RWEDP Report No.32

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

PROCEEDINGS OF THE REGIONAL EXPERT CONSULTATION ON SELECTION CRITERIA AND PRIORITY RATING FOR ASSISTANCE TO TRADITIONAL BIOMASS ENERGY USING INDUSTRIES

Penang, Malaysia
15-18 January 1996

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Bangkok, July 1997

This publication is printed by
the FAO Regional Wood Energy Development Programme in Asia,
Bangkok, Thailand

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FOREWORD

Numerous industries in Asia use wood or other biomass as their main source of energy. Many of these industries are small scale and agriculture-based, often located in a rural environment and employing traditional production processes. Some others utilise modern technology so as to obtain more efficient use of wood and biomass fuels in a cost-effective way. The fuels serve principally to supply heat for production processes, such as drying, smoking, baking and firing, but in a few cases they are also used to generate power. Traditional woodfuel-using industries often face serious problems in today's markets, which tend to be increasingly competitive. At the same time, these industries provide an essential contribution to local and national economies.

The prime strategy for relief of the problems of woodfuel-based industries is not to encourage a switch to fossil fuels. That option may be beyond the financial and technical resources of many of the industries concerned, may imply too many risks or may be unfeasible because of unreliable supplies and local socio-economic conditions. Rather, the first option is to assist the industries in improving their production technologies and practices. However, even though improved technologies are available in principle, even at low cost, simply introducing them is not sufficient to ensure sustained improvements, as their effectiveness depends on many related factors, which are partly beyond control of the industries themselves.

The Regional Expert Consultation on Selection Criteria and Priority Rating for Assistance to Traditional Biomass Energy Using Industries looked into these problems and came up with a number of conclusions and recommendations on how best to address them. The consultation also identified industries in the region which should be given priority for assistance. Among them were brick and roof tile industries; sugar, gur and jaggery making; tobacco curing; timber drying; lime burning; and fuel processing, such as charcoal making and briquetting.

The consultation, which was jointly organized by the FAO Regional Wood Energy Development Programme (RWEDP) and the Forest Research Institute Malaysia (FRIM), took place in Penang, Malaysia in January 1996. The meeting drew from the expertise of some 40 experts and resource persons representing all the RWEDP member countries, and saw a good deal of wide-ranging and productive discussion among the participants. Also, the programme benefitted from highly relevant and stimulating site visits offered to nearby Malaysian industries using biomass fuels.

The present report gives an account of the main inputs and outputs of the consultation. Based on the results obtained in Penang, RWEDP and partners will proceed with further activities in the development of wood and biomass energy-using industries. It is hoped that the report will stimulate other interested organizations to make contributions in this field.

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1. INTRODUCTION

Out of more than 2.9 billion people living in the Asia-Pacific region, 60 percent – 1.75 billion people – are classified as agricultural population. Aggregate production of food and other agricultural commodities from rural areas are vitally important to the countries in the region, in terms of their economies and in many other ways.

However, even in these agricultural economies, industrial activities are gaining in importance. Many of these activities consist of the processing of local raw materials such as agricultural products and local minerals. Although enterprises connected with agricultural production are commonly scattered over large areas, varying enormously in scale, they play a key role in generating income and employment in rural areas, as well as supporting agricultural activities.

These rural industries almost always require energy, often in the form of heat. As wood, agricultural residues etc are locally available and the technology to utilise them is already in place, they are frequently used in place of more conventional fuels. Studies conducted by or on behalf of the FAO have indicated that, given the various economic, social and environmental considerations, continued use of these biomass fuels is often the best energy option for rural industries, and so it should be supported and possibly even encouraged.

However, while this may be true, rural industries are often tied to inefficient technologies and practices and are unwilling or unable to make the necessary improvements independently, due to their relatively small scale, lack of available capital, traditional nature and other factors. For this reason, the FAO Regional Wood Energy Development Programme (RWEDP) has initiated a variety of activities to assist policy-makers and coordinate interventions, particularly with regard to improving fuel efficiency.

Resources to do this are lacking in many respects. The fruits of previous expert consultations – one in Rome in 1986, the other in Hat Yai, Thailand in 1990 – and of further research have included great improvements in the data base, but obtaining reliable information is still, as it always has been, a major problem. Cooperation from both governmental and non-governmental organisations has steadily increased and carried the work a long way forward, but the sector is vast, varied and widely dispersed, particularly in the developing Asian countries covered by the RWEDP. Hence it is clear that the RWEDP's efforts and resources must be carefully targeted in order to achieve the maximum impact.

The Regional Expert Consultation on Selection Criteria and Priority Rating for Assistance to Traditional Biomass Energy Using Industries, held in Penang, Malaysia on January 15–18, 1996, was called in order to draw up a set of criteria to be used in choosing and prioritising five small or medium-scale biomass fuel-using rural industries which could be the prime recipients of direct assistance from the RWEDP.

The industries under consideration were all rural industries which could be roughly categorised as being of small to medium scale and reliant on woodfuel or other biomass fuels. It should be noted that the word rural is used here in a wider context, and enterprises classified as rural industries could also be located in semi-urban and even urban areas.

1.1 Participants

Experts from the RWEDP's 15 member countries were invited to share their experiences and perceptions of industrial biomass energy use, and to join together in determining the required lection and priority rating criteria. All 28 experts had first-hand experience with development activities relating to the type of industries being considered, particularly in the small and medium-scale sectors.

Besides the regional experts, the consultation was also attended by distinguished resource persons from the region and representatives of the FAO head office and the RWEDP.

1.2 Structure of the Consultation

Day 1

The consultation opened at the Holiday Inn Resort, Penang on 15 January. Dr Abdul Razak Mohd Ali, director-general of the Forest Research Institute of Malaysia, gave the first address, speaking of the urgent need to maximise utilisation of forestry and agricultural residues in Malaysia, as they represent a huge but currently wasted source of energy. If this could be achieved, particularly to fuel large, energy-intensive industries, it would contribute significantly to Malaysia's efforts to become a fully developed and industrialised nation by 2020, he said.

He continued that biomass fuel, as a sustainable energy source, was an important alternative to petroleum fuels such as oil and gas, for while Malaysia had good reserves of conventional fuels, they were recognised to be unsustainable and depletable. Finally, he called upon national R&D institutions to step up their work in finding ways to maximise utilisation of the huge amount of biomass residue currently discarded in Malaysia every year, saying that it was not enough to leave industries themselves to solve the problem.

Addressing the meeting next, Mr M A Trossero of FAO/HQRS Rome said it was the RWEDP's responsibility to ensure that the rapid economic and industrial development that is the primary concern of developing countries was as sustainable and had as little environmental impact as possible. For this reason, he hoped the consultation would, besides its stated objectives, also provide an opportunity to discuss parameters and indicators for environmentally sound wood energy sources, the sustainable development of the areas and sectors involved, and the internalisation of the externalities which are the main driving forces behind the promotion of wood energy, as well as describing and developing linkages with other related sectors

In the opening address of the consultation, Mr Koay Kar Huah, representative of the State Government of Penang, called on all countries in the region to pool resources, experience and information in the development of biomass fuel technologies through collaborative programmes, and welcomed the amount of time in the expert consultation being devoted to R&D and the promotion of relevant new technologies.

Dr Wim Hulscher (third from left) presents Mr Koay Kar Huah (second from left) with a token of the consultation participants' appreciation

Prof. Dr Baharudin Bin Yatim of Universiti Kebangsaan Malaysia then delivered the keynote address (summarised in Section 2.1).

After the opening ceremony, Mr

Auke Koopmans of RWEDP, Bangkok introduced the framework of the expert consultation, and then presented the paper an Overview of Industries and Biomass Energy Use (also summarised in Section 2.2).

This was followed by presentation of country statements from the first nine RWEDP member countries represented at the consultation: Bangladesh, Bhutan, China, India, Indonesia, Maldives, Malaysia, Myanmar and Laos. (All the country statements are summarised in Section 3).

Day 2

January 16's morning session opened with the remaining country statements, from Nepal, Pakistan, the Philippines, Sri Lanka, Thailand and Vietnam. The rest of the morning saw papers from various resource persons present (summarised in Section 4).

After lunch, Dr Hulscher of the RWEDP delivered a paper on Characteristics of Small Industries and Energy Use (also summarised in Section 4), which was followed by a question and answer session. The rest of the afternoon was devoted to group discussions, introduced by Mr Koopmans.

Day 3

January 17's morning session started with a presentation by Yoltan Briquettes (M) Sdn Bhd, a local Malaysian firm producing fuel briquettes from saw dust, followed by questions and answers. After this, the discussion groups were asked to present the outcomes of their discussions, which was followed by questions and answers from the other participants. During the afternoon, conclusions and recommendations coming out of the consultation were discussed and endorsed.

Day 4

The last day was taken up with visits to two local industries using biomass fuels: the Malayawata Steel Berhad charcoal mill in Butterworth and the Mee Hoon noodle factory in Rawang, Selangor.

2. KEYNOTE ADDRESS AND OVERVIEW

2.1 Keynote Address: Perceptions and Experiences of Traditional Biomass Energy Using Industries in Malaysia

Prof. Dr Baharudin Bin Yatim, Universiti Kebangsaan Malaysia

The paper begins with basic geographical and climatic information about the country. The total land area of Malaysia is almost 33 million hectares, of which over 20 million hectares are under natural forest and close to five million hectares under agricultural cultivation. Of the latter, nearly 40 per cent is under rubber, over 34 per cent under oil palm, over 12 per cent under rice and over six per cent under coconut. Malaysia's official energy demand for 1993 was 18.3 Mtoe. This was met with 54 per cent oil, 34 per cent natural gas, five per cent hydro and seven per cent coal. Biomass is not accounted for in the national energy balance, but an estimated 2.5 Mtoe was utilised in industry in the same year.

The 1980s saw both a dramatic increase in rural electrification and a substantial migration to the cities. In response to relatively high energy costs and a depleting fossil fuel reserve, the government has embarked on a number of programmes to diversify the country's energy supply and utilisation. The National Energy Policy seeks to ensure supply, efficient utilisation and environmental protection, but has concentrated on the four-fuel strategy of replacing oil with gas, coal and hydro, and thus greatly reducing the country's dependence on oil. However, as a major producer of agricultural commodities and forest products, Malaysia has also taken an interest in biomass energy technologies, and a number of research programmes and pilot projects have been undertaken.

Forestry or wood residues are generally forms of wood that cannot be marketed at a profit in the current economic and technological climate. However, this can change, as it did recently when new technology began successfully converting rubber wood into value-added products like furniture. Logging residues, such as bark, stumps, tops and branches, total around 5.1 million m^3 per year, but cannot easily be recovered under current logging practices. Primary manufacturing residues include slabs, trimmings and sawdust (2.92 million m^3). Plywood residues include veneer cores, defective ends and irregular sheet pieces (0.91 million m^3). Secondary manufacturing residues include sawdust, planer shavings and edgings (0.9 million m^3).

The main sources of agricultural wastes are: rubber wood residues which are available when felling for replanting (10 million m^3 per year); oil palm residues, including fruit fibres, shells and empty fruit bunches (8.69 million m^3); and rice husk residues, which are available only seasonally (3.41 million m^3).

Malaysia has a long tradition of using biomass as fuel, particularly rubber wood, oil palm and sawmilling waste. There are some 560 drying kiln units installed in the wood industries. Palm oil mills are self-sufficient in energy, burning fruit fibre and shells to generate steam and electricity. The mills could generate surplus electricity if their systems were upgraded and optimised. Wood residue and rubber wood are used in the manufacture of charcoal and about 100,000 tonnes of charcoal is produced annually. The three production methods in use are the sawdust clamp, the beehive kiln and the transportable metal kiln, this latter having been developed by the Forest Research Institute of Malaysia and reported to be very economical and well adapted to the needs of small operators.

Wood briquetting converts loose waste into a dense, consolidated form by pressure and high temperatures, and without a binding agent. There are five manufacturing companies in Malaysia, but almost 100 per cent of the briquettes produced are exported.

Recently, there have been developments in biomass combustion equipment. Two companies are involved in particular. One manufactures a New Zealand burner system under license, used for drying cocoa and rubber sheets. The other manufactures solid fuel burners for similar applications, which have had some success in the export market.

Cogenerating systems have been introduced under the successful ASEAN-EC COGEN programme. Two plants generate process steam for drying kilns. A third phase began in 1995 and will install five more plants. The Forest Research Institute of Malaysia and the Technology University have run pilot studies on the gasification of wood in gasifier-engine-generator systems for the generation of electricity in rural areas. Costs were reportedly cheaper than for a diesel generator. Three rice mills have been installed with the King Chastain Energy Reactor rice husk combustor for paddy drying, and a further two have installed rice husk combustor cogeneration systems where heat is used for both drying and electricity generation. A table gives details of the utilisation of biomass energy in Malaysia.

Suggested criteria for the acceptance and success of wood energy technology include: sustainability of fuel supply; availability of fuel at point of use; ability for conversion to higher energy density and/ or ease of handling and transportation; the necessity to dispose of biomass residues; that overall costs are less than for conventional fuels; and acceptability of new technology. Guiding principles include: energy security, competitive costs, environmental acceptability and compatibility with other development objectives.

2.2 Overview of Industries and Biomass Energy Use, and Creation of a Priority Rating System to Select Five Traditional Woodfuel Using Industries

Auke Koopmans, Wood Energy Conservation Specialist, RWEDP

2.2.1 Background

Various studies and results of other activities carried out by the FAO since the early 1980s have strongly indicated that:

- Biomass-using rural industries contribute significantly to the generation of income and socio-economic development in rural areas;
- Apart from domestic applications such as cooking and heating, woodfuel plays an equally important role for the rural industrial sector, even though its share in overall biomass consumption is generally only about 10-30 per cent of the total;
- Processing technologies and energy-conversion devices used by rural industries are in general traditional and inefficient;
- Due to their small scale and limited access to external support, rural enterprises are generally weak;
- Institutional support and an effective delivery system are lacking.

The 1990 FAO-RWEDP regional expert consultation in Hat Yai, Thailand, on biomass-based rural industries concluded that, as long as it is accompanied by suitable policies and interventions, the use of biomass fuels by rural enterprises should be accepted and possibly even encouraged. The meeting also highlighted the following:

- The need to formulate policy on rural biomass-based industries, including the need for data gathering and management at the national level;
- The need for programme planning and implementation at the national level;
- The need for field-based activities; and
- The need for concerted regional cooperation in support for these industries.

Based on the outcome of the meeting, the RWEDP has already undertaken several activities, and more are planned. These include a number of national-level policy-identification meetings, and the programme is also to support programme planning and implementation at the national level for biomass-based rural industries.

2.2.2 Selecting Industries and/or Industrial Sectors

In order to prevent resources from being spread too thinly to be effective, the workplan of the FAO-RWEDP calls for five traditional woodfuel-using industries to be selected for assistance. For this selection, a priority rating needs to be formulated. With regard to this selection process, one important precondition for selection is set by the FAO and the donor: industries to be supported should in principle be sustainable, and a critical assessment must be made of whether the woodfuels used are themselves sustainable. This precondition will form the basis of selection criteria and of priority-setting. However, while at present an industry may not be sustainable, this may be subject to change due to various factors, such as internal cost-cutting measures, changes in the prices of energy substitutes and changes in prices and/or availability of competing products. The latter often results from government energy and other policies. However, these policies will not be covered here as they are set at the national level and so come under a different part of the FAO-RWEDP workplan (Activity 3.5.7).

2.2.3 Selection Criteria

These should include, among others, the scale of the industry and the type of agencies needed to provide assistance. Another important criterion is the effect assistance would have on factors such as woodfuel use and profitability.

Scale of Industries

Universal yardsticks are needed for classifying industries by size, intensity, etc. They must be independent of the various means of classification used by different countries and organisations, such as number of employees, use of machinery, value of fixed assets, etc.

During the Rome expert consultation on biomass-based rural industries (1986), there was extensive discussion of the scale factor, and this resulted in a division into three main categories: cottage activities, village activities and rural industries. An adaptation of these categories is summarised in Table 1. It should be kept in mind that such a classification system cannot properly cover all relevant activities, and some industries are carried out in more than one scale category.

The report indicated that in general the vast majority of industrial units are in the smaller categories – for example in Thailand, almost two-thirds of industrial units have less than 10 employees. Around half are in urban or semi-urban areas.

These concentrations are crucial in policy-making, as small-scale industries are usually less able to deal with problems; they often operate with relatively low levels of investment and high levels of labour intensity; their production processes are often traditional and in many cases wasteful, in particular with regard to energy consumption; and they usually operate under highly competitive conditions, both from similar producers and the large-scale industrial sector. Many are seasonal, semi-legal, not registered, or operate without the legal security of the land on which they are located, thus having little or no collateral for loans and credit. All these factors reinforce their isolation from the more formal sources of financial, technical and other assistance.

This has a profound influence on the type of intervention required and the change agencies to be involved in support of that intervention. This is particularly true for smaller-scale industries, so support organisations for small industries (GOs or NGOs) normally need to put more effort and time into reaching them, and more assistance, particularly financial, is required. Providing assistance to large-scale industries, which may be easier and more "visible", and so possibly more attractive to support organisations, may force smaller-scale competitors out of the market.

Impact

Another potentially useful classification system concerns the level of positive impact the assistance would have. Suggested criteria to identify "high-impact" industries include:

Raw materials and fuel:

- Sustainability of the industry's supply of raw materials and biomass energy sources;
- Biomass use, including both amount consumed and proportion of production costs accounted for by fuel costs;
- Degree of biomass fuel savings possible.

Products and productivity:

- Opportunity/need for improvements in product quality and product marketability;
- Need for improved productivity.

Environment:

- Effect of the industry's biomass fuel consumption on its resource base over time, and the effect on the working and local environments;
- Contribution to socio-economic and rural development through, for example, upgrading skills.

Support activities:

- Likelihood of acceptance of innovations/improvements in efficiency and/or product quality to be offered, including access to support services, and the level of concentration, which affects how easy it is for organizations to assist industries;
- Accessibility to credit sources;
- Cost-benefit ratio of assistance provided;
- Need for intersectoral cooperation (industry, agriculture, forestry, etc.).

An example of the type of ranking system needed to decide which industries are prioritised is given in the table below. This example could be considered as a first step, to be followed up with a multiplier system whereby some criteria are given greater weight than others.

It should be noted that the industries themselves may have different priorities to those held by external support organisations, and it is therefore important to make sure the interests and view-points of both sides are taken into account, so that the maximum benefits accrue from the scheme.

Addendum

An addendum to the paper, reproduced as Annex 4 of this report, attempts to classify industries into the seven main industrial categories given earlier, while at the same time providing some, but still limited, information on selection criteria for the first main group.

Table 1: Categorisation of Rural Industries

	Category		
Criterion	Cottage	Village	Rural
Labour	Family	Extended family/village	Local population
Organization	Non-waged/shared tasks	Non-waged/rudimentary wages	Formal wages
Technology	Low	Low to medium	Medium to high
Regularity	Non-regular	Seasonal/regular	Regular
Formality	Informal	Informal/formal	Formal
Fuel flexibility	Low	Low/medium	Medium/high
Concentration	High	Medium	High

3. Country Statements

Bangladesh

Kazi Aktaruzzaman, Institute of Fuel Research and Development,

The paper begins with geographical, meteorological, political and demographic outlines of the country. The main sources of energy are biomass, gas, oil, electricity and coal. Total biomass consumption is around 39 million tonnes and includes wood in the form of fuelwood, charcoal, twigs and leaves; and agricultural residues such as plant residues, paddy husk and bran, bagasse, jute sticks and animal dung.

Over 12 billion cubic feet (3.396 million m^3) of natural gas has been discovered to date, but pipeline supply to rural areas is not economically feasible in riverine Bangladesh. The country uses around 1.5 million tonnes of petroleum and petroleum products per year, all imported and accounting for almost two-thirds of total export earnings. Over 700 million tonnes of bituminous coal have been discovered at two sites, at one of which the coal lies at the prohibitive depth of 900 metres and at the other at the more feasible depth of 160 metres. All coal is currently imported (between 100,000 and 150,000 tonnes) and is mostly used for brick firing.

Because of the country's flatness, there is little potential for large-scale hydro-electrical development, although 230 MW is currently harnessed from the Kaptai Dam and there may be potential for mini- and micro-hydro plants.

Although there is an estimated 133 million tonnes of peat in the country, it all remains under water for almost half of the year and extraction is impossible without the development of new technologies.

A table shows the energy balance of the country. The major points are: the domestic sector consumes over 64 per cent of total energy; biomass accounts for 73 per cent of consumption and commercial fuels for 27 per cent; of biomass, agricultural residues account for over 46 per cent and fuelwood for only 16 per cent; industrial use of biomass accounts for around 16 per cent of total energy consumption; and within the industrial sector biomass accounts for almost two-thirds of energy consumption. Figures are given showing total energy consumption by sector and by sources.

A second table gives energy consumption by end use and fuel type in rural areas. The main points are: biomass and commercial fuels account for 83 per cent and 17 per cent of rural energy respectively; agricultural residues account for over 43 per cent of rural energy and 52 per cent of biomass energy; and industrial use accounts for over 16 per cent of rural energy and 20 per cent of biomass energy.

