td>482</td>
<td>710</td>
<td>2,129</td>
</tr>
<tr>
<td>[system losses]</td>
<td>32.1%</td>
<td>19.3%</td>
<td>18.7%</td>
<td>25.3%</td>
</tr>
</tbody>
</table>

SOURCE: ADB, 1987

The NPC's generation increased from 18,682 GWh in 1983 to 20,995 GWh in 1987 (see Table 24), at the rate of 3% per annum. Oil-based generation declined from about 11,514 GWh in 1983 to 9,183 GWh in 1987, i.e., by about 20% [ADB, 87]. This was made possible by an increase in hydroelectric and coal-based generation, as well as from geothermal sources, during the 1983 to 1987 period.

Luzon accounted for 76% of NPC's total generation in 1987. About 53% of Luzon's generation was derived from oil-fired
steam power plants, about 23% from geothermal plants, 12% from coal-fired plants, and the remaining 12% from hydropower plants. In Mindanao, which accounted for 16% of NPC’s total generation in 1987, most of the supply was provided by hydropower plants (more than 99%) while the rest was generated by diesel power plants. The NPC’s generation in Visayas accounted for just over 8% of the total in 1987; however, other than Cebu, each of the major islands grids in Visayas is heavily dependent on a particular generation source (Negros, Leyte and Samar on geothermal; Panay and Bohol on diesel). The generation mix is expected to be diversified when the planned inter-island connections (in Visayas) and expansion of the transmission networks are completed [Abano, 91].

Table 24: NPC’s Generation Mix
(percentage share in 1987)

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>43.7%</td>
</tr>
<tr>
<td>Geothermal</td>
<td>21.5%</td>
</tr>
<tr>
<td>Coal</td>
<td>9.8%</td>
</tr>
<tr>
<td>Hydropower</td>
<td>24.9%</td>
</tr>
</tbody>
</table>

Source: ADB, 1989
System Losses

The relatively short transmission distances for most of the load in each grid tends to keep the level of transmission losses low. In 1987, NPC's transmission losses averaged 3.2% of gross generation in all three regions - 3.1% in Luzon, 2.3% in Visayas and 4.0% in Mindanao. Auxiliary consumption in NPC's power stations averaged 4.7% of gross generation in 1987. Inter-regional differences in auxiliary consumption were significant, 5.2% in Luzon and 9.5% in Visayas in 1987, where the bulk of the generation is thermal; and 0.5% in Mindanao, which relies mainly on hydropower. Power plant auxiliary consumption is higher in Visayas compared to Luzon because the former has several small generating stations [Abano, 91].

Overall system losses, both technical (due to inadequate transmission and distribution) and non-technical (illegal tapping of distribution lines, incorrect billing and metering, non-payment of utility bills), are high in many distributing utilities and electric power cooperatives. For example, in 1987, transmission and distribution losses in the MERALCO system were about 24% of gross generation plus purchases from NPC. The average line losses in all electric power cooperatives were 25% in 1987, and some cooperatives had losses as high as 50%. The average loss level for cooperatives in Luzon was about 32%. According to ADB
estimates, line losses in the range of 7-9% are considered reasonable. The high system losses result in high tariffs to recoup some of the lost revenue, and inadequate total revenue to ensure satisfactory performance of the private/municipal utilities and the NEA. The largest component of losses is non-technical losses, resulting from authorised or fraudulent use of electricity.

System Expansion

The NPC's recently revised load projections show an annual average growth in energy generation of 8.2% from 1988 to 1993. Growth of energy generation in Luzon is projected at 7.8% per annum; and in Visayas and Mindanao, at 8.7% and 9.6%, respectively. Growth in the latter region is higher than in Luzon as a result of the considerable scope for rural electrification in Visayas and Mindanao, as only 35% to 40% of households are served by electricity. During the same period, 1988 to 1993, peak demand is expected to grow at 7.8%, 7.3% and 11.7% per annum in Luzon, Visayas and Mindanao, respectively. These load projections were developed using a set of detailed econometric models, and have been used by NPC as a basis for preparing its Power Development Program (PDP) [Abano, 91].

The NPC's PDP extends beyond 1993 to the year 2000, and includes the commissioning of about 2,450 MW of generating
capacity (all thermal), including 2x300 MW coal-based thermal units, which are expected to come on line in 1993 [Abano, 91]. However, owing to Government policy favouring development of indigenous coal over coal imports, and a lack of data on the economic cost of local coal, the plans for future coal-fired thermal plants may not accurately reflect an economic least-cost development scenario. Future commitment to coal-fired plants is still some years away due to the low quality of domestic coal, and studies to examine alternatives, such as using imported coal, are envisaged by NPC.

The development of geothermal resources for power generation is also emphasised. According to the latest PDP, nearly 1,650 MW of geothermal capacity is to be commissioned from 1988 to 2000 [NPC, 91].

The Government's decision not to operate the sole nuclear power plant (620 MW) has committed NPC to alternative base load generating capacity - the Calaca II 300 MW coal-fired plant and the Bacon-Manito 110 MW geothermal plant in Southern Luzon. Owing to the long lead time required to design and construct these plants and the relatively high load growth experienced recently, NPC has included about 700 MW of gas turbine generating plant for Luzon in its latest plans. These plants can be commissioned in 18 months from the time of initial commitment. The NPC's latest expansion
program provides for the commissioning of approximately 6,292 MW of generating plant between 1988 and the year 2000 [ADB, 87].

Most of the transmission system developments in the next five years are associated with the planned generating plant additions, or are principally for reinforcement of the existing systems. Only a few projects will extend the transmission system into new areas such as the Luzon-Mindoro and the Cebu-Negros interconnections.

Electricity Market

In the 1960s and early 1970's, electricity sales grew at a rate of over 15% per annum. With the steep rise in oil prices in 1973, electricity tariffs were increased which led several groups of consumers to adopt energy conservation measures, and the annual growth rate for electrical energy sales declined to about 12% [ADB, 87]. Additional tariff increases and the economic recession after 1979 reduced the electricity energy sales growth rate further to about 8% per annum until 1982.

NPC

NPC recorded a total sales increase from 17,089 GWh in 1983 to 19,292 GWh in 1987, an increase of 3.1% per annum.
During 1984 and 1985, NPC's total sales were below the 1983 level, due partly to the economic recession that the Philippines was experiencing [NPC, 91]. The yearly changes in NPC's total sales since 1983 reflect the changing growth pattern only partially; geographical expansion of NPC's power systems and of the rural electric systems have also contributed to these variations.

Substantial increases in NPC's energy sales were recorded from 1983 to 1987 in the following areas:

(i) Visayas, where sales grew from 933 GWh to 1,488 GWh during the five year period at a rate of 12.4% per annum; and

(ii) Mindanao, where sales increased from 2,248 GWh to 3,116 GWh, at the annual average rate of 8.5%.

These increases resulted from considerable expansion in NPC's transmission grids in the two regions, which facilitated connections to additional consumers, and the meeting of previously suppressed demand. However in Luzon, where planned system expansion was nearly completed by 1983 and where industrial demand began to stagnate, NPC's sales grew from 13,908 GWh in 1983 to 14,688 GWh in 1987 at the rate of less than 1.4% per annum [ADB, 87].

In 1987, of NPC's total sales of 19,292 GWh, about 19% were
to direct consumers (mostly industrial), and nearly 81% were in bulk to the utilities, including:

(i) 11,367 GWh to MERALCO; and

(ii) 937 GWh to electric power cooperatives in Luzon, 482 GWh to electric power cooperatives in Luzon, 482 GWh in Visayas, and 710 GWh in Mindanao [ADB, 87].

(b) MERALCO

Although MERALCO’s franchise area doubled between 1983 and 1987, its total sales to ultimate consumers declined from about 9,164 GWh in 1983 to 8,828 GWh in 1987. The decline was particularly evident during the economic recessions of 1984 and 1986 when MERALCO’s sales decreased from 8,428 GWh in 1984, to 7,880 GWh in 1985, and increased only marginally to 7,938 GWh in 1986. In 1987, MERALCO served over 1.65 million consumers, of which more than 90% were residential. Owing to improvement in economic conditions in 1987, the share of MERALCO’s sales to industrial consumers increases from 30% in 1986 to 31.3% in 1987, although it remained below the 1983 share of 35% [ADB, 87].
Table 25: MERALCO's electricity sales (percentage share)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>34.5%</td>
</tr>
<tr>
<td>Commercial/services</td>
<td>33.3%</td>
</tr>
<tr>
<td>Industrial</td>
<td>31.3%</td>
</tr>
</tbody>
</table>

Source: ADB, 1987

(c) Others

Sales in rural electric cooperatives remained more or less unchanged during the 1983 to 1987, at about 2,000-2,100 GWh per year. In 1986, the most recent year for which data are available, the residential sector accounted for about 41% of total sales, industrial consumers about 28%, and commercial/service and other consumers about 31% [ADB, 87].

5.3 Rural Electrification

The NEA is responsible for rural electrification, with its
The prime objective being total national electrification. The first rural electrification program was initiated in 1969; since then the program has been expanded considerably. While service connections to the first million rural households required a decade (1969 to 1979), the second million households were connected by 1982. By the end of FY87, of the total 34,500 villages, 20,170 (58%) had been electrified, and nearly 2.86 million consumers (about 49% of the total) had access to electricity. Besides extending distribution networks NEA also constructed mini-hydropower and dendrothermal plants [Santos, 91].

In 1986, NEA's target was to provide electricity to at least 90% of the rural population by 1994. However, economic conditions and budgetary constraints may delay the achievement of this target [Santos, 91].

Collecting payments from the end-users has been problematic in the past. On average, the cooperatives collects 70-75% of the payments required from the consumers. The government is aiming to increase this to 95% [Santos, 1991].

5.4 Tariffs

There is no single authority responsible for the review and approval of tariffs, although the Government has adopted in principal a proposal for a single tariff regulatory body.
At present, the NPC Board is responsible for setting its tariffs, although tariff increases are invariably subject to Government concurrence. The NEA establishes the tariffs of rural electric cooperatives. The Energy Regulatory Board is responsible for approving the tariffs of MERALCO and other private utilities.

(a) NPC

As NPC sells a large share of its energy in bulk to various utilities and cooperatives, its average revenue per kWh sales is lower than that of utilities and cooperatives who make direct sales to ultimate consumers. In 1987, average revenue earnings per kWh sales by NPC, MERALCO and NEAS's cooperatives were 0.92 pesos, 1.736 pesos and 1.66 pesos, respectively [NPC, 91].

The NPC's tariff structure, which became effective in February 1980, consisted of a demand charge per kW and a progressive block energy charge per kWh. Until May 1988, the structure remained virtually unchanged except for minor modifications. These included:

(i) the introduction of currency exchange rate adjustment (CERA) intended to cover adverse effects from foreign rate fluctuations on debt service;
(ii) a fuel (oil) cost adjustment (FCA);

(iii) a steam cost adjustment (SCA); and

(iv) a coal cost adjustment (CCA).

The FCA, SCA and CCA are applied only to the tariffs of consumers supplied by geothermal, oil-fired and coal-fired thermal plants [NPC, 91].

In line with the objectives of rationalising power tariffs, NPC implemented provisional power rates for the different grids in May 1988. In general, the implementation of the provisional power rates are based on the following guidelines:

(i) rates on Luzon are to attain an average revenue of P 1.02 per kWh;

(ii) average power rates in the various grids in the Visayas are to cover cash operating expenses, but in no grid is the provisional average revenue to exceed P 1.11 per kWh, the 1987 average revenue in the Negros grid;

(iii) power rates on Mindanao are to be increased to approximate an 8% return on rate base; and
(iv) all further price adjustment mechanisms - fuel (oil, steam and coal), foreign exchange and provisional discounts - are to be suspended to avoid wide fluctuations in monthly average rates.

The fuel cost adjustments and currency exchange rates adjustments in existence until the May 1988 revision were fully consolidated in the provisional tariffs. The introduction of these provisional power rates is intended to give NPC time to study and rationalise its power rates, in order to reflect actual cost, correct pricing distortions, give the right pricing signals to consumers, and ensure a reasonable return on its assets.

A new tariff covenant, formulated as part of a loan agreement with ADB, provides greater scope and flexibility to NPC in terms of timing and approach for responding to changes in costs (such as fuel, local inflation and exchange rate losses), while retaining the principle that tariff revenue and income be adequate to maintain a sound financial position.

Although the tariff structure is designed to reflect differences in the sources and costs of power generation between the regions of Luzon, Mindanao, and Visayas, the structure is not designed to differentiate rates by delivery
voltage level, or by differences between various grids in the same region. Some cross-subsidisation between grids and between consumer groups occurs. Lower rates to private electric utilities and electric cooperatives compared with industries (for contracted loads and sales up to a certain limit) subsidise lower income groups and supports the rural electrification program. A prompt payment discount of 3% is also to be granted to consumers paying their bills within 15 days of the due date [Heruela, 1991].

The NPC's average revenue in 1987 was P 0.92/kWh; in Luzon, Visayas and Mindanao it was P 0.98/kWh, P 0.87/kWh, P 0.57/kWh, respectively. The NPC’s average revenue in 1987 declined by about 15%, from P 1.08/kWh in 1985 due largely to:

(i) negative fuel cost adjustment, as fuel cost to NPC decreased from P 4.14/litre in 1985 to P 2.08/litre in 1987; and

(ii) additional discounts offered in 1987 to encourage customers to make prompt payments [ADB, 87].

To provide a sound basis for the formulation of a rational tariff structure, ADB provided technical assistance in 1985 for a comprehensive tariff study involving all power utilities and electric cooperatives. The basic
recommendations of the study included the following:

(i) tariffs should be established on the basis of long-term marginal costs of supply at different voltage levels for each grid; and

(ii) seasonal and time-of-day tariffs should be introduced.

While the Cabinet approved in principle the use of marginal costs pricing in establishing power tariffs, the decision has not yet been implemented because of the stance taken not to operate the 620 MW nuclear power plant and the effects of this on the PDP required a recalculation of the long-term marginal costs.

