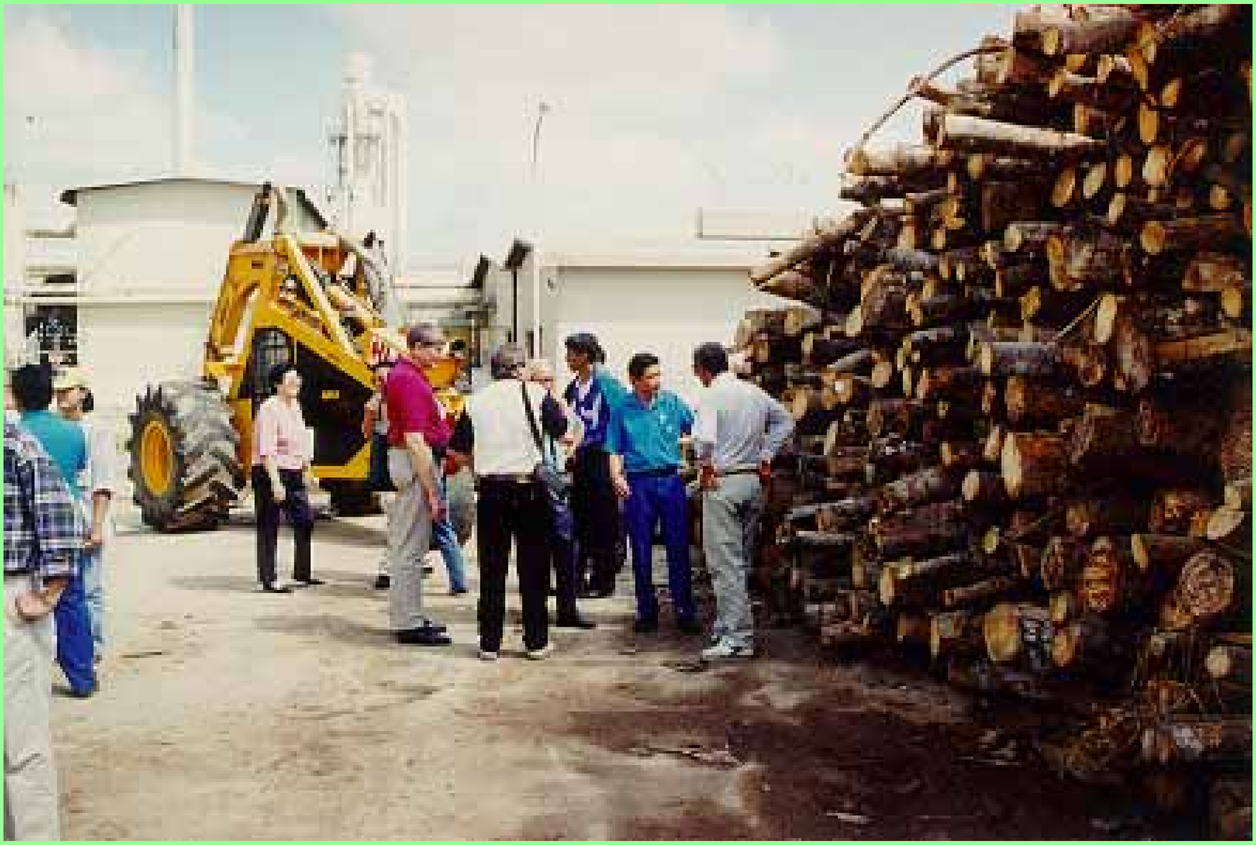
RWEDP Report No.36

REGIONAL WOOD ENERGY DEVELOPMENT PROGRAMME IN ASIA
GCP/RAS/154/NET

PROCEEDINGS OF THE REGIONAL EXPERT CONSULTATION ON MODERN APPLICATIONS OF BIOMASS ENERGY

Kuala Lumpur, Malaysia
6-10 January 1997



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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Foreword

Modern applications of biomass energy are clean, convenient, efficient, reliable, and economically and environmentally sound. "Modern" does not necessarily imply large-scale, and electricity is not necessarily part of the application. When we accept these functional criteria, a small domestic cookstove can be as modern as a large wood-fired power plant. Either could also be traditional, depending on their characteristics.

Whatever we accept as criteria for modern, it is not the fuel per se which makes biomass energy modern or traditional. Paradoxically, in industrialized countries, biomass is largely considered a modern fuel, whereas in developing countries it is usually looked at as traditional. However, what really matters is the technology matching with the application.

Thirty experts came together in Kuala Lumpur in January 1997 to jointly analyse and discuss modern applications of biomass energy. They came from government and private sector organizations, as well as institutes focusing on R&D. The present report gives an account of their findings.

All experts agreed that in the context of the increasing demand for energy and power in Asia, biomass can and should play a greater role. The hurdles identified are both technical and institutional. The experts underlined the importance of transfer of knowledge and modern technology amongst RWEDP member countries themselves, as well as from outside the region.

RWEDP is thankful to Malaysia not only for hosting the meetings but also for demonstrating inspiring examples of modern applications of biomass energy. As usual, the Forest Research Institute of Malaysia did an excellent job in co-organizing the Expert Consultation, and the key contributions from Dr Hoy Why Kong are gratefully acknowledged. Thanks are due to Messrs Auke Koopmans and Jaap Koppejan of RWEDP for conceptualizing and preparing the meetings.

Dr W S Hulscher,
Chief Technical Adviser,
Regional Wood Energy Development Programme in Asia

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1. INTRODUCTION

1.1 Background

For a whole range of applications, from domestic cooking and lighting to providing power for modern industry, wood and other biomass fuels are still an important source of energy. As biomass fuels are available almost everywhere on earth, often relatively cheap, virtually inexhaustible, and, when properly managed, renewable and environmentally friendly, this situation is expected to continue into the foreseeable future.

The biomass energy supply that can be made available on a sustainable basis at competitive prices is large: around 270 EJ per year, or around 70 per cent of total world energy consumption in 1990 [1]. However, the actual amount used is much smaller, at around 12 per cent of world primary energy consumption, according to the World Energy Council [2]. Thus, there would seem to be considerable scope for more intensive use of biomass as an energy source.

Biomass is a versatile fuel type which takes many forms and can be used for many very different applications. These applications can be loosely divided into "traditional" and "modern". The Regional Wood Energy Development Programme in Asia roughly defines "modern" applications as clean, convenient, efficient, reliable and economically and environmentally sound. Many of these are or can be used to substitute conventional sources of energy such as coal, oil and gaseous fuels. This definition can cover anything from relatively simple but efficient and clean boilers to more complex technologies such as electrical power generation and applications which use biomass-derived fuels such as ethanol, bio-diesel or biogas. For several reasons, modern applications are usually of relatively large scale.

Traditional biomass applications are, generally, those which do not meet these criteria. They are generally on a relatively small scale and are frequently, but not always, beyond the market place. The use of fuelwood in domestic cooking and space heating and in small-scale industry (brick burning, lime burning, food processing, etc.), common in many countries in the developing world, are typical examples of traditional biomass energy applications.

The following are a few examples of successful modern applications of biomass fuels:

- Electricity production based on biomass, mainly in the form of cogeneration in the pulp and paper industry, has in the United States increased by a factor of 36 (from 250 MW_e to around 9,000 MW_e) over a period of roughly 10 years (WEC ibid);
- In Austria, biomass in the form of wood chips has become an important source of fuel for district heating. During the last 10 years, primary energy consumption from biomass increased from two or three per cent to 10 per cent (WEC ibid). At present, some 11,000 district heating systems of 1-2 MW_{th} average capacity use wood chips as fuel;
- Production of charcoal as a substitute for coal in pig-iron and steel production in Brazil currently amounts to around seven million tonnes per year (WEC ibid);
- Sugar-cane bagasse-based electricity generation accounts for around 10 per cent of total electricity generation in the island state of Mauritius (WEC ibid);
- In Northeast Brazil, existing sugar-cane residues and future potential production of wood on dedicated plantations could be used to generate annually up to 41 TWh_e and 1,400 TWh_e of electricity respectively, compared with present total annual generation of around 30 TWh_e. Currently, a 25 MW_e

[1] *Biomass and Bioenergy,* vol. II, nos 1 to 6, J Coombs, D O Hall, R P Overend and W H Smith (eds), 1992
[2] *New Renewable Energy Resources: A Guide to the Future*, World Energy Council, 1994

biomass gasifier/gas turbine combined cycle demonstration project is being developed, fuelled with wood from a standing eucalyptus plantation. This design phase was supported by a grant of US$ seven million from the Global Environmental Facility, which has also set aside an additional US$23 million for the construction phase.

Among the other projects are ones using straw, biogas and municipal solid waste (MSW) in Denmark; landfill gas in the USA and UK; gasifiers in Finland; cogeneration from biomass in Sweden; and straw in the UK.

Modern biomass energy consumption is still low compared both to traditional biomass energy consumption and to overall energy consumption. Table 1 provides a brief overview of the use of renewable energy sources in terms of their share of the total amount of primary energy consumed world-wide in 1992.

Region	Modern Biomass	Traditional Biomass[1]	"New" Renewable energy [2]	Large hydro power	**Total renewable energy**	**Total primary energy**	**Total renewable as % of total primary**
North America	19	38	12	127	196	2,157	9.1
Latin America	46	125	3	80	254	577	44.0
Western Europe	10	20	10	99	139	1,462	9.5
Central/Eastern Europe/CIS	10	30	5	55	100	1,739	5.8
Middle East and Africa	5	162	2	14	183	583	31.4
Southeast Asia and Pacific	23	351	9	70	453	1,843	24.6
South Asia	8	204	2	20	234	446	52.5
TOTAL	**121**	**930**	**12**	**465**	**1,559**	**8,807**	
% of global primary energy	**1.4%**	**10.6%**	**0.1%**	**5.3%**	**17.7%**	**100.0%**	**17.7%**

Table 1 Use of renewable sources of energy by regions, in Mtoe primary energy

Notes 1: Traditional biomass energy consumption is, by its nature, very hard to estimate.
2: New renewable energy includes solar, wind, geothermal, wave and ocean energy, and micro hydro power.

Source: Adapted from WEC ibid

Based on the above, it is clear that traditional biomass energy use is still seven or eight times more than modern biomass energy use. At the same time, it is also clear that opportunities exist to apply modern biomass energy technologies to a much larger extent than is done at present. In the RWEDP member countries, large amounts of biomass are already available as residues from agriculture and industries, and biomass could meet a significant part of the countries' energy demands if the appropriate technologies were introduced.

The following technological options appear to be the most promising. Many of the success stories could also be introduced and improved in other parts of the world, including Asia:

- Direct combustion of various types of biomass to produce heat, steam or electricity (cogeneration, CHP, dendro-thermal power plants, etc.);
- Gasification of biomass for electricity generation, using technologies such as BIG/STIG;
- Production of charcoal and char;
- Production of liquid fuels (alcohol, ethanol, methanol, etc.) from energy crops;

- Anaerobic digestion of agricultural residues, manure, sewage or municipal solid wastes to produce biogas and eliminate environmentally hazardous disposal of these materials.

Yet despite the great potential, these modern biomass energy applications are still relatively rarely used. The factors which influence decisions on whether to implement them are not always clear, but they are probably related to the relative complexity of the projects. It is, for example, usually much easier to introduce cleaner and more efficient biomass-fired boilers in industries to generate heat than to introduce electricity generation using residues from agro-industries, as the latter involves, among other things, arranging appropriate contractual agreements with utilities. The situation is even more complex when dedicated energy plantations are considered for power generation, as long-term contracts with farmers also have to be drawn up.

Thus there are several barriers, either real or perceived, that can obstruct implementation of modern biomass energy applications. These barriers may be technical, financial, economic, institutional or a combination. The financial, economic and technical barriers are generally influenced by the following factors:

- Biomass residues may become scarcer, and are subject to market cycles;
- Biomass energy projects suffer from not having a level playing field in competition with conventional energy sources (i.e. tax policies, power-purchase agreements, etc. often favour conventional energy projects);
- Biomass-based energy projects may have competition for their fuel source from higher-value applications, such as the furniture industry in the case of wood;
- Substantial incentives may be necessary to persuade people to undertake modern biomass energy projects, especially for afforestation programmes;
- Available biomass energy technologies may not be sufficiently mature to represent an acceptable risk to private-sector investors;
- Technologies and applications may not offer sufficiently high returns to interest private-sector investors.

Besides these, there are also institutional constraints, which vary from country to country and over time, depending on prevailing conditions. These can be summarized as follows:

- Current energy policies are often biased against renewable energy sources;
- Power-generating utilities are often reluctant to purchase excess power or to offer back-up power;
- Taxes and subsidies often encourage fossil fuels, favouring operating costs over long-term investment;
- Energy prices do not reflect external social costs such as the effects of air pollution;
- Cooperation between developers/researchers, manufacturers and potential users is not well coordinated and needs to be improved;
- Biomass producers may not be willing to plant energy crops unless they are assured of a market for their output. At the same time, the power utilities may not be willing to build bioenergy power facilities unless they have assurances that fuel will be available;
- Biomass is still considered a ‘backward’ fuel, characteristic of small-scale industry.

