PACIFIC HOUSEHOLD AND RURAL ENERGY SEMINAR

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PREFACE

The Pacific Household and Rural Energy Seminar, which was held in Port Vila, Vanuatu, from November 5-9, 1991, was organized by the World Bank/UNDP Energy Sector Management Assistance Programme (ESMAP) and the Pacific Energy Department Programme (PEDP). Support was also provided by the Forum Secretariat Energy Division, the European Community and the United Nations Fund for Science and Technology for Development.

This document, which consists of two volumes, brings together a summary of the delegates' deliberations as well as the papers presented during the Seminar week. The papers presented by country delegates and consultants have been reproduced largely in their original form. However, there are instances where minor editing was deemed necessary or where faulty diskettes prevented full recovery of complete texts. In the latter case, more extensive editing was done.

I. SUMMARY

OVERVIEW AND CONCLUSIONS

The seminar was held to identify and discuss the principal issues and options in the household and rural energy sector in the Pacific island countries. The aim was to provoke an open debate to obtain preliminary information on key issues for consideration in the forthcoming Pacific Regional Energy Assessment (PREA). 1/ The seminar was also expected to produce a series of recommendations for action by donor agencies and the governments of the participating countries.

Seventeen countries and territories, in total, were invited to the seminar. They occupy a vast area of many millions of square kilometers of ocean. The populations represented ranged from the 8000 people of Tuvalu up to the 3.5 million of Papua New Guinea. Levels of economic development and resource endowments show an equally large range of variation.

The challenge was to find common ground for the analysis of problems and discussion of the potential solutions which might be applied. This summary paper attempts to weave together seminars the main themes and provide a synthesis of the principal conclusions reached.

Key Constraints on Energy Sector Development

Development of the energy sector in most of the countries is heavily constrained in a number of ways. Apart from Papua New Guinea, none of the countries has any known fossil fuel reserves. Indigenous energy resources are mostly in the dispersed form of biomass and renewables, principally hydro and solar.

The fact that the national territory of many of the countries is divided into a large number of islands, often separated by long distances, imposes heavy transport and communication costs. Tuvalu, for example, consists of nine coral atolls widely scattered over 1.2 million square kilometers of ocean. Such dispersion of the national territory makes it virtually impossible to achieve the economies of scale which can normally be obtained as energy demands increase and diversify.

In some countries, the lack of purchasing power in the rural areas makes it difficult to recover the costs of rural electrification, or indeed of any rural energy initiatives. In the Solomon Islands, for example, the great majority of the rural population live by subsistence farming and fishing.

In other countries, rural incomes may be considerably higher and are often complemented by substantial remittances from abroad. But even where rural purchasing power

1/ The PREA is a joint programme of the World Bank, the PEDP and the Forum Secretariat Energy Division (FSED) under the World Bank management.

and consumer expectations are high, the generally small and dispersed population base makes it difficult to obtain an adequate return on investments in energy infrastructure.

The fact that a high proportion of land is held under customary tenure can be another major obstacle to energy developments. Negotiating rights to the use of land for a minihydro scheme, together with its access roads, can be time-consuming and expensive if not a complete blockage to carrying out the project.

Small populations also make it difficult for governments to establish energy sector agencies with the critical mass required for project assessment and the development of policy. The result is that a high proportion of the energy programmes which have been carried out in the region have been donor-driven, reflecting the preoccupations of the agencies concerned rather than the real needs and priorities of the recipient countries. Many countries resent the fact that the consultants provided under such programmes often have little awareness of local conditions and consequently lack the ability to identify local problems or devise relevant programmes of action in the energy area.

Major Issues of Concern

Fuelwood is the main cooking fuel throughout the region. This is particularly the case in the rural areas where cooking by conventional fuels is relatively uncommon. In areas where copra is produced, coconut shells and fronds tend to be plentiful and are frequently used as a supplement to woodfuel for domestic cooking and copra drying.

In most of the urban areas, fuelwood is still the main domestic cooking fuel, though the use of kerosene is becoming increasingly common. In some countries, LPG is also used for cooking in the urban areas, mainly by the better off. The use of electricity for cooking is mainly confined to upper income urban families. Where an electricity supply is not available, kerosene is used for lighting in both urban and rural areas.

While the total wood resources of the region are large in relation to the population, only a small proportion are readily accessible. The result is that traditional sources of fuelwood are coming under pressure in many places. The high population growth rates in most countries mean that the natural forests are being cleared in order to increase the area of land under subsistence agriculture. Cash crop cultivation and beef and dairy farming also involve the clearing of the natural forest cover especially in the coastal plain areas. The loss of natural forests in this way is sometimes described as agro-deforestation.

Logging is carried out on an extensive scale in a number of countries. While this has obvious environmental implications, it has little direct bearing on woodfuel availability as a considerable proportion of the trees as well as large quantities of logging waste are left behind. Sawmill wastes also represent a substantial addition to local fuelwood supplies but remain unutilized in most cases.

Agro-deforestation, in contrast, reduces the supply of fuelwood in the immediate vicinity of people's homes. In such areas people therefore find that they must travel further to obtain their woodfuel supplies.

Imported petroleum fuels supply the bulk of the commercial energy demand in all the countries of the region. They are used for land and sea transport, power generation, and, in the form of kerosene, for lighting and a certain amount of cooking. Consumption continues to grow, albeit slowly; the annual growth for the whole region in the period 1984-98 was just 0.8% per year. As there is little prospect of significantly reducing this dependence, paying for oil imports is going to remain a problem for most of the countries of the region.

There is strong pressure in many countries to increase the pace of rural electrification. The generally low levels of rural electricity demand and the dispersed communities being served, however, mean that rural electrification programmes tend to be technically difficult and almost always costly to implement.

Extending the grid to small island communities is not a feasible option. The use of isolated diesel generators is the most common approach but the costs of this can be extremely high and maintenance can be a major problem. Microhydro is of limited application in about half the Pacific island countries and tends to be expensive.

Photovoltaic systems can provide the small amounts of power required for lighting, but the capital costs are high. Fuel costs are zero and the maintenance requirements are, in principle, very much less than for diesel. But experience has shown that unless there is adequate organizational backup to ensure that spare parts are available when needed and the maintenance requirements are met on a regular basis, a high proportion of photovoltaic systems go out of action within a couple of years.

Because of the high costs of rural electrification, subsidies are commonly provided. The precise rationale and justification for these are often unclear. It is not, for example, necessary to provide all rural consumers with heavily subsidized supplies in order to ensure that electricity is available at schools and health clinics. The result is that, despite their cost to the governments concerned, rural electrification subsidies are often economically and socially inefficient.

The institutional capacity to address and resolve energy issues in the household and rural energy sectors in an integrated and systematic manner is lacking, or weak, in most of the Pacific island countries. To a large extent, this is because energy, apart from the electricity and petroleum sectors, is rarely a government priority and energy offices 2/ tend to be poorly supported and funded. Rapid turnover of staff is also a common problem and leads to a lack of institutional memory and a poor capacity to benefit from experience.

The result is generally to the detriment of the energy sector. Issues are often poorly understood, the full range of options available for resolving them is unexplored, and the policies adopted by governments are less effective than they might be. The projects which do take place tend to be extremely small, technically based, donor-driven, and often of scant relevance to local needs.

Need for Systematic Data Collection and Analysis

The data base on biomass fuel resources and consumption patterns is generally poor. Although numerous surveys, of varying coverage and quality, have been carried out, these provide no more than a snapshot picture of conditions and behavior at a particular time. It is also worth

2/ The expression "energy office" is used to designate the government agency or administrative unit with primary responsibility for energy matters.

noting that many of these surveys were carried out at the urging of donors rather than as a response to any clearly perceived need for the information at a national policy-making level.

The great majority of the surveys which have been carried out give no information on how fuel consumption patterns are changing with time, how people react to changing availability of fuelwood, what economies or fuel substitutions they make, and how important or difficult they feel such adjustments to be.

A number of surveys, for example, have suggested that fuelwood scarcities are being experienced in certain areas and, in response, have proposed a variety of actions including improved stove programmes and the promotion of fuelwood plantations. But because of the lack of any quantification or agreed definition of what scarcity means, it is impossible to know whether local people feel such responses are appropriate.

Before realistic proposals for interventions in the fuelwood sector can be formulated, it is necessary to go beyond simply finding out whether people consider fuelwood to be scarce. It is also necessary to know what actions, beyond economizing on fuel use or substituting other readily available fuel sources, they are themselves prepared to take to deal with the problems they are facing. There is therefore a need, not just for the collection of consumption data, but for carefully designed and structured surveys on attitudes to fuel use, preferences between fuel types, and the actions that people would themselves be willing to take to increase their supplies or improve the efficiency with which they use household energy.

Data on household and rural energy use are also scarce in the petroleum sector. It is known, for example, that kerosene is universally used for lighting; but little is recorded about the number of rooms lit, the time during which lighting is provided and the activities carried out. Similarly, it is known that kerosene and LPG are used to a certain extent for cooking in the urban areas, but virtually nothing is known about what motivates people to make the switch away from fuelwood to the use of such fuels.

In many countries, heavy subsidies are provided for both urban and rural electrification; it is believed these are essential if programmes are to succeed and access to electricity is to be equitably distributed. There are, however, still serious gaps in the knowledge about electrification and its role in the developmental process. It is therefore impossible to say whether these subsidies are necessary or efficient in achieving their developmental and social objectives.

<u>The Role of Women</u>

Women, because of their central role in the family, are the most deeply concerned with the availability and use of household energy. When wood becomes scarce, they usually have to bear the brunt of longer collection times; though in parts of Polynesia, woodfuel collection is done mainly by men.

Everywhere, it is the women who must make adjustments in cooking methods when there is an enforced switch from firewood to less convenient biomass fuels. Women are also central to the decision to switch from fuelwood to conventional fuels with all its implications for cooking methods, the types of food cooked and the impact on the household budget.

It is therefore vital that women are consulted when efforts are made to design improved cooking stoves whether to save fuel, reduce cooking times or improve the kitchen environment. Stove programmes have no hope of success if the advantages they offer have a low priority among the target group of women.

When rural electrification is being planned, it is almost universally assumed that lighting is the highest priority for rural electricity use. In fact, rural electrification is frequently seen simply as the provision of rural lighting.

Because of this, rural electricity supplies are often only provided during the evenings, or are based upon the use of photovoltaic lighting systems. While there is no doubt that women welcome the availability of light, they are rarely consulted to find out if this is all they want from rural electrification. If they place a high priority on the use of domestic appliances such as irons, kettles, fan or other means of reducing their workloads, improving their living conditions or developing home-based income-generating activities, the present approach to rural electrification in many countries will need to be fundamentally reconsidered.

Energy Conservation

Petroleum imports are a major burden on the balance of payments of most countries in the region. This is particularly the case at present when oil prices have been raised by the Gulf crisis. But even at pre-crisis prices, oil imports represented a substantial drain on scarce foreign currency resources.

Energy conservation offers major opportunities for improving the efficiency with which petroleum and other fuels are used in the economy. This is particularly important when, as is the case over most of the region, the bulk of electricity generation is by diesel.

There are, for example, many cost-effective electric appliances which are little known and often not even available in the region. This is largely a result of lack of knowledge on the part of governments and the public as well as the higher initial costs of such appliances. In the case of light bulbs, or globes as they are known in the Pacific, the new fluorescent types have up to five times the efficiency of conventional incandescent bulbs and last up to ten times longer. Although highly cost-effective over their lifetime, these tend to be little used because of their high initial cost which is 10-20 times higher than the conventional type.

The use of energy in commercial and government buildings, especially for air conditioning, is grossly wasteful in many cases. Energy audits can play at important role in highlighting the areas of greatest waste and identifying the most effective ways of reducing it. Campaigns to heighten public awareness, and inform people of where they can make energy savings may also be effective in promoting a more economical use of energy imports. Such campaigns can be reinforced by incentives in the form of credit, or by higher tariffs.

Energy conservation programmes not only save petroleum imports. They can also delay the need for expansions of the electricity supply system thus saving on capital investment.

Available Technical Options

The available technical options for intervention in the household and rural energy sectors are often extremely limited. This is particularly the case where woodfuel, or other biomass substitutes, are not yet commercialized. People who do not pay for their domestic fuel are normally not interested in paying for methods of improving their efficiency of energy use. Neither are they likely to invest time or other resources in improving the level of woodfuel availability by planting trees.

Where biomass fuels are commercialized, a wider range of intervention options is normally available. Improved stoves, for example, may enable women to reduce the family expenditure on woodfuel, or make better use of the amounts they normally purchase. It is important to note, however, that the benefits of improved stoves are almost entirely felt at a household level; even if programmes are extremely successful they are likely to have little impact on agro-deforestation.

Rural electrification needs to be carefully considered at both an institutional and technical level. Some of the seminar participants felt strongly that it is best handled by an agency which is organizationally separate from the electricity utility.

Technically, there may be a range of supply options available for rural electrification programmes. If extension of the grid is not feasible, the choice can include diesel, photovoltaics, minihydro where the conditions are suitable, and occasionally biomass steam systems. Particular care needs to be taken in the case of photovoltaics to ensure that potential users are provided with assistance in sizing the installation and choosing equipment with a proven record of reliability.

In all cases, it needs to be borne in mind that the task is to meet the local electricity demand as cheaply and effectively as possible. It is important that the choice of technology does not predetermine and impose the pattern of consumption but is, rather, based upon the needs of consumers. The crucial factor when assessing different options is the cost of providing the required service, rather than the cost per kWh of electricity.

When renewable energy sources, such as photovoltaics, are being considered, it is legitimate to consider their lifecycle costs. Although their initial costs are generally much higher than diesel, their running and maintenance costs are much lower.

But it is also important to compare renewable energy sources on an equal footing with conventional alternatives. If this is not done there is a danger that they will be promoted for their own sakes, rather than because they are the optimum technical solution. This is a particular danger when funds for rural energy projects are made available from the arm of a donor agency with a particular mandate for the promotion of renewable energy systems.

A number of surveys have found that dry cell batteries are an important element in family expenditure especially in remote atolls and villages. The use of rechargeable batteries, possibly relying on solar rechargers may be able to offer significant savings to consumers, as well as cutting down on battery imports. This option deserves to be further studied, though it met with limited success in Fiji.

Environmental Implications

Agro-deforestation is probably the main environmental threat in most of the countries of the region. This has serious long term implications for the countries concerned but there is little, if any, effective action which can be taken in the energy sector to counter or alleviate this. Similarly, worldwide threats, such as global warming, or regional issues such as nuclear testing or waste incineration are outside the scope of local energy planners.

There are, however, a number of specific areas where energy is directly involved. Oil spillages especially at service stations are, for example, becoming an increasing menace in some areas. Discarded lead acid and dry cell batteries are also becoming a problem in some areas.

The environmental legislation varies greatly across the region. While some countries, as yet, have little environmental legislation in place, others have a framework which, at least in principle, provides them with the necessary powers for the assessment and regulation of the environmental impact of energy activities. The capacity and will to enforce such environmental legislation is, however, lacking in many cases.

Energy Pricing

Energy pricing is a matter of considerable concern to both governments and consumers. In the case of petroleum fuels, the basic price of imports is largely outside the control of governments, though 10-20% reductions in wholesale or bulk supply prices have been obtained by governments as a result of firm negotiations.

Electricity tariffs, however, offer a much wider range of discretion to governments and utilities and the way in which the benefits of subsidies, if they are used, are distributed. Care should be taken to ensure that subsidies which are used should not continue beyond when they are justified. It is therefore important that pricing policies are subject to regular review.

It was broadly accepted by the seminar participants that energy consumers should not be shielded from the true costs of the energy they consume. Thus, rises in petroleum products prices as are happening at present as a result of the Gulf crisis will, in general, be passed on to consumers. Similarly, in the case of urban electricity supplies, it is generally agreed that consumer charges should cover the full costs of the supply.

In the case of rural electrification, it was felt that consumers should be charged at least the full operating and management costs of their supply. This would not preclude the provision of subsidized supplies to rural schools, health centers and other social and public services.

In order to enable people to benefit from photovoltaic systems which require a high initial investment but have low recurrent costs, it is essential that financing methods which allow consumers to pay off these costs in regular installments are developed and put in place. Such charges must, however, be realistically related to the capital and maintenance costs of the installation. Users must also be made responsible for wilful damage to equipment. Experience across the region clearly shows that programmes where photovoltaic systems are installed and maintained free of charge invariably fail because of lack of proper care and maintenance of the equipment.

Capital subsidies, in the form of low interest rates, may also be acceptable in the case of rural electrification programmes, especially in the early years. There must, however, be a realistic prospect of demand growth and hence an improving rate of return with time.

Institutional Issues and Options

The list of functions which, ideally, need to be fulfilled if energy planning and policy making is to be effectively carried out at a national level include the following:

(a) Assessment of energy resources;

(b) Collection of data on consumption patterns and what determines them;

(c) Monitoring the technical and financial performance of existing energy organizations and proposing options for improving them;

(d) identifying problems and areas where effective energy-related intervention is possible;

(e) Assessing and evaluating the options available for such interventions;

(f) Providing energy policy recommendations and advice to government;

(g) Raising awareness and educating the public on energy issues.

(h) Supervision of the implementation of energy projects;

(i) Monitoring and evaluating the performance of completed energy projects as a means of providing feedback into policy-making.

The reality in most countries falls far short of this ideal. Energy policy tends to have a low national priority, especially in the household and rural energy sectors. Energy offices are generally under-staffed and poorly funded.

Improving this position requires a realistic assessment of the resources likely to be made available for energy offices. It also requires a realistic assessment of priorities within the household and rural energy sector bearing in mind that energy policy is not an end in itself but simply one of the inputs to an overall strategy for the achievement of overall national developmental goals.

In countries where there is adequate organizational capacity, and a sufficient volume of work, a central energy office, mandated to carry out all, or a high proportion of the functions listed above, may well be justified and feasible. In the smaller countries where, realistically, the energy office is unlikely to be staffed by more than two or three people, a high degree of prioritisation of tasks will be required.

In all cases, it is essential that the work of the energy office is firmly rooted in local needs and priorities. Where a large centralized energy office is established, it is important that it does not become isolated from concerns at a village and household level.

Selection of potential solutions to energy problems requires careful dialogue with those who are expected to be the beneficiaries. When household energy programmes are being planned, it is particularly important that women's priorities are identified and taken into account.

It is essential that the relationship of the energy office with other agencies in the energy area clarified and the respective spheres of responsibility are defined. This is particularly important in relation to the electric power and petroleum sectors. In some cases, it may be appropriate for the energy division to have an overall coordinating role in these sectors, thus preventing the fragmentation of expertise and policy-making capacity; in others, the energy division may simply provide a service in the form of information and advice.

External assistance to the household and rural energy sector will normally be channeled through the energy office. In filling this role, the energy office has the important function of rejecting or redirecting inappropriate projects and ensuring that the projects which are implemented are relevant and sustainable. The energy office will also be the initiating or coordinating agency for requests for donor funding and technical assistance in the household and rural energy sector.

The exact definition and allocation of the tasks of the energy office will thus depend upon the size of the country and the magnitude and complexity of the energy problems it faces. Given the limitations in funding and staffing which inevitably apply in the smaller countries, many of the tasks will require the assistance of other government agencies, NGOs, consultants or outside agencies. Church groups because of their widespread presence and powerful influence can also play an important part. In countries where the internal technical and administrative capacities are greater, the role of external agencies will be correspondingly reduced.

The role of the PEDP up to the present, and the FSED, from next year onwards, in providing specialist assistance and advice, as well as training for energy personnel is absolutely vital to the effective functioning of energy offices throughout the region. In the case of the smaller countries, where staff turnover in the energy division tends to be particularly rapid, such regional bodies may well turn out to provide the only institutional memory on survey data and experience with previously implemented programmes and projects. Such regional bodies must, however, be seen as complementary to effective national energy divisions rather than substitutes for them.

Recommendations

The number of agencies engaged in energy activities in the region is large. It includes national governments, regional organizations, multilateral donor agencies, development banks, bilateral donors and NGOs. Given the scarcity of technical and administrative resources in the region, it is important that the activities of all these agencies do not lead to duplication or fragmentation of efforts in the household and rural energy sector.

The forthcoming Pacific Regional Energy Assessment (PREA) provides a unique opportunity for the definition of the region's energy problems and priorities. In making its recommendations, the seminar was particularly conscious of the role that the PREA can play in creating regional and national frameworks within which the present and likely future problems of the household and rural energy can be assessed, prioritised and addressed.

The following recommendations are variously relevant to energy offices, governments, donor agencies and other organizations active in the household and rural energy sector. In addition, they are intended by the seminar to act as key inputs to the data collection and deliberations of the PREA.

(a) Each national energy office should carry out a review of its existing functions. This should cover areas in which it is already active and those where it feels it has a role to play.

(b) Each energy office should consider and discuss with its government the structure, staffing and resources which it feels it requires to fulfill its appropriate functions.

(c) Considerations should be given to ways in which energy offices can recruit and retain the staff they need. One possible way of removing the present disincentives to this is to ensure that staff in the energy office are provided with clear career paths and realistic promotion prospects.

(d) Regional organizations should ensure that the performance of consultants is assessed for its competence and relevance to the region. Where their performance is deemed inadequate, consultants should not be assigned further tasks in the region.

(e) Energy offices should seek close cooperation with NGOs and the private sector in developing and implementing policies:

(f) Regional energy bodies should provide countries with the necessary technical assistance for collecting and analyzing their own national energy data. The regional energy bodies should also act as a clearing house, supplying countries with energy data and information about experience with energy programmes.

(g) Governments should endeavour to develop policies and technical interventions which will slow the rate of deterioration of natural biomass resources. The aim should be to develop economically efficient and environmentally sustainable approaches to the production and use of biomass, including fuelwood and agro-industrial residues.

(h) Environmental legislation should be put in place where it is still lacking and governments should insist on an independent environmental impact assessment of all energy projects.

(i) Subsidies for household fuels should in general be avoided. Lifeline tariffs or the elimination of fixed metering charges may be considered for low income electricity consumers but the costs should be contained by restricting the quantity subsidized to the lowest level compatible with achieving the intended social objectives.

(j) In areas where rural electrification programmes are being subsidized, consumers should pay the full operating and maintenance costs of the system and part of the capital costs.

(k) A module, or set of questions, concerning household and rural energy should be developed which can be included in the regular censuses and household income and budget surveys carried out by governments. These can be extracted for quicker processing and analysis than the overall survey.

II. WELCOME ADDRESS

Honorable Mr. Harold Qualao
Minister of Trade, Commerce, Cooperative, Industry and Energy

Ladies and gentlemen, distinguished visitors and guests,

Welcome to Vanuatu for the first seminar ever held in this country - or even in the South Pacific region - specifically dealing with the issues and problems of using energy effectively for our urban and rural households. We are all aware that we are faced by a potential oil crisis, possibly in terms of fuel supply if the Iraqi situation is not settled peacefully, definitely in terms of ability to pay as petroleum product prices continue to increase. Here in the Pacific Islands, jet fuel has tripled in price ex-Singapore since July and the effects are expected to be severe on our tourism industry. As you know better than I, jet fuel is close in specification to kerosene, and most widely used of commercial fuels here and throughout the Pacific for cooking and lighting. The prices of the two rise and fall in tandem so we expect our household fuel prices to increase dramatically in the near future. I hope that this meeting can help us to consider means of reducing the terrible impact of these increases on lower income households.

I'm delighted to see a good number of women at this seminar. Energy meetings and energy decisions tend to be dominated by men whereas it may well be women who best understand the issues as their families are affected. When fuelwood is scarce, when kerosene prices rise, it is they who feel the impact directly and quickly.

It is also pleasing to see representatives of the NOrth Pacific states and our colleagues from French Polynesia and New Caledonia. For too long, the NOrth Pacific and the South Pacific have been isolated by vast distances. We have much to learn from each other and this meeting is an opportunity to share our experiences.

Numerous assistance agencies have been working closely together to organize and finance this meeting. The main sponsors are the joint World Bank/UNDP Energy Sector Management Assistance Programme which has organized similar meetings elsewhere in the world and the UN Pacific Energy Development Programme (PEDP) which is well known for its good work in the Pacific. In addition the Forum Secretariat Energy Division, the European Community, the UN Fund for Science and Technology for Development and finally the Asian Development Bank have added their resources. We within Pacific Island governments sometimes criticize the donors and regional bodies for poor coordination. I understand that the above bodies are genuinely working together and already plan to incorporate the findings of this seminar into the "Pacific Regional Energy Assessment", a series of national energy sector assessments in twelve Pacific Island countries including Vanuatu which begins early next year under ESMAP management.

I'd like to thank the various donors for their valuable assistance, their increased willingness to work more closely together, and for this opportunity for us to meet together. I hope that you enjoy your brief stay in Vanuatu and have a productive and pleasant meeting.

III. KEYNOTE ADDRESSES

ECONOMIC POLICY AND ENERGY IN THE PACIFIC

Savenaca Siwatibau, Head
ESCAP Pacific Operations Center
Vanuatu

Mr Chairman, I note that of all the people in this room I am the least competent to talk on the important subject of household and rural energy. When Peter of PEDP invited me to come address you, he left the subject open. So I thought that I should make some broad observations upon some of the issues we face in the Pacific region.

The island countries of the South Pacific are dispersed over millions of square kilometers of ocean. Most of them are fragmented with numerous island groups spread over great distances. Transportation both internally and to their main markets are difficult hurdles which they have in common.

But while there are similarities, contrasts abound. Papua New Guinea, PNG, is comparatively very large. It has a population of 3.6 million and land area of 462,840 sq km. It is very rugged. It is endowed with rich mineral deposits. In more recent times, it's enclave copper and gold mining sector has come to dominate the economy. Now, the fiscal position of the government, the balance of payments, foreign reserves and the gross domestic product are determined to a very large extent by the fortunes of this sector. PNG has rich soil, forests and abundant living and non-living resources within her exclusive economic zone (EEZ). Besides cold and copper, the country exports coffee, timber, palm oil, copra, coconut oil and fish. The potential for future developments in PNG is extremely good. Its realization will be a function of appropriate domestic policies, supportive international environment and future social and political evolution and developments which succeed in containing centrifugal tendencies and in fostering strong national feelings of identification and belonging.

At the other end of the spectrum is Tuvalu. This country has a population of only 81500 with an area of only 26 sq.Km. Its soil is very saline and poor. The population density at 347 is very high. The economy and the environment are extremely fragile. Most of the land area over the nine atolls which make up Tuvalu is below five meters above sea level. The predictions of the sea level rising in the wake of rising world atmospheric temperatures are of acute concern in Tuvalu. The trade balance and the current account in the balance of payments accumulate substantial deficits annually. Aid which finances the total development expenditures every year accounts for the surpluses in the annual overall account of the balance of payments and fori the comfortable level of foreign reserves (over 12 months of imports) in recent years.

Vanuatu, the Solomon Islands and Fiji, like PNG, have large rugged mainly volcanic islands which are relatively rich in natural resources. They have fertile land and abundant timber and mineral resources. Gold and sugar are important exports for Fiji. Gold deposits have been reported in the Solomon Islands and in Vanuatu. All three countries have abundant non-living and living resources within their exclusive economic zones.

Micronesia and Polynesia are made up of groups of smaller islands. A small number of these islands, Tonga and Western Samoa have rich soil. But in the main, the islands are small isolated atolls with poor soil. Forestry is important only in Samoa. The seas of Polynesia and Micronesia are well endowed with living resources. Tonga and Western Samoa export a range of agricultural products. They run substantial trade deficits which are financed through aid and remittances. In Tonga remittances are as high as three times the value of exports and about half that of imports and 29 percent that of GDP. Similar orders of magnitude for remittances are current in Western Samoa. Tourism has a lot of potential for further development in these two countries. The actual population growth rates have been low due to the high levels of emigration over the past years. The bulk of development expenditures are financed through aid. Tonga and Western Samoa are capable of achieving economic viability in the long term. But this calls for appropriate domestic policies which might necessitate the acceptance of lower standards of living temporarily.

The other island countries comprising Niue, Tuvalu, Kiribati, the Cook Islands and the Marshall Islands are relatively small in area. Except for Niue and the Cook Islands, whose people have free access to New Zealand, they have relatively high population growth rates. Land is poor and limited in area. Except for the living resources of the seas, natural resources are severely limited.

The economies and environment of this group of countries are extremely fragile. Substantial trade deficits which cannot be sustained except with ongoing large inflows of aid are experienced every year. Remittances are very important for these countries. The high level of consumption and welfare are underwritten by aid.

The other sources of foreign exchange for these countries are copra and other minor agricultural produce, rent on fishing rights granted to the vessels of other nations and artifacts. Earnings from commemorative stamps were once important in Tuvalu and the Cook Islands. The public sectors, the activities of which are to a large extent supported by aid, dominate the economies. The small private sectors depend heavily upon the goods and services which they supply to the governments. GDP, government revenue, the national import bill and the movements in the external accounts are highly sensitive to public sector expenditures.

Long term financial and economic independence is likely to be an elusive target for these group of countries. Sharpened skills in rent seeking, emigration arrangements with metropolitan countries or closer association with other countries are some of the strategies which may have to be pursued.

The physical and economic structures of the Pacific island countries range over a wide spectrum. But quite a number of common characteristics are discernible. Among those that may be noted are:

(a) the large distances from their external markets and the very high costs of transportation;

(b) the high degree of fragmentation of their domestic markets;

(c) the exposure to natural disasters particularly hurricanes;

(d) the very open economy with heavy dependence upon international trade and finance. The export bases are very narrow. The economies are subjected to frequent shocks emanating from external factors. The fragility of the external sectors necessitates the holding of relatively large external reserves to help cushion the impacts of unexpected shocks;

(e) aid per capita is generally very large. This enviable position has enabled difficult adjustment measures to be postponed or avoided;

(f) the open economies, fixed exchange rates and relative ease with which capital move in and out imply that active monetary policy does not have a role to play. Fiscal policies which call for unsustainable inflationary financing from the central bank or active credit policies aimed at boosting economic growth invariably result in high inflation rates, weak external sector positions and possibly mounting external debt;

(g) the public sectors dominate the economy. The private sectors could play a much enhanced role towards the achievement of the ambitious objectives outlined in all the development plans of the island countries. The public sectors have been the trend setters in wage settlements and in many cases these have been at rates well above those necessary to maintain competitiveness;

(h) over regulation and control of the economies are still widespread;

(i) population growth rates while declining steadily are still generally high except for a limited number of countries such as Western Samoa, Tonga, Niue and the Cook Islands where steady emigration has taken place over the years;

(j) technical and management skills are still scarce;

(k) average economic growth rates were low over the last ten years. They were consistently lower than those targeted in development plans;

(l) domestic savings are low; much lower than domestic investments as manifested in the large current account deficits which reflect the volume of imported savings from the rest of the world. A lot of flexibility exists for increasing domestic resource mobilization if the financial sectors were less repressed than they are at present;

(m) the unavoidable change in value systems which follow in the wake of economic changes and which are themselves necessary for economic development are still somewhat difficult to digest. Instead of managing changes in ways which steer economic and social development along chosen paths, ambivalence and hesitancy have remained difficult to surmount;

(n) the procurement of development finance has not to date presented any difficulty. The constraints appear to be in the generation of bankable projects and programmes which manifestly won't contribute to the enhancement of the productive capacity of a country have attracted and received external aid support; and

(o) difficult land tenure systems which impede development in the agricultural and other sectors remain to be addressed effectively, particularly in parts Melanesia.

Development in some Pacific island countries has been associated with uncontrolled exploitation of natural resources. In the absence of environmental standards, these have generally resulted in irreparable harm to the fragile ecosystems.

An integral component of sound economic growth in the long term is careful management of the environment on a sustainable basis. This requires an appreciation of the delicate balance which surround the life-support systems such as air, soil and water, as well as the natural communities such as rainforests, mangroves, coral reefs, and deep sea marine life. The threats that development activities pose on the long term viability of these natural communities has become a matter of increasing concern in recent years.

It is likely that the persistent neglect of environmental issues could, over the long term, frustrate the economic development of many resource poor Pacific island nations. The current deforestation - whether for expanding human settlements, for agriculture or for timber extraction, may, without sound management, not only lead to increased soil erosion but also the loss of a whole range of species comprising the forest ecosystem. Environmental scientists tell us that Pacific Oceania has one of the highest rates of endemic species in the world. These species are found nowhere else outside of these island countries. They also claim that the Pacific region has one of the highest species extraction rates in the world.