At 168 kgoe, the country's per capita consumption is very low and its contribution to global environmental degradation is insignificant. However, internally, deforestation is so far advanced that its deleterious effect on the environment has become visible. There has as yet been no study made of the environmental impact of energy consumption and the need for environmental impact assessment (EIA) has become imperative.

A table gives the country's projected fuel demands up to 2010. Because of increased development and rising population, the demand for all commercial fuels except kerosene will rise significantly. This calls for the promotion of affordable, environmentally sound technologies and appropriate strategies at regional and international levels to check environmental degradation.

Another table gives the nutrient status of the most important agricultural soils in Bangladesh. It shows that levels of organic matter and nutrients are already alarmingly low, which is reflected, for instance, in falling rice yields.

A fifth table shows the comparative costs of useful energy for different fuels. Of those considered, natural gas is the most economical, but prices vary from industry to industry. The figures also reflect the real scarcity of biomass fuels and show the need for immediate intervention.

A list is given of some 34 rural industries and three other activities that consume fuelwood and other biomass fuels. A sixth table gives fuelwood and residue consumption in some of these.

Bhutan

Kesang Dukpang, Forest Department

The paper begins with a geological and meteorological outline of the country. Because of its mountainous nature, Bhutan has excellent potential for hydro-electrical power. The country is still 60 per cent under forest cover, and though the government has a strong conservation policy, depletion is occurring.

Wood is the cheapest and most readily available source of energy, consumed in the daily lives of virtually every citizen. Total fuelwood consumption is estimated to be 1.12 million m^3 per year (about 90 per cent of total energy consumption), and per capita consumption, at 1.92 m^3, is among the highest in the world.

Forested areas near the capital, Thimpu, have already been depleted of their broad-leaved species. Population growth, at 3.1 per cent, is expected to worsen the situation.

A one-day fuelwood workshop was held in Thimpu on 5 June 1995 to identify the reasons for high consumption of fuelwood and to explore possible solutions and alternatives. Recommendations included: the supply of free or subsidized electrical devices; the revitalization of the National Committee on Wood Energy Development; the exploration of alternative energy resources; and increasing popular participation in afforestation through agroforestry etc.

Suggested alternative energy sources include: the provision of electrification in accessible rural villages; the further encouragement of the use of kerosene (over seven million litres were imported in 1994 and the figure is expected to have increased by 50 per cent in 1995); the encouragement of the use of LPG, already the most popular energy source in urban areas (1,800 tonnes were imported in 1994, and this is expected to have doubled in 1995); the use of coal in institutional cooking; and the use of biogas, solar energy, agricultural residues, sawdust and dung.

A list is given of industrial sectors using mainly biomass energy. Only metal and mineral-based industries use a significant amount of energy from non-biomass sources.

China

Lei Zhentian, Research Institute of Chemical Processing and Utilisation of Forest Products,

China is rich in natural resources. The workable reserves of coal and oil are 966.7 Gt and 78.7 Gt respectively. The country also has a gas reserve of 6,000 billion m^3 and a workable hydro resource of 380 GW. Almost 14 per cent of the country is covered with forests. However, per capita resources are quite low because of the size of the population (some 1.2 billion). Of these, some 0.85 billion live in rural villages, and 80 per cent of total household energy consumption in rural areas comes from biomass such as agricultural residues and fuelwood. Biomass is the only alternative for many village-based industries.

For several years the Chinese economy has been growing at around 10 per cent per year, and many small industries have been established in rural areas, causing local energy shortages. Rural industrial production accounts for 63 per cent of rural gross production and 24 per cent of gross national production. In 1992, rural energy consumption was 570 million tonnes coal equivalent (Mtce), of which 330 Mtce were from conventional energy (coal, oil, electricity) and 240 Mtce from biomass and solar energy. Since 1980, rural energy consumption has soared by 10 per cent per year, and since national conventional energy production has been growing at only five per cent per year, rural industries have relied heavily on biomass, accelerating deforestation and threatening the environment.

Coal provides 75 per cent of total industrial energy and 80 per cent of urban household energy. Output was 1,116 Mt in 1992 and 1,490 Mt in 1993. The heavy use of coal is causing serious air pollution. Oil output was 145 Mt in 1993, an increase of over two per cent on the previous year, and natural gas output is around 16.5 billion m^3 per year, but output of both is expected to fall well short of demand in the next decade. Electricity output was 839.5 MWh in 1993, of which hydro power accounts for 18 per cent. In absolute terms, this ranks China fourth in the world, but per capita consumption, at 54 kWh, is only 1.5 per cent of that in the United States, and 120 million people have no access to electricity at all.

Solar energy utilization includes water heaters, cookers, PV cells and passive solar houses. In 1993, solar water heaters with a combined heating area of 2.5 million square metres were in use, each square metre saving between 100 and 150 kg of coal per year. Passive solar houses account for a further 1.8 million square metres, and there were around 160,000 solar cookers in use. In 1993, wind power contributed 14.6 MW of electricity to the grid, and a further 120,000 units supplied electricity to households, generating over 17 MW for 500,000 people. Geothermal power stations provided over 28 MW in 1993.

The dependence on biomass in rural areas is unlikely to diminish in the near future, and the government has adopted a number of policies to accelerate research and development in biomass energy utilization. These include the establishment of fuelwood forest areas, the development of biomass energy conversion technologies and equipment, and dissemination and training. A large number of ministries and research institutes are involved in the programme.

Agro-residues are the dominant energy resource in rural villages. A table gives figures for production in 1992. Of a total production of 554 Mt, 276 Mt was burned for energy. Between 1982 and 1993, 4.65 million hectares of fuelwood forest were planted, and annual output is now some 3.5 million tonnes. Imported species are increasingly being planted (the total to date is 80,000 hectares) giving yields two or three times higher than were obtained with native species. In 1992, 164 Mt of fuelwood were burnt as household fuel.

Direct combustion of biomass for heat and power predominates in rural villages (80 per cent of it for consumption), where traditional stoves have a low efficiency of between eight and ten per cent. China has been promoting improved stoves (efficiency 25-30 per cent) since 1986, reaching 149 million households by 1992. A similar programme has been running to disseminate improved industrial boilers, burning fuelwood and wood wastes, with efficiencies of between 65 and 85 per cent (details given).

China was one of the first countries to promote the use of biogas. In 1992, there were some five million biogas digesters, producing 1.2 billion m^3 of biogas annually. About 300,000 tonnes of charcoal are produced annually, and efficient carbonising furnaces have been developed. Briquetting, or 'biomass coal', uses agro and forest wastes through extrusion, and successful machinery has been developed and disseminated (details given).

Biomass such as sawdust, fuelwood and agro-residues is being converted to combustible gas by gasification, for use in rural industries, households and for generating electricity. A number of efficient gasifiers have been developed and manufactured, and some have been exported (details given).

India

N P Singh, Ministry of Non-conventional Energy Sources

The paper begins with geographical, demographic and agricultural information about the country. National energy consumption has increased from less than 65 Mtoe in 1973 to over 117 Mtoe in 1983 and over 212 Mtoe in 1993. Per capita consumption has risen from 108 kgoe in 1970 to 236 kgoe in 1990. Biomass contributes about 40 per cent of the country's energy needs. A table gives the percentage shares in commercial energy by sector.

Biomass energy-using industries are classified in the following categories: agro-processing; food-processing; forest products; metal processing; mineral-based; textile-based; and miscellaneous (details are given in an annex). Biomass is consumed by: direct burning in furnaces, ovens and boilers; baling and burning; and fluidised bed combustion in boilers. Traditional technologies have very low conversion efficiencies, pollute the atmosphere and use more biomass. Modern technologies are the opposite on all three counts.

The Ministry of Non-Conventional Energy Sources (MNES) has been implementing various programmes on combustion, gasification and biomethanation technologies for industrial applications, as follows. A national programme on bagasse-based cogeneration for sugar mills has been in place since 1994. The scheme offers a capital subsidy of up to 30 per cent for new equipment. A further scheme was established in 1995-96 to provide interest subsidies to financial institutions such as the Indian Renewable Energy Development Agency (IREDA).

Some 350 million tonnes of agro- and agro-industrial residues are generated every year. A scheme on biomass combustion-based power generation is being implemented, and offers subsidies. The MNES is implementing a scheme for the use of biomass gasifiers for thermal, mechanical and electrical applications. Capital subsidies of 30 per cent for thermal, 60 per cent for mechanical and electrical and 75 per cent for rural electrification are provided.

The recovery of energy and resources from solid and liquid wastes of the urban, municipal and industrial sectors has immense potential, with an estimated combined 1,000 MW of power to be generated. A five-year programme in collaboration with UNDP/GEF was launched in 1995, offering interest subsidies on loans. Briquetting makes biomass transportable, more efficient, less polluting and substitutable for coal and oil in small industrial boilers and furnaces.

An outline is given of the types of programme implementation agencies, industrial support organisations and international organisations at work in the field. Selection criteria for support should include: the role of the industry in the region; employment potential; environmental effects; discouragement of migration to cities; improvement of productivity and product quality; attractiveness of alternative fuels; assistance cost-benefit ration; improvement of working conditions; and geographical locations for larger demonstration.

Suggested priority industries are baking, handloom processing, *jaggery* making and small soap-making industries and potteries. Support for these could include combinations of the following: improved supply of wood through plantation; technical assistance in improving furnace efficiency; and supply of biomass briquettes. Of these, the last has the most immediate potential in rural areas. A table is given showing suggested priorities for types of assistance for different industries.

Indonesia

By Tjutju Nurhayati, Forest Department

Biomass energy accounts for 43.25 per cent of total energy consumption in Indonesia, made up of 37.71 per cent by households and home industry, and the remaining 5.54 per cent by rural industry.

Fuelwood, at around six Rp/Mj, is the cheapest available fuel, narrowly undercutting coal and significantly cheaper than charcoal (16 Rp/Mj), kerosene fuels (12.5 Rp/Mj) and LPG (15.5 Rp/Mj).

Sources of biomass fuel include forestry (from logging waste, plywood industry waste, wood mill waste, thinning, energy forests etc.); agro-plantations (from rejuvenation etc.); and village land (from mixed gardens, dry fields, rice fields, the village etc.).

In forest exploitation, the waste generated during the initial logging phase goes as biomass fuel for rural industry, home industry and households. Out of the 47 per cent of wood lost during processing, 44 per cent is converted into energy to fuel the processing.

The wood-processing and plantations industries both use biomass fuel. Typical products are plywood, wood drying, pulp, veneer and essential oils (wood-processing) and cacao, copra, rubber, tobacco curing, palm oil and others (plantation).

Examples of high energy efficiency applications are given: the copra industry, which uses waste heat recovery; cacao, using a heat gasifier; households, using SAE stoves; and wood drying, using steam boiler-fired stoves and air duct-fired stoves.

Industries with high energy consumption are wood drying and the wood industry; crumb rubber; the food industry; shops and *warungs* (small restaurants); brick making and tile-making.

There are networks to support sustainable biomass energy management in the forestry and plantation industries, but not in village lands.

Household, home industry and rural industry biomass energy consumers must act as managers if sustainable biomass energy use.

Improvements in industrial stoves, and subsequent dissemination, are needed; as are local training and study tours for biomass energy-using industries.

The data base on wood and biomass energy use in Indonesia is limited.

The programme for wood and biomass energy development includes strengthening of regional and national cooperation; improving national capabilities in wood energy planning, policy and strategy formulation; improving wood energy production and management; improving strategies and approaches to woodfuel conservation and utilisation; and promotion of improved systems of production, distribution, marketing and utilisation of woodfuels, to increase their contribution to economic development.

Laos

Pheng Souvangthong and Sengrath Phirasack, Forestry Department

The paper begins with an outline of the geographical, economic and demographic features of the country. Forest covers over 11 million hectares, or 47 per cent of land. Forest plantation in 1994 was close to 4,000 hectares and regeneration over 34,000 hectares. The net loss of forest cover is estimated at 67,000 hectares per year, for which the consumption of fuelwood is blamed as one of the main culprits.

Government policy seeks to encourage the private sector to undertake the entire spectrum of forest industry activities, including reforestation, tree harvesting, timber processing and marketing of lumber; all business ventures are required to undertake tree planting. A 1994 decree offers attractive incentives to local communities for reforestation for their own fuelwood use.

There are increasing fuelwood shortages. Even though there are alternative fuels, wood remains the principal energy source, even in urban areas. Rural industries consume 0.75 million m^3 of fuelwood and households almost 2.4 million kg annually. Household consumption is about 0.58 tonnes per capita per year in rural areas and 0.3 tonnes in urban districts (includes charcoal and sawdust).

Examples of the highest consumers of fuelwood among rural industries are: brick making, consuming 35 m^3 for 60,000 bricks; salt making, consuming 20 m^3 of rice husk or 10 m^3 of sawdust for 10 tonnes of salt; tobacco drying; sugar, consuming 12 m^3 of fuelwood per 1,000 kg; fish sauce, consuming 10 m^3 of fuelwood per 1,000 litres; torch products; and blacksmithing, consuming two kg of charcoal to make one 500g knife.

A table is given showing the composition of fuelwood in a range of tree species. Actual consumption of specific species depends more often on traditional, religious and medicinal qualities. Though forest depletion and fuelwood shortages are recognised problems, there are very few resources available to tackle them. The lack of a wood energy sector in the Department of Forestry and the lack of data, support and experience regarding improved technologies at the local level are all problems to be faced. Suggested priorities are:

- The strengthening of the institutional capacity of the Department of Forestry, including the establishment of a national wood energy network secretariat and the organising of training, study tours, seminars, workshops etc.
- The promotion of an agro-forestry strategy to promote the participation of local people, including women and minority groups, in wood energy resources production, management, distribution and trade.
- Cooperation between different sectors at national and regional levels.

Assistance is sought from the Regional Wood Energy Development Programme for training, information exchange and the establishment of the national wood energy network secretariat, which would collect data, exchange information at regional and national levels and elaborate on national strategies and the integration of these into energy planning and rural development.

Malaysia

Ma Ah Ngan, Palm Oil Research Institute of Malaysia (PORIM) and Aminah Ang, Standards and Industrial Research Institute of Malaysia (SIRIM)

The total land area of Malaysia is almost 33 million hectares, of which 60 per cent is under natural forest and 15 per cent under agricultural cultivation. These two sectors of the economy have been overtaken by manufacturing in recent years. However in 1993, Malaysia produced 7.4 million tonnes of crude palm oil, 1.07 million tonnes of rubber and over 49 million m^3 of tropical timber products, making it the world's leading exporter of all three. The biomass generated by these and a large number of other activities is enormous.

The oil palm (*Elaeis guineesis*) is grown for palm oil and palm kernel oil. There are over 2.4 million hectares under oil palm cultivation. The amounts of biomass generated and the heat value of each type are given in a table. All palm oil mills in Malaysia use fibre and shell as boiler fuel to produce steam and electricity, accounting for between two and three per cent of the country's energy needs, but the industry still has a substantial amount of surplus waste. For example, though empty fruit bunches (EFB) are another valuable biomass energy source, they are rarely used. Other factors in this are its bulk and high moisture content, needing pre-treatment. But dry EFB has a heat value of 15.5 MJ/kg. Thus the total heat energy from EFB in 1994 would have been 48.5×10^{12} kJ, or enough to generate over 12 million tonnes of steam and 407 million kWh of electricity. This amount of energy could be doubled by the use of condensing turbines working at a vacuum of 0.25 kg/cm^2 (absolute). Moreover EFB, unlike fibre, is easily collected and transported, making power-generating plants located near palm oil mill concentrations a viable proposition. The feasibility of briquetting EFB and excess fibre and shell also merits consideration.

Palm oil mills also generate large quantities of palm oil mill effluent (POME). Because of stringent environmental controls, this has to be treated before it can be discharged into a watercourse. For every tonne of palm oil produced, there is 3.5 tonnes of POME, hence over 25 million tonnes were generated in 1994.

Treatment is an anaerobic process which generates biogas containing 60–70 per cent methane. The properties of the biogas are compared to other gaseous fuels in a table. About 28 m^3 of biogas is generated for every tonne of POME treated. Thus in 1994, some 705 million m^3 was generated nationally. Most of this was not recovered and was flared off or released into the atmosphere, in both cases contributing to the greenhouse effect.

To date only a few mills have harnessed the biogas for heat and electricity generation. A gas engine can generate about 1.8 kWh from one cubic metre of biogas. The potential energy from biogas is given in a table. In 1994, this would have amounted to 1.27 billion kWh, and by 2000 this will have risen to 1.41 billion kWh. Since the mills have no need of the energy, and the costs of transportation and storage of the biogas are prohibitive, it is suggested that industries be sited in the vicinity of the mills, to capitalise on the energy resource.

The oil palm has a life of some 25 years and palm fronds and trunks are currently chipped and left to rot in the field. Each hectare would yield 87 tonnes of dried trunks and 16 tonnes of dried fronds. These would have a similar heat value to fibre; thus a heat value of 1,905 x 10^6 MJ per hectare is available at replanting, and since 100,000 hectares were replanted in 1995, the quantity of heat energy obtainable would be considerable. A drawback is that the replanting areas are widely spread throughout the country making collection and transportation difficult, but it could replace decreasingly available rubber wood as fuel for small industries.

Rubber trees have a life of between 25 and 30 years, and about 3.3 million tonnes of rubber wood is produced annually from felling. Besides this, residues such as barks, stumps and branches and industrial waste such as sawdust and trimmings are available. Traditionally, rubber wood is used as fuel in the kiln drying of timber, rubber smoking, tobacco curing and brick making, and in charcoal production for the steel industry. Though rubber wood is an excellent fuel, it has also been recently discovered to be an excellent material for the manufacture of furniture and other high-value products. It is thus envisaged that its availability as a fuel will decline dramatically.

There are around 1,000 sawmills and 70 plymills in the country and it is difficult to estimate the total amount of residues, though an average recovery rate of 60 per cent is often quoted. The timber industry generates some 12 million tonnes of logging residues and three million tonnes of wood waste, with a total estimated potential heat energy of 280 x 10^{15} J, or about 6.6 Mtoe.

Off-cuts and other wood residues are being used as fuel in two cogeneration plants for integrated wood complexes. These have shown an attractive rate of return with a payback period of between one and 2.5 years. The wood industries are large energy consumers, but generally rely on diesel and/or bunker oil, making energy one of the major production costs. The utilisation of wood wastes, especially through cogeneration, would make the industry more cost-effective. There are also five wood briquetting companies in Malaysia, and other potential energy producing technologies, such as pyrolysis and gasification, are being developed.

Rice cultivation and milling generates two types of residue: paddy straw (three million tonnes available per year) and rice husk (434,000 tonnes available). Both are useful as fuel. The availability of both is given in a table. Rice husk currently constitutes an environmental problem at milling sites. It has a calorific value of 13.2 MJ/kg and thus the potential energy available is 5.7 PJ or 0.136 Mtoe. Because of its low calorific value and low bulk density, transportation and storage is a problem and it has not been commercially exploited. However, it has been estimated that the rice husk residue from a mill would be enough to meet its energy requirements.

The paddy straw has no commercial value, is not collected and is usually left to rot, burnt and ploughed back into the paddy field. This situation is unlikely to change.

Maldives

Ayesha Manike and Aishath Nihad, Ministry of Fisheries and Agriculture,

The Republic of Maldives consists of 1,190 coral islands, most of which are smaller than two square kilometres and less than two metres above sea level. There has been a dramatic rise in population, and energy consumption is also rising. A reforestation programme was initiated in the 1980s, planting mainly casuarina and *Ipil Ipil* for firewood. Though local people had difficulty in accepting these new species, the first generation plants have proved their worth.

Uninhabited islands are leased to individuals, who are required to account to the Ministry of Fisheries and Agriculture for amounts of coconut and timber felled. However, the accuracy of the returns is in doubt and the Ministry is in need of an accurate database, a well-planned programme and more finance and staff. Planning and integrating wood in energy is difficult because of a lack of information as to the economic viability of available islands for planting. However, the government is aware of the need to grow more wood or find alternative sources of energy. Existing cooking practices and fireplaces are very wasteful of fuelwood, and the introduction of improved stoves would help save fuel as well as improving household conditions and women's health.

Almost 40 per cent of the population is involved in fishing, making it the second biggest industry. Smoked fish accounts for six per cent of the total product. Currently, the process is wasteful of fuel and unhealthy – there is a need to borrow technology and improved techniques. Until recently, almost all construction work was by lime and coral stone. The lime is made by burning large quantities of wood with coral in an open pit, most of the heat energy escaping to the atmosphere. Though coral mining is now prohibited in certain parts of the archipelago and ready-made cement is now cheaper because of a reduction in duty, lime making continues on remote islands. Blacksmiths continue to use coconut shells and *pemphis* (*kuredhi*) plant in the forge, but the superiority of casuarina is causing them to switch.

In the Maldives' traditional land-tenure system, operative on all inhabited islands, villagers are entitled to a rent-free home allotment, although the land remains the property of the state. Although this is an incentive for agriculture, the feeling that the land can be taken away makes tree planting less attractive. The tenure system should be revised.