1.2 Objective of the Consultation

The Regional Expert Consultation on Modern Industrial Biomass Energy Technologies, which took place in Kuala Lumpur, Malaysia in January 1997, was co-organized by the RWEDP and the Forest Research Institute, Malaysia. The objective of the consultation was to be a forum for senior officials at the policy-making level to:

- Exchange information and experience, and discuss the current status of modern biomass energy technologies in the various RWEDP member countries;
- Make recommendations about wider dissemination of those technologies;
- Focus on particular types of industries for which modern biomass energy systems have large potential;
- Look at typical economic and environmental conditions that prevail in RWEDP member countries, which might influence the use of modern biomass energy;
- Examine the policy frameworks (legislation, subsidies, etc.) governing modern biomass energy technologies, and their possible influence, positive or negative, on implementation of those technologies in a particular country;
- Discuss the real and perceived barriers to the introduction and use of efficient wood energy technologies; and
- If possible, identify problems with availability and accessibility of information on biomass energy technologies, use of biomass resources, etc., and how to improve the situation.

1.3 Participants

The 10 RWEDP member countries were represented at the consultation by 21 participants. Also present were a number of expert resource persons and RWEDP staff, speakers and observers. All the participants were senior policy-makers in the energy or forestry sectors of their respective governments. The resource persons came from a variety of relevant fields: academic and both the public and the private sectors, in order to provide a broad range of expertise, experience and perspectives.

1.4 Preparation

As preparation for the consultation, participants were asked to research and write brief papers on the present status of modern biomass energy technologies in their own countries. These were not presented, due to time constraints, but were distributed and were a useful starting point and resource for discussions, particularly the country-specific follow-ups. In preparing these country papers, participants were asked to consider the following points.

Electricity demand

- What is the situation regarding availability of electricity? Are there regular brownouts or blackouts and do the utilities use load-shedding in some sectors or areas?
- Are public utilities capable of keeping their investments in line with the growth of electricity demand?
- What is the pricing structure for electricity, and is it subsidized in rural areas?

Environment

- Is there strict environmental legislation in place that motivates companies to invest in clean, modern equipment?

- What energy sources are being replaced in conventional power plants if electricity generation takes place using biomass residues in private industries?
- What is being done with the biomass residues at present, and what will be the environmental impacts if they are used instead for heat and/or power generation?

Grid delivery

- Is there a legal framework that allows private companies to supply electricity to the public grid?
- Do electricity utilities offer long-term power purchase contracts under a clear pricing framework?

Purchase of equipment

- Are there local manufacturers from whom modern power-generating equipment can be purchased, or would it have to be imported?
- What is the availability of equity in the industries that produce significant amounts of biomass residues (wood processing, rice, sugar, etc.)?

Human resource development

- What is the attitude of the management in the target industries to energy efficiency and environmental pollution?
- What are the options for training staff to operate and maintain modern biomass energy equipment?

Government

- How do the different government agencies stimulate or obstruct private power generation and clean energy technologies?
- What positive or negative experiences with biomass-based private power generation does the country have?

1.5 Structure of the Consultation

The consultation comprised three main activities. Presentations of papers by resource persons gave valuable inputs on the present status of modern biomass energy. Field visits gave participants a chance to see modern biomass energy technologies in action and to speak to the managers of the facilities where they were installed. Finally, groups discussions allowed the participants to pull together what they had learned and to draw up conclusions on the various issues involved and recommendations for further action, and to identify possible follow-ups in their own countries.

Day 1

Opening ceremony

Dr Wim Hulscher, Chief Technical Adviser of the FAO-RWEDP, addressed the workshop first, introducing the resource persons and FAO representatives and thanking Dr Abdul Razak and his staff at the Forest Research Institute, Malaysia for their past and present cooperation with the RWEDP. Particular thanks were extended to Dr Hoi Why Kong for his efforts in preparing and organizing the consultation.

Dr Hulscher stressed the importance of cooperation and consultation to the realization of the RWEDP's aims, and highlighted out the programme's true role as a platform for the exchange of experience between member countries.

He then introduced the subject of the consultation, highlighting potential advantages of biomass-based power generation and the fact that these advantages are being recognized and acted on by policy makers around the world. Dr Hulscher also emphasized that while biomass energy is economically and environmentally sound in one set of conditions, it may not work in another. To identify the right conditions was more or less the subject of the consultation's deliberations, he added.

Dr Abdul Razak Mohd Ali, director-general of FRIM, gave the opening address. He said the consultation was particularly timely for Malaysia, as it is aiming for a fully developed and industrialized economy by 2020. Energy had been recognized as vital to economic growth, and with the uncertainty of the world energy market and the unsustainability of oil and gas in the long term, it is vital to explore alternative energy resources, particularly renewable resources such as biomass, he said.

Dr Razak noted the abundance of wood residues produced by logging and wood processing in Malaysia and the positive contribution to industrial development these could make if they were exploited for energy instead of simply dumped, as they tended to be at present. He also stressed the importance of research and development to biomass energy, and called on all the countries in the region to pool their resources and cooperate in R&D.

Mr Auke Koopmans, Wood Energy Conservation Specialist of the RWEDP, then proposed a vote of thanks, closing the opening ceremony.

Presentations

The technical session opened with Dr Hoi Why Kong welcoming the participants to the consultation. For the rest of the morning and the afternoon of the first day of the consultation, papers were presented by resource persons and RWEDP staff.

Day 2

Field trips

In the morning, the participants were taken to a sawdust briquetting factory and to a medium-density fibreboard factory using a mix of wood chips, bark and commercial fuel to generate process heat. After lunch, the participants were taken to an integrated wood-processing complex where there was a Cogen full-scale demonstration project using a sawdust and wastewood-fired boiler for kiln-drying heat and power generation, manufactured by Belgian company Vyncke NV.

In the evening, there was a meeting of the Dendropower Steering Committee.

Day 3

The morning's proceedings opened with a technical presentation by manufacturers Jebsen and Jessen Engineering (Malaysia) Ltd.

Working group discussions

After the presentation, the participants divided into four groups to discuss conditions for cogeneration. Each group was given a different topic, and participants were invited to put themselves in one of the groups. The topics were: Awareness, Financial/Economic Issues, Data and Information Requirements and the Role of the Government. The resource persons divided their time between the groups to offer support and useful inputs.

In the afternoon, a spokesperson from each group presented the outcomes of the group's discussions to the expert consultation. These presentations were followed by a plenary discussion on the issues raised in the consultation so far. At the end of the afternoon, the task for preparing country-specific recommendations was set.

Day 4

Field visit

In the morning, the participants were taken to visit a rice mill with a rice husk combustor system, then were taken to the Forest Research Institute, Malaysia for lunch. In the afternoon, still at the institute, Mr Yoram Katz gave a second presentation, a practical framework for realization of a biomass-based power project. This was followed by discussion and approval of recommendations and concludions for the expert consultation.

2. Papers Presented

2.1 Energy, Electricity and Development in Asia

W S Hulscher and A Koopmans, FAO RWEDP

Energy consumption in Asia is rising rapidly to keep pace with industrial development. The process of industrialization is set to continue, but should energy consumption simply rise with it? Energy use can be rationalized, with many benefits to the country and the world. This rationalization involves both supply and demand strategies, particularly through optimal use of technology transfer and proper investment analyses. Modern wood and other biomass energy applications fit well in such strategies.

By plotting energy intensity (as the amount of energy used per unit of GDP) of various industrializing countries and regions over time since the first industrial revolution in Britain, two trends become clear. Firstly, each of them fairly quickly reaches a peak of energy intensity and then becomes gradually more energy efficient even as industrial development continues. Secondly, technology transfer means that each newly industrializing country or region's peak of energy intensity tends to be lower, often much lower, than its predecessors'. This is a major benefit of technology transfer.

Another trend, which has long been noticed, is for per capita electricity consumption to rise with per capita GDP. While this can be demonstrated as being true in general, by comparing different countries, we can see several exceptions and variations. One should not assume that more electricity consumption automatically leads to more economic development.

Clearly there is a more complex interplay of forces at work. Energy efficiency in the power sector and overall economic structures can both have a strong influence. In Japan, in the wake of the 1973 oil crisis, a concerted effort was made to decrease energy intensity and transmission losses. Energy consumption even went down in 1975, during a period of rapid economic growth, and since then, although consumption has continued to rise, it has not kept pace with economic growth. This has been the result of good energy management, in which cogeneration of heat and power from biomass can play an important role. Thailand and the Philippines both showed similar fluctuations, which basically coincide with the massive hikes in oil prices of 1973 and 1979.

By comparing the development of energy intensity in different parts of the world during the period 1974–94, we can see that there has been an overall rationalization in industrialized countries, which has not yet happened in the more recently developed Asia. If biomass energy use were to be included, the level of energy intensity in Asia would be even higher.

Primary energy consumption per capita is a popular indicator for the level of development. It is thus often used in discussing disparities between different countries' consumption of primary energy (and other) resources. While this is useful as an indicator, care should be taken in drawing conclusions from it. As a first point, wood and biomass energy are not usually included. In Nepal wood/biomass is about 92% of the national energy consumption, and in Pakistan about 47%, so the consumption figures normally used are significantly short of the real situation.

Another way of calculating resource use would be to analyse primary energy consumption per unit of GDP. A very different picture is then obtained for the RWEDP member countries. This gives an indication of quality of technological development, from the point of view of energy efficiency. (Again, consumption of wood and other biomass energy is not included in the data.) According to this indicator, China, starting from a very energy-intensive economy, has made tremendous advancements over the period 1974–94 (although it still uses nearly 1.5 toe to produce US$ 1,000, more than 0.5 toe higher than Vietnam, the next most energy intensive economy in the region). In the same period, Malaysia and many other countries show a reverse trend – that is, they are using more energy to produce a unit of GDP than they were 10 or 20 years ago. An interesting case is Sri Lanka, which shows consistent improvements in energy intensity over the years. However, once again, care should be taken in interpreting such data, because the valuation of, for instance, GDP and currency exchange rate (e.g. for Myanmar) may hide some clues. Finally, it should be noted that Singapore, which has a very high primary energy consumption per capita compared to the RWEDP member countries (over eight tonnes of oil equivalent per capita, compared to less than half a tonne for most RWEDP members), actually has a very reasonable energy consumption per unit of GDP (just under 0.5 toe per US$ 1,000 of GDP).

Electricity consumption can similarly be analysed per capita and per unit of GDP. Over the period 1974–94, all RWEDP countries have experienced substantial growth in electricity consumption per capita, particularly in rapidly industrializing countries like Malaysia and Thailand and in China.

Electricity consumption per unit of GDP has also increased over the years in almost all countries. This trend would mainly be driven by increased consumptive use of electricity (e.g. in the domestic sector), though increased productive use (e.g. in industry) also contributes. China, though, is a notable exception to this trend, as the figure has not risen in this way. This could be explained by efficiency improvements in the power sector and by rationalization of production per se.

The same analyses show us that overall, the annual growth rates in primary energy supplies in the RWEDP countries, already substantial, accelerated further over the last decade. The average annual growth rates in electricity consumption are even higher, with 10 per cent and more being far from exceptional. India, for example, with an electricity consumption growth rate of almost nine per cent per year, needs an extra 8,000 MW of installed power generation capacity, representing at least US$ 10 billion, per year to continue this trend. This situation implies that there are ample investment opportunities in the power sector in Asia.

However, simply to install more capacity to meet this demand would be irresponsible and out of date. While clearly increases in capacity are still necessary, rationalization and energy management on the demand side are also needed, as has already taken place in many industrialized countries. Modern combined heat and power generation, which can operate efficiently using cheap biomass fuels, fits well into such strategies, as the technology allows for doubling the efficiency of primary energy utilization, and helps to reduce transmission losses, if applied in decentralized systems.

2.2 Single Purpose Dendropower Production Systems and Large-scale Woodfuel Production Sectors in the RWEDP Region: Preliminary Findings

Dr P R Shukla, Indian Institute of Management, Dr N P Singh, Biomass Energy Division, MNES, Government of India

Introduction

India has seen renewed interest in dendropower in recent years, particularly in the light of the 1970s oil crisis, which illustrated the danger of too great reliance on imported oil, and in view of the gap between energy supply and demand, which presently causes frequent black-outs and brown-outs, even in the country's major cities. On top of this, the Indian government is trying to decentralize electricity generation, for which locally available fuels are desirable. Without significant changes in usage patterns, India's own fossil fuel reserves are expected to run out soon.