The loss of many rare species of plants and animals means the loss to the region and to the world of important economic organisms which are potential sources of food and medicine in the future. The loss of forest ecosystem deprives the island landscape of a distinctive feature that would form an important component of an effective tourist attraction package. Sound management of the environment should therefore be an important component of development strategies in the island countries.

A sustainable development path for the island countries with a stable physical and biological environment may not, in the long term, be achievable without the willing co-operation of countries outside the region. Driftnet fishing still threatens the ocean resources upon which the Pacific island economies heavily depend. The greenhouse effect could mean, according to pessimists, the wholesale relocation of the populations of small nations such as Kiribati, Tuvalu, Tokelau and Marshall Islands.

The impact of aid upon the balance of payments and the government budgets of the Pacific island countries is significant. Questions as to whether aid is flowing efficiently into sectors which maximize return or promote long term viability and not increasing dependence could perhaps be raised. Aid which finances projects and programmes which are carefully evaluated and which are economically and financially viable and likely to improve upon the productive capacity of a country should be preferred. Those falling outside of this category are likely to add additional pressures upon a country's recurrent budget and contribute to growing aid dependence over time. Aid flows, have, in a number of island countries, allowed relatively higher wages and salaries to be maintained and supported in the public sectors. This situation contributes to upward pressures upon wages and salaries throughout the economy.

Large aid inflows have had a secondary negative impact upon the tradable goods sector including agriculture. They enable countries to avoid, for long periods, currency adjustments which are necessary for long term growth. The combination of high wage levels and relatively strong currencies, which are supported by aid flows, have tended to erode the competitiveness of the economies in the South Pacific.

Remittances are particularly significant in five of the South Pacific countries. Private transfers as proportions of GDP hover around 23.7%, 22.8%, 8.6% In tong, Western Samoa and Kiribati. Figures for the Cook Islands and niue are not available but they are as important as they are in Tonga and Samoa. In these countries the impact of remittances upon GDP, employment, revenue, wages and salaries, the current account and foreign reserves are as important as those of aid receipts. By helping to induce high labor costs and enabling the maintenance of overvalued currencies, large remittances have had negative repercussions upon the tradable goods sector. Remittances if applied mainly for increased consumption, over time, steadily transform the structure of an economy to one of increasing dependence.

Remittances are likely to increase with the number of residents leaving to reside in another country. So long as emigration into developed countries are allowed without restraint, as in the cases of the cook islanders and Niueans to New Zealand, the assumption of continuing real growth in remittances will probably hold.

For countries which do not enjoy similar arrangements it would be advisable to build more conservative assumptions upon remittances into their long-term economic strategies. This is probably important as the level of remittances is likely to be inversely related to the length of residency overseas.

The economies of the South Pacific countries are very open. Capital flows relatively freely in and out. National income, revenue and the balance of payments fluctuate with goods and services,and aid receipts. The maintenance of stable and sustainable balance of payments positions and comfortable levels of external reserves are preconditions to steady growth. In the majority of island countries, external financial stability has been underwritten by aid and, in a number of cases, remittances.

The Pacific island countries have fixed exchange rate regimes. But fixed exchange rates, economic openness and high mobility of capital in and out in the country makes active monetary policy relatively ineffective. Liberal credit policy aimed at promoting growth is not likely to work as aggregate demand will increase, prices will rise, labor costs will increase, the balance of payments deficit will rise, net capital outflow will increase, reserves will fall and the external debt position is likely to deteriorate quickly. Gains in output through such a policy are likely to be short lived as adjustment policies will become unavoidable in the interest of re-establishing national financial stability.

External prices and exchange rate changes influence domestic prices in small open economies more immediately than they do in bigger and less open economies. Exchange rate devaluations quickly increase the prices of domestically produced tradable goods. Through increased cost of living wages and salaries, rapidly adjust to maintain their levels in real terms. The prices of non-tradable goods will of course keep pace. A devaluation will therefore rapidly manifest itself in price increases throughout the economy. Unless wages and salaries are determined so that they do not maintain their levels in real terms, a devaluation which aims at giving momentum to growth will not succeed but will certainly result in increased inflation. The Pacific island countries should ensure through fiscal, exchange rate, monetary and income policies that the real effective exchange rates of their currencies move in directions which increase the competitiveness of their economies.

The link between budget deficits and the balance of payments is particularly direct in small open economies. Budgetary excesses result in increased credit by the banking system and inflationary financing by the central bank. Under such conditions the private sector finds itself crowded out of the credit market to the detriment of private sector investments.

The Pacific islands are subject to sudden internal and external economic chocks. It is therefore important for external reserve to be maintained at relatively high levels. This is because adjustments to such shocks are economically and socially painful if financing through owned or borrowed reserves cannot be readily accessed. Ready access to borrowed reserves is itself a function of good country credit standing which is in turn a function of sound national financial management. Investments by the private sector is likely to be encouraged if national financial stability looks assured.

Agriculture and fishing supports the bulk of the population in the region. It is the sector upon which sound economic development and economic independence will continue to be based. There are good prospects for diversification and deepening of commercial agricultural activities, particularly in the larger island countries.

In Tonga, vanilla, a high value low volume product, has become the largest export earner ahead of copra. Other non-traditional export crops which are being tried or under consideration by departments of agriculture in the region include avocado pear, pawpaw, mango, spices (vanilla, pepper, cloves, chilies), pumpkin, medicinal plants, orchids, flowers and other tropical ornamental. Possibilities exist in the field of mariculture including seaweeds, shell fish, crustaceans, eels, pearls, beche de mer, black and pink corals. The development of these new items will require technical and marketing research. It would be important for the South Pacific countries to develop niches in the market place upon which to capitalise. But increased reliance should be placed with private sector with public sector playing at most, a supportive role.

Offshore fishing in the expansive exclusive economic zones (EEZ) in the region presents a lot of potential. But technology, capital and know-how will need to be imported. Tuna fishing and deep sea fishing for high priced fish such as deep sea schnapper have become possible with overseas capital, technology and know-how. Some countries such as the Cook Islands, Vanuatu and Kiribati have offered licenses for fees to overseas fishing organizations. This arrangement presents additional sources of income in the short term. The possibility of increased local private capital involvement in this important sector should improve over time.

Tourism is already a major industry in Fiji, Vanuatu and the Cook Islands. It is growing in importance in Tonga, Western Samoa and the Solomon. The other countries in the region are also actively encouraging its growth.

Heavy investments in tourist infrastructure have been undertaken. More are proposed. These include the building and extension of airfields and airport facilities, electricity supply, roads, water supply, telecommunication and sewerage systems; all involving large public sector outlays supported through bilateral and multilateral aid.

Tourism will become more important to the economies of the region and its growth is seen as a necessary diversification of their economic base. It will supplement but not supplant agriculture and fishing the South Pacific countries.

The deregulation of the business environment is slowly gaining acceptance. A number of countries have started cautiously along this path. Corporatisation followed by progressive sales of shares to members of the public has been tried in a number of island countries. Similar experimentation are likely to be pursued in the coming years.

The South Pacific countries are now promoting private sector investments. The level of domestic savings in the region fall far short of required domestic investments implying the important role for overseas investments in the future development of the region.

External events whether around the Pacific rim or beyond now have instantaneous and unexpected impacts upon our economies and the standards of living of all our people. Independence of many countries has never been this high. Global developments around us we shall need to watch closely. Will the focus of the industrial western countries and the multilateral financial institutions upon Eastern Europe increased have negative effects upon the future flows of grant and loan and equity capital to our part of the world?

Among the package of policies and strategies which our countries will need to firmly put in place are the following:

(a) the exposure of the domestic economies to outside competition aimed at improving domestic efficiencies;

(b) allowing the price mechanism to determine resource allocations;

(c) the removal of all impediments against exportation;

(d) the containment of public sector role in the production of goods and services and allowing the private sector to play a greater role in economic activities;

(e) freeing the financial sector by removing repressive policies so that savers would save more as returns to them increase. This policy ensures that domestic savings will increase and flow into investments which yield the highest returns to the economy; and

(f) the employment of macro-economic policies, fiscal, monetary, incomes and exchange rates, which assures financial stability at all times.

The trend towards economic and financial liberalization world-wide will have far reaching implications. The margins of advantage which we enjoy. Under Sparteca and the Lome agreements will steadily decline. The message comes to us loud and clear. Increasingly, we shall have to learn to earn our living. We shall have to accept that economic reforms and appropriate domestic policies must be implemented. Also that we have to produce at very competitive prices goods and services which the export market wants.

The current crisis in the Middle East is already having its toll upon the world economy. The IMF recently guesstimated that it will reduce the total real GDP of the industrial countries by 1/4% in 1990 and by 1/2% in 1991 and will increase the level of consumer prices for these countries by over 1/4% and by 3/4% respectively for the same two years. These countries will need to maintain firm monetary policies to contain inflation so that world interest rates may be expected to remain relatively high.

In the Pacific island countries, we shall expect:

(a) price levels to rise;

(b) import bills to rise; and

(c) some adverse movements in our commodity prices and perhaps upon tourism as the rates of growth in the industrial countries fall.

The share of imported energy sources constitute large proportions of total imports in the Pacific countries. These had declined markedly since the middle of this decade. But in the wake of the middle east crisis these proportions will again increase noticeably. The rising fuel import and the expected softening in commodity export prices will impose further pressures upon the current account of the balance of payments and the foreign exchange levels of the Pacific Island countries calling for appropriate macro-economic policies aimed at maintaining internal and external financial stability in these countries.

ENERGY OPTIONS FOR HOUSEHOLD AND RURAL ENERGY USE IN THE PACIFIC

Suresh Hurry
Senior Technical Advisor
UN Fund for Science and Technology for Development
UNDP New York

Distinguished Participants,
Ladies and Gentlemen,

I would like to join the preceding speakers in welcoming you to this seminar which is co-sponsored by UNDP. UNDP has been involved in the economic and social development of the Pacific Island Countries (PICs) for a number of years and continues to do so in priority areas identified by the respective governments. The energy sector of some PICs has received or is presently receiving UNDP assistance either directly through each country's Indicative Planning Figure or on a regional basis through the UNDP-funded Pacific Energy Development Programme.

The views I express here are personal and may not necessarily reflect official UNDP position on household and rural energy. My comments will be directed mainly at the rural areas of developing countries where almost 80% of the population lives.

UNDP has directly participated in rural energy assessment and development in the PICS through the jointly funded UNDP/World Bank/bilateral donors ESMAP programme. Fuelwood and charcoal constitute a significant component of household energy in the PICs especially in the rural areas. Electricity and petroleum products are consumed to some extent but are not available everywhere. With the growing population, there is an increased demand on land for food and wood fuel and with minimal or almost no reforestation programmes, degradation of the environment takes place. What are, therefore, the household energy options available for the rural areas?

(a) Improved cookstoves: numerous designs exist but all cookstove programmes met with only limited success due to the fact that the users, i.e, the women were not consulted in their design, with the result that, for example, the openings for the pots were not of the right size. Also these stoves have to be purchased whereas in the rural areas wood is normally available free, although a considerable amount of time is spent on wood collection, and no costing is made for the time spent on collection;

(b) Charcoal: it has a potential for use as a cooking fuel in the rural areas but is not available free; it has to be purchased. Also, the charcoal stove has to be purchased.

(c) Kerosene and LPG: again these have to be purchased, together with the stoves, and are often not readily available in the rural areas.

(d) Electricity: it is not available everywhere because of the high cost of erecting distribution systems and the low load factor. Although rural electrification is often considered uneconomical, no costing is provided for not having electricity at all.

(e) Solar cookers: there are several excellent designs available but they are not popular among the main users, i.e. the women.

(f) Biogas: this has been successful to some extent at the individual level but has met with management problems at the village level.

(g) Integrated approach: this seems to be the best solution as it integrates the various energy options available and we hope to reach some consensus on this at this Seminar.

Rural energy is utilized for a variety of purposes, Viz, transport, communication, community centers, medical clinics, etc. Rural electrification reaches only a fraction of the rural population. It is very common in the rural areas to see overhead distribution lines, whereas the majority of the villagers is not connected to the supply because of lack of money to pay for the connection and monthly consumption.

Biomass gasifiers for electrical/mechanical power are available but their operation and maintenance are problematic in a rural setting due to the unavailability of qualified manpower. A promising technology is photovoltaics (PV). Although PV technology requires a high investment cost, it is technically proven, requires minimal maintenance and is economically viable on a life-cycle cost basis for small amounts of power in remote locations. However, the objectives of introducing PV in rural areas should be clearly defined. For example, the difference should be made between rural electrification and rural lighting when only PV lighting is provided. Otherwise, the rural consumer quickly gets disappointed because, apart from lighting, he is unable to utilize any electrical appliance. And in order to promote the dissemination/commercialization of photovoltaic systems for rural areas, UNDP, the French Agency for Energy Management (AFME) and the US Department of Energy are presently working on a strategy document.

Finally, while focussing on household and rural energy, we should not forget the human development aspect which aims at improving the quality of life for the rural poor. Unfortunately, this is not always the case. For example, the Human Development Report published recently on the occasion of the 40th anniversary of UNDP indicates, among others, that some developing countries have a higher per capita number of soldiers than doctors or teachers, which makes us wonder whether the priorities are right.

Thank you.

IV. COUNTRY STATEMENTS ON HOUSEHOLD ENERGY AND RURAL ENERGY ISSUES

AMERICAN SAMOA

Ms Tagi Tunoa
Programme Officer

The Territorial Energy Office of the American Samoa Government was established in 1977 following the creation of the U.S. Department of Energy. Originally, TEO was created as an advisory body to the Government on energy issues. Over the years, the role of TEO has developed from a passive point to a leading agency in the promotion of energy conservation in all sectors of the Government, development of educational materials for school populations, and demonstration of feasible alternative energy sources in Samoa.

In 1981, the Energy House in Tafuna was completed to house the TEO staff. The Energy House was designed for local weather to withstand strong winds, while incorporating structural features to maximize use of trade winds for natural venti'ation and skylights for natural lighting. Other features of the house include orientation, sloped ceiling for warmer air rise, east-west windowless walls, and insulation.

A photovoltaic system was installed to provide supplemental power for fans, typewriters and lights. The system consisted of 48-40 watt peak panels which supplies 28-12v batteries. The batteries are run through a DC/AC 60 Hz 110v inverter for house-load synchronization.

A 30 gallon (110 liters) heat pump supplies hot water to the kitchen. One 3 ft by 5 ft solar collector supplies hot water to the 80 gallon (300 liters) water tank for shower and bathroom use. (Since its feasibility demonstration of local application in 1984, about 80% of residential hot water consumers have installed solar collectors in lieu of electric heaters, and 10% use solar heating as a supplemental source).

The cost of energy in American Samoa is directly affected by U.S. oil issue developments. The 1973 and 1976 OPEC embargoes started to make local consumers energy conscious. As the embargoes were lifted and oil prices dropped, this awareness also faded. Following the recent Middle East Crisis (Iraq/Kuwait), oil prices have increased by more than 45% of 1989 costs.

With the exception of Rose Atoll, all islands are inhabited. Roads have accessed all villages, and likewise power, water and communications. Swains Island, with a population of less than 30 people, has a 25kW diesel generator to supply power to the School, dispensary and radio equipment. (This generator will be replaced with a PV system in 1991.)

TEO is operated by U.S. Federal Grants under the U.S. Department of Energy State Energy Conservation Plan, Institution (Schools & Hospitals) Conservation Program and Energy Extension Services, and U.S. Housing and Urban Development (HUD), Low Income Home Energy Assistance Program.

Population

The 1989 mid-year population estimate for American Samoa was 38,200, an increase of about 1.9% since 1988 and 16.5% since 1980. The new projections prepared using the program showed much lower projections than those published in previous years. The decline in age-specific fertility rates and continuous out-migration contributed to these lower projections. The projected population for 1990 is about 39,000 and more than 45,000 in the year 2000.

The Eastern District still constituted more than 50% of the population of Tutuila although there has been a general trend toward the Western District (36% in 1974 to 41% in 1980). The Manu'a District remained at about 5% of the population for the territory. Population density is about 77% higher in the Eastern District than in the Western District, and Manu'a has about one-tenth as many persons per square mile as the Eastern District.

The population is young but is gradually getting older, with the median age increasing from 17 years in 1974 to 20 years in 1985. Males continued to outnumber females by 51% to 49%. About 42% of the population age 15 years and older were not unmarried in 1985 compared to 28% in 1980. Single mean age at first marriage also went up from 25 years in 1980 to 27 years in 1985.

About 58.3% of the population were born in American Samoa in 1985 compared to 57.5% in 1980. Of the 41.7% foreign-born (13,415 persons) in 1985, about 71% were born in Western Samoa followed by 19% in 10% percent born in the United States and other countries respectively. Samoan still remained the dominating single ethnic group (91%) in the territory.

MID-YEAR POPULATION ESTIMATES
1960 - 1989

YEAR	POPULATION	YEAR	POPULATION
1989	38,200	1978	31,430
1988	37,450	1977	30,890
1987	36,960	1976	30,270
1986	36,260	1975	29,660
1985	35,600	1974	29,070
1984	24,940	1973	28,610
1983	34,300	1972	28,150
1982	33,660	1971	27,710
1981	33,050	1970	26,950
1980	32,450	1965	23,510
1979	31,980	1960	20,140

Source: Economic Development Planning Office.

MIGRATION AND NATURAL INCREASE
1970 - 1980

	Component	1970 - 1974	1974 - 1980
1.	First Census Population	27,159	119,190
2.	Second Census Population	29,190	32,297
3.	Net Increase	2,031	3,107
4.	Births	4,143	5,936
5.	Deaths	602	724
6.	Natural Increase	3,541	5,212
7.	Apparent Net Migration	(1,510)	(2,105)
8.	Percent Intercensal Increase	7.5	10.6
9.	Percent Intercensal Natural Increase	13.0	17.9
10.	Percent Intercensal Net Migration	-5.6	7.2
11.	Annual Rate of Growth (percent)	1.7	1.9

Source: Economic Development Planning Office, LBJ Tropical Medical Center.

Land Ownership, Housing Characteristics and Construction Permits

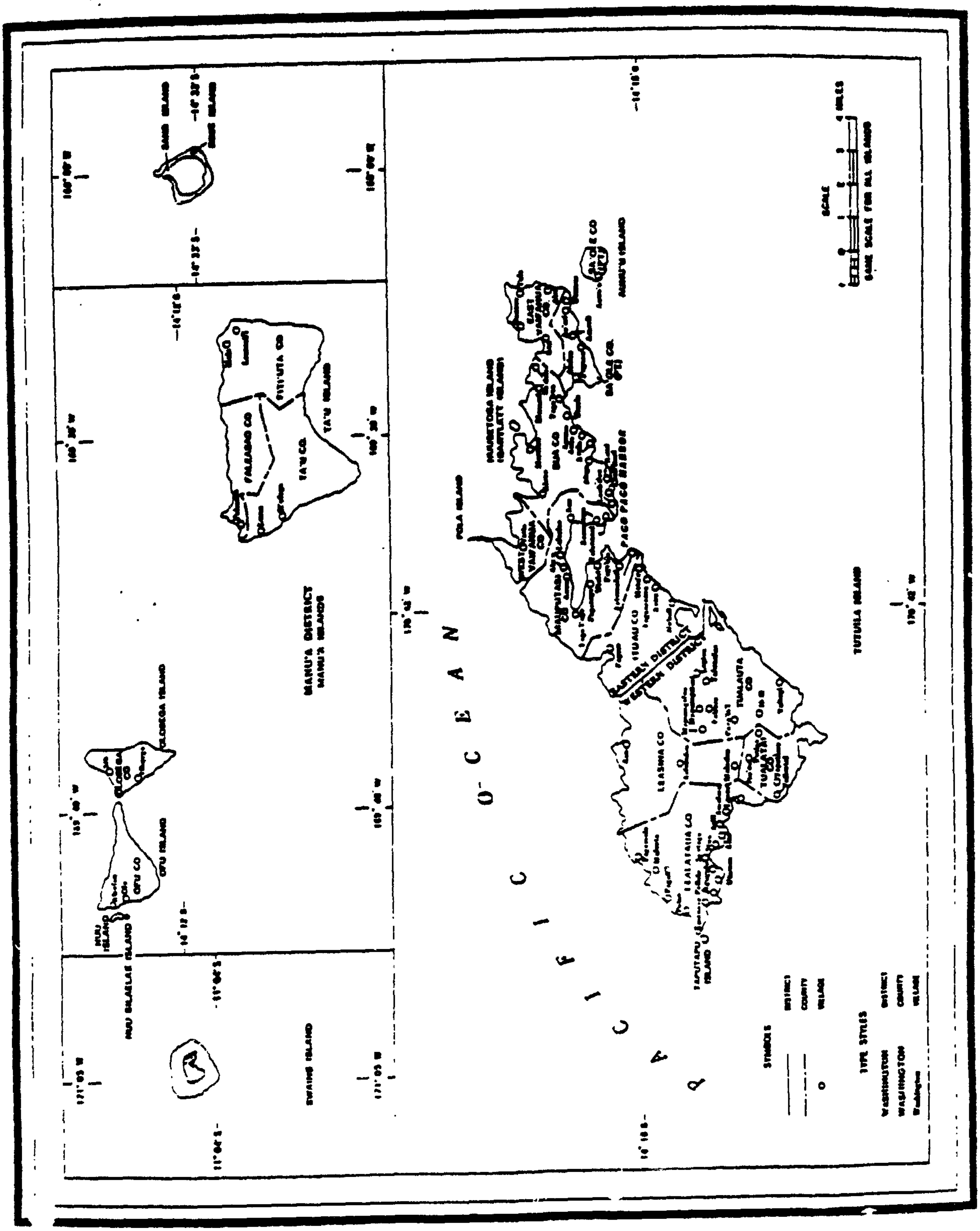
About two-thirds of the land in the territory is steeply slopping and virtually inaccessible. This distinction characterized settlement patterns of the local population along coastal areas. The last available data (1977) indicated that almost 85% of the land in the territory was undeveloped.

Land in American Samoa is classified by the following definitions:

Freehold Land:	Land acquired by individuals before 1900 through grants issued by the Supreme Court of Samoa. This is the only land that has no restrictions on transfer of title or lease tenure.
Government Land:	Land which was transferred by the U.S. Department of the Interior to the American Samoa Government; land conveyed to the Government by native owners; right-of-way easements; and reclaimed land.
Church Land:	Land acquired by religious organizations through Court grants or through conveyances by native owners.
Communal Land:	Land subject to the existing native land tenure system.
Individually Owned Land:	Land acquired by individuals by means of Court grants after the year 1900 or through the transfer of communal land with the approval of the Governor of American Samoa.

In 1980, there were 4,688 year-round housing units in the territory; 4,513 (96%) were occupied and only 4% vacant. Of the 4,513 occupied units, 52% were in the Eastern District; 42% in the Western District and only 6% in Manu'a and Swains Island.

Districts, Islands, Counties, and Villages



There were 418 land use and building permits issued by the Building Branch Division in 1988. About 59% of all permits were issued for new building. There were 397 non-government land use and building permits issued in 1988. A little over US$10 million was the estimated value of all non-government constructions and about US$7 million was for all new buildings.

COOLING DEGREE DAYS (BASE 65 DEGREES F)
BY MONTH: 1984 TO 1988

MONTH	1988	1987	1986	1985	1984
Total	5,945	5,804	5,848	5,793	5,777
JANUARY	550	521	510	481	495
FEBRUARY	552	497	474	470	487
MARCH	563	541	538	543	514
APRIL	499	520	490	480	504
MAY	525	485	489	487	528
JUNE	496	412	476	458	472
JULY	457	420	452	457	442
AUGUST	484	419	421	468	462
SEPTEMBER	459	449	454	449	445
OCTOBER	473	485	506	500	459
NOVEMBER	450	514	511	474	487
DECEMBER	467	541	527	526	482

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration.

Commerce and Trade

Total imports for 1988 valued at US$334 million while total exports amounted to US$368 million, resulting in a favorable trade balance of about US$29 million. Imports dropped by about 3% since 1987 and exports increased by about 25%.

Exported items were as much dominated by canned tuna which accounted for about 96% of all exports in 1988. The number of cases of canned tuna exported in 1988 was a little over 14 million.

Imports by country of origin showed the United States leading with about 67% of total value, followed by Australia with 10%, Japan with 9%, New Zealand with 6% and the remaining 11% from other countries.

Of the total value of imports, food items constituted about 18%, fuel and oil with 24%, and textiles and clothing items accounting for 4%. The most significant increase was seen for machinery items and equipment which accounted for about 9% of total imports. Miscellaneous group accounted for about 36% due to unclassified goods and metalware for fish canning industries.

Businesses in 1988 were classified according to the U.S. Standard Industrial Classification System (1972) manual. A total of 1,668 businesses were registered in 1988; an increase of about 8% since 1987. Major group summaries showed retail trade again, leading with about 40% of all businesses, followed by service establishments and transportation/communication/gas, and sanitary businesses with 20% and 19% respectively.

FY 1988 Imports	Value	Percent
Food	$ 27,500,000	18.5
Fuel & Oil	36,000,000	24.3
Clothing	6,416,000	4.3
Machines & Parts	13,431,000	9.0
Jewelry	95,000	0.1
Miscellaneous	53,565,000	36.1
Alcoholic Beverages & Cigarettes	4,691,000	3.2
Building Materials	6,744,000	4.5
Total Imports	$148,442,000	

Source: Department of Port Administration, Department of Treasury, Customs & Excise Tax Division.

Ms. Myint Sein
Ministry of Energy

Location and Area

The Cook Islands is a group of 15 islands situated between 8 degrees and 23 degrees South latitude and 156 degrees and 167 degrees West longitude. It's territorial sea and exclusive economic zone covers an area of nearly 2 million sq. kilometers (750,000 sq. miles); in comparison to the total land mass of only 240 sq. kilometers (93 sq. miles).

Population

The population of the Cook Islands is 17,463 (taken from the 1986 census report), where 15,218 people are living on 8 islands of the Southern group of the Cook Islands and 2,245 are living on 7 islands of the Northern group islands.

Energy Sector

Imported Fuel

All of the petroleum fuel needed for the country's transportation, electricity generation, agriculture and trade is imported.

Cost of Fuel Imports

The cost of imported fuels and minerals is about 12% of the total imports to the country. The percentage of fuel and mineral imports to the total imports is as follows.

Year	Percent of Total Imports
1984	9.54
1985	12.67
1986	13.16
1987	11.39
1988	12.01
1989	11.79

Volume of Fuel Imports

The volume of petroleum fuel imports in kiloliters to the Cook Islands is as follows:

Table 1: Petroleum Fuel Imports

	1984	1985	1986	1987	1988	1989
Distillate	4070	3133	4036	5050	8310	6079
Motor Spirit	3073	3029	2535	2568	3299	3567
Kerosene	152	52	78	76	50	55
White Benzine	30	20	8	1	13	16
LPG	290	300	304	310	505	591
Total Ground Fuels	7615	6534	6961	8005	10177	10308
AVGAS	518	579	329	714	804	783
Jet Fuel	4277	5454	5116	3669	7652	4280
Total all Fuels	12410	12567	12406	12388	18633	15374

Electricity

Ten out of the 13 inhabited islands have reticulated electric power available from 12 to 24 hours per day. Electricity generation is through diesel driven generators of varying sizes, between 1600 kVA and 4.0 kVA. The 24 hour power supply is on the islands of Rarotonga and Aitutaki, with the other islands namely Atiu, Mangaia, Mauke, Mitiaro, Manihiki, Rakahanga, Penrhyn having the 12 hour per day power supply. Recently in May 1990, Pukapuka has been equipped with a 4.0 kVA generator which supplies power for government offices.

Generation

The major source of energy in the Cook Islands is electricity, and the generation of electricity is by diesel generators using the imported diesel fuel. Yearly total generated mega-watt-hour ranges from 20 MWH to 12,000 MWH depending on the installed capacity and the number of hours run. The total generated mega-watt-hour (MWH) for each island from the budget year 1986/87 to 1989/90 is as follows:

Generated (MWH)

Island	1986/87	1987/88	1988/89	1989/90
Southern Group				
Rarotonga	10390	11178	11956	12603
Aitukaki	1050	1006	1079	1119
Atiu	147	182	191	194
Mauke	5	5	1	30
Mitiaro	7	15	29	35
Mangaia	134	115	149	209
Northern Group				
Penrhyn	43	58	76	83
Manihiki	36	55	48	69
Palmerston	7	-	3	
Rakahanga	11	34	15	25
TOTAL	11830	12648	13578	143485

Distribution

The Electric Power Supply (EPS) - is a state run department and is solely responsible for generating, transmitting and distributing electric power on all the islands.

The total sale of electricity for each island for the budget year 1986/87 to 1989/90 is as per following table:

SALE (MWH)

Southern Group	1986/87	1987/88	1988/89	1989/90
Rarotonga	9840	10108	10757	11382
Aitutaki	798	806	934	397
Atiu	125	159	171	163
Mauke	71	74	99	115
Mitiaro	4	13	25	27
Mangaia	91	105	131	180
Northern Group				
Penrhyn	53	66	67	65
Manihiki	41	58	66	64
Palmerston	6	-	3	12
Rakahanga	11	30	17	23
TOTAL	11040	11419	12270	12928

Remarks: The complete information from some outer islands are not available.

Consumers

In 1989/90, 57% of the total electricity sales was consumed by commercial sectors and 43% by domestic sectors in Rarotonga. In 1989/90 the total number of consumers for the whole Cook Islands was 4,806, domestic consumers being 86% and commercial consumers 14% of the total.

Island	No of Consumers (1989/90) Domestic	Commercial
Southern Group		
Rarotonga	2709	472
Aitutaki	459	47
Atiu	243	31
Mauke	156	19
Mitiaro	60	4
Mangaia	220	22
Northern Group		
Penrhyn	165	10
Manihiki	113	18
Palmerston	15	4
Pakahanga	-	-
Total	4140	627

Electricity Tariff

Electricity tariffs have been constant since 1986. In 1986/87 the tariff per kwh paid by domestic consumers was 36% of the production cost, and tariff per kwh paid by the commercial consumers was 70% of the production cost. The government is subsidizing the production of electricity for the outer islands. Electricity Tariff rate depends on the type of consumers.

For domestic consumers	20 c/kwh for first 120 units
	25 c/kwh for over 120 units
commercial consumers	39 c/kwh

Upgrading of EPS

Up to February 1990, the electricity for Rarotonga has been generated by generators which have been running for more than twenty years. In December 1989, a new 1.6 MW generator was installed under an aid project from the New Zealand Government and this generator was commissioned in February 1990. Beginning in October 1990, the upgrading of the distribution lines and the power station facilities will get underway from a 9 million dollar French loan, which will also include 2 new 2 MW generators.

Restructuring of Ministry of Energy

With the recent changes in EPS, it is necessary to review the organizational structure of the Ministry of Energy and financial status of EPS. The preliminary report was prepared by United Nations Pacific Energy Development Program (UN-PEDP) in January 1990 with comments on a new organizational structure, a recommendation for financial review and terms of reference for the new positions to be filled.

Recently, the Chief Executive Secretary position for the Ministry of Energy was recruited with partial funding by CFTC (Commonwealth Fund for Technical Co-operation). In October 1990, one firm from New Zealand visited Rarotonga to collect data for a financial review of EPS. The cost of this activity is funded by New Zealand Aid Program.

Wood Steam Plant

Feasibility studies for wood steam plants to generate electricity on the islands of Mauke and Atiu were carried out with the aid of New Zealand Government and UN-PEDP in 1985, but the project: was deferred.

Solar

Solar Water Heating

Solar energy was introduced to the Cook Islands in the mid 1950's with the use of a solar hot water heater in a private residence. Since then the use of solar hot water heaters has increased.

The Rarotonga Hospital was equipped with solar water heating in 1984. In June 1989, the system was found to be non-operational, so the design was changed to a thermo-syphon type to be operational.

Seven government houses have been installed with solar water heaters in 1985 and another seven houses in 1987. These two projects were funded by the South Pacific Bureau of Economic Cooperation (SPEC).