(b) MERALCO

One of the recommendations of the tariff study for MERALCO related to a reduction in subsidies for small consumers. Although steps have been taken in this direction, large industrial, commercial and residential consumers continue to subsidise residential consumers (up to 90 kWh/month of consumption), small commercial establishments (up to 60 kWh/month), and government hospitals and street lighting. MERALCO's average revenue in 1987 for industrial, residential commercial, and street lighting consumption was about P 2.098 per kWh, P 2.05 per kWh, P 1.139 kWh, and P
Industrial and agricultural consumers in electric power cooperatives are subject to demand and energy rates. Since 1985, the average revenue per kWh sold in the cooperatives has remained fairly stable at P 1.66 kWh. In 1987, average revenue realised by MERALCO was higher (P 1.736 per kWh), because residential consumers accounted for 34.5% of total sales MERALCO, compared to nearly 41% in the cooperatives [ADB, 87].

5.5 Solar pv

Average insolation value in the Philippines is 5kWh/m²/day, yearly bright sunshine totalling over 2000 hours with humidity at 85% [Summary report, 1990]. As such, flat plate collectors are more suitable than concentrated collectors.

The Verde Islands rural electrification project introduced solar pv on a commercial basis. Commercialisation is measured in terms of the volume of oil displaced and is geared towards markets that utilise oil. Solar thermal systems such as hot water heaters are based on replacing expensive oil, and are marketed towards large scale urban users.

The German government have provided funding to pursue
projects on solar pv systems, in addition to USAID and UNDP assistance on non-conventional energy supplies. However, apart from bilateral aid projects, very few solar pv projects have been implemented.

Presently, the cost of electricity generation from solar pv cells is P 17 kWh compared to P 2.50 kWh from a large scale power plant is [OEA, 1991]. However, solar pv systems should not be ruled out as economically non-viable. If the system is located more than 17 km from the local grid, then the pv system becomes cost competitive [GTZ, 1988]. It was also discovered that in very remote areas, pv systems can actively compete with diesel generator sets. In Zambales, a pv powered system cost P55/kWh compared to a diesel generator set which cost P202/kWh [OEA, 1988].

One local application where pv systems are an attractive option is for water pumping. A locally developed jack pump, and a locally fabricated incubator for a solar powered chicken hatchery have also been developed and utilised in a few industries.

Some R&D has been carried out on Solar Home Systems (SHS). The 1984 cost was P12,000 for a 50 W module which would power two 20w flourescent lights, one black & white television, and a radio casette player. DC versions of almost all these appliances are generally available.
Solar Thermal

The market for solar water heaters is well developed in the Philippines, with more than five companies engaged in their manufacture and sales. These systems are found in the commercial, industrial, and domestic market, although the domestic market is still limited to middle and upper income families. There is no government or private sector initiative to actively promote this technology, so owners acquire the solar water heaters on their own initiatives.

5.6 Small hydro

In 1979, Power Gen, the authority in charge of electricity generation, began the concerted use of small hydro power. The potential for small hydro amounts to 5,000 MW for there are approximately 7,000 small islands each having an abundance of small streams and rivers. However, the preference is for diesel generator sets which can be sized, installed, and operational within a matter of weeks. Given the current political and social situation in the Philippines, the fact that small hydro is more capital and time intensive reduces its commercial attraction.

Nevertheless, the Office of Energy Affairs is conducting further studies to develop this technology. Possibilities
for joint ventures between local firms and manufacturers from other countries is being explored.

5.7 Biogas

In the early 1970s, the Philippines was quite active in the field of biogas. Many of these projects have fallen into disrepair due to poor design and construction, but there has been some effort on the part of affiliated non-conventional energy centres to rehabilitate these systems and to introduce new and improved designs.

In the field of large scale biogas plants, the Maya Farm project is often cited as a good example. It has five larger biogas digestors to process 38 tons of manure daily from 25,000 pigs, producing 2,150 m$^3$ of gas and 3.8 tons of feed material. Biogas is used to fire the retorts in the rendering plants, the scalding tank in the slaughterhouse and the cooking vats in the processing plant. The rest of the biogas is used as fuel for converted petrol engines which serves as prime movers for the deepwell pumps, feedmill machinery, refrigeration systems and electrical generators. Maya Farms has provided consultancy services to 16 piggery farms which have a combined biogas capacity of 9,260 m$^3$/day.
Biofuels

As there is an abundance of sugar cane in the Philippines; its utilisation for energy has been well researched. Ethanol fuels have been developed from the fermentation process of molasses. The ethanol is then distilled to a hydrous grade (95% alcohol purity) or to an anhydrous grade (99.5% alcohol purity). Either grade can be blended with or substituted for petrol.

Using ethanol in its pure form requires major engine adjustments. However, existing internal combustion engines can adapt very well to the anhydrous ethanol and petrol blend of up to 20% alcohol without major engine modifications. This was the fuel used in the briefly implemented alcogas program in Negros and Panay Island.

The production of anhydrous ethanol, however, entails several constraints such as high operating cost, fluctuating price of raw materials, and a reliable supply of the raw materials.

Coconut oil or a coconut oil derived compound, coco methyl ester (formed by the reaction of coconut oil with methanol) can be blended with or substituted for diesel. In performance tests, it has been observed that solid particles
in crude coconut oil clogged nozzles, resulting in more frequent changes of fuel filters. Storage of crude coconut oil is difficult as it solidifies at temperatures below 22 degrees celcius. For the same reason that the alcogas program was discontinued, coconut oil as a diesel substitute is no longer being actively studied.

Biomass Gasification

The present programme for gasifier systems is composed of projects that aim to improve the efficiency of the gasification process through improved feedstock and design of equipment. Studies on the different applications of producer gas are being undertaken to evaluate practicability and economic viability. Favourable results of these studies will possibility widen the market.

Gasification of densified rice husks is being studied to test the feasibility of the densification process. Densification will pack loose rice husks into briquettes, cubes, or pellets that can be fed into the briquetting machine. Other feedstocks such as corn cobs, coconut shells, and wood-waste are being tested.

5.8 Wind

In the Philippines, the following areas have wind speed that
exceed 10 km/h with consistently strong winds: Basco, Batanes, Cuyo, Palawan and Iloilo. In Panay, the wind speeds average 15 km/h all year round. Most applications for wind energy systems are for water pumping and low power electricity generation.

Current project activities in wind turbine systems include the installation of two units with capacities of 60 kW each. These were installed for demonstration purposes in areas with high speeds.

A serious problem with wind energy in the Philippines is that some areas have a high incidence of tropical cyclones. An average of 19 cyclones pass through each year with centre winds greater than 200 km/h. Indigenous "typhoon resistant" designs are required or systems that can be dismantled and reinstalled easily. However, given the current scenario, wind energy systems will play a limited role, with water pumping being its most feasible application.

5.9 Rational Use of Energy

The Philippines has probably the most comprehensive RUE programmes of all the countries studied in this thesis. It is supported by several Presidential decrees, and there is a separate division in the Office of Energy Affairs devoted entirely to the promotion of energy conservation and energy
An essential part of the government's energy policy, the RUE programme's objectives are "to eliminate unnecessary and wasteful use of energy, lower over-all demand and encourage the use of indigenous and renewable sources of energy" [Tablante, 1990]. The programme is primarily directed towards industry, transport and commercial sectors, in view of their large share in total energy consumption.

The following activities are included in the RUE Programme:

(a) Information Dissemination and Training
(b) Energy Conservation Briefings
(c) Publications
(d) Energy Information Centre
(e) Consultancy and Project Engineering Services, such as free energy audits intended to assist owners, managers and operators to analyse energy use and to determine areas where energy savings can be made, and to estimate the magnitude of cost savings;

Project engineering services, involves assisting industries in the evaluation and implementation of energy conservation projects to reduce energy cost. This would include retrofit, expansion and removing barriers to project implementation.
Recently an OEA conducted project engineering study and detailed audit on two industrial plants, with an emphasis on boiler retrofit and waste heat recovery, estimated savings of 497.4 kilolitre fuel oil equivalent or $109.4 thousand in foreign exchange annually.

OEA also provides and installs instruments to record the relevant parameters, including flue gas analysis, heat flow, temperature, and furnace pressure. Additionally, the energy efficiency testing program is equipped with a calorimeter room for testing air conditioners; a pilot-scale boiler for testing the combustion performance of various types of fuels, such as fuel oil, diesel, rice husk briquettes, sawdust and other non-conventional fuels.
Chapter 6 Thailand

Thailand's gross domestic product in 1989 grew by 12.2% in real terms over the previous year. This rapid growth was distributed over various sectors, especially the industrial sector, in addition to construction, trade and service sectors. Reflecting the economic expansion, final energy consumption in 1989 increased by 15.9% over the previous year, the highest growth rate recorded [NEA, 89]. The increase in energy consumption was dispersed to all economic sectors.

6.1 Energy Context

6.2 Consumption and Supply

Total primary energy supply has increased by 14.0% since 1988, amounting to a total of 37 mtoe, of which 58.0% came from indigenous sources and 42.0% from imports. Thailand continues to be a net importer of energy. Considerable efforts have been made to set up local energy supplies, with the result that oil, which accounted for over 90% of primary commercial energy consumption during the 1970's, accounted for only 62% in 1987. In the 1970's, hydropower accounted for most of the remainder, but in the 1980's indigenous lignite and natural gas emerged as important sources of energy. As a result, net energy import dependency also
declined from over 90% in the 1970's to 56% in 1987 [NEA, 89].

Steam and combined cycle power plants are the dominant source of power generation. In addition to 0.9 mtoe of indigenous hydropower, nearly 5.5 mtoe of fossil fuels were used for electricity generation in 1987. Electricity imports from Lao People's Democratic Republic accounted for about 0.04 mtoe in 1987 [NEA, 89].

In 1987, the total final commercial energy consumption was 14.3 mtoe, and per capita consumption 267 kgoe. Nearly 4.2 mtoe of primary commercial energy supplies were lost in petroleum refining and in power generation, transmission and distribution. Data on final energy consumption in 1987 is shown in table 26.

Table 26: Final Commercial Energy Consumption (percentage share)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>55</td>
</tr>
<tr>
<td>Other Sectors</td>
<td>3</td>
</tr>
<tr>
<td>Agricultural</td>
<td>6</td>
</tr>
<tr>
<td>Industrial</td>
<td>24</td>
</tr>
<tr>
<td>Res./Commercial</td>
<td>12</td>
</tr>
</tbody>
</table>

1987

Source: ADB, 1987
6.2.1 Indigenous Sources

Domestic energy production in 1989 totalled 22.5 mtoe, an increase of 8.2% over the preceding year. This amount comprised crude oil, natural gas condensate, lignite and hydro power with a share of 48.5% of the total indigenous production, and fuel wood, paddy husk and bagasse for renewable energy with a share of 51.5% [NEA, 89].

Crude oil

According to the NEA, the average production of crude oil in 1989 was about 21,351 bpd (barrel per day), an increase of 4.8% from the preceding year. The total production of crude oil was 1.06 mtoe, a share of 4.7% of the total indigenous production.

Natural Gas

Natural gas has become a major domestic source particularly for electricity generation. As a result of technical problems, the average daily production of natural gas for 1989 was about 579 mscfd (million standard cubic feet) which was a slight decrease from the preceding year. The total production was 5.19 mtoe, a share of 23.1% of the total indigenous production [NEA, 89].
Condensate

The average production of condensate in 1989 was about 18,441 bpd, an increase of 2.7% from the year earlier. The total production was 0.84 mtoe, a share of 3.7% of the total indigenous production [NEA, 89].

Lignite

Lignite, one of the major domestic energy sources, is used not only for electricity generation but also in industry. In 1989, the average production of lignite was about 24,387 tons per day, an increase of 26.5% over the previous year. The total production was 2.59 mtoe, a share of 11.5% of the total indigenous production [NEA, 89].

Hydro Power

Hydro power has been developed for power generation since 1964. In 1989, electricity generated from hydro power totalled 1.23 mtoe, an increase of 47.4% over the previous year, and accounted for 5.5% of the total indigenous production [ADB, 87].

Renewable Energy

Comprising fuelwood, paddy husk and bagasse, the total
production of renewable energy in 1989 was about 11.6 mtoe, an increase of 6.4% from the previous year. This accounted for 51.5% of the total indigenous production.

Fuelwood has been a primary source of energy. In 1989, fuelwood was produced at approximately 8.5 mtoe which was a slight decrease from the previous year. This accounted for 37.8% of the total indigenous production.

In 1989, paddy husk, the by product from rice mills, was consumed as a fuel at 1.2 mtoe, approximately 5.3% of the total indigenous production.

Bagasse, a by-product of the sugar industry, is another source of energy. In 1989, bagasse was consumed as a fuel at 1.9 mtoe, with a share of 8.4% of the total indigenous production [ADB, 89].

6.2.2 Imports

With an increase of 30.3% over the previous year, total energy imports in 1989 reached 15.8 mtoe, of which 99.8% was conventional energy and 0.2% renewable energy. The total value of imported energy grew by 47.1% to 56,897.6 million baht [NEA, 89].
Petroleum

Encompassing crude oil and petroleum products, total petroleum imports reached 15.4 mtoe, an increase of 30.2% from 1988. This accounted for 97.6% of the total energy imported. The total value of petroleum imports soared to 54,601.6 million baht [NEA, 89].

Coal

Coal imports in 1989, including steam coal, anthracite, coke and other coal, totalled 0.3 mtoe, an increase of 25.0% from the previous year, which accounted for 1.9% of the total energy imported. The value of coal imports was about 704.6 million baht [ADB, 89].

ELECTRICITY

In 1989, electricity imports totalled 0.055 mtoe, an increase of 48.6% from the previous year, and accounted for 0.3% of the total energy imported. The imported value was 355.1 million baht [ADB, 89].

Charcoal

The Thai government instituted a logging ban policy to reduce the amount of wood that can be harvested in hopes of
curtailing the deforestation that has occurred over the past decade. Resulting from the logging ban policy, charcoal imports in 1989 reached 0.026 mtoe with a sharp increase of 136.4% over the previous year. This share amounted to 0.2% of the total energy imported at a value of 60.2 million baht [NEA, 89].

6.2.3 Exports

Total energy exports for 1989 were 0.79 mtoe, an increase of 15.3% over the previous year. Condensate was a major component with a share of 88.1% of the total energy export. The rest was renewable energy in the form of fuelwood and charcoal, petroleum products and electricity with shares of 10.8%, 0.9%, and 0.2% respectively [NEA, 89].

6.2.4 Final Energy Consumption

As a result of economic expansion, the total final energy consumption for 1989 reached 26.6 mtoe, a remarkable increase of 15.9% over the previous year. The details are as follows:
By Type of Energy

Petroleum Products

Petroleum products still holds the greatest proportion of final energy consumption. In 1989, petroleum consumption totalled 15 mtoe, an increase of 17.7% over the previous year and accounted for 56.5% of the final energy consumption. The consumption pattern can be seen in the table below.