Currently, although oil's share in India's total imports is going down in monetary terms, the actual volume of kerosene and diesel oil being imported is rising rapidly. This has worried policy makers and is pushing dendropower back into the spotlight. In the 1970s and 1980s, wood was widely considered a poor man's fuel, and not a serious energy option for the future. This has gradually changed, and wood is now considered an option, albeit a last-minute one, for power generation. While the old prejudices persist to a large extent, policy makers are gradually coming to see biomass as a commercially viable, competitive and modern energy resource. Compared with the alternatives, wood and biomass from agro-industries or from dedicated plantations create much more employment and may also have multiple environmental benefits. Greenhouse gas emissions can be effectively reduced through sustainable management of fuelwood, and plantations may lead to improved watershed management.

Professor Shukla

Barriers

There are, however, some distinguishing features that require attention when dedicated energy plantations using short rotation species are to deliver the fuel for large-scale commercial energy conversion. Both components operate under different natural and competitive environments and therefore require different response strategies.

There are some features typical in developing a dendropower system. Markets tend to be weak or non-existent, while the energy converters tend to operate in a niche market, using readily available wood or biomass residues. The market for wood from energy plantations is not yet fully developed. The producers tend to have only a few customers, most of them industrial. Also, fuelwood producers are affected by diversity of climate, soil and other factors. In the past improper site and species selection has led to supply problems in both the Philippines and Brazil. Improper wood storage leads to degradation and loss. In contrast with agricultural crops that return profit within a year, fuelwood can only be harvested four or five years after planting, leaving the grower without income for this period.

The energy converters have to deal with varying types and qualities of feed stock as well as customers. Without firm price and quantity guarantees, future yield and price fluctuations of both feedstock and energy produced make the economic feasibility uncertain. Also, biomass-based power generation is a relatively new concept and its reliability, robustness and maintainability need to be proven. As most of these technologies were initially developed in industrialized countries, local adaptations may be necessary. The technologies may not yet be available through local manufacturers, likely making them more expensive. In addition, well-trained operating and maintenance staff may not yet be available.

Institutional Support

In the absence of a fully operational market, a supply push is the initial approach to be taken. Once the benefits are clear for the parties involved, a demand pull (i.e. market) can be expected for the dendropower industry.

Because of its multiple socio-economic and environmental benefits, governments may allocate land specifically for energy plantations and promote the conversion technology through R&D, demonstration projects and subsidy schemes. Also, dendropower may qualify for funds from international agencies such as the Global Environmental Facility.

Through media and business organizations, awareness can be created concerning dendropower technologies. To deal with the high initial capital demand and long gestation periods of fuelwood plantations, governments may provide loans to growers. Consistent institutional support has to come from a broad range of related agencies such as the electricity boards, the forest departments and financial institutions. Interaction and coordination between all the parties involved (growers, power plants and end users) are necessary. For example, community involvement in the decision-making process has proven beneficial in several fuelwood plantations in India. Both growers and converters need appropriate training organizations to supply the staff for them.

Producers face high levels of uncertainty, mostly due to ecological factors, while the less serious uncertainties facing converters are mainly economic. Scarcity of feedstock, due either to crop failure or competition for the wood for other applications, is one of the more serious risk factors.

To offset the risk of bad harvest, producers can take out crop insurance. Similarly, converters can insure against lack of feedstock availability, so they can purchase more expensive fuels from other sources if necessary. In fuelwood purchase agreements, the producers can obtain guarantees that there will be a market for the wood, while the converters can obtain price guarantees.

Once the market is fully functioning, governments may impose market pull policies such as the internalization of external costs in tarifs on fossil fuels and electricity. Subsidies on both fossil fuels (coal, diesel and kerosene in India) and electricity hinder the spread of decentralized biomass power generation and may need to be removed. In India, for example, it is estimated that the introduction of carbon taxes will have a major influence on the penetration of dendropower in the first decades of the next century.

2.3 Generation, Utilization and Availability of Agricultural and Forest Residues

Auke Koopmans and Jaap Koppejan, RWEDP

Background

The 15 RWEDP countries combined account for 51 per cent of the total world population, living on 13.4 per cent of the world's total land area. This land area includes only 8.7 per cent of the world's total forest area.

Most of the people in the RWEDP region live in rural areas and are engaged in agriculture-related activities, though population shifts towards urban centres are expected to continue. This will influence energy use, as people tend to use more commercial sources of energy due to better access. In countries such as Thailand and Malaysia, with well-developed infrastructure, commercial energy sources are also easily available in rural areas, so the shift towards commercial energy sources is also reasonably fast in rural areas as well.

However, despite this trend, population growth and other factors mean that the total amount of traditional energy sources used is still rising.

Average per capita energy consumption in the RWEDP countries is low, at around 18.3 GJ against a world average of around 62.6 GJ. However, some studies, including national energy statistics, show considerably higher figures for RWEDP nations than those on which these estimates are based, particularly with regard to use of renewable energy sources.

Biomass energy sources are often considered as old fashioned as well as environmentally destructive due to depletion of forests. However, this is not necessarily true. Traditional biomass energy sources can be converted into “modern” energy through power generation, co-generation, etc. Also, studies have shown that a considerable amount of fuelwood, often more than 50 per cent, is obtained from non-forest areas, and anyway, a considerable part of the biomass consists of forest-based or agriculture-based residues.

In fact, biomass fuels can be more environmentally friendly than convetnional energy sources. Managing them in a proper and sustainable way can help in soil as well as water conservation, restore fertility and increase agricultural productivity, reduce soil erosion and can act as a barrier against degradation.

It is also worth noting that traditional energy sources often create jobs, particularly in rural areas.

The Residue Resource Base

Forest and Wood-processing Residues

- Logging: about 40 per cent waste;
- Sawmilling: about 50 per cent waste, in the form of 38 per cent wood and 12 per cent sawdust;
- Plywood production: about 50 per cent waste, in the form of 45 per cent wood and five per cent dust;
- Particle board etc. production: most of the waste is recycled, about 10 per cent real waste in the form of sanderdust and fines.

Residues from Perennial Crops

Rubber, coconut, palm-oil, cocoa and others all produce residues, both during production and during processing. During production, residues are available in the form of fronds, prunings etc., as well as solid wood from replanting of non-productive trees (every 25–30 years). However, a drawback is that they become available in short, concentrated bursts, with large intervals in between when no residues are available. Besides these woody residues, during processing, crop residues such as husks, shells, empty bunches and pods are generated.

Residues from Annual Crops

Waste/residues in the form of straw, stalks, hulls, cobs, leaves, husks, etc. Are available. Quantities are difficult to establish due to the widely varying growing conditions (soil, climate, irrigation) and species used.

Residue Availability

Literature gives residue-to-product ratios (RPRs) for various crops, which can be used to calculate the amount of residues generated. However, using RPR figures is not a particularly reliable method, and where possible such figures should be checked in the field. Using crop and cropping areas is another option, but large variations in crop yield are common, so extreme care should also be taken in applying this method.

In establishing the amount of residues available, a distinction should be made between field-based and process-based residues. Process-based residues will be available in relatively high concentrations, whiler field-based residues will probably be scattered, making it diffcult to collect and use.

Rough estimates can be made of residue availability based on residue production, using general RPR ratios etc., and on use/consumption, using energy balances and other sources of information. Such calculations are useful in establishing a general perspective, but they should treated with extreme caution. Apart from the limitations of these methods outlined above, there are also the questions of competing uses (see below), seasonality, access and how much of the residues, particularly field-based residues, are needed to maintain soil quality and fertility. Little is known about this, even by local people, and only further costsly and time-consuming R&D will be able to give the answer, and the results of these may also be influenced by “normal” changes over time.

Demand for the Residues

Applications of biomass residues are summarized in the Six Fs: fuel, fodder, fertilizer, fibre, feedstock and further uses (e.g. conditioning soil, straw for mushroom growing and packing material). Some even have multiple purpose: for example, rice husk can be burnt as fuel and the ashes used by the steel industry as an insulator and a source of carbon.

Despite the fact that residues are wastes, it is unwise to assume they are by definition free, even though farmers, sawmill owners etc may not charge for them at present. In a monetized economy, everything which has a use will sooner rather than later acquire monetary value. Even where this is not true of residues, there may already be use made of them, and this will probably be much more evident to the locals than to outsiders. Any attempt to use residues without offering any compensation is likely to run into problems, and care must also be taken that the money is going to the right person in order to avoid social disruptions.

Amounts Used

Very little is known about amounts of residues presently used, with the possible exception of the sugar industry. However, by combining the available information with that on agricultural residue generation and consumption of agricultural residues as energy, a very rough overview can be made of the supply/demand situation for agricultural residues in the RWEDP member countries.

While this calculation indicates that there are relatIvely large amounts of agricultural residues still available in most of the RWEDP member countries, it is based on such scant information that it is of very limited use for any practical assessment of actual residue availability. It is also very important to note that this calculation does not take into account non-energy uses.

Concluding Remarks

The expected increase in energy use will put more pressure on the resource base. In the case of conventional energy sources, this has an influence on the resource base itself, as the resources are non-renewable. For many countries, the foreign exchange position may be affected: more foreign exchange will be needed to import energy or conversely, less foreign exchange will be earned by those countries which are nett energy exporters. Besides, the commercial energy sector often requires massive investments, such as in generating capacities, refineries, etc. The increase in commercial energy use may also have a negative influence on the environment. Energy policy and planning has therefore become an important priority in many countries, though it often puts economic considerations over environmental ones.

Unfortunately, energy policies in many countries appear to be biased against traditional energy sources, due to factors such as lack of information, negative prejudices against traditional energy etc.

However, even though traditional sources of energy have several advantages over commercial ones, this should not be taken to mean that it is the best option in all cases. Careful study of competing traditional uses and other factors is needed before it can be promoted.

Considering the pros and cons of traditional sources of energy, two questions need to be answered:

- What role will traditional sources of energy play in the near future (say within the next 50 years) within the overall energy scene?
- What role should traditional sources of energy play?

With regard to the first question, it is beyond doubt that traditional energy will remain an extremely important source of energy for millions if not billions of people who cannot afford or have no access to a guaranteed supply of conventional energy sources. As for the second question, one should consider carefully the implications of promoting the use of commercial sources of energy over traditional sources of energy, in particular on the environment. It is clear that there are upper limits to both conventional and traditional sources of energy, so action should be taken on both.

Action with regard to the traditional energy sector can be sub-divided into three major areas:

- Policy and planning;
- Increasing the resource base;
- Managing the available traditional energy sources in a better way.

With regard to the last area, several options exist. These range from benefaction through drying, size reduction, compaction (briquetting), conversion, etc. to reducing losses during handling, transport and storage properties, to energy conservation measures such as introducing more efficient combustion and conversion equipment like stoves, furnaces, kilns, boilers, etc. Promoting the use of residues in, for instance, power generation and cogeneration could also be feasible options, as is evident from the palm-oil and sugar industries, where cogeneration is widely practised.

There is enormous diversity in residue production and utilization in different areas. Coupled with the unreliability of available data, this indicates that perhaps even national-level databases on residue production and utilization are of very limited use, and sub-national or smaller-area databases may be required.

It should also be noted that somewhere in all the statistical information and calculations made, sight may have been lost of the possible impacts on real life, i.e. the use of residues as domestic fuel, farmers who produce residues as a byproduct, etc. Very little, if any, information is available on how the farmers themselves see their situation and the trade-offs they make willingly or are forced to make with regard to residue generation and use. Studies should be carried out to determine the effects increased use of residues will have at the farm level, such as on soil conservation and degradation (and effect on crop growth), income generation and side effects for the local environment (through, for example, increased use of other sources of energy), as well as the effect on local communities (relating to access to residues etc.).

Promoting the use of residues for other applications such as power generation will not only put a value on the residues but may even deprive a part of the population (often the poorest section) of their cooking and heating fuel. These factors should also be considered when deciding upon a strategy for increased use of residues.

2.4 Biomass-based Power Generation: Experiences in the ASEAN Region

Dr Ludovic Lacrosse, EC-ASEAN Cogen Programme

The aim of the EC-ASEAN Cogen programme is to accelerate the implementation of proven technologies generating heat and/or power from wood and agro-industrial residues through partnerships between European and ASEAN companies.

In Europe, the Cogen secretariat deals with equipment suppliers, through consultants. In ASEAN, the secretariat, based in Thailand, deals through country coordinators with customers, policy makers and business partners.

The rationale underlying the Cogen programme is based on the facts that the energy situation in ASEAN is characterized by high growth rate in energy demand; a need for clean energy strategies; and a need for private-sector power, while biomass residues in ASEAN are available, indigenous and renewable. However, in the region, there is a lack of references for the biomass energy technologies needed to exploit these biomass residues, while these technologies are available in and from Europe. Cogen therefore aims to bring together policy makers and potential purchasers and business partners in ASEAN with equipment suppliers in Europe.