Solar Lighting

Mitiaro

Using solar energy as a means for lighting started in the Cook Islands on the island of Mitiaro, an outer island in the southern group, in 1984.

The solar lighting project was funded by the South Pacific Commission (SPC), where 50 houses were installed each with 1 solar panel, 2-6 volt batteries and 3-15 watt fluorescent lights.

In February 1989, a survey was carried out on the existing system on the island. From this survey, it was found that only 19 houses out of the 50 still had operational solar equipment. The solar systems were non-operational due to the need of replacement parts and to lack of proper maintenance.

In November 1989, the status of the project was again surveyed, and this time only 5 houses could still use the solar lights. The island also has an A.C. generator which runs 12 hours per day, which is also one reason why the solar lights were given less attention.

In 1990 SPC again funded NZ$5,000 for purchasing solar equipment for lighting of the Mitiaro Health Clinic.

Nassau

In April 1989, the first massive solar installation was carried out on the island of Nassau, a northern group island.

The installation had a total of 90 solar panels, 88-6 volt batteries, 91 fluorescent lights, 3 refrigerators, 1 freezer and 1 water pump. The lights are 9 watts, 11 watts and 22 watts (two 11 watts in one fixture).

The solar installation covers 63 buildings including 1 Hospital Community hall, 3 churches and other private residences.

The total cost of the project was NZ$66,500; PEDP'S contribution to the project being NZ$35,000 with government contributing the balance of NZ$31,500.

Pukapuka

Just recently in October 1990, the solar installation of 3 community halls on the island of Pukapuka was completed. The Government carried out this installation after purchasing NZ$110,000 worth of solar equipment from GIE Soler (Tahiti), so as to demonstrate to the people of the Pukapuka and other islands in the Northern group the reliability of solar energy as a source of power supply.

The installation was carried out with the help of solar experts and technicians from SPIRE (South Pacific Institute for Renewable Energy) working together with local personnel. The installation cost for the three community halls was funded by Forum Secretariat. At the same time, the team from SPIRE carries out a survey for the solar project which is to be implemented with a NZ$2 million French loan. The project will be implemented in two stages.

Phase 1 - The detailed project formulation stage.
Phase 2 - The implementation stage.

The cost of about NZ$50,000 for phase (1) was funded by a grant from the South Pacific Development Fund, France, and the NZ$2 million French loan will be for phase (2), the implementation stage, which SPIRE will be taking full responsibility to implement as a turn key project.

Wind Energy

Wind energy is the next promising source of energy after solar energy. For the time being in Cook Islands, wind energy is used for water pumping on outer islands.

Island	No of Wind Mills	Remarks
Mangaia	1	
Mauke	2	1 is not working
Atiu	2	
Mitiaro	1	not working

Biomass

Wood is extensively used in the outer islands as a household energy source, but the data are not recorded and thus not available. In Rarotonga, wood is also used in preparing several umu kai (big feast) but the data is not available. There are two projects underway relating to the use of wood; gasifier and smokeless stove projects.

Gasifier

A gasifier was installed in Atiu (a southern group island) in early 1983 using chopped wood to run the Lister diesel engine. It was operational for only a few months having difficulties with mechanical problems which was diagnosed by the assessment team from New Zealand supplier Fluidyne as the lack of on site instruction and maintenance.

Smokeless Stoves

In May 1987, a two week workshop on smokeless stoves utilization was conducted by the Women's Division, Ministry of Internal Affairs for the women of the island of Mangaia, (a southern group island). 109 women attended that workshop and a demonstration was carried out on how to make smokeless and charcoal stoves to encourage the use of low cost cooking facilities.

Biogas

Two biogas digesters were built in Rarotonga, the capital island, in 1985. None of them are operational now. In April 1990 one digester was built at Titikaveka College, in Rarotonga as a demonstration unit for students, using pig manure to produce methane gas. The project is funded by New Zealand Aid program.

Micro-Hydro

The potential of Micro-Hydro power in Rarotonga was surveyed in 1981, and a report was prepared with the comments that the most practical and economical possibility for micro-hydro development could be the installation of a series of micro-hydro stations generating at load factor of 100% into the existing grid, and it is probable that all such installations would only be capable of generating at peak output of 5 and 10 kw . The conclusion of that report was, more detailed site specific information is required to fully evaluate and price the possibility for micro-hydro development.

Wave Energy

As the first step towards the feasibility study of wave energy for the Cook Islands, a buoy equipped with data collecting equipment was set out at the eastern side of Rarotonga in 1986. Ministry of Internal Affairs organized this project in co-operation with CCOP/SOPAC.

Energy Statistics

Recently the Energy Division of the Ministry of Energy has completed compiling all the data concerning electricity power supply in the Cook Islands. The data are collected within the limit of availability of the information, some outer islands are still having difficulty recording data regularly and consistently.

FEDERATED STATES OF MICRONESIA

R. Hardley

Introduction

The Federated States of Micronesia is a democratic, constitutional federation of four States - Kosrae, Pohnpei, Truk, and Yap - which came into existence as a distinct political entity in 1979. The National and State Government of Federated States of Micronesia were installed and the Constitution took effect on May 10, 1979. The National and State Governments have now assumed responsibility for virtually all internal and external affairs functions formerly by Administering Authority. On October 1, 1982, the Government of the Federated States of Micronesia and the Government of the United States executed a Compact of Free Association between the two governments. As a sovereign nation, the Federated States of Micronesia will continue to exercise full control over its own affairs. The latest population census of the Federated States of Micronesia in 1985 is 28, 879. Land area is 270.8 square miles and lagoon area is 2,776 square miles. Marine and Agriculture are the main resources.

Institutional Arrangements for Energy

The Department of Public Works and the Department of Conservation and Resource Surveillance, Division of Energy are responsible for energy supply for Pohnpei State.

Their energy roles are clearly specified.

(a) Pohnpei is caught between rising expectation for more energy consumption and declining rate of growth of the Government budget.

(b) Energy use is believed to be strongly tied to economic growth and social development in Pohnpei.

(c) The rates charged for electricity are too low and amount to a heavy subsidy to those with access to electricity.

Energy Supply and Consumption

Other than traditional fuels, the government is the main supplier of energy.

(a) Traditional Fuels - Biomass in the form of wood, coconut husks and related island foliage is a major source of energy for the rural area. No study has been done yet to assess its importance, but it is estimated to provide between two-thirds and three-quarters of the energy used in the State. Wood will remain the major fuel source for cooking, food processing and traditional uses during the plan period. An additional contribution from wood will be developed by producing electricity through a 2MW biomass plant.

(b) Petroleum - Petroleum-based energy is primarily used in two major areas (1) electricity generation and (2) land and sea transportation. Diesel fuel is used in generation of electricity.

(c) Electricity consumption is heavily subsidized by the government. The revenues generated from the electricity sold in FY 1985 amounted to only $492,400, 31 percent of the total fund expenditure for electricity generation.

Household and Rural Energy

(a) General - The government does perceive that there is a household/rural energy problem. There is a high demand, while supply is constrained.

(b) Household Energy Policy and Practice - Due to the lack of energy (29% of the island population used energy), the government does not have an established policy. The common practice is adopt United States energy policies.

(c) Stoves - The commonly used stoves are the traditional wood stoves in the rural areas. Urban areas do use petroleum energy for cooking. There hasn't been a programme provided, apart from studies for the extension of petroleum energy in the rural areas.

(d) Fuel Pricing - At the present time, there is no policy on the prices for urban and rural areas. The urban area pays a high price due to its high consumption. Outer Island (or highland) is given solar energy to ensure safety of their medication.

(e) Rural Electrification - About 71% of the rural population is without electricity. 29% of the total population of Pohnpei uses electricity. The government is in the process of extending power into the rural areas. The government is also in the process of expanding the min-hydro capacity to be able to produce the needed source. Following are the generating stations:

(i) Nanpohnmal Diesel Power Station
(ii) A'CO Barge Diesel Power Station
(iii) Nanpil Hydro Power Station.

(f) Biomass Energy Use - There has been a perceived fuelwood problem on the island. Forestry does have documentation and policies on wood. Fuelwood is the responsibility of each household. Each household woman has her own programme on the fuelwood.

Women's Roles in Household & Rural Energy Choices

There has not been much choice for rural women in terms of energy supplies. Cooling is done the traditional way, and lighting uses kerosene.

Urban women do have a better choice in their energy supplies. The use of petroleum energy is available as well as traditional fuels.

There has been a study conducted by KRTA, a firm from New Zealand, to extend electrical lines to the rural areas. The government is in the process of funding these projects.

Environment - Energy Issue in Households and Rural Communities

There is an explicit policy on the environmental aspects of energy production/consumption which affects household and rural energy. the Environmental Protection Agency is responsible for ensuring that the production of energy is handled properly so that its use does not effect the environment. There has been no reference on possible health problems associated with traditional cooking methods. Environmental Protection Agency (EPA) is again responsible for ensuring the construction sites of energy projects. This is the agency that handles environmental matters.

Conclusion and Recommendations

Population and electrical load growth to 1995 have been estimated at 3.6% and 13% respectively. This means an increase of 5 MW for the overall generation and distribution system.

The short term load growth resulting from the electrification of new areas will have an impact on the plans for generation capacity and it is recommended that immediate steps are taken to ensure that sufficient generating capacity is available to meet this short term increase.

The main recommendation is that the new lines around the Island and spur lines are built with predominantly 35ft. poles and horizontal line configuration. Solar energy needs to be made available for the Outer Island (or highland).

The government need to have solar energy available to the rural areas that cannot be hooked to the grid.

References

- Pohnpei State Statistics Yearbook - 1989

- First State Development Plan - 1987-1991

- 13.8KV Around Island Power Line - 1988

- Small Hydro Power Workshop - 1988

Introduction

The Republic of Fiji is an archipelagic country spanning an area of 709,600 square kilometers of ocean in the heart of the South Pacific. It is made of 382 islands which vary in size from 10,000 square kilometers to tiny islets a few meters in circumference.

The islands of Fiji are home to many different peoples predominantly Fijians and Indians with part-Europeans, Chinese and other Pacific Islanders in small numbers. In December 1989, official estimates put the total population at 727,104 of whom 48.4% were Fijians, 46.4% were Indians and the balance were part-Europeans, Chinese and other Pacific Islanders. About 61.3% of the population live as rural dwellers. The 1986 census showed an overall average growth rate of 1.9%.

Although spread over a vast expanse of ocean, the total land area is only about 17,638 square kilometers. The majority of the larger islands are of volcanic origin; most of the smaller ones are formed of limestone. Generally the larger islands are rugged with mountain ranges of moderate height; but they have conspicuous areas of flat land; many of the rivers have built extensive deltas and the coasts are fringed with fertile plains.

The climate is regarded as being good for the tropics and healthy. The prevailing wind usually blows from the South-east between April and November. The two larger islands Viti Levu and Vanua Levu show a marked difference between their windward and leeward sides. The average annual rainfall on the windward coast is 3000 mm; on the leeward coast it varies from 1700 mm to 2000 mm according to locality with very low rainfall drops between June and October. It is the existence of this dry spell which causes the "North-west" to be known as the "dry zone.

Natural Resources

Fiji has at its disposal a considerable forest reserve-both natural and plantations. This includes rainforest, scrub, coconut, pine and hardwood plantations. Generally the South-eastern parts of each island are covered with a dense growth of tropical rain forest and the North-eastern parts have natural vegetation, namely grass and scrub.

Table 1 shows the tree cover for the whole of Fiji by category and type of ownership.

Table 1: Analysis of Natural Tree Cover (1978)

Arrears in Hectares

Forest Category	Private	Land Ownership Crown	Forest Reserve	Leased to F.D.	Communal	Total
Production Forest (Unexploited)	16024	6107	987	3803	226321	249171
Production Forest (Exploited)	4224	1273	2271	171	38775	50856
Conservation Forest	10941	18088	13580	71	208021	250721
Non Commercial Forest	13619	16776	719	938	219757	251828
Mangrove	--	18400	--	--	--	18400
Timber Plantation	--	50	1000	8450	--	9500

Source: AC Frith - Wood Resources of Fiji - Department of Forestry.

There are certain constraints in the exploitation of these resources. Apart from economical and ecological, there are also social constraints. Most of the land in Viti Levu and Vanua Levu has been subdivided and leased for individual farming. In the smaller islands most of the land belongs to the "mataqali" or extended family unit. These lands are available to the members of the "mataqali" for their livelihood. A good proportion of the land in Fiji (85%) is classified as "communal" or "native" land and any development will have to be carried out with the full cooperation of the Native Land Department and the Land-owning unit "mataqali").

Explorations for mineral and marine resources have taken place during the last few years and there are encouraging indications for commercially exploitable quantities.

Economy

Fiji's economy has always had an agricultural base with sugar production the mainstay of the economy. However, the agricultural sector is now diversifying production into citrus fruits, cocoa, ginger, poultry and pig production, timber, fish (chiefly tuna), copra and the production of cash crops are considered priority development sectors. Tourism has become increasingly important in Fiji in recent years and has been actually encouraged by the Government in order to reduce the economy's heavy dependence on sugar. The industry recorded US$185 million earnings in 1986 with a record number of 258,000 visitors. Because of the political situation, the number of tourists visiting Fiji in 1987 dropped to 190,000. Last year visitor arrival increased considerably to pre-coup levels when an estimated 250,000 tourists visited Fiji and expected earnings were F$280 million.

Manufacturing provided 11% of GDP in 1988. Fiji recognizes the potential for the development of its manufacturing industry. A high priority is placed on developing export oriented industries and incentives are offered to local and overseas investors. A major incentive is the establishment of the Tax Free Zone and the Tax Free Factory Scheme for enterprises exporting 95% or more of their output. Up until the beginning of this year about 90 companies have been granted tax free licenses.

As a result of the pronounced recoveries in the sugar and tourism sectors, growth in non-traditional exports and the favorable world prices, the country's economic performance last year has been very, encouraging. The key economic indicators are:

(a) Industrial production - increase of 8.6%

(b) Paid employment - increase of 8.1%

(c) Level of lending by commercial banks - increase of 31.6%

(d) Trade deficit - widened to F$151 million compared with F$106 million last year. (This is mainly due to the growth in imports.)

(e) Gross Foreign Reserve - F$315 million

(f) Inflation rate - 6.4%

GDP grew by about 12% in real terms in 1989 and this year growth of about 4.5% was expected.

Energy Resources

Major sources of energy in Fiji are imported petroleum fuels, hydro electricity, imported coal and indigenous biomass. Fiji is heavily dependent on imported petroleum fuels. Last year Fiji imported 633.8 million liters of petroleum fuels which cost about F$156 million. Of this 74% was for transport fuels, 13% for industrial sector, 7% for household use and 6% for government use.

The Monasavu Hydro Power Project, completed in 1983 at a cost of well over F$200 million, is now generating power to satisfy the needs of Viti Levu. The completion of this ambitious project has resulted in annual savings of about F$22 million in petroleum imports.

Of the indigenous biomass, fuelwood is the most important. A survey in 1982 of household energy use in some urban, semi-urban and rural areas of Viti Levu indicated that 62% and 88% of the households with electricity and 88% of those without electricity is woodfuel for cooking.

Institutional Arrangements for Energy

The present Department of Energy could be said to have been borne out of the "Alternate Fuel Technical Committee" which was set up in 1974 at Cabinet instigation. The purpose of this Committee was to explore possible alternative sources of energy in order to save petroleum imports and foreign exchange during the oil crises of 1973 and 1974. One of the major recommendations of this Committee was the creation of a unit, within Government, with specific responsibility in energy matters.

This resulted in the establishment of a Ministry of Energy in 1981 to be responsible, in the energy field, for policy formulation, research, technical advice, incentives, foreign aid and public education. A Minister of State was appointed for this ministry in January 1981 but no staff were available until March when one part-time and one full time professional were loaned from other ministries. Following Parliament approval for staffing and financing more staff were recruited. Appendix 1 shows the structure and personnel of the Ministry of Energy during its establishment in 1981. A detail of the responsibilities of each Energy Section is given in Appendix 2.

After undergoing two major reorganizations in 1982 and 1987 respectively, the Department of Energy is now part of the new Ministry of Tourism, Civil Aviation, Meteorology and Energy. At present there are six professional staff three of whom are expatriates, and six support staff. The present organizational structure is shown in Appendix 3.

The present responsibility of the Department of Energy has not changed from that of the Ministry of Energy established in 1981. However, its role as the Government's energy planning and development department also covers the important area of energy conservation. In relation to this, the department is responsible for implementing a national energy management programme which includes establishing the necessary data base on energy utilization and targeting energy conservation programmes to the necessary sectors of the economy, particularly in the commercial sector.

These responsibilities require close liaison and extensive consultations with other government organizations, statutory bodies, private sector as well as voluntary and other social/community development organizations.

The Central Planning Office has overall control in that the final decision on project implementation is made here and (All projects are vested here) for economic/financial viability.

The Aid Coordination Unit is part of the Ministry of Finance, who coordinate project funding, either through aid or government funds.

The Fuel Price Control Authority, of the Prices and Incomes Board undertakes quarterly reviews of all fuel prices given the market conditions. It adjusts prices accordingly and these are gazetted for all areas of Fiji.

FEA, the electric power utility is a statutory body with a mandate to provide electricity to a wide sector - urban, industrial and rural consumers. They submit proposed tariff structure to Cabinet for approval.

Energy Supply and Consumption

Most of Fiji's total energy consumption is supplied from local energy resources. Imported energy is largely utilized by the transport industry, which is entirely dependent on petroleum fuels. The table below shows the National Energy Consumption, by source, in 1986.

Table 2

Source	Supply	Quantity	Percentage
Local	Wood	270,742 tons	All local 60.68%
	Bagasse	984,682 tons	
	Hydro	3,324 Mwh	
	Wind/Solar	Insignificant	
	Petroleum Products	360,000 KL	
Imported:	Coal	15,217 tons	All imported: 39.32%
	LPG	3,722 tons	

Source: Department of Energy, 1987.

As can be seen from the table, wood and bagasse are the main sources of local energy. The different end uses of wood for 1986 are shown in Table 4 below:

Table 3: National Wood Use for 1986

Source	End Use	Rural	Urban	Total	Equivalent GJ
	Cooking & other Household use	137,655	21,653	159,308	3,186,160
Wood	Copra Drying	78,666	--	78,666	1,573,320
	Cocoa Drying	?	847	847	16,940
	Crematoria	--	2,662	2,662	53,240
	Industrial Boiler	--	29,259	29,259	585,180
TOTAL		216,321	54,242	270,742	17,414,840

Bagasse is widely used by the Fiji Sugar Corporation for generating electricity in all its four sugar mills. The table below summarizes the bagasse produced and used by Fiji Sugar Corporation from 1986 - 1989.

Table 4

Year	Bagasse Produced (Tons)	Used as Fuel	Equivalent GJ
1986	983,682	998,822	19,377,146
1987	779,294	763,078	14,803,713
1988	784,230	771,955	14,975,927
1989	1,000,000	936,016	18,158,710
TOTAL	3,547,206	3,469,871	67,315,496

Source: Fiji Sugar Corporation (1990).

Petroleum products accounted for 13.5% of Fiji's total import last year. A total of 629.02 million liters of petroleum fuels were imported at a cost F$157 million. The table below shows the petroleum imports and value for the last three years.

Table 5

	1987		1988		1989	
Products	Volume	Value	Volume	Value	Volume	Value
Aviation Turbine Fuel	81.5	16.7	118.4	22.9	111.0	27.9
Aviation Gasoline	2.5	1.1	5.0	1.4	3.4	1.6
Motor Spirit	92.3	20.3	76.0	15.5	132.8	31.5
Kerosene	29.0	5.9	12.6	2.7	48.1	12.2
Automotive Distillate	106.9	21.8	133.5	26.2	222.2	53.0
Industrial	41.6	7.7	43.6	7.8	74.2	17.0
Residual Fuel Oil	8.5	9.2	8.7	9.3	13.8	2.2
OTHERS						
Coal	5.5	0.3	0.002	0.004	13.1	1.4
Solvent	3.1	0.7	3.6	1.1	3.5	1.1
Grease	0.3	0.3	0.03	0.04	0.22	0.432
Benzine	0.08	0.07	0.07	0.06	--	--
LPG	5.0	2.0	4.5	2.0	6.2	2.8
TOTAL	376.28	86.07	406.00	89.00	628.52	151.1

Notes: 1. Quantity in million liters.
2. Value in million of Fiji Dollars.

Source: Bureau of Statistics - Current Economic Statistics, October 1989.

As can be readily seen from the above table, the road transport is the most single important user of petroleum products utilizing about 30%.

The two tables which follow show the annual per capita consumption and the unit price of petroleum products for the last five years.

Table 6: Annual Consumption per capita of Petroleum Products

Product	Unit	1985	1986	1987	1988
LPG	kg	5.71	5.24	6.58	5.97
Kerosene	liter	16.35	23.03	28.76	37.40
Benzine	liter	0.16	0.11	0.11	0.09
Automotive Distillate	liter	126.56	124.97	101.24	116.87
Motor Spirit	liter	86.81	78.24	79.26	57.55

Source: Current Economic Statistics - Bureau of Statistics, October 1989.

Table 7: Retail Prices of Petroleum Products

Product	Unit	1985	1986	1987	1988	1989	1990
LPG	kg	$1.13	$1.13	$1.23	$1.20	$1.20	$1.20
Kerosene	liter	$0.42	$0.23	$0.26	$0.32	$0.38	$0.40
Benzine	liter	$0.48	$0.42	$0.43	$0.45	$0.52	$0.47
Automotive Distillate	liter	$0.48	$0.38	$0.44	$0.47	$0.51	$0.48
Motor Spirit	liter	$0.68	$0.61	$0.66	$0.68	$0.74	$0.65

Source: Current Economic Statistics - Bureau of Statistics, October 1989.

Household and Rural Energy

There are two main areas that the Government perceives as areas of concern in the household and rural energy:

(a) the rapid depletion of fuelwood resources around the village, and

(b) the heavy dependence on imported fuels.

Consumption and Production

In rural Fiji the traditional method of slash, burn and shift farming is widely practiced. This, to a great extent, has exacerbated the depletion of fuelwood supply available around the villages. But there are other factors which act more rapidly in reducing this fuelwood resources. Prominent among these are the following:

(a) Rate of consumption

(b) Increase in population

(c) Increase in agricultural development

(d) Increase in commercial use of wood e.g., copra,/cocoa drying, industrial boilers

(e) Increase in timber production

(f) Change in meal patterns (form 2 to 3 times a day); and

(g) Change in food patterns (certain recipes require more cooking time)

As the available tree resources declines the pressure of woodfuel consumption on what remains steadily increases. Fuelwood collection can now be a time consuming and physically taxing activity in some rural places and a heavy bundle of wood must be carried in approximately four times a week (Siwatibau 1981) regardless of the weather. Siwatibau (1981) estimated that the per capita annual consumption of fuelwood in rural Fiji was 506 kg. There has also been an increase in the use of fuelwood in urban areas. The social and economically disadvantaged groups in urban and peri-urban areas have a high dependency on fuelwood for cooking. It is quite obvious from surveys (Siwatibau 1981, USP 198211 that wood is overwhelmingly the predominant source of rural household energy in Fiji. However, there is also an increase in the use of imported fuels. Siwatibau ascertains that there is a correlation between increase in cash income and use of kerosene stoves. This is supported by the Government Central Planning Office estimate on trend in wood use in Fiji (1978). Indeed, it is a worldwide phenomenon.

The popular choice for kerosene may be due to the following:

(a) the availability of a number of cheap kerosene stoves

(b) the availability of price controlled kerosene in nearly all village stores.

(c) the easy transportation of kerosene even when purchased from one of the main centers

(d) collecting firewood is tiresome, especially in bad weather

(e) gathering wood and cooking over wood fires is time consuming

(f) open fire smoke is detrimental to health

Common domestic end uses of energy in rural Fiji are heat for cooking, baking, crop drying, food preservation, ironing and light for illumination. According to a survey (Siwatibau

1981) the total energy consumed by a rural person's domestic activities not significantly lower than that of an urban person.

The table below shows the domestic household energy consumption for case study communities in Siwatibau's Survey 1981.

Table 8

Community	Wood Energy		Consumption		Liquid Fuels		Total Energy	
	KG/P	GJ/P	SUS Y	C H/W	L/P	GJ/P	GJ/P	% Wood
Matia	1462	28.8	x 5	2	12.3	0.46	29.26	98
Yaroi	1793	35.32	x13	6	32.7	1.22	36.54	97
Nacamaki	701	13.81	x 8	7.2	5.7	0.21	14.02	99
Naqaleuai	283	5.58	x 8	NA	10.0	0.37	5.95	94
Farms	334	6.58	NA	NA	11.0	0.41	6.99	94
OVERALL	506	9.97	NA	NA	15.8	0.59	10.56	94

Notes:

(1) Wood consumption is dry weight at 19.70 GJ/ton (4.7 Kcal/g) which may be conservative.
(2) x5 means 5 times current consumption.
(3) P = Person, SUS Y = Sustainable Yield, C H/W = Collection Hours per Week.

In 1982, a domestic household energy survey was carried out between Nadi and Lautoka. This area covers urban, peri-urban and rural areas. A comparison of the energy consumption of people in the three different areas is given in the table below.

Table 9: Per Capita Energy Consumption

Energy Source	Urban	Peri-Urban	Rural
Electricity	262 kWh	174 kWh	152 kWh
Woodfuel	146 kg	182 kg	3285 kg
Kerosene	34 l	36 l	26 l
LPG	30 kg	23 kg	12 kg

Source: Nadi-Lautoka Domestic Energy Survey INR 1982.

The two surveys: Siwatibau's survey of Domestic Rural Energy Uses and Potential and the USP'S - Nadi - Lautoka Domestic Energy Survey are the only two large scale surveys undertaken on household energy use. In particular, Siwatibau's survey forms a baseline in developing rural energy projects in the absence of a national rural energy policy.

Woodstoves

In rural areas, more people rely on wood for their basic energy needs than any other fuel. Some 92% of rural families surveyed by Siwatibau use the open fire cooking. This method has a lot of disadvantages. Apart from being very inefficient, it is dirty, laborious, and detrimental to health.

The Department of Energy has a key role in the developing and testing of improved domestic wood stoves in Fiji. Other governmental and non-governmental organizations also have intensive programme on the design, testing and dissemination of suitable woodstoves. As a result there is quite a number of woodstoves designs available in Fiji. The Department of Energy under its woodstove programme is also working on the improvement of institutional woodstoves. Currently it is working on a design which it hopes will last and work more efficiently.

The Department of Energy is also instrumental in promoting woodstoves education and promotion workshops in Fiji. Together with the Fiji National Council for Women they organized a number of workshops in 1987. Two of these were held at national level for village and community leaders and seventeen at village and community level.

These workshops were primarily aimed for women but the interest in woodstoves also attracted some menfolks. Unfortunately the woodstove programme in the mid 1980's did not sufficiently test stoves prior to dissemination. The DOE, in co-operation with all stove promoters in Fiji, is in the middle of a stove identification programme with stoves undergoing laboratory and field testing. This work was initially funded by PEDP and from November 1990, by GTZ.

Fuel Pricing

This is one of the items that comes under the Prices and Incomes Board, a statutory body established in 1972 by an act of Parliament to "afford power of control over prices, charges, remuneration, dividends and rents; and for connected purposes".

Fuel prices in rural areas are at prices declared by the PIB or in certain cases higher due to high handling costs. Prices in urban areas are highly competitive. As a result prices in some places can be lower than that set by PIB.

Rural Electrification

The Government has assigned high priority to rural electrification in its development objectives. Apart from the principal goal of satisfying basic needs, rural electrification is regarded as a measure to counter the urban immigration.

In Fiji, the Public Works Department is responsible for the electrification of rural areas with stand alone diesel generators. These areas are usually remote villages and settlements which cannot economically be reached by the FEA grid. Whenever possible, Aid funds are used by the Government to extend the existing gird into the rural areas, particularly those with an established load center e.g., under Lome 111, 26 rural extension will be funded; the Chinese Government is also funding extension work.

Policy

For a village or settlement to qualify for PWD stand alone diesel generator it has to have at least 20 houses. They are required to pay a capital contribution of one-sixth of the total estimated cost or 50.00 per house, whichever the less. The village has to pay the one half of the basic village contribution prior to a survey being conducted. On payment the village will not necessarily be electrified that year but will join other villages on a priority list. Electrification is done on "first come first serve" basis.

Apart from the capital contribution the villagers have to provide free accommodation for the PWD workmen while engaged on electrification work and provide unskilled labor for digging back filling trenches, loading and unloading. After commissioning, the village is given a grace period of 6 months in which the PWD workmen will provide maintenance free of charge.

For all other subsequent maintenance after the grace period, the village is levied US$100.00 for two annual maintenance visits by PWD. At the rate of 7 projects per year it, would take PWD 50 years to electrify all rural areas in Fiji.

Small diesel power plants have been used for more stand alone rural electrification systems than any other technology. Perhaps the reasons for their popularity are basically the relatively low capital cost and familiarity. However their operating cost and the problems of supplying remote rural communities with fuel of adequate quality, replacement parts and technical support for maintenance and repair are substantial hidden costs.

This experience from diesel RE schemes coupled with the government's policy of reducing imported fuel cost has placed pressure on the Government to look for alternative technologies. As a result there has been intensive work carried out on new and renewable sources of energy. of particular interest are:

(a) Small Hydro Schemes

(b) Solar Photo Voltaic, and

(c) Steam Plants.

Mini and Micro Hydro Schemes

These schemes are financed by aid agencies. Though the potential is quite high their exploitation will depend very much on financial and technical aid donors. The priority is to survey the potential of all identified sites in Fiji.

Solar Photovoltaic

This is the newest of the rural electrification technologies. Photovoltaics have not really penetrated the rural electrification market, though there are signs of rising interest in the technology in Fiji as shown in Appendix 4.

Steam Plants

Though researchers indicate that there is potential for biomass steam plants, for some reason its exploitation has not been so intensive as that of hydro and photovoltaics. Its use as a RE technology has been limited because of the availability of biomass around the village. Subsistence and commercial farming has denuded fuelwood resources around the village.

What is left is usually utilized for cooking. The village is only left with the option to gather fuelwood for steam plant generation further away from the village, sometime rendering it uneconomical.

In order to alleviate this fuelwood problem, the Forestry Department has identified a number of fast growing trees which can be planted and harvested in four years time. They have quite a number of projects in selected sites in Fiji. The DOE is currently evaluating the potential for utilizing established, remote community pine plantations as a fuel source for steam plants to provide the power for rural development. Pilot projects based on saw mill operations, powered by steam generated electricity, to provide basic rural industry are proposed.

Biomass Resources

Forestry resources in Fiji, both traditional and plantation type give immense potential for electricity generation from waste. Estimates show that a single hectare of mature pine (15 years old) will produce over 56,000 kg of wood waste when cut. Other source of biomass are crop wastes. These include rice straws and husks, sugar cane tops and bagasse and coconut tree, husks and shells.

Coconut trees are widespread throughout the eastern and southern parts of the two major islands as well as in all the other islands of the Fiji Group. The area covered by coconut trees all over Fiji is around 80,000 hectare.

Women and Household and Rural Energy

Most of the women's activities are centered around domestic chores. One estimate (Bolabola 1989) shows that rural women spend 16 hours of their day doing their domestic work. 40-50% of this is spent in cooking related activities. Calling them Transport and Energy Managers, Bolabola claims that women, whether they be rural or urban, are always responsible for the family energy supply.

The position of women in some rural places in Fiji is not encouraging. The task of supplying the family's fuel needs becomes more difficult and time consuming. Instead of being able to collect what they need around their immediate surroundings women are driven further afield in search of their cooking fuel. Women interviewed by Siwatibau (1981) made four trips a week, each trip taking at least an hour. In some of the drier parts of Fiji, fuelwood scarcity is a reality.

Improving the living condition of rural people is one of the main goals of the current development plan. Of interest to us here is the work done to try and improve cooking methods in rural areas. As already been highlighted there are woodstove programmes by different organizations. All these organizations have the same basic aims of improving the cooking methods and an efficient use of the limited fuel available, thus our women will be able to cook in a healthy environment; more so it will reduce the time for collecting fuelwood. The introduction of electricity in rural areas will no doubt help in improving living standards. However, most of these RE schemes are for lighting only, thus restricting one of mankind most versatile technologies.