Myanmar

Win Naing, Ministry of Forestry

The paper begins with geographical, topographical, climatic and political/administrative information about the country. Myanmar is utilising its forest and agro-residue resources on a conservative scale as fuel for households and small industries. Industries burning fuelwood include brick making, pottery and tobacco curing; those burning leaves, dung and husks include jaggery making; and those using rice husk include rice mills. Under the Forest Law of 1992, brick making, pottery, tobacco curing etc. facilities are strictly prohibited from burning fuelwood, but are allowed alternatives. As these are not so effective, the industries are dwindling. A table gives a breakdown of information on biomass consumption in 1990. The household sector accounts for over 99 per cent of biomass consumption, almost 90 per cent of which was fuelwood. Since the Forest Law does not apply to household energy, the threat to the forests remains and new systematic management and plantation is necessary.

A table gives a detailed breakdown of types of forest land remaining and a further breakdown by state and division is given in an annex. Another table gives details of types of plantation, in which the Forestry Department is increasing capacity. With an average harvest of over 1.2 million tonnes of hardwoods, at least 0.5 million tonnes of waste could be extracted as fuelwood, to which could be added some 0.2 million tonnes of sawmill residues. There are no accurate estimates of fuelwood supply in Myanmar, but suggested figures and values from a World Bank study are given (total 68.288 million acres, or 27.636 million hectares, of woodfuel supply).

The agricultural sector is expanding rapidly, with over 30 million acres (12.141 million hectares) now under cultivation, of which rice accounts for over half. Estimates are given in table form of residues available for fuel, after deducting amounts used for cattle feed, fertiliser etc. A total of some 5.625 million tonnes is quoted.

Beginning in 1993/94, the government is implementing a programme of greening of the nine dry central districts of Myanmar, assisted by a two-year UNDP-funded fuelwood plantation project in the country's Mandalay and Magway divisions. The objectives of the greening programme are to: establish fuelwood plantations; establish extension capabilities in the Forest Department for sustainable fuelwood resources at grass roots levels; reduce pressure on heavily degraded local supply reserves; and prevent further encroachment on valuable hardwood forests. To date over 33,000 acres (13,355 hectares) have been planted.

The paper states that thanks to the government's programme, the country will have abundant supplies of fuelwood/biomass in the very near future, allowing the recovery of the small-scale industries affected by the Forest Law. However, to ensure forest conservation, rural and urban people should be educated by the authorities to use more efficient stoves.

Nepal

Dr G R Bhatta, Water and Energy Commission Secretariat

Nepal's two major indigenous energy resources are hydro-power and traditional biomass fuels, such as fuelwood, agricultural residue and dung. The economically viable hydro potential of 42,000 MW remains almost untapped, leaving biomass to supply almost 96 per cent of the country's total energy. Around 3.4 million hectares of forests, shrub and grasslands are available for fuelwood collection. In 1992–93, the total agro-residue available was about 11 million tonnes, and available dung was around 2.3 million tonnes. Electricity is both imported from and exported to India. The net import in 1992–93 was 23 GWh; in the same year, 56,000 tonnes of coal and 418 million litres of petroleum products were imported.

A table and a figure give the sectoral breakdown of energy consumption. The domestic sector predominates at 91.3 per cent, followed by industry at 3.4 per cent, transport at 3.2 per cent, commerce at 1.4 per cent and agriculture at 0.7 per cent. Two tables give the historical trends in energy consumption by sector and fuel type.

The rural industries which consume fuelwood are food processing, agro-processing, potteries, building materials, forest products processing, metal-working, village applications and miscellaneous. Details of the products manufactured in all of these industries are given.

Although in quantitative terms the industrial sector's energy consumption tripled between 1980 and 1992, its share of consumption in recent years has increased only marginally. In 1992–93, the sector consumed over nine million GJ, or about 3.4 per cent of total consumption. A figure gives the share of various forms of energy in the sector, showing that fuelwood, at almost 43 per cent, is the major resource. Detailed tables are given showing: the fuelwood consumption of large-scale rural industries (total 57,000 tonnes); the fuelwood consumption projection of medium-scale village enterprises (1.01 Mt); and estimated fuelwood consumption in small-scale cottage and village activities (1.761 Mt).

Extensive details are given of the institutional support available to rural industries and research and development institutes in the field. For the purposes of the study, fuelwood requirement for rural industries and village activities is estimated as 2.8 tonnes and the assumed total deficit of fuelwood requirements at 8.0 million tonnes. Current efforts towards afforestation and improvement of domestic fuel stoves are too small to meet this staggering deficit. Suggested strategies include: improved forest management systems; introduction of fast growing multipurpose trees; increased participation in tree planting; the utilisation of all parts of harvested trees; introduction of more efficient harvesting tools; and increased efficiency of wood/energy conversion devices.

Institutionally, the following strategies must also be put in place: promotion of better coordination of concerned national agencies; strengthening of institutions responsible for small rural industries, with an emphasis on manpower training and development; upgrading of the database on all aspects of rural industries; conducting of detailed investigations of selected fuelwood species for rural industries; field pilot activities on high-impact rural industries; more responsibilities granted to R&D institutes for action research directly related to improvement of systems and applications in rural industries.

In industry, food and agro-processing, building materials production, metal-working and forest product processing, together consume the most wood energy. Having them switch to alternative energy options is very difficult, and the process is hampered by a serious lack of data. However, the Eighth Five-year Plan (1992–97) has supported the idea of increasing supplies of alternatives such as micro-hydro, biogas, solar and wind power.

The current situation is an uncomfortable one. A vicious circle exists of deforestation, use of agro-residues to the detriment of the soil, low productivity of farm lands, new opening of farm lands for crops, and increasing demands for fuelwood and fodder due to rapid growth in both human and animal populations, leading to further deforestation. The only apparent way out of this pressing situation is progress in the planned harnessing of the huge hydro potential.

For now, since wood-based energy systems currently meet virtually all the needs of rural households and industries, the protection of existing forests, as well as afforestation and reforestation programmes, must receive an increasingly large share of the government's development expenditure. The forestry sector's master plan proposes a two-pronged approach: to reduce demand by the efficient use of supply; and to increase the production of, and access to, fuelwood.

Philippines

Marites I Cabrera, Department of Energy and Domingo T Bacalla, Forest Management Bureau

The paper opens with an outline of the economic success of the Philippines (RP) over the last decade and its present economic stability. The present administration is aiming for newly industrialised country status by the year 2000.

Industry and services together reportedly contributed 90 per cent of growth in GDP in 1995, and manufacturing represented 70 per cent of industrial output. Available statistics indicate that 99 per cent of manufacturing establishments are in the small (total assets less than 15 million pesos) and medium (total assets between 15 million and 60 million pesos) enterprise range (referred to as SMEs). Hence, the government has recognised the importance of this sector to overall national development.

A 1990 official survey revealed that 39 percent of business establishments in 20 industries in the RP used fuelwood and/or fuelwood substitutes such as coconut shell, coconut shell charcoal and bamboo. Total annual fuelwood consumption was put at 7,822,480 m^3, and total annual fuelwood substitute consumption at 6,330,810 m^3. The same survey and one by the Department of Energy indicated that the industries with the highest consumption of biomass fuel were bakeries, fish canning, sugar milling and refining, rice milling and tobacco drying.

Estimates put the total proportion of biomass energy used in the RP by industry at 25 per cent, with the rest used domestically. It was projected that in 1996, biomass would account for 28 per cent of the total energy mix in the country.

An outline is given of government support for SME development. This ends with an outline of sources and types of training and technical assistance provided for SMEs.

The Department of Energy is the main body responsible for development and utilization of biomass energy. The DOE presently implements programmes and activities that address the technical, financial, social and other aspects of the commercial use of energy conversion systems using fuelwood and various agricultural and forestry residues. The Forest Management Bureau is also conducting activities favourable to the production and more efficient use of fuelwood, and the Department of Science and Technology is also mandated to conduct R&D on the development of more efficient and appropriate technologies, including energy conversion systems.

The significance of SMEs' contribution to the economy and to development of rural areas is recognised by the government of the RP, as is their energy requirement. It is hoped that improving the efficiency, lowering the price and ensuring the availability of biomass energy , both fuelwood and non-fuelwood, will help to ensure the operation of the SMEs can be sustained and enhanced, helping to push RP towards its goal of becoming a newly industrialised nation by the year 2000.

Thailand

Winai Panyathanya, Somkiat Sutiratana and Pisamai Sathienyanon, Royal Forest Department and Department of Energy Development and Promotion

The recent growth of the Thai economy has increased energy demand at an alarming rate. In 1994, total demand was almost 48 Mtoe, an increase of 11.5 per cent on the previous year. Petroleum products accounted for over 53 per cent, biomass for over 26 per cent and the remaining 20 per cent was electricity, coal, lignite and natural gas. Although the share of biomass consumption has fallen from 36 per cent in 1985, in absolute terms it has been increasing by 6.8 per cent per annum.

Biomass is consumed in two economic sectors. Total biomass energy consumption in 1994 was almost 11.5 Mtoe, of which the residential and commercial sector accounted for 66 per cent and the manufacturing sector 34 per cent. Over 8.3 Mtoe of charcoal and fuelwood was consumed, an increase of 6 per cent on the previous year. About 91 per cent of this was consumed by the residential and commercial sectors and the remainder in manufacturing. Nearly 2.3 Mtoe of bagasse was consumed, all in manufacturing, an increase of nearly 35 per cent on the previous year. Almost 4.5 Mtoe of rice husk was consumed, again only in manufacturing, an increase of 15.6 per cent on 1993. Bagasse consumption has doubled in the decade, and rice husk consumption has decreased significantly.

Energy consumption in the manufacturing sector, divided into nine sub-sectors, has increased by 11.5 per cent per annum. Of these, food and beverages, non-metal, chemical and wood and furniture, use biomass. Food and beverages is the largest consumer, in sugar mills, rice mills, noodle factories, canneries and tobacco curing, using mainly bagasse and rice husk. The other three sub-sectors are smaller consumers, using mainly fuelwood.

Biomass conversion technologies in use include gasification, densification, pyrolysis, combustion and biogas. Cogeneration is attractive to many industries providing process heating and electricity for their own consumption as well as selling surplus to the grid. The major constraints in utilisation include: assessment of resources; low bulk density, high moisture content; problems of collection, transportation and storage, and availability and reliability. In addition, the current state of technologies in smaller operations is characterised by low burning efficiency and difficulties in operation and maintenance.

The Seventh National Economic and Social Development Plan (1992–96) includes the following relevant policies: emphasis on developing domestic energy resources; encouragement of efficient use and conservation of energy; and promotion of private-sector involvement in energy development. The Plan formulated a number of strategies, including: promotion of renewable energy such as solar energy and agricultural and industrial residues; promotion of appropriate commercial equipment; enhancement of private sector involvement in reforestation and rural energy; reduction of customs on machinery and equipment that is energy efficient, conserves energy, reduces energy imports or reduces pollution; encouragement of small-scale producers to invest in cogeneration; and improvement of public awareness of the importance of energy conservation.

Vietnam

Sinh Phi Kim, Rural Energy Planning and Fuel Department

The Vietnamese economy is steadily expanding. GDP grew at 6.4 per cent in 1991, increasing to 9.5 per cent in 1995. Inflation has been reduced and living standards are rising. Much of this growth has come from the small- and medium-scale industries, especially in rural areas. These industries include: construction materials and ceramics; agricultural product processing; food processing; wood processing; metallurgy; salt refining; soap making; and road tarring.

Biomass, mainly fuelwood and agro-residues, accounts for over 80 per cent of total national energy consumption. The total tonnage of fuelwood from forest and plantation is 43,634.2 x 10^3 t/year, wood processing residues 582 x 10^3 t/year, industrial trees 4,697 x 10^3 t/year, and other fuelwood residues 600 x 10^3 t/year. Total agricultural residues are estimated at 18,926.8 x 10^3 t/year.

The paper provides information in table form on the consumption of biomass energy and coal in small and medium industries and average consumption of household fuel. From these it can be said that biomass energy accounts for almost 66 per cent of total consumption of industries. The construction materials/ceramics sector is the largest consumer, feeding the building boom of recent years. The agricultural product/food-processing sector depends almost entirely on biomass for energy. In rural industries, unimproved equipment and kilns with low efficiency are common, wasting fuel and increasing production costs.

It is proposed that: investment on equipment, technology and training is necessary in the construction materials/ceramics sector; a survey should be undertaken of all the non-household users of biomass; and the potential to create biomass energy resources should be expanded.

4. Papers Presented by Resource Persons

4.1 The Use of Fuelwood for Energy in Rural Areas

Dr Hoi Why Kong, Forest Research Institute, Malaysia

Tobacco curing, smoking of rubber sheets, firing of bricks, drying of foodstuffs and kiln drying of timber together account for 95 per cent of total fuelwood consumption in Malaysia, but wood contributes only 10 per cent of total energy consumption. A table shows that the cost of fuelwood energy, at 0.09 RM/10 Mcal is between a fifth and a half of the cost of conventional fuels.

Rubber wood accounts for almost 90 per cent of fuelwood species used. It has an air-dry density of 560-646 kg/m^3, a calorific value of about 3,560 kcal/kg and an ash content of one per cent. It is used for rubber sheet drying, tobacco curing, brick firing and charcoal, particularly for the steel industry.

A description is given of the Malaysian tobacco industry, including its turnover, numbers employed, location, numbers of curing stations and curing process in a typical 'barn'. A table gives the findings of an energy audit in two barns. The energy consumption of a barn using rubber wood is around 7.5 kg/kg cured leaf. Thermal efficiency is very low, at 14 per cent, mainly because of huge losses through poor insulation, ventilation ports and the furnace front, all of which problems should be addressed.

Since rubber plantations account for almost 45 per cent of agricultural land, and the industry contributes some 5.7 per cent of GNP, the government has instituted a variety of research and development programmes to enhance competitiveness and efficiency. An outline is given of the rubber smoking process and the design of the average smokehouse. A table gives the findings of an energy audit in a smokehouse. The energy consumption using rubber wood is around 1.4 kg/kg product. Thermal efficiency, at 12 per cent, is low, caused by poor insulation and radiation losses at the furnace front. A number of suggestions are made to obviate these problems. Gasification of rubber wood is an economic alternative and comparative costs are given in two tables, giving an annual saving of RM 18,440 per year at an average plant.

A description is given of the process for firing bricks and ceramics. The average specific fuel consumption (SFC) of firing bricks is 0.2 kg per unit brick with a weight of 1.5 kg. The thermal efficiency of a typical updraft kiln is 12 per cent. Though drying of fish is waning in importance due to developments in cold-storage technology, it is still common in rural areas. In drying *ikan bilis* (dried fish), the SFC is 1.6 kg/kg product. The drying efficiency is 25 per cent.

The cost of rubber wood has risen by 10 per cent per year since 1987. This has been caused by a combination of factors, including the difficulty of getting contract labour to cut and load the wood in the field and increasing competition from other consumers. These factors have led to difficulties in maintaining adequate and consistent supply. There has also been relatively little technological transfer from R&D institutions to smallholder manufacturers. Certain research priorities require immediate attention. These include the utilisation of alternative fuels and improvements in system design and construction.

Alternative fuelwood species should be tried, with selection based on: rapid growth rates; coppicing ability; adaptability in sites and soils; density; ease of handling; and minimal ash and sulphur content. The properties of some alternative species are discussed in an annex. The use of briquettes from rice husk and sawdust, natural gas and solar energy should be further investigated.

Improvements in system design and construction should focus on: SFC improvement; reduction of heat loss and leakage; improved control of temperature, humidity and air movement; a reduction in the necessity for repairs and replacement; reduction of process times; provision of better fire-safety systems; improved loading and unloading techniques; and mechanisation of operations. More specific suggestions are made for tobacco barns, smokehouses and kilns.

4.2 Dissemination of R&D Results on the Use of Fuelwood for Energy in Rural Areas – Problems and Prospects

Dr Abdul Razak Mohd. Ali and Dr Hoi Why Kong, Forest Research Institute, Malaysia

The paper seeks to draw together different aspects of research into biomass energy development and to highlight the need for quick and efficient dissemination of research results and their direct modification to suit local needs and conditions.

Five major areas where research and development can have an important impact are as follows: identification, documentation and characterisation of wood energy problems, including environmental problems inherent in present practices; development of suitable harvesting and transportation methods; establishing of methods to accurately measure total biomass yields and standardising conversion factors; determining wood densities, calorific values and burning characteristics of different species in varying degrees of dryness; and studying cogeneration of energy in wood-based industries and adapting conversion and end-use technologies to suit local needs, skills, finances and resources.

Adaptative research is of the utmost importance and cannot be over-emphasized. However, implementation need not be carried out in a technological vacuum. The basic technology exists in the region on the whole spectrum of fuelwood production and utilization systems. Very little research has been done into the rate of adaptation of improved biomass energy systems, but studies from India, Thailand and Korea show that it is a far from simple process.

Identified problems are as follows:

Programmes are often limited by a lack of interest and cooperation on the part of local people. From an external perspective, reasons stated include apathy, a lack of education and outmoded traditions. But viewed from a local perspective the reasons might be the avoidance of risk, inconvenience of new designs and indifference to energy concerns as compared with others which are more pressing. It is essential that programmes understand and accommodate the needs and attitudes of local people.

Because of these top-down approaches, extension services are often ineffective, in the first place because of a lack of manpower and resources, but also for a number of other reasons. These include low commitment of extension workers, poor coordination and an unwillingness to respond to local needs. All of these contribute to scepticism towards government programmes and personnel. People want to know that the benefits of the programme will go to them.

The implementation of wood energy programmes is often complicated by the realities of social and economic conditions prevailing locally, and which are constantly changing under modernisation, population growth and other external and internal factors. While the cost of adoption can be measured by financial and labour inputs, indirect costs are also important. A decision to take a particular course means to forgo the benefits of doing something else. This problem is minimised in the case of a programme with direct financial results, but looms large in programmes that focus on fuel conservation, convenience, environmental protection, soil fertility or public health, as is the case with many domestic energy programmes.

In introducing new schemes, skills and infrastructure are important considerations. These include skills in building and using new equipment, knowledge of the new techniques, local manufacturing and maintenance capabilities, credit facilities and transportation networks. These capabilities vary from country to country and from region to region.

For success, efficient extension services are necessary. These depend upon: ascertaining features that are attractive to users; stimulating participation in development and implementation; demonstration, training and the provision of advice and backup; and monitoring to assess progress and provide improvements. This can only be achieved using bottom-up approaches, which are more costly and complex, but ultimately much more successful.

Good technical solutions are valuable but are not sufficient to solve the problems outlined above. Thus, low cost and convenience are often the dominating factors in determining acceptance of new equipment, and can override the importance of system efficiency as the primary design criterion. Many of the current energy systems were designed for use in the industrialised countries, but there is great scope for extensive adaptation for use in the developing world.

Economic tools should be used, such as direct grants and subsidies, low-interest loan funds and accurate targeting. Communal energy systems, such as the dendrothermal programmes of the Philippines, have many advantages, through pooling local land, skills and capital.

In all developing countries there is much more emphasis on R&D in agriculture than in wood energy, and institutions devoted to the study of the latter are in dire need of upgrading within national structures. And though there are a large number of national and international agencies involved in biomass energy research, there is a lack of communication and cooperation, resulting in duplication. Collaboration could be improved in the following ways: the establishment of a body within each country that would coordinate those groups and institutions working in biomass energy development; the exchange of information and technology and experience of implementation strategies and problem solutions; the exchange of experience through seminars, workshops and study tours; and the provision of advisory services, training courses and demonstrations where necessary.

Every country must assess and develop its own potential according to its needs, priorities, resources and socio-economic conditions. Research efforts should therefore carefully investigate, not only technical solutions but also appropriate social, economic and institutional approaches.

4.3 Policies and Strategies for Harmonising Rural Industrial Development – an Integrated Approach to Sustainable Biomass Systems

Dr J S Juneja, India

The paper begins by outlining the recent growth in the Indian economy, and especially that in rural manufacturing. A shortage of commercial energy has led to an increased use of biomass, particularly agro-residues. The paper makes a case for an integrated policy approach to harmonise all aspects of rural development.

Forests account for almost 33 per cent of the land area, or 75 million hectares. Of this, 45 million hectares are exploited and 16 million hectares are potentially exploitable. An outline is given of the types of products produced. There is a downward trend in the use of traditional energy sources, from 40 per cent of the total in 1979 to about 30 per cent today, and it is projected to fall to 11 per cent by the end of the century. However, this projection would require a 3.5-fold increase in commercial energy.

India has coal reserves of close to 150 billion tonnes, of which some 60 billion tonnes are minable. Distribution is uneven, however. Some 216 million tonnes of lignite and 27 million tonnes of oil were produced in 1992-93. Gross electricity generation stood at 70.311 billion kWh in 1993-94, but demand outstrips supply. About 110 million tonnes of agro-residues are produced per year, of which bagasse contributes 61 million tonnes, cotton stalk 24 million tonnes, rice husk 18 million tonnes, and coconut, ground nut shell, jute stick and maize cob the remainder. A substantial amount of animal dung is also burned, several times more than the amount of chemical fertilizer used nationally, to the detriment of the soil. More fuelwood is consumed than agro-residues and dung put together. A table gives the projected rise in demand for fuelwood, rising from 350 million m^3 in 1991 to almost 470 million m^3 in 2011. Demand outstrips supply, and a further table projects the shortfall, from some 300 million m^3 in 1991 to 427 million m^3 in 2011.