Cogen uses two sets of tools: information (the Cogen database and the Cogen Business Line, which facilitate contact between various agencies and companies) and full-scale demonstration projects. These are showcase installations in ASEAN countries of proven technologies, being implemented in order to show their reliability and economic viability, and so convince other potential customers of the viability of that technology. There are three selection criteria for such projects: technical and commercial viability, replicability and impacts on energy use and on the environment. Cogen makes a relatively small contribution towards the investment in the projects, as well as providing training and monitoring the installations.

The intended impacts of a full-scale demonstration project are as follows:

- For the customer: savings on energy costs;
- For the equipment supplier: opening of the market; and
- For the ASEAN region: reduction of dependence on fossil fuels and protection of the environment.

In industries such as rice and sugar processing, an excess of energy can be produced during processing, which means there is potential for export of energy, should it prove economically viable. In the plywood industry, only self-sufficiency in energy is possible.

A description followed of a number of full-scale demonstration projects currently operating in the ASEAN region. The specifications of those projects are given in Annex 5.

It was noted that some of the technology used in Cogen projects is not particularly modern, but it is proven and reliable.

Cogen is expected soon to expand its operations in Asia to the new ASEAN member countries: Vietnam, Laos, Cambodia and possibly Myanmar. On top of this, there are some indications that similar programmes will be established in some non-ASEAN countries, notably India and China.

2.5 Technical and Economic Feasibility of Cogeneration Projects from Rice Husk

Francis Himpe, Vyncke NV

Rice and rice husk production in the rice-producing countries of ASEAN:

Country	Rice production (mn tonnes/yr)	Rice husk production (mn tonnes/yr)	Percentage of ASEAN total
Philippines	9.5	2.375	9.5
Thailand	19.9	4.975	19.9
Indonesia	47.3	11.825	47.3
Malaysia	1.78	0.445	1.8
Vietnam	21.5	5.375	21.5
Total	**@ 100**	**@ 25**	**100**

Based on 24 hours per day, 320 days per year operation of rice mills, this means 3,255 tonnes of rice husk are produced in ASEAN every hour. Assuming an energy content of 3,000 kcal per kg of rice husk and 75 per cent boiler efficiency, this represents potential production of superheated steam at 30 bar, 250^{o} C, of:

3,255 tonnes/hr x 3,000 kcal/kg = 9,765,000,000 kcal/hr
9,765,000,000 / 650 = $\pm$ 15,000,000 kg of steam/hr

Using a reasonably efficient fully condensing steam turbine, consuming 5.4 kg/kW, we can produce:

15,000,000 kg/hr / 5.4 kg/kW = 2,778,000 kW = 2, 778 MWe

The total average energy consumption per hour for the five countries named above is 16,628 Mwe, so rice husk could theoretically supply 13.6 % of the total electricity consumption of the five countries.

However, these figures might be slightly misleading, as the potential for power generation depends on the size of the mills. While Indonesia has the highest level of rice production, the mills are generally very small, so the amount of rice husk produced, and hence the potential for power generation, at each mill is low. Malaysia and the Philippines, conversely have high potential because the have large mills.

Rice Mills

A description is given of rice drying and milling processes. Energy is needed to for both the driers (thermal and electrical energy) and the de-husking crushers in the milling section (electrical energy). Demand fluctuates, as the driers only operate during the paddy season (around 80 days per year) while the crushers operate all year round.

As the cost per installed kWh of cogeneration equipment and the cost of thermal energy for drying or for a rice husk-fired boiler are all high, it makes little sense to install cogeneration capacity for the drying section, and it is better to generate the thermal energy for the drying from the exhaust heat of the power plant. Thus, the best solution is pure cogeneration: electricity generation for the complete milling section and, seasonally, thermal energy production for the paddy drying.

The above conclusion is valid for small-scale power generation (under one MW). If we talk about bigger power generation capacities, where rice husk is usually coming from more than one mill, it is usually advisable to go for pure power generation. There are several reasons for this: at this level of capacity, part or all of the power is usually sold to the grid, so it is best to maximize the power produced. This is done best in an efficient fully condensing system. The exhaust heat from this kind of system is not sufficient to heat up the driers to the required temperature. Also, as thermal energy is usually produced for only one of the supplying mills, it is difficult to find a fair pricing structure, particularly as it will involve loss of efficiency in the power generation.

Rice Husk

By comparing rice husk with other biomass residues we can see that: the heating value of rice husk is not very high, but high enough to burn rather easily without predrying, and the moisture content is low and very constant over the fuel. However, there are also three problems associated with it:

The ash content (20 per cent) is very high – a 1.5 MWe plant will produce around 700 kg of ash per hour. It is strongly recommended that de-ashing is fully automatic, not manual. Ash has often been the cause of failure of installed systems, as the ashes cannot be removed fast enough and the system starts to clog up.

The very high silica content of the ashes (70–80 per cent) causes high wear and tear both on the fuel feeding side and wherever the ashes pass by.

The high level of volatile matters in the husk means that flame temperature is high and so the ashes can reach even their rather high melting temperature if combustion is not properly regulated. Ash melting causes the ashes to clinker and become very sticky, clogging tubes, dust collectors, grates etc.

Ashes must be removed as soon as possible after combustion, and the fluegas speed is therefore lower than in other biomass-fired boilers. The manufacturer also has to ensure that the combustion is not violent or disturbed, as this would increase the chance of ash being sucked through the system.

As it is vital that ashes do not melt, good regulation of the amount of combustion air and the amount of fuel is necessary to achieve a complete, environmentally friendly combustion. Also, the combustion room should be spacious enough and the combustion grate should preferably be water cooled to ensure the ash melting temperature is never reached.

Mr Francis Himpe and Mr Patrick Durst (seated)

Economical Feasibility of Rice Husk-fired Cogeneration Projects

Savings that can be made, in order of importance, are:

- Electricty savings and/or income generated from sales of power to the grid;
- Income from the sales of rice husk ashes, mainly to the steel industry;
- Savings in the disposal cost of the rice husk;
- Savings in oil for the paddy dryers or in investment in a rice husk-fired boiler

Besides the initial investment in the project, there are four main sources of costs to be considered:

- Labour: a qualified steam engineer and a qualified boilerman are needed;
- Maintenance and repair: in a well-designed system, the costs can be limited to one per cent of the initial investment on a yearly basis;
- Depreciation;
- Finance: varies from country to country and from the access of the buyer to financial resources.

A description of the installation at the Ban Heng Bee rice mill was given (see Annex 5).

2.6 In-country Barriers and Policy Strategies for Developing Biomass Power Projects

Yoram Katz, Imperial Private Power

To attract investors in biomass energy development, a country must:

- Have a renewable energy programme in place that includes:
  - Priority given to projects utilizing biomass;
  - Identification of resources available for development;
  - A pricing structure for the purchase of power by a credit-worthy entity (government or private);
  - A fast-track approval procedure;
  - A guarantee of the availability of the fuel supply, either directly or indirectly through government agencies. This is crucial in obtaining finance;
  - A reasonable set-aside quota for renewable energy within private power purchase quotas.
- Have a policy for power purchase from privately owned utilities, along with an established pricing structure which recognizes the different costs and merits of different types of power project;
- Have a creditworthiness guarantee from the government or government-owned utility for the minimum take or pay in the power purchase agreement;
- Allow hybrid plants as insurance against the seasonal nature and uncertainty of biomass supply and against attempts to push up prices by fuel suppliers acting as a cartel;
- Institute a pollution offset programme which awards credits in power purchase for reduced sulphur, CO_2 and ash emissions;

- In the case of wood waste or dendropower projects, institute a reforestation programme;
- Recognize the socio-economic value of biomass energy projects: biomass power generation is far more manpower-intensive than conventional power generation;
- Offer tax credits (on import duties as well as a few years of tax holidays) for biomass energy plants in order to attract investors; and
- With the aid of financial institutions, promote set-aside monies for research and development in biomass energy.

The key to any power generation project is the power purchase agreement (PPA). For various reasons, the PPA for a biomass power project needs to be substantially different from that for a conventional fuel power plant. Certain points are vital to a good biomass PPA:

First, the power utility must agree to purchase all the electricity the plant generates. As it is time-consuming to start up the plant and very difficult to vary output, it cannot be treated as a peaking plant or be dispatchable.

Second, payment for the energy must be higher than for a conventional plant because of the higher investment, higher fuel collection costs and the higher risk involved. Third, allowances should be specified for offsetting of pollution. There should be strict *force-majure* clauses, so that if the plant is unable to operate for a time due to crop failure or other temporary problems, payments are still made by the purchaser, and credits offered when the plant is again running at capacity. There should also be clauses to allow use of alternative fuels should there be a problem with the regular fuel supply. Lastly, there should be minimum take-or-pay clauses, so that the purchaser is bound to pay even when it does not use the power generated.

In the US, biomass power generation plants have been in use for around 30 years, and the country has become the leader in biomass technology. Despite dissenting voices in the region, Imperial Private Power believes the same technology that is used in the US could be transfered to the RWEDP countries – the obstacles to it that exist in Asia are related to logistics and management, not technology. Thus, research and development funds in RWEDP countries could usefully be spent on visits to successful and long-lived projects in, for example, the US, to identify usable technologies, instead of being sunk into large amounts of research, which is often duplicated or abandoned.

2.7 Steps in the Realization of a Biomass-based Power Generation Project

Idea ↓		
Data collection (in the office) ↓	- Fuel availability - Country policy - Government regulations - Political situtaion - Creditworthiness of country	**CONCEPTUAL PHASE**
Investigation (at the site) ↓	- Meet with government officials - Visit actual operations - Look into question of transportation - Look at fuel resources	
Financial model ↓		
Go or no go? ↓		
Detailed site investigation ↓	- Proposed location - Proposed transportation	**FEASIBILITY PHASE**
Feasibility study ↓	- How big - What fuel - What technology - What performance - Projected costs - Return on investment	
Presentation, Q&A ↓	- Adjust plans	
Negotiation of power purchase agreement (PPA) ↓	- Price - Terms - Recourse	
Drafting of PPA ↓		**EXECUTION PHASE**
Accreditation ↓		
Specification ↓	- Engineering and procurement - Operation and management - Fuel supply - Transportation	
Site selection ↓	- Purchase option on land	
Environmental study ↓		
Contract EPC ↓	- Performance guarantee - Completion	
Contract O&M ↓	- Availability - Maintenance	
Other contracts ↓	- Fuel - Transportation	
Financial package ↓		
Ground breaking ↓		
Equity/debt ↓		
Financial closing		

2.7 Steps in the Realization of a Biomass-based Power Generation Project

Yoram Katz

(These notes supplement the scheme opposite.)

Conceptual Phase

This guide applies specifically to plants selling power to the national grid. It will take a developer about three years from the initial concept to closing the financing deal. All of this process must be completed before implementation can start.

Once the idea has been had to set up a grid-connected biomass power plant, the first step is to collect relevant data on the country or region where the plant is to be located. Along with availability of biomass fuels, such things as national energy and investment policy, the political situtation, the country's creditworthiness and government regulations will have an important bearing on the ultimate success of the project. Most of this information can be obtained from publications, so this stage can be done in the office.

The next step involves travelling to the area under consideration. It consists of meeting with goevernment officials to sound out the government's attitude towards the idea and how much they might be willing to pay for power, investigating local fuel resources, transportation costs and feasibility, etc.

Once these stages are over, a financial model must be generated. At this point a decision should be made about whether to abandon the project or see it through.

Feasibility Phase

Once the decision has been made to push ahead, a detailed site investigation is needed, in order to decide on a more precise location and transportation options. Next will come a feasibility study, determining the size, precise fuel type, performance and costs of the plant, what technology iis to be used and what return on investment can be expected. The outcome will then need to be formally presented to all concerned individuals and agencies. Feedback from and during these presentations can be used to improve and finalize the plans.

Execution Phase

The power purchase agreement (PPA) is the most important document in any grid-connected power generation project. Over a series of meetings, usually five or six, involving lawyers from all sides, the terms of the PPA – including such issues as the price to be paid for the electricity and recourse in case of technical or fuel supply problems, lack of demand from the power purchaser etc. – must be finalized. It is essential for the generator to obtain a minimum take-or-pay clause (i.e the grid owner has to pay even if it does not use all of the energy it has agreed to purchase). On the basis of these meetings, the PPA can be drawn up.

The next thing to be obtained is accreditation, usually from the country's Department of Energy or its equivalent, which licenses the generator to produce power for the grid. There will be a lot of conditions about type of fuel used, etc. It is conceivable that at this point the host country will turn down the project.

Once accreditation as been obtained, specifications will need to be drawn up for things like the engineering and procurement contract (EPC), the operation and maintenance (O&M) contract, fuel supply, and transportation. These are then sent out to potential contractors who will have a fixed period, usually

69 days, to bid for the contracts. Logging companies, with large fleets of trucks, are often good choices for road transportation.

Next will come selection of the exact site for the plant. At this stage only an option to purchase the land should be bought, as the future of the project still depends on obtaining financial backing and the outcome of the environmental study. It is a good idea to get a local to purchase the option in order to keep prices down.