Environment - Energy Uses in Households and Rural Communities

While there is an Environmental Management Committee to advise Government on environment matters, its role has been limited to that of advisory only. Furthermore, environmental policies are explicit enough to cover important aspects of the environment.

The impact of agriculture and forestry upon the environment is accelerating at a phenomenal rate. Most of these forestry and agricultural developments are taking place right at the door of the rural people. The traditional farmer is still familiar with and practices his annual shift farming techniques, provided there is land there is no legislation to compel him from doing so.

Bush fires are common sights in the dry areas where nature has been so unkind to bestow little vegetation, consequently denuding resources available for fuelwood around the villages.

Traditional open fire cooking is still prevalent in the rural households. We do not need a health expert to tell us that this method is a health hazard. Siwatibau (1981) discovered that a great number of women in the rural villages complained of eye irritation by smoke. She also ascertained that "greater frequency of chest complaints in Fijian populations may be influenced by sleeping in and sustained exposure to, smokey atmosphere". Tests have shown that the exposure to some of the pollutants found in third world kitchens can in some cases be equivalent to smoking 20 packets of cigarettes per day (Commission of the European Communities).

Overseas Technical Committee

Like most of Pacific Island neighbors, Fiji depends heavily on aid agencies for the realization of most of its major development projects. Most of these island countries, including Fiji, do not have the resources to implement priority projects. In the energy field there are a quite a number of on-going rural energy projects which are funded externally. For example our woodstove programme is being funded by UNDP.

The rural electrification programme utilizing photovoltaics is regional aid provided under the Lome II agreement.

The fuelwood projects in selected rural sites are funded by German aid (GTZ). In Fiji all energy projects are coordinated by the Department of Energy irrespective of whether they are funded internally or externally.

Conclusion and Recommendations

Household energy constitutes an economic sector. With its relationship to social welfare and quality of life, the household energy sector should be viewed as a priority not solely from policy-making but also from research, planning and investment point of view. Energy in the rural household is an issue on which national planners seem to place little significance in the overall national development plan.

For rural households, energy problems can be just one set of a range of problems besetting the rural population. In fact, experts believe that rural household energy problems are always associated with rural under development. It follows that to rural energy household problems, one really has to look realistically at the whole plan of work for rural development.

Information about rural energy resources, use, trends, consumption and all the data important in realistically working out solutions should be readily available. In this regard, the Department of Energy should be responsible for an information system whereby departmental energy related information are coordinated. Of importance here is the continuity of information gathering.

Providing adequate energy supplies for the household is crucial. Basic lighting units provided for by RE schemes are becoming more and more inadequate. In some RE schemes, households are levied US$2.00 per week which amounts to US$8.00 per month. This is not too far off the amount paid by a grid connected urban consumer who enjoys amongst other things, refrigeration, cooking and ironing.

Prices of imported fuels should be realistically set for rural populations. The current distribution system forces the rural consumers to pay more than his urban counterpart.

We have to remind ourselves that wood will continue to be the main source of energy in the rural areas. We, therefore, have to devise conservation measures for the resources available. Rational management of fuelwood based on sound natural resource and land utilization concept is mandatory. Traditional annual shift farming should be illegal.

Work on alternative energy resources should be intensified. Hydroelectricity potential in Fiji is quite high. Other options such as small hydro, solar, wind power could prove to be the best option in attending to rural household energy needs.

There should be a clear policy on rural household energy. This will ensure better management of household energy.

A public education programme on energy management is becoming increasingly necessary.

The total role of women in household energy is so critical, that it is vitally important that their involvement in energy planning, policy making, research and investment should be encouraged.

There should be a clear policy interface between energy and the environment. This interface should be enforced by legislative frameworks that are not confusing, inconsistent nor inadequate.

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Minister of Energy

Director

Director of Energy Planning & Development (1)

ENERGY PLANNING MANAGEMENT SECTION	RENEWABLE ENERGY SYSTEMS & SPECIAL PROJECT SECTION	POWER SYSTEMS & PETROLEUM SECTION	OFFICE ADMINISTRATION
- Chief Energy Analyst (1)	- Chief Energy Project Engineer (1)	- Chief Power Systems Planner (1)	- Chief Power Systems Planner (1)
- Principal Energy Conservation Officer (1)	- Principal Energy Special Project Officer (1)	- Principal Petroleum Fuels Officer (1)	- Principal Petroleum Fuels Officer (1)
- Senior Energy Research Officer (2)	- Senior Energy Combustion Systems Engineer (1)	- Principal	- Principal
	- Messenger/ Driver unestablished (2)	- Director's PA/Steno/ Typist (1)	- Director's PA/Steno/ Typist (1)

ENERGY PLANNING AND MANAGEMENT SECTION

- responsible for overall energy planning and policy including electricity tariff analysis, fuel pricing, fuel taxes/duties, rural electricification subsidies.
- development and maintenance of up-to-date sectoral energy data base (Industry, Govt, Households).
- development of national energy accounting system and energy modelling.
- development of energy auditing capability.
- development of national energy conservation programme.
- forecast of energy production, demand and prices.
- development and maintenance of up-to-date energy resources inventory.
- economic analysis of energy programmes & projects.
- development of public energy awareness programme.
- review and advise on energy-related codes, laws & regulations (including building standards).

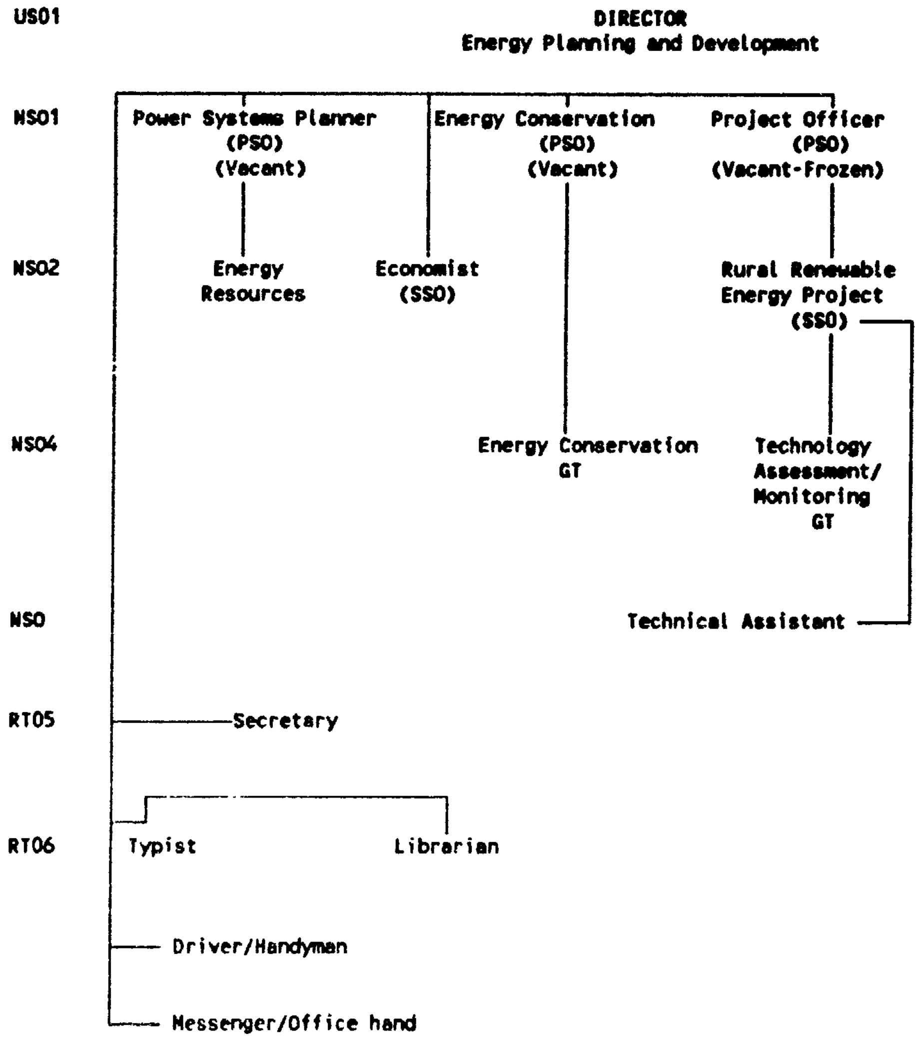
RENEWABLE ENERGY SYSTEMS SPECIAL PROJECTS SECTION

- analysis and development of new, renewable, and non-conventional energy systems.
- analysis of ethanol fuels. Programmes including liaison with Fiji Sugar Corporation.
- analysis of social, environmental, and land-use implications of energy development projects.
- responsibility for biogas, biomass, solar, wind, wood, charcoal, related development.
- assessment of longer term energy possibilities including seawave, OTEC and geothermal energy.
- assess & develop improved rural cooking and lighting systems.
- special projects as necessary.

POWER SYSTEMS AND PETROLEUM SECTION

- Responsibility for electricity petroleum and conventional energy systems planning and analysis.
- Analysis of long-term electric power investment needs and options.
- Analysis of electricity distribution network.
- Analysis of rural electrification programme.
- Analysis of all FEA papers and programmes.
- Assessment of petroleum supply options.
- Analysis of petroleum supply contracts.
- Assessment (with appropriate Ministries) petroleum exploration agreements.
- Analysis of technical options to existing combustion techniques and fuels.
- Analysis of suitability of existing petroleum fuels for Fiji market (RON of petrol, etc.).
- Development of fuel and power.

Table 10


US01
DIRECTOR
Energy Planning and Development
NS01
Power Systems Planner
(PSO)
(Vacant)
Energy Conservation
(PSO)
(Vacant)
Project Officer
(PSO)
(Vacant-Frozen)
NS02
Energy
Resources
Economist
(SSO)
Rural Renewable
Energy Project
(SSO)
NS04
Energy Conservation
GT
Technology
Assessment/
Monitoring
GT
NSO
Technical Assistant
RT05
Secretary
RT06
Typist
Librarian
Driver/Handyman
Messenger/Office hand

NUMBER OF SOLAR PV UNITS INSTALLED AROUND FIJI GROUP

Name of Institution	Location	No. of Units Installed	Date/Month Installed
Health Center & Boarding School	Draketi, Qamea	9	Sept. 1983
Boarding Schools & Private Homes	Katei, Totoya	12	Nov. 1983
Health Center, Boarding School & Priv. Homes	Vatulele Koro	21	Nov. 1983
Boarding Schools & Private Homes	Namara Kadavu	43	Feb. 1984
Health Center	Nasauvuki Moturiki	2	June 1984
Boarding School	Nasau Koro	5	Feb. 1984
Health Center	Lekutu Bua	4	March 1984
Health Center	Naroi Moala	4	April 1984
Boarding School	Kavala Bay Kadavu	2	April 1984
Health Center	Yaroi Matuku	2	March 1985
Boarding School	Levukaidaku Matuku	1	April 1985
Health Center	Udu Kabara	1	Feb. 1986
Boarding School	Nukuilau Keyasi	4	March 1986
Health Center	Nadarivatu Naitasiri	2	April 1986
Private Homes	Madhuvani Rakiraki	74	Oct. 1986
Health Center	Tukavesi Buca Bay	4	Sept. 1987
Health Center	Lomati Cicia	8	June 1987
Ra Provincial Office	Nanukuloa Ra	2	Sept. 1987
Private Homes	Vaidoko Ra	21	Dec. 1987
Private Homes	Dobuilevu Ra	105	Nov. 1987
Hospital	Vunidawa Naitasiri	1	Feb. 1988

Mr. R. Ioteba

Introduction

Kiribati is made up of thirty three islands located in the Central Pacific Ocean, straddling the equator and the International Date Line. It is sub-divided into three main groups:-

(a) The Gilbert Group: a chain of 17 atolls spread over 680 kilometers in the western sector which includes Tarawa, the seat of Government;

(b) The Phoenix Group: a cluster of 18 atolls lying about half way between the Gilbert and Line Islands;

(c) The Line Islands: a chain of 8 atolls spread over 2,000 kilometers located some 3,000 kilometers east of the Gilbert Group on the other side of the date line. They include Kiritimati which accounts for half the country's land area.

These atolls rarely rise more than 5 meters above sea level, and are composed entirely of coral debris and calcareous structures. Frequently they consist of a thin broken ribbon of land partly enclosing a lagoon. They are widely dispersed three distinct 200 mile exclusive economic zones (EEZ's) which cover three million square kilometers of ocean. The total land area of all the islands however, is only 746 square kilometers.

According to the 1985 census, the population had increased to 66,100 from its 1978 level of 58,512. The resident population of 63,883 in 1985 represents an overall increase of 13.6 per cent over the 1978 population, implying an annual actual population growth rate, which takes into account fertility, mortality and migration of 2.1 per cent per annum between the census years. The natural rate of growth of the indigenous population is 2.4 per cent per annum. Population growth is presently viewed the most critical issue affecting the potential economic and environmental viability of the country.

The physical distribution of population is skewed towards the Gilbert Group, on which Tarawa is located. The number of people in South Tarawa rose from 17,921 in 1978 to 21,190 in 1985. Population density also rose from 1134 persons per square kilometer to 1311 persons per square kilometer during the same period. Population density in South Tarawa is much higher than the rest of the country.

Economic dualism is a characteristic of feature of our production, where subsistence livelihood predominates in much of the outer islands, and a monetized economy exist in urban Tarawa and Kiritimati island. GDP per capita was nearly $500 in 1985 though the measurement of subsistence activity requires improvement.

The subsistence economy is by and large self-sufficient in providing most basic needs of the population on the outer islands. Apart from fishing, which is an important occupation, and provides an important component in the nation's diet, the main crops are nanao (swamp taro), pandanus and breadfruit. Coconuts are grown for domestic consumption and export. Chickens and pigs are also raised for home consumption. Because of the harsh cultivation, of agricultural crops is difficult, entailing a lot of effort. However, some expansion in home vegetable gardens is now taking place. Local materials are widely used in housing construction. The major trade goods required in the subsistence sector include fuel, cloth, some food such as rice, sugar and flour, and items such as soap, tobacco and matches. Other items such as pots and crockery, radios, bikes and some motorbikes and outboard engines are also occasionally purchased.

Public enterprise dominates the cash economy which is centered in urban Tarawa, the administratives eat of Government, and Kiritimati island which caters to a limited amount of tourism. Small scale industries had been encouraged and so far there are small industries which make slippers and chairs. There are also many more which are expected to operate early next year, 1991. Most private enterprise is situated on South Tarawa and is concentrated in the small scale service sector, such as taxis, buses, film showing and food vendors. Exports are basically copra and marine export while import consist of a wide range of consumer and capital goods.

Kiribati atolls represent one of the most limited resource bases for existence in the Pacific. Kiribati experiences a maritime equatorial climate with rainfall more frequent in the northern Gilbert and Line Island groups but drought conditions lasting up to three years have been experienced on most of the islands. Because of poor soil conditions, which are mostly sandy, filtration is quite rapid and surface fresh water is therefore rarely present. The atoll environment produces limitations on agricultural production. A thin and porous layer of top soil, a high level of salinity, salt sprays and lack of surface water produce only a few flora and fauna that are adapted to these rigorous conditions.

Energy Resources

Biomass, primarily in the form of coconut fronds, husk, spathe sheathe and nut, is historically the principal source of energy within Kiribati both in rural areas and in the more densely populated urban area of South Tarawa. Other tree species such as casuarina, te uri, iron wood, te mao, pandanus and breadfruit are also utilized.

Coconut oil may provide a viable alternative as along term fuel supply for power generation and ground transport needs. However, there has no work been done to determine its potential viability and also there is no work planned to explore its potential viability.

There is a considerable scope for the economic utilization of solar radiation in Kiribati with its very favorable solar regime. From data presently available, on South Tarawa it is conservatively estimated that an average of $5kWh/m^2/day$ is available for utilization using various conversion technologies. On Kiritimati island average solar insolation is estimated at $5.6kWh/m^2$ /day.

From presently available data, wind speeds in the Gilbert group appear to be low and non-persistent averaging in the range of 4.0-6.0 meters per second. However, on Kiritimati island wind speeds are reported to average 6.6m/s and are consistent over much of the year. In this case the wind resources may well constitute a long term energy source for the island. In the past years, there were windmills installed on Kiritimati in the Line and Phoenix group and Nikunau in the Gilbert group to operate water pumps. The windmill on Kiritimati is still working while the windmill in Nikunau had been replaced by solar. At present there is no work planned to explore the potential of wind.

There does appear to be a long term future potential for the utilization of ocean thermal energy conversion (OTEC) with seawater temperature differences of approximately 24 degrees celsius to 1000 meters depth. Development of this technology is still in its infancy, however, and with scale economies also dictating minimum plant sizes presently estimated at 3 megawatts before commercial viability is considered along with many other factors, there is no likelihood of application within the country for the foreseeable future.

No surveys have yet been carried out to determine the potential for conversion of energy from seawaves although there was a proposal by one Norwegian company (Kraevnar Brug) currently being under consideration by the Kiribati Government.

Institutional Arrangements for Energy

The Energy Planning Unit (EPU) which is attached to the Ministry of Works and Energy (MWE) was established in January 1984. Its present responsibilities and expected functions include the overall monitoring of the energy sector within Kiribati, including the determination of present and future energy requirements, consumption patterns and trends and to formulate specific policy proposals for the future development of the sector. In conjunction with the establishment of policy recommendations, the Unit is also responsible for the establishment of goals and strategies for policy implementation and to coordinate and assist where necessary with the implementation of projects designed to achieve these goals. The EPU is not directly involved in project implementation but confines its activities with project design and coordination and to provide organizational and technical assistance to the implementing agency where necessary. The technical area which the EPU is expected to encompass includes petroleum supply and pricing, power supply and pricing and energy conservation, renewable energy technologies and the wide range of specialist skills and experience needed to adequately fulfill its analysis and planning role, this policy must be rigidly applied if the EPU is to maintain its functional integrity.

At present there are 2 staff of the EPU: the Acting Energy Planner who currently head the Unit and the Assistant Energy Planner. The former Energy Planner and Energy Project Engineer had been transferred on promotion for the positions of Manager of the Kiribati Oil Company Limited (KOIL) and Manager of the Solar Energy Company respectively. The Unit now is not functioning to its full capacity for several reasons. The first one is that there are only 2 staff who don't have the expertise in fulfilling the Unit responsibilities, dealing with the technical areas of the Unit function. The second one is that the role of the EPU is not really clear to other Ministries and the PUB. The KOIL is aware of the EPU role, since its present General Manager was the EPU former Energy Planner. For the future, it is therefore necessary for the EPU staff to be trained in the following areas, petroleum supply and pricing, power supply and pricing and energy conversation and renewable energy technologies and also measures should be taken in making the PUB and other Ministries aware of, and understand the role of the Unit. The training in the three technical areas will enable the EPU to handle and fulfill its expected role especially in energy planning. Also close relationship with the PUB, KOIL and SEC must be developed such that they will cooperate and interact in the decision making and policy making process.

The EPU always seek management, technical and financial assistance from the Pacific Energy Development Program, Forum Secretariat Energy Division and South Pacific Institute for Renewable Energy. The assistance provided had upgraded the EPU skill and knowledge in the areas of Solar PV and management. Assistance, and training in the areas of power and petroleum is still needed by the Unit.

The present capability of the EPU staff is mainly in the area of solar PV. They are capable in providing assistance in the design maintenance and repair work and also installation of PV systems. The expertise in this area was developed as a result of PV training courses being attended by the EPU staff. However, expertise in the areas of petroleum and power needs to be developed at this stage.

The Energy Planning Unit (EPU) is presently involved in the collection of data from KOIL and the Public Utilities Board (PUB). The data collected from the KOIL include the price and the amount of ground and aviation fuel imported and consumed in the country. Data collected from the PUB include the installation capacity, mega-Watt-hour send out, maximum demand, fuel consumption, losses, etc. The data will enable the EPU to monitor fuel consumption patterns and trends and to formulate specific policy proposals for the future development of the sectors. The present staff does not have the expertise in analyzing the data and also in formulating specific policy proposals.

The Public Utilities Board is responsible for the supplying of power, water and sewerage. At present the PUB is concentrating its activities on South Tarawa which is considered to be an urban area. However, the PUB will soon electrify North Tarawa which is considered to be a rural area. There is no immediate plan by PUB to electrify all of the rural areas.

The Solar Energy Company (SEC) is responsible for the purchasing and selling of solar powered product and equipment. At present it is becoming a practice that the SEC is contracted for the implementing of solar PV projects. Also, it is currently in a planning stage of electrifying rural areas using solar PV systems. This is not the Government policy to use PV but it is the SEC initiative. The Government seems to be supporting the idea of using solar PV as a mean of electrifying rural areas. The most common applications of PV systems on outer islands are lighting and water pumping.

Mobil Oil Australia supplies ground products in bulk to Tarawa while PRI supplies ground and aviation fuels to Kiritimati. KOIL is responsible for the storage and selling of ground fuel for the Gilbert group and ground and aviation fuel for the Line and Phoenix Group while B.P South West Pacific provides aviation fuel for the Gilbert Group only. The KOIL headquarter is located on South Tarawa and it is responsible for the Gilbert group only while its branch at Kiritimati is responsible for the Line and Phoenix group.

The involvement of the Energy Planning Unit (EPU) with Kiribati Oil Company Limited (KOIL), Public Utilities Board (PUB) and Solar Energy Company (SEC) is that the EPU is a body representing the Government and it is responsible for the formulation of energy policies in the areas of power and energy conservation, petroleum and renewable energy. Therefore, in order for the EPU to fulfill this expected responsibilities, it is necessary to monitor all the activities of the three said companies. Apart from that, the EPU is also expected to give assistance to the three said companies either in the implementation of their projects (if necessary) or to provide advise for the improvement of their functions and responsibilities. The relationship between the EPU and SEC and KOIL is very good as SEC and KOIL always seek advice from the EPU when needed. The EPU relationship with the PUB is beginning to improve after the last couple of months. The PUB is now approaching the EPU for assistance.

The National Planning Office (NPO) which is attached to the Ministry of Finance and Economic Planning; Development Coordination Committee (DCC), which members are comprised of Secretaries from all Ministries; the Rural Planning Unit (RPU) which is attached to the Ministry of Home Affairs and Decentralization were also involved in energy projects. The RPU deals mainly with rural areas therefore all energy projects from and for rural areas had to go to the RPU. In the case of solar PV projects which are proposed from outer islands, they had to go to the RPU. The RPU will then send them to the EPU for the designing of the system and the SEC for quotation. From here it will be submitted to the NPO for their comment and inclusion in the DCC meeting for approval. Implementation of PV projects will be carried out by the SEC.

Energy projects for outer islands proposed by either the EPU or other Ministries will go to the RPU for their comment and information before submitting them to NPO and then the DCC for approval. And, as normally done, the Ministry of Foreign Affairs will send a request to donors.

At present, the EPU didn't have the competence in giving assistance in the areas of power and petroleum. However, the EPU is competence enough in giving the assistance in the area of PV. It is in this regard that the EPU will develop its expertise in the areas of petroleum and power. Therefore, in order to develop this expertise, the one staff will start its attachment with the Regional Petroleum Unit sometime in October next year, 1991. Another staff will be trained in the area of power later.

Energy Supply and Consumption

Kiribati is currently importing approximately 30 per cent of her total energy, relying for the balance on indigenous biomass resources i.e. locally obtained fuelwood. From 1981 - 1985 about 44 thousand kiloliters of ground and aviation fuel were imported. In 1985 alone, about 6.5 thousand kiloliters of ground and aviation fuel was consumed. From this amount 3.5 thousand liters is ADO, 2.0 thousand kiloliters of mogas, 0.1 thousand kiloliters of kerosene, 0.5 thousand kilolitres of Jet Al and 0.4 thousand kiloliters of Avgas. From 1986 - 1988, about 3.62 thousand kilolitres of aviation fuel was imported along with about 20.0 thousand kilolitres of groundfuel; about 18.7 thousand kilolitres were consumed. In 1989 alone, about 6.36 thousand kilolitres were imported while 6.51 thousand kilolitres was consumed. Biomass resources will be expected to provide the bulk of the country's energy needs for the foreseeable future. Other energy sources including solar, and in specific area wind, offer limited alternative energy sources for exploitation. These alternatives may offset future dependence on imports and contribute to the overall aim of achieving the maximum degree of energy independence while providing opportunities for development primarily in the rural sector.

The utilization of these energy resources in South Tarawa, compared with outer islands, clearly reflects their different levels of development. About 90% of the imported fuels are used on South Tarawa only while the remaining 10% is consumed on outer islands (rural areas).

Household and Rural Energy

It has been realized that, on South Tarawa alone, the supply of fuelwood is becoming scarce and people tend to use imported fuel. About 60 per cent of the households have been electrified. On Betio alone about 97 percent of the population used kerosene stoves. The rest are using paper and cardboard as fuelwood. People had to travel more than 15 miles in order to get firewoods which are normally used. On outer islands the supply of fuelwood is not at present a problem as there is still plenty of supply.

The fuel wood shortage on South Tarawa, which is considered to be an urban area, was determined by its availability which is at present very low. A few years back, people living on south Tarawa, especially those living on Betio, fount it hard to get fuel wood and therefore they turned to cardboard, papers, and saw dust and others. The fuel wood shortage makes people use kerosene stoves, the choice of the women living on south Tarawa. The Government tried to prevent this problem by its replanting trees program but it never worked out as expected. At present, there is no plan to find solutions for this fuelwood shortage problem since most of the people used kerosene stoves.

The supply of fuelwood in rural areas is not a problem at this stage. Nearly 100 percent of the rural area population used fuelwood for cooking. Only Government workers, and those who had the money, which may represents nearly 1 per cent of the rural area population, used kerosene stove for cooking.

Consumption and Production

According to the results of the household energy survey carried out in October 1985 by the Energy Planning Unit of the Ministry of Works and Energy with the assistance of the Pacific Energy Development Programme (PEDP), fuelwood consumption on outer islands is about 1.9 kilograms per person per day compared to South Tarawa which is about 1.2 kilograms per person per day. This reflects the scarcity of fuelwood on South Tarawa and also indicate that people living on south Tarawa had a higher income and, therefore, can afford the use of kerosene, electric or gas stoves. There is not yet evidence of fuelwood shortage in the outer islands. Even though there is still plenty of fuelwood supply on outer islands, there are still people who used imported fuel for cooking and lighting. Even some used imported fuel for transport (motorbikes, outboard motors and cars). The amount of imported fuel used on outer islands is still less when compared to South Tarawa only.

According to the 1989 fuel consumption data, South Tarawa alone consumed 5,756.345 kilolitres while the rest of outer islands, where about 70 percent of the population lived, only consumed 753.844 kilolitres.

It is the experience of the past years that the supply of imported fuel to outer islands is sometimes unreliable. Most of the time people on outer islands can wait several months before their supply arrived. The Kiribati Oil Company Limited, in close collaboration with the Shipping Corporation of Kiribati, are still looking at ways of improving the supply of fuel to rural areas. Also fuel price is unpredictable and can increase at any time. Because of this problem and the cost of PV systems which are cheaper to use, many people in rural areas prefer to use solar PV systems.

Household Energy Policy and Practice

On South Tarawa where there is a centralized power station, the policy in practice is that people with either low or high income had to pay a connection fee of $70 if they want to be connected to the main grid. Also they were charged the same rate for the kilo-Watt-hour used at the end of each month. The supplied voltage is 240 volts. If fees are not paid at a set time then you will be disconnected from the grid. A fee of $10 is applicable to all for reconnection to the main grid. Also there are three tariff rates used. Domestic tariff rate which is currently at 29 cents per kWh and commercial and industrial rates which are currently both at 33 cents per kWh.

On outer islands, each individual are allowed to purchase their own small diesel generators, solar PV system or pressure lamp for lighting, kerosene stove for cooking and so on as long as they can afford them. Even though the supply of fuel can sometimes a bit unreliable, most of the people still use fuel as their source of energy. There are also high schools which still use diesel generators. However, the use of solar PV is becoming popular as most of the high schools and people living in the rural areas used solar PV for lighting and pumping. Even rest houses in rural areas used solar PV systems.

Stoves

An open fire cooking method is the most common type of cooking used in the country. Almost 100 per cent of the population used this type of cooking. The type of cooking is considered to be cheap as only two metal bars were needed and can be found anywhere. On South Tarawa the use of kerosene stoves is more popular. There are some using gas stoves and a few using electric stoves. There had been a wood burning stove programme in Kiribati which have been carried out in the past. The programme didn't work as people still prefer the traditional cooking method as it cost them no money and also there was no organization interesting in making the programme work.

The original programme on wood burning stoves was carried out in 1985. The programme was part of the CHOGRM programme on renewable energy use. The programme was then handed over to Herb Wade of PEDP. One stove was built at Tarawa Training Institute (TTI) during the time the Energy Planning Unit carried out a household energy survey on South Tarawa and Abaiang. The stove programme was carried out at the same time the EPU conducted a PV training course. The EPU was not interested in the programme at that time because of staff constraints.

Late in 1989, a demonstration on the use of more efficient wood burning stoves and a solar cooker was carried out on South Tarawa and Abaiang. This was part of the CHORGM programme in the promotion of more efficient wood burning stoves. The aim of the demonstration was to promote the use of cooking facilities that consumed less fuelwoods and no fuels. The concept behind this demonstration is to let the people use such cooking facilities so that fuelwood supply is still surplus. As part of the demonstration, water was boiled using a wood burning stove and fish and rice were cooked using a solar cooker. There were two types of a wood burning stove. One is fabricated in the country using cement and sand and the other one was a portable metal stove. The demonstration was considered to be a success as there are many people who would like to own the stoves and the solar cooker and also the stoves and solar cookers can be made locally. The solar cooker and stoves are not yet promoted through out the country for the following reasons. The first reason is that the solar cooker needs to be modified such that it satisfies the people's needs in terms of its costs, which should be kept at a minimum; and the size of the pots used which need to be increased. After the follow up programme, which is likely to take place next year, further steps will be taken regarding the promotion of the stoves and solar cookers. The Energy Planning Unit view on this program is that it is second priority to their main areas of interests, however, the Kiribati National Womens' Organization (AMAK) will be involved in the follow-up program. Therefore, in order for this programme to success, other Non-government organizations like the Save the Children Federation, Aia Maea Ainen Kiribati (AMAK or Kiribati National Women Association) and Reitan Ainen Kiribati (RAK), both women association, etc must take part in the implementation and promotion of the program.

The Kiribati National Womens' Organization (AMAK) is the right hand of the Kiribati Government whose functions and responsibilities include the improvement of Kiribati women welfare in the areas of households, family, villages and islands through training and practical experience. AMAK is also responsible for maintaining customs, cultures and handicrafts and the teaching of women in the areas of sewing and cooking.

AMAK started its training program on smokeless stoves back in 1973, where women living in rural areas were trained in the use and fabrication of wood burning smokeless stoves made of cement and sand only. The program failed since the stoves were cracked after been used for at least 6 months. According to the report received by AMAK headquarter, which is located on South Tarawa, from the users of the stoves in rural areas, all women living in rural areas prefer a smokeless stove which must be cheap and last long. AMAK approached the Tarawa Technical Institute (TTI) to design a better stove. Even though TTI came up with a design, the stove did not last long too as it has been rejected by the women. Right now the Kiribati National Women Organization is looking for a better design.

It has been realized that smokeless stoves are very much needed in rural areas as the supply of fuelwoods is surplus while women on South Tarawa prefer kerosene stoves as the supply of fuel woods is becoming scarce.

Fuel Pricing

During the Mobil agency days, pricing of fuel was entirely under the control of the Secretary for Works and Energy. It was found that the price of fuel on outer islands was always higher than the fuel price on Tarawa. The method used in determining the price of fuel at that time was not clear, however, the only factor which is likely to cause the difference in fuel price is the freight of fuel drums to outer islands whereby fuel outlets on outer islands had to pay. Pricing of fuel was passed to the Kiribati Oil Company after it was established in 1987. The price on outer islands was still higher than fuel price on Tarawa as the outer islands fuel outlets were still charged on freight on drums.

In 1990 a new method of determining the price of fuel was used and as a result the price of fuel is the same throughout the Gilbert islands. Also the Government played a certain role as it controlled the price of certain fuel products.