Table 27: Consumption of Petroleum Products by Sector

<table>
<thead>
<tr>
<th>Sector</th>
<th>Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>67.8%</td>
</tr>
<tr>
<td>Industrial and Mining</td>
<td>14.6%</td>
</tr>
<tr>
<td>Agriculture</td>
<td>10.9%</td>
</tr>
<tr>
<td>Residential and Commercial</td>
<td>6.0%</td>
</tr>
<tr>
<td>Construction</td>
<td>0.7%</td>
</tr>
</tbody>
</table>

Natural Gas

Natural gas consumption in 1989 totalled 0.11 mtoe, a sharp increase of 90.1% from the previous year and accounted for 0.4% of the final energy consumption. Fifty two percent of natural gas was used by the ceramic industry, 34.1% by the
petrochemical industry, and 8.7% by cement industries [NEA, 89].

Coal and lignite

Coal and lignite were mainly used for industry. The consumption in 1982 was 1.08 mtoe, a share of 4.1% of the final energy consumption. Leading coal and lignite consumers are shown in the table below [NEA, 89].

Table 28: Consumption of Coal and Lignite by Sector

<table>
<thead>
<tr>
<th>Sector</th>
<th>Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>70.4%</td>
</tr>
<tr>
<td>Paper</td>
<td>14.1%</td>
</tr>
<tr>
<td>Food</td>
<td>8.8%</td>
</tr>
<tr>
<td>Other industries</td>
<td>6.7%</td>
</tr>
</tbody>
</table>

Electricity

Total electricity consumption for 1989 increased by 16.2% over the previous year to 2.28 mtoe and accounted for 13.5% of the final energy consumption. The industrial sector was the largest consumer with a share of 47.0% of the total consumption, followed by the commercial, residential and other sectors with shares of 30.8%, 21.4% and 0.8%
respectively [NEA, 89].

Table 29: Consumption of Electricity by Sector

<table>
<thead>
<tr>
<th>Sector</th>
<th>Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>47.0%</td>
</tr>
<tr>
<td>Commercial</td>
<td>30.8%</td>
</tr>
<tr>
<td>Residential</td>
<td>21.4%</td>
</tr>
<tr>
<td>Other sectors</td>
<td>0.8%</td>
</tr>
</tbody>
</table>

Fuelwood

Fuelwood is widely consumed by some types of industries and households, particularly in the rural area. In 1989, the consumption totalled 2.79 mtoe which is a slight decreased from the previous year and accounted for 10.5% of the final energy consumption [NEA, 89].

Charcoal

Charcoal is another type of energy which is widely used in households in both urban and rural areas for cooking. The consumption in 1989 totalled 2.0 mtoe, a decrease of 2.8 from the year earlier and accounted for 7.6% of the final energy consumption [NEA, 89].
Paddy Husk

Major paddy husk consumers include industry, particularly rice mills, and households in rural areas. With an increase of 21.3% over the previous year, total paddy husk consumption in 1989 rose to 0.88 mtoe, of which 70.6% was consumed by the industrial sector and 29.4% by the residential sector. The total consumption accounted for 3.3% of the final energy consumption [NEA, 89].

Bagasse

Bagasse is mainly consumed by the sugar factory. In 1989, the consumption reached 1.9 mtoe, a sharp increase of 47.1% from the preceding year due to the 50.4% increase in sugar production. The total consumption accounted for 7.1% of the final energy consumption [NEA, 89].

By economic sector:

Agricultural Sector

Agricultural energy consumption in 1989 rose to 1.64 mtoe, an increase of 7.6% over the year earlier and accounted for 6.2% of the final energy consumption. This was due to an increase in crop and fishery production [NEA, 89].
Industrial Sector

Including the manufacturing, mining and construction sectors, the industrial energy consumption for 1989 rose to 7.9 mtoe, a relatively high growth of 26.8% over the previous year and accounted for 29.6% of the final energy consumption. This resulted mainly from the rapid growth in manufacturing, the increase in construction of housing and commercial buildings, as well as an increase in mining [NEA, 89].

Residential & Commercial Sector

Most of the energy consumption for the residential and commercial sector, which includes government and private industry, is used for cooking, lighting, air-conditioning, water pumping, and other electrical appliances. In 1989, the residential and commercial energy consumption increased by 3.2% to 6.9 mtoe due to the increase in government and private sector expenditure. The total consumption accounted for 25.9% of the final consumption [NEA, 89].

Transportation Sector

With the introduction of an economic policy to distribute development to the non-Bangkok area, combined with an increase in purchasing power, particularly in durable goods
such as automobiles and motorcycles, the transportation energy consumption for 1989 increased from 19.4% to 38.3% of the final consumption [NEA, 89].

6.3 Energy Policy

The underlying rationale and objectives of the energy policy proposed by the National Economic and Social Development Board (NESDB) in its 1985 policy paper is to provide secure and low cost energy. This in turn will support the major economic growth objectives of the Sixth National Economic and Social Development Plan (1987-1991). A comprehensive energy strategy adopted for the Sixth Plan has the following major objectives [ADB, 1989]:

(i) continued and accelerated exploration and development of diversified indigenous energy supplies, including natural gas, oil, lignite, hydroelectric potential and non-commercial energy,

(ii) encouragement of private sector investment (expansion in the hydrocarbon area and introduction in the electric power sub-sector), accompanied by price reform and deregulation; and

(iii) demand management through: (a) rationalisation of prices of various energy
sources to reflect their economic costs of supply; (b) energy conservation, particularly in industry, transport and commercial buildings; and (c) development and efficient use of appropriate types of energy in rural areas.

The main reason for encouraging private sector investment is to alleviate the financial burden that energy sector development programs place on the government. In line with this, the Government is considering private sector participation in power generation to reduce public sector financing of EGAT's investment program (US$3.1 billion in the Sixth Plan Period alone). The main options being considered are:

(i) privatising EGAT gradually by selling some of its shares to private investors through the stock exchange;

(ii) allowing the private sector to set up some of the power plants included in EGAT's Power Development Plan and sell electricity to the grid system;

(iii) allowing industrial plants to generate electricity and sell surplus power to the grid system; and
(iv) privatising certain parts of EGAT's operations.

Electric Power

Institution and Structure

There are three state-owned power utilities in Thailand, and a few small franchised agencies that are being progressively merged with the three utilities. The three utilities are the Electricity Generating Authority of Thailand (EGAT), the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA).

EGAT, established in 1969, is responsible for most of the generation (accounting for about 95% of the total) and transmission of power in Thailand. It is directly responsible to the Prime Minister's office. EGAT has electricity interchange arrangements with the National Electricity Board of Malaysia and Electricite du Laos, and sells power in bulk to MEA and PEA, and to large direct consumers.

MEA was established in 1958 by a merger of the power companies which were then servicing the Bangkok area. It
distributes power to Bangkok and its environs. The PEA was established in 1960 as a government owned corporation to provide and distribute electricity to all parts of the country except those served by MEA. Both MEA and PEA are responsible to the Ministry of Interior.

Other government agencies directly involved in policy making for the electricity sector include the National Economic and Social Development Board; the Ministry of Finance (MOF); and the National Energy Administration (NEA). In addition, in response to earlier concerns about decentralised policy formulation and coordination, the National Energy Policy Committee (NEPC) was established in October 1986. This cabinet level Committee, chaired by the Prime Minister, now has authority to make all energy policy and coordination decisions. The Committee is supported by three sub-committees (the Petroleum Policy Sub-committee for petroleum related matters, the National Energy Policy Formulation Sub-committee for all other energy matters; and the Energy Demand and Supply Sub-committee for energy planning matters), the Energy Research Steering Group and a small secretariat (the National Energy Policy Office, NEPO). The NEPC is expected to unify the functions of the various energy policy committees and to centralize key decision making into a single body. The new approach has not reduced the number of agencies involved in the energy sector, nor changed the reporting responsibilities of line agencies.
The need for time consuming and potentially sub-optimal consensus building will continue to prevail. Because the poli-centric nature of decision making has been the basic strength of the Thai system of public management, the Thailand Development Research institute has recommended that it be maintained, suggesting instead that efforts be concentrated on improving the pace of decision making and subsequent implementation.

Electricity Market

During the period of FY 75 to FY 87, EGAT's peak demand increased from 1,407 MW to 4,734 MW at a rate of 10.6% per annum, and its generation plus purchases from 8,212 GWh to 28,176 GWh, by 10.8% per annum [ADB, 87].

Over 95% of EGAT's sales are to MEA and PEA. Despite the accelerated pace of PEA's rural electrification programme, EGAT's bulk sales to PEA in FY 87 were about 45.3% of its total sales, compared to 50% to MEA. Although loads remain concentrated in Bangkok and the surrounding areas, the gap between sales to MEA and PEA has narrowed considerable since FY 83 and PEA is expected to exceed MEA in sales in FY 91 [ADB, 87].

During FY 87, PEA supplied power to over five million consumers. About 95% of the consumers were in the
residential/domestic category, and accounted for about 29% of PEA's total sales. During the same year, MEA supplied power to over one million consumers. Nearly 83% were residential/domestic consumers and accounted for about 21% of MEA's total sales. For the nation as a whole, nearly 5.7 million residential consumers (93.1% of the total) consumed about 5,750 GWh of electricity (23% of the total direct sales) in FY 87. During FY 83 to FY 87, the growth in the total number of residential/domestic consumers and their consumption averaged 10.3% and 8.9%, respectively [ADB, 87].

The industrial sector accounts for a major share of electricity consumption. In FY 87, its share was about 45.8% in the provinces served by PEA and 43.6% in the MEA area. The share of sales made by PEA to consumers in the commercial category, however, were only about 24% in FY 87, whereas commercial consumers accounted for over 33% of MEA's total sales [ADB, 87].

6.4 Rural Electrification

Provision of power to provincial areas (covering about 99.4% of the country's geographic area) began on a planned basis in 1960, following the formation of PEA. Since then, PEA has progressively expanded its area of operations, and during the period of 1978-1987 it achieved a 12.7% average annual compound growth in sales and an almost fourfold
increase in the number of consumers, while progressively reducing transmission/distribution losses to about 8.3% in FY 87. In its rural electrification activities, PEA has been able to achieve satisfactory economic viability through relatively successful load promotion and appropriate technical standards of design and construction. Over 50,000 villages were electrified by the end of 1988, covering about 86% of the total number of villages.

The PEA's average annual load growth for the Sixth Plan period (1987-91) is projected at 14.9%. It is expected that by the end of the Sixth Plan, PEA will have extended its service to over 59,000 villages, covering about 96% of the villages in Thailand.

The major area of concern for the Sixth Plan period relates to the financial burden that rural electrification activities impose on PEA, i.e., system expansion costs increase sharply as the more isolated and smaller villages are electrified. At present, about 55% of PEA's residential consumers use less than 35 kWh per month. As these consumers are subsidised (average revenue of B 0.90/kWh realised from them is about 53% of the average operating supply cost of 1.7 B/kWh), supplying power to them places considerable financial strain on PEA. Moreover, as the number of residential consumers is increasing rapidly, the ability of other consumers to continue this cross subsidy is
being strained, and adjustments in residential tariffs, particularly beyond the initial 50-100 kWh of monthly consumption, are necessary.

6.5 Tariffs

The Government has identified the following objectives in pricing electricity [ADB, 1989]:

(i) reflection of true economic costs;

(ii) adequate self-financing of investments by the supply organisations;

(iii) subsidisation of PEA consumers by MEA consumers; and

(iv) effective demand management.

Considerable action has already taken place towards achieving these objectives. A recent study by the National Institute of Development Administration (NIDA) of electricity tariffs in Thailand indicated that at the bulk supply level, EGAT's average selling price is not less than 90% of the estimated consolidated average long-run marginal costs (LRMC). In June, 1987, the Government introduced new tariff schedules for the three power utilities, using the
NIDA study as a basis. Under the latest retail tariff, demand charges for certain industrial categories nearly doubled and energy charges were reduced by some 20%. With these changes, the tariffs now reflect more accurately the structure of capacity and energy supply costs, and the average retail tariff revenue of MEA and PEA is in line with average revenue resulting from strict LRMC-based pricing.

The new tariffs represent the first step in a plan to introduce electricity prices (at a wholesale and retail levels) which correspond more closely to the structure of economic costs; while at the same time ensuring that actual price levels help the utilities to achieve adequate levels of financing performance. The ultimate objective, which is anticipated to be achieved in the mid-1990's, is to structure prices to reflect supply cost at different voltage levels and time-of-day rates, and to set prices at levels which will result in a self-financing ratio of at least 25%. Self-financing of about 20% is projected for the FY90-92 period.

EGAT charges both MEA and PEA at flat rates: the rate for MEA is B 1.4777/kWh, and for PEA B 1.0399/kWh. The EGAT's bulk transfer price to MEA slightly exceeds LRMC of generation and transmission, while the price to PEA is below LMRC. As it is more expensive for EGAT to supply PEA's dispersed load than to supply the concentrated load of MEA,
PEA consumers are crossed subsidised by MEA consumers. The lower price levied on PEA enables it to maintain a reasonable level of financial viability. The PEA’s tariff provides for subsidised electricity supply to rural consumers in general and to domestic consumers in particular. Also, service is being provided to remote areas, where the marginal cost of supply is estimated to be as high as B 8/kWh compared to the revenue of less than B 1/kWh for consumption up to 35 kWh/month. The PEA’s tariff results in a large disparity between cost incurred by low income rural households using kerosene for lighting and those using electricity. The former are estimated to spend B 50 per month to provide two hours of lighting per evening, while those with electricity spend only B 5 per month for four hours per evening of fluorescent lighting. However, such subsidised electricity supply to PEA’s consumers has been justified on equity grounds.

6.6 Solar pv

Daily total solar radiation in Thailand has an annual average intensity of 17 MJ/m² or 4.72 kWh/m²/day, which is approximately equal to the heat released from combustion of 1 kg of dry wood.

Research and development of pv technology has increased recently in many institutions. A Schottky barrier silicon
solar cell and p-n junction single crystal solar cell have been fabricated at Chulalongkorn University [Panuakeow, 1980]. Typical efficiencies of these solar cells were 3 and 11%, respectively.

However, BP solar is now manufacturing solar panels in Thailand. It is hoped that this will commercialise the technology which is essentially still at the R&D phase. Currently, the biggest users are the military and the telecommunications sector.