An environmental study of the site will then be needed. This usually takes two to three months, and costs around US$ 150,000. It should be undertaken by an independent consultant.

Once the bidding period is over, it will be necessary to select providers and sign contracts for the various aspects of implementation. The EPC must include performance guarantees and completion guarantees. These will often take the form of letters of credit from the providers, which can be drawn upon should they fail to fulfil the terms of the contract. The O&M contract will usually include bonuses for the contractors if they pass set targets.

It is vital that some consideration is paid for the fuel, even if it is offered free of charge. Without a consideration, there can be no contract, which means there is no guarantee of fuel supply or steady price.

Once all the stages above have been completed, it is time to draw up financial packages to send to financial institutions who may be persuaded to provide either the debt (70 per cent) or equity (30 per cent) portions of finance for the project.

Up to this point, around US$ two million will have been spent by the developer.

Once financing of the equity and debt portions of the investment has been negotiated, the deal can be closed.

3. Working Group Discussions

On the morning of Wednesday 8 January, the participants separated into four working groups to discuss specific conditions for cogeneration. The participants were given the opportunity to select which group they joined. The results of the discussions, presented in the afternoon, were as follows:

Group A: Data/information Requirements

Mok Sian Tuan (chairman)
Arlene Lafrades (rapporteur)
Praset Verapong
Aminah Ang
Nguyen Van Hanh
Ng Seng Huat
Do Thiet Hung
Albert Cheong

Major data requirements identified

- Energy supply/demand
- Resource supply/demand
- Technology information
- Financial/economic feasibility
- Financial options available

Group B: Awareness

Winai Panyathanya
Liang Baofen
D L Shrestha
M N Lian
Younis Suleiman
Chan Keh Yap

How can technical expertise for end-users and local manufacturers be brought in?

- Identification of biomass potential and end-users
- Identification of technology and manufacturers
- Identification of sources of funding for identification of projects
- Creation/assignment of a government agency to promote industrial cooperation
- Use the Internet for information dissemination

How can we learn from each other's successes and failures?/How can successful projects be replicated?

Communication through:

- The Internet
- Workshops
- Seminars
- Conferences
- Publications

What scope is there for standardization of biomass energy technologies?

- Utilization of proven and environmentally acceptable technology. Little reason for standardization.

Should industries be assisted with quick pre-feasibility studies? If yes, who should do this and how?

- The government or international agencies should provide quick pre-feasibility studies to promote potential utilization of biomass.

Group C: Financial/economic Issues

B K Khanal
Abdur Rouf
Yao Xiangjun
Prof. P R Shukla
Jaap Koppejan
Yoram Katz

Governments need to consider basic social needs such as education and health.

Types of subsidies which should be granted are:

- Technical (including machinery costs)
- Financial (including tax holidays, reductions of tariffs and granting of soft loans to biomass energy projects.

Guarantees should exist in the form of:

- Power purchase agreements (PPAs)
- Performance and completion
- Insurance for damage to machinery.

A detailed feasibility study is needed before financing is sought, covering:

- The location
- Raw materials and manpower
- The feeding catchment area
- The market
- Risk and profit.

Options should be spelt out clearly by both sides in the agreement.

Group D: Role of Government

Suwarto Martosudia
Yulinda Rudjito
U Myint Swe
U Tun Aung
A R Chadha
Leonard Liew
P R Shukla

Monitoring:

- To take stock of availability vis-a-vis consumption of biomass
- To ensure sustained availability of biomass in the country
- To ensure efficient and effective use of various types of biomass
- To ensure environmentally friendly use of biomass.

Regulatory:

- To enact/enforce appropriate legislation for efficient and effective biomass energy utilization
- To promote utilization of and provide incentives for environmentally friendly eneryg technologies
- To draft/enact laws consistent with global understandings

4. Conclusions and Recommendations

4.1 Conclusions

1. In recent years, countries within the region have generally experienced relatively high rates of economic growth, accompanied by high average annual increases in energy consumption.

2. Electricity consumption, as a proportion of total energy consumption, has in many cases shown even higher average annual growth rates.

3. Growth rates in energy as well as electricity consumption are expected to remain high in the near future due to various factors, such as fast-growing industrial activity, electrification of rural and other non-electrified areas and improvements in quality of life.

4. This will put a strain on the resources of many countries, as much of these expected increases will be based on fossil fuels which need to be imported (putting strain on foreign exchange earnings for both fossil fuel importing and exporting countries). They will also have an adverse impact on the environment due to the non-renewable nature of fossil fuels.

5. At the same time, other potential energy sources are available in most countries: forest residues, wood-processing residues, agro-residues, agro-processing residues, municipal solid waste etc.

6. Part of these residues is used for various purposes, e.g. as raw material for particle board, fibre board etc., as fodder and fertilizer (in the case of agro-residues etc.) or to provide energy for both domestic and industrial use.

7. However, a large portion still remains unused within the region and in particular in the 16 RWEDP member countries. There appears, therefore, to be considerable potential for increased and efficient use of these residues.

8. One option for increased use of these residues is as a source of energy, through various means, such as upgrading their quality and fuel characteristics through drying, size reduction, briquetting, carbonization, gasification, liquefaction etc., and power generation through cogeneration, heat generation etc.

9. Biomass residues are a renewable and potentially environmentally friendly fuel option for additional power generation, in particular in those areas where the demand for power is increasing at a high rate. Power generation does not have to be limited to grid-connected applications but can also be used for stand-alone systems, for example in remote areas.

10. Besides their use as a source of energy, there are also other options available for increased use of biomass residues, for example as substitutes for other raw materials. An example is the use of empty palmoil fruit bunches (EFB) as a source of fibre to replace wood-based fibres. However, these options were considered as being outside the scope of the consultation and were therefore not covered.

11. Due to the multitude of residues generated and used for various purposes, there is a need to get

more reliable information on various aspects of residue use (unused amounts still available, possible uses for residues, prices of residues, competing uses etc.) than is presently available in data base systems maintained within the region.

12. There is also a need to set up and/or improve existing information systems on how residues are presently being used as energy sources, for example, what direct combustion systems are being used and other conversion processes used (technology data base).

13. Efficient, mature and proven energy conversion technologies exist outside as well as within the region.

14. In various countries in the region, experience exists with regard to the use of such modern technologies

15. The exchange of information and sharing of experiences with regard to the use of modern biomass energy technologies among relevant implementing organizations is considered important to facilitate the transfer of technology both within the region and from outside the region. Unfortunately, systems to facilitate this sharing and exchange are at present still lacking.

16. Government support with regard to the increased use of residues is often inadequate or at times conflicting. This may result in implementing agencies being unable to carry out their mandated tasks.

4.2 Recommendations

1. Maximum use should be made of the biomass residues available within the countries of the region. This is not limited to simply maximizing the quantities used, but also includes improving the efficiency of existing end-uses and promoting substitution where possible. Maximizing the use of residues as a source of energy may help countries to improve their balance of payments vis-a-vis oil and other commercial energy sources.

2. However, maximizing the use of biomass residues should only be considered where this is not associated with negative environmental and/or social impacts.

3. Where appropriate, the private sector should be encouraged to use residues as a substitute for other raw biomass resources.

4. In order to facilitate the use of residues, it is important that countries set up data base systems on the various aspects of residue use (amounts used, amounts remaining unused, competing uses, prices, residue conversion technologies, etc.).

5. Such data base systems should not be limited to the use of policy-making bodies, but should be set up in such a way that they are also useful and accessible for project implementing agencies, financing agencies and end-users.

6. As it may be difficult for individual countries to set up and maintain such data base systems, there is a need to institutionalize the exchange of information within and between the countries concerned with regard to the various aspects of residue use. RWEDP could take a leading role in coordinating such activities with a view to institutionalization.

7. At the same time, efforts should be made to establish some form of networking to facilitate the exchange of information with regard to residue use. RWEDP could take a leading role to facilitate such a network.

8. Increased use of biomass residues will often imply the use of new and modern equipment. Since many of the modern technologies available are designed for use in a different economic, institutional and managerial environment, careful consideration is needed when introducing them.

9. Systems for the transfer of technology should take into account both the hardware and software aspects (localization of equipment, management, operational training requirements, maintenance requirements and capabilities, technical backstopping etc.).

10. Due to seasonal fluctuation, biomass energy conversion technologies should preferably be flexible with regard to their fuel requirements (hybrid-fuel option, multi-fuel boilers, etc.)

11. Besides the increased use of wood and other residues, countries are encouraged to promote actively the growing of multi-purpose trees in areas fallow or uncultivated -(wastelands etc.).

12. Such tree-planting activities need to be flexible in their goals and objectives, as external factors may play a role in changing the original goals and/or objectives under which the programme was initiated.

13. Also, site-specific as well as timeframe-specific influences should be considered in the design of multi-purpose tree-planting programmes.

14. Governments should formulate clear-cut, implementable policies which encourage the active involvement of the private sector.

15. Research and development for the application of biomass residues for productive uses should be continued and, where necessary, strengthened.

ANNEXES

Annex 1

List of Participants

Bangladesh

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Annex 2

Programme of the Workshop

Monday 6 January

Morning

Opening Ceremony

Welcome address by Dr Abdul Razak Mohd Ali, Director General, FRIM

Address by Dr W Hulscher, Chief Technical Adviser, RWEDP

Vote of thanks by Mr Auke Koopmans, Wood Energy Conservation Specialist, RWEDP

Technical Session

Introduction to the expert consultation, by Dr Hoi Why Kong, FRIM

"Energy, Electricity and Development in Asia", by Dr W Hulscher and Mr Auke Koopmans, RWEDP

"Single-purpose Dendropower Production Systems and Large-scale Woodfuel-producing Sectors in the RWEDP Region: Preliminary Findings", by Prof. P R Shukla, Indian Institute of Management

Discussion

Afternoon

"Generation, Utilization and Availability of Agricultural and Forest Residues for Power Generation", by Auke Koopmans and Mr Jaap Koppejan, Assistant Project Officer for Wood Energy Conservation, RWEDP

"Biomass-based Power Generation: Experiences in the ASEAN Region", by Dr Ludovic Lacrosse, EC-ASEAN Cogen programme

Discussion

"Technical and Economic Feasibility of Cogeneration Projects from Rice Husk", by Mr Francis K Himpe, Vyncke NV

"In-country Barriers and Policy Strategies for Developing Biomass Power Projects", by Mr Yoram Katz, President, Imperial Private Power

Discussion and announcement of working group topics

Tuesday 7 January

Morning

Field Visits

To sawdust briquetting factory

To medium-density fibreboard (MDF) factory

Afternoon

To wood-processing complex with Cogen demonstration project and Vyncke cogeneration plant

Evening

Meeting of Dendropower Steering Committee (committee members only)

Wednesday 8 January

Morning

"2,600-kW, 100-per cent Wastewood-fired Extraction Condensing Steam Cycle Cogeneration Plant", by Jebsen & Jessen Engineering (Malaysia) Sdn Bhd

Working Group Discussions

Afternoon

Presentation of outcomes of working group discussions

Plenary discussion

Task for evaluation of country-specific situations set

Thursday 9 January

Morning

Field Visit

To rice mill with rice husk combustor system

Transfer to Forest Research Institute Malaysia

Afternoon

"Steps in the Realization of a Biomass-based Power Generation Project", By Yoram Katz

Discussion and endorsement of conclusions and recommendations

Annex 3

Country Papers

Bangladesh

Mohd Abdur Rouf, Bangladesh Forest Industries Development Corporation and Dr Mohd Omar Faruquekhan, Ministry of Environment and Forests, Government of Bangladesh

Wood-based power generation is currently non-existent and is not under consideration in Bangladesh, not least because forest resources are insufficient and of poor quality. However, it may be explored in the future.

Biomass energy from agricultural and other residues is used by small-scale enterprises in the processing of paddy, sugar, rubber and wood. They are very important to these industries, as there is an electricity shortfall in Bangladesh, and the existing supply is highly unreliable. However, development of these industrial applications is hampered by lack of technology. Also, at present there is no shortage of equity funds for biomass energy projects, but industries tend to use their own budgets for financing.

Government initiatives are raising awareness of industrial pollution and the need for energy efficiency. Most enterprises or industrial sectors have their own facilities for training staff in the operation and maintenance of modern equipment.

On the power generation side, due to pressure from the World Bank and lack of resources and expertise on the part of the power utilities, private domestic and foreign investment in power generation is now being encouraged. Power pricing is being set to reflect the real cost of generation, and subsidy is opposed in principle, though it is still widespread. Government policy currently encourages clean technologies. Private and public sector power generating enterprises now enjoy similar or uniform investment incentives.

Various government agencies conduct activities to stimulate private power generation. However, constraints still exist in the form of, among others, a good deal of red tape in public-sector decision-making; vested interests; unrest in the labour force; and lack of capability in the private sector.