The present method used in determining fuel prices to fuel outlets on South Tarawa and rural areas was as explained below:

Landing Price (CIF Tarawa price) plus 10 per cent mark-up plus Kiribati Oil Company Limited Overhead Costs;

That is:

Landing Price
(plus) + 10 Per cent of Landing Price
(plus) + Overhead Costs
(equal) = Selling Price

N.B. Overhead Costs include all expenses incurred by the Kiribati Oil Company Limited in the handling of fuel which include the discharging of fuel from the ship and in delivering it to fuel outlets, etc.

The Kiribati Government through the Ministry of Trade Industry and Labor controlled the prices of mogas and kerosene only. The method used by this Ministry in determining the prices is that a 25 percent mark up on the landing price is applied but since the Kiribati Oil Company Limited had already given a 10 percent mark up on the fuel landing price then the Ministry of Trade Industry and Labor had to give a 15 per cent on the Kiribati Oil Company selling price in order to get the maximum retail price in fuel outlets on both rural and urban areas. Fuel outlets found to be charging more than the price set will be dealt with accordingly.

Kiribati Oil Company Limited on Kiritimati had a different case since it was supplied by Pacific Resources Incorporated (PRI) in Hawaii. The fuel products include ground and aviation fuels. KOIL had to pay the freight and insurance since the fuel were shipped to Kiritimati with a FOB price. The method used in determining the selling price is still the same with the one used for the Gilbert Group. In here there are many factors to consider in determining the fuel price as the volume is given in U.S Gallons and therefore had to be changed to Liters. However, the landing price is still used in determining the retail price.

The method used by the KOIL in determining their selling price is not proper as it ends up getting a clear 10 percent profit on the imported fuels. The Energy Planning Unit recommends that fuel pricing method used by the KOIL should be reviewed. Fuel prices can go down if the overhead costs is cancelled while maintaining the 10 percent mark-up or, the overhead costs are maintained while reducing the mark-up on the landing price to 3-5 percent.

Just recently Mobil Oil Australia replaced PRI in the supply of fuels to Kiritimati. With Mobil calculating the price of fuel is more simpler as the fuel was sent in Liters and Mobil is paying for the Insurance and Freight therefore the landing price is the CIF one.

Rural Electrification

On South Tarawa, where about 30 per cent of the population of Kiribati lived, about 94 per cent of the households had been connected to the grid. Therefore about 70 per cent of Kiribati had not yet been electrified. There is no national policy for rural electrification. However, there are plans to carry out a national rural solar electrification in the foreseeable future by the Solar Energy Company.

The Public Utilities Board (PUB) is a Government owned company. It is the only company permitted to provide power to private houses, commercial and industrial sectors. It is at present concentrating its activities on South Tarawa only which is considered to be an urban area. A connection fee of $70 is applicable to everyone. There are 3 different types of tariff rates, there is a domestic tariff, industrial tariff and commercial tariff. The tariff remained the same for the kilo-Watt-hour used for the three sectors. In every house which is connected to the grid, a kilo-Watt-hour meter is installed and a reading is taken at the end of each month. Each households, industrial and commercial sectors had to pay the amount due for their kilo-Watt-hour consumed at the end of every month to the Public Utilities Board(PUB). The PUB had no immediate plan by to electrify all rural areas.

However, the Public Utilities Board had a project on the extension of its main grid to half of North Tarawa which is considered as a rural area. Even though the actual cost of rural electrification by using either solar or diesel generation had not yet been determined, the project is likely to go ahead soon. The next step will then be to electrify the rest of North Tarawa.

Initially, the project included only the upgrading of the South Tarawa distribution system. The project was approved and the Asian Development Bank (ADB) was approached for a loan. ADB recommended that a rural area be included in this project. As a result the expansion of the grid to half of North Tarawa was included as part of the project. Therefore the project consists now of three phases. Phase I is the upgrading of the distribution system on South Tarawa; Phase II is the purchasing of a 700kW generator which will be installed at Bikenibeu and its function is to meet the night time peak demand; and Phase III is the expansion of the grid to North Tarawa.

The expansion of the grid will start from Tanaea and stops at Nabeina. KRTA assumed that about 75 per cent of the households in this area will be electrified. Also, KRTA assumed that the electrification of North Tarawa will attract people to move there and therefore North Tarawa will soon become a commercial and an industrial area. This is doubtful as there is no plan for the area to become industrialized and also a survey had not been carried out to determine the actual number of households that really want to be connected to the grid. The expansion of the grid only will cost around AU$700,000 but it can increase due to inflation. Therefore, there is a possibility for the PUB to increase the present tariff through the PUB will subsidize this otherwise PUB will not be able to repay the loan and its interest.

The only alternative which can be used for the electrification of North Tarawa is the use of solar PV systems. PV systems had been proved to be the only renewable energy technology to be economically viable in Kiribati. However, people today still thinks that solar PV systems are not reliable. This is true in cases where owners of PV systems cannot maintain their system. The Energy Planning Unit had conducted 2 PV training courses for outer island technicians. This is part of the EPU program in increasing the reliability of PV systems as technicians will be available on the site.

With regard to the use of solar PV systems, there is a Japanese project on the formulation of the "Master Plan" for rural solar electrification. The project is to install Japanese PV equipment in Government houses and offices at North Tarawa, Nonouti and Marakei. Initially, the selected site was Nonouti but Marakei is included to represent Northern Gilbert. The EPU and the SEC then selected North Tarawa due to its proximity to South Tarawa. Facilitating the collection of data and maintenance and repair work. Also it will be very cheap to visit the site for monitoring purposes. The Japanese will use their own equipment and they will install the system themselves. Their counterpart (Solar Energy Company) will assist them in the collection of data and other works required. The duration of the project is two years. After this period had elapsed, a "Master Plan" for rural solar electrification will be formulated.

The next Japanese team is expected to visit Kiribati early in 1991 for the discussion of the project in more detail.

However, there is a plan by the Energy Planning Unit of the Ministry of Works and Energy in collaboration with the Solar Energy Company to carry out the Japanese project such that it reflects what really the Kiribati Government would like to carry out with respect to rural solar electrification. The Japanese would like to install their PV Systems in Government Buildings only including the rest house, Police Station, Island Council Office etc. However, the Kiribati Government would like to modify the Japanese original scope of work. That is, the PV system must be owned by the Solar Energy Company and to install them in one village including privately owned houses. A fee, depending on the size of the system, will be collected.

The proposed modifications by the Kiribati Government will go in-line with proposed changed in the Solar Energy Company activities. The main aim of the plan is for the SEC to act as a utility and to sell power to the people. All solar PV equipment will be rented out to people who want them and a monthly/weekly fee will be collected depending on the size of the system. The reason for collecting the fee is for the SEC to be able to meet the costs in carrying out the repair and maintenance work and also to be able to replace the broken down PV components. In order to implement this plan, there are certain factors which needs to be looked into. This includes the method of collecting fees, number of trained personnel and a survey to determine if rural solar electrification is the choice of the people. A survey to determine the choice of the people will be carried out sometime in November. The Ministry of Works and Energy had no objection against this plan and it is at a stage where a proposal will be drafted after the results of the survey have been analyzed.

Biomass Energy Use

Biomass provide about 70 per cent of the country's energy. At present the supply of fuelwood on most of the rural areas is surplus while the supply on South Tarawa was already a problem.

On South Tarawa, alone, about 91 per cent of the population used firewood. According to the survey, which was carried out in 1985, the amount of firewood used in open fires cooking method is about 1.2 kilograms per person per day, a value considerably lower than that found in other Pacific surveys. This is believed to reflect the scarcity of wood fuels. Most households which found it hard to get woodfuel switched to kerosene stoves. It has been found that a kerosene stove is the choice of the people living in urban areas since the supply of fuelwood is scarce while a wood burning stove is the choice of people living in rural areas since the supply is still surplus.

In rural areas people can collect firewood from any place where they can find them and they can use the fire woods the way they like. The collection of firewoods is not a hard work as they don't have to travel a long distance. This used to be the case too on South Tarawa but now it has been changed due to the scarcity of wood fuel. At present, on South Tarawa, land owners should be informed if people were going to collect firewood from their land. It has been found on South Tarawa that most land owners charged people for collecting firewood on their piece of land.

In the past years the Government implemented a program on replanting of trees for fuelwood in order to maintain the supply of wood fuels. The program failed when the people realized that it will take more than ten years before a coconut tree can be used for fuelwood. Therefore, a big area will be required for this program and such an area is not available in Kiribati. Eventually people tends to ignore the program completely and as a result the program failed.

Women's Role in Household & Rural Energy Choices

The energy technology to be used is determined from the choices made by the women as they are involved mostly in the use of energy for cooking. The main reason the past programme on stove failed was that women neither involved nor convinced about the advantages of the stoves used in the programme. Also, since the supply of fuelwood is still plenty in rural areas, women seems to be not care in using more efficient wood burning stoves as they cost money. There is no present policy for rural electrification but ways of improving women's conditions through improved cooking facility should be given first priority when formulating policies for rural electrification. It has been reported by the Kiribati National Women Organization that women living in rural areas prefer a wood burning stove while women living on South Tarawa prefer kerosene stoves.

Environment - Energy Issues in Households and Rural Communities

Energy environmental impact is one of the most important criteria that needs to be well observed when dealing with energy projects. It is therefore the responsibility of the Energy Planning Unit to advise on the environmental impact of all energy projects. At this stage the EPU cannot provide this advise.

In Kiribati the traditional cooking method used is an open fire one. The method emits a lot of smoke and can cause health problems. Even though there are reports on health problems available from the Ministry of Health, most people in the rural and urban areas are still not aware of them. AMAK was awarded of this and therefore recommend the use of smokeless stoves.

Overseas Technical Assistance and Household Energy

There has been considerable external assistance for energy projects which have been carried out in the country. This assistance can sometimes has positive influence and other times has negative influence. The main problem which was always encountered is that donors want the recipient to implement the project the way they want and not the way the recipient wants. A good example on assistance that have negative influences is the Japanese project on rural electrification which will soon be implemented if approved. The Japanese Government wants the Japanese made equipment to be used and also want the project to be implemented their way while Kiribati wants the project implemented their way whereby all the PV equipment must be owned by the Solar Energy Company. Another example is the extension of the grid to North Tarawa whereby the Asian Development Bank changes the original scope of work of the project to what they will benefit more from.

Conclusions and Recommendations

From the report it can be concluded that it will be most appropriate for all power sectors in the country to be aware of the role the Energy Planning Unit played and also consulted for advice on all energy development projects. In order for the EPU to be able to fulfill its expected responsibilities and functions, measures should be taken in doing this. It can include the writing of a circular to all Ministries and power sectors within the country concerning the role and functions of the EPU. The circular should also state that all energy projects will not go through the Development Coordinating Committee for approval without the EPU inputs.

It is recommended that the present staff of the EPU are sent for further training in the areas of petroleum, supply and pricing and power supply and pricing and energy conservation and renewable energy technologies.

Also a good relationship between the Forum Secretariat, United Nation Pacific Energy Development Programme and the South Pacific Institute for Renewable Energy must be maintained.

It is also recommended that training on the use and production of wood burning stoves is conducted in Kiribati to the Kiribati National Womens' Organization. Also women's view, with regard to problems faced by women in rural areas, must be considered in the designing of wood burning stoves and therefore AMAK is willing to let its center used, by Ministries which are involved in the stove program, for training purposes.

It will be most appreciated if donors give the full responsibility to recipients with regards to the implementation of aid funded projects and therefore accept the strategies which have been set out by recipients concerning projects implementation.

NEW CALEDONIA TERRITORIAL COMMITTEE FOR ENERGY MANAGEMENT

T. Mouraud

The New Caledonian Committee for Energy Management (CTME), set up in 1981 by the French Agency for Energy Management (AFME), has been actively promoting the use of renewable sources of energy within the general framework of the development policies of the Territory of New Caledonia.

Co-operation between the French Agency for Energy Management and the Territorial Government of New Caledonia was instituted by four agreements signed respectively in 1982, 1984, 1986 and 1990, and has led to implementation through the New Caledonian Department of Mines and Energy of ten annual programmes funded by the two parties. This co-operation has resulted in the installation, over a period of less than ten years, of nearly 800 photovoltaic generators with a combined peak capacity of about 140 KW, of nine small hydropower stations with a combined capacity of 510 KW, and of ten solar water-pumping units.

Rural Electrification

New Caledonia, because of its geographic features, (a long island cut in two by a mountain range) and its demographic features (a scattered and isolated rural population) has always found it difficult to supply its population with electricity.

In this context, renewable sources of energy are an ideal solution to the problem of how to ensure electrification of the Territory as rapidly as possible, and at the lowest possible cost to each community.

Although a considerable financial effort was made in 1983 and 1989 with the establishment of the Rural Electrification Fund and two five-years plans, in order to speed up extension of main electricity supply to isolated rural communities, the Territorial Government also decided to seek alternative solutions that were economically feasible.

Indeed, the Rural Electrification Fund, under the five year priority plans, can only hope to serve the more accessible rural communities.

The remaining households, nearly 2000 in 1988, can only be connected to the main supply at very great cost, and are therefore natural targets for electricity supply systems based on renewable sources of energy.

The initial objective was to offer these isolated households in rural areas the modern conveniences made possible by electricity and thus to slow down migration towards the towns, particularly the capital of Noumea. This objective has now been largely achieved.

The two techniques that have proved most useful over the years in New Caledonia are:

(a) small hydropower stations, and

(b) photovoltaic generators.

Small Hydropower Stations

In the context, and with the objectives described above, small hydropower stations, designed to supply small autonomous distribution networks, are an particularly appropriate and cost-effective way of meeting the electricity needs of the remote Melanesian tribal villages located near one of the many high waterfalls existing in the Territory.

As soon as it was established in 1981, the Territorial Committee for Energy Management funded a hydrological survey for the establishment of a network of measuring stations, the long term aim of which was to produce precise maps of the sites suitable for hydroelectric development and to assess the energy potential site by site.

This survey, conducted by ENERCAL, the New Caledonian energy company which is the major supplier of electricity to the rural areas of New Caledonia, led to flow rates and other characteristics being determined for about 70 sites.

Using these measurements, ENERCAL has, since 1982, set up eight small hydropower stations producing from 26 to 160 KVA, which give a large number of households an electricity supply comparable to that provided by conventional means.

The CTME paid about 15 % of the capital cost of these stations.

Some of these small hydropower stations replaced previously used fuel-driven generators that were costly to run and provided only a discontinuous supply. They thus give better service at lower cost to the user and also entail considerable savings on the Territory's imported fuel bill.

At present a small hydropower station with a capacity of 160 KW is being built by ENERCAL.

Photovoltaic Electrification

Use of photovoltaic generators has, over the past ten years, proved a simple, reliable, economic, pragmatic and elegant solution for supplying electricity to households that are a long way from the main supply, giving them sufficient power for the basic conveniences such as lighting, audio-visual equipment and refrigeration:

A reliable and simple solution when compared with the many disadvantages of conventional solutions such as the fuel driven generator.

An economic and pragmatic solution when compared with the cost of extending a mains supply.

As the life span of photovoltaic system is about 10 years, this solution is a very cost effective one, both for the community and for the user, because a subsidy covers about 75 % of the cost of the equipment, which only leaves a small portion, compatible with their income, to be paid by them.

Households equipped with photovoltaic systems have enough electricity for basic conveniences while they are waiting to be connected to the main supply, which will eventually be done. The two electricity supply companies in New Caledonia are well aware of this and they have become two of the three major installers of photovoltaic systems in the Territory.

An elegant solution since it uses an abundant and inexhaustible local resource. With 5 Kwh/m2/d on an average, the amount of energy available in New Caledonia from the sun is one of the largest in the world. The solution is also clean and silent, unlike the conventional generator.

A reliable solution since it requires no maintenance, apart from a change of batteries every three to five years. No major technical problem has in fact ever occurred in the photovoltaic systems installed in New Caledonia since 1981.

The Territorial Committee for Energy Management has, since its establishment in 1981, vigorously advertised, promoted and financially supported this technology which can greatly enhance the quality of life of isolated rural communities in New Caledonia.

The procedures for obtaining financial assistance from the CTME have gradually been refined and made more flexible. Standard kits have been designed in co-operation with the photovoltaic installation companies in the Territory, which now enables the latter to meet requests very swiftly and appropriately.

Supporting actions and back-up research, such as studies of solar radiation in the central mountain range, production of booklets, leaflets, cartoon strips and audio-visual material for schools and the public at large, have also been carried out.

In recent years, CTME has been endeavouring to extend the scope of its electrification projects by setting up and financing installations in the isolated Melanesian villages of the Territory. Five tribal villages have thus been completely electrified with solar systems and two more are in the process of being electrified in the same way.

In addition, the EDF regional solar photovoltaic electrification programme coordinated by the South Pacific Commission has been implemented in New Caledonia. Under this programme 183 photovoltaic kits will be installed in about 40 tribal villages on the mainland and in the islands.

The CTME chooses the sites for this programme and is paying about 24 % of the total cost. The first stage of the programme, which involves installation of 16 photovoltaic systems in community halls and dispensaries, was completed in 1989.

Lastly, specific uses of photovoltaic electricity that can be seen in New Caledonia include one electrically operated sluice valve in a dam, television transmitters, maritime beacons and various measuring stations for a total installed capacity of about 15 Kw.

Rural Water Supply

Water pumping in isolated rural areas has been a major technical and financial priority in the past few years for the CTME in conjunction with the New Caledonian Department of Rural Economic Development (DIDER).

Photovoltaic water pumping during sunlight hours, (i.e. without storage) has been installed at ten sites for drinking water supply to four tribal villages, stock watering ponds and troughs on a cattle station, and small scale irrigation at an agricultural research center, for a total installed capacity of about 10 Kw.

CTME is pursuing this programme in 1990 and is planning to install six more pumping units in isolated sites. Although this technology is particularly well suited to New Caledonia, its extension is handicapped by the high cost of drilling and equipment.

Since 1987, the CTME has also started promoting French wind-powered systems for water supply to stock watering places, irrigation of pastures and vegetable crops. Two slow multi-blade wind-pumps have been installed under this programme.

New Caledonia, especially the west coast plains, where most of the cattle stations are located, is particularly well-suited, because of the steady trade winds it enjoys, to operation of these wind powered pumping units which require an average wind speed of only 2 to 3 meters per second.

Water supply is, of course, an essential prerequisite for rural development in New Caledonia and enables cattle farmers who are a long way from public water distribution networks to reorganize their grazing lands and to rotate cattle over different ranges, which must each have a watering place. It is also the necessary starting point for the development of diversified and efficient agriculture in isolated areas.

Financial assistance granted by CTME for photovoltaic and wind-powered pumping units, which covers 50 % of the cost of the energy conversion equipment, is supplementary to the assistance provided by DIDER for pipes, reservoirs, and stock watering places, and shows the Territory's and AFME'S determination to promote wider use of these technologies.

G. Decherong

Introduction

The Republic of Palau is an archi-pelago of 350 islands and islets. Its main group of islands is dominated by the 390 square kilometers island of Babeldaob. A chain of smaller high and low islands running 200 kilometers in length, and four small coral atolls some 400 kilometers to the southwest make up the rest of the Republic. The combined total land area of the islands is about 490 square kilometers.

Just over 15,000 people live in the Republic of Palau. Adjacent to Babeldaob and connected to it by a single-span bridge is the smaller island of Koror, where about 9821 people live, and which has been the administrative center of the archipelago since the era of Japanese control.

The Palau group land mass is volcanic in origin with basaltic structure and limestone formations predominating. The main islands are reasonably well-watered and thickly vegetated. Babeldaob's rolling hills reach an elevation of about 210 meter in places. Its forested interior contains many streams and rivers. Much of the upland area supports only coarse grasses; hardwood trees and other useful plants occur in certain areas of the interior.

The Republic of Palau presently relies entirely on petroleum fuels for energy. Koror and the southern part of Babeldaob are served by the central power system. Peleliu and Angaur have small systems of their own. The Southwest Islands and Kayangel a classic atoll at the northern top of Palau's have Solar Photovoltaics on each individual homes.

Institutional Arrangements for Energy

The Energy Planning Programs in the Republic was classified into the Bureau of Public Works in 1990. Even though it has been in existence since 1980, it was never classified position with the Civil Service System.

The office is managed by one local person. Its general responsibly is managing a U.S. Federal grant on Energy Conservation and the development and use of renewable sources of energy (mainly implementation of rural solar photovoltaic lighting and refrigeration systems) on remote island of the Republic. Total grant to Palau in FY 1990 was $19,000.00. There is no clear role of the energy office at present. As such, there is no coordination among the agencies involved. As mentioned earlier, the office is merely managing the functions of the U.S. Department of Energy grant.

As an energy official, we are faced with problems of other agencies requesting grants for programs but do not inform or provide us with their plans and this sometimes creates duplication of efforts. Other agencies also request assistance from U.N. or other agencies without informing the energy office and this also creates confusions and duplication of efforts.

Energy Supply and Consumption

The Republic of Palau had a total quantity of petroleum imports of 12,100,000 gallons for 1989.

Total electricity generation was 40,975,848 KWH with a total fuel consumption of the power plant at 2,823,064 gallons.

In the urban area, Koror and its vicinity, gasoline is selling at the pumps an average of $1.699 for regular and super at $1.769 per gallon. Kerosene is sold at $2.00 per gallon. Diesel is sold at $1.949 per gallon.

In the rural areas, gasoline is sold at an average of $2.00 per gallon, Kerosene is sold at $3.00 per gallon and Diesel on limited quantity at $2.50 per gallon.

The household or rural energy problem that the government faces is the high cost of fuel, mainly kerosene and gasoline in the rural areas. Individual households are forced to commute to Koror to buy such fuels because the local distributors charges twice as much as on Koror. The government has initiated its rural electrification programs in trying to ease the problems of the rural Babeldaob areas by extending the electricity to the remote areas. This effort however is being hampered by the lack of infrastructures in the remote areas and very little funding support.

Household Energy Policy and Practice

There is no national policy for household energy use. Individual States are very much dependent on their own elected officials in deciding energy policy for their states. The main reason there is no policy is that elected officials have not put together a policy that covers the entire nation.

Consumers have very little role in the implementation of the policies. Although they may make their ideas known or heard officials very much do what they feel is good for the people. This is true for women. Again, politics play a major role in any decisions made.

Stoves

There is now a charcoal stoves program which is being administered by the PCAA (Palau Community Action Agency) with funding from a U.S. Federal agency, the Community Services Block Grants.

In the past there was also a wood stoves program which was demonstrated by the South Pacific Commission Mobil training unit in Palau in 1985. This program was partly successful. One of the major problems associated with it was the crack on the cement after about 6 months after its construction. Stoves are seen as a rural energy development issue. Most of these stoves were constructed at school kitchens at various locations in Babeldaob. They are, not in use now and have since been replaced by LPG stoves which are popular among the school kitchen cooks because of their efficiencies.

Fuel Pricing

There is no policy on urban versus rural fuel prices. There is no fuel subsidy provided to rural communities.

Rural Electrification

The policy of RE is to extend electricity to all States on Babeldaob from the main power plant at Aimeliik. At present only 3 states out of the 10 states in Babeldaob have been connected to the main power plant. And as soon as funds become available and the roads interconnected all of the other 7 states will be hooked on to the main grid.

The two other island states of Peleliu and Angaur already have electricity provided by their own generators. These two states get no fuel subsidy from the national government.

The smaller states of Kayangel and the Southwest Island states have PV systems on each individual homes. At Kayangel there are 39 systems installed. At the Southwest there are a total of 24 systems installed on 3 separate main islands.

The U.S. Department of Energy has been the force behind the program to encourage appropriate technologies to these remote island locations.

Biomass Energy Use

Fuel wood is not a problem at all in the Republic of Palau. Fuelwood does not fall under any department in the government as yet. There is no social forestry or fuelwood planting programs. Women have no role (or perceived role) in existing or planned fuelwood programs.

Common people can only comment on choices of energy technologies

Women's roles in rural and household energy choices are very much limited as to where they would prefer to locate a cooking facility. In other words, women do not have much involvement in policy making. Occasionally, they do choose one cooking stove over another (Kerosene vs LPG) but not so much on policy decisions.

The present set up of the Palau Environmental Protection Agency deals mainly with capital improvement projects such as roads water and other big structures being built around Palau. There are no explicit policies on energy production or consumption, although, they do monitor the dumping of used oil and other matters related to power plants wastes. There are no information available on health problems associated with traditional method of cooking.

Overseas Technical Assistance and Household Energy

Regional and/or bilateral assistance programs have been of great assistance to the government in its efforts to provide rural areas with developments projects. They have been used in many ways to look at new and better technologies to develop the areas. They have had a positive influence in the urban areas, however, some have been poorly planned and even not well coordinated.

These assistance programs should be centrally coordinated through a local agency of the government where the assistance can be screened and evaluated to better serve the local rural households.

Conclusions and Recommendations

The present energy planning programs in the Republic of Palau do not address the household and rural energy situation now or in the long term. There is no clear policy or mandate from the national government dealing with rural areas. There is no energy policy of the national government towards the individual states. Each state is very much left out to make their own policy decision through their elected officials.

This is a problem that needs to be addressed. And this cannot continue on and will not be solved by Palau alone. We need special assistance from all the organizations and agencies involved.

The Palau Energy programs for 1991 which began October 1, 1990 includes a project which will contract out a well qualified PV firm to conduct a post - PV electrification study or survey of Kayangel and our Southwest Islands, the two most remote atoll island of Palau. This project is a start of what we hope will be a continuous effort to collect data on energy use and patterns in the rural households of Palau.

The survey will gather data on energy use pattern since the installation of the individual home PV lighting system. We would also like to find out other improvements to the systems in use. This effort is being funded by the U.S. Department of Energy.

This seminar could not have come at a more appropriate time. Rural areas of Palau are aggressively pursuing development projects, be it road, water, sewers or energy. Some of the states closer to Koror have started building their own roads to connect to the dirt road to Koror. This is because the transmission line from the Power Plant comes through the dirt road. This has caused an undeclared policy of each state in Babeldaob, to connect to the main power supply no matter what the cost. And one can understand if you can only see the light at night but cannot have it for the last so many years.

We need assistance in setting up the institutional framework for the energy planning programs in Palau. This probably could be done by getting technical assistance from donor countries or agencies to have studies done on household and rural energy.

It seems appropriate at this time that a household and rural energy study be done for Palau. By doing the study, all the agencies involved in the Pacific energy programs and the government of Palau as well as other countries can learn some lessons from the Palau experience. Because it is not the lack of planning that has caused such a situation in Palau, but too much uncoordinated top down planning which has resulted in nowhere. It is the zealous efforts of all involved in trying to address the energy problems in Palau that seemed to have distorted the directions of policies in dealing with the problem. But it is not too late. And we are hopeful that this seminar will pinpoint some recommendations and possible solutions towards this very important missing link in the energy situation we are faced with.

Another issue that has been identified, but one that is not receiving enough attention in the energy planning program for Palau, is the training needs of local staff to be able to handle

the problems as they arise. Palau needs training on PV system maintenance and repairs. We also need training on energy management and data collection and processing.

Ajit Yadav
Assistant Secretary (Policy)
Department of Minerals & Energy

Government Objectives and Policy Guidelines

The overall socio-economic guidelines that reflect government objectives focus on this social welfare of the people, and the State's obligation to facilitate people to improve themselves, through:

(a) provision of educational opportunities;

(b) access to health care and social welfare services, (provision of improved water supply and sanitary facilities are important pre-requisites for any rural health improvement programme); and

(c) provision of adequate infrastructure and rural extension services for more productive resource utilization.

The availability of rural energy in adequate quantities and in appropriate forms has close bearing upon a wide range of development aspects in rural economies. Some of the more important aspects in this context are:

(a) levels of food production (contingent upon irrigation waters, fertilizer inputs, mechanization of agriculture, etc., and more profound trade-offs as between alternative uses of resources for food production and energy production);

(b) employment opportunities (for example, through the development of small-scale industries); and

(c) social, educational and health amenities (through, for instance, improved lighting and communications).

Rural electrification and energy supply requires a coordinated policy and more attention than currently focussed on it. The major problems faced in PNG in the development of new and renewable sources of energy are:

(a) the lack of availability of finance to implement proven technologies, both in government and commercial agencies;

(b) the lack of trained and competent PNG citizens for evaluation and introduction of new and renewable sources of energy technology; and

(c) the lack of local manufacturing industry resulting in continued reliance on expensive imports.

The C-centers and Rural Electrification Issues

The problem of C-centers and Rural Electrification in general consists of:

(a) lack of a properly constituted organization for rural electrification,

(b) fragmented management responsibilities resulting in mismanagement,

(c) lack of billing and revenue collection,

(d) lack of proper oversight in ensuring regular inspections and maintenance of the diesel-generators,

(e) lack of profitability due to low loads,

(f) lack of trained and skilled manpower.

Institutional Set-up for "RE" in Papua New Guinea - Electricity Division (DME)

The PNG government has come to realize that a national commitment to RE should be reflected by the creation of a specific RE agency in the central administration to facilitate the implementation of RE projects on a sustainable basis.

The only solution to the problem is an adequately funded and properly constituted organizational setup responsible for overall management of the C-centers and promotion of rural electrification on a nation wide scale in an organized manner. In other words, setting up of a Rural Electrification Division, perhaps under a reorganized Department of Minerals and Energy with adequate manpower and budgetary funding support is the key to the problem.

The establishment of effective institutional arrangements for RE is crucial to program success. The successful administration of an RE program requires a strong organization to define and coordinate numerous complex technical and planning tasks. Field Technicians, Inspectors & Supervisors are required at provincial level with the technical capabilities to conduct the routine maintenance work on RE facilities and to supervise revenue collections.

A policy submission has been made seeking Cabinet (NEC) approval and directives for the creation of an Electricity Division (ED) within the Department of Minerals and Energy for promotion of Rural Electrification.

This proposal on the future of "C" Centers and Rural Electrification (RE) has been prompted by the concern to minimize subsidies required to supply electricity to rural "C" Centers, and by the potential benefits from rural electrification that can accrue to both the Government and the general public especially in the rural areas.

An electricity supply is rarely enough in itself to generate economic activity and business development in rural areas. However, if targeted at areas with good infrastructure and access to markets, or promoted alongside new infrastructure developments, electricity can facilitate the growth of agro industries and other business ventures.

In most rural areas of PNG, electricity offers social rather than direct economic benefits. Only households with significant cash incomes will be able to afford improvements to their lifestyle through higher-quality lighting. Also, rural energy studies have shown that electricity is often a lower priority for household and community spending than other services. On the other hand, in the absence of electricity supply there is neither the scope nor any motivation for anyone to strive and improve their socio economic levels.

However, rural electrification will provide maximum benefit to all income groups if used to improve essential services, by supplying power to institutions (ICI centers, schools, missions) and community projects (health, water pumping etc). The majority of electricity costs in these cases must be seen as part of the overall cost of these social services.

The proposed institutional setup as outlined in this submission will strive to implement policies which range from cost minimization policies to policies of improving rural electricity services, but does initially involve moderate increases in Government spending in this sector. Another submission will be made to the NEC in 1991 on "Rural Electrification Policy" in general.

The current PIP projects of Mini Hydro Development Programme and the Rural Energy Development Programme would become part of the Electricity Division. For that purpose DME would retain an expert group on renewable and rural energy technology, who would perform a technical assistance and public education role with respect to small rural electricity projects, particularly those using renewable energy sources.

The ED would coordinate rural electricity projects with other infrastructure projects, and with planned productive activities, in order to promote an integrated development approach. It would also review and recommend the levels of subsidy required for new RE Projects. The ED will address wider rural electrification issues and will fulfil government policy objectives at minimum cost, rather than to supply electricity as a commercial undertaking. It will also evaluate subsidy levels and make proposals for Elcom takeover of Centers which become close to commercial.

The other primary role to be fulfilled by an appropriate government agency is to offer technical assistance in the field of small scale renewable energy projects in the rural areas of all provinces and to communities nation-wide, including evaluation of community energy needs, identification of the most appropriate energy sources to meet those needs, advice on energy technology and on funding sources, training for communities, and fulfilling a public education role.