A list of criteria to determine the eligibility for support of fuelwood-burning industries is given, as are examples of industries in the following categories: food processing, agro-processing, production of building materials, metal working and miscellaneous. An outline is given of the climatic and geographical differences affecting the siting of various industries throughout the country.

A comprehensive survey is needed to study and improve the energy consumption of these industries. The average bakery burns some 70 kg of fuelwood for every 100 kg of produce. The efficiency of the ovens could be improved by increasing the batch size and the use of dry wood. Fish smoking consumes around 20,000 tonnes of fuelwood per year.

Large modern factories making sugar use efficient, bagasse-fired steam boilers, but *khandsari* (unprocessed cane sugar) manufacturers use open-hearth furnaces burning rice husk. Distilleries use one kg of fuelwood or two kg of bagasse to produce one litre of alcohol. The *vanaspati ghee* (hydrogenated vegetable oil) industry consumes huge quantities of fuelwood, coal and agro-residues. Between 30 and 40 tonnes of fuelwood is burned to produce 100 tonnes of ghee.

Coconut oil manufacture consumes 75 kg of fuelwood for every tonne of oil. Rubber sheet smoking consumes large quantities of fuelwood, and the industry's consumption is expanding steadily, from 152,000 tonnes in 1982 to 220,000 tonnes in 1987, consuming one kg of wood for every kg of raw latex. The parboiling of rice consumes 0.1 kg of wood for every kg of rice. India produces some 0.5 million tonnes of tobacco annually, consuming some five kg of wood per kg of tobacco –

about 438,000 tonnes of wood annually. India accounts for between 30 and 40 per cent of world tea production, and processing consumes one tonne of fuelwood for every 10 tonnes of leaves.

Almost 100 per cent of brick production in India takes place in small-scale units. Between eight and 10 tonnes of fuelwood or four tonnes of coal are consumed to produce 100,000 bricks. Shortages of fuel frequently result in the burning of tyres and other toxic substances. As availability of fuelwood falls, roof tile manufacturers are increasingly switching to lignite, but traditionally around 10 tonnes of fuelwood is required to fire 120,000 tiles. The production of one kg of lime requires about 0.34 kg of fuelwood. The making of *surkhi* consumes about 100 kg of fuelwood for every tonne of dry clay. Potteries consume between 0.5 and 1.5 kg of fuelwood per kg of fired product. Metal working foundries consume one kg of coke to melt between three and four kg of iron.

Biomass is also used in various village industries. Examples include soap manufacture, which requires 250 to 300 kg of fuelwood to produce between 400 and 500 kg of soap. The ratio of fuelwood to animal tallow is 6:1. As much as 30 kg of fuelwood is consumed to make one kg of silk, though improved technologies are available which can reduce energy consumption by as much as 50 per cent. Tyre retreading consumes one tonne of fuelwood for every 50 tyres.

The Department of Non-Conventional Energy Sources has seven biomass research centres throughout the country, and undertakes a range of research and development projects, dissemination activities etc. The National Small Industries Corporation (NSIC) and the FAO have contributed much in the field of energy management.

Technological developments in India include the following: a two-tier bakery oven gave a fuel saving of 30 per cent; a fuel briquetting plant produces bricks with a calorific value of 4,000 kcal/kg; a biomass gas stove gives fuel savings of 45 per cent. Details are also given of modified diesel engines, electronic ballast and solar cookers.

An extensive annex gives full details of types of institutional support and institutional support organisations.

4.4 Financing of Small and Medium Scale Industries in Malaysia

Malaysian Technology Development Corporation

Small and Medium Scale Industries (SMIs) are defined as not exceeding RM2.5 million in shareholder funds and employing five or more full time workers. In 1993–94 there were over 12,000 SMIs in Malaysia, and the government actively promotes their establishment and their importance as the backbone of the manufacturing sector, which has emerged in the last decade as the leading economic sector. The country has been transformed from being a commodity-driven economy to a leading exporter of technology-intensive products. Thus the provision of an environment conducive to the growth of SMIs is central to the government's industrialisation policy.

The government has several strategies, in particular assistance with R&D, which is often beyond the means of smaller companies. There are five leading agencies involved in promoting SMIs, and under these are several other agencies which seek to promote and market products, identify foreign investors and counterparts in technology sharing, and assist in technology procurement.

The government and local financial institutions provide several schemes offering financial and credit assistance to manufacturers, although government help is being phased out. Access to funding is the most important factor affecting the growth and development of SMIs and an outline is given of the most relevant issues.

Since 1992 a number of venture capital funds have been established in Malaysia. Local financial institutions and corporations are reticent however, and there is a trend for the establishment of local offices of foreign venture capital firms. Thus the government has set up Perbadanan Usahawan Nasional Berhad and the Malaysia Technology Development Corporation (MTDC). The primary purpose of MTDC is the commercialisation of research and development findings, as a venture capital company. Details of its objectives are given. The financial services it provides are seed, start-up and expansion financing; the non-financial services include technical consultancy, assistance in technology transfer, technical support, assistance in improving productivity and other services such as patent registration and industrial design. An outline of MTDC's work to date is given.

In conclusion, the paper states that technology financing involves not only monetary issues but the necessity to identify the right people in the right company.

A number of technologies related to the utilisation of biomass materials are described in an annex.

In the pyrolysis of high moisture content biomass in low-cost portable units, research sought to achieve a target price acceptable to rural communities. Though some 1.4 million tonnes of palm kernel shells are produced annually in palm oil mills, it is currently used only for the production of heat in furnaces for steam raising. Its production vastly exceeds demand and thus poses a serious waste-management problem. The main problems with the material as fuel are difficulty in handling and the accretion of dirt and by-products in the furnace. A downdraft gasifier was developed and found to be very stable, reasonably efficient and appropriate for use in rural areas needing cheap energy for drying, heating and even power generation.

Rice husk is one of the most common agricultural wastes in the country and a pollutant in local environments. About 250,000 tonnes is produced annually. It contains 80-85 per cent organic matter and 15-20 per cent silica. A procedure has been developed to extract pure amorphous silica, or zeolite, an important fluidised cracking catalyst in the petroleum and petrochemical industries.

In the production of ceramic materials based on silicon dioxide from rice husk, researchers are attempting to use rice husk as a starting material for the ceramics and other silica-based industries and to produce nitride materials for bearings, cutting tools and components in diesel engines, gas turbines and heat exchangers.

In the production of agricultural ash as a partial cement replacement material, research conducted at the Universiti Teknologi Malaysia has found that the ash of rice husk and palm oil fuel can be used as a replacement for up to 30 per cent of a cement mix without affecting its strength.

In the utilization of oil palm by-product fibres, research has shown that oil palm trunk can be converted into good dietary fibre, and the remainder is a good roughage source for ruminant feed and a number of industrial uses.

Processing of shrimp skin, crab and king-crab shell can yield chitin and chitosan. Chitin is a biopolymer and it, chitosan and other derivatives have a wide range of uses. These include as feed ingredients; seed, fruit and soil treatment; and cosmetics, food and beverages, health care, ophthalmology, dental therapeutics and artificial skin.

4.5 Energy and Small Scale Industries

Dr W S Hulscher, CTA, FAO-RWEDP

The paper starts with various standard criteria for identifying small and medium-scale industries (SMIs). SMIs are defined as typically having more than five and less than 100 employees and less than US$50,000 in fixed assets. It is noted that definitions and criteria vary widely in different countries. Typical characteristics of SMIs include:

- The organizational structure has very few levels between workers and management;
- All managerial functions are in the hands of one or a few persons, and no specialist staff functions exist;
- Management has limited control procedures and administrative tools for decision making;
- Management has difficulty in keeping abreast of modern developments (lack of time and information resources);
- Systematic training of personnel is very rare;
- SMIs have little control of external conditions with regard to markets and resources;
- SMIs do not have easy access to the organized capital market;
- SMIs have no bargaining power in buying or selling in a major market.

SMIs can occur in rural areas, rural towns and in cities, and can be part of the informal sector of the economy. A comparison is given between informal and modern industries: modern industries tend to rely on institutional credit for their capital, while informal industries generally use savings as they tend to be unregistered and so ineligible for institutional credit. Fixed capital tends to grow in proportion to working capital the more modern and less informal an industry is. Modern industries tend to be of larger scale than informal industries.

SMIs are very important to the economies of developing countries, where they make up over 90 per cent of the number of industries above the level of handicrafts, and generally employ between 35 and 55 per cent of the industrial workforce. In rural areas, SMIs account for 20–30 per cent of employment, rising to 40 per cent when rural towns are included. In rural areas, SMIs contribute to stability of income for rural workers, who tend to be badly affected by seasonal production variations.

In addition, SMIs utilise existing potential and play a useful role in regional development, decentralisation and rural growth. They are also seedbeds for entrepreneurship and a means of developing talent for organization and management, which is typically lacking in developing countries.

Many SMIs in Asia use wood as an energy source. Despite their overwhelming numbers compared to larger-scale industries, SMIs represent a small share of national energy consumption, so the main cause for concern is the strengths and weaknesses of the SMIs themselves, of which, as demonstrated above, energy-related problems are only a part.

Energy problems experienced by Asian SMIs generally take two forms: those related to energy costs and efficiency, and those related to availability and continuity of supply.

The current trend is for energy prices, already a significant cost factor for SMIs, to rise, and this is expected to continue. Production processes in developing countries tend to be 10–30 per cent more energy intensive than those in industrialised countries, this, along with poor system layout, inefficient resource utilisation and a lack of adequate energy housekeeping practices, may put a relatively high burden on their working capital. In terms of supply, even though SMIs are not great users of commercial energy, national shortages and restrictions have a direct impact on them. Coupled with often inadequate supply organisation and infrastructure, these shortages can lead to frequent power cuts, load shedding and fuel shortages, and thus to plant downtime.

However, in some SMIs, energy is just one of a number of problems, and dealing with it separately would be far less effective than integrating it with management of other factors such as personnel, technology and finance. Improvements in overall efficiency and quality control can lead to a significant reduction in energy costs per unit of output.

Energy management starts with an internal energy audit, and can be followed up with one or more of: energy conservation, energy substitution, energy resource development and improved overall management. These leave aside more drastic changes such as abandoning certain processes or products, which are strategic decisions to be taken by each SMI's management.

The energy management discussed here is most relevant to SMIs in a position of modest or low growth – where adequate capital exists for investment to improve cost-effectiveness, but not for large-scale strategic investment – and those in which energy costs are between around one and 15 per cent of total production costs. In these industries, energy management is often relatively new. It is up to the SMIs' management to identify energy problems and to institute appropriate responses. This may well initially involve input from outside specialists, after which a member of existing staff can take up the role of energy manager.

Skilled roles in energy management include:

- energy planners and managers;
- energy economists;
- energy engineers, who can work out the costs of different technical options;
- energy technicians;
- skilled operators and workers, who stick to energy efficient practices.

It can be said that the general lack of specialised functions in SMIs complicate energy management tasks.

Energy management tools include:

Energy auditing – Monitoring energy consumption and energy costs; the first step in any energy conservation programme, followed by *data interpretation* and often extrapolation, and then *evaluation* of the results with respect to relevant criteria.

For decision-making, other inputs are needed besides the results of the audit, such as: *technology assessment*, including the selection and application of energy conversion techniques; *resource evaluation*, including the evaluation of biomass and other renewable energy resources; and *feasibility studies*, when new investments are considered. The last include *cost-benefit analysis* as well as *multi-criteria analysis* when non-economic criteria are also involved.

Such analyses are to appraise energy options or any other options for investments. They are part of *project planning*, including project formulation and project preparation, leading to project implementation.

Finally, *manpower development and training* is another useful tool. Such tools, of course, like appraisal techniques and project planning, are not exclusively for energy management. It will depend on the characteristics and potential of each firm which energy management tools can be applied.

The success of any action following up on the audit is strongly dependent on factors outside the firm. SMIs, particularly in rural areas, have limited control over their environment, and instead have to adapt to it to a very large extent.

These external factors include socio-cultural factors, various established practices and habits, market segments and the interests of different social groups. Constraints will also depend on the physical and institutional infrastructure of the firm's environment, existing legislation, national government policy and the macro-economic aspects of energy.

Recent research into the problems of energy-intensive SMI's in Asia implemented by graduate students of the University of Twente and ITC in the Netherlands have given rise to the following observations:

- SMIs follow their own interests and criteria for production, notwithstanding seemingly irrational energy practices and pleasant responses to outside advisers
- Successful interventions can only be based on a clear understanding and appreciation of the conditions and interests of the entrepreneurs. If the entrepreneurs were interested in anything, it was in further increasing their profits by increasing their markets;
- Technological assistance falls short if managerial issues are not addressed concurrently;
- There are many problems involved in addressing a substantial number of small entrepreneurs who are in the same position but who are competitors and are not linked to any organisation. Demonstration equipment on site, combined with adequate organisational efforts, would be prerequisites for successful interventions;
- Local traditions and social structures can counteract rationalisation of production practices;
- Aimed interventions which lack proper resources do not work out; and
- Small producers respond positively to initiatives which are well designed by local experts and authorities and are based on thorough site-specific knowledge.

4.6 Wood and Charcoal Briquetting in Malaysia

Ng Seng Huat, Yoltan Briquettes (M) Sdn Bhd, Malaysia

Briquetting technology is relatively new in Malaysia, only six companies having been established, the first in 1985. The actual use of briquettes in the country is very low, mainly because of poor marketing, and almost all are exported to Korea, Japan and Taiwan. To suit these markets, 90 per cent are charcoal briquettes, and the business has been expanding rapidly in recent years.

Only one company makes rice-husk briquettes, using its own husk heating and forming machine – the company itself developed the concept of continuously crushing and solidifying the husk by high kinetic force and temperature. The briquettes are sold in Japan, where they are pulverised to a dust to be used as a plasticiser. The machine can produce 450 kg per hour. A table gives the specifications of the briquettes.

Another company makes about 10 tonnes per month of wood charcoal pellets from fines from charcoal mills, bound together with starch in a paddle mixer. These are then pressed and dried in a commercial dryer and sold locally.

Most popular are wood charcoal briquettes without a binding agent, manufactured using the unique screw-feeder system. The briquettes are then carbonised in rectangular brick kilns. The extrusion cylinder is heated to about 300^{o}C. Sawdust is the most important material (70 per cent), the rest being wood wastes such as bark dust, planer wastes and sander and chip dusts. For sawdust, 1.8 tonnes gives one tonne of briquettes.

A flow chart is given showing the manufacturing process. The sawdust is sieved in a vibrator, and the screened sawdust is then brought by screw conveyor to the rotary dryer. The drying procedure is both dangerous (because of the risk of fire) and crucial to the quality of the product. The sawdust passes through a rotating cylindrical shell with internal flights to lift and shower the dust through the passing hot gas. The gas is produced by burning waste wood in a furnace and is forced through the dryer by a fan. One company flash-drys the sawdust instantly using an oil furnace. The dust is then conveyed to a separating cyclone to separate out the gas, which is vented outside. The sawdust is then fed by gravity to the inlet of a heated screw press which produces the briquettes. Tables are given showing the production capacity of a typical extruder and the comparative quality of charcoal and local wood briquettes.

Drawbacks of the screw-extrusion plants include the abrasive nature of sawdust, which necessitates constant maintenance, and variations in the moisture content in different seasons and in the original tree species. There are also environmental problems since the process produces a lot of smoke and pollutant gases. Storage is also a problem. In the rainy season, the briquettes can absorb moisture and become loose and in the dry season they can spontaneously combust.

A detailed financial analysis of a typical plant is given in three tables. The figures point up the attractiveness of the industry to new investors. However, this is based on currently high export demands which are not elastic. Over-production or excess competition would threaten the stability of the industry.

5. Conclusions and Recommendations

5.1 Conclusions

1. Rural industries are important in all countries in the region. They provide employment and generate income, process local raw materials and thereby add value not only to the products but also to the local economy. They often make use of energy sources which are locally available, particularly biomass energy in the form of wood, charcoal and residues in various forms.

2. Even though agriculture is still by far the most important sector of the economy in most countries, the industrial sector is gaining in importance as is evident from the increase in the share of industry in the gross domestic product of most countries in the region.

3. The increased importance of the industrial sector has positive effects as it can provide employment opportunities in particular in rural, mainly agricultural areas. Evidence suggest that the small-scale industries are particularly important due to their relatively high employment elasticity, which is likely to raise employment opportunities in rural areas and thereby possibly slow rural to urban migration.

4. At the same time, however, the small industries are facing – and possibly even cause – problems, due to a variety of factors. Among these problems are low productivity, often coupled with low conversion efficiencies in terms of both raw materials and energy, environmental pollution, managerial weaknesses, low-grade products, a lack of information both on market conditions and on what types of support are available, a lack of a conducive policy environment and/or uncertainties in the availability of raw materials and energy sources. However, with proper interventions or incentives many of these problem areas can be mitigated to the benefit of the rural economy.

5. Since the last regional expert consultation on "Wood-based Energy Systems for Rural Industries and Village Applications" in Hat Yai, Thailand in March 1990, progress has been made with support from the Dutch-funded FAO-Regional Wood Energy Development Programme with regard to putting rural industries "on the map". Several countries have or are in the process of:

   - Organising national policy formulation meetings on rural biomass energy-based industries. As a result, policy-makers are now more aware of the importance of rural industries and the problems they encounter with regard to the supplies of sufficient quantities of biomass energy, including wood.
   - Carrying out activities to improve the data base systems with regard to biomass energy use. This has resulted in better access to data by policy-makers, which in turn may enable them to adjust policies and programmes with regard to woodfuel-using rural- based industries.
   - Undertaking capacity-building activities to develop the human resource base.

6. However, even though a considerable amount of information is now available in most countries, more needs to be done to fill data gaps, incompatibilities and anomalies in the sources of

information (at local, national as well as international levels). At the same time, there is a need for regular updating and upgrading of the data sources available. This will allow policy-makers to base their decisions upon accurate and timely information.

7. The execution mechanisms for policy and planning directives for rural industries are often weak and need to be improved through the strengthening of institutional support organisations.

8. During the RWEDP-organised Hat Yai consultation, it was concluded that, because of the high costs and/or limited access of other energy sources (due to various factors such as lack of infrastructure) and the socio-economic and environmental arguments in its favour, the rational use of biomass energy in a sustainable manner (without upsetting the supply/demand balance) should be accepted and possibly even encouraged rather than discouraged. The conclusion made at that time is still valid and has been acted upon. Evidence suggests that changes are taking place within some industries, notably the wood-processing, sugar and rice-milling industries. These industries are shifting to or making better use of the available renewable sources of energy through means such as more efficient conversion technologies.

9. Additional support is needed for biomass energy-using industries. It was recognised that this is principally a task to be undertaken at policy level in individual countries. FAO-RWEDP may be able to provide support to this process, however, through the supply of information, background material, back-up support, expertise and specialised meetings.

10. As there are so many different biomass-using rural-based industries which are in need of support, priorities must be set, both between industries and between scales of industries. Several criteria and indicators for the selection of the best industries to whom to give assistance were brought to the attention of the meeting. However, it was recognised that, in order to be able to apply these criteria, a thorough understanding should be obtained about the environment in which the industries operate. The meeting discussed that the following criteria (which, however, are not in order of priority) should be considered in the setting of priorities:

- The sustainability of the industry in terms of supplies of raw material and fuels (including seasonal considerations affecting availability and potential competition from other value-added products, such as furniture-making in the case of rubber-wood fuel), availability of the necessary skilled/unskilled manpower, product marketability (both local and export markets), access to credit, etc;
- The industry's effect on the local environment and the need for improvements;
- The industry's effect on workers' health and the need for improvements;
- Opportunities/need for improved productivity and product quality;
- Amount of woodfuels consumed by a particular industry in absolute terms;
- Degree of concentration of particular industries and their effect on the local resource base;
- Effect of the industry's woodfuel consumption on its resource base over time;
- Contribution of fuel costs to total production costs;
- Specific energy consumption in terms of product output, labour input, etc.;
- Options for energy conservation;
- Options for energy substitution;

- The price of biomass energy;
- Satisfying basic needs (food, shelter, clothing, etc.)
- Value-added effect of rural industrial activities;
- The industry's contribution to socio-economic and rural development;
- Employment generation potential;
- Gender considerations;
- Level of technical intervention required to support the industry;
- Probability of acceptance of innovations/improvements in efficiency and/or product quality to be offered;
- Degree of access to actual or potential support services;
- Cost-benefit ratio of assistance provided.

From these criteria for the selection of high-impact industries, it was recommended that the following be used on a priority basis. However, it was also noted that conditions in the various member countries vary widely, particularly with regard to upstream/downstream linkages, and this will have a localised influence on the degree of importance of selection criteria.

- Contribution to the satisfaction of basic needs;
- Socio-economic contribution of the industry (in relation to the biomass energy system as well as the industry itself);
- Criteria related to fuel quantity, e.g. total amount used, specific energy consumption, the effect of biomass energy use on its resource base (degree of concentration) and the contribution of the price of biomass energy in relation to production costs;
- The sustainability of the industry;
- The capital intensity of the industry;
- The level of intervention required to support the industry.
- Environmental considerations.

12. It was concluded that, due to the degree of regional variation, no absolute selection of five industries to be given for assistance could be reached. However, by applying the criteria discussed during the expert consultation, it was recommended that the following five should be considered by the RWEDP on a priority basis:

- Brick and roof tile industries
- Sugar/gur/jaggery making
- Tobacco curing
- Timber drying
- Lime burning

13. Besides particular industries, some processing technologies should also receive attention: charcoal making and briquetting of biomass residues.