China

Liang Baofen, Dept of Environmental Protection and Energy and Yao Xiangjun, Chinese Academy of Agricultural Engineering Research and Planning

New and renewable energy sources, particularly biomass, are viewed as the key to the rural energy structure and thus to sustainable rural development. As a result they are being vigorously promoted and the government is currently conducting extensive research into rural energy development. Coal is currently the most widely used fuel in rural industry, while biomass dominates in the domestic sector.

Biogas is favoured as an energy source, particularly as its production leaves a substantial amount of biomass residue which can be returned to the field as fertilizer. However, so far only biogas has been developed to a commercial level. Besides biogas, liquid biomass-derived fuels are also considered important, and their use is increasing at an annual rate of about 40 per cent. Development of briquetting and carbonization technologies has reached a commercial level and is expected to grow further.

Practical power generation in 1995 was one PWh, a 7.8 per cent increase on 1994, but power development is inconsistent and there are still shortages. Meanwhile, demand continues to rise rapidly. At the same time, 17 counties and 100 million people still had no electrification at the end of 1995. Power from renewable sources is expected to meet some of the extra demand, particularly in remote and poor areas which the national grid cannot, for the moment, reach.

Of the renewable energy sources for power generation, hydropower is the most widely used. Rice husk also has a certain potential, and both direct combustion and gasifying power generation technologies based on it are presently in use. However, current rural economic reform is resulting in decentralization of rice production, so collection and transportation are becoming more serious considerations in the large-scale utilization of husk. Its use in power generation is therefore declining. Generation based on sugarcane bagasse has a much brighter future, as sugar production is both expanding and geographically concentrated.

As part of its drive to promote the development of renewable energy, the Chinese government has a policy to subsidize various aspects of its development and use. Subsidies are available for, among other things, the operating expenses of sectors involved in renewable energy research, administration and management; research into and implementation of renewable energy technologies; interest on renewable energy development loans; and project inputs.

However, some problems remain in the development of industrial biomass applications. Firstly, the technology is not fully developed. Biogas and direct combustion technologies tend to be relatively mature, but gasification and briquetting technologies are still inadequate. Secondly, there is a need for greater commercialization of biomass technology. Use of biomass is small, and capital for investment is lacking. Compared with the larger, more commercial industries, the managements of biomass-based plants tend to have less market awareness. Finally, policy on biomass utilization is not very clear, and varies in different areas.

By the end of 1994, there was around 6.2 million hectares of recoverable firewood forest across the country. At present, firewood consumption is still higher than these forests can supply, but ongoing afforestation and plantation programmes are expected to alleviate this.

Other available biomass fuel sources are wood-processing residues (around 24 million m^3 per year); animal dung (1.2 billion tonnes in 1995); agricultural residues (600 million tonnes in 1995, of which 300 tonnes are presently utilized; rice husk: 50 million tonnes in 1995); domestic waste; and sugarcane bagasse (around 10–20 million tonnes per year).

India: "Demand and Supply of Fuelwood, Timber and Fodder in India"

S N Rai and S K Chakrabarti, Forest Survey of India

India is a highly pressured land. It holds 16.1 per cent of world's human population and 15.1 per cent of the world's livestock population, but occupies only 2.47 per cent of the world's geographical area and has only one per cent of the world's forests. The monsoon climate leaves between six and 10 months of the year dry, adding to the pressure on the land. India is a largely agricultural country, with nearly 70 percent of the population living in rural areas.

In order to mitigate the effects of mushrooming human and livestock populations on natural resources and land, suitable management practices are needed. The two main methods for improving and maintaining the health of the land are eco-restoration and agro-forestry. The total recorded forest area in the country is 765,210 km^2 (23.28 per cent of geographical area). Of this, 435,499 km^2 needs urgent attention to be brought to the optimal level of productivity.

People's dependence on wood resources is considerable, leading to depletion of forests, particularly since the middle of seventeenth century. Around 62 percent of the domestic fuel needs in rural areas and 35 percent in urban areas are met by wood. There have been a number of estimates on the consumption of fuelwood in India. The Study Group on Fuelwood and Fodder set up by the Planning Commission has estimated demand in 1996 to be 343 million tonnes, and projects that this will rise to 384 million tonnes in 2001. However, this is the highest of several published estimates, which themselves vary widely due to a number of factors. In view of the difficulties experienced in estimation of the fuelwood requirement, a new approach has been adopted using the non-aggregated primary data from studies by the Forest Survey of India (FSI), the NCAER and the Operations Research Group. This produced figures for domestic consumption of fuelwood of 162, 180 and 199 million tonnes for 1996, 2001 and 2006 respectively, and 201 million tonnes as the total nationwide consumption in 1996.

Demand for timber is currently estimated at 64 million m^3 per year. The current sustainable production of fuelwood from forests is 17 million tonnes and from farm forestry and other areas 98 million tonnes. There is a net deficit of 86 million tonnes of fuelwood, which as a compulsion is being removed from the forests. The situation regarding timber (at current productivity) is not grave, but a moratorium on felling and market demands create pressure. Paradoxically, forests produce 70 per cent timber and 30 per cent fuelwood, while the demand for wood is around 70 per cent as fuelwood and 30 per cent for timber. This greatly exacerbates the pressure on resources. Forests in India are now under at least five times the pressure they can withstand.

Indonesia

Dr Suwarto Martosudirjo, ASEAN SCNCER

The Indonesian archipelago is rich in forest resources and is home to some 200 million people. It contains abundant energy resources, both conventional and non-conventional. In the last 20 years, national energy demand rose an average of 14 per cent annually, and was met principally by conventional energy, particularly from oil and gas. However, it has been observed that energy supply is not meeting the needs of the expanding industrial sector. In addition, the national grid is being expanded to cover more islands and remote rural areas.

Government energy policy centres around three main objectives: intensification, diversification and conservation. Under intensification fall projects to seek out further energy resources, including biomass. Diversification is aimed at reducing Indonesia's reliance on oil for domestic consumption and investigating alternative energy sources, including biomass. Conservation concerns rationalization of energy use and introducing greater energy efficiency through the application of energy management in various sectors.

Use of biomass residues for fuel already occurs frequently in plantations and agro- and wood-processing industries. At present, despite Indonesia's relatively large production of rice, rice milling is generally done by small, scattered enterprises, so the husk is not considered a viable fuel for industrial application. According to a recent study, the palm oil, sugar and wood-processing industries do now produce residues in sufficient quantities and concentrations to make them viable for cogeneration. However, current energy prices and competition with conventional energy make such projects economically unattractive.

The government recently allowed the private sector into the power generation market, ending the monopoly of the state-owned PLN. Large-scale projects (over 30 MW capacity) are limited to conventional energy. However, a new scheme has simplified procedures for small private enterprises and cooperatives (PSKSKs) to participate in power generation for sale to PLN and thus the grid. The Ministry of Mines and Energy also hopes this will support the application of new and renewable energy technologies.

The scheme covers plants with maximum 30 MW installed power capacity or excess capacity in one central generating station within the Java-Bali system, while outside this region, the maximum is 15 MW.

Under the scheme, two types of contract to private enterprises and cooperatives: non-firm capacity contracting (contract of up to one year, where PLN pays only for the energy it uses) and firm capacity contracting (contract of between three and years, where PLN agrees to pay for a fixed amount of power and energy every year). Both types of contract can be renewed by mutual agreement.

The PSKSK scheme gives first priority in small-scale power generation to wind, solar and mini-hydro energy; and second priority to agricultural and industrial biomass residues, municipal waste, dendrothermal energy, geothermal energy, and cogeneration from residues, depending on efficiency. Conventional energy applications are placed in the third and fourth priority categories.

Electricity prices offered are based on the type of contract. However, in both cases the price paid per kWh depends on whether supply is at peak or off-peak load periods.

All responsibility for procurement, setting up etc. of the generating plant is left with the PSKSK. However, technical design must comply with the PLN system, and the standard operating procedures of the PLN must be followed in the operation of the generator.

Malaysia

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Around 60 per cent of Malaysia's land area is under natural forest, and 15 per cent under agricultural cultivation, so the country has great potential for the development of biomass energy. Forestry, wood processing, agriculture and agro-processing produce large amounts of biomass residues for which there is otherwise no economic use. The Department of Environment has now started to discourage open burning of the residues, creating great interest in biomass energy.

Several cogeneration systems are available in Malaysia. These are installed in integrated wood complexes and generate heat and power from the various types of wood waste. Wood waste and felled rubberwood are also used for smoking rubber, drying food, curing tobacco, brick firing, charcoal production and briquetting. Pyrolysis and gasification technologies are still at the experimental stage.

The palm-oil industry produces a substantial amount of residue in the form of empty fruit bunches, fibre and shells (an estimated 9.7 million, 5.8 million and 2.5 million tonnes respectively in 1995). Almost all palm-oil mills use the fibres and shells to generate steam and electricity. However, there is usually fibre and shell to spare. EFBs have a high moisture content so they are not as useful for fuel as fibre and shells and are hence not used by the mills. However, the viability of briquetting the EFBs is being studied. Another palm-oil residue, palm-oil milling effluent, is generated in large quantities. As it is highly pollutant, mills are obliged to treat it according to set standards. One treatment yields combustible biogas, but few mills have the equipment installed to make use of it, and consequently flare it off or release it into the atmosphere.

Rice production and processing is high in Malaysia, generating large amounts of straw and husk. Unused husk poses environmental problems, so alternative applications are being sought. Rice husk energy is already used in a variety of applications both inside and outside the rice industry, including cogeneration.

Most types of biomass energy conversion systems are on the market in Malaysia. Various programmes exist which promote the utilization of biomass wastes for energy, among them the Cogen programme. As a result, there are a number of demonstration plants in Malaysia which prospective buyers can visit.

Myanmar

U Myint Swe, Asst Director, Eastern Shan State and U Htun Aung, Myanmar Electric Power Enterprise

Wood is by far the most commonly used fuel in Myanmar, accounting for around 80 per cent of total energy consumption in 1989. Wood and other biomass fuels, such as charcoal, grasses, agricultural residues, agro and wood-processing residues, bamboo and aquatic weeds, are used extensively in both domestic and small-scale industrial sectors, providing 86 per cent of the two sectors' total energy needs in 1986–87. They are also fairly widely used in large-scale applications, including steam engines.

The government is presently trying to boost the efficiency of woodfuel use and promote substitute fuels in order to relieve pressure on natural resources. This is deemed necessary, as deforestation to make way for agriculture continues and even current reforestation programmes are certain to fall short of satisfying fuelwood demand. Transfer of technology and expertise is very badly needed, but under present conditions the country is having to rely on outside assistance to obtain it.

Steam engines have long been widely used in industry, and many running on biomass fuels are installed. However, most have been abandoned, as other sources of energy which were considered more progressive became available. Entrepreneurs are not familiar with the use of more modern biomass energy technologies. These are economically out of the reach of most private industries. The government is presently committed to industrial privatization.

As a step towards boosting the efficiency of biomass fuel use, there are both public and private-sector factories producing briquettes made from wood chips, rice husk, coal etc. However, the briquettes are not widely used, as dissemination and distribution have been poor.

The electricity sector is run entirely by the state-owned Myanmar Electric Power Enterprise (MEPE). However, certain government agencies produce electricity for their own consumption independent of the MEPE, and some private sugar mills also produce their own power from bagasse. Hydropower and convential power plants currently meet the country's electricity demand, though consumption is presently rising at 15–20 per cent per year. Black-outs and brown-outs are rare. Load shedding occurs occasionally only in the upper region. MEPE is currently investing in generating and trasnmission equipment to improve grid supply.

The Government created a new Science and Technology Ministry in 1996, whose Central Research Organization has constructed a rice husk gasifier capable of generating 50 kW of electricity. If commercialized, this has considerable potential, as rice husk is widely available and cheap.

Since 1994, the private sector has been allowed to participate in or jointly implement power projects with the MEPE. Investment opportunities include the building of new power plants either on a BOT or joint-venture basis. Subsidized tariffs were raised in 1994, after 50 years with no change, to make investment in generation more attractive. However, tariffs are still very low. Foreign investors are allowed to supply power to small areas with high concentrations of users willing to pay higher rates, such as industrial zones.

The government recognizes the need for substantial investment in power generation over the next few years. As a result, a number of incentives may be available to foreign investors, though few precendents have yet been set. The Science and Technology Ministry is exected to encourage industries such as pulp and paper and sugar to improve their energy efficiency, particularly through cogeneration.

Nepal

D L Shrestha, Water and Energy Commission Secretariat and B K Khanal, Department of Forests

Nepal is heavily reliant on biomass fuels, particularly wood, for cooking and heating purposes in both industrial and domestic sectors. Around 82 per cent of industry is cottage-scale, and these cottage industries are very often located in remote areas where alternative fuels are not available at reasonable cost. Energy consumption by the industrial sector in 1994–5 was an estimated 12.44 GJ, about 58 per cent of which was generated from fuelwood. Although this total is just 4.4 per cent of total energy consumption consumption, it is growing strongly, and industrial energy consumption doubled over the period 1984/5–1994/5.