<u>Consumer Charges</u>

Excluding the wiring and village distribution costs, the true cost of electricity in a rural center is typical around 50-60t/kilo Watt Hour (KWH) using available and proven technologies of diesel, hydro, and solar energy.

Elcom's current policy is to charge the uniform national tariff of 14-16t/kwh to all consumers. Given the difference between these consumer charges and true costs, a direct subsidy will often be required if current Elcom tariff is to be applied to rural areas.

Obviously, some businesses, institutions and high-income households in rural areas are willing to pay the full costs of generating their own power from diesel or other sources. This may be true of rural electrification projects in areas where economic growth is strong.

However, this is rarely the case for socially-oriented (ie non-income generating) community projects, particularly those using renewable technologies with high up-front costs. Aid funding, or at least favorable credit terms, will be required for capital expenditure if these projects are to be widely undertaken in Papua New Guinea.

Tariffs charged should reflect the recurrent operating costs. The idea should be to make power supplies self supporting in terms of recurrent operating & maintenance costs.

Objectives of the Electricity Division

(a) To promote national government objectives and policies in relation to socio-economic welfare of the rural areas through provision of electricity as part of a wider rural electrification (infra-structure) development programme,

(b) To promote effective utilization of indigenous renew able energy resources (hydro/solar/wind/ biomass/ geothermal) for meeting the small scale energy needs of rural areas (needs such as for water pumping, medical and commercial refrigeration, street and institutional lighting, and for Elcom's power system planning),

(c) To effect improvement in the quality and reduce costs of existing C-center minor power houses, and,

(d) To assist Elcom in the implementation of national power system planning including addressing the power needs of large mining and petroleum enclave developments.

Functions of the Electricity Division

(a) To plan, coordinate, and promote electrification of rural areas through:

  (i) extension of Elcom's transmission/distribution lines to surrounding C-centers and villages within close proximity of existing stations,

  (ii) displacement of diesel generators in C-centers by hydro/solar/wind powered generators or hybrid systems where technically and economically possible,

  (iii) introduction of new hydro/solar/wind electricity for meeting basic needs of rural institutions (such as health centers, community, and vocational schools) and villages in remote areas where technically and economically feasible. Only those technological alternatives that have been proven under Pacific Island conditions should be considered for extensive use in the near future. Proven alternatives in the Pacific are grid extensions, diesel generators, solar P-V, small hydros, and solar-diesel or solar-hydro hybrid plants.

  Since PNG lies near the equator (3 S to 11 S), it is in a favorable geographical location for solar energy input throughout the year. The average insolation in most parts of the country is in the range 400-800 W/m2 with mean sunshine ranging from 4.5 to 8 hours. This clearly shows that solar energy has considerable potential. However, the present contribution of solar energy to the total energy uses is estimated at only 1%, mostly for water heating application in the urban sector and for crop drying in rural areas. Photovoltaic technology has been found appropriate and economical for meeting the small power needs of rural and remote communities and is expected to play an important role in PNG.

(b) To plan, coordinate, and prepare C-centers to facilitate a phased takeover by Elcom (for operation, maintenance, and management responsibilities),

(c) To assist and liaise with other national departments and agencies involved in rural infra-structure and economic development (Agriculture & Livestock, Forestry, Works, Transport, Development Authorities and Agencies) to enable adoption of an integrated approach in energy planning,

(d) To assist provincial governments in planning and implementation of rural energy projects through technical assistance and foreign aid co-ordination,

(e) To fulfil a public education and advisory role (both rural and urban) on efficient utilization of energy resources.

The operations & maintenance branch of the proposed ED will work towards making the rural power supplies self supporting in terms of recurrent operating costs through:

(a) improved overall management through establishment and implementation of firm policies on C-center operations;

(b) metering, billing and revenue collection leading to increased income (reduced subsidies);

(c) improved inspection, maintenance, and repairs (reduced downtimes, replacement and upgrading costs); and

(d) training of District Managers and power station operators for day to day management, record keeping, and reporting;

The electricity division would introduce meters, and implement a more efficient system of meter reading and disconnections. As the cost of metering all consumers would be substantial a phased programme would be introduced as follows:

(a) immediately all government and private commercial consumers would be metered and charged the current Elcom tariff;

(b) a phased programme would be implemented for metering high and low covenant consumers commencing at Centers operating on a 24 hour/day basis; and

(c) an interim flat monthly tariff would be applied to high and low covenant consumers scaled to the operating hours of the centers.

Implementation of RE Projects

(a) Elcom will be responsible for rural electrification projects that are commercially viable at 10% real rate of return criteria, using their uniform tariff.

Projects requiring a top up subsidy will be handled by the ED which may contract Elcom for the actual construction/implementation.

(b) The Electricity Division (ED) will subsidize and coordinate rural electrification projects that are economically but not yet commercially viable.

These will include the non-commercial C-centers and institutional/village level projects that are clearly economically productive and meet basic needs (health care, school, water supply etc, or which provide other administrative services). These criteria will be strictly adhered to.

(c) In general, the approach will be to attract overseas grant aid funding for capital costs of the projects to be implemented by the ED.

(d) Only technical assistance, but no subsidies, will be provided to communities/projects that do not meet the criteria listed above (2). In other words, ED will provide only non-financial assistance to those willing or able to pay for the projects that do not meet the basic needs criteria or government policy objectives.

(e) ED may contract Elcom to construct, operate and maintain projects where necessary. As far as possible and subject to cost competitiveness, Elcom may be involved in all transmission/distribution line contracts.

S. Fifita

Introduction

The Kingdom of Tonga is a small South Pacific nation comprising 171 islands of which about 37 are inhabited. The total land area is about 700 square kilometers, but the territorial waters cover about 700,000 square kilometers.

The 1986 the population of Tonga was 95,000. About 64,000 people (67% of the total population) live on Tongatapu, with about 45% (29,000) living in Nuku'alofa's urban areas. The Vava'u and Ha'apai groups have about 15,170 and 9,000 inhabitants respectively, most of whom live on small islands and villages. Population growth has slowed recently to below .5% per annum which is due in part to substantial emigration. Internally, there has been steady migration to Tongatapu, particularly to Nuku'alofa and nearby villages.

Agricultural production is the predominant activity in the Tongan economy. Agricultural and agro-based products account for about 80% of the total export earnings. In the years 1979-1980 to 1982-1983, economic growth averaged 11.5% per year, due largely to a considerable investment in agriculture, a big increase in foreign aid and private remittances from Tongans overseas. While the local economy has grown, Tonga has become increasingly dependent upon imports to satisfy the local demand for goods and services.

Institutional Arrangements for Energy

The Energy Planning Unit (EPU) is the focal point within the Kingdom for all matters pertaining to energy. It was established in 1983 to administer and implement the national energy policies and planning of the Kingdom as determined from time to time by the National Energy Committee (NEC). The EPU is presently being manned by three locals with an annual budget of US$30,000. EPU is responsible for the implementation of renewable energy projects in rural and remote communities. The major problem faced by the EPU is the long dormancy of the NEC which has recently been rectified.

The Competent Authority under the Ministry of Labor, Commerce and Industries is responsible for setting the prices of petroleum products and methane gas.

The Tonga Electricity Power Board (TEPB) is responsible for the generation, distribution and sale of electricity. The Board sets its tariff rates and also makes decisions regarding the extension of the grid to remote and rural communities.

The Forestry Division of the Ministry of Agriculture and Forests is responsible for forest development and the replanting of trees for timber, fuelwood and other purposes. The extension services of the Ministry also carry out the upgrading of kitchens which includes the introduction of woodstoves.

The above institutions are all represented in the National Energy Committee. However, the EPU is represented in the Fuel Sub-committee of the TEPB.

Energy Supply and Consumption

Tonga, like all the small island states of the South Pacific, have one energy problem in common; their geographical locations and their geological characteristics do not favor the existence and/or the economic feasibilities of an abundant supply of energy sources. There is no river; hence there is no potential for hydropower. Coal, geothermal and hydrocarbon products are not likely to be present on a commercial basis.

The Kingdom's primary energy resources are mainly confined to biomass and petroleum products. Although solar and wind energy sources are being used, the magnitude of those uses are to insignificant to be incorporated into the Kingdom's energy balance. Electricity, however, make up 100% of the secondary energy resources.

In 1987, biomass continued to be the dominant energy source, estimated to account for 56% (26.73 kTOE) of the energy balance. Of this 56%, domestic consumption for the purposes of cooking, water heating and crop drying account for 52% which is the largest consuming subsector of biomass. Agro-industries and the manufacturing/commerce subsectors account for 46% and 2% respectively. Per capita consumption of biomass is estimated at .28 toe per year. Recent studies on biomass revealed that Tonga will face a severe wood shortage in the very near future.

The remaining natural forest cover is estimated at 3,000 hectares, concentrating mostly on the island of 'Eua. Tongatapu, holding the major share of the population, has suffered substantial deforestation due to migration from the outer islands and the resultant increased pressure on available lands for food production and residential purposes. Furthermore, the extensive dependence on biomass for domestic and crop drying purposes is contributed to Tongatapu's virtual lack of forest cover. In addition, the "api" system which governs land allocation in Tonga, when coupled with Tongatapu's high population density, means that there is virtually no "free" land for establishing fuelwood plantations. Therefore, fuelwood demand is dependent on scattered large trees and small shrubs on individual "apis" or plots. Clearly, urgent measures are needed to preserve and upgrade Tongatapu's forest resource. At the same time, efforts must be made to increase the end use efficiency in domestic cooking and crop drying methods.

Petroleum accounts for 44% of the energy balance. Of this 44%, 21% goes to power generation and the remaining 79% is for net domestic consumption. This net domestic consumption is further disaggregated to sectoral consumption with 7% for domestic, 87% for transport and 6% for manufacturing / commerce. The total demand for petroleum in 1987 was 22 million liters whereas it was 27 million liters last year. Between 1988 and 1989, sales of petroleum products in the Kingdom have grown by 12%.

The electricity tariff is presently set at T$3.14 for the first 11 kWH and 23.85 cents for each extra unit. However, a surcharge of 2.52 cents is also imposed to reflect the increasing cost of fuel.

Household and Rural Energy

In 1984, PEDP carried out a household energy survey on Tongatapu. Data from the survey revealed that there will be a fuelwood shortage in Tonga in the years to come. This gave rise to some work on introducing woodstoves in Tonga. For some technical reasons, the introduced stoves did not work according to the expectations and so the project was abandoned awaiting further improvements in the stove design.

There is no national policy for household energy use at the moment. Consumers can use any source of energy as long as they can afford it. However, women do play a role in selecting what source of energy they use for their cooking as well as for other domestic purposes.

Government has been promoting the replanting of fuelwood trees as well as the use of efficient stove. The Ministry of Agriculture and Forests together with the EPU are promoting the replanting of fuelwood trees. The major problem with fuelwood replanting is the lack of free land, however, people are now encouraged to plant fuelwood trees along the boundaries of their respective allotments. Agriculture tried to promote the use of woodstoves in homes during the 70's. The EPU picked it up from Agriculture in the 80's. both projects have not worked well.

On Tongatapu and in the other centers of the outer islands the prices for energy resources in the rural areas are the same as those found in the urban centers.

Government policy on rural electrification is to put photovoltaics on islands which do not have access to diesel-based electricity generators.

Women's Role in Household and Rural Energy Choices

As there is no national policy with regards to household energy use, women do in fact dictate the energy resources used in the households. Most of the energy resources used in the households are for food preparation and for other activities which are carried out by women (ironing, washing, cleaning etc.) and because women carry out these tasks, they therefore dictate the energy resources which best suit their needs depending on whichever energy resource is affordable to them.

Environment - Energy Issues in Households and Rural Communities

At the moment, there is no explicit policy on the environmental aspects of energy production and consumption which affect household and rural energy. However, there is always a concern for the environment when energy projects are designed. This was illustrated when the Asian Development Bank consulted the Environment Planning Section when it carried out the feasibility study on the expansion of the existing generation capacity.

The traditional method of cooking on open fires has been widely considered as a health problem although no firm statistics has been made available from the Ministry of Health.

Conclusion

Providing energy resources to the rural communities is a time consuming and a very expensive exercise. Hence, there is always a need for interaction of all concerned government, quasi-government and private institutions with the recipient communities. Providing the rural communities with the appropriate energy source is one of the conditions for developing the rural areas. However, these rural development projects must be able to:

(a) Increase the rural production and the real income of the rural households;

(b) Create employment and income opportunities in rural areas;

(c) reduce rural out-migration;

(d) Improve the quality of village life;

(e) Achieve spatially balanced rural development;

(f) Achieve self-sustained and self sufficient rural development;

(g) Involve the rural population more intensively in the development process; and

(h) Develop a socio-economic data-base.

If rural energy projects do not address the above objectives, then those projects ought to be reexamined in order to determine their appropriateness for the rural areas.

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Introduction

This report documents the development of solar power in Tuvalu. A brief introduction offers an overview of the cou::try's land area and topography, population and annual growth rates, current levels of, economic activity, the natural resource base, and the energy sector. The report then recounts the history of solar power development in Tuvalu and the difficulties associated with establishing a successful solar programme. Recent programme activity, the prospects for future development, and the management structure of the Tuvalu Solar Electric Cooperative Society (TSECS) are also highlighted, emphasizing the strengths and weaknesses of the current institutional arrangement to develop solar power. Finally, a few concluding remarks are offered on Tuvalu's solar power experience and how it might relate to solar development programmes elsewhere.

Land

Tuvalu, which consists of nine coral atolls, is widely dispersed over 1.2 million square kilometers of the Central Pacific. The total land area of the country is approximately 24.4 square kilometers, which is relatively evenly distributed across the nine atolls. All of the islands of Tuvalu are low coral formations seldom rising more than four meters above sea level.

Economy and Population

The total population of Tuvalu is roughly 8,100 (1989) 1/. The forecasted annual growth rate of the population is 2.7% through 1995. Tuvalu's economy is small, fragmented and highly vulnerable to e: :.rnal economic influences. This is particularly evident in the energy sector where recent price i...:eases for imported petroleum products have seriously impacted on the country's current accounts. Tuvalu's 1989 Gross Domestic Product (GDP) is estimated at roughly A$6.5-7 million. Total 1989 (merchandise) imports of A$5.6 million are equivalent to over 80% of GDP. Tuvalu has a negative trade balance, with 1989 exports of only A$0.21 million.

1/ This estimate does not include seamen working overseas, or students and other citizens and their family members working in Australia, New Zealand, Fiji, Kiribati, and Nauru.

Resources

Tuvalu's natural resource endowment is very limited. The land available is generally of a low quality and poor fertility and, therefore, restricted in its capacity to support agriculture. The country's exclusive economic zone covers approximately 750,00 square kilometers of oceanic waters. The fisheries resources within this area offer potential for upgrading and expanding the country's fishing industry. The potential for the exploitation of offshore minerals is largely unknown. 2/

Energy

The scarcity of indigenous energy resources makes Tuvalu heavily dependent on expensive imported fuel to meet its energy requirements. With the expansion of diesel-generated electricity production and the introduction of solar power to the outer islands, approximately 50% of the households in Tuvalu have some form of electric lighting. In 1989, the cost of fuel imports as a percent of total imports and exports was roughly 12% and 300%, respectively. Other resource constraints aside, the country is endowed with an abundant supply of year-round sunlight which makes it an ideal location for the development of solar power.

Background

The use of solar power was first introduced into Tuvalu in 1979 to power the inter-island telecommunication system. In 1984, following the success of Telecom's solar programme, the Tuvalu branch of the Save the Children Federation (SCF) embarked on a programme to provide small household lighting kits to the outer islands. At this time, kerosene-fueled hurricane and pressure lamps were the most common form of household lighting. SCF recognized that solar power's high start-up costs and inherent limitations to low power application were more than offset by access to a plentiful energy supply, relatively easy system installation, and low maintenance costs.

SCF and the local government proposed that solar electricity be made available to households throughout Tuvalu, with SCF coordinating project implementation. The result was the establishment of the Tuvalu Solar Electric Cooperative Society (TSECS), a commercial enterprise administered by SCF and assigned to implement and manage the household solar lighting project. TSECS was registered on 26 April 1984 under the Cooperative Society Act. As the implementing agency, TSECS would serve to facilitate solar development in the outer islands by purchasing solar units at reduced rates through bulk orders; qualifying for low interest loans; sharing the risk of defective or damaged equipment; providing technical assistance; and monitoring areas of potential system abuse. As an independent commercial operation, TSECS was also responsible for all financial aspects of the programme, including deposits, the monthly fee structure and collection, default of payments, and the overall profitability of the organization.

2/ Recent geological surveys conducted by the Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas (CCOP-SOPAC) in Tuvalu waters indicate possible deposits of phosphate and manganese nodules.

Lighting Systems

In May 1984, in addition to project funding from SCF, USAID, the European Economic Community (EEC) and shareholders, a 10-year interest free loan of A$25,000 was secured from Barclays Bank International Limited Development Fund to help TSECS finance the purchase of solar lighting units.

The original 170 lighting kits (each designed to provide approximately four hours of lighting per night) contained the following components:

(a) one 12-volt, 42-watt solar panel;

(b) one 12-volt refillable battery;

(c) two fluorescent light bulbs; and

(d) a terminal panel with a radio adopter and a nickel-cadmium (NI-Cad) battery charger.

Each island formed its own branch of TSECS when a minimum of twenty households agreed to put down a A$50.00 deposit (per household) and expressed the willingness-to-pay a A$6.25 monthly fee. This financial arrangement was structured to cover maintenance costs over the lifetime of the system and replacement costs for any component no longer operating up to specifications as a result of normal use or accidental damage.

The first Branch chapter of TSECS was established in 1984 and by late-1985, all 170 of the original sol ar lighting kits had been installed. In September 1985, the Tuvalu Government signed a memorandum of understanding with the EEC for 150 new household solar lighting units and eight meeting house (maneapa) lighting kits. These units were financed by the EEC under the LOME II Regional Energy Programme for the Pacific.

Phase One Results

Following implementation of the initial 170 lighting kits, two problems arose with the units already installed - one problem a product of the other. Of initial concern was that the systems were supplying less than the originally anticipated four hours of lighting time per night. In hindsight, the kits were inadequately designed for their intended application. The original system components were chosen based on their performance in telecommunications applications, not household lighting. The primary weakness was that the design failed to provide adequate safeguards against system abuse (i.e., over-use) when installed in households. Operating at peak efficiency, the charged system supplied four hours of lighting time. The damage arose when households used more than four hours of lighting per night. This was especially true when there was inadequate exposure levels during daylight to fully recharge the system. Within a short period, batteries become chronically flat. Due to deep cycling, approximately 66% of the batteries eventually needed replacement.

Phase Two Results

The second phase of the programme begun in 1987 involved installation of the 150 household kits and eight meeting house lighting systems provided by the EEC under LOME II.

Compared to the original systems installed under Phase I, these kits were modified to include a controller to help prevent abusive patterns of use. Unfortunately, the controller was poorly designed and, ironically, actually wasted or lost a significant percentage of the system's power capability. The University of the South Pacific (USP) was contracted to analyze the performance of the system and determined that the kits were under designed. Under-sizing of the equipment has proved to be the primary cause of equipment failure during the initial stages of development. The only other equipment problem has been the propensity of lamp capacitors to fail. To date roughly 23% have needed replacement. USP recommended that all household lighting kits be up-graded with an extra panel, a new battery and a new system controller. Following an international tender, equipment was ordered from GIE Solar, French Polynesia, in April 1990. The order was for 160 panels including frames and wire), 165 batteries (including too I S), and 175 controllers. Installation of the maneapa lighting systems began in 1987 and was completed the following year. Each system is owned by the island councils, with regular maintenance supplied by TSECS.

PV Refrigeration Project

Solar refrigerators were introduced in 1987 for use in the outer island medical dispensaries. The project involved the installation of nine Pv-powered refrigerators. As part of the original contract, an extra refrigerator was ordered as a spare. If equipment failure occurred and the unit could not be repaired on-site, a replacement was temporarily available. The original set-up called for a six-panel system. In the development phase, it was determined that the refrigerators were severely under-powered given unit size and power requirement. Again, following the recommendations of USP, the system was upgraded to ten panels per refrigerator instead of the original six. 3/ Project funding was made available by the EEC. The Government of Tuvalu is the sole owner of the systems, but has a service contract with TSECS for regular maintenance.

TSECS To Date

In June 1988, SCF abruptly severed its ties with TSECS. TSECS is now a completely independent commercial enterprise, wholely owned and operated by Tuvaluans. This was a critical period in the development of solar power in Tuvalu. The utilization of solar power on a relatively large scale was new, virtually untested, and to date not entirely successful. Public confidence in the viability of solar systems was eroding rapidly. In January 1988, with the assistance of the French Government, 200 additional batteries and controllers were delivered to Tuvalu. The new equipment had a successful history of field performance in French Polynesia and helped iron-out the design weaknesses inherent in the first and second phases of solar development. The new equipment, combined with renewed emphasis on proper system usage and improved technical expertise, is improving the aggregate performance of TSECS household lighting systems.

Management Structure

The Tuvalu Solar Electric Cooperative Limited, as constituted by Tuvalu's Cooperative Societies Ordinance (Cap 64, Section 7), is governed by a Management Committee. The Management Committee acts as a policy-making body consisting of eight members; one from

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3/ A full report on the present status of these systems can be found in the recently completed USP Monitoring Final Report.

each, of Tuvalu's eight islands. 4/ Members of the Management Committee are elected annually to their posts by their respective Branch shareholders. The Management Team is responsible for the day-to-day operation and project implementation of TSECS and consists of a Manager appointed by the Management Committee and three technical/support staff who are appointed by the TSECS Manager. The field staff consists of one Branch Technical Assistant on each of the seven outer islands. They are responsible for routine maintenance and repair of equipment when the technical staff is between site-visits. Currently, TSECS has eleven staff members, not including the Management Committee.

The Tuvalu Government plays a limited role in the management of TSECS. Under the Cooperative Society Act, the Management Committee is directly responsible to the Registrar of Cooperative Societies located in the Ministry of Finance and Commerce. As such, all project funding is channeled through the Ministry first before being dispensed to TSECS.

Membership and Fees

Through June 1990, TSECS membership totaled 342 compared with 329 in June 1989, an increase of 13 members. To date 265 solar systems are installed or in development with the remaining 77 members awaiting delivery and installation of lighting kits. The breakeven point for TSECS operations is roughly 300 members, not including replacement costs. At present, TSECS earns roughly A$1.00 per unit per month which is rolled back into replacements costs. The remaining A$5.25 of the A$6.25 monthly fee covers current overhead costs, including salaries, rent, office supplies, equipment, and routine maintenance.

New Membership

The future success of TSECS will be dependent on attracting new membership. Of Tuvalu's approximately 8,100 residents (1989), nearly 3,000 live on the main island of Funafuti. Because of local statutes, TSECS is not allowed to compete head-to-head with the Tuvalu Electricity Authority (TEA) for household lighting within TEA'S service area 5/. Since most of Funafuti's households have access to the grid (and those who do not, soon will), TSECS'S prospects for additional membership coming from Funafuti is severely limited. That leaves approximately 5,100 people on the outer islands. With an average of six people per household, that leaves a customer base of 850 potential TSECS members - assuming Tuvalu's population remains constant over-time. While a 100% market saturation of 850 households (including the current membership of 342) is unlikely, installing lighting kits in 500 households or 60% of the outer island market is possible. From a operational stand point, overhead costs remain virtually the same at 500 or more members as at 300 members. More importantly, a 60% market penetration will cover all replacement costs.

4/ Niulakita, the ninth and southern most atoll in the Tuvalu Group, with a population of only 75, is to small to economically support solar development at this time.

5/ TEA is the national electric utility. It has an installed diesel-fired capacity of 600 kW.

Costs

As was noted above, TSECS' shorter, overhead costs (O&M) are being met through the current enrollment. TSECS estimates that an additional 175 members, bringing total membership to over 500, will be required to also cover long-term replacement costs. As membership increases, O&M costs as a percentage of total operating expenses will decrease. That is, operations and maintenance costs will remain relatively static as membership increases. This will release an additional percentage of funds (above the current A$1.00 per month collected from each member) that can be rolled back into the long-term replacement fund. To date, total TSECS capital investment is roughly A$350.00 ($1990). By the mid-1990's, based on current membership, annual TSECS capital replacement costs are estimated at approximately A$ 30,000 per year. Current annual replacement costs are roughly 0.5% of total capital investment. As the first generation of panels, batteries, and controllers reach the end of their operational life, that figure is likely to increase to 7-10%. If efforts fail to adequately increase membership and/or users cannot support higher monthly fees, the establishment of a TSECS Trust Fund has been proposed. It is estimated that interest returns on an endowment of A$150,000 would be sufficient to cover 50% of equipment replacement costs, assuming a 10% annual return on investment. At this time, it is unknown how a fund of that size could be established.

Current Programme and Future Prospects

During 1989-90, TSECS operations have been restructured to reflect four main areas activity: system upgrades, expansion of the product line, policy research, and the coordination/consolidation of existing programmes.

Installed Capacity

By year-end 1991, based on the number of units installed, solar power in Tuvalu will be generating over 44,000 kwh per year of electricity. This estimate is based on a combined installed capacity of 33.2 kW (household and meeting hall lighting and refrigerator units); a capacity utilization rate of 70%; and a refrigerator duty cycle of 50%. 6/ All else equal, solar power will be providing over 7% of total 1991 household electricity demand. This assumes household demand will increase by 5% for TEA-generated electricity.

The estimate of 44,00 kWh assumes all 342 currently enrolled members of TSECS are out-fitted with two-panel household lighting systems and all system upgrades repairs have been completed by year-end 1991. The estimate is calculated by the following equations:

(a) $L\ kWh/y = [u*(p*W*c) * (h/y)]/1000$

(b) $R\ kWh/y = [u*(p*W*c*d) * (h/y)]/1000$

Total generation is the sum of lighting and refrigeration

6/ This estimate does not include the production of electricity by ouster island generators. Nevertheless, the estimate is a basis for which to establish the overall contribution of solar power to the household sector.

(c) $kWh/y = L\ kWh/y + R\ kWh/y$

where

L = lighting
R = refrigeration
u = total number of units (household and meeting hall, or refrigerators)
p = total number of panels per unit (e.g., two panels per lighting unit)
W = maximum rated capacity of each solar panel (42 watts)
c = capacity utilization term (0.7)
d = refrigerator duty cycle of 12 hours (0.5)
h/y = maximum hours of operation per unit per year
kWh = kilowatt hours

Note: Each system operates for different intervals. For example, the two-panel 84-watt household system operating at 70% capacity utilization (roughly 60 watts) will generate 240 wh (60 watt*4 hours) of power per day.

Product Expansion

In the planning stage as part of the LOME II Follow-up Programme is the continued development of the TSECS product line, which will include expanding the capacity of individual household systems. Currently, TSECS only provides household lighting kits. As outer island demand for modern consumer appliances increases, TSECS will be positioned to meet growing household power requirements. (However, the possibility of outer island diesel-generated electrification decreases somewhat the potential for TSECS market expansion).

Under the above plan, the current two-panel, 84-watt system would be expanded to include additional batteries, panels and controllers depending upon individual household load requirements. A fully independent system consisting of a maximum of sixteen panels would be available to power a refrigerator, additional lights, stereo and video machines and possibly other equipment. An increase in the monthly fee would be commensurate with the size of the system. To avoid the development problems associated with earlier solar projects, TSECS will implement the expansion programme one stage at a time. TSECS plans to first acquire several solar refrigerators of different makes and the necessary peripheral equipment (panels, batteries, etc.) to be part of a pilot programme to test which size and model offers the best performance for Tuvalu. Once the system is identified and data is collected, TSECS can establish a financing package for members and begin seeking additional loans or grants to launch the new service.

Programme Consolidation

As part of an overall programme to consolidate all solar related activities, TSECS is in the process of negotiating with Tuvalu's Telecommunication Division to assume responsibilities for equipment maintenance and replacement of outer island solar telecom facilities. In the long-run, this will increase the technical skill of TSECS staff, avoid costly duplication of solar support services, and strengthen the financial position of TSECS. In addition, at the completion of objectives outlined above in Sections 4.4 and 4.5 and in-line with the goals of the LOME II PV Follow-up Programme, TSECS should possess the capability to design, purchase, install, operate and maintain all solar-related projects and equipment. To ensure success in all areas of operations, TSECS must seek to maintain an effective liaison with organizations concerned with solar power research, or the development, demonstration, or manufacture of systems and components for the utilization of solar energy.

TSECS Experience

Despite certain advantages of solar power over other forms of power production, TSECS is currently facing operational problems that must be addressed to ensure the long-term success of solar power in Tuvalu. We suspect many of the difficulties faced by TSECS in the past and those anticipated in the future are not unique to TSECS or Tuvalu, but are endemic to solar power development in many small island countries.

First, TSECS's capital stock is not operating at full capacity. A recent survey has indicated that only 68% of TSECS's installed capacity of 26.7 kW (based on 265 on line members, plus the meeting hall and refrigeration systems) is currently operational. This is largely due to system failures in the original units. These units are part of the EEC Regional Photovoltaic Lighting Project which began in 1985. The EEC is currently in the last stage of delivering improved replacement equipment as part of its upgrading project. Unfortunately, delays in the delivery of the new equipment has put the upgrading project more than a year behind schedule. The upgrades are scheduled to begin in December of 1990. We recommend that firms or government agencies engaged in household or rural development of solar power should, when possible, diversify their sources of technical and financial aid. In doing so, solar power programmes can increase their opportunities by sharing risk among several firms or agencies rather than being dependent on one supplier.

Second, and of critical importance to any solar cooperative is the setting of the monthly fee structure. The current TSECS fee structure of A$6.25/month per household (for one lighting kit) does not accurately capture the true cost of equipment maintenance and replacement over the lifetime of the system. The fee structure, as originally established in 1984, is not inflation indexed and has not captured the rising costs solar equipment over-time. As the real value of the fee continues to erode, the ability of TSECS to finance the maintenance or replacement of capital stock, particularly as equipment nears the end of its operational life, will be severely diminished. Monthly fees must be set such that they capture inflationary pressure and generate the necessary financial support to ensure that the firm covers its long-term costs of operation.

Third, efforts are underway to increase the business and accounting skills of the TSECS management staff. The experience of TSECS has shown that improper management of monthly fees can be the Achilles Heel of an operation of this type. Effective business skills and proper management techniques will help increase membership and ensure that TSECS will cover its long-term replacement costs and to operate independently of aid assistance. It is hoped that in-country training presently being provided by S.P.I.R.E. under a French aid package will meet these requirements. 7/

Fourth, the TSECS is of the experience that similar organizations elsewhere should be allowed develop independent of any government interference or regulation. The local government should not provide subsidies or discounts to TSECS-like institutions since the organizational structure of The Coop acts to equitably distribute the costs of equipment and services provided. In this example, the cost of solar power should accurately reflect the true cost of the service. From a development standpoint, by imposing distortions through government subsidies or otherwise, the likelihood of overlooking cheaper sources or perhaps more appropriate sources of energy is increased. That is not say local government should take a hands-off approach. On the

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7/ S.P.I.R.E. is the South Pacific Institute for Renewable Energy located in Tahiti, French Polynesia.

contrary. It is in the interest of firms attempting to develop solar power to actively seek out the institutional interest and support of the government to PV electrification. This is true whether the organization is private or is an agency of the government.

Concluding Remarks

The inherent nature of the Co-operative organization has been an effective forum through which (a) members can discuss individual problems and ideas with others, (b) mistakes are quickly corrected, and (c) the continued development of solar power is encouraged. Indeed, on most accounts, the co-operative arrangement has been an ideal vehicle in which to facilitate solar development in Tuvalu.

Note: A complete historical data base of Tuvalu's energy sector from 1984-present is in the development stage. Availability permitting, data will be published for both monthly and annual estimates. Included in the data base is energy consumption by fuel-type, by sector (including demand for individual petroleum products), the cost of fuel imports by product-type, wholesale (delivered cost) and retail prices for petroleum fuels, as well as electricity production, consumption, installed capacity, average load factors, peak loads, fuel consumption, losses, utilization rates, tariff rates, and the number of household electricity users. I anticipate the project to be completed in early 1991. For those interested in obtaining a copy of Tuvalu's Energy Statistical Yearbook, please contact James M. Conway, Energy Planner, Department of Foreign Affairs and Economic Planning, Funafuti, Tuvalu.