14. In some countries, suitable policies for the promotion of rural biomass energy-based industries are lacking. This hampers the development of the small-scale rural biomass energy-based industrial sector.

15. With regard to wood fuel supplies, it was concluded that the policy environment is not always conducive to the supply of wood fuels to the industrial sector.

16. It was concluded that within the region, there is a distinct need for a range of activities such as training and exchange of information, experiences and expertise.

5.2 Recommendations

1. FAO-RWEDP should, where it is found to be feasible, provide support to the industries identified through its focal points: NATCOM and NATWEG.

2. Simultaneously, countries could take initiatives themselves, and the participants to this expert consultation were urged to brief national policy-makers on the situation and importance of rural biomass energy-based industries.

3. Countries should take action themselves to provide support as soon as possible. FAO-RWEDP and other international agencies were called upon to assist individual countries to identify additional source of support, in particular from outside donors.

4. FAO-RWEDP should explore ways and means to attract interest in this important sector from other specialised international organizations like UNIDO, UNDP and ILO, and/or from donor organisations.

5. FAO-RWEDP should explore ways to bring the situation in which the rural biomass energy-based industries find themselves to the attention of policy-makers through various means, including direct presentations to high-level policy makers if the opportunity arises.

6. Given the inter-sectoral linkages (industry, agriculture, forestry etc.), efforts should be made by the countries themselves to coordinate activities which have a direct bearing on the well-being of biomass energy-based rural industries.

7. Forest management and/or tree production systems should be directed to undertake additional activities to ensure a woodfuel supply that is sustainable both in terms of the resource base and with regard to the users of woodfuels, including the rural industrial sector.

8. Specific legislation against the use of some fuels, in particular woodfuels, should be reconsidered, unless they are justified from the viewpoint of sustainability.

9. Further studies should be carried out with regard to the situation of the rural biomass energy-using industrial sector in those countries where the data base is considered weak.

10. Effective market mechanisms, including infrastructure for woodfuel, should be developed and/or encouraged, based on real fuel prices to avoid market distortions

11. Direct interaction between FAO-RWEDP and governments through the national committees (NATCOM) should be developed to reinforce calls to recognise the importance of rural industries and the need to strengthen institutional support in order to enhance result-oriented activities and regional cooperation.

12. FAO-RWEDP should explore ways and means to provide opportunities to relevant persons and institutions in the region to be strengthened through provision of training, training materials, manuals, apprenticeships etc., and to encourage them to promote the mutual exchange of expertise.

ANNEX 1

REPORT ON THE FIELD VISITS

On the last day of the consultation, the participants were transferred from Penang to Kuala Lumpur. During the overland trip, two field visits were made: the first in Butterworth, to the Malayawata Steel factory, the second to the Mee Hoon noodle factory in Rawang, Selangor (near Kuala Lumpur).

Malayawata Steel Berhad

Malayawata Steel Berhad is said to be the first and only fully integrated steel works in Southeast Asia. The quality of its steel products are considered high due to the low sulphur content of the iron produced. The complex consists of two rolling mills with a combined capacity of 400,000 tonnes per year, which is sufficient to cover all domestic needs.

Within the sintering plant, which is the first step in the production process, a reducing agent is used, in the form of carbon. This carbon is derived either from charcoal or from coke. While charcoal was originally the main reducing agent used, the balance has changed over time. This is evident from the amounts used: earlier, about 10,000 tonnes of charcoal were used per month, but this has now decreased to around 1,500 to 2,000 tonnes per month. During the visit, the following issues were discussed with the management of the steel complex.

The reason for the decline in charcoal use can be traced back to problems with the raw material supply in the form of wood waste, wood from rubber trees, etc. and, related to this, the cost of charcoal. The charcoal produced in Malayawata's own charcoal factories is based on wood from rubber plantations and other wood waste. While this used to be available almost free of charge, much of the wood is now used for other purposes, such as furniture making, chipboard manufacture etc. Consequently, the price of the wood waste has risen, pushing up the cost of the charcoal. As a result, charcoal is now much more expensive than coke (RM 350 per tonne, as against RM 100 per tonne for coke). The latter is imported mainly from India and/or Australia.

The steel mill prefers to use coke, not only because of the lower price, but also due to a number of other factors (more uniform quality, making the steel making process easier to control etc.). However, the use of charcoal is still required for speciality steels. On top of this, the management also indicated that there were social obligations which made them keep on the production and use of charcoal: Malayawata Steel owns the charcoal factories, which employ about 230 people. Closing the charcoal-making operation would mean the dismissal of the employees, and under present conditions this was considered difficult. At the same time, as charcoal was still required for some of the company's steel products, closing down the charcoal factories would mean uncertainties relating to the quality of charcoal bought on the open market.

Mee Hoon noodle factory

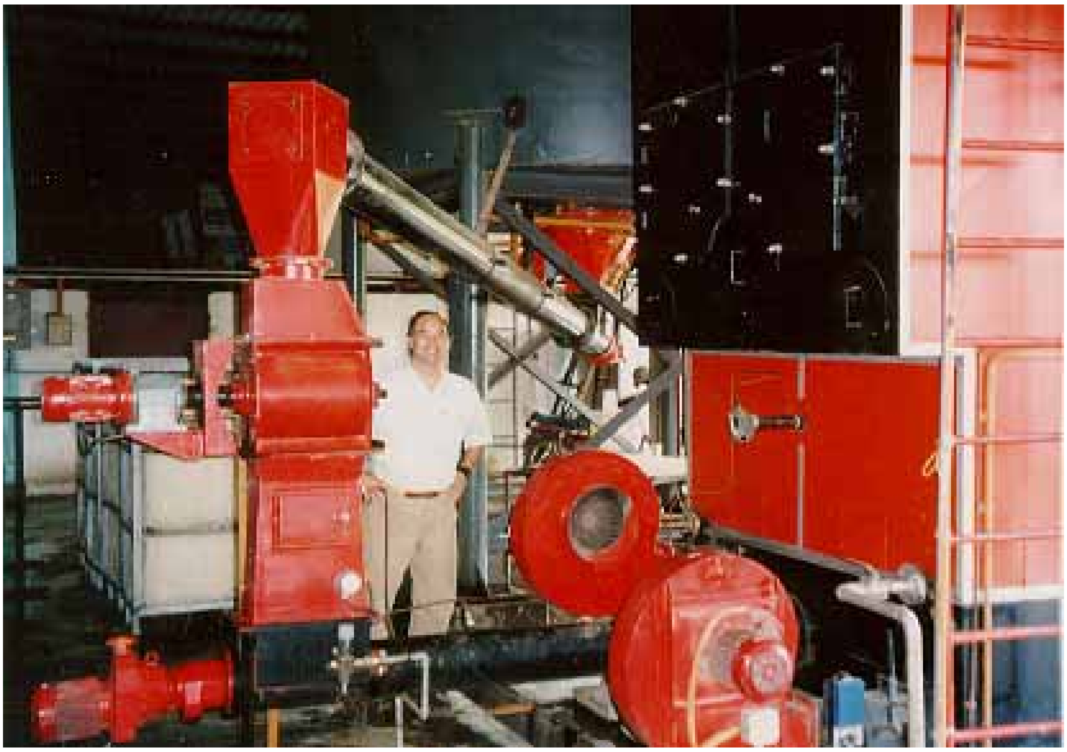
Steam is used at two stages of the noodle-making process. First, the noodles, which are made from a mixture of rice flour and water using an extrusion process, have to be steamed to make them palatable. They are then cooled, after which steam is used to dry them before they are packed for sale.

Formerly, fuel oil was used to produce the steam in a boiler. This was a straightforward process, and no problems were encountered except the cost of fuel oil. At the same time, Malaysia promulgated several environmental regulations which, among other things, prohibited the dumping of waste materials. This in its turn meant that woodworking factories were no longer able to dump their wood shavings, sander dust, etc. at municipal dump sites. Thus the factories had to find some other means of disposing of the wastes, with the result that substantial amounts of wood waste were now available at low or no cost. In fact, some wood-processing plants were and are still willing to pay for the removal of the wood waste.

As the wood waste could be obtained free of charge, the management of the Mee Hoon factory decided to switch from fuel oil to wood waste, even though this would require changes in the steam generation equipment. A fully automatic wood waste-fired steam boiler was acquired through a local company. The owner of the noodle factory claimed that using wood waste instead of fuel oil did not cause any problems. As the wood waste is basically free of charge, the owner was also very happy with the economics of installing and using the wood waste-fired boiler system. Unfortunately, no data could be obtained to ascertain the relative economics of wood waste and fuel oil.

Comments

Both examples show that external factors can have a positive as well as a negative impact on the operation and use of wood wastes. In the first case, competing uses for wood waste have resulted in a decline in charcoal production as well as employment. In the latter case, stringent environmental regulations, which are enforced, resulted in wood waste becoming available at low costs. It was therefore clear that within any decision-making process with regard to the use of wood waste, such external factors will have to be considered.



Top: The automatic sawdust feeding system coupled to the boiler at the Mee Hoon noodle factory

Bottom left: The autoclave for steaming in the Mee Hoon factory

Top: Noodles ready to be steamed in autoclave

ANNEX 2

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ANNEX 3

PROGRAMME OF THE CONSULTATION

January 15

Registration of participants

Address by Dr Abdul Razak Mohd Ali, Director-General, FRIM

Address by Mr M Trossero, FAO, Rome

Opening address by Mr Koay Kar Huah, representative of the Penang state government

Keynote address by Prof Dr Baharudin Yatim, Universiti Kebangsaan Malaysia

Introduction of participants; introduction to the framework of the expert consultation by Mr A Koopmans, RWEDP

Overview of Industries and Biomass Energy Use by Mr A Koopmans

Presentation of Country Statements

January 16

Presentation of Country Statements continued

'The Use of Fuelwood for Energy in Rural Areas', by Dr Hoi Why Kong, Forest Research institute Malaysia

'Dissemination of R&D Results on the Use of Fuelwood for Energy in Rural Areas – Problems and Prospects', by Dr Abdul Razak Mohd Ali and Dr Hoi Why Kong, Forest Research Institute Malaysia

'Policies and Strategies for Harmonising Rural Industrial Development – an Integrated Approach to Sustainable Biomass Systems', by Dr J S Juneja, India

'Financing of Small and Medium Scale Industries in Malaysia', by En Anuar Mohd Nor, Malaysian Technology Development Corporation

Questions and answers

'Energy and Small Scale Industries', by Dr W S Hulscher, FAO-RWEDP

Questions and Answers

Introduction to group discussions by Mr A Koopmans, RWEDP

Group discussions

January 17

'Wood and Charcoal Briquetting in Malaysia', by Ng Seng Huat, Yoltan Briquettes, Malaysia (M) Sdn Bhd

Questions and answers

Presentation of group discussions

Questions and answers

Discussion of draft conclusions and recommendations

Endorsement of conclusions and recommendations
Closing remarks

January 18

Visit to Malayawata charcoal mill, Butterworth

Visit to Mee Hoon factory in Rawang, Selangor

ANNEX 4

MAJOR WOODFUEL USING INDUSTRIES: PROCESS DESCRIPTION, ENERGY USE AND ENERGY CONSERVATION OPTIONS

Introduction

The following gives a brief overview of some of the major industries which are known to use woodfuels as a source of heat during one or more of their processing stages. The process is described briefly and, where reliable information is available, specific energy consumption data is provided. Besides the process-specific information, some indications are given of energy conservation possibilities and/or other options. Also where information is available, the importance of the industry within the region in terms of geographic coverage and production levels in comparison to total world production is given. Reference should also be made to more detailed information provided elsewhere (production levels, amount of wastes produced which could possibly be used as sources of energy etc.), such as in national and international statistics.

This is an overview, and is therefore not comprehensive in its coverage with regard to processes used, specific energy consumption figures or options for energy conservation. It is intended only as a background document to assist the prioritisation of industries where energy conservation and/or alternative use of wastes produced can be considered, for example where there are proven options, equipment or expertise available.

The information provided here is based on that presented at several workshops organised by the RWEDP and on presentations to national-level workshops held in India and Nepal. Where possible, the information has been updated from other sources. For the near future, it is planned to enlarge and update the contents, for instance through the inclusion of process-flow sheets, information on typical process equipment such as oil expellers for oil extraction technologies, etc. It is hoped that in this way an information resource comparable to a data base will be available for use by organisations, institutions etc. that may want to provide assistance to a particular industry.

Options for interventions with regard to energy conservation can be sub-divided into three main sectors: housekeeping measures; process improvements; and major equipment changes. The three can be applied either individually or in combination. With regard to the relative importance of the three options, reference is made to a study carried out in Thailand in 1985–86[1]. This study, based on energy audits of 285 of the larger factories, showed that housekeeping alone could save over eight per cent of the energy used by the manufacturing sector, improvements in processes used could save over 11 per cent, and major equipment changes could save about another four to five per cent.

Most energy conservation possibilities through improvements in housekeeping are in general cheap and easy to implement. However, it should be noted that even though these measures can be implemented without any problems (i.e. they are technically and economically feasible), there are also many non-technical factors to consider, particularly regarding management and labour. Management may be aware of the energy-saving options, but the housekeeping measures often require a change in operational practices. The labour involved may object to this unless proper incentives are offered. Most housekeeping energy-conservation measures can be introduced by the factory owners themselves without the need for outside technical assistance. Publicity, promotion and demonstrations are important tools in getting this message across. In the following, these housekeeping measures are not mentioned, as most of them are obvious, for example: proper control of primary and secondary air in fireboxes in ceramic kilns (where savings of up to 20 per cent are possible), furnaces for small-scale food processing etc.; drying of fuel; proper sizing of fuel; and consistent feeding of fuel.

Process improvements are another option, but most rural industries, being small and based in tradition, often do not have the in-house capacity to carry these out without some form of outside assistance. It should be kept in mind that besides publicity, promotion and demonstration, there will also be a need for technical assistance. An example is the lime industry, where the introduction of simple mechanical slakers would improve the quality of the slaked lime and the quantity produced from the same amount of quick lime, when compared to manual slaking. In the small-scale sugar industry, improved evaporators, which may need more handling, can reduce energy consumption to a considerable extent.

Major equipment changes can be introduced also, but this will in most cases require, besides the publicity, promotion and demonstrations, technical and managerial assistance and back-up service in case problems develop. Examples of this are the introduction of tobacco bulk curing systems, continuous lime-burning kilns, continuous brick-firing kilns, etc.

The industries covered have been divided into seven main groupings: agro-processing industries, food processing industries, metal processing industries, mineral processing industries, forest products industries, textile-based industries and other activities or miscellaneous activities.

1. Agro-processing Industries

1.1 Cocoa

Cocoa is grown in four RWEDP countries: Malaysia, Indonesia, the Philippines and Sri Lanka. These countries account for about 20 per cent of the total production in the world, but register a growth rate far above the world average (20 to 30 per cent in Malaysia and Indonesia, against a world average of five per cent).

Cocoa processing consists of picking the fruit, hulling and removing the beans, fermenting the beans in boxes or in heaps, during which the temperature rises to 45–48^{o}C, washing, drying and sorting/grading. Drying can be done with natural heat (sun drying) or with artificial heat, or with a combination of both. Different types of driers are used, including large concrete floors with movable roofing, special multi-floor drying buildings or horizontal driers with electric fan-assisted hot air supply systems, sometimes using gasifiers to provide process heat.

Sun drying of beans is preferred, as it is said this improves the aroma. However, drying the beans down to a sufficiently low moisture content (six to seven per cent) is difficult. Therefore, sun drying is normally done until the moisture content has reached 30 per cent (from 70 or 80 per cent). This takes about 12 hours, whereafter the beans are placed in artificial driers. Typical fuelwood consumption data (in Indonesia) show about six to 10 m^3 per tonne of dries beans. In cases where the drier is fired with oil, the consumption is about 120–350 litres per tonne of dried beans. These values are, however, based on drying in large multi-floored buildings with perforated floors. In the case of horizontal driers, the specific fuel consumption can vary from about two to five m^3 fuelwood or between 115 and 135 litres of oil per tonne of dried beans, in addition to 120 to 150 kWh of electricity. Artificial drying methods are mainly used by relatively large-scale operators, while smallholders use natural drying. Wastes generated (cocoa bean pods) are normally not used as a source of energy as their moisture content is quite high.

Cocoa also generates field wastes. Cocoa trees have to be pruned regularly and, once they have reached the end of their productive life (after about 25 years), they are cut down to make way for replanting. Prunings (on average around 25 dry tonnes per ha per year) are often left in the field, while during replanting many of the trees are simply burnt in order to dispose of them.

Options for energy conservation:

- Use of gasification systems for process heat generation (drying). Some of these systems are in use in Malaysia and Indonesia. Equipment is commercially available from Indonesia.
- Wood from prunings and replanting could possibly be converted to charcoal. Research has shown that charcoal from cocoa wood has a low density but otherwise is comparable to that produced from mangroves (more or less the same calorific value, the same friability, easy ignition, etc.).

1.2 Coconut Products, Including Coconut Oil

Coconuts are grown in almost all countries in the region, with processing being done both at both smallholder and large scale. The region accounts for about 85 per cent of the world's coconut production. The yields of coconut palms vary considerably, depending on the variety and management practices. Yields of non-improved varieties under traditional harvesting practices (smallholdings) vary from about 0.5 to one tonne of copra per hectare (between around three and seven kg of copra per palm per year). With better management, such as on larger plantations, the yield was found to be about 1.36 to 1.66 tonnes per hectare. However, with improved varieties and proper management, the yield may be as high as three to nine tonnes per hectare.

Besides the copra, processing of the coconuts yields other products, such as the shell (which can be used as a source of energy), the husk (a source of fibre) and coconut water. The approximate composition of coconuts is (on a wet basis):

Husks	33–35 per cent
Shell	12–15 per cent
Meat	28–30 per cent
Water	22–25 per cent

Besides the coconut products, the coconut tree can be a source of toddy, palm sugar and timber. Heat and power are required in the processing of coconut products, which include copra, coconut oil and desiccated coconut, with most of the heat requirements being woodfuel-based. Copra making is the exception, as the coconut shells and sometimes also the husks are often used as sources of energy.

In copra drying, three basic methods are used: sun drying, direct hot air or smoke drying and indirect hot air drying. A combination of sun drying followed by kiln drying is also sometimes used. Processing consists of harvesting the mature nuts, removing the husks, cracking the nuts (halving) and draining the water. Where the sun drying process is used, the halved shell containing the copra is laid on the ground or on a rack in the full sun. After about two days the copra can be removed from the shell, whereafter another three to five days are required to dry the copra, in the full sun, down to a moisture content of about six per cent. In practice, however, the halved nuts are sun dried for one day to reduce the moisture content to about 30 to 35 per cent. The halved nuts (shells and copra) are then dried directly in a simple kiln-fired with coconut shells (other fuels are not used, as their smoke reduces the quality of the copra) to reduce the moisture content to about six per cent, which takes about four to five days. On the second or third day, the shells are removed to be used as fuel or for other purposes. The fuel consumption is stated to vary from 0.45 to 0.9 kg of coconut shells (about 50 per cent of the total amount of shells produced) per kg of dry copra. Fuelwood is normally not used, as it affects the colour, smell and possibly the taste of the final product made from the copra. The dry copra is graded into three categories, depending mainly on the colour, texture and appearance.

In order to obtain a high-grade product, the copra may be dried in indirectly heated and fan-assisted driers. The energy consumption is stated to be 0.5 to 0.6 kg of shells per kg of dry copra, and some electricity to drive the fan. Drying is much faster and, as the copra is not contaminated by combustion products, the quality is in general considerably better than that of copra obtained with the more traditional systems described earlier. Using a typical drier, three tonnes of copra can be obtained in a 24-hour period, and this requires about 1,600 kg of shells and about 70 to 80 kWh electricity.

In coconut oil production, much depends on the level of production. For small-scale production such as for own use at the household level, the fresh copra is grated and mixed with hot water. The mixture is kneaded, producing coconut milk, a white emulsion. This kneading process is repeated several times and the coconut milk is added to the first batch. The coconut milk is then left to stand and the liquid separates into two layers, a watery layer at the bottom and a creamy layer on top. The two layers are separated and the creamy emulsion is then boiled in a pan for several hours, which separates the oil from the water. The water is drained off and the oil is left to cool, filtered and stored in bottles or other suitable containers. The oil yield is about 60 per cent of the total amount of oil contained in the fresh copra. The energy consumption in the so-called “wet process” is not known, but maybe as high as 400 kg of fuelwood per tonne of oil.

The other, or “conventional”, method consists of processing the dry copra. The dry copra is cut into small pieces (less than 10 mm in size) and is then cooked (in fact drying and heating the copra to a temperature of about 60 to 120°C, which makes removal of the oil easier) in an indirect heated drier which has an efficiency of about 50 to 60 per cent. The hot copra is then pressed in screw expellers to extract the oil, which then undergoes a further filtering process. About 75 kg of fuelwood is said to be required to produce one tonne of oil.