The growing demand for energy has meant that wood has been used at an unsustainable rate. Fuelwood is gathered from various sources, from natural forests to trees on private land. Deforestation has meant that wood is now being transported to some urban areas from forests more than 400 km away, which involves using substantial amounts of imported vehicle fuels. With no viable substitute fuel in sight, there is a danger that wood shortages will hamper industrial production in rural areas and lead to social disruption. There is thus a need for alternative energy sources and for raising the efficiency of biomass energy conversion processes in order to rationalize biomass fuel consumption. Introducing more modern biomass energy conversion technologies is one of the most important means to achieve this.

Electricity generation from renewable sources is considered the most attractive energy option. It is estimated that a total of around 42,000 MW could be produced economically from hydropower, satisfying all of Nepal's power demand for the foreseeable future. Power generation is already dominated by hydropower (253.6 MW installed capacity), supplemented by diesel plants (47.2 MW installed capacity). There is also exchange of power between Nepal and neighbouring India.

At present, electricity represents a mere 0.99 per cent of total energy consumption, though it is expected to rise by around 10.5 per cent per annum for the next decade. In 1994–5, only 13 per cent of households had electricity. However, the present installed generating capacity is insufficient even for this small level of consumption, so the government is trying to encourage private investment in the power sector. The 1992 Energy Act has provided opportunities for private power generators and other private companies to produce and sell electricity to the grid under long-term power purchase contracts with a clear pricing framework.

Biomass is so far not used for electricity generation, but there is ample scope for its development to supply remote rural areas. Biomass is, on a small scale, commonly converted into briquettes, biogas, charcoal and liquid fuels such as plant oil. There are around 30,000 biogas plants and 20 briquetting factories in Nepal. Plant oils are mainly used for ritual purposes. Commercially available charcoal is now only produced illegally and is therefore often of very poor quality.

Obstacles to the development of biomass energy include the fact that current energy policies are often biased against renewable energy sources; poor coordination of cooperation between researchers, manufacturers and potential users; the lack of any major institutional marketing of biofuels in the past; and the continued perception of biomass as a grass-roots fuel, typical of small-scale industry. On top of this, there is no single government agency with responsibility for coordinating forestry, agriculture, power generation and industry, so government approaches have always been sectoral and have thus met with limited success.

It needs to be recognized that there is an enormous untapped potential for biomass energy in the improved utilization of existing forest and other land resources (including residues) and in higher crop productivity. It is essential that greater effort is put into producing and using biomass efficiently as a fuel as it is so widely available.

Philippines

Arlene S M Lafrades

In 1996, aggregate biomass energy resources were put at 132.8 million metric barrels of fuel oil equivalent (MMBFOE). Of these, 60.5 of were wood residues, the rest mainly agri-residues primarily from rice, coconut, sugar and corn cultivation, forest residues, animal residues, agro-industrial wastes and aquatic biomass. The industrial and commercial sectors are bulk users of biomass energy, though use of bagasse by sugar-processing facilities represents about 78 per cent of their total bio-energy consumption.

About 93 per cent of total biomass resources consumed for energy are used in power generation. The sugar industry evidently utilizes all of its raw material residues to generate power for use within the facilities, but despite large potential for self-sufficiency and even exporting power, still depends on supplementary power from the grid. The EC-ASEAN Cogen programme is involved in addressing this problem.

Private-sector involvement in power generation is encouraged under the Government's Executive Order No. 15. However, currently, only power and cogeneration projects based on renewable energy resources (including biomass) are exempt from a government moratorium on awarding power projects.

The National Power Corporation (NPC) is currently seeking approval for a New and Renewable Energy Sources (NRES) programme, under which NPC accommodates under its Power Development Program (PDP) about 50 MW per year of additional capacity from NRES (of which 15 MW is to be from biomass), starting in 1998. The programme's aggregate target is to install 300 MW of NRES-based capacity by 2003. It has been calculated that, without subsidy, the NRES Programme would mean an increase in power rates to consumers. This is balanced out by the environmental benefits, increased electrification of remote areas, and increased private sector involvement. Solicitations for NRES power projects are set to start at the end of 1997 or early in 1998. However, several proposals have already been received.

The salient points of the NRES programme implementation guidelines are: NPC shall purchase all power output from NRES power plants awarded under the programme; NPC may increase capacity allocation to a particular NRES by the amount not utilized by other NRES; NPC shall add the following year the balance capacity not contracted in a given year; proponents shall run the plant entirely on NRES; conventional fuels shall only be used for start-up operations; proponents may or may not connect the NRES power plant to the main NPC grid; proponents shall be responsible for the associated transmission lines, but NPC shall have the option to provide; the NRES programme is on a BOO scheme.

Thailand

Winai Panyathanya, Prasert Verapong

Agriculture and related rural activities remain important to the Thai economy despite the rapid growth of other sectors in recent years. Over 40 per cent of Thailand's total land area is used for agriculture. An estimated 18.7 million people work in the sector, which accounts for 10.41 per cent of GDP and close to 30 per cent of all exports.

The Thai government's energy policy is as follows:

- The government is firmly committed to liberalizing the power generation industry;
- Increased power exchange through grid interconnection with neighbouring countries in the ASEAN region, on a commercial basis, is urged;
- State power utilities will adapt themselves towards more business-like operation for greater efficiency;
- Electricity tariffs will be made to more closely reflect production costs;
- More demand-side management measures will be implemented by state agencies to further improve energy efficiency among end users.

Some changes in line with these policies have already taken place in recent years, with internal restructuring of the state-owned Electricity Generating Authority of Thailand and solicitations for power purchase from small power producers (SPPs) and independent power producing projects (IPPs). EGAT has also instituted several renewable energy projects to test their commercial and economic viability.

Energy consumption in Thailand is rising quite rapidly and is expected to continue doing so for the next 40–50 years, making development of the energy sector a major national priority. In 1995, the total final energy demand was around 48,766 Mtoe. This was an increase of 11.2 per cent over the previous year. Biomass fuels accounted for 24.2 per cent of total energy consumption in 1995. Power sales rose 14.36 per cent in the same year to 72,780 million kWh, and power development is advancing quickly, including new hydropower plants, power exchange deals with neighbouring countries, SPPs and/or IPPs. Electricity generation is largely based on fossil fuels, while renewables account for only 8.7 per cent. Biomass only accounts for a negligible proportion of this.

The last few years have seen several large-scale tree planting programmes. Government feasibility studies on using planted eucalyptus to fuel a power plant have yielded promising results.

Agricultural biomass residues are currently used for energy on a small scale – for example, sugar mills already use bagasse waste to fuel boilers. However, each year, Thailand produces 4.6 million tonnes of paddy husk, 35 million tonnes of rice straw and seven million tonnes of bagasse, with an estimated energy value of 13.3 Mtoe of which only 1.6 Mtoe is currently used, indicating that there is considerable scope for increased utilization of biomass energy. Biomass types currently used for energy include rice husk, bagasse, charcoal, fuelwood and sawdust.

Since 1992, the government has been pursuing a policy of increasing power purchase from SPPs (defined as under 90 MW installed capacity). As of 1 December 1995, EGAT has announced its willingness to purchase a maximum of 1,444 MW from SPPs. While this was meant to support cogeneration, utilization of residues and other renewable energy sources, the majority of contracts issued so far have been for conventional plants. A total of 4,493 MW was offered to EGAT in 84 applications, with 22 applications (representing 229 MW) based on biomass energy. The remaining 62 applications (4,264 MW) were based on conventional energy sources.

In view of this, and the fact that power demand is rising faster than expected, it is envisaged that purchases from SPPs will be increased. At the same time, there are plans to rewrite rules and regulations governing biomass-based SPP plants in order to promote their development.

Vietnam

Nguyen Van Hanh and Do Thiet Hung, Insitute of Energy

Around 80 per cent of the Vietnamese population live in rural and mountainous communities. As a result, since 1985, the government has been carrying out formal studies of rural development and, particularly, rural energy development.

According to studies conducted between 1985 and 1990, rural energy consumption is based mainly on wood and other biomass fuels (70–80 per cent), with 10–20 per cent from animal power and 10 per cent from conventional energy sources (electricity, coal and kerosene). Putting these figures together with the proportion of rural people in Vietnam, we can estimate that wood and biomass energy account for 60–65 per cent of the national energy balance.

The principal biomass fuels are: crop residues, such as straw and rice husk, collected after harvesting and processing; wood collected from forest and non-forest areas; and charcoal. The main applications are domestic cooking and space-heating, along with village industries. Energy efficiency tends to be extremely low (typically 8-12 per cent) and there is generally 100 per cent self-sufficiency of fuel in rural household economies.

In response to the country's uneven economic development (average per capita GDP in rural areas is US$110, while the average per capita GDP across the whole country is US$274), the government has put considerable effort into enhancing the rural-urban balance, in the field of energy among others.

Vietnam's biomass energy technology studies have been incorporated in the framework of three rural energy programmes: electrification, fuel supply (for domestic and village industrial applications), and application of new and renewable energy technologies.

Thanks to the electrification programme, rural electrification reached 1.5 billion kWh (14 per cent of total national electricity sales and 25 kWh per rural capita per year) in 1995. The average annual growth rate in rural electrification was 24.5 per cent, and by 1995, 67.6 per cent of rural households had electricity supply.

The other two programmes have focused on two areas: traditional biomass use (replacing inefficient traditional cookstoves) and modern biomass energy use. The latter has looked at biogas digestors based on the anaerobic digestion of crop residues and animal dung, and electricity generation from rice husk and other agro-processing residues using cleaner boilers or gasification equipment, mainly in the Red River and Mekong River delta areas.

Biogas technology based on pig dung and crop residues is considered one of the most promising and relevant options for rural energy development, not least because of its service in reducing negative environmental impacts from these materials. Trials using a number of different designs have been carried out, mostly with good results. To date, the number of biogas plants in Vietnam is estimated to be about 3,000. The gas is used mostly for cooking and lighting, with a part used for small-scale electricity generation in areas with no access to the national grid.

As for industrial application of technologies using direct combustion of biomass fuels, the improvement or replacement of inefficient boilers in various light industries (food-processing, agro-processing, textiles, paper, brick and tile production etc.) is being considered as a major energy conservation project at the national level.

Around 49 per cent of energy used in rural industry comes from woodfuel, another 35 per cent from wood-processing and other biomass residues and only 16 per cent from conventional fuels.

However, in implementing biomass energy projects, both domestic and industrial, Vietnamese energy planners and researchers encounter several obstacles:

- Limited perception by central and provincial administrative and energy authorities of the importance of energy conservation and environmental protection;

- The tendency towards self-sufficiency in biomass fuel use in rural Vietnam, which limits availability for other uses;

- The lack of a national professional institution responsible for managing energy conservation, including efficiency of end-use; and

- The lack of an investment and financial subsidy mechanism for major biomass energy projects.

In response to the very low average per capita GDP in Vietnam and the even lower average per capita income in rural areas (US$ 274 and US$ 110 respectively in 1995), the government has decided that the most important criterion for assessing the feasibility of a rural energy development project is its ability to enhance the living standards and moral/cultural level of the rural population, as well as reducing the rural–urban split. This is placed above economic and financial considerations.

Annex 4
Field Visits

A4.1 Briquetting Factory

The factory converted sawdust from wood-processing industries into charcoal briquettes.

Residues used: Sawdust from wood-processing plants, generally within a 40-kilometre radius. Although the plants generally supply the sawdust free of charge – environmental regulations in Malaysia forbid open burning, so the factory is offering a useful service – storage, transportation and other costs make the real cost of the sawdust between 8.30 and 8.40 RM per cubic metre.

Input and output: The plant processes 500 m^3 of raw sawdust per day, and produces 800-900 tonnes per month of charcoal. The plant runs with a staff of around 75. All of the charcoal was exported to Japan and Korea, almost all for the restaurant industry.

Process/system: Raw sawdust was first fed into a seiving machine to remove wood chips and other debris too large for the system. From there it went into a rotary drier to reduce the moisture content and so boost its combustion performance. The drier used hot gases from combustion of sawdust and the unusable components of sawdust. Multi-cyclones at the exit from the drier separated off dust particles which were too fine for use in the briquettes, while the coarser, usable dust went into temporary storage or direct into heated screw compressors which produced the briquettes. These briquettes were loaded into kilns, where they carbonized for three days before being cooled and packed for sale. Gases from the carbonization were burnt in flues above the kilns before being released, in order to minimize pollution.

No power was generated during the process, so electric components used commercial power from the grid.

Maintenance: Due to the characteristics of sawdust, each of the two driers needs cleaning every two weeks, and must be shut down for more thorough maintenance work every six weeks.

Misc: Due to its important role in reducing pollution from the local wood industry, the factory has enjoyed a good deal of non-financial support and assistance from the public sector.