Solar Thermal Energy

More than five companies manufacture flat plate collectors for water heating. Total area of installed collectors exceeds 40,000 m². Current annual production of flat plate collectors in the country is about 10,000 m². About 50% of the collectors are installed in hotels and hospitals and the rest are used for domestic water heating [Wibulswas, 1988]. An economic assessment performed by the Technological Promotion Association indicates that a pay-back period of about 7-10 years may be achieved in comparison with electric water heating.

In the past decade, several flat plate collectors have been developed in Thailand, such as serpentine double-glazed collectors [Wibulswas, 1983], compound parabolic collectors
[Jitnomrat, 1982], and reversed flat plate collectors [Wibulswas, 1985]. However, these new improved collectors have not yet penetrated the market.

To promote the quality of locally produced flat plate collectors, an industrial standard for solar thermal flat plate collectors was drafted by Thai Industrial Standards Institute [TISRI, 1987]. A relatively simple test standard for thermosyphon solar water heaters has been developed [Wibulswas, 1985a] and unofficially used in Thailand. A national test standard for solar water heaters should be urgently implemented. A solar simulator has been designed and built in order to facilitate testings of solar thermal and photovoltaic equipment [Kirtikara, 1985].

To improve the efficiency of flat plate collectors, techniques for selective coating of black-chrome and black-nickel have been developed in Thailand for pilot demonstrations [Kirtikara, 1985a] and is readily available to be transferred to industry. A study on different types of bondages between fins and tubes of flat plate collectors was conducted, and suitable types of strapping wires were identified [Soponronnarit, 1984].

6.7 Small Hydro

Most small hydro potential is located in the north. (see Fig.
The National Energy Administration's Masterplan on Micro-Hydro Development has looked at 1,138 sites within the 200-6000 kW range, and found that there is small hydro potential for 64 sites which forms a total of 150 MW of installed capacity. Most of these schemes will be grid connected to reduce line losses but a few will be isolated systems for village electrification.

Most of the small hydropower plants will utilise locally manufactured equipment. Originally, equipment for small hydropower plants was imported from China and from developed countries. Since the late 1970s, Thailand has developed and constructed its own equipment although parts are still imported at times. The Thai technology has been modified so that it uses simple construction methods which can be standardised. However, micro-hydro is still thought not to be commercially viable.

6.8 Biomass

In 1988, 22.60 million tons of wood, 3.09 million tons of paddy husk and 7.20 million tons of bagasse contributed 33.29% of total primary energy supply. About 33% of wood was used for heat production and the rest was converted to charcoal. About half of the total paddy husk was used to produce electricity and mechanical power for rice milling processes, and the remainder was used as fuel for household
cooking, charcoal production and rural industries [Chantavorapap, 1990].

The consumption of fuelwood and charcoal in 1983 was $7.9 \times 10^7$ GJ and $1.01 \times 10^8$ GJ, respectively, and it is expected that the demand will annually increase at a rate of 2-2.5%, which will not be able to be met by the trees from the natural forest [UN, 1985]. Therefore the government of Thailand is actively encouraging development of improved cookstoves and charcoal kilns.

**Biogas Digesters**

The total availability of manure in Thailand is approximately 57 million tons (in reality only about 20% of this would actually be available due to problems with collection). This includes cattle manure, pig manure, and fowl droplets. Potential biogas production is 1,633 million cubic metres or $4.1 \times 10^7$ GJ [UN, 85]. There are about 3,000 family-sized digesters that have been installed which were to generate 1-2 cubic meters of gas/day for household use. The author's estimate is that 70% of these are non-functional. Four community-size digesters were built, each generating 20-30 cubic metres of gas/day for crop irrigation and village electrification, which is insignificant compared with its potential.
Biomass Gasification

Studies on the gasification of charcoal and wood and the utilisation of the gas produced for power generation through both gasoline and diesel engines have already been undertaken at Prince of Songkla University. The studies have shown that it is possible to develop inexpensive producer gas systems using locally available materials and equipment for applications in the rural areas. Several producer gas systems fuelled by charcoal and wood have been installed for field trials and the results of these trials have been encouraging.

A down-draught gasifier has been developed and tested for future applications. The engine used was a 6-cylinder, 4 cycle, 2735 cc capacity petrol engine. The generator utilised was single phase with maximum rated output of 20 kW at the operational speed of 1500 r.p.m. Being an automobile engine it is capable of developing high output power at high rotational speed. The engine was coupled to the generator through a conventional automobile gear transmission so that the engine could be operated at high speed while the generator operated at 1500 r.p.m. The maximum power output was 16 kW.
6.8 Wind

In Thailand, wind energy systems have been utilised for water pumping for decades. The wooden-blade type and the sail-type traditional windmills are used mainly in rice fields and for salt production. These are usually constructed by village craftsmen at relatively low cost, however, their efficiencies are also very low [Wibulswas, 1986]. Steel multi-blade windmills are also manufactured in the country. In spite of higher efficiencies, a recent assessment of two multi-blade windmill pumping projects indicated that the systems were not economically feasible [NEA/USAID, 1984]. One main reason was that their initial costs were rather high at 50,000-80,000 bahts.

Another application is for electricity generation. Small wind electric power systems have been developed and a few demonstration sites have been monitored and assessed by EGAT. One of which is a hybrid system which uses both wind turbines and solar pv; however, the potential for wind energy is not high as very few sites exists with suitable wind speeds.

6.9 Rational Use of Energy

Government policy on RUE for the industrial sector is that factories receive energy auditing service from the
government free of charge, and if equipment is installed that improves energy efficiency they are then eligible for tax reductions [Gritiyaranansan, 1990]. The Energy Conservation Centre of Thailand (ECCT) has a boiler tuning service program to help adjust the boiler combustion efficiencies so there can be immediate savings.

During 1989-90, 120 factories were audited. The following industries were chosen: food, textile, wood, paper, chemical, metal, and non-metal. ECCT states the industries can save as much as 29.7 million litres of fuel equivalent per year or 7% of their total consumption (398.6 million litres of fuel equivalent).

As elsewhere, it is not mandatory that industries follow the recommendations of ECCT.
Chapter 7 Operation and Management

The author has concluded, after much discussion with energy specialist, and after visiting many sites utilising renewable energy that one of the major problems in the dissemination of renewable energy systems has been the lack of system maintenance. To highlight this, small hydroelectric generation will be used as a representative of non-conventional energy systems. A discussion of the problems encountered and how they may be rectified follows.

7.1 Small Hydroelectric plants

Frequent problems with small hydroelectric plant operation and maintenance are:

** Unsuitable administrative, organisational and financial arrangements;

** Insufficient liaison between the plant management and the local community and its organisations;

** Limited capabilities for plant management and operation in rural communities;
** Operating and maintenance costs disproportionately high in relation to the energy produced;

** Excessive bureaucracy in the centralised management of small plants;

** The high cost and problems of social adaptation associated with operators brought in from outside the community;

** The frequently inadequate skill levels of locally recruited operators;

** Excessively high tariff rates, inhibiting development in rural areas;

** Rates too low to cover the costs of operation and maintenance;

** Absence of technical support for maintenance and repair;

** Inadequate component standardisation and lack of spare parts.

The problems of small hydroelectric generation are basically simple. The chief difficulties are institutional in nature and
have to do with the running and management of the plants as well as with the origin and technical background of the operators and maintenance personnel. Among the various administrative arrangements that may be adopted for small hydroelectric generation management, two typical ones are discussed below.

1. Direct subordination to a government or regional electric power authority.

Advantages:

** The possibility of centralising actions of greater technical complexity and of taking advantage of the economies of scale inherent in the overall management of groups of plants;

** high skill levels on the part of the personnel;

** and solid financial and technical backing.

Disadvantages:

** Each plant is by itself too small in the context of a large organisation, with the result that, of the extended decision-making channels, it may be neglected;
** high operating costs as a consequence of high general expenses (overheads) and operator and maintenance costs;

** the remoteness of the authority, and thus of the plant, from the local community and its problems;

** problems in reconciling water needs for irrigation and generation;

** and difficulties in mobilising community support for maintenance work at the site.

2. Establishment of a community energy enterprise, possibly in the form of a municipal enterprise, co-operative or other type of association.

Advantages:

** Activities centralised at a level facilitating service-related decision-making;

** greater ease in mobilizing community support for maintenance work;

** the resolution, within the community, of conflicts of
interest regarding the use of water;

** and lower operating cost.

** Disadvantages:

** little experience and know-how in business management;

** problems in collecting electricity bills and in the use of financial reserves (which might occasionally be improperly diverted to other purposes) for replacement and maintenance;

** the possibility for faulty maintenance;

** and poor opportunities for economies of scale.

The decision as to which arrangement to use would have to be site specific. In some villages, cooperatives have been noteworthy in their smooth operation, whereas in nearby villages, cooperatives have had disastrous effects on community life.

It is notable that little of the development of decentralised power systems has been the work of national power authorities. They are simply not accustomed to executing small projects at the local level. This opens the wider issue: should the private
sector be brought into the power generation business? This is a promising concept, but runs against the grain of power planning over the past several decades [Flavin, 1986]. In countries like Indonesia and Thailand, issues such as national security are raised whenever the topic private power generation is invoked. The ideal should be to create hybrid competitive power systems in which there is some central planning and control, but in which private companies are encouraged to bring innovation and efficiency to the system.
8.1 Overview of Private Generation

A private power enterprise, even in countries with a market economy, raises problems when applied to public service renewable energy projects in rural areas, since such plants are not generally regarded as investment opportunities offering an adequate profit margin, but as tools for the promotion of development. Normally, the best prospects for such an alternative are provided by independent producers who require energy for their production activities (for example, agro-industries, sawmills, mines) and can sell any surplus power to nearby communities. The selection of the applicable administrative arrangement will depend on the socio-economic structure of the country, the extent to which such plants have been developed there, the capacity and nature of the electric power enterprises, the size and remoteness of the plants, and finally the traditions, work experience, and managerial skills of the community.

The funding for power system expansion programmes are a major burden on national budgets. Typically 20% of a development budget may be allocated to power system expansion and 40% of foreign debt outstanding may be for the power sector [Lucas,
To the extent that private generation can be properly coordinated with utility expansion, funds would then be made available for other purposes or it could be used to ensure a reasonable pay-back period on the initial investment.

The use of private power generation has mainly been restricted to conventional power supplies such as oil, coal and more importantly natural gas. However there have been instances where renewable energy has been considered in the use of Build, Operate and Transfer (BOT) Schemes, and Build, Operate and Own (BOO) Schemes. The third option, Build, Operate and Sell (BOS) is seldom used for renewable energy systems.

BOT schemes are best used when there is a currency mismatch i.e., when electricity is seen as a basic commodity (usually when this occurs tariff raising is limited and a cash flow deficiency is supported by the government. This is a diluted form of guarantee.), and where there is a long gestation period. A commercial bank using the export credit system does not want a payback period for longer than eight years. Each bank "floats" a loan every six months. The interbank office rate is 1.5% of the cost of funds.

If the government is the buyer of the BOT scheme, then this gives the creditor some comfort as there is a measure of security in
this investment. If industry is purchasing the scheme, the creditor will check to see if they are a viable business and will want a long-term supply agreement with tariffs negotiated before hand. For example, they will wish to know if there is a fuel cost increase, can the private sector then pass on the cost to the buyer?

Large scale government projects in ASEAN are financed through commercial banks and not usually through development banks. However, the best source of funding for private sector power generation are aid agencies, the Asian Development Bank, and the World Bank. The International Finance Company does a credit package from the above sources at a fixed rate of 9-10%. There is a grace period for up to 6 to 7 years.

Presently, private generation of energy connected to the grid in the Asia and Pacific is small and insignificant. However, theoretical studies show that stability is enhanced at peak load with the injection of electricity from private suppliers [Chang, 91].

According to a study conducted by the California Energy Commission (CEC) Energy Technology Export Program, a potential demand for 18,900 MW of power projects with a value of more than US$19 billion exists in Indonesia, the Philippines and Thailand
CEC found that all three countries prefer build-operate-transfer (BOT) arrangements, although Thailand is limiting this to co-generation projects. EGAT still prefers to deal with individual suppliers rather than turnkey developers and gives highest priority to hydro-electric and coal projects which tap the country's natural resources. Funding is most likely to come from IBRD/ADB sources.

Despite a preference for BOT, Indonesia also seeks quotations on equipment rather than turnkey arrangements as it has no price schedule for purchase. High priority is given to hydro, lignite and geothermal with financing sought from IBRD/ADB.

The Philippines strongly favours BOT projects, particularly if a developer can be identified who finances construction while the PNOC assumes debt and ownership on completion.

8.2 Country Activities in Financing Private Power Generation

A thorough investigation by the author has provided the following information on country activities in financing private power generation.
8.2.1 Malaysia

Malaysia has recently privatised its generating authority, and the other countries in the region are closely watching the outcome of this venture.

The Pulau Tioman small hydro project for rural electrification was funded by the Prime Minister’s office. It currently makes a profit of 60,000 MYR per month. The operation and maintenance is 5,000 MYR per year. The government has provided 50% of the cost financing (through cross-subsidies) and the structures are given free. However, operation and maintenance cost must be born by the project operators, which in this case was BP Solar.

Presently, TEN’s generation cost are very low and other electricity vendors can not compete with this. The average cost for electricity is 2-3 cents/KW. This has hindered the development of additional private power projects.

8.2.2 Philippines

The private sector is encouraged to participate in power generation. The National Electricity Authority (NEA) has implemented most of the rural electrification schemes through electric cooperatives which are privately owned by the rural
people. Loans are secured through the NEA on very soft terms with the World Bank and the Asian Development Bank supplying financing for materials.

The Development Bank of the Philippines (DBP) has no specific funding set aside for energy financing. However, energy is included in the strategic sector and as such energy projects could receive financing through this category. Most projects are evaluated on a "first come, first served" basis.

The IBRD Private Line for energy development is available through the DBP. It offers an interest rate of 12% and repayment terms at 7 years. To date, all that this fund has financed is a solar thermal hot water heater for a hotel. Adequate financing is available, but not tapped which may possibly be due to a lack of awareness.

The Asian Development Bank, located in Manila, has no funding set aside specifically for renewable energy projects. Renewable energy technologies may be included, on a small scale, in conjunction with large scale conventional power generation projects.