Leo Moli
Energy Unit

Country Background

The Republic of Vanuatu comprises a "Y"-Shaped archipelago of over 80 islands located west of Fiji and southeast of the Solomon Islands, between 13° and 23° latitude and 166° and 172° east longitude. The islands extend roughly north to south over some 850 km. The climate varies from tropical in the north to subtropical in the south. Significant variations can be seen throughout the group. In part of the year, trade winds blow from southeast, generally weaker in the north and stronger in the south.

Natural Resources

The main natural resource of the Republic is the land itself, with a total area of approximately 12,200 km^2. The largest island are Espiritu Santo with 4,010 km^2, Malekula with 2,053 km^2 and Efate with 923 km^2. The terrain on most of the larger island is mountainous with limited coastal plains. An estimated 5,500 km^2 or 45% can be considered potential arable land. Both the climate and soils are conducive to agriculture and livestock husbandry.

Form preliminary estimates of forest area, accessibility and volumes of merchantable species, made during the pilot phase of the Vanuatu National Forest Resources Inventory, a more realistic estimate of merchantable timber volume would be in the order of 1.5 - 2.0 million cubic metres. However, the possible biomass volume of all species available for energy conversion would probably exceed 5.0 million cubic metres. Verification of these estimates can be improved as data from the current field work is processed.

Vanuatu has a rich and diverse potential energy resource base which, however, is yet to be fully quantified. Biomass from natural vegetation, residues from forestry and agriculture, followed by hydro, geothermal, solar and wind. Also being a nation consisting of islands surrounded by sea, wave energy is another potential resource.

People

The figures for 1989 population census showed a total of 142,630 which represents an increase of more than 31, 00 or 28%, over the last 10 years. This represents an annual growth rate of 2.4% between 1979 and 1989. The population is largely rural (116,330 or 82%) with only 18% or 26,300 living in the two urban areas. Of this, 13% (19,400) live in Vila on Efate and 5% (6,900) live in Luganvile on Santo.

The average population density is approximately 11 people per km. The rural population density averages 9 per km. However, there is a wide variation in population density on different averages 9 per km. However, there is a wide variation in population density on different island. On many islands most people live in the coastal areas or on small islands offshore from the larger ones, while the interior is virtually uninhabited.

Economy

Economic activity in Vanuatu is centered around subsistence gardening and fishing Wage employment in Vanuatu is confirmed mainly to Port Vila and Luganville, where the government sector is dominant. Principle exports are copra, cocoa, beef and timber. In 1984, copra exports accounted from 85% of the total value of exports, but world prices have fallen considerably and the relative importance of copra decline to 47% of the total exports value in 1989. After copra, comes tourism, Vanuatu's second largest source of foreign exchange. Vanuatu also has a diversified base of aid donors. These donors are Australia, Britain, Canada, France, Japan and New Zealand, while other aids come in through multilateral organizations such as USAID, UNDP, EEC, ADB, CFTC, SPC etc.

Table 1

1989 Census

Local Government Regions	Households	Male	Females	Total
BANKS/TORRES	1080	3020	2950	5970
SANTO/MALO	4920	13380	11970	25350
AMBAE/MAEWO	2180	5780	5220	11000
PENTECOST	2280	5580	5660	11240
MALEKULA	3850	9920	9330	19250
AMBRYM	1460	3600	3400	7000
PAAMA	450	790	900	1690
TONGOA/SHEPHERDS	750	1930	1770	3700
EFATE	6140	16360	14640	31000
TAFEA	4430	11310	11140	22450
Total - Vanuatu	28220	73590	69040	142630

Table 2

Urban Population by Sex & Municipality

Municipality	Households	Males	Females	Total
Luganville	1390	3660	3240	6900
Port Vila	4090	10300	9100	1940
Total - Urban	5480	13960	12340	26300

Total export value have fallen considerably from 1984 to 1987, an average annual decrease of 31.3%. The value of imports fluctuated from 1984 to 1987 but generally increased, an average increase of 3.9%.

In current terms, GDP fell sightly from 1984 to 1987 but declined substantially in real terms due to inflation.

Table 3

Vanuatu: Selected Indicators
(million Vatu, current prices)

	1984	1985	1986	1987
GDP	10,846	10,966	10,751	10,821
Export	4,395	3,263	1,518	1,942
Imports	6,811	7,537	6,105	7,638
Inflation rate (%)	6.4	2.7	5.7	15.9
Exchange rate (Vatu/US$	94.86	110.66	116.66	100.86
Population ('000)	131	135	139	140

Sources: Reserve Bank of Vanuatu, Quarterly Economic Review, Port Vila, Vanuatu, December 1987.
GDP from Vanuatu Statistic Office.

Land Tenure

In Vanuatu, custom land is not only the site of production but it is the mainstay of a vision of the world. Land represents life, materially and spiritually. A man derives his social status, his strength and moral feeling from his native land. Those who live on their own clan's land are its masters and control everything on it.

When Vanuatu gained independence, the land provisions of the Constitution ruled that all land belongs to indigenous custom owners, except for land that is required by the government for public purposes. The land legislation also allow any person or company to seek a certificate to negotiate a lease with the custom owners. Once registered under the Land Lease Act, the leases are guaranteed by law.

In development of indigenous energy resources, land tenure system must be understood and respect. Any time a development project requires land, the impact of custom ownership has to be recognized as a very important planning factor.

Institutional Arrangements for Energy

Such is the importance of energy in the economy and development of the country that, in 1985 the Vanuatu Government employed the service of an ADB funded Energy Planner who established an Energy Unit. A Ten Year National Energy Development Plan was also compiled and released in April 1987. Six posts were approved from this United, but due to the lack of qualified energy personnel and government's budgetary constraints, only two posts have been filled.

Currently the energy Unit consists of two locals, one for petroleum matters and the other is responsible for rural energy. Both officers report directly to the Second Secretary of the Ministry of Trade, Commerce, Cooperatives, Industry & Energy (TCCIE).

Given the current situation, it is obvious that Vanuatu's National Energy Unit will require substantial support from the Regional Energy Programmes in terms of advisory services, appropriate training of officers and even assistance in project implementation in some cases.

The purpose of setting up an Energy Unit is to do overall energy planning, coordinating, energy policy making and that operational responsibilities will be left to relevant government agencies or private companies. However, it is not very clear now where the Energy Unit stands because there is no good or close coordination between these government bodies where their duties overlap. Below is what was proposed that the responsibilities should be when the Unit was first established.

It is understood that the Council of Women are planning their own rural household programme such as ways of upgrading life in the kitchen, the Women's Affairs Department are carrying out demonstration programmes in rural areas such as cheap ways of building wood stoves, sawing machine repair and the Environmental Health Section are also constructing stoves and moulds of dissemination to rural areas. A great many initiatives have been taken and many policy issues raised by various government agencies who are currently involve in certain appropriate energy technologies, but there is no formal liaison between these agencies to avoid unnecessary duplications.

Component	Departmental Main	Responsi bilities Subsidiary
Overall Energy Planning	TCCIE	NPSO
Resources	TCCIE/GMRWS	AFF & NPSO
Petroleum Pricing	TCCIE ?	FH ? or HA ?
Government Petroleum Contract	TCCIE	FH, PWD & AG
Urban Electricity Policy	TCCIE	NPSO & AG
Rural Electrification (RE) Policy	TCCIE	NPSO, PWD & GMRWS
RE Operation and Maintenance	PWD/E	TCCIE
Fuelwood Plantation	AFF	TCCIE
Household Cooking (Wood stoves)	EHS	TCCIE, NS & WA

NPSO	- National Planning & Statistics Office
TCCIE	- Ministry of Trade, Commerce, Cooperatives, Industry & Energy
AFF	- Ministry of Agriculture, Forestry & Fisheries
GMRWS	- Department of Geology, Mines & Rural Water Supply
HA	- Ministry of Home Affairs
FH	- Ministry of Finance & Housing
PWD	- Public Works Department
AG	- Attorney General's Department
EHS	- Environment Health Section
WA	- Women's Affairs
E	- Education Department
NS	- Nutrition Section

Energy Supply and Consumption

Petroleum Fuels

Petroleum fuels are supplied to Vanuatu by Local Coastal Tankers (LCTs), and products are marketed by Mobil, Shell and BP. Commercial energy consumption is entirely dependent on imported petroleum products, with the major sector being transportation (about 69%) and power generation (about 23%). As shown in Table 4 that while petroleum imports have increased.

Table 4

Vanuatu: Role of Energy Imports
(Vatu million, current prices)

	1985	1986	1987	1988	1989
Cost of fuel imports	651	573	634	584	640
Percent of "home use" imports(1)	10	9.7	8.5	8.3	8.1
Percent of domestic exports	33.8	61	42	31.9	24

Note: (1) "Home use" imports that are consumed in Vanuatu, i.e. they are not re-exported.

Sources: Reserve Bank of Vanuatu, Quarterly Economic, Port Vila, Vanuatu, December 1987.
Statistics Office, 1989 Statistical Indicator

Trends in Imported Energy Demand

Demand for imported petroleum fuels for 1984 to 1989 is shown in Table 5. Auto & Industrial diesel fuel accounted for 56% of total demand in 1989 and motor spirit comprised 16%.

Table 5

Vanuatu: Demand for Petroleum Fuels
(kilolitres)

	1984	1985	1986	1987	1988	1989
Distillate	17053	17387	16760	18420	16246	15811
Motor Spirit	6608	6525	6114	5670	5315	4685
Kerosene	1032	984	831	843	716	856
Fuel Oil (Lubes)	544	538	467	467	486	470
LPG	864	870	130	1307	1212	1181
Total Ground Fuels	26101	26304	25479	26070	23975	23003
Avgas	80	720	579	478	1001	944
Jeg Fuel	2420	6200	3164	4090	4376	4520
Total All Fuels	29101	33224	29222	31275	29352	28467

Sources: Energy Unit, Ministry of Trade, Commerce, Cooperatives, Industry and Energy.

Table 6

Vanuatu: Retail Prices
(Vatu/litre)

	1981	1985	1986	1987	1988	1989	1990
Motor Spirit	75.3	70.5	55.13	84.8	84.8	84.8	97.2
Diesel	53.6	57.7	47.42	62.5	62.5	62.5	73.5
Kerosene	50.5	n.a.	41.3	59.1	59.1	59.1	70.4

Note: n.a. - Note Available

Sources: Energy Unit, Ministry of Trade, Commerce, Cooperatives Industry and Energy detailing information from Shell, BP, Mobil and Boral Gas.

The actual prices for petroleum products in remote areas is not known but it is assumed to be almost double or even more as compared to Vila and Luganville. This is because of the distance and transport involve in getting the fuel in drums to these remote areas.

e.g. Motor gasoline (Vatu)

1 drum (200 litres) deposit	7000
Wharf price in urban area	17,900 (89.5 Vatu/lt)
Average freight per drum	1,200
Landed price on island	26,100 (130.5 Vatu/lt)
Selling price on island is not known	
The price LPG to rural remote areas is also not known.	

Electricity

Electricity generation is the second largest user of petroleum fuel after transportation, accounting for about 23% of total consumption. Electricity supply system is entirely diesel-based and consists of 8.5 MW urban power system around Port Vila, operated by a private

French company -"Societe d'Union Electrique du Vanuatu" (UNELCO). A second urban system rated at 1.1 MW for Luganville, operated by another private company "Compagnie d'Electrique de Santo (CES) with 85% of UNELCO owned.

No surveys have actual been conducted, but it is understood that there are many small diesel generators that are financed, operated and maintained in the rural areas by the Education Department, Public Works Department, Health Department, religious organizations, village communities and some private companies. There is no compiled information available on the diesel generating capacity, ages or makes etc. These generators are being used mainly to provide power for lightings, freezers, saw-millings and videos.

About 15% or urban and suburban households have access to electricity. Maybe more people could have had electricity if its cost is lower or affordable by the low income earners. However, because there is no Urban Electricity Legislation, the government is unable to monitor UNELCO and CES's tariff structures. Even though it was stated clearly in a contract with the government that UNELCO will provide certain information as required by the government, this has not been fulfilled. Tariff rates for the Port Vila system in mid 1990 were:

Small Domestic Consumers:

17.80 Vatu (first 60 k Wh/month)
27.39 Vatu for the next 60 k Wh/month
46.56 Vatu for over 120 KWh/month

Basic energy rate for general purpose consumers:

27.39 Vatu
plus a monthly minimum demand charge of 542 Vatu/contracted k VA.

Basic energy rate for high voltage consumers:

18.35
plus a minimum monthly demand charge of 505 Vatu/contracted kVA.

The minimum monthly demand charge per contracted kVA is understood from UNELCO that it is for the meter rental and maintenance.

Private households supplied from government and private operated generators in rural areas are paying tariffs which probably only cover the fuel costs. Observations made by the Energy Unit on 10 rural government institutions showed that each household pays only 250-400 Vatu per month regardless of what appliances they are using. That is they are not metered and the operation costs of the generators are not properly recorded.

Household and Rural Energy

There are always problems attached to household and rural energy, for example, the obvious ones are health problems, financial constraints, communications and environmental forces. Though the government is aware of these, there is lack of finance, insufficient technical and management skills in relevant government departments such as Social Development, Health

Department, Industry Department and the Energy Unit for initiating programmes (Solar PV Systems, Improved Wood Stoves, Improved Health Sanitation, Create Small Industries) to upgrade life.

Consumption and Production

There is a lack of data on sectoral energy consumption, especially pertaining to biomass. Various attempts have been made during the past to improve the energy supply to people in rural areas, particularly electricity and fuel supply, but to date no real improvements have been achieved. It could be that the demand is not big therefore is expensive or supply of fuel in drums to these remote areas is not efficient (unreliable shippings) and may be people in the rural cannot really afford to pay for the electricity cost because of the lack of income generation in their areas. Also lack of skilled manpower in their areas to up-keep the energy supply system and lack of funds for a follow up evaluation of previous programmes.

This is now a concern because the price of fuel is going up and its impacts on energy supplies for the people in the rural areas and also in the urban areas will be greatly felt.

Biomass from natural vegetation covers some 75% of the total land areas or 900,000 hectares. These areas represent a vast biomass potential which, when determining the real potential it should be noted that a major part is located in inaccessible areas and in practical terms is out of reach of the villagers.

Biomass fuels are used mainly for domestic cooking and crop drying. Though no surveys have been conducted to determine the magnitude of consumption, quantitative estimates from different expert reports indicated following levels.

Table 7

Vanuatu: Annual Biomass Fuel Consumption, 1985

	Quantity	Unit Consumption	Annual Consumption
Rural domestic cooking	115,000 cap.	0.5 tonne/cap.	57,500
Urban domestic cooking	20,600 cap.	0.2 tonne/cap.	4,000
Copra drying (smoke)	29,700 tonne.	2.5 tonne/tonne.	74,300
Copra drying (hot air)	9,300 tonne	1.0 tonne/tonne.	9,300
Cocoa drying	800 tonne	1.0 tonne/tonne.	800
Total			149,900 tonne

Source: Energy Ten Year Plan: Cook Islands

The Forestry Service has two major plantation programmes, Local Supply Plantations (LPS) and Industrial Forestry Plantations (IFP). The IFP include an annual planting of approximately 80,200 hectares and at present the programme have covered an estimated area of 2,159 hectares.

Household Energy Policy & Practice

There are no national policy guidelines for household energy use that are set down specifically for low-income, rural households or urban households. The National Council of Women and Women's Affairs Office have participated in implementing household projects but this is not a policy orientated programme. Upgrading life in the kitchen is now being planned but it is not yet clear when and how this will come about and who will finance the programme, also who will take the leading role, the National of Women or the Women's Affairs in the Social Development Department.

Stoves

In most areas fuel wood supplies are abundant. However, in some densely populated areas, the women spend many hours daily collecting firewood. Usually earth-ovens and open fires are used for cooking. Both methods have a very low efficiency as compared to the demonstrated wood and charcoal stoves. KITOW (at Tnna) and Onesua High School (on Efate) have experimented with production of improved wood and charcoal stoves as part of practical training courses and for sale. However, the fuel efficiency of these new stoves has not been proven and may not be the right answer to the areas such as Paama and Mota Lava islands where there is scarce fuel resources. Though stoves produced were not too cheap, they could improve both the health standard and the fuel efficiency.

The Environment Health Section has initiated trials with various types of stoves and an attempt has been made to direct these efforts into a national woodstoves programme involving stove testing, training of extension officers from the Ministry of Health and Social Development Department, dissemination of moulds to LGC Headquarters and promotion through the media. The objects of this programme are:

(a) to improve comfort in cooking environment, thus preventing health hazard because of smoke;

(b) to improve fuel efficiency, thus saving time presently used for fuelwood collection; and

(c) to prevent households from using the more comfortable but very expensive kerosene and gas units, thus saving cash and foreign exchange.

The Ministries of Education, Health and Social Development have proposed to introduce institution wood stoves at Boarding schools and rural hospitals. However,

(a) there are no funds set aside to finance this project;

(b) there is no local that is qualified to undertake stove programme and direct it towards a national programme and to make an awareness programme, also assessing the costs against the benefits expected; and

(c) the private organization that was once behind this programme went out of business for some time.

In the mid-1980's a mould was received from Suva to construct institutional wood stoves. It was understood that only one stove was produced and no further progress has been made after that.

However, the wood stoves programme was not forgotten. There are still requests coming to the Environment Health Section and Women's Affairs for wood stoves.

Fuel Pricing

There is not yet a commercial market for indigenous fuels, thus no comparable prices are available.

Presently the oil companies operating in Vanuatu set their own product prices and the pricing structure used is not know to the government or the consumers. One area that has been noted was that, there is no pricing competition in the market for fuel products. All three companies have the same wholesale and retail prices throughout the country even though there is no price control system.

There is also no price control on the pricing of LPG which is imported in bulk from Australia by Boral Gas (Vanuatu) Ltd., who is also responsible for storage and distribution.

Although the price control system ceased in 1988, fuel sales for distribution to rural areas and outer islands is still fixed since mid-1986 at 7.7 Vatu/litre less than urban wholesale price. Drums are delivered at the wharf in either Vila or Luganville and the transport from there is at the rural retailer's responsibility and expense. The difference is supposed to cover the marine transport cost on average.

On top of the fuel price the consumer pays a deposit of 7,000 Vatu for one 200 litre drum and 3,500 Vatu for a 12.5 kg LPG bottle (1st quarter 1990 prices). After use, the drums are returned for refilling but in most cases the drums are lost because of the distance and handling involved, thus the rural retailer has to include this extra cost in the unit price of the fuel.

Rural Electrification (RE)

Because of the nature of rural districts in Vanuatu, the extension of urban grid to these areas will never be possible. This is mainly due to:

(a) Rural areas on the two main islands (Santo & Efate) are very far away from the urban power supply. Also the electricity agreement between the Government and UNELCO only allows supply of power to within 15km radius of the Power Station; and

(b) On bigger islands in the group, plenty of people also live in small islands off-shore.

At present there is no national RE policy nor is there a national tariff. The incentive for RE is to improve the quality of rural life, perhaps helps to slow down urban drift, enable rural population to increase its cash incomes, encouraging the decentralization of industries and improve standards of education. Most people (82% of total population) prefer to live in their on lands where almost their daily needs are available at no cost as compared to the urban areas where everything is money.

Various studies on alternative sources of energy (hydro, geothermal, wave) have been carried out on some islands in the country but this is only in either preliminary or prefeasibility stages. Direct utilization of solar energy at present takes place on a very small scale, that is solar water heating in urban areas and PV power production in rural areas for operation of repeater stations and rural radio telephones. Many of these are in inaccessible locations where a diesel generator could not be operated. UNELCO-Vanuatu provided in 1984 five (5) solar PV systems for schools and community houses for some outer islands and one (1) system was provided by the South Pacific Commission (SPC) in 1985 for a tourist resort as part of a demonstration scheme. But no follow up evaluation or feed-backs from the users to assess their viability. The installed solar capacity varies from a 40 W peak for the smallest stations up to 2,200 W at the largest.

Biomass Energy Use

The energy resource potential of biomass in Vanuatu is both large and diversified as it comprises the following:

(a) agricultural residues;

(b) forestry residues;

(c) senile coconut trees; and

(d) native forest and bush.

Although there is no comprehensive biomass resource survey, there does not appear to be any short-term lack of biomass for present energy requirements in vanuatu because of the dispersed nature of both the population and biomass resources. About 900,000 hectares is estimated to be under natural vegetation. Inventories of forest area and wood volumes have been limited to preliminary surveys in some of the better forest areas, however, as mentioned earlier that possible biomass volume of all species available for energy conversation would probably exceed 5.0 million cubic metres (Source: Forestry Department).

The Forestry Department also included in their IFP programme a fuelwood programme which the Department has carried out some trial plantations but to date the yield is not yet fully assessed.

For the past twelve months the Department of Forestry has been engaged in the Vanuatu National Forest Resource Inventory. The objective of this project is to provide the Vanuatu Government with an improved capability to formulate integrated plans for long term management, development and efficient exploitation of Vanuatu's natural forest resources. Following preparation of the implementation document for the pilot stage of the project, an additional survey of village level wood use has been included in the project. This is intended to complement the work carried out under the auspices of the FAO project.

There is no existing major fuelwood programme that involve women, but the Forestry Department has employed women in the IFP programme, that is mainly in the nursery and planting of young trees.

Women's Roles in Household and Rural Energy Choices

The Women's Affairs Department has involved many women in the rural communities through teaching of certain appropriate technologies such as:

(a) water tanks;

(b) smokeless stoves;

(c) charcoal stoves;

(d) ventilated improve pits (VIP) toilets

(e) water jars

Though all these activities are going on, there is not yet a policy guideline that is set down to improve women's conditions in the rural and urban areas.

As is the case throughout the Pacific Island countries, women are always the caretaker of the households whilst men as head of the household.

Environment - Energy Issues in Households and Rural Communities

There are no policies on the environmental aspects of energy production or consumption which affect household and rural energy. Some brief guidelines or conditions have been set to assess mining and tourism development but none that is directed towards energy production.

The present practice for any new development that is likely to affect the environment has to go through the Environment Section before it can go ahead.

The Minister responsible for the Environment, has announced during his speech on the commencement of Phase II of Vanuatu National Conservation Strategy that much of the future economic prosperity of the country will depend on the development of its natural resources. However, emphasised the Minister, it is vital to ensure that the quality of the environment and the ability of its natural resources to support island populations today and in the future is not severely affected by such developments. We must therefore ensure development is carried out in an environmentally sensitivie way.

There is no statistical information available on possible health problems associated with traditional cooking methods, however, it has been observed that many women and men in the rural areas have some sort of eye problems. This is believe to be caused by the smoke from open fires.

Overseas Technical Assistance and Household Energy

It is true that regional and bilateral aid programmes provide for nearly all of the capital funding for household (especially rural) energy projects. This is the case for nearly all development projects. All development projects have both a positive and negative influence. One would hope that when a project is proposed it has to have more benefits than costs. One of the negative influences of energy projects is that they are require to be maintained and the recurrent cost implications are often overlooked by the receipients. Another negative influence is the change to the lifestyle, e.g. electrical power to the villages enables them to watch videos and this may divert people from their traditional tasks.

One aspect that has been noted is that the time taken until a project actually starts is sometimes too long. Sometimes, events have taken place that affected the project viability. Most of the projects are planned by expatriates and before the projects commence, these expatriate promoters have completed their contracts or moved to other jobs.

The role of coodination of the work of aid agencies is the role of the National Planning Office.

Conclusions and Recommendations

The Republic of Vanuatu is fully concerned with the economic development of rural areas, therefore much assistance is needed (through regional outside technical advise and aids assistance) to speed up development of the country's manpower and indigenous energy resources. This would no doubt be a positive step towards the drive for economic self-reliance which is very much the major objective in the development perspective.

(a) Without trained personnel, government's energy sector programmes will continue to be hindered, even with efficient regional back-up. Greater attention needs to be paid to training, if the countries are to be assisted towards greater self-sufficiency. Such training is necessary at all levels from village technician to national policy formulation. Whatever training courses are organised, the utilisation of local expertise as resource personnel should always be considered;

(b) Curently the general public's understanding of conservation is very limited, therefore environment and energy conservation must be considered. Though 900,000 hectares is estimated to be under natural vegetation, efficient use of fuelwood through stoves programme must be encouraged more in the rural areas. This will not only be fuelwood and environment conservation but also a healthy cooking environment.

(c) The international petroleum market is currently very volatile, therefore it is necessary tgo create Energy Acts where possible to control, monitor and set standards for the country to use, e.g. for electricity and petroleum. With the present high oil product prices and the impact on household energy uses (electricity, kerosene and LPG), the government perhaps could reconsider setting up the Price Control Office again.

(d) Currently there are more than two government agencies involve in some rural appropriate technology programes such as smokeless stoves, charcoal stoves, water tanks and imorove toilets. Though these programmes have developed to certain stages, there is no good coordination between these agencies. This resulted in a lot of duplication and sometimes failure because of different project concepts for each organisation invovled. A meeting of understanding between these agencies should be held to avoid unnecessary time and costs involve.

(e) Encourage more private sector participation in energy related programs and projects. If the government has no funds for certain rural technologies, e.g. solar PV, maybe the private companies could assist to meet the cost of equipment as UNELCO did in 1984 when it provided free of charge 5 solar PV system for community houses and shcools in the rural areas.

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ENERGY STATISTICS RELEVANT TO HOUSEHOLD AND RURAL ENERGY ISSUES IN THE PACIFIC ISLAND

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Introduction

This paper assembles, in a summary form, information relevant to household energy consumption in both urban and rural areas which has been obtained from a number of energy surveys carried out in Pacific Island countries in recent years. Before presenting and analyzing the summary data, some general aspects of survey planning and design are discussed.

Value of Household Energy Surveys

Household energy surveys make an important contribution to the formulation of policies and assist with the planning and development of necessary infrastructure related to the supply of household energy needs. In addition, it is also important for the determination of appropriate strategies in the development of rural electrification programmes. The per-household consumption of commercial energy sources for lighting, cooking refrigeration and dry cell battery applications and the associated expenditure will assist in determining likely responses of households to changing energy supply conditions both in terms of price and availability.

It will also assist policy makers to assess how much households might be prepared to pay for rural electrification. Estimates of household cash incomes will assist in determining whether proposed contributions of households towards the financing of rural electrification schemes are within their capacity to pay.

It is usually worthwhile to gather information on all applications of commercial energy, such as petrol and diesel used for transport and kerosene and LP gas for cooking and lighting. It is also appropriate to survey the use and availability of wood fuels particularly if it is suspected that supply problems are developing. In some areas action to maintain wood supplies may be a higher priority than other developments like electrification. Such as the case in an area of the Morobe highlands of Papua New Guinea where a microhydro scheme had been built (Bowman 1985).

Surveys may be able to establish correlations between income level and rate of use of various energy forms such as liquid fuels, electricity and wood fuels. This information, together with projections of population growth and economic development can be used to develop energy demand forecasts. The weakness of the data presented in this report is however that each survey is a "snapshot" of energy use at a specific time at a specific location and gives no indication of the rate of change of energy consumption which is necessary for reliable energy demand forecasting.

Survey Design and Processing

Survey Design

Energy planners should decide on the specific policy issues that they want to investigate and design their survey accordingly. Selection of the survey area and the way in which households are selected within the area (complete random sampling or stratified according to one or more variables such as connection to the electricity grid or level household cash income) will affect the usefulness of the results.

PEDP's experience to date indicates that a suitable sample size for a survey examining a number of policy areas is about 200 households (up to 10% of the total population of the area being surveyed). A survey of this size gives reasonably accurate estimates for most areas of inquiry and can be carried out by a small survey team in a week or two.

Most surveys carried out in the Pacific have been based on the questionnaires developed for larger surveys in Fiji in the early 1980's with modifications made according to characteristics of the survey area and information sought. PEDP's survey questionnaires for Tonga, Kiribati, Tuvalu, and the Solomon Islands evolved in this way. It is essential to trial-run the survey questionnaire on some households in the survey area before the main survey as differences in life style make some questions asked in other surveys irrelevant and additional ones necessary.

In surveys of rural areas, a compromise must be made between sampling a small percentage of households in each of a large number of villages or sampling most or all he households in a smaller number of villages. Where there are known differences between villages which are likely to affect energy use (for example coastal/inland or with/without income from cash crops), sampling designs should include in the sample villages from each of the categories that have been identified. This will increase the number of villages to be sampled.

However, it seems desirable to survey all the households in at least some villages so as to get a clear picture of the proportion of households in the village who might benefit and be able to afford a proposed development like electrification.

Where ever possible it is recommended to check estimates of a household fuel used against local fuel sales, especially on islands or in other remote areas where there are only a few sales outlets. However, it should be kept in mind that, even on remote islands, some fuel may be carried in privately on boats and often will not show up in sales records from the local stores.

Processing Survey Data

Survey processing now takes advantage of the analytical capacity of IBM PC-compatible microcomputers possessed by energy offices throughout the region. With the use of microcomputers for processing and report-writing, a draft survey report can be presented within 3 months of the field survey. Energy offices can also easily re-examine the data from this type of survey at any time in the future. By contrast, surveys processed on mainframe or mini-computers (or by hand), have required a much longer period of analysis before the survey report can be presented, and it is very unlikely that governments will ever re-analyze the data because of the difficulties and time delays involved with using larger computers or re-analyzing hand-processed data.

Consolidated Information on Selected Energy Uses

This section presents consolidated information relating to individual end-use applications (lighting, use of dry cell batteries, and use of electrical appliances) from most of the surveys. An overall examination of generalized survey data is also presented using energy consumption figures related to overall survey populations from 14 surveys.

Kerosene and Benzine Lighting

Table 1 shows the mean consumption levels of kerosene, benzine (and coconut oil) for lighting found in the different surveys. The mean consumption figures shown are means for users of kerosene or benzine lighting only, not for the entire sample.

Electrified households are excluded for most of the surveys, as they do not consume significant amounts of kerosene or benzine for lighting. The exception here is the Nadi-Lautoka survey, in which a small proportion of electrified households did use non-electric lighting regularly.

In the surveys carried out by PEDP (Tarawa, Abaiang, Tongatapu, Vaitupu, Marovo Lagoon, and Honiara) means for kerosene consumption for lighting have been calculated from the subsample of non-electrified households which do not use a kerosene stove. This had to be done because in these surveys the householders were only asked to estimate their total kerosene consumption so if they used kerosene for both lighting and cooking there was no way to estimate the proportion used for lighting. Households with kerosene stoves as well as kerosene lamps might use more kerosene for lighting than those without stoves as use of a kerosene stove rather than firewood for cooking generally indicates higher-than-average household income. In the Nadi-Lautoka and Suva studies, households were asked to make separate estimates of their consumption for lighting and cooking, so the means are for all users of kerosene or benzine lighting.

In areas where both kerosene and benzine are used for lighting (Tongatapu, Nadi-Lautoka and Suva), there are some households which use both fuels. For example, in the Nadi-Lautoka survey, 97% of non-electrified households used kerosene lamps and 64% used benzine lamps, so 61% were using both lamp types. In these three surveys mean total fuel use for lighting (kerosene plus benzine) for the average non-electrified household will be greater than either mean kerosene use or mean benzine use shown in Table 4.1, but less than the sum of these two means because there are some households using only one of the fuels.

The lowest level of consumption by far was at Baindoang village, a remote highland village in the Papua New Guinea highlands accessible only by air. Household cash incomes were very low, with many households having a purely subsistence lifestyle. Consumption averaged only 0.6 liters per household per month for users and only 50% of households used kerosene at all 50% relying solely on wood fuel for household lighting.

Mean consumption levels of kerosene in non-electrified households are about 4 liters per month in rural areas of Kiribati, Tuvalu and the Solomon Islands. Most households in these countries have some cash income through copra sales or remittances from relatives. The most common lamp type in these areas is the kerosene pressure lamps and they used them sparingly, only 2 hours per night on average, whereas hurricane lamps ere used for an average of 5 hours per night. Thirty five percent of households on Tamana island, Kiribati also consumed small quantities of coconut oil for lighting.