A4.2 Medium-density Fibreboard (MDF) Factory

Residue used: Unproductive rubberwood felled for replanting. Mostly, the wood is too small for use in the furniture industry, which is able to pay more for larger pieces. The cost of the wood is around 45 RM per tonne.

Input/output: Under normal conditions, the plant every day processes between 400 and 600 tonnes of wood, and outputs 600 m^3 of MDF for use in the furniture industry.

Process: The rubberwood is first debarked and any rotten or otherwise inferior parts removed (there is usually 15–20 per cent waste), before being chipped and fibred. The fibres are then dried in an oil-fired drier before being entering the presses, which form it into MDF. The presses are heated to 250^o C using steam from a boiler fired by a mix of bark, waste wood and commercial fuel. Although the plant uses around 5-10 MW of electricity for wood chipping and pressing, no generators have been installed. Heat is only produced and used for drying the wood chips and pressing the MDF.

Field visit to briquetting factory

Inside MDF factory

Furnace, boiler and superheater of the COGEN full-scale demonstration project at the IB Timber Industries Sdn Bhd wood processing plant

Control panel of the rice drying and packing plant

A4.3 Wood-processing Complex Using a Cogeneration System for Power Generation and Kiln Drying

Residues used: Waste wood and sawdust from the complex's wood-processing activities.

Output: Enough power to meet the needs of the complex (1.5 MW capacity) and up to four tonnes of steam for kiln drying.

Process: Under normal operation, a mix of wet and dried sawdust is fed automatically into the boiler furnace from underneath by two underfeed screw stokers, while larger woodwaste is fed by two metering belt conveyer systems. Combustion air entering the furnace is strictly controlled. Steam generated in the boiler goes to two turbines – a back pressure turbine and a fully condensing turbine – which together generate 1.5 MW. Another four tph of back-pressure steam goes to kiln driers. Dust is collected above the furnace in order to minimize air pollution.

However, on the day of our visit, one of the turbines and neither automatic feeding system was in use. Woodwaste from another factory was being manually fed into the boiler furnace, resulting in overfeeding, unregulated mix of combustion air and fuel, and other problems. The reason why imported woodwaste was being used was that the complex's own output was low, and wrong and inefficient operation of the cogeneration plant meant that the waste it did generate was now insufficient to meet the demand for steam and power. The reason for the manual feeding was that a locally manufactured storage silo, thought to be cheaper than Vyncke's own, specially designed silo, had been installed for the larger woodwaste, but it was improperly designed and did not work.

It turned out that the management of the complex had changed, and all but one of the original staff trained to use the equipment had left. The new management was unfamiliar with the equipment but had made no effort to seek training for its staff, despite the fact that the previous management had paid at least 90 per cent of the cost of the plant and the likelihood of serious, possibly irrepairable damage to the plant if it continued to be used in this way.

A4.4 Rice Drying and Packing Plant

Residues used: Rice husk from the plant's own activities. Can also run on sawdust from sawmills.

Input\output: 300–400 tonnes of paddy dried from 25 per cent moisture content to 15 per cent moisture content, per day during the wet season. Once dried, a lot is stored in silos to even out processing throughout the year. The plant processes around five tonnes of rice per hour, which produces around one tonne of husk. Ash from the burnt rice husk (which is only 70 per cent combusted) is sold to steel factories for about 50 RM per tonne. The rice is all for the domestic market.

Process: Unground husk is fed into an incinerator, hot gases from which pass through boilers, generating 17.5 bar of steam pressure. Ash is removed from the incinerator by a water jacket screw conveyor. When originally installed, the complex was self sufficient. A steam turbine generated electricity, after which the hot gases, now cooled to around 300^{o}C, were passed through three sets of driers – LSUs, flatbeds and inclined beds. However, the driers are now powered by diesel, and only electricity is generated (225 kW), though this is insufficient to run the plant (total demand 600 kW) and has to be supplemented from the grid.

Maintenance: Dust in the hot gases from the incinerator causes wear and tear to pipes. There is also wear and tear from silica in the husk, though the problem is offset by the husk being only 70 per cent combusted.

Misc: The boiler was manufactured in Malaysia, but was designed in the US. The US company provides training for operators. The rice-husk burning system was originally installed after open burning of a huge accumulation of husk caused complaints from the local population. Rice production in the area is now going down, and 20 per cent of the rice is imported from Thailand for packing only.

Annex 5

TECHNICAL DATA

A5.1 Installation in the Bang Heng Bee Rice Mill, by Vynke NV

The Drum Feeder system: a rotary air airlock system distributes the husk evenly over the feeding mouth of the combustion chamber. The system is airtight to prevent fire hazard and to maintain the coorect air balance and underpressure in the boiler.

The combustion chamber: the husk falls onto a water-cooled step-grate, with pusher-plates to ensure even distribution over the grate. The water cooling prolongs the life of the grate and allows for greater regulation of combustion temperature. The step-grate is divided into several distinct zones with their own separate regulation of combustion air and pusher speed. A reddler evacuates 90 per cent of the dust, without opening the boiler doors or disrupting combustion.

The chamber is surrounded by water-tube walls connected with water in a fire-tube two-pass drum, allowing for maximum harnessing of combustion heat. Before the flue-gases enter the fire-tube, their direction is changed by two walls, causing another five per cent of the ashes to drop out.

After leaving the boiler, the flue-gases pass through a multi-cyclone dust collector. All dust goes to one central storage point to make it easier to package and sell on.

The whole system is in under-pressure by the induced draught fan, making it safe and ensuring the right amount of combustion air is maintained at any operating capacity. The installation is steered from a central control panel.

The power generation system: the steam produced by the boiler is brought to a back-pressure turbine. Exhaust steam from this goes into a steam receiver, where it heats up water that either goew directly to the driers or to another heat exchanger where it heats up the water in the drying system. Any remaining steam is condensed and returned to the boiler, making it a closed system.

A5.2 Specific Information on EU-ASEAN COGEN Full Scale Demonstration Projects

Ludovic Lacrosse, COGEN

Below are some brief summaries of COGEN full-scale demonstration projects in the RWEDP region. All of the projected pay-back periods given include one year of set-up time. The costs quoted do not take into account tax rates, which vary from country to country. Fuller calculations and figures for any of the full-scale demonstration projects are available from COGEN on request.

Wood Complex in Indonesia

- 5.55 MW power plant
- Steam boiler: 40 tph, 30 bar, 385°C
- Turbine: fully condensing
- Cost: US$ 4,488,000
- Pay-back period: 3.6 years
- Main suppliers from: Germany and the UK

Plymill in Indonesia

- Steam generation plant
- Steam boiler: 35 tph, 35 bar, 380° C
- Cost: US$ 1,600,000
- Pay-back period: 2.4 years
- Main suppliers from: Denmark

Palm-oil Mill in Thailand

- 48.6 MW cogeneration plant
- Boiler: 179 tph, 62 bar, 482° C
- Turbine: extraction condensing
- Cost: US$ 39,395,000
- Pay-back period: 6.1 years
- Main supplier from: France

Palm-oil Mill in Malaysia

- 1.2 MW cogeneration plant
- Steam boiler: 35 tph, 23 bar, saturated
- Turbine: back pressure (4.1 bar)
- Cost US$ 693,300 (US$ 580/kW)
- Pay-back period: 3.7 years
- Main suppliers from Germany and the UK

MDF Factory in Malaysia

- Steam generation plant
- Boilers:

  Thermal oil with steam generation (22 Gcal/h)
  Steam boiler: 5 tph, 12.3 bar, 193° C
- Cost: US$ 5,630,000
- Pay-back period: 3.5 years
- Main suppliers from: Sweden and Denmark

Rice Mill in Thailand

- 2.5 MW cogeneration plant
- Steam boiler: 17 tph, 35 bar, 420° C
- Turbine type: condensing
- Cost: US$ 3,865,000 (US$ 1,550/kW)
- Pay-back period: 3.6 years
- Main supplier from: Germany

Sawmill in Malaysia

- Steam generation plant
- Steam boiler: 5tph, 12.3 bar, 193° C
- Cost: US$ 274,800
- Pay-back period: 2.9 years
- Main supplier from: Denmark

Wood Complex in Malaysia

- 1.5 MW cogeneration plant
- Steam boiler: 16 tph, 22 bar, 280° C
- Turbine type: condensing (900 kW); back pressure (600 kW)
- Cost: US$ 1,611,000 (US$ 1,075/kW)
- Pay-back period: 3.5 years
- Main suppliers from: Belgium and Germany

Rubberwood Complex in Thailand

- 2.5 MW cogeneration plant
- Steam boiler: 21 tph, 24 bar, 320° C
- Turbine type: extraction condensing
- Cost: US$ 2,187,000 (US$ 875/kW)
- Pay-back period: 2.9 years
- Main suppliers from: Belgium and Germany

Parquet Flooring Factory in Thailand

- Wood waste collection and combustion
- Dust collector, silo
- Hot water boiler: 1,250,000 kcal/h
- Kiln dryers
- Cost: US$ 180,000
- Pay-back period: 2.9 years
- Main suppliers from: Italy

Woodwaste collection and combustion

- Dust collector, silo
- Hot water boiler: 400,000 kcal/h
- Kiln dryers
- Cost: US$ 342,000
- Pay-back period: 2.7 years
- Main suppliers from Italy and Belgium

Wood Complex in Malaysia

- 1.65 MW cogeneration plant
- Steam boiler: 30 tph, 30 bar, saturated
- Turbine: condensing
- Cost: US$ 1,994,000 (US$ 1,210/kW)
- Pay-back period: 3.1 years
- Main suppliers from: Denmark and Germany

Paper Mill in Thailand

- 600 kW Cogeneration Plant
- Turbine: back pressure (20 bar, 5 bar)
- Cost: US$ 102,000
- Pay-back period: 1.4 years
- Main supplier from: Germany

Rubber Factory in Malaysia

- Waste water treatment plant
- Anaerobic digester
- Cost: US$ 1,507,000
- Pay-back period: 4.1 years
- Main suppliers from: Belgium

Wood Complex in Malaysia

- 10 MW power plant
- Steam boiler: US$ 7,045,000 (US$ 700/kW)
- Pay-back period: 3.1 years
- Main suppliers from: Germany and the UK

A5.3 2600 kW, 100 % Wood Waste Fired Extraction Condensing Steam

Jebsen & Jessen Engineering (M) Sdn Bhd

Operation

No of Shifts per Day	3
Hours per Shift	8
Days per Month	26
Months per Year	12
Net Operation Time per Month	624 hours
Net Operation Time per Year	7,488 hours

Fuel Resources

Mill Capacity
Plywood Mill

Raw Material Input per Month	20,000 m^3
Raw Material Input per Hour	32.05 m^3
Wood Density (meranti)	635 kg/m^3
End Product in % of Raw Materials	50 %
Residue in % of Raw Materials	50 %
Total Available Residue (Plymill)	10,176 kg/h
Average Calorific Value of Residue (LHV)	2,800 kcal/kg
Average Calorific Value of Residue (LHV)	11,723 kJ/kg
Total Calorific Value of Waste	119,293,248 kJ/h
Boiler Efficiency	78 %
Total Heat Load (Output)	93,048,733 kJ/h

Energy (Thermal)

Inlet Water Temperature	120 ℃
Inlet Steam Pressure	30 bar (abs)
Inlet Steam Temperature	350 ℃
Inlet Steam Enthalpy	3115 kJ/kg
Energy Required	2612.68 kJ/kg
Amount of Steam Generated	35,614 kg/hour
Amount of Steam Required	35,000 kg/hour
Shortage (steam)	614 kg/hour
Fuel indication (+ = excess fuel)	(Waste) 175 kg/h
(- = shortage fuel)	4.21 tonnes/day

Operation Cost Without Steam

Turbine Power Generation

Average Power Requirement	2600 kWh
Diesel Fuel	0.269 litres/kWh
Cost of Diesel per Year	3,665,975 RM
O&M Cost of Diesel Set	194,688 RM (= 1 cent per kWh)
Total Diesel Genset Operating Cost per year	**3,860,663 RM**

Operating Cost with Steam Turbine Power Generation

Fuel Cost (Diesel Genset)

Power Generation Makeup (3 days)	2600 kWh
Power Consurnption:	2,600 kWh
Diesel Fuel	0.269 litres/kWh
Cost of Diesel per Year	35,250 RM
O&M Cost of Diesel Set	1,123 RM/year
Total Diesel Genset Makeup Cost	36,373 RM/year
Maintainance Cost for Steam Turbine	50,000 RM/year
Total Operation Cost per Year	**86,373 RM**
Total Saving per Year (Electricity)	**3,774,290 RM**

Capital Investment

Boiler Incremental Cost (35T, 30 bar, 350 ℃)	900,000 RM
Turbine Power Plant	3,350,000 RM
Water Treatment Incremental Cost	150,000 RM
Civil Work	60,000 RM
Total Capital Investment	**4,460,000 RM**
SIMPLE PAYBACK	**1.18 YEARS**