The manufacture of desiccated coconut (DC) requires heat for the sterilisation of the peeled coconuts (halves) for about 1.5 minutes, as well as for desiccating (drying out) the coconuts. For sterilisation, water in a tank is heated to close to boiling point. The fuel consumption of a typical sterilising tank is about 0.3 kg of fuelwood per kg of DC. Such a tank has sufficient capacity to produce about 400 kg of DC per hour. The efficiency is about 45 per cent. The high temperature of the fluegas (about 400°C) could possibly be used for drying purposes (no information available). Drying is done at a temperature of about 80 °C, using hot air. This hot air, generated by burning fuelwood, coconut husks and/or shells in a furnace connected to a heat exchanger (thermal efficiency estimated at about 20 per cent), consumes another 0.7 kg of fuelwood per kg of DC, resulting in a total consumption of one kg of fuelwood per kg of desiccated coconut.

However, energy consumption data given vary widely and much depends on the scale of the operation. Copra production takes place mainly at the smallholder level, while desiccated coconut production is normally a large-scale operation. Coconut oil can be both a small-scale (mainly for own use or local sale) and a large-scale operation. In order to produce one tonne of copra with a moisture content of six per cent, about 4,500 to 5,000 coconuts are required. This amount of nuts would produce about 0.8 to one tonne of coconut shells. One tonne of coconut oil requires copra from about 7,200 to 8,200 nuts, while one tonne of desiccated coconut requires from 4,000 to 6,900 nuts.

Husks, shells and fronds are used as sources of energy, and the industry can be considered as being energy self-sufficient. However, where the harvesting of coconuts is separated from processing, other sources of energy (electricity, diesel, fuelwood and fuel oil, etc.) are used, in particular at the large-scale level.

Options for energy conservation:

- Coconut shells can be carbonised to obtain high quality charcoal, a valuable commodity for activated carbon production. In Sri Lanka, at least one factory carbonises the shells and burns the off-gases in the hot air supply system for DC drying.
- Use of the high temperature of the exhaust gases of the sterilising tank for preheating air.
- Improvements in the kiln and drying methods used for small-scale processing of copra.
- Possibly cogeneration where both steam and electricity are required, such as for coconut oil production (processing at plantation site).

1.3 Coffee

Coffee is processed in a similar way to cocoa, i.e. the beans are picked, washed, bruised, fermented, washed and dried (wet method). Equipment used varies from country to country, while size (capacity) also has a large influence. Processing can also be done using other (dry) methods, but little information is available on these other than that the coffee berries are often left on the tree until dry, or are picked and then dried with the coffee beans still inside.

In both cases, drying can be in the sun but, for larger quantities and the wet process, special drying buildings or mechanical driers are used. The drying temperature should not exceed 85°C in the initial phase of drying of coffee processed with the wet method. After a few hours, the temperature should be reduced to 75 to 80°C until the beans are dry, which will take from 30 to 36 hours (mechanical drying). Where the coffee is partially dried in the sun, the temperatures should not exceed 65°C once the beans have been moved to the mechanical drier.

The weight loss during drying (from drained beans to dry beans) is about 40 per cent. The energy consumption varies from 750 to 1,000 kg of fuelwood per tonne of dried beans, or from 150 to 200 litres of oil per tonne of dry beans. Part of the fuelwood is derived from prunings from shade trees, etc. and the rest is obtained from elsewhere. Besides fuelwood, coffee husks are also used as a source of energy, both in the industry itself and by other industries. Coffee is grown in most of the RWEDP member countries (10 out of 15), and these countries account for 15 to 20 per cent of worldwide production.

Options for energy conservation:

No information is available, but possibly the use of gasification systems for process heat generation (see also cocoa).

1.4 Oil seed processing (except coconut oil)

Oil seed crops are in many Asian countries a major food crop, next to food grains such as rice. Examples of these oil seed crops are palm oil, ground nuts, mustard seed, rape seed, sunflower seed, safflower seed, soya beans, cotton seed, rice bran, etc. Both small-scale and large-scale processing takes place. A typical production process consists of harvesting the seeds, cleaning, dehulling, size reduction, heat treatment (cooking), oil extraction and filtering. Where solvent extraction is used, an additional step, distillation and solvent removal, also forms part of the process. However, in most cases mechanical presses such as screw presses are used to extract the oil.

Specific energy consumption values vary greatly with the scale of operation, the type of oil seed processed, the moisture content and whether or not the seed is heat treated (cooked) before pressing. For small-scale operation, without heat treatment, the specific energy consumption ranges from about 1,100 to 1,500 MJ per tonne of oil seed

<u>Options for energy conservation:</u>

- Replacing traditional oil-pressing equipment with more modern equipment can help in reducing the energy requirements as well increase the oil extraction rate.
- Improving the steam generating system can result in energy saving (wastes are often used as a source of energy).
- Cogeneration of heat in the form of steam and electrical power to drive the equipment may be an option for larger-sized units.

The processing steps in the production of crude palm oil are: picking the fruit bunches, sterilisation of the bunches, removal of fruit from the bunch, fruit digestion, oil extraction, clarification, drying/ centrifugation and filtering. These steps in the production process are valid for both small and large-scale operations. However, in small-scale production, the fruit is often removed from the bunches before sterilisation or not sterilised at all. Steam is used for the sterilisation step in the production process (inactivating lipases and lipoxidase in the mesocarp), in the digestion step (breaking up of the mesocarp to facilitate oil removal) and for drying of the nuts and the oil.

However, in all steps, electrical power (about 20 kWh per tonne of fresh fruit bunches or FFBs processed) is used as well. For small-scale operation (village size, which is not very common in the RWEDP countries), manual power is used for handling and processing instead of mechanical power. FFBs in general contain (fresh weight) about 27 per cent palm oil, six to seven per cent palm kernel, 14–15 per cent fibre, six to seven per cent shells, and 23 per cent empty fruit bunch or EFB (Ma et al., 1996).

Large-scale processing is completely energy self-sufficient, and in fact a certain amount of waste material is not used. Kernels and fibres left after the oil removal stage are used for steam generation. For relatively small-scale operations (between one and four tonnes of FFB per hour) the specific energy consumption ranges from 150–600 kg per hour or about 120–150 kg per tonne of FFB per hour. Left over kernels are either used by other industries or are sometimes used for country road construction. The empty bunches, which are soaking wet after the sterilisation process (moisture content 50–65 per cent), are often disposed of in large vertical incinerators.

Besides the solid residues, palm oil mills also generate about 3.5 tonnes of liquid effluents or POME per tonne of palm oil produced. To treat this liquid effluent, anaerobic processes can be used, during which biogas is produced (about 28 m^3 per tonne of POME treated). Burning this gas in a gas engine can generate considerable amounts of power or electricity (1.8 kWh per m^3 of biogas). Palm oil mills, being energy self-sufficient, have little use for the power generated and most of the gas is flared or just released into the atmosphere, adding to the greenhouse effect.

Besides, the processing residues, palm oil plantations also generate large amounts of woody residues during the replanting process yielding about 87 tonnes of fronds and 16 tonnes of tree trunks per hectare replanted (on average once every 25 years). Most of these residues are disposed of through burning as it is not economic to collect and transport them over long distances. Malaysia, Indonesia and Thailand are the three main RWEDP countries where palm oil is processed, together accounting for about 75–80 per cent of world production.

Options for energy conservation:

No information available. Possibly options for steam generation using EFBs; briquetting of EFBs, excess fibre and shells; and productive use of biogas for local power generation.

1.5 Rice milling and parboiling

Rice growing is common in all RWEDP countries as rice is one of the staple crops and the region accounts for close to 90 per cent of the total production in the world. Rice is milled in a large variety of sizes ranging from very small scale (household) to very large. At the very small scale milling is a complete manual operation but in somewhat larger scales of operation milling involves mechanical power for milling. Rice mills buy raw rice from farmers and market places for milling and selling onwards and for contract milling. The latter is normally found at the village level where the farmers brings their rice to the mill where it is to be processed. Husks and bran are in that case often retained by the rice mill.

Before milling, the rice is dried to a suitably low moisture content (below 14 per cent but ideally between 10 and 12 per cent) as otherwise the quality of the rice will deteriorate. This is done both at farm level and at rice mills. Natural drying (spreading the rice in a thin layer on a suitable surface such as a concrete floor) is practised in both small and large-scale operation. However, some of the larger-sized units use artificial driers (electric fan and hot air generated by burning oil, etc.).

Parboiling on a small scale (village or household) involves soaking of paddy overnight in water and then boiling in a perforated tank or an open pan. The boiled paddy is sun-dried and then milled to separate the husk and rice.

Larger operations normally purchase paddy from farmers, market places, fields or auction yards. Those larger mills use steam boilers. Parboiling is done in conical vertical tanks, each containing about 13.5 tonnes of paddy. Paddy is fully soaked (dipped) in hot water at a temperature of 80 to 85°C and heated by continuously passing steam through it. Paddy is kept in these tanks for six to eight hours, and from there is transferred to big perforated trays for drying. Hot air at 120–140°C is passed at a rate of 17 m^3 per minute through the tray for five or six hours to complete the drying process.

Normally rice husk is used as fuel for parboiling, but in India, for small-scale processing, some fuelwood is also used. In such cases, consumption is estimated at about 0.1 kg of fuelwood per kg of raw paddy processed. In Bangladesh, however, the specific energy consumption in small-scale operations (at the household level), is reported to be 0.3–0.4 kg of rice husks per kg of rice. The difference in specific energy consumption is not known, but is probably caused by difference in processing size (steam boilers versus open fire), while combustion of the fuel (pile burning of rice husks) will also have an influence. The standard unit of measurement may also differ, as per kg of raw paddy in India and per kg of rice in Bangladesh.

Rice milling requires mechanical power, for which either small engines or electrical power is used (normally direct-coupled internal combustion engines; steam engines, widely used in Thailand; electricity from the grid; and/or self generation with steam turbines). The industry's energy requirement for milling is about 30 kWh per tonne of paddy. The amount of husks produced is more than sufficient to cover all the industry's energy needs, as the generation of electricity would require about 2.7 kg per kWh (for units with capacities ranging from 0.3 to one MW). In fact, a fair amount of husk is used by other industries as a source of energy, for example brick firing. In the larger parboiling mills, about 30 per cent of the husks remain unused while for white rice (non-parboiled), assuming that husks are used for steam generation, up to 50 per cent are not used.

<u>Options for energy conservation:</u>

- Use of gasification and other systems to generate electrical power (steam generation and turbines).
- Cogeneration for larger units.

1.6 Rubber sheet smoking

RWEDP member countries account for over 90 per cent of the total world rubber production, with Malaysia, Indonesia and Thailand being the top three producers in the world, respectively.

The process of rubber making involves tree tapping, collection of latex, sieving to remove dirt, diluting with water, mixing the latex with a coagulant, pouring the prepared latex in moulds or trays, coagulating, squeezing the coagulated latex, rolling of squeezed latex into sheet form and drying the sheets in air or sun and then in smoke houses. The smoke house is a chamber heated directly by hot gas and smoke from a simple non-grated furnace located at the base. The rubber sheets are closely hung over poles in many rows and tiers mounted directly in the smokehouse or on through-trolleys.

Other processes are also used which give air-dried sheets, block rubber, crepe rubber and latex concentrate. Each product has its own specific process, and variations in specific energy requirements vary widely depending on the process used and the end product obtained.

The average specific fuelwood consumption for smoked rubber sheets in India is stated to vary between 0.5 kg of fuelwood (in smokehouses supplied by Low Heat Driers Pvt. Ltd) and about one to 1.2 kg of fuelwood in conventional smoke houses, both per kg of fresh raw latex (Planters Energy Network, 1993). In Sri Lanka, the specific energy consumption is said to be 0.8 kg of fuel per kg of sheet; in Thailand, 1.6 to two kg of wood per kg of dried rubber; and in Malaysia, about two kg of wood per kg of sheet rubber. A direct comparison cannot be made as drying times are apparently different and units of measurement also differ. Crepe rubber and air-dried sheets are produced using hot air only with fuelwood use an average of 0.1–0.2 kg per kg of crepe rubber.

<u>Options for energy conservation:</u>

- There appears to be scope for energy conservation by using a combination of air/sun drying and smoking in smoke houses. A reduction in fuelwood consumption of up to 70 per cent is said to be possible.

- Dehumidification of the air and/or drying the wood helps in reducing the drying time. However, its effect on energy consumption is not known, and may be negligible or even negative (i.e. more fuelwood is used).
- During rubber processing, a considerable amount of liquid effluent is produced which can be used as a feedstock for biogas production. The biogas can possibly be used within the processing system for non-smoked rubber or for electricity generation.

1.7 Spice processing

Cardamom pods are normally stored for a few days to allow them to ripen evenly. In small-scale production, the cardamom is then dried in a traditional fuelwood-fired kiln for 36 to 72 hours in a slow fire, or in an improved kiln, which uses an indirect firing system. It takes 4.7 kg of fresh material to produce one kg of dry cardamom at 10 per cent moisture content. Specific fuelwood consumption varies, with six to 12 kg per kg of dry cardamom in Nepal and about 16 kg of fuelwood per kg of cardamom in India. In larger-scale units, more elaborate drying systems are used which normally consist of indirectly fired tray driers. Energy consumption varies, but in India is claimed to be about five kg of good quality fuelwood per kg of cardamom. Solar energy (both hot air and hot water) systems have been tried with success in India but other sources of energy are still required during the night.

Ginger rhizomes are harvested, cleaned physically by rubbing the individual rhizomes, and then dried either in the sun for seven to 10 days or by using traditional fuelwood-fired kilns. During drying, the rhizomes lose from 60–70 per cent of their weight before they reach a moisture content of seven to 12 per cent. Care has to be taken to prevent mould growth during drying. Traditional drying methods often result in losses of up to 20 per cent of volatile oils as well as other valuable components. Artificial drying, when carried out properly under controlled conditions, prevents this loss to a large extent. Solar driers are also being used on an experimental basis. Fuelwood consumption tends to be high, and six to eight kg of fuelwood per kg of ginger have been mentioned in Nepal. The value of the woodfuel accounts in that case for 12 to 16 per cent of the production cost.

Pepper is normally harvested on the spikes, which are then left for one or more days to pre-dry. The berries are then removed by rubbing. These berries, after removal from the spikes, are either sun dried or dried mechanically. A variation of sun drying is where the fresh berries are submerged in boiling water for about one minute. It is claimed that this improves drying, as the product is more uniform. At the same time, microbial contamination is reduced. The natural drying process takes from three to 12 days, while with dunking in boiling water the drying time is from two to four days. Artificial or mechanical driers speed up the process considerably, and drying the berries from a moisture content of 65 per cent down to the required 10 or 11 per cent may take only eight hours.

Turmeric is widely used in South-Asian kitchens as it adds colour and flavour to curries. It is also antiseptic and its powder is used in local medicines. Turmeric, after harvesting, is graded into thick and thin tubers. The graded turmeric is then boiled in big cauldrons of about 1.5 m in diameter, and spread out in the open to sun dry for about one to two months. The sun-dried turmeric is then rolled in drums in order to get rid of roots and other impurities.

<u>Options for energy conservation:</u>

There appears to be scope for improvements in the drying kilns/cabinets used for spice processing. However, even though this may have a positive effect on the quality of the spices, the effect on energy use appears to be ambiguous – i.e. the available literature says both higher and lower energy consumptions are found as a result of using improved driers.

1.8 Sugar production

1.8.1 Cane sugar. Sugarcane is a common crop in most countries in Asia. The RWEDP member countries produce about 480 million tonnes of cane, equal to about 40 per cent of the total world production. Energy used for sugar production consists of electrical power and heat in the form of steam.

The production capacity of most of the sugar factories range from 20 to 60 tonnes of cane per day. The production process consists of crushing the cane, collecting the juice, clarifying it, boiling and crystallisation. Two main process types can be identified: the open pan and the vacuum pan method. The former is common in rural areas for small-scale production and is used to produce raw sugar, while vacuum pan technology is used by large-scale production units to produce refined sugar. Raw sugar production again can be subdivided into two methods: with or without the addition of lime and/or sulphur. With the former method, milk of lime and/or sulphur is added to the juice during the boiling process to improve the quality of the sugar, as the milk of lime helps in precipitating impurities which then can be removed as a slag. Adding sulphur bleaches the sugar.

Small-sized units often use relatively simple juice-boiling/evaporation technologies, but large modern factories may use very efficient systems such as cogeneration of heat and power using bagasse as fuel. This meets their energy requirements and at the same time can provide surplus power for sale to the grid. However, the smaller sugar factories often have to depend on rice husk, fuelwood etc. to meet their fuel requirements as the amount of bagasse (about 300 kg per tonne of cane crushed) is insufficient due to generally low energy efficiency. Some of them use press mud, a by-product during sugar manufacturing, for their extra fuel requirements.

Instead of being used as fuel, bagasse can also be used for paper and board manufacturing, which provide a higher value product. Some countries have also developed processes for the manufacture of other products, such as cattle feed, organic fertiliser, etc.

Energy consumption varies with scale of operation and with technology used. Raw sugar (*gur*) production requires about 30 MJ per tonne of cane (electrically powered) or 115 MJ per tonne (diesel engine-powered) and about 3,500 MJ per tonne of cane in the form of bagasse. The same specific energy data are also valid for processing *khandsari*, raw sugar processed using lime while, where the sulphitation process is used, the mechanical power requirements are slightly higher: 50 MJ per tonne using electricity, or 190 MJ per tonne using diesel oil.

For refined sugar production, the energy requirements are considerably lower: seven to eight MJ per tonne of cane in the form of electricity, 25–30 MJ per tonne where diesel engines are used, while for boiling/evaporation, about 2,900 MJ per tonne of cane are required. However, as the cane-to-sugar-recovery rates for refined sugar production are higher than for smaller and lower-technology units, the difference in specific energy requirement per unit product is in fact even larger.

<u>Options for energy conservation:</u>

- Improvements in furnaces used for the boiling/evaporation of the juice for the small-scale units can reduce the amount of fuel (including bagasse) required per unit product. Although this may not have a large influence on the production costs as bagasse is a by-product, improving the combustion process may also help in improving the quality of the product which, in its turn, can improve the economics of small-scale sugar processing.

- Improving the crushing technology used for small-scale operation (the use of screw expellers instead of roller crushers) will improve the recovery rate of juice (and thus of sugar). However, the effect on energy consumption is expected to be low per unit output as energy required for crushing forms only a minor part of the overall energy requirements.
- For large-scale operations, the introduction of more efficient boilers and increasing the operation pressure can reduce the amount of energy required to produce sugar considerably. Existing traditional boiler/power generation systems require about nine kg of bagasse per kWh. Upgrading the existing boiler/power generation systems can reduce this figure to about six kg per kWh while, where high-pressure boilers are installed (80 bar, 520^{o} C), the specific energy consumption figure can drop to three kg of bagasse per kWh.

1.8.2 Palm sugar. Palm sugar processing, in comparison with sugar production from cane, is a small-scale operation. The process involves tapping the juice, then filtration and boiling/evaporation of the juice till the sugar starts crystallizing. The thickened juice is then poured into moulds, where it sets and hardens. It is then ready to be marketed. Specific energy consumption data vary widely depending on the capacity, which ranges from very small scale (a few litres of sap per batch) to a few hundred litres of sap per batch.

<u>Options for energy conservation:</u>

The options for energy conservation are more or less the same as for small-scale cane sugar processing, with the exception of improvements in crushing technologies, which are not applicable in palm sugar processing.

1.9 Tea leaf processing

Tea is widely grown in Asia, and the RWEDP member countries account for about 70 per cent of the total world production. Tea processing consists of picking the leaves, withering and drying. Within the withering and drying processes, two different technologies can be used: a) the traditional process and b) the so-called CTC (crush-twist-curl) process. The main difference is the process after withering: in the traditional one, the leaves are rolled in order to release the juice, while in the CTC process, the leaves are cut to release the juice. In both cases, the leaves are then fermented, dried, sieved, graded and packed.

Withering and drying of the tea leaves are important stages in the production process. Both require process heat. A continuous supply of fuelwood for the furnace is required to maintain a temperature of 110 to 120^{o}C. The initial heating time required is about three to four hours. The fuelwood is fed at intervals of 45 to 60 minutes in order to maintain the temperature.

In India, where fuelwood, coal, gas and oil are used as energy sources, a unit processing about 10 tonnes of tea leaves per day requires about 0.9 to one tonne of fuelwood. This translates to about 0.4 kg per kg of dried leaves. In Sri Lanka, with wood-fired air heaters, fuelwood consumption is about 1.3 kg of fuelwood per kg of tea, and where oil is used instead, it is about 0.2 litres per kg of tea. In Bangladesh, fuelwood, oil and natural gas are used, with three to five kg of fuelwood used per kg of dry leaves, equal to about 60.26 GJ per tonne of leaves (5.7 kg per kg of dried leaves in Nepal), while where oil or gas are used, specific energy consumption data are respectively 24.2 and 22.5 GJ per tonne of dry leaves. The differences in fuelwood consumption in the countries are possibly caused by the scale of operation, type of equipment used and location and elevation of the factory.

Options for energy conservation:

The use of more efficient driers appears a promising option to reduce specific energy consumption in tea processing. Efficient air heaters recently installed at two Sri Lankan tea estates reduced the fuelwood consumption drastically to about 0.9 kg per kg of made tea. However, this is still far higher than the SEC value from India, and there may be scope for further reductions in the SEC for tea processing.