In urban and peri-urban area where household incomes are higher, kerosene consumption is 6 to 7 liters per household per month for South Tarawa and Honiara. The mean consumption of kerosene and/or benzine in Tongatapu is similar. The Fijian surveys show higher levels of consumption: the mean consumption of kerosene and/or benzine is about 11 liters per household per month in Suva and 13 liters per household per month in Nadi-Lautoka. The great majority of non-electrified households in these surveys had kerosene and /or benzine pressure lamps. Higher consumption seems mainly explainable through the higher incomes in Fiji.

The levels of consumption estimated for non-electrified rural Fijian villages in the Fiji Rural Electrification Study commissioned by Tata Consulting Engineers (1984) are very high in comparison with the results in Table 1. This study estimated mean monthly consumption of 10 liters of kerosene and 8 liters of benzine (mean for all households) for non-cooking uses, i.e. lighting and ironing. It appears that the unit of measurement used in the survey was the number of drums of fuel used per month. This would grossly inflate the consumption estimates, because households will round up their consumption to the nearest drum (or half-drum at best), even if they only use 1 or 2 liters per week. It is suggested that these results should not be used for rural electrification planning purposes.

The survey of Gaire Village, about 80 km by road from Port Moresby in New Guinea is of interest because kerosene consumption was accurately measured over a month period. The effect of income on consumption is clearly shown in this survey. The households of businessmen in the village consumed more than twice as much, on average, as did the households of villagers without businesses or salaried jobs (some of the businessmen's consumption was to light trade stores). the Households of salaried workers were intermediate. Most households in all three categories had at least one pressure lamp. It was estimated that in addition to the cost of parts, lamps would have to be replaced every 3 years.

Benzine for Lighting

Two surveys, the Suva Urban Energy Survey and the Survey of Five Rural ARea, estimated the consumption of benzine used for ironing in non-electrified homes with 65% of the 301 non-electrified homes using benzine iron. Mean consumption of benzine for ironing was estimated to be 5.2 liters per household per month in Suva and 5.5 liters per household per month in rural Fiji.

Table 1

Kerosene and/or Benzine Consumption for Lighting in Non-Electrified Households
(Consumption figures are mean values for households which actually use the specified fuel)

SURVEY	FUEL	CONSUMPTION (liters/hh/month)	NUMBER OF HHS ON WHICH ESTIMATE IS BASED
Baindoang village (P.N.G)	Kerosene[1]	0.6	33
Abaiang (Kiribati)	Kerosene	4.3	48
Tamana (Kiribati)	Kerosene	3.8	99
	coconut oil	less than 1.5	35
Vaitupu (Tuvalu)	Kerosene	4.7	88
Funafuti (Tuvalu)	Kerosene	23.1	169
Marovo Lagoon (Solomon Is.)	Kerosene	4.4	108
Honiara (Solomon Is.)	Kerosene	6.5	95
South Tarawa (Kiribati)	Kerosene	7.7	48
Tongatapu (Tonga)	Kerosene	5.6 (urban)	80
	kerosene	5.5 (rural)	163
	Benzine[2]	less than 3.1 (urban)	17
	benzine	less than 3.6 (rural)	64
Nadi-Lautoka (Fiji)	Kerosene	5.2 (electrified)[3]	90
	kerosene	8.2	84
	Benzine	7.3 (electrified)	23
	benzine	9.4	64
Suva (Fiji	Kerosene	6.9	283
	benzine	8.0	193
Gaire village (P.N.G.)	Kerosene	23 (businessmen)	5
	kerosene	12 (salary earners)	9
	kerosene	9.2 (villagers)	15
Papua New Guinea[4]	Kerosene	5.5 (trad.sector)	110

1. Only 50% of households in Baindoang used kerosene for lighting; the others burned split bamboo.
2. Benzine use in the Tongatapu survey includes use for benzine iron, which are used by more households than are benzine lamps.
3. Electrified households in the Nadi-Lautoka survey which used significant amounts of kerosene or benzine
4. Average across 3 regions, highland, midlands and coastal

Dry Cell Batteries

Table 2 summarizes the mean consumption levels for dry cell batteries in the surveys for which this data has been obtained. In all the surveys more than half of the households use batteries and in most cases more than three-quarters use batteries. Monthly use of batteries for user households ranges from a low of 9 on South Tarawa, Kiribati, to a high of 39 on Vaitupu, Tuvalu. The latter figure seems extremely high but records of battery sales at the islands' stores confirm the estimate obtained in the survey.

In all surveys, the "D" sized cell has been by far the most commonly used type and the main uses for batteries have been torches and radios or radio-cassette players.

Although the amount of energy supplied by dry cell batteries is very small, the cost to households is high. If mean expenditure levels for the entire sample including non-users are considered, the cost of batteries is similar to or higher than that of kerosene and/or benzine for lighting for all the surveys listed in Table 4.2 except South Tarawa. Exact comparisons are not presented here because of fluctuations in exchange rates and fuel and battery prices: up-to-date prices can be applied to the quantities given in Tables 1 and 2.

In all these surveys, the annual cost of batteries to the average household (including non-users) exceeded US$ 20 and in most cases it was substantially higher. If rural electrification programmes can eliminate or reduce these levels of expenditure on batteries, the cost savings to households will be substantial.

It is noteworthy that electrified households in Honiara use only slightly fewer batteries than do non-electrified households. This shows that electrification of households does not by itself eliminate purchase of dry cell batteries. For rural electrification programmes to reduce battery use there must be consumer education programmes and technology support (for example, introduction of rechargeable nickel-cadmium batteries and/or power points for radios)

Table 2

Use of Dry-Cell Batteries in Electrified and Non-Electrified Households
(Consumption figures are mean values for households which actually use batteries)

SURVEY	CONSUMPTION (batteries/hh/month)	NUMBER OF HHS ON WHICH ESTIMATE IS BASED
Abaiang (Kiribati)	7 (all hhs)	50
	9 (hhs using batteries)	37
Tamana (Kiribati)	11 (all hhs)	99
	13 (hhs using batteries)	85
Vaitupu (Tuvalu)	35 (all hhs)	120
	39 (hhs using batteries)	109
Funfuti (Tuvalu)	7 (all hhs)	168
	8 (hhs using batteries)	145
Marovo Lagoon (Solomon Is.)	12 (all hhs used batteries)	108
Honiara (Solomon Is.)	7 (all electrified hhs)	190
	13 (electrified hhs. using batts.)	99
	11 (all non-electrified hhs)	95
	15 (non-electrified hhs using batts)	74
South Tarawa (Kiribati)	7 (all hhs)	244
	13 (hhs using batteries)	134
Tongatapu (Tonga)	12 (all urban hhs)	276
	16 (urban hhs using batts)	207
	18 (all rural hhs)	329
	21 (rural hhs using batts.)	276
Papua New Guinea Traditional Sector	16 (region 1)	38
	21 (region 2)	25
	20 (region 3)	44
	19 (all trad. hhs using batts)	107
Modern Sector	32 (region 1)	79
	40 (region 2)	32
	32 (region 3)	21
	38 (all mod. hhs using batts)	132

Electrical Appliance Ownership

Table 3 shows the percentage ownership of electrical appliances for the surveys in which these data were collected. In all cases the percentages are based only on those households consuming electricity, not on the total number of households surveyed. Note that not all households owning appliances will use them regularly, or at all. The percentages of regular users will therefore be somewhat lower than the ownership figures shown below, with the exception of lighting, which is always used regularly.

Examination of table 3 shows that electrical appliances usage amongst electrified households is widespread. Radios/cassette players, clothes irons and refrigerators are owned by 25% or more of the electrified households in all cases. Fans and washing machines are less common. The heaviest consumers of electricity - water heaters, stoves, and air conditioners - are used by very few consumers, except in Fiji.

For all the surveys shown below, the percentage ownership levels of electrical appliances are based on the sub-sample of households actually consuming electricity, not the total number of households surveyed.

Table 3

Electrical Appliance Ownership

	SOUTH TARAWA	TONGATAPU URBAN	TONGATAPU RURAL	NADI-LAUTOKA[7]	SUVA	HONIARA	PNG[5]	W.SAMOA[6] URBAN	W.SAMOA[6] RURAL
YEAR	1985	1984	1984	1982	1982	1987	1988	1988	
Incandescent lamp	85	93	88	n.d.	87	98	n.d.	46	40
Fluorescent lamp	88	89	87	n.d.	77	57	n.d.	76	55
Electric light	100	100	100	100	100	100	n.d.	90	95
Water Heater	<1	<1	<1	24U 11P 4R	40[8]	0	7	n.a.	
Stove/Cooker	1	9	7	11U 11P 3R	21	4	13	20	25
Electric jug	8	24	24	n.d.	26	18	32	56	85
Toaster	3	13	6	n.d.	n.d.	5	5	32	35
Iron	41	93	85	n.d.	97	49	24	84	75
Fan	25	5	7	n.d.	46	41	3	38	25
Radio/ Tape player	72	67	45	n.d.	62	55	53	62	75
Video	5	8	<1	20U 7P 6R	23	12	14	42	25
Washing machine	2	37	31	26U 8P 6R	20	7	14	6	5
Refrigerator	25	42	31	89U 87P 82R	90	55	40	46	60
Freezer (separate)	7	3	3	n.d.	46	41	5	10	5
Air conditioner	<1	<1	<1	5U 4P 3R	4	1	0	n.a.	
Other	7	2	3	n.d.	19	4	8	16	30

5. Users of public grid only. Total sample size 95 hhs
6. See Ah Wa, R. (1989) Impact of Urbanization on Household Energy Economy of Samoa (MA Thesis)
7. For the Nadi-Lautoka survey, ownership levels in urban (U), peri-urban (P) and rural (R) households consuming electricity are shown
8. Storage heaters 23%, instant heaters 8%, and immersion heaters 9% of electrified households. Only 24% of storage heater owners switched on their heaters more than 0.5 hr/day

Presentation of Summary Data

Tables 3.1.1 and 3.1.2 provides a summary of data obtained from 12 surveys presented in this report. The Tongatapu and Papua New Guinea surveys have been subdivided in order to highlight differences between consumer groups which were clearly distinguished within the two surveys and to allow further generalized comparison with socio-economic groups in other countries.

The charts which follows tables 3.1.1 and 3.1.2 (Figures 3.1 - 3.19) illustrate trends in household energy consumption patterns only between the areas surveyed and provide a preliminary comparison only of rural versus urban consumption for both commercial and non-commercial energy forms utilized.

There are several factors which severely limit the usefulness of the data for drawing general conclusions regarding either overall national or Pacific regional energy consumption characteristics. Generalizations of this nature are inappropriate due to the following reasons:

(a) end-use surveys are not uniform in their objectives or design criteria leading to possible biasing of survey populations e.g. rural areas surveyed in Fiji were selected on the basis of higher than average household income;

(b) surveyed populations generally represent only a very small percentage of national populations e.g. Honiara population surveyed represented only 0.3% of the national population of approximately 292,000 in 1987, and therefore can not be used to confidently extrapolate results to cover the total national population;

(c) data presented in this paper includes surveys that have been carried out in six Pacific Island countries (Fiji, Kiribati, Papua New Guinea, Solomon Islands, Tonga and Tuvalu) only;

(d) inflation rates and exchange rates between countries fluctuated over the ten year period (1977-1987) during which the surveys were carried out so that a meaningful present day comparison of energy consumption and expenditures on energy is therefore not possible;

(e) there are significant gaps in the data due to specific survey design, the method of analysis and/or the reporting of survey data which restricts deduction of consumption figures for specific energy forms (Suva, Nadi/Lautoka, Fiji rural, Papua New Guinea) e.g. questions on battery usage within the Nadi/Lautoka area Suva city and within rural areas in Fiji were not included in the survey questionnaire; the quantity of woodfuel used in households within the surveyed areas of PNG was not measured;

(f) local or regional factors can have a major influence on energy use patterns and consumption at a national level e.g. petrol consumption in the Morovo lagoon area in the Solomon Islands is significantly higher than other rural areas surveyed due to the predominance of water based transport; and

(g) methods used to determine household consumption of specific fuel types were not uniform leading to possible inconsistencies in sample data e.g. the volume of kerosene consumed in rural households in Fiji 1/ was based on an estimate of the number of full 4 gallon containers consumed.

Particular caution must therefore be exercised before extrapolating data to cover similar socio-economic groups or when making broad assumptions covering the national population.

Differences are noticeable in usage of energy commodity types and in quantities used between survey areas and between urban and rural populations. Differences are generally explainable when taking into account the characteristics of the populations surveyed (geographical location, income levels, availability of energy types, energy prices etc.).

1/ Reference 17

Table 3.1.1

HOUSEHOLD SURVEYS - SUMMARY OF DATA

SURVEY	NAD/LAU	SUVA	HONIARA	FUNAFUTI	PNGMOD	S.TARAWA	TONGURB
REGION	Nadi/Lautoka	Suva	Honiara	Funafuti	3 Regions	South Tarawa	Tongatapu
COUNTRY	Fiji	Fiji	Solomon Is.	Tuvalu	PNG	Kiribati	Tonga
CLASSIFICATION	Urban/Rural	Urban	Urban	Urban	Rural/Modern	Urban	Peri-Urban
Year of Survey	1982	1982	Jul 1987	May 1987	Jul 1987	Oct 1985	Nov 1984
Currency Units	Fiji$	Fiji$	SI$	Aust$	Kina	Aust$	Pa'anga
No. of HHs Surveyed	826	1312	285	169	134	244	276
% of Survey Area Population	7.2%	7.3%	n.a.	40.2%	n.a.	8.4%	9.7%
% of National Population	0.7%	1.1%	0.3%	15.3%	0.02%	2.7%	2.1%
Mean HH Size (pers/HH)	5.8	5.6	7.3	7.7	5.8	7.2	7
Mean Cash Income ($/HH/yr)	5000	4312	n.a.	4966	5785	3405	3000
% HHs Using (% total HHs)							
Kerosene	82%	81%	93%	97%	83%	88%	76%
Benzine	18%	77%	0%	3%	0%	0%	13%
LPG	42%	12%	45%	8%	4%	1%	24%
Petrol	37%	na	33%	19%	0%	37%	15%
Diesel	0%	0%	2%	1%	0%	0%	0%
Electricity	66%	72%	67%	75%	71%	60%	77%
Batteries	n.a.	n.a.	59%	86%	92%	55%	75%
Woodfuel	62%	n.a.	93%	93%	95%	91%	55%
Purchasing Woodfuel	16%	n.a.	36%	n.a.	n.a.	10%	n.a.
Mean Consumption of Total HHS (Units/HH/yr)							
Kerosene (liters)	186	250	56	277	104	180	96
Benzine (liters)	12	28	0	n.s.	0	0	6
Petrol (liters)	509	400	0	539	0	320	180
Diesel (liters)	36	0	0	1.0	0	0	8.6
LPG (kgs)	48	15.4	66	1.4	n.s.	0	38.4
Electricity (MWh)	1.06	1.26	0.80	0.88	1.89	0.31	0.53
Woodfuel (kgs w.b.)	846	580	1900	2858	n.a.	3100	3600
Batteries (batts)	n.a.	n.a.	96	86	452	87	140
Gross Energy Usage (GJ/HH/yr)							
Kerosene	6.6	8.9	2.0	9.9	3.7	6.4	3.4
Benzine	0.4	1.0	0.0	0.0	0.0	0.0	0.2
Petrol	17.8	14.0	0.0	18.9	0.0	11.2	6.3
Diesel	1.4	0.0	0.0	n.s.	0.0	0.0	1.9
LPG	2.4	0.8	3.3	0.1	0.0	0.0	1.9
Electricity	3.8	4.5	2.9	3.2	6.8	1.1	1.9
Woodfuel	12.7	8.7	28.5	42.9	n.a.	46.5	54.0
Batteries	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
TOTAL	45.2	37.9	36.7	74.8	n.a.	65.2	68.1
Percent Mean Annual Income Spend on Energy	n.a.	n.a.	n.a.	11%	5%	18%	15%

n.a. - not available
n.s. - not significant

Table 3.1.2

Household Surveys - Summary of Data

SURVEY	ABAIANG	TAMANA	VAITUPU	TONGRUR	MAROVO	PNGTRAD	FIJIRUR
REGION	Abaiang	Tamana	Vaitupu	Tongatapu	Marovo	Villages	5 Comms.
COUNTRY	Kiribati	Kiribati	Tuvalu	Tonga	Solomon Is.	PNG	Fiji
CLASSIFICATION	Rural	Rural	Rural	Rural	Rural	Rural/Trad.	Rural
Year of Survey	Oct 1985	Oct 1985	Mar 1986	Nov 1984	1987	Jul 1987	1977
Currency Units	Aust$	Aust$	Aust$	Pa'anga	SI$	Kina	Fiji$
No. of HHs Surveyed	50	99	120	329	125	142	255
% of Survey Area Population	6.6%	41.0%	94.5%	5.8%	n.a.	n.a.	n.a.
% of National Population	0.4%	0.9%	9.0%	2.4%	0.3%	0.03%	0.3%
Mean HH Size (pers/HH)	5.7	5.8	6.3	7	7.7	6.2	5.8
Mean Cash Income ($/HH/yr)	624	520	1341	2250	980	661	n.a.
% HHs Using (% total HHs)							
Kerosene	100%	98%	100%	84%	100%	83%	69%
Benzine	0%	0%	16%	21%	0%	0%	49%
LPG	0%	0%	0%	11%	0%	0%	13%
Petrol	27%	4%	19%	9%	87%	0%	n.a.
Diesel	0%	0%	0%	2%	n.a.	0%	n.a.
Electricity	0%	0%	14%	41%	0%	1%	51%
Batteries	77%	86%	91%	84%	100%	73%	n.a.
Woodfuel	100%	100%	100%	85%	100%	98%	79%
Purchasing Woodfuel	0%	0%	0%	n.a.	n.a.	n.a.	n.a.
Mean Consumption of Total HHs (Units/HH/yr)							
Kerosene (liters)	56	46	62	67	53	76.8	309.6
Benzine (liters)	0	0	12	13	0	0	87.6
Petrol (liters)	72	1.2	170	170	530	0	n.a.
Diesel (liters)	0	0	0	5.8	0	0	n.a.
LPG (kgs)	0	0	0	9.6	0	0	20.4
Electricity (MWh)	0	0	0	0.21	0	0	0.6
Woodfuel (kgs w.b.)	4000	5900	4800	5100	n.a.	n.a.	1032
Batteries (batts)	84	132	430	210	140	231	n.a.
Gross Energy Usage (GJ/HH/yr)							
Kerosene	2.0	1.6	2.2	2.4	1.9	2.7	11.0
Benzine	0.0	0.0	0.4	0.5	0.0	0.0	3.1
Petrol	2.5	0.0	6.0	6.0	18.6	0.0	n.a.
Diesel	0.0	0.0	0.0	0.2	0.0	0.0	n.a.
LPG	0.0	0.0	0.0	0.5	0.0	0.0	1.0
Electricity	0.0	0.0	0.0	0.8	0.0	0.0	2.07
Woodfuels	60.0	88.5	72.0	76.5	n.a.	n.a.	15.5
Batteries	n.s.	n.s.	n.s.	n.s.	n.s.	n.a.	n.a.
TOTAL	64.5	90.2	80.6	86.8	n.c.	n.c.	32.7
Percent Mean Annual Income Spend on Energy	21%	15%	21%	14%	n.a.	24%	n.a.

n.a. - not available
n.s. - not significant

Figure 3.1

Mean Household Size

(Persons Per Household)

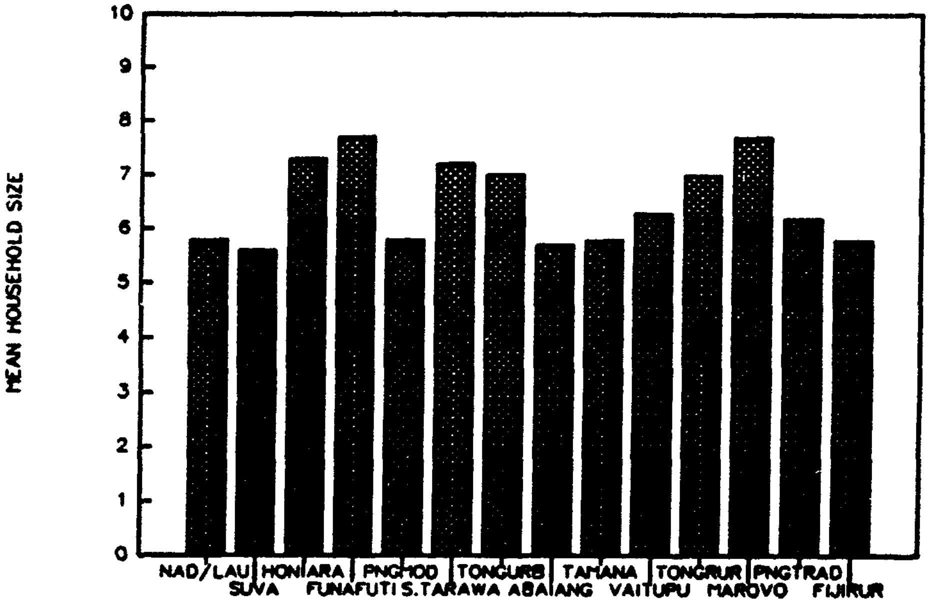
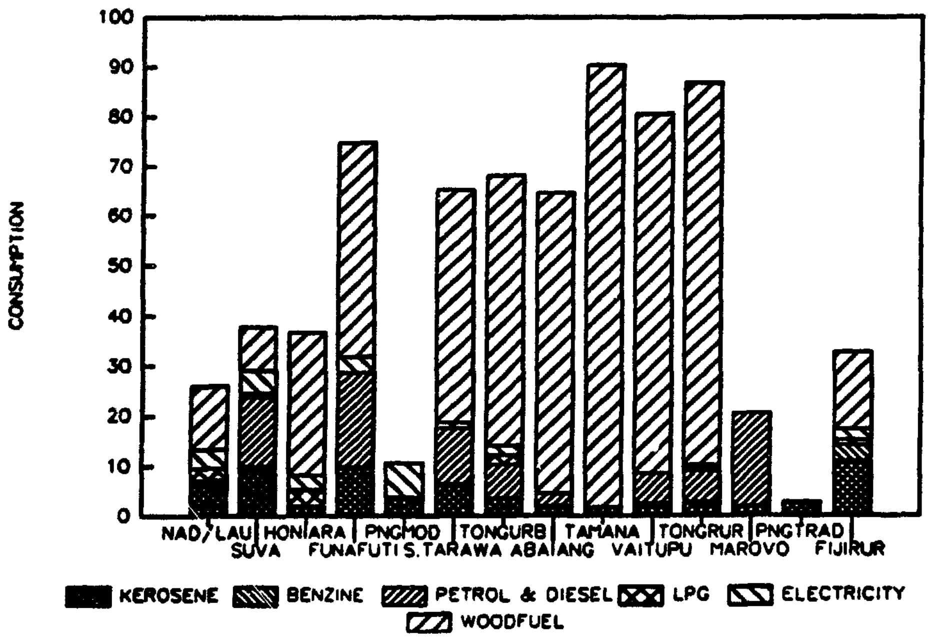


Figure 3.2 2/

Total Household Energy Consumption

(GJ/Household/Year)



2/ No information was collected on the amount of wood consumed by PNG "modern" and "traditional" and Marovo Lagoon households.

Figure 3.3 3/

Household Commercial Energy Consumption
(GJ/Household/Year)

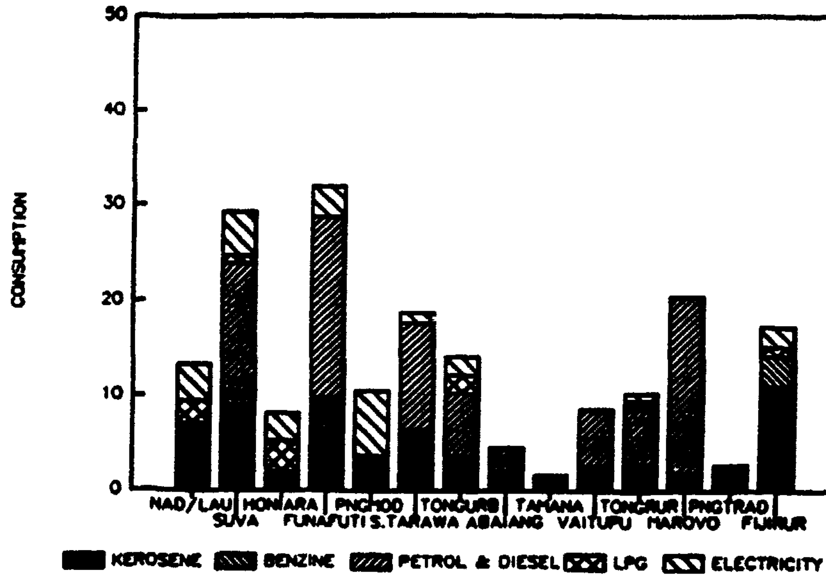
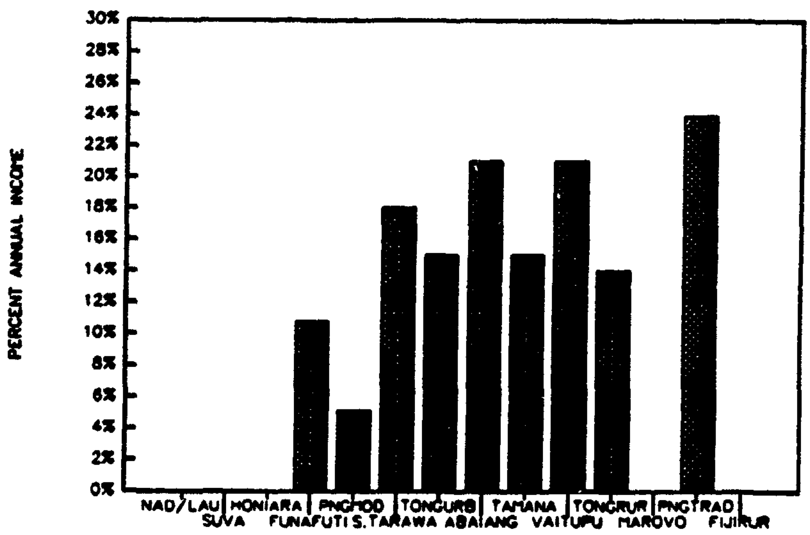


Figure 3.4 4/

Household Energy Consumption
(% Annual Income)



3/ Gross energy consumption from batteries is assumed negligible

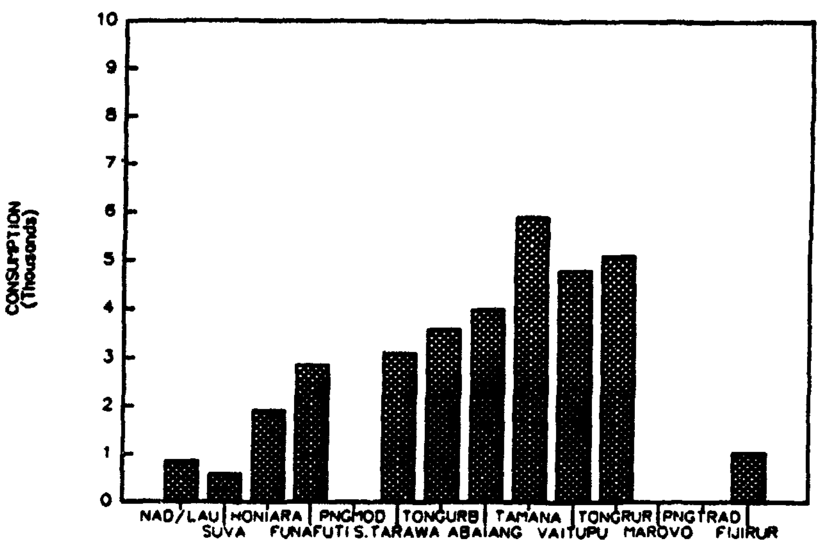
4/ Percentage of household income expended on energy for Nadi/Lautoka, Suva, Honiara, Marovo Lagoon and rural areas of Fiji not calculable from survey data.

Figure 3.5 5/

Woodfuel Usage
(% Total Surveyed Households)

Figure 3.6 6/

Woodfuel Consumption
(KGS/Household/Year)



5/ Percentage of sampled households using woodfuel in Suva urban area was not determinable from survey data.

6/ Quantity of woodfuel consumed in Marovo Lagoon and Papua New Guinea "modern" and "traditional" sectors was not obtained during the surveys.

Figure 3.7

Kerosene Usage
(% Total Surveyed Households)

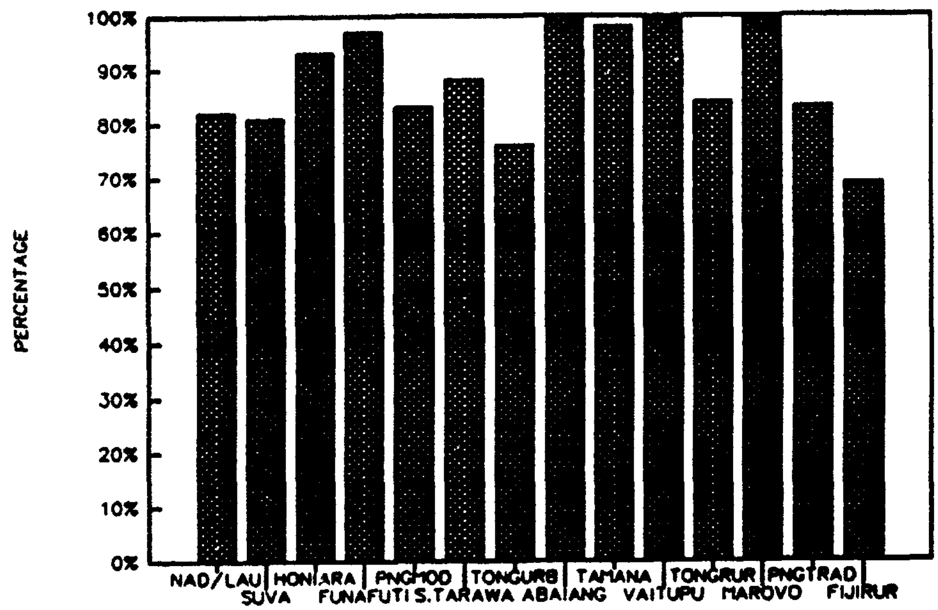


Figure 3.8

Kerosene Consumption
(Liters/Household/Year)

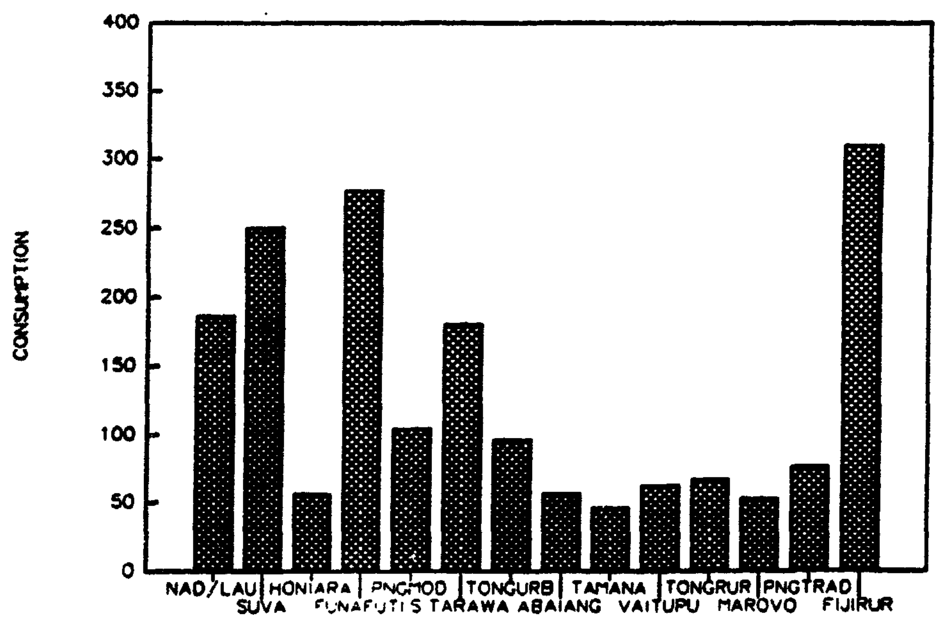


Figure 3.9 7/

Benzine Usage
(% Total Surveyed Households)