Approximately US$ 40 million will be spent on the energy sector over the next five years. This small amount will be comprised of
mixed credits. There is a new proposal to increase private sector interest in energy financing as it is the biggest energy consumers and generally need a reliable supply of electricity. It is hoped that the Office of Energy Affairs (OEA) will then be able to focus on technical assistance and that the private sector as well as bilateral donor agencies will provide the capital.

8.2.3 Thailand

In Thailand as well as other South East Asian countries, there is little direct financing available for energy generation for individual consumers. The author has investigated financing systems already available and the following schemes listed can be used for energy projects as long as they are related to the funder's mission. For example, the Bank for Agriculture and Agricultural Cooperatives (BAAC) in Bangkok will loan money for energy projects as long as they have an agricultural application.

The BAAC, which is a government bank, lends to farmers only for agricultural activities, agricultural related activities or government sponsored promotional activities. The lending rate for these loans is 9% and the payback period depends on the life span of the project. There are also long term loans (greater than 5 years) which have an interest rate of 11.5% and short term loans (less than 5 years) with a 12.5% interest rate.
These credit extension agencies reach 54% of the population. Loans are given out to individual farmers and the BAAC has reached over two billion clients. The lending structure is organised so that the farmers cooperatives association receives the money and then lends it out to its members. The cooperatives are charged interest at a rate of 9.5%. There are certain contingencies included: if a farmer has a bad season, the cooperatives are allowed to postpone repayment for another season. The amount lent to the farmers is equal to about 60% of the market value of any surplus the farmer has. If a farmer has not had a surplus, he must acquire money from the informal sector such as private money lenders who will then charge him at an interest rate of 3-10% per month. The only other option is if the government requests that a particular farmers' cooperative, which has been made insolvent and needs immediate financial assistance, be given a loan, then the BAAC will supply the financial assistance provided that the government contributes infrastructure, land and technical assistance. Many projects are done this way.

A typical gross income for a dairy farmer is 32,000 baht per year [BAAC, 1990]. Sixty per cent of the population are farmers (classified by family). A farmer's income from agricultural activities is generally dependent on weather and soil conditions.
which means that the income is variable. In order to provide some financial stability non-agricultural activities such as salt mining, and fishing are also undertaken. For example, a typical net cash income from agricultural activities is 9,000 baht per year and from the non-agricultural enterprises is 13,300 baht per year. Cash expenses would be in the area of 19,000 baht per year so the net surplus would be approximately 3,300 baht per year. The process for establishing loan eligibility takes 1-2 weeks.

Some of the loans have been used for investing in biogas digesters, diesel generator sets, and government promotion of renewable energy projects such as wind energy for water pumping.

The Department of Agricultural Extension (DOAE) promotes only crops and as such has indirect contact with livestock and fisheries departments. The DOAE works from the Ministerial level down to the kampong (village) level. It collects data and diffuses knowledge to each organisation via the kasi kampong (extension worker). The Farm Machinery Section is actively promoting "natural energy" such as solar, wind, draught animals, and natural gas as these applications are cheaper than diesel or gas. There is a problem supplying most villages with fossil fuels, although the larger and richer farmers would own their own petrol stations. The smaller farmers however, have problems getting the energy that they need. Fortunately, the percentage
of energy consumed is quite small, and this could be readily supplied by the use of renewable energy technologies. In the central plain, most farmers currently use diesel or petrol generator sets, whereas in the Northeast most farmers use draught animals. Biomass (fuelwood) would be used for home consumption only.

DOAE does not participate in direct financing of any sorts but operates through the BAAC. The farmers are approached through extension agents, and with their assistance are asked to prepare a farm plan. This farm plan is necessary for loan approval and needs to be endorsed by the extension agent.

The ASEAN-USAID Growth Plan for Potential Joint Ventures can be used for financing renewable energy schemes amongst other things. However, USAID has changed its policy directives from an emphasis on renewable energy to energy conservation, where the bulk of the financing is now used.

8.2.4. Indonesia

The President’s Rural Energy Credit provides the start up capital for 3,000 small decentralised energy projects. This would then become a revolving loan fund with repayment being worked out according to income level. All repayments are placed back into
the fund which will then be made available to prospective purchasers of renewable energy systems.

Most of the small scale decentralised energy financing is through bilateral agreements with donor agencies. Whereas, the large, centralised energy projects have been funded by the Asian Development Bank and the World Bank. Financing arrangements would be similar to the situation in the Philippines.

8.3 Activities in Private Power Generation

8.3.1 Thailand

Mitsubishi has begun the first Build Operate and Sale (BOS) plant in Thailand at a cost of 85 million dollars. The electricity tariff is on a progressive rate, where the more energy used the more expensive it becomes. However, the private sector wants to use the avoidance cost (the amount of money saved by the utility in not having to build another power plant) cost in calculating the buying rate.

Build, Operate and Transfer (BOT) may become feasible in Thailand but at present EGAT is economically strong enough to discourage this. However, EGAT is considering using BOT for the debt-service ratio (when importers buy goods or services from other
countries they usually need to pay in terms of the the currency of the exporting country) but the worker's union is very much against any move to privatise the energy sector.

8.3.2 Indonesia

Build, Operate and Own (BOO) and BOT are very feasible as the PLN loses money on its operations outside Java even though prices are cross-subsidised.

Most private power generation is for industrial use. Before 1959, excess electricity could be sold to the national grid. From 1955 until 1959, the electricity generating authority was nationalised and made a state monopoly with captive power generation being excluded. Industries were allowed to continue generating their own power as the state utility could not guarantee a reliable supply of electricity. Currently, the installed capacity, which is about 8,000 MW, is equal to the captive power generated. Most industries utilise diesel generator sets as the price of diesel is heavily subsidised (250 Rp/l), but a few such as the sugar industry and the palm oil estates utilise biogas and biofuels. However, the diesel subsidy goes against government policy as there is no incentive to change to a non-oil based fuel.
PLN covers all of Indonesia, but in areas where PLN is not able to extend the grid other entities can generate power privately. There is also a governmental promotion to motivate the private sector and industries to sell excess power to either the utility or to local communities. It has been calculated that the sugar industry alone produces 10 MW of excess power from biomass residues [PLN, 90].

Cooperatives are encouraged to generate their own power. But there is no incentive to privatise the energy utility as it would be difficult for one private utility to meet the demand in every island. Yet if each island could have its own utility, or several private utilities, the demand could be met in a cost-effective way.

8.3.3 The Philippines

Presently, there are 127 active electric cooperatives [OEA, 1991]. The National Power Corporation in coordination with NEA has taken over power supply functions on a cross subsidy arrangement of initially, 14 small island cooperatives.

The Association of Private Utilities - Philippine Electric Plant Owner's Association has several private utilities which are utilised on an emergency basis to sell power to the NPC. Most of
these plants use steam or diesel but a few use large hydro and one located in Mindanou is looking at developing its micro hydro reserves. There is a bill pending that will give financial incentives to the private sector if they utilise small hydro for power generation.

It is difficult for industry or the private sector to sell electricity to the NPC as there is a lack of agreement over the buying price. Hence, industrial plants have generators for stand-by generation only. For example, the copper industry runs a boiler which drives a steam turbine with a generating capacity of 6MW, but the bulk of the supply comes from NPC.

8.3.4 Malaysia

As the national utility has recently been privatised, all electrical energy generated by this utility can be considered as privately produced power. However, in the past, most of the activity in private power generation has been in the industrial sectors. The National Padi and Rice Board (LPN) has plants known as Rice Husk Energy Conversion Plants (RHECP) that are used to dry padi. LPN is also in the process of building a $1.5 million dollar generator which will help the board to save $112,000 a year in electricity cost [New Straits Times, 1991].
The palm oil industry utilises oil palm residues to power some of its operations. Fibre and shell are used as boiler feedstock for electricity generation, and palm oil mill effluent has been used in anaerobic digestors.

The rubber industry utilises wood waste for electricity and process heat. Gasification systems have been developed for this application and have worked so well that the system is being exported to Indonesia.

8.4 Conclusions

Financing for renewable energy systems is good at the end-user level. However, whether or not this financing is utilised depends on the price structure and the level of convenience that accompanies the technology. All of the governmental organisations appear to be dedicated to the transfer of renewable energy systems technology through programme components such as training, extension work to follow up services, research and financial support. Nevertheless, legislation to assist in the further dissemination of alternative energy technologies is necessary for this to succeed.

Opening the power system to private competition is both a way to bring financial resources to electricity projects and a way to
spur the development of innovative technologies. Countries with different political systems and power industries appear to be moving in similar directions. The end of the era of exclusive government power monopolies will almost certainly open opportunities to improve the reliability and cost-effectiveness of electricity systems.
Chapter 9 - Target Groups for Commercialisation

Given the technological, social and economic levels in the countries studied, the author recommends that the following technologies should be actively marketed:

1. **Biomass Gasifiers** (in particular rice husk gasifiers).

   (a) Biomass Gasification Technologies for Combined Cycle Power Generation.
   (b) Biomass Gasification for Gas Turbine Power Generation.

2. **Biogas Utilisation for Large Scale Industries**

3. **Solar Thermal for large scale industrial use.**

4. **Solar Thermal for domestic use.**

In the area of rational use of electricity, the author proposes that the following be actively pursued for commercialisation.

1. **Energy Efficient Air Conditioning for Commercial Buildings.**

2. **Energy Efficient Commercial Lighting.**
3. Low Electricity Appliances and Electronic Office Equipment.

4. Improved Cookstoves, Kilns and Charcoal.

These technologies were chosen because they:

1. make use of abundant local resources,
2. have demonstrated themselves as being able to meet the needs of the consumer on a reliable basis,
3. assist in pollution abatement,
4. make use of technical skills already in existence,
5. have a certain degree of social acceptance and/or,
6. have a large potential market share.

As renewable energy systems are generally deemed to be inferior to conventional power supplies such as oil, coal and natural gas, it would be wise to use renewable energy sources which can exploit conventional energy generation equipment. With this thought in mind, two new generation technologies may be added to the list: Biomass Gasification Technologies for Combined Cycle Power Generation and Biomass Gasification for Gas Turbine Power Generation. These systems, although commercially available, are not yet widely found in the market due to the high capital investment.
However, with more R&D done to lower the cost and to make the systems operational on different types of biomass, the market potential, especially in the industrial sector, would be significant, and there could be applications in the commercial sector as well. The high probability of being able to sell surplus electricity to the utility makes the technology more financially viable. In addition, due to the fact that these systems make use of "western technology", they appear to be more socially acceptable.

9.1 Technologies Not Chosen - Rationale

9.1.1 Solar pv systems

Second generation solar pv systems are still working commendably. This proves the reliability and durability of the system. In addition, solar pv systems have made immense progress in improving efficiency levels. However, these systems were not selected for the following reasons.

(a) The author visited many rural electrification schemes and spoke with the end-users on product satisfaction. Although generally enthusiastic about having electricity connections for the first time, they also had many complaints. Renewable energy systems are generally perceived as being a "second-class" energy technology. The average consumer in S.E. Asia is fairly sophisticated. They
are very aware of how "the other half lives" i.e. people in urban areas or people connected to the national grid. They are also aware that these people are able to have electricity on demand. A solar pv system will usually supply anywhere from 4 to 8 hours of electricity per day (depending on system use and climatic conditions). This was unacceptable to most of the people that the author interviewed.

(b) As the consumer became familiar with the system, they started to demand more from it. Most systems are designed to provide 18 to 56 Wp. This is not enough to power many of the additional electrical appliances that rural people wish to purchase. The consumers very soon outgrow the system because it is not economical to upgrade it to the desired output.

(c) Another reason that solar pv systems are excluded was due to the conflict over land usage. In several villages studied, coconut trees had to be cut in order to place the panels at the most advantageous site. Although, the villagers were reimbursed for each tree cut down, it was claimed that they lost money. The villagers made their livelihood from the coconut crops and a reduction in the number of trees meant a reduction in the level of future income.
Conclusions

Cell research will have to be geared towards high efficiency technology rather than low cost cells. High solar cell efficiencies are desirable in order to cut the cost of the pv systems. In particular, the higher cell efficiencies will make it possible to reduce the cost of the supporting structures and civil engineering and ground work needed for the installation of solar modules and arrays, and simplify cabling and interconnections [Lugue, 1990]. Furthermore, there will be a corresponding reduction of the area needed for the installation of pv collectors in the large-scale implementation schemes of the future.

Presently, solar pv systems are generally used as a "stop-gap" measure to extend electricity to communities as quickly as possible until power can be supplied by the grid to their village. As such, the market potential is small. Systems can be dismantled and moved to other sites once the grid is extended, therefore it is not necessary to buy more systems if the same ones can be re-used.

Solar pv is also vying for a shrinking market. Most areas in S.E. Asia are becoming less rural and remote. The majority of governments have very ambitious plans to increase extension of their grids or to set up mini-grids operated on conventional energy supplies such as coal and
natural gas. The only area for growth would be in very specialised applications such as telecommunications, and navigation. The Japanese New Energy Development Organisation in conjunction with several R&D organisations has been developing a semi-transparent pv panel that can be used as a window for commercial, industrial, and domestic buildings. According to the World Solar Markets, the ultimate market for solar pv systems is in grid-connected power generation for utilities. Until solar pv systems can compete in grid connected systems, their use is likely to be very limited. The above examples would indeed be the way forward for developing a strong market for solar pv systems.

9.1.2 Small Hydro Systems

Small hydro power systems have been noteworthy in supplying electricity reliably to rural consumers for years. With the trumpeting of small is beautiful, there was a proliferation of these schemes. Some worked well and some did not. In view of the fact that "small" was the objective, many engineers did not conduct feasibility studies, and the few that were conducted lacked reliable data on local water resources, and climatic conditions in order to make sound decisions. Many systems used miniaturised versions of large scale hydropower designs and because of this and the above reasons, there was an abundance of failures. However, this is not the reason why these systems did not make it to the
"target group" list.

The reason is this: small may be beautiful but experience has shown that larger is better, at least when deciding between micro (< 100 kW), mini (101 to 500 kW) and small hydro (501 kW - 1000 kW). Many of the waterways that would be suitable for micro hydro installations have already been developed for such. Presently, countries like Malaysia, and Indonesia are concentrating on developing their small and mini hydro potential. Nevertheless, this is a shrinking market. Once suitable sites have been chosen and developed, there will be no further development in the market for this technology.

Conclusions

The last frontier for small hydro will most likely be for either utilisation as a mini-grid or interconnected with the national grid to reduce load losses and improve transmission. For rural electrification, its use will diminish for the same reason as solar pv systems in that it is aiming for a market that is becoming less rural and remote.