1.10 Tobacco leaf curing

Tobacco is grown in most of the RWEDP member countries. Combined, these countries account for over 50 per cent of the total tobacco production in the world. Processing of tobacco consists of picking the leaves, hanging them on sticks and then in barns and drying/curing the leaves. Most of the tobacco is cured on-farm but sometimes the leaves are taken to large central curing stations. Seven types of tobacco are grown and all varieties require curing, but only two types of tobacco require fuel for flue-curing, while the other five types are hung or spread out for curing in air or sun in various types of barns, which are usually constructed from wooden poles.

Flue-cured tobacco leaves are those which require artificial heat. The tobacco industry mainly uses fuelwood for tobacco curing. Thailand has in fact prohibited the use of fuelwood in tobacco curing but, in practice, it is still widely used. Fresh tobacco leaves contain more than 80 per cent water (wet basis) and must be dried shortly after harvesting if a product of good quality is to be obtained. Curing of tobacco leaves take 90 to 110 hours and is carried out in four stages: yellowing, colour fixing, leaf drying and finally stem drying, each stage requiring a distinct temperature rise and range.

The curing barns, which vary in size, are normally built with brick walls. Fresh air inlet holes are located along the bottom of the side walls while ventilation valves are located in the roof. Hot flue gas is passed through pipes located inside the barn and these are exhausted through the chimney. Heat is transferred from the gas through the flue pipes to the air inside the barn, and the hot air in turn heats and dries the tobacco leaves. The heating rate is regulated by controlled burning of fuelwood, while the drying rate is regulated by adjusting the vents. The overall thermal efficiency of these types of barn is said to be about 10 to 15 per cent.

A study carried out in India indicates a specific fuel consumption (SFC) varying from four to 10 kg of wood per kg of cured tobacco, with an average of about 5.31 kg of wood per kg of tobacco; or, where coal was used, the range quoted was from 2.5–4.5 kg of coal per kg of tobacco, with an average figure of four kg. Improvement in the efficiency of combustion process in most of flue-curing barns is essential to reduce fuel consumption.

Other methods for curing tobacco exist, such as in bulk-curing units which make use of steam (indirect heating with steam generated by burning wood or other fuel)) and forced ventilation systems, which requires electrical power. The specific energy consumption is said to be considerably lower, but at present no data are available to the author.

Options for energy conservation:

- The use of an improved furnace can decrease fuelwood consumption by about 25 per cent compared to the traditional system. A new furnace, developed in India and locally known as the JTS-ILTD system, may also be suitable in other countries.

- By insulating the barn, optimising the ventilation rate and improving the heat exchange system, substantial savings in fuelwood consumption can be achieved, as reported in countries such as Thailand and the Philippines.
- Changing from the traditional barn system to bulk-curing systems can reduce the specific energy consumption to a considerable extent.

1.11 Vanaspati ghee

Hydrogenated vegetable oil production is an important industry in many Asian countries. Oil is taken from various crops such as coconut, rape seed, sunflower seeds, groundnuts, oil palm, etc. and processed. The process consists of pre-refining, vacuum treatment, pre-bleaching and hydrogenation and requires both high-pressure and low-pressure steam (total about 200 tonnes of steam per 100 tonnes of ghee produced in a batch mode). In addition, about 450 kWh electricity is required for the process itself, mainly for the production of distilled water (for hydrogen production) and for chilling.

Large quantities of fuelwood, coal and/or agro-wastes are used as sources of energy in the steam boilers. To produce 30 tonnes of ghee or edible oil, about 20 tonnes of fuelwood or lignite, 15 tonnes of coal or 50 tonnes of groundnut shell are required. The type of fuel used often depends upon the type of waste which is available in the vicinity of the industrial units.

Options for energy conservation:

Improvements in the steam-generation system (fluidised-bed technology etc.) are possible, which would result in considerable energy savings. Cogeneration may also be an option.

2. Food Processing Industries

2.1 Bakeries

Bakery products such as bread, biscuits and pastry are widely consumed in the region at breakfast and tea times. Production capacities in the small-scale sector range from 50 to 500 kg, and in the medium-scale sector range from 500 kg to eight tonnes per day. Big bakery units can produce about 150 tonnes per day per factory, and use electric ovens. Almost all bakeries in the small and medium-scale sectors use fuelwood for baking.

A typical wood-fired oven measures about six feet wide and eight feet deep, and is semi-cylindrical in shape, with a height of about 4.5 feet. A door is provided on one side with a chimney or chimney-hood located directly above it. Fuelwood is burned inside the oven until the oven reaches the required baking temperature, whereafter the ashes and cinder are removed and the actual baking begins. Broken glass and common salt, which are often used in the floor of the oven, are said to retain the heat for a longer period. The total cost of installing these ovens ranges from Indian Rs 15,000 to IRs 35,000, depending upon the capacity of the oven. Data gathered from bakeries in India indicate that about 70 kg of fuelwood is required for every 100 kg of output from a bakery, while in Bangladesh, Nepal and the Philippines the specific fuelwood consumption is stated, respectively, as one to 1.25 kg of wood per kg of bread, 1.5 to 2.5 kg of wood per kg of bread, and 0.82 kg of wood per kg of flour.

Some village bakeries use indirectly fired ovens. A metal oven is usually 0.7–1.0 m3 and can contain up to five shelves on which up to 200 loaves of bread can be baked in one firing. Fuelwood is burned in a furnace located underneath the oven. In Sri Lanka experiments have been carried out in which a saw-dust filled barrel is placed under the oven and ignited. Fuel savings with such indirectly fired ovens can be considerable and it is estimated that these savings could amount to about 80 per cent of the consumption rate in directly fired ovens.

Options for energy conservation:

The scope in fuelwood conservation in traditional directly fired ovens may lie in improving the efficiency (which varies in the range five to 15 per cent) of these ovens by making a more productive use of the heat generated and baking frequency, which can be done in several ways such as by increasing the batch size, using more baking layers (shelves) in the oven, using dry fuelwood, enhancing better fuelwood combustion, etc. A two tier baking oven, used in India, reduces fuelwood consumption by about 20 to 25 per cent. The upper tier is used for baking items which require less heat. However, since fuelwood is not a major production cost, other features need to be incorporated along with fuel efficiency to win acceptance.

2.2 Dairy products

These are products for which milk is used and which are produced in rural areas. The most important dairy products are curd, butter or ghee (clarified butter), cheese and concentrated whole milk (in Nepal called *khuwa* and in Pakistan, *khoya*).

2.21 Curd is a fermented product, similar to yoghurt, prepared from whole milk using natural starter culture (lactic bacteria). The whole milk may be boiled or used fresh.

2.2.2 Clarified butter or ghee is prepared either from the curd or straight from milk. Specially designed wooden butter extractors are used to extract the milk fat, which is converted into ghee by boiling to remove moisture, whereafter the resulting mass is clarified. The process is essentially the same whether it is cow, buffalo or yak milk. However, with yak milk, the usual end product is butter and not ghee. The fuelwood consumption is around three to five kg of fuelwood per kg of product, while fuelwood accounts for four to six per cent of the total production cost of NRs 80 per kg of ghee produced.

2.2.3 Khuwa or khoya consists of the solid constituents of milk including the fat. It is prepared by gently heating the milk and stirring until almost all the water has been removed and the remainder becomes a pasty mass. This item is the main constituent of many varieties of sweetmeat. It is a long process and fuelwood consumption therefore tends to be high. It has been estimated that in Nepal, six to eight kg of fuelwood per kg of product are required, which amount accounts for 15–20 per cent of the production cost of NRs 40 per kg of khuwa. In Pakistan, the fuelwood consumption is reportedly about 10 kg of wood per kg of khoya produced.

2.3 Distilleries

Many distilleries, ranging from large to very small capacities, are associated with sugar production for reasons of easy availability of molasses. The distilleries produce ethyl alcohol from the molasses. The molasses is diluted and fermented with yeast for about 36 to 48 hours in fermentation tanks. Thereafter, it is pumped to the distillation columns, where alcohol is evaporated by steam heating and then rectified. The water in the diluted molasses comes out at the bottom of the distillation column. In a distillery, the energy is consumed mainly during the distillation operation, where steam is used for evaporating the alcohol. On average, three kg of steam and one kg of firewood or two of bagasse are required for every litre of alcohol produced. The steam consumption could be reduced to two kg per litre of alcohol by adopting energy conservation measures such as recovery of the waste heat in the distillery effluents, which come out at about 95^{o} C, and by adopting improved distillation technology.

On a small scale, molasses is not always used, and alcoholic beverages can be prepared from locally available cereal grains like millet, rice and wheat. The grain is steamed or cooked and mashed in some cases, and then allowed to ferment for some days using local starter yeast. The alcoholic beverage in Nepal called *jad* is extracted from the fermented mash using hot or cold water. The alcohol content of such beverages varies from six to 10 per cent.

Another alcoholic drink made in Nepal is called *rakshi*, which may have an alcohol content varying between 20 to 45 per cent. Cereals like rice, wheat, millet and barley, or molasses are generally used as the major raw materials depending upon availability and also on the cultural practice. When grain is used, it is first malted and a locally available starter culture is added. The mix is then allowed to ferment for a week to a month depending on ambient temperatures. Then an aliquot portion is distilled in a specially designed distillation unit. When molasses is used as a raw material, some malted grain and beaten rice are added for starch and the rest of the process is the same as above. Different fruits are also added for their characteristic flavours. The fuelwood consumption varies between two and four kg per litre of rakshi distilled and accounts for between four and eight per cent of the production cost, which has been estimated to be NRs 50 per litre.

2.4 Fish smoking

Fish smoking is very common along the coasts and is done mainly for preservation purposes. Smoking may be “hot” or “cold”. In cold smoking, the fish is hung at some distance from the smoking fire, while in hot smoking, they are kept close, and the fish are partially cooked while being smoked. During smoking, the wood must burn slowly to produce copious amounts of smoke. Hardwood is generally used since softwoods or pinus species contain resins that impart poor taste to the product. Oak and hickory are generally regarded as producing the best flavour, although mahogany and some other wood species also give satisfactory results.

The fish-smoking process consists of the following stages: checking, cutting, removal of blood clots, salting/brining and drying. These stages are all preparatory to the actual smoking, which will take another 10 to 12 hours with the fish spread out on wire nets. After the smoking, the fish is aired and stored for sale or later use. About 2.5 to three kg of fresh fish is required to obtain one kg of smoked fish. Fuel consumption rates for fish smoking vary greatly with the type of fish, type and sophistication of the drier, and fuelwood conditions. Fuelwood consumption rates from 1.5 to 12 kg per kg of smoked fish have been reported. Various attempts have been made in Africa to introduce improved smoking and drying units, which have resulted in a 50 per cent reduction in fuelwood consumption while at the same time improving the quality of the product. By fitting a separate sawdust drier connected to the smoker by an integrated tunnel, fuelwood consumption can be lowered to 20 per cent of that in open-fire smokers.

In Asia, by tradition and consumer preference, many varieties of fish are salted and sun dried. Prior to drying, the fish must be dressed, washed, salted and cured since these processes reduce the moisture content by about 50 per cent. Unfortunately, the sun-drying process takes a lot of time (and thus involves some risk of product degradation) and often does not reduce the final water content to the desired level of about 15 per cent. The total production of smoked fish in the region is not known, but statistics show that in 1983 in Indonesia, Myanmar, the Philippines and Thailand a total amount of 92,000 tonnes of fish was smoked, accounting for about 12.5 per cent of the total recorded world production.

2.5 Sweetmeat products

Many varieties of sweetmeat are prepared in several countries, using different raw materials such as wheat flour, rice flour, sugar, khuwa, coconut, etc., alone or in combinations. The sweetmeats are deep fried in ghee or edible oil while colours, flavours and toppings are added before or after frying. The nature of the product varies in form, texture, sweetness etc. Fuelwood consumption varies with the type of sweetmeat made, but can be taken as two to three kg of fuelwood per kg of product for soft varieties, while for the hard varieties about three to four kg are needed per kg of product. The cost of fuelwood used varies between five and eight per cent of the production costs of NRs 40–50, depending on the type of sweetmeat.

2.6 Sugar products

Products based on *jaggery* or sugar, produced from sugarcane, coconut and sugar palms, are common in many rural communities, and are prepared locally. Deriving sugar from sugarcane is basically a process of crushing the cane, pressing out the juice and then concentrating it. But there are great variations between traditional and modern methods. The concentration process is mostly carried out in an open pan, either a single pan or a series of pans (up to seven) on one furnace, with the liquid is transferred on the counter-current principle. The trick is to judge the correct consistency so that when poured into moulds or pits in the ground the liquid sugar solidifies on cooling. The product so obtained is in the form of jaggery. Alternatively, the thick syrup is poured into wooden vessels and rubbed or ground with wooden pestles into powdered brown sugar. Light brown crystalline sugar can also be obtained by a process of clarification and crystallisation on straw mats.

2.6.1 Treacle is produced from unrefined jaggery which is heated in a vessel, usually a big open pan, but other vessels can be and are used. A batch usually weighs about 20 kg and takes about two hours of heating. The mass is stirred with wooden ladles or other suitable stirrers. The boiled mass, once it has changed to the correct colour, is taken out and kneaded with mustard oil, so that it does not become sticky. It is also hammered with a mallet. Then the mass is proportioned and is sold as flat pieces or round balls. The treacle becomes the base for many other preparations, mixed with sesame seed, khuwa or medicinal herb powder. This is usually a cottage industry and about 70 kg of fuelwood is needed to process 160 kg of treacle in eight batches of 20 kg each in one day by one person.

3. Metal Working Industries

3.1 Blacksmithing

Even today, the majority of blacksmiths work in villages, making and mending essential farm and household tools and implements. The workshop consists of powerful hand-operated bellows made of hides with counterweights and valves. The hearth, normally made of clay, is fired mainly by charcoal. The basic process involves heating the metal in the glowing charcoal hearth and hammering it for a number of repeat cycles to obtain the desired shape. Rough griding may be required prior to the last heat treatment and quenching. Charcoal or coal/coke may be only a small part of fuel use, but are indispensable, as they are the most effective metal reductants, as well as providing heat energy.

3.2 Foundries

Foundries are the backbone of most of the engineering industries. The larger foundries often use a cupola, which is essentially a firebrick-lined vertical cylinder. The shell or outer casing is made of steel plate about six mm thick, and within the shell a refractory lining of bricks is made. Around the base of the shell, a wind box supplying air evenly to all the *tuyeres* completely encircles the cupola. Two hinged semi-circular doors close up to form the bottom. After each run a prop is withdrawn, allowing the doors to open downward, and the remaining iron, coke and slag fall together on the floor. The molten metal flows out of the tap hole down the spout at the front of the cupola, and from there into a ladle. Another opening, called the slag hole, is located at the back of the cupola, just below the tuyeres. It allows the excess slag which floats on top of the molten iron to be removed. A charging door, through which the charges of iron and coke enter the cupola, is located in the opposite side of the tap hole, at a certain distance above the tuyeres. Good strong coke is the fuel used for a cupola. The inside diameter of a cupola determines the amounts of coke that can be burnt and of iron that can be melted per hour. If this coke could be burnt with 100 per cent efficiency, one kg would melt 12 kg of iron per hour, but, in practice, it melts only three to four kg per hour. Not much is known about the consumption of fuelwood for starting up the cupola, but by assuming that in India most foundries use the 30 inch size cupola and that the cupolas are operated every second day, fuelwood consumption can be estimated at about 45,000 tonnes per year. However, further in-depth studies are needed to verify this figure.

3.3 Brass and bronze casting

Brass and bronze articles are often cast by the lost-wax method. First of all, a wax model in one or several pieces, depending on the complexity of the article to be produced, is prepared. This is dipped in a slurry of clay until a proper thickness is achieved all around, and then sun-dried. It is again coated with layers of clay and rice husk, where the successive layers have more and more clay. A hole, which can be closed up, is left in an appropriate place in the mould. The whole is once again dried in the sun or the open air. The dried mould is then heated in a charcoal fire and the wax is allowed to drain out. The brass or bronze are melted in a furnace and poured into the preheated moulds. When the moulds are cooled enough to handle, they are dipped in water and the clay layers crack open. The product is given a final finish by joining the pieces together and engraving of intricate designs. Ordinary household metal-wares are mostly finished by turning on a mechanical lathe.

4. Mineral-based Industries

4.1 Brick manufacture

Billions of bricks are produced by numerous small-scale and larger units in all the countries of Asia. Despite the fact that it generates a good deal of employment and means high-quality construction materials are made locally, the industry is facing serious problems, in that raw materials, such as fuel (wood, coal etc.), which accounts for between 44 and 57 per cent of the production cost, is increasing in expensive. Brick making is seasonal, labour intensive and in almost all small-scale production, involves no machinery or electrical energy. The rate of output and quality of bricks depend mainly on the skill of the labourers. Bricks moulded by hand are sun dried and are fired in clamps or Bull's trench kilns, using fuelwood, agricultural residues or coal as fuel.

The firing process strengthens the bricks, as the formation of complex glass-forms takes place at temperatures of about 1000°C. Low-temperature firing results in underfiring, while higher temperature results in melting and deformed bricks. Underfired bricks are prone to efflorescence and fungus growth, are less durable and are prone to early deterioration while still in use.

Usually two types of kilns are used for brick firing. The first are batch-type intermittent kilns, like clamp or up-draft models. The other kilns are continuous types with permanent structure and fixed or movable chimneys, like the Bull's Trench kiln, the high draft (HD) kiln and the Hoffmann kiln. Batch-type intermittent kilns, often wood-fired, are employed mostly by small production units and have capacities ranging from 50,000 to 100,000 bricks at a time. Clamp kilns and other intermittent kiln types are not thermally efficient compared to the continuous type, because a large amount of heat is lost in flue gases, from open furnaces, from cooling of the fired bricks and from poor firing practices. The thermal efficiencies of these kilns are around 10 per cent, with firewood requirements varying widely depending on size of the kiln, raw brick clay composition, firing duration and firing temperature.

On the other hand, in the Bull's Trench kiln, heat in flue gases are utilised in preheating the bricks, and heat from the cooling zone is utilised in preheating of the primary air required for burning of the fuel at the firing zone. The distribution of temperature in general is found to be uniform through the whole cross section. The fire travel and draught can be easily controlled in continuous kilns, but there is much less control in clamp types. Moreover, the firing capacity of a Bull's Trench kiln is 25,000 to 30,000 bricks per day, giving five to six million bricks per six-month season. Loss of bricks due to underfiring and overfiring is higher in clamp kilns than in the Bull's Trench.

In China, another type of continuous brick kiln has been developed, called the vertical shaft brick kiln, or VSBK. This uses coal fines as fuel and, as far as is known, has not been used (or perhaps cannot be used) with woodfuels. The kiln consist of a square or rectangular vertical shaft measuring one metre by one metre, or nowadays one m by 1.5 m, (internal) with a height of about six to 10 metres. The kiln can use low-grade coal, while the specific energy consumption is said to be very low, even surpassing the most modern tunnel kilns built in the West. Efforts have been made to transfer the technology to other countries, notably Nepal, Pakistan, Bangladesh and India. The results up to now have been mixed, due to a number of reasons, among them management/labour problems and unsuitability of the clay used to make the bricks. The data shown in the table below give some typical specific energy consumption (SEC) figures for brick kilns.

Specific energy consumption data for different brick kilns

Kiln type	Location	SEC (kJ/kg of fired brick)
Single-shaft VSBK	Funan, China	970
Double-shaft VSBK	Tongbai, China	915
Double-shaft VSBK	Kathmandu, Nepal	1,030
Double-shaft VSBK	Peshawar, Pakistan	1,130
Gas-fired tunnel kiln	Great Britain	1,800
Coal-fired Hoffmann kiln	China	1,650–2,200
Bull's Trench kiln	Peshawar, Pakistan	2,820
Coal-fired clamp kiln	Africa	2,600–3,000
Intermittent updraft kiln	Indonesia	3,140

With regard to SEC values, it should be noted that widely varying data are found in the available literature. In Bangladesh, specific energy consumption of 25–36 tonnes of coal or 65–72 tonnes of fuelwood (both per 100,000 bricks) are given. These figures are higher than in India, which be attributed to differences in the heating value of the coal available, size and weight of the bricks, quality of clay raw material, firing temperature, etc. In Indonesia, average specific energy consumptions of 3,140 kJ per kg of brick in updraft (intermittent) kilns and 1,850 kJ per kg of brick in continuous kilns have been given.

4.2 Lime burning

Lime is a common traditional construction material and a cheap source of chemical raw material for various applications. Lime making is an ancient practice. The kilns used are rectangular and cylindrical in shape and are made from mud and bricks. For instance, a five-tonne capacity cylindrical kiln has a diameter of about 20 feet, a height of about 25 feet and walls about five feet thick. Four openings are generally provided at the bottom of the kiln for starting firing and for removing the lime. These openings are generally five feet wide and nine feet high.