9.1.3 Wind

In the region, wind has only had a cursory examination in
the field. Although there have been many demonstration sites established to study this technology, it has had mixed success in small scale applications such as water pumping and low power electricity generation. The major problem, as discussed before, is the corrosion of the turbines and the propensity of cyclones in the Asia and Pacific area. In Eastern Thailand, the DOAE has been using wind power quite successfully for the past several years, but for the countries studied in this region there is no government (and very little private sector) initiative to promote this technology due to its very poor reliability record.

Conclusions

When wind energy is compared to other renewable energy systems for the same applications, solar pv systems are preferred. Operation, and maintenance on pv systems is simpler so less man hours are invested in system training and maintenance.

9.2 Target Groups


The greatest market is for industrial applications, especially industries that already utilise biomass for
direct combustion or are agriculturally or forestry based. The 1976 figures of direct combustion of bagasse, coconut shell and husks, sawmill waste in the agri- and wood processing industries in the Philippines generated power and process heat equivalent to 7 million boe or about 8% of the country’s total usage of commercial energy. Only 13% of the agro-forestry waste is utilised [OEA, 1898].

In Indonesia, rice is one of the main agricultural crops. Based on the 1985 figures for rice production, the potential availability of rice husks is 11 million tons [Manurung, 1986]. An open core down-draft gasifier capable of continuous processing of rice husks has been developed in Twente University of Technology, the Netherlands. The diesel fuel replacement of up to 70% can be achieved and based on this the rice husk to electric conversion factor is found to be 2.4 kg/kWh. The 1985 cost savings would be Rp 7000 per day [Manurung, 1985].

Another possibility is the ferrocement gasifier which can be fabricated using local craft skills and readily available materials. This resolves many of the obstacles, such as tooling and system costs, methods of dissemination, corrosion, gas sealing and scaling to match available internal combustion engines which are encountered with conventional charcoal gasifier systems [Ucok, 1988]. It also facilitates ease of repair, operation and maintenance.
According to the 1988-1992 National Program for the Development Promotions, Utilisation and Commercialisation of Non-Conventional Energy Systems (the Philippines), the potential market for producer gas-fueled internal combustion engines includes:

(a) Irrigation pumps using petrol or diesel engines of up to 175 W capacity,

(b) Stationary farm machineries such as rice threshers, palay driers, generator sets powered by 15 W to 30 W petrol or kerosene engines,

(c) Ricemills with 34 W to 40 W diesel engines,

(d) Small ice plants (up to 2 tons per day capacity) driven by 110 W petrol engines,

(e) Specialised applications requiring special designs and installation schemes using diesel and petrol engines with capacities of 200 W and below.

The market for direct heat gasifiers is for the following systems with heat requirements of up to 2,000 kW:

(a) Boiler applications,
(b) Rotary kilns,
(c) Stationary or rotary dryers, and
(d) Furnaces.


Biomass is well placed to take advantage of developments in gas turbine power generation. Like coal, biomass can be gasified into a volatile gas suitable for burning in a gas turbine, but it has two crucial advantages: it is much more reactive than coal, so it can be gasified at a lower temperature; and it contains little or no sulphur, therefore the additional expense and loss associated with sulphur removal is avoided.

Although far more effort has been expended on research into coal gasification, suitable biomass processes can to a large extent draw on such research. It is quite possible that biomass gasification for high performance gas turbine stations could well reach commercialisation first\(^2\) as the cost seems almost certain to be lower, and the efficiency could be comparable or higher [Larsen, 1989]. This is not to minimise the uncertainties (crop failure, shape and

\(^2\) Coal gasification systems are and have been marketed but the market share is still negligible. Biomass gasification systems have the potential of developing a larger market share.
density of feedstock) associated with using such a diverse resource for this application, but the prospects, if sufficient R&D is applied, appear to be very good.

9.2.3. Biomass Gasification Technologies for Combined Cycle Power Generation

Natural gas has been used to run combined cycle power plants (in the past coal gasification was the sole medium for combined cycle generation); however, biomass is now being researched as a feedstock for combined cycle power plants. This technology requires the adaptation of the coal gasification technology already in existence. Reed and Bryant (1978) have developed a case for using densified biomass as a combustion fuel to replace coal, oil, or gas. As stated above, coal has 5 to 20% ash and 1 to 5% sulphur which causes disposal and pollution problems; biomass has less than 1% ash and very little sulphur (0.1%) hence pollution abatement is less of a problem [Bungay, 1981].

Fresh biomass has about 1/3 the energy of coal per unit weight and about 1/4 the energy of coal per unit volume. Densification can change these relationships to 2/3 and almost 3/4, respectively [Bungay, 81]. Densified biomass has been developed and tested in every country studied. In addition biomass gasification systems are already being utilised. New applications for combined cycle power
generation should be developed as the future market looks promising.

9.2.4 Biogas Utilisation for Large Scale Industries

All the hope for this technology was placed on village level applications for domestic use or small scale industrial use. However, the greatest potential for this technology is in industrial applications and not for energy generation but for pollution abatement. Industries such as tapioca, slaughterhouses, and palm oil produce large amounts of effluent which could be treated by the usage of this technology. In 1983, the potential agricultural and industrial waste in the Philippines amounted to $3 \times 10^7$ metric tons [UN, 85]. The author estimates that approximately 30% of this would be in the form of liquid effluent that could be treated with biogas digesters. This is a significant amount and with stricter environmental regulations in formation, this technology will assist in maintaining or developing water purity standards.

In addition, biogas still has a role to play in supplying process heat and for internal combustion engine use. This application is more expensive but further R&D efforts can decrease the cost.
Conclusions

Many of the drawbacks of using biomass have now been removed. Issues such as transportation, and storage of biomass are no longer a matter of concern in that the biomass can be used at the site and immediately converted into thermal energy by gasification (this solves the storage problem). Excess electricity could then be sold to a utility (as in Malaysia, Indonesia, or the Philippines) or sold to the surrounding communities.

In Thai sugar mills, installed generating capacity from sugar residue into electrical and mechanical power is estimated at approximately 1000 MW or about 15% of the total capacity of the public utility [Wibulswas, 90]. The percentage of the 1000 MW of total generating capacity that is no longer needed by the sugar mills would allow for the utility to expand services to residential and commercial consumers.

Another advantage is that biomass waste, such as coconut shells, rice husks, forestry waste, oil palm waste, is generally utilised for energy generation so there is no competition with food enterprises for resources. Industries, in this environmentally aware climate, must find suitable ways to dispose of their agricultural and
industrial residues. Rice husks have generally been burned in the fields or at the plant so the heat and ash is simply released to the atmosphere.

Systems must be well designed and provide for automatic or easy loading of biomass. Parts must be readily available to reduce downtime, and personnel must be thoroughly trained. As biomass is utilised by the majority of homes and industries in the rural areas, its usage should be maximised through improved technologies.

The major obstacle at present appears to be that the electrical industry is poorly structured to promote or pursue interest in biomass; while those involved in biomass do not have the capital or technical expertise to undertake such a development programme.

9.2.5 Solar Thermal for large scale industrial/commercial use.

This is still a relatively untapped market. Hotels and hospitals have started purchasing solar hot water systems but the cost is still too high when compared to conventional electric water heaters. However, large units for commercial establishments suffer fewer installation flaws since their high cost justifies professional design and construction. Operation and maintenance are the primary problems with
Another application is solar drying for agri-industries. Solar thermal use for crop and timber drying has been well researched and developed. Field test in Thailand have shown large scale solar dryers to be more economical than smaller ones [Wibulswas, 1896] so market emphasis should be on this technology rather than on solar dryers for small rural industries.

9.2.6 Solar Thermal for domestic use.

One particular niche in the domestic market for hot water heaters is the urban, upper middle class. This is a fairly well developed market. However, as Brazilians living in similar climates have turned to heated water [World Bank Report, 1990], it can be anticipated that hot water heaters will find a larger market that transcends socio-economic considerations. Therefore, the government should sponsor development, or at least encourage the private sector to do so, of low-cost systems that rely on solar energy for hot water, use outdoor storage, but provides electric boosts when conditions do not permit full use of the sun. Since water heaters are much simpler than most other appliances, their development and testing could take place rapidly, within 2 or 3 years. Being relatively simple to make, these
water heaters could be produced by local companies. Presently, most solar water heaters are produced in joint-ventures with European, Japanese or Australian companies.

Conclusions

The demand for hot water will undoubtedly grow in S.E. Asia as more and more low cost, and reliable systems penetrate the market.

Any contract for large-scale installation should include operator training and an extensive maintenance guide. Since most large scale installations are custom designed, contractors rarely take the time to properly document the installation or provide a complete trouble shooting and operations manual.

9.2.7 Energy Efficient Air Conditioning for Commercial Buildings.

Although equivalent figures for S.E. Asia are not available, studies have shown that about 30 kWh/m²/year of electricity is needed for the processing and distribution of air in new Swedish office buildings incorporating air-conditioning systems [Abel, 1989]. The electricity demand of air conditioning systems can be reduced by careful design. The aim must be to reduce the generation of surplus heat. Other
significant savings can be made by correct selection and installation of fans and by proper aerodynamic design of the duct systems. Savings of the order of 10-20% in electricity use for air processing and air distribution can be achieved without significantly affecting system costs [Abel, 1989].

Conclusions

Knowledge about the amount of electrical energy consumed by HVAC (heating, ventilation and air conditioning and cooling systems) or VAV (variable air volume systems) in the countries studied is extremely limited. Nevertheless, the hot, humid climate in S.E. Asia necessitates that the amount of electricity utilised by air conditioning systems will increase. Although there are no figures to confirm this, interviews with HVAC salesmen have confirmed increased sales of their systems (private communication, 1991).

Additionally, waste heat recovery from air conditioning systems can be used to preheat water in hotels and hospitals, thereby producing further savings.

9.2.8 Energy Efficient Commercial Lighting.

Lighting remains a significant load for electric utilities, representing from 8-17 percent of the total electricity consumption in industrialised countries, according to recent
estimates by the International Commission on Illumination (CIE) Committee. Although no similar figures are available for newly-industrialised countries, it can be assumed that a very substantial portion of electricity could be saved through energy efficient lighting.

New lighting technologies have the potential to substantially improve lighting efficiency and reduce total lighting energy use. In some systems, a three fold increase in efficiency per socket can be achieved [McGowan, 1989]. Implementing effective strategies to utilise this potential and putting it into the hands of lighting users will be the key to any significant lighting energy reductions.

Conclusions

Substantially less energy can be used for lighting than at present. Policy to utilise energy efficient lighting have been developed by all countries studied. However, what is now needed is an implementation strategy. Many high efficiency lights have to be imported and most countries impose enormous taxes on imported items. As such many consumers are not willing to pay the high initial capital investment even if long term gains can be proven. How to take advantage of the technology is a key component to implementing energy-saving hardware and techniques. Organisational control is required to determine lighting
priorities. However, the interest on the part of the private sector for energy efficient lighting is already apparent as noted by government energy conservation organisations [ECCT, 1990]. As such the future market will be significant.

9.2.9 Low Electricity Domestic Appliances and Electronic Office Equipment.

As the countries studied are referred to as middle income economies (with the exception of Indonesia which is classified as a low-income economy) [World Development Report, 1991], growth in the usage of domestic appliances and electronic office equipment will increase. In the U.S., office equipment electricity use in 1995 could range from 130 TWh ("market saturation", using current technology, and with extensive use of computerised printing), to about 25 TWh if today's most efficient hardware and operating systems became the market standard [Norford, 1989].

Domestic appliances would include irons, refrigerators, washing machines, and spin dryers. Office electronic equipment would include: computers and associated peripherals, printers, fax machines, photocopiers. In Denmark, 45% of the electricity goes to run appliances. Norgard states that Danish life-styles can be maintained at the current level with total electrical energy consumption
at only 26% of the present consumption, if efforts are directed at development and implementation of efficient technology. The estimated added costs for the advanced efficient technology corresponds to an average price of approximately 2.5 US cents per kWh electricity saved which is well below electricity costs in all countries [Norgard, 1981].

Conclusions

Although there is very little available data on electrical energy consumption of office equipment or appliances in S.E. Asia, one can expect that this market is likely to increase. As such energy efficient office equipment, if the initial capital investment is reasonable, will increase in sales. However, energy efficient technology is more expensive, and immediate savings would be preferable to most consumers than long-term savings. Government initiatives to supply tax incentives or rebates for those that purchase energy efficient appliances and office equipment would do more to commercialise these technologies than anything else.

9.2.10 Improved Cookstoves, Kilns and Charcoal.

As biomass in the form of fuelwood and charcoal is still being used in many rural and urban areas, the market for these technologies should be quite large and growing. It is
not. However, given technologies that make efficient use of the feedstock and conforms to local customs and traditions, the market potential appears to be promising.

One of the reasons for the lack of advancement of these systems has been the high purchase cost of the improved cookstoves compared to the traditional cookstove. Although education of the rural villagers has been done by extension agents to show the future savings in money (cost of ownership) through the usage of improved cookstoves, kilns, and charcoal, the initial capital investment is so high that people will not purchase them. This may change as tests are being performed to improve efficiency of cheaper local materials. Studies are also being performed by local governments to develop better marketing procedures. It is hoped that with the above strategies, the market for these systems will grow.
Table 20

Block diagram of stove design showing points of interest to consumers

The iterative nature of the design process
9.3. Implementation Strategy

To further the dissemination of renewable energy systems a strong government policy must be in place with appropriate steps taken to implement this policy. This directive need the support of utilities and cooperatives. Additionally, the role that donor countries, and the role that energy financing plays in technological choice must be re-evaluated.

9.3.1 Government Policy

Each government in the countries studied has stated the need to reduce their dependency on imported fuels, and actively to develop indigenous energy resources. Domestic coal and natural gas are being vigorously promoted, but the same cannot be said of renewable energy systems.

In order to disseminate further renewable energy systems, tariffs for conventional power supplies should be set at the actual cost to produce 1 kWh of electricity instead of at a cost based on social and political considerations. Although, it is unlikely that this will be accomplished, it is possible to implement financial incentives to reduce the capital cost of renewable energy systems. This can be done by:
(a) removing or reducing the import tax or luxury item tax associated with purchasing renewable energy systems, energy efficient equipment or appliances; or

(b) giving a tax rebate. At the end of the fiscal year a deduction could be made for all equipment that uses energy efficient technologies or renewable energy systems.

The government needs to take the initiative by introducing legislation that encourages the use of the above systems. This could be done by:

(a) mandating that all government buildings use energy efficient lights, and that all new purchases of office equipment make use of energy efficient technologies.

(b) including the rational use of energy and renewable energy technologies in primary and secondary school curricula so that future generations will be responsible electricity consumers.

(c) sub-contracting renewable energy and energy conservation projects out to utilities. This would give the utilities experience with renewable energy systems which many of them presently lack.
9.3.2. Utilities and Cooperatives

Utilities and cooperatives should play a dominant role in the future development of renewable energy systems technologies and the rational use of energy. In the past, renewable resources were used for small scale decentralised energy systems in each of the countries studied and as such were generally handled by the Ministry of Rural and National Development or its equivalent. This led to a lack of innovation in system evolution, because most projects were either turnkey or donated by Western countries in bilateral aid agreements.

As the new focus should be larger centralised systems (an area that most engineers feel more competent in), utilities and cooperatives will be in a good position to utilise these technologies, as well as adapt them in an unprecedented way to accelerate the further dissemination of these systems.

9.3.3 Role for Western Countries

The past and present role of western or donor countries in energy development has had both a positive and a negative effect on renewable energy system dissemination. It has introduced lower and middle income economies to small scale decentralised systems, which make use of different feedstocks and produce varying qualities of electricity or
thermal supply to meet development objectives. Donor countries have also taken traditional forms of renewable energy technologies and assisted in their upgading, thereby maximising their efficiency, durability and reliability.

The negative effect is that projects have been quickly put into place with little input from the countries themselves, or more particularly from the people who are to benefit from these systems. Recipient countries have also been guilty of implementing projects where local people have not been consulted. As a result there has been a lack of interest on the part of recipient countries and villages actively to maintain these projects, and they frequently fall into disrepair. Donor countries also look upon developing countries as a testing ground for their technologies, and this has also contributed to the high number of system failures.

Therefore, donor countries should not continue to execute aid projects that centre on energy development, but should allow and encourage their industries to actively market their own systems rather than have their governments execute this for them through aid projects. This would allow for greater competition which would spur the utilisation of appropriate and cost-effective technologies. Recipient countries would than be able to purchase the system that best satisfies their energy demand, and will then have adequate back-up support when things go awry.
Granted, it will be difficult for recipient countries to reject financial assistance that is tied to energy development. Nonetheless, the question that must be asked by both donor countries and recipient countries is "will this be money well spent?". If not, it behoves both countries to reject the present scenario and begin again.

9.3.4 Direct Financial Support

There presently exists adequate financial packages for energy financing. However, these are untapped basically due to a lack awareness on both the part of the lendee as well as on the part of the lender. Most banks have "lines" that are available for energy development, but have in the past only made money serviceable for diesel generator sets. However, after much discussion with bank officials, the author found that money would be lent for the purchase of renewable energy systems or energy efficient equipment.

However, prospective lendees need to have access to this information, and governments as well as banks could do much to advertise this. Governments can also encourage banks to make more money available for energy efficient technologies by guaranteeing loans up to a certain amount.
Chapter 10 - Conclusions and Recommendations

The author's foregoing survey of renewable energy usage and areas for market penetration leads to the following conclusions.

In *Energy Policy and the Greenhouse Effect*, Michael Grubb states that:

"a review of global energy resources at the opening of the 1990s thus stands in sharp contrast to those presented twenty years earlier. Despite the politically-driven upheavals in the oil market, new discoveries and the overall march of technologies for locating and extracting fossil fuels more cheaply, mean that the spectre of resource shortages has largely receded. Contrary to the fears which then dominated popular debates, there is widespread belief that fossil resources will prove adequate to support global economic expansion for many decades at acceptable costs. Another twenty years could perhaps reverse the picture again if growth is rapid and oil and gas reserves do not expand significantly (though this could not really apply to coal), but environmental constraints now loom larger."

The criterion used when deciding whether or not to implement a renewable energy project has, in the past, been the price of oil. If the price of oil was over US$40/barrel, then, as a rule, renewable energy projects became economical. During and after the first and second oil crisis of the early and late 70s, non-conventional energy generation escalated. However, the opposite has occurred during the past several years of stable oil prices. Hence, the price of oil argument no longer holds the strength that it used to. Today, the strongest argument in favour of the use of renewable energy systems is to reduce the environmental
impact of fossil fuel usage. However, it is doubtful that small scale decentralised systems will do much to reduce greenhouse emissions from petroleum products. Nor will they do much to meet the growing energy demand in the world's fastest growing economy. Hence, a re-think on what systems to use must be carried out.

Fritz [1982] cites five reasons why conventional energy is likely to be chosen instead of renewables:

(a) conventional energy sources can usually be used more widely and effectively than renewables,

(b) the technology of conventional energy is tested and readily available,

(c) conventional energy has been the basis of growth in industrialised countries: "it is out of the question for most of the developing countries not to take the same road to success",

(d) there are climatological as well as social barriers to renewables developing in densely populated areas of the Third World,

(e) renewable energy "does not replace imported fuels to a significant degree...it is very difficult for renewable energy
applications focused at village levels to make sizable reductions in oil imports".

It is from this perspective that the author suggest that non-conventional generating equipment based on conventional power supplies be more widely promoted. More energy will be needed by Pacific Rim countries to meet their development objectives. This power source will need to be environmentally less harmful than that produced by fossil fuels, as there is a growing global awareness of the environmental impact of power generation. As such, legislation is being formalised by the governments in the S.E. Asian region for pollution abatement. The technologies chosen can assist in meeting this objective.

It is clear that energy conservation and energy efficiency has an extremely important role to play in energy planning in S.E. Asia. The rational use of energy is considered to be another source of energy, as the savings generated by technically improved energy supplies and more efficient use of energy technologies could be quite substantial. Governments have mandated that organisations be established to perform energy audits and to make recommendations on where energy savings can be generated. The private sector has been galvanised to make use of these organisations, and tax breaks and incentives are either in place or are being developed to induce further energy savings in the
industrial and commercial sectors. However, more needs to be done for domestic consumers, as they are still not actively involved in RUE. Household appliances use outdated technologies, and the consumer needs to be made more aware of the energy consumption of different household appliances. The government can assist by supplying energy efficiency ratings and by giving tax rebates, or some other financial incentives, for each low energy appliance purchased.

Financing for energy systems is available but untapped. The author visited many lending organisations (such as the Asian Development bank, the Bank Pembangunan Malaysia Berhad, Bank for Agriculture and Agricultural Cooperatives, the Development Bank of the Philippines, Midland Montagu) and found that there are adequate financial resources for energy investments. Most of these funds are used to purchase diesel generators, but can just as easily be used to purchase, for example, a solar water heater. Unfortunately, there is a definite bias against lending for renewable energy projects; however, if the business plan states the advantages and the rationale, for example of using a solar pv system in preference to a diesel generator set, lending officers have stated that they would lend money on this basis [Norain and Poh, 1991].

In the next century, electric energy will supply an ever-
expanding array of services. The integration and adoption of advanced technologies would give governments new opportunities to establish policies that promote energy security, environmental protection and sustainable economic development while maintaining a vital power industry and reliable electric service. Large amounts of new electric generating capacity will be needed to meet demand growth and replace retired plants, even if there are substantial improvements in the efficiency of electricity production and use. Problems of public acceptance may limit the expanded use of nuclear power and some renewable energy technologies, and environmental concerns may cause increasing difficulties in siting other types of power plants. In particular, the global warming issue could discourage fossil fuel use for power generation, whereas power generation from renewable energy sources may be costly. The electricity industry and the private sector need to find a path through such constraints. Yet regulatory change and the availability of new technologies may improve relations between utilities and consumers, as well as provide support to demand side management options, especially pricing policies that encourage energy conservation.
Appendices
Country Sheet: Malaysia September 1990

Data from Petronas

**Geography / Meteorology**

- Land area: 330,000 km²
- Temperature range: 23°C - 31°C (Kuala Lumpur)
- Daily average temperature: 26°C
- Rainfall: 2,100mm
- Average daily Insolation: ~5 kWh/m²d (depending on location)

- Population: 18 million
- Population density: 50 inhabitants/km²
- Urban population: 35%
- Population growth rate: 1.98%
- Population with access to electricity: 82%

**Currency**: Ringgit
**Exchange rate (Sept. 1990)**: US$ 1 = M$ 2.70

**Economy**

- Total external debt (1990): 16,400 million US$
- Energy consumption (1988): ~77 million Barrels of Fuel Oil Equivalent (BFOE)
- G.N.P. growth (1990): 8.5%
- G.N.P./head (1990): $2,050
- Inflation rate 1988: 1989: 1990: 5%
- Main primary products: Oil, natural gas, wood, copper, iron-ore, bauxite, rubber, palm oil.
- Major Industries: Electronics, cars, car tires, food processing, textiles.
- Main exports: Rubber, oil, wood, garments, textiles, electrical goods, cars.

**Average manpower costs**

<table>
<thead>
<tr>
<th>Engineer</th>
<th>Technician</th>
<th>Utility man</th>
</tr>
</thead>
</table>

**Fuel prices**

<table>
<thead>
<tr>
<th></th>
<th>Premium gasoline</th>
<th>Gasoline</th>
<th>Diesel</th>
<th>Kerosene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Official Retail price (as at 1/8)</td>
<td>$1.02/lit</td>
<td>$0.95/lit</td>
<td>$0.54/lit</td>
<td>$0.59/lit</td>
</tr>
<tr>
<td>of which:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customs duty</td>
<td>$0.4298</td>
<td>$0.4491</td>
<td>$0.0915</td>
<td>$0.1156</td>
</tr>
<tr>
<td>Value added tax</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hauling charge</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dealers mark up</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fuel prices in Lube oil**

- Kerosene pressure lamps:
  - Average service life:
  - Yearly maintenance:
  - Fuel consumption:

- Kerosene wicklamp:
  - Average service life:
  - Fuel consumption:

**Dry cell batteries**

**Lead acid (car) batteries**

**Electricity kWh price**: ~$0.10 - $0.11 (SESCO & SEB)
Heal cost of grid extensions

- Diesel gensets
- Gasoline gensets

**Commercial prices of selected locally available PV system components**: $6 FOB
- Panel:
- G.I. panel frame:
- Battery Control Unit:
- Solar battery:
- DC-DC converter:
- Cables & Switches:

**Commercial prices of locally available DC appliances**: ($)
- 12 VDC, 20 W fluorescent tube, incl. holder + ballast
- 12 VDC, 10 W/15 W/20 W incandescent bulb
- 12 VDC B&W TV 12":
- 12 VDC Video player
- 12 VDC Electric (car) fan:
- Rechargeable NiCd batteries size D (1.2VDC, 2.0Ah)
Data from Shell Malaysia

Geography / Meteorology

- Land area: 330,000 km²
- Temperature range: 23°C - 31°C (Kuala Lumpur)
- Daily average temperature: 26°C
- Rainfall: 2,100mm
- Average daily insolation: ~ 5 kWh/m²d (depending on location)

Population

- Population: 18 million
- Population density: 50 inhabitants/km²
- Urban population: 35%
- Population growth rate: 1.98%
- Population with access to electricity: 82%

Currency:

- Currency: Ringgit
- Exchange rate (Sept. 1990): US$ 1 = M$ 2.70

Economy

- Total external debt (1990): 16,400 million US$
- Energy consumption (1988): ~ 77 million Barrels of Fuel Oil Equivalent (BFOE)
- G.N.P. growth (1990): 8.5%
- G.N.P./head (1990): $2,050
- Main primary products: Oil, natural gas, wood, copper, iron-ore, bauxite, rubber, palm oil.
- Major Industries: Electronics, cars, car tires, food processing, textiles.
- Main exports: Rubber, oil, wood, garments, textiles, electrical goods, cars.

Average manpower costs

- Government (GOV)/Private: MYR2000/month (PS)
- Engineer: MYR1000/month (PS)
- Technician: MYR 1200/month (GOV)
- Utility man: MYR 600/month (GOV)

Fuel prices in $/l based on oil price of US$20/1 March 1991 data

<table>
<thead>
<tr>
<th>Premium gasoline</th>
<th>Gasoline</th>
<th>Diesel</th>
<th>Kerosene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Official Retail price</td>
<td>MYR 1.13</td>
<td>MYR 1.06</td>
<td>MYR 0.6510</td>
</tr>
<tr>
<td>of which: Customs duty</td>
<td>MYR 0.3893</td>
<td>MYR 0.4142</td>
<td>MYR 0.01</td>
</tr>
<tr>
<td>Value added tax</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Hauling charge</td>
<td>depends on location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dealers mark up</td>
<td>MYR 0.0518</td>
<td>MYR 0.0462</td>
<td>MYR 0.0247</td>
</tr>
</tbody>
</table>

Retail price in Kuala Lumpur

- Lube oil: MYR2.50/l

Kerosene pressure lamps: MYR 30 - 40
- Average service life: 7-8 years
- Yearly maintenance: MYR 10.00
- Fuel consumption: 0.12 l/hour

Dry cell batteries

- MYR 0.30 - 0.40

Electricity kWh price: ~ $0.10 - $0.11 (SESCO & SEB)

Real cost of grid extensions

- Diesel gensets
  - 3kVA US$ 180.00
  - US$ 1500.00

- Gasoline gensets
  - 600 W US$ 120.00
  - not appropriate

Commercial prices of selected locally available PV system components (*).