The kiln is loaded with five tonnes of limestone in seven layers, each on average 12 inches (34 cm) thick. In between each layer, a layer of fuelwood or coal is placed. For starting the firing, some fuelwood is required even if coal or lignite is used in between layers. A charge of five tonnes of limestone gives a yield of about 2.5 tonnes of lime. Usually 10–12 unskilled workers are employed to keep a battery of kilns in continuous operation. The kilns are stopped once a week for repair. In continuous kiln types, fuelwood is required only for the initial starting of the firing. After this, limestone and coal/lignite are fed from the top. The top of these kilns are fully open for exit of hot gases and for loading. The specific energy consumption in India is about 0.34 kg of fuelwood per kg of limestone, while in Bangladesh, 1.25 kg of fuelwood per kg of lime is said to be used and in Thailand the figure of 1.1 kg of fuelwood per kg of lime has been given.

In India, a simple kiln to burn 1.5 tonnes of limestone has been developed by ASTRA. The kiln is made of pressed soil blocks and uses a grate and controlled air inlets. Alternate layers of fuelwood and limestone are stacked in the kiln and the fire is started from below. Once the bottom-most layer of fuelwood catches fire, the air-vents are closed down to four holes of three cm diameter each. These small holes facilitate slow and complete calcination of the limestone. Fuel savings in the ASTRA kiln are reported to be about 30 per cent compared with the traditional kilns. Improvement in traditional village kilns can be achieved by increasing the height so that the heat generated can be utilised fully prior to exhaust. However, an appropriate ratio between the height and diameter of the kiln needs to be established for optimising both the thermal and manual loading efficiencies.

A direct comparison between the figures cannot be given, as in the case of Bangladesh neither the type of lime (quick or slaked lime) nor the type of kiln used is given. Efficiencies of about 17 per cent have been given for intermittent kilns in Thailand and in Indonesia while for larger continuous kilns an efficiency of 26 per cent has been found. However, a well-designed kiln can have efficiency a factor two or three higher than that of the traditional kiln, but the investment cost is at least three times higher than that of the traditional continuous kiln.

4.3 Ceramics

The production of ceramic pots, bowls, jars, pitchers, traditional roof tiles, etc. is mainly a village craft, and potters invariably operate it seasonally. The entire process – mixing the clay and then throwing pots on the potters wheel or forming of roof tiles, etc. – is manually performed. The open-top cylindrical kiln and/or mound is normally fired with a mix of fuelwood, dung cakes and agriresidues. The rate of firing is controlled by the opening or closing of the bottom primary air holes of the kiln. No chimney is provided for the flue gas outlet. The fuel consumption varies from 0.5 to 1.5 kg per kg of fired product, depending on the type of fuel, size of kiln, firing temperature and duration, type of product (glazed or unglazed), etc.

The traditional production and use of earthen pots are in many countries threatened by the widespread introduction of mass-produced metal and plastic utensils. Village potteries are usually family industries, and provide the family's sole, major or additional source of earning. Future efforts should be geared towards product diversification and marketing, for example of decorative items, souvenirs, garden furniture, etc., which could help in maintaining rural people's incomes and traditions.

4.4 Surkhi (burnt clay)

Soils containing a high percentage of clay are ideally suited for production of *surkhi*, a pozzolanic material with cement-like properties generally used in construction. The clay is formed into brick-like briquettes of 7.5 by 7.5 by 2.5 cm, and are allowed to dry before stacking in the kiln with alternate layers of fuelwood. About 100 kg of fuelwood are needed for every tonne of dry clay. The firing of the briquettes must be slow to achieve uniform burning at a temperature of 700–800^{o}C. The kiln used for the production of surkhi is the same as that for the manufacture of lime. The burnt briquettes are crushed, and the crushed material can then be fine-ground in a ball mill until the particle size is finer than 90 microns. Use of rice husk (10 per cent by weight of clay) in the clay briquettes reduces not only the fuel consumption but also the grinding energy required and results in a better pozzolanic activity. Hence it is desirable to use a mixture of rice husk and clay whenever rice husk is available. In this case, fuelwood is needed only for lighting the kiln.

5. Forest Products Industries

5.1 Extraction/distillation

In Nepal, *katha* and *kutch* are extracted by boiling chips of the heartwood of *Acacia catechu*. Katha, chewed with betel nut, is the main product and kutch, a crystalline substance used in tanning leather, is a by-product. Essential oils are distilled from wood like juniper, fir etc. by steam distillation and separation of the essential oil from the condensates, while extracts are also made using hot water or other solvents. Rosin and turpentine, which are used for paper, soap, paint and varnish productions, are steam distillation products from the crude resin, which is tapped from chir pine (*Pinus roxburghii*). The distillation of crude resin yields about 65–75 per cent rosin and about 15–20 per cent turpentine. The fuelwood requirement is not known.

Options for energy conservation:

No information available.

5.2 Paper making

5.2.1 Small scale – hand-made paper. Hand-made paper based on forest products is an industry found in some countries in the region. In Nepal, the bark of *lokta* (*Daphne spp.*) is boiled with ash lye or, nowadays, with a caustic soda solution. The boiling or digestion is done in two stages, with the bark being cleaned in between. Each cooking lasts around three or four hours. The mass is finally washed with water and then pounded with wooden hammers to produce a proper pulp. An aliquot portion of the pulp is taken in a mould-frame with cloth backing and the pulp is distributed evenly in the frame with a swinging movement in water. The paper is sun dried on the frame itself and peeled off. Modern innovations are the use of pressure digesters, and ensuing steam to heat metal plates over which the stacks of wet paper sheets are dried to some extent. Hollander-type beaters are replacing hand pounding in some units. The pulp is mixed with a mucilaginous substance like propylene dioxide and lifted on wire frames, couched and pressed to drive out water.

5.2.2 Large(r) scale – paper and paper board products. Paper and paper board factories can be classified into four main categories with respect to the processing of the pulp, which are:

a. Units which have hydra-pulping facilities in order to convert waste paper into pulp to be used as a raw material for producing wrapping paper, paper board or corrugated paper;

b. Units which have a digester for chemical treatment of agricultural residues like rice straw for making pulp, without bleaching facilities, to manufacture straw board or kraft board;

c. Units which have fully fledged capacity for chemical digestion of agricultural residues along with bleaching facilities to produce kraft paper as well as writing and printing papers;

d. Units processing bamboos and hardwoods as the principal raw material along with soda recovery and bleaching facilities to produce pulp which can be offered to other units to manufacture a wide range of papers and paper products.

Large and medium-scale paper-manufacturing units use coal or lignite in the steam boilers, whereas small-scale units use fuelwood, lignite etc. The small-scale units are mainly engaged in the production of mill board, gray and straw boards.*5*

5.2.3 Particle board production

Particle board production basically involves size reduction of the wood, drying, screening, mixing with resins and additives, forming of a so-called mat, pressing and finishing. All types of wood are used for the production of particle board, such as solid wood and solid wood residues (off cuts, trimmings, etc.). However, low-grade waste such as hogged sawmill waste, sawdust, planer shavings, etc. are also used nowadays. Due to this wide variation in raw materials, the wood has to be sorted by size and specie before size reduction, for which chippers, knife ring flakers, hammer mills, disc refiners, etc. are used. After size reduction, the wood particles have to be dried down to a moisture content of around three to eight per cent to facilitate bonding of the particles with the liquid resins.

The particle drying is a continuous process, with the particles moving along the length of a rotating horizontal drier using hot air as the drying medium. The air is heated in heat exchangers (using steam, hot water, thermic oil), with the heat being produced by the burning of residues, oil or gas. Immediately after drying, the particles are screened and sized. Oversized particle are recirculated and fines (about five per cent of the total) are discarded for use as fuel, etc.

The dried and sized particles are then mixed with adhesives such as urea, phenol and melamine formaldehyde. Adhesives used represent from three to 10 per cent of the finished board by weight, while other additives for purposes such as making the board fire resistant, may also be added. The particles are then spread evenly in moulds or on mats, making sure that the particles are evenly distributed and that the finest particles form the surface layer while the coarser particles are used for the core. The moulded layers are then pressed between heated platens in a press (140–200^{o} C, depending on adhesive and/or type of press used) with heat being supplied by steam, hot water or oil.

After pressing, the boards are cooled, trimmed (about 17 per cent of the boards are lost as trimmings, but these are, however, being recycled) and planed and/or sanded (about five per cent residues are generated in the form of sander dust, which are normally us used as boiler fuel) to attain the required thickness (19 mm is the most common).

Energy consumption varies widely with plant capacity (rated and actual), age, species used, etc., but in general will be from two to 4.5 GJ per m^3 produced. For units with a production capacity of

100–500 m^3 per day, the energy input is about 160 kWh electrical for hardwood species or 120 kWh for softwood, three GJ of thermal energy for hardwood or two GJ for softwood and about three litres of diesel oil for material transport within the plant, all per m3 of particle board. Overall, electrical energy accounts for about 18 per cent of energy consumption, while thermal energy accounts for the remaining 82 per cent. Particle drying accounts for 61–62 per cent and hot pressing for 20–21 per cent of the energy consumption.

Options for energy conservation:

Various options for energy conservation exist. Energy conservation measures in drying would probably have the largest impact, such as heat recovery of the drying air, using the exhaust gases of boiler systems for preheating of air, etc.

5.4 Plywood production

Plywood making is a large-scale operation and involves, after receipt of the logs, cutting them to the required length, debarking and cleaning them. After these preparatory operations, the logs are sliced, i.e. the logs are rotated in a machine, while a knife slices or peels off veneer sheets. The veneer is then cut to the required size and dried and is then ready for further processing. The dry veneer slices are sorted, with sheets which have holes or other irregularities being rejected. The sheets are then glued and hot pressed into plywood sheets, The plywood sheets are trimmed (cutting into standard sizes), sanded and graded, and are then ready to be shipped. Waste is generated during several steps in the process: five per cent of the amount of logs used as raw material input becomes waste in the form of log ends; the bark forms another five per cent; round-offs, log cores, trimmings and rejected veneer form the largest amount of waste (25–30 per cent of the log input); while sanding the plywood sheets results in another five per cent loss in the form of sander dust.

During the process, power is needed along with heat in the form of steam for drying, hot pressing, etc. The power consumption varies widely with the size of the plywood mill and is stated to be anywhere between 120 and 300 kWh per m3 of plywood. In some plywood mills, steam is used to produce electricity with turbines, but often, particularly in Indonesia, diesel engines are used to generate the electricity. The amount of steam required is not known.

Options for energy conservation:

- The use of woodwaste for heat and power generation, using boilers and steam turbines in stead of diesel engines (cogeneration).
- Installation of more efficient steam boilers (high-pressure boilers).

5.5 Sawmilling

Energy in the form of electrical or mechanical power is used in the sawmilling process. In the conversion of logs into sawn wood, considerable quantities of residues are produced in the form of bark (about 12 per cent of log input) off-cuts, slabs and trimmings (about 34 per cent of log input), saw dust (12 per cent of log input), etc. Such residues could be used to generate power and process heat (for drying) through cogeneration. Gasification of the residues is also possibly an option where reliable gasification systems can be obtained.

5.6 Timber drying

Timber needs to be dried, particularly if it is to be used for good-quality products, and this is done in a drying kiln, which is essentially an air-leak-proof structure made of bricks or other suitable materials. The size of the kiln varies with its required capacity. It has loading and unloading doors and is equipped with auxiliary equipment for heating, humidifying, venting and air circulation. Heat is normally provided by burning fuelwood or woodwaste in a furnace connected to finned or unfinned pipes inside the kiln, which act as heat exchangers. Circulation of hot air using one or more fans inside the kiln is necessary, as otherwise localised drying could occur, which could have a negative effect on the timber quality.

The drying process, which is carried out according to a drying schedule, consists of three stages: a) the warming up and initial drying period, b) the main drying period and c) the final drying period, which includes equalising and conditioning treatments. The drying schedule depends on the type of wood species, size and thickness of the timber, initial moisture condition, etc. A timber which is moderately difficult to dry would require about 315 kg of fuelwood per m3 of dried timber, while the costs of the fuel, in a small kiln, can be up to 60 per cent of the operating costs.

6. Textile-based Industries

6.1 Fabric printing and dyeing

The fabric printing industry generally requires abundant steam, for which steam boilers are used. In fabric printing, the following processes are used: setting, printing and finishing. Colour fixing in the printing process normally requires heat, and while this used to be done by passing steam through the processing pan, it is now done by silicate processing. With this new process, steam is not required and the fabric, after printing, is passed through a silicate solution and then kept for curing from six to eight hours at room temperature. Afterwards, the fabric is washed in an open place, e.g. in fields outside the factory. Plenty of water and space are required for washing and drying in sunlight. Warm water, at approximately 40° C, is required for washing, which is done in big aluminium containers heated with fuelwood. Approximately 50 kg of fuelwood is required to warm the water, sufficient to wash 500 pieces of cloth of *sari* size.

6.2 Silk yarn processing

Sericulture (rearing silk worms, and silk yarn and silk fabric processing) is a labour-intensive rural activity combining agriculture and industry, and has recently created good opportunities for the socially and economically weaker sections of rural societies, particularly women, in many countries in Asia. At cottage industry scale, silk cocoons are boiled in water over traditional stoves. Fuelwood is the main fuel used. The production of raw silk, yielding about 400 grams of silk thread from one kg of dry cocoon, is very common in rural areas of countries like Bangladesh, China, India, Pakistan and Thailand. In India, about 25 kg of fuelwood is required to produce one kg of silk yarn, while in Pakistan, 15 kg is said to be required per kg of silk cocoon.

More efficient and smokeless stove types could improve the working environment (by reducing exposure to smoke and heat) and conserve fuelwood in improving the overall performance of the industry. It is estimated that a quarter to one half of the quantity of fuelwood presently used can be saved with more efficient stoves.

7. Miscellaneous Industries and Village Applications

7.1 Ceremonies

Religious ceremonies, such as *yagyas* and *homs* in Nepal, are essentially open-air bonfires, with specified wood species used as fuel, at least at the start, and the feeding of cereal grains and clarified butter, frequently accompanied with prayers and worship. The small ceremonies may consume only five to 10 kg of wood, whereas the most elaborate ones may need all the logs from a good sized tree. In these, it is the production of flames and odour that is most important, rather than the utilisation of heat. In some cases, there are fixed traditional sites for the fire, but in the majority of cases it may be made anywhere. Most of the fakirs (*sadhu*) sit before a fire. The eternal fires have fixed locations. In India, tonnes of fuelwood are burnt during the *holi* festivals every year. Fuelwood usage varies greatly from one place to another, depending on availability of and access to natural forests and on cultures, customs, rituals etc.

7.2 Cremations

An important use of fuelwood in quite a few countries is for cremations. The funeral pyre is generally one metre in height, two metres long and less than a metre in width, with the logs criss-crossing the layers and with gaps of about 20 cm. In most cases, extra fuelwood is added as it is needed. To save fuelwood, a covering of wet straw is sometimes made. Cremations are usually done along river banks, especially around confluences, and certain communities have fixed locations.

In India, the scarcity of fuelwood and its high price have created a very serious problem for poor families. It is common to see remains being thrown into rivers. About 220 kg of fuelwood and 50 kg of cow dung cake are required for one cremation, in addition to other ingredients according to social status and local customs.

It can be noted here that improved designs for wood-burning crematoria have been developed in India and are currently being promoted. In addition, electrically powered crematoria facilities have been made available at a number of places, especially in cities. However, a lot of people, in particular those from villages, prefer to use fuelwood, as it fits in with their customs and rituals. The total expenses incurred in a cremation using a traditional pyre is about IRs 400, while where an electric-operated crematorium is used, only IRs 100 is needed.

7.3 Extraction of animal tallow

The Khadi and Village Industries Commission (KVIC) in India has established flaying centres in the vicinity of major urban areas all over the country. Dead animals are collected and taken to the centres. After flaying the skin, the fatty mass is fed into large open pan or vertical drum cookers, up to 300–400 kg per charge. The open pan or drum is heated underneath by burning fuelwood in a simple hearth. The content is boiled for a period of eight to 10 hours. The fat portion, floating on the top, is removed manually, whereas the left-over mass is sold for poultry feed production. The extracted tallow is sold for making laundry soap. Each centre processes about 300 animals a month in four or five cookers. Approximately 30 kg of fuelwood is used in each cooker, and five kg of animal tallow is extracted. Hence, the ratio of fuelwood to animal tallow is 6:1. Considerable fuelwood savings are possible if the cooker and stove are redesigned.

7.4 Road tarring

Substantial amounts of fuelwood are used in most countries of the region for preparing the mixture for surfacing and repair of local roads. Open fires are built at roadsides to melt the coal-tar or bitumen, and for heating gravel and sand to remove moisture. Sometimes, specially constructed movable furnaces are used. The efficiencies of the open fire and the movable furnace are very poor. Practically no attention has been paid in this direction. It has been estimated that in Nepal, for an area of about 10 m2 of new roads, about 50 kg of bitumen is needed, and this would require, where an open pan is used at the roadside, about 70 kg of fuelwood, dropping to about 20 kg where an efficient hot-mix system is used.

7.5 Soap manufacture

Soap, at the small scale, is prepared by boiling a mixture of oil and fat and a caustic soda solution, with constant stirring, to complete saponification, so that neither excess oil and fat nor caustic soda remains. Rosin, sodium silicate, talcum, alkaline earth etc. are added as washing aids and fillers in washing soaps. From the start of heating the charge, the process takes about two or three hours. When the mass has cooled down and begun to solidify, it is hand shaped into balls of the required size. The soap mass may be mechanically treated in a pug mill, with the addition of colour and perfumes, and extruded into bars which are cut into cakes and stamped. In bigger units, the heating is done by steam under pressure.

A small unit with the capacity to produce 50 to 100 kg of soap per day uses a stove over which the soap solution is boiled in open pans. A soap unit manufacturing 400 to 500 kg per batch requires an amalgamator, a milling machine, a plodder and a cutting and stamping machine. About 250 to 300 kg of wood is required for a batch of 400 to 500 kg of soap. A larger unit, having the production capacity of one tonne per charge, is normally equipped with a soap-boiling pan with an arrangement transferring heat through the pans with closed steam coils. Medium and large-scale soap manufacturing units use coal, lignite or oil-fired boilers for steam generation. A medium-scale soap manufacturing unit produces about 500 tonnes of soap per month using fuelwood and/or lignite in the boiler. About 2.5 tonnes of steam, is required to produce one tonne of soap.

The cost of generating one tonne of steam in India has been worked out to be about IRs 175–200 depending upon the quality of fuelwood and lignite. The cost of heat energy input, although forming only a small part (2.8 per cent) of the production cost, can be reduced by using a more efficient boiler and furnace.

7.6 Tyre-retreading

The process of tyre-retreading consists of the following stages: buffing of used tyres, spraying of rubber solution, fixing of tread rubber and vulcanising of the retreaded tyre in a moulding machine. A continuous supply of fuelwood to the boiler is required to generate steam to achieve the required working temperature. On average, one tonne of fuelwood is required to generate sufficient steam for vulcanising about 50 tyres.

7.7 Restaurant and catering industry

This primarily involves cooking of food and drinks, and often, to a lesser extent, heating of water and space. Boiling, frying, baking and grilling are the four main types of cooking. In the boiling process, food and water along with some additives such as salt and spices, are heated to the water's boiling point for a certain length of time, depending on the type of food and cultural practice. Frying may be shallow frying, with some coating of oil in the pan, or deep frying, where the food is actually immersed in hot oil and the temperature is maintained near about 170^o C. Baking involves heating the food from all sides in an oven, and the temperature involved is around 250^o C. Grilling can be described as the cooking of food directly over or under the heat source. In between these four ways of cooking are various other styles, depending on locality and tastes. In most catering establishments, the fire is kept going for a long period of time during the day and the evening, and adjusted according to need. Stoves or furnaces used range from simple three stones stoves to more complicated and bigger versions, with or without a chimney, and grates are evident in only a few cases. Fuelwood is often preferred because of its availability and convenience of use. Unfortunately, not much is known about these village applications to make a further description.

List of Abbreviations

ASEAN	Association of Southeast Asian Nations
Cogen	EC-ASEAN Cogen Programme
CTA	chief technical adviser
DENR	Department of Environment and Natural Resources, the Philippines
EC	European Community
FAO-HQRS	Headquarters of the UN Food and Agriculture Organisation
FFB	full fruit bunches
FRIM	Forest Research Institute Malaysia
GDP	gross domestic product
GEF	Global Environmental Facility
GJ	gigajoules (billion joules*)
GO	governmental organisation
Gt	gigatonnes
GW	gigawatts
GWh	gigawatt hours
ILO	International Labour Organisation of the United Nations
ITC	International Institute of Aerospace Survey and Earth Sciences, in the Netherlands
J	joules
kgoe	kilogrammes of oil equivalent
kJ	kilojoules
kWh	kilowatt hours
LPG	liquefied petroleum gas
Mcal	megacalories (million calories)
Mtce	million tonnes of coal equivalent
MTDC	Malaysian Technology Development Corporation
Mtoe	million tonnes of oil equivalent
MW	megawatts
MWh	megawatt hours
NATCOM	National Advisory Committee
NATWEG	National Wood Energy Working Group
NGO	non-governmental organisation
NR	Nepalese rupees
PJ	petajoules (thousand trillion joules*)
POME	palm-oil mill effluent
PV	photo-voltaic
R&D	research and development
RM	Malaysian ringgit
Rp	rupee
Rp/MJ	rupee per megajoule
SFC	specific fuel consumption
SME	small to medium-scale enterprises
SMI	small to medium-scale industry
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organisation

* One billion here equals 1×10^9; one trillion is 1×10^{12}