- Panel: US$7-8 pWatt (excluding duty) $6 FOB
- G.I. panel frame: US$100.00
- Battery Control Unit: US$150.00 (100 Ah)
- DC-DC converter: US$100.00
- Cables & Switches: US$30.00

Commercial prices of locally available DC appliances (*)

- 12 VDC, 20 W fluorescent tube, incl. holder + ballast: US$20.00
- 12 VDC, 10 W/15 W/20 W Incandescent bulb (PL lights): US$30.00
- 12 VDC B&W TV 12": US$120.00
- 12 VDC Videoplayer: US$10.00
- Rechargeable NiCd batteries size D (1.25VDC, 2,000mA): US$3.00

(*) subject to change

### Geography / Meteorology

<table>
<thead>
<tr>
<th>Landarea:</th>
<th>2,000,000 km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population:</td>
<td>191 million</td>
</tr>
<tr>
<td>Temperature range:</td>
<td>23°C - 33°C (Jakarta)</td>
</tr>
<tr>
<td>Rainfall:</td>
<td>1,800 mm - 4,600 mm</td>
</tr>
<tr>
<td>Average daily Insolation:</td>
<td>4 - 5 kWh/m²d (depending on location)</td>
</tr>
<tr>
<td>Population density:</td>
<td>96 inhabitants/km²</td>
</tr>
<tr>
<td>Urban population:</td>
<td>22 %</td>
</tr>
<tr>
<td>Population growth rate:</td>
<td>1.96 %</td>
</tr>
<tr>
<td>Population with access to electricity:</td>
<td>22 %</td>
</tr>
<tr>
<td>Currency:</td>
<td>Rupiah</td>
</tr>
<tr>
<td>Exchange rate (Oct. 1990):</td>
<td>US$ 1 = R 1,855</td>
</tr>
</tbody>
</table>

### Economy

| Trade balance (1990): | -2,200 million US$ |
| Total external debt (1990): | 53,100 million US$ |
| Energy consumption (1989): | ~223 million Barrels of Fuel Oil Equivalent (BFOE) |
| G.N.P. (1990): | ~80,200 million US$ |
| G.N.P. growth (1990): | 6.5% |
| G.N.P./head (1990): | $520 |
| Inflation rate: | 1988: 6.4% |
| Main primary products: | Oil, tin, natural gas, nickel, bauxite, coal, gold, silver, wood, rice, sugar, palm oil |
| Major industries: | Textiles, steel, vehicle assembly, cement, cigarettes, plywood, food processing |
| Main exports: | Oil, natural gas, wood, rubber, tea, coffee |

### Average manpower costs

<table>
<thead>
<tr>
<th>Engineer</th>
<th>Technician</th>
<th>Utility man</th>
</tr>
</thead>
</table>

### Fuel prices in $/l based on oil price of

<table>
<thead>
<tr>
<th>Premium gasoline</th>
<th>Gasoline</th>
<th>Diesel</th>
<th>Kerosene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Official Retail price (as at 1/8) of which:</td>
<td>660 rp/lit</td>
<td>235 rp/lit</td>
<td></td>
</tr>
<tr>
<td>Customs duty</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value added tax</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hauling charge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dealers mark up</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Lube oil:

- Kerosene pressure lamps:
  - Average service life:
  - Yearly maintenance:
  - Fuel consumption:
- Kerosene wicklamp:
  - Average service life:
- Fuel consumption:

### Dry cell batteries

### Lead acid (car) batteries

### Electricity kWh price:

<table>
<thead>
<tr>
<th>Diesel gensets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real cost of grid extensions</td>
</tr>
</tbody>
</table>

### Commercial prices of selected locally available PV system components (*).

<table>
<thead>
<tr>
<th>Panel:</th>
</tr>
</thead>
<tbody>
<tr>
<td>G.I. panel frame:</td>
</tr>
<tr>
<td>Battery Control Unit:</td>
</tr>
<tr>
<td>Solar battery:</td>
</tr>
<tr>
<td>DC-DC converter:</td>
</tr>
<tr>
<td>Cables &amp; Switches:</td>
</tr>
</tbody>
</table>

### Commercial prices of locally available DC appliances (*).

- 12 VDC, 20 W fluorescent tube, incl. holder + ballast
- 12 VDC, 10 W/ 15 W/ 20 W Incandescent bulb
- 12 VDC B&W TV 12":
- 12 VDC Videoplayer:
- 12 VDC Electric (car) fan:
- Rechargeable NiCd batteries size D (1.25VDC, 2,000mA):

*subject to change |

Country Sheet: Thailand September 1990
Data from Economics Department Thammasat University

Geography / Meteorology
- Land area: 515,000 km²
- Temperature range: 21°C - 38°C (Bangkok)
- Daily average temperature: ~ 5 kWh/m²d (depending on location)
- Rainfall: 4
- Average daily insolation: 5 kWh/m²d

Population:
- Population: 57 million
- Population density: 106 inhabitants/km²
- Urban population: 20%
- Population growth rate: 1.7%
- Population with access to electricity: 59%

Currency:
- Currency: Baht
- Exchange rate (Sept. 1990): US$ 1 = B 25

Economy
- Trade balance (1990): -2,200 million US$
- Total external debt (1990): 27,300 million US$
- Energy consumption (1988): ~242 million Barrels of Fuel Oil Equivalent (BFOE), energy imports 90 million BFOE
- G.N.P. growth (1990): 11%
- G.N.P./head (1990): $1,194
- Inflation rate: 1988: 3.7% 1989: 5.8%

Main primary products: Tin, natural gas, wood, lead, fish, gypsum, lignite, rice, sugar, rubber.

Main industries: Textiles, automobile assembly, cement, tobacco, food processing, electronics.

Main exports: Rice, sugar, maize, tapioca, rubber, minerals, garments, electronics.

Fuel prices in $/l based on oil price of $20/barrel ($1 = 25 baht) March 4, 91 data

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Premium gasoline</th>
<th>Gasoline (83RON)</th>
<th>Diesel (12S)</th>
<th>Kerosene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Official Retail price</td>
<td>0.43</td>
<td>0.40</td>
<td>0.34</td>
<td>0.35</td>
</tr>
<tr>
<td>of which: Customs duty</td>
<td>0.14</td>
<td>0.14</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Value added tax</td>
<td>0.12</td>
<td>0.12</td>
<td>0.02</td>
<td>0.05</td>
</tr>
<tr>
<td>Margin</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.016</td>
</tr>
</tbody>
</table>

Kerosene pressure lamps:
- Average service life:
- Yearly maintenance:
- Fuel consumption:

Dry cell batteries

Lead acid (car) batteries

Electricity kWh price: $0.06 (P.E.A.)
Real cost of grid extensions up to $0.32/kWh (P.E.A.)

Diesel gensets

Gasoline gensets

Commercial prices of selected locally available PV system components (*).
- Panel 1988: $8 - $14/Wp (no tax incentives).
- G.I. panel frame:
- Battery Control Unit:
- Solar battery:
- DC-DC converter:
- Cables & Switches:

Commercial prices of locally available DC appliances (*).
- 12 VDC, 20 W fluorescent tube, incl. holder + ballast
- 12 VDC, 10 W/15 W/20 W incandescent bulb
- 12 VDC B&W TV 12".
- 12 VDC Videoplay:
- 12 VDC Electric (car) fan:
- Rechargeable NiCd batteries size D (1.25VDC, 2.000mA):
Data from Petronas

Geography / Meteorology

<table>
<thead>
<tr>
<th>Landarea:</th>
<th>515,000 km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature range</td>
<td>21°C - 38°C (Bangkok)</td>
</tr>
<tr>
<td>Rainfall:</td>
<td></td>
</tr>
<tr>
<td>Average daily Insolation</td>
<td>~ 5 kWh/m²d (depending on location)</td>
</tr>
</tbody>
</table>

Population:
- Population: 57 million
- Population density: 106 inhabitants/km²
- Urban population: 20%
- Population growth rate: 1.7%
- Population with access to electricity: 59%

Currency: Baht

Exchange rate (Sept. 1990): US$ 1 = B 25

Economy

Trade balance (1990): -2,200 million US$
Total external debt (1990): 27,300 million US$
Energy consumption (1988): ~242 million Barrels of Fuel Oil Equivalent (BFOE), energy imports 90 million BFOE
G.N.P. growth (1990): 11%
G.N.P./head (1990): $1,194
Inflation rate: 1988: 3.7% 1989: 1990: 5.8%
Main primary products: Tin, natural gas, wood, lead, fish, gypsum, lignite, rice, sugar, rubber.
Major industries: Textiles, automobile assembly, cement, tobacco, food processing, electronics.
Main exports: Rice, sugar, maize, tapioca, rubber, minerals, garments, electronics.

Average manpower costs

<table>
<thead>
<tr>
<th>Engineer</th>
<th>Technician</th>
<th>Utility man</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fuel prices in $/l based on oil price of

<table>
<thead>
<tr>
<th>Official Retail price (as at 1/8)</th>
<th>Premium gasoline</th>
<th>Gasoline</th>
<th>Diesel</th>
<th>Kerosene</th>
</tr>
</thead>
<tbody>
<tr>
<td>of which:</td>
<td>8.45 B/lit</td>
<td>7.75 B/lit</td>
<td>6.10 B/lit</td>
<td></td>
</tr>
<tr>
<td>Customs duty</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value added tax</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hauling charge</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dealers mark up</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Retail price in

Lube oil:

Kerosene pressure lamps:
- Average service life:
- Yearly maintenance:
- Fuel consumption:

Kerosene wicklamp:
- Average service life:

Dry cell batteries

Lead acid (car) batteries

Electricity kWh price: $0.06 (P.E.A.)
Real cost of grid extensions up to $0.32/kWh (P.E.A.)

Diesel gensets

Gasoline gensets

Commercial prices of selected locally available PV system components (*).
- Panel 1988: $8 - $14/Wp (no tax incentives).
- G.L. panel frame:
- Battery Control Unit:
- Solar battery:
- DC-DC converter:
- Cables & Switches:

Commercial prices of locally available DC appliances (*).
- 12 VDC, 20 W fluorescent tube, incl. holder + ballast
- 12 VDC, 10 W/ 15 W/ 20 W Incandescent bulb
- 12 VDC B&W TV 12":
- 12 VDC Videoplayer
- 12 VDC Electric (car) fan:
- Rechargeable NiCd batteries size D (1.25VDC, 2,000mA):
Country Sheet: Philippines July 1990

Geography / Meteorology
Landarea: 300,000 km²
7,100 islands - approx. 2,800 inhabited islands
Temperature range: 21°C - 34°C
Rainfall: 2,080 mm Lyzon
Average daily insolation: ~ 5 kWh/m²d Bulacan

Population:
Population density: 211 inhabitants/km²
Urban population: 35 - 40 %
Population growth rate: 2.5 %
Population with access to electricity: 40 %

Economy
Trade balance (1988): ~ 530 million US$
Total external debt (1989): ~ 27,000 million US$
Energy consumption (1989): 106 million Barrels of Fuel Oil Equivalent (BFOE), oil imports 46 million BFOE
G.N.P. growth (1990): 5.7%
G.N.P./head (1990): $727
Inflation rate: 1988: 8.8% 1989: 9.5% 1990: 10.8%

Main primary products:
- Rice, maize, coconuts, sugar cane, abaca, rubber, tobacco, pineapples, bananas, coffee, timber, fish, copper, chrome, gold, silver, iron, nickel, coal, crude oil.

Major industries:
- Agriculture, food processing, textiles, chemicals, forestry, fishing, mining.

Main exports:
- Electrical goods (semiconductors), clothing, metal ores, coconut oil, sugar, fruit & vegetables, timber, abaca.

Average manpower costs

<table>
<thead>
<tr>
<th>Engineer</th>
<th>Technician</th>
<th>Utility man</th>
</tr>
</thead>
<tbody>
<tr>
<td>$200 - $250 / month</td>
<td>$100 - $125 / month</td>
<td>$75 - $100 / month</td>
</tr>
</tbody>
</table>

Fuel prices (June 1989) in $/L based on oil price of $16.50/barrel ($1 = P21.50)

<table>
<thead>
<tr>
<th>Premium gasoline</th>
<th>Gasoline</th>
<th>Diesel</th>
<th>Kerosene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Official Retail price</td>
<td>0.30</td>
<td>0.27</td>
<td>0.23</td>
</tr>
<tr>
<td>of which: Customs duty</td>
<td>0.001</td>
<td>0.001</td>
<td>0.002</td>
</tr>
<tr>
<td>Value added tax</td>
<td>0.14</td>
<td>0.12</td>
<td>0.05</td>
</tr>
<tr>
<td>Hauling charge</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
</tr>
<tr>
<td>Dealers mark up</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Retail price in Buan, Tawi-Tawi</td>
<td>0.75</td>
<td>0.98</td>
<td></td>
</tr>
</tbody>
</table>

Kerosene pressure lamps:
- $40 - $50
- Average service life: 7 - 8 years
- Yearly maintenance: $13
- Fuel consumption: 0.1 - 0.2 L/hour

Kerosene wicklamp:
- $0.50
- Average service life: 1 year
- Fuel consumption: 0.01 L/hour

Dry cell batteries
<table>
<thead>
<tr>
<th>Size AA</th>
<th>Size C</th>
<th>Size D</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.20</td>
<td>$0.25</td>
<td>$0.35</td>
</tr>
</tbody>
</table>

Lead acid (car) batteries
<table>
<thead>
<tr>
<th>12 V DC, 40 Ah</th>
<th>12 V DC, 75 Ah</th>
<th>12 V DC, 100 Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td>$30</td>
<td>$40</td>
<td>$55</td>
</tr>
</tbody>
</table>

Electricity kWh price: $0.12 (by Decree)
Real cost of grid extensions 7,5/13,5 kV line: $4,000 - $5,000 / km

Diesel gensets
<table>
<thead>
<tr>
<th>3 kVA</th>
<th>10 kVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3,100</td>
<td>$5,000</td>
</tr>
<tr>
<td>30,000-40,000 hours of operation, if overhauled every 8,000 hours</td>
<td></td>
</tr>
</tbody>
</table>

Gasoline gensets
<table>
<thead>
<tr>
<th>600 W</th>
<th>1,000 W</th>
</tr>
</thead>
<tbody>
<tr>
<td>$550</td>
<td>$700</td>
</tr>
<tr>
<td>6,000 - 7,000 hours of operation, if overhauled every 2,000 hours</td>
<td></td>
</tr>
</tbody>
</table>

Commercial prices of selected locally available PV system components (*).
- Panel 53 Wp: approx $400
- G.I. panel frame (max. 3 panels of 53 Wp): $35
- Battery Control Unit (12 VDC, 10A): $30
- Solar battery (12 VDC, 100 Ah): $50
- DC-DC converter (12-9, 7.5, 6, 4.5, 3 VDC - 1A): $18
- Cables & Switches: approx. $0.50 / Wp

Commercial prices of locally available DC appliances (*).
- 12 VDC, 20 W fluorescent tube, incl. holder + ballast: $18
- 12 VDC, 10 W/15 W/20 W Incandescent bulb: $0.50
- 12 VDC B&W TV 12": $110 (16": $175)
- 12 VDC Video player (Betamax): $280
- 12 VDC Electric (car) fan: $30
- Rechargeable NiCd batteries size D (1.25VDC, 2000mA): $6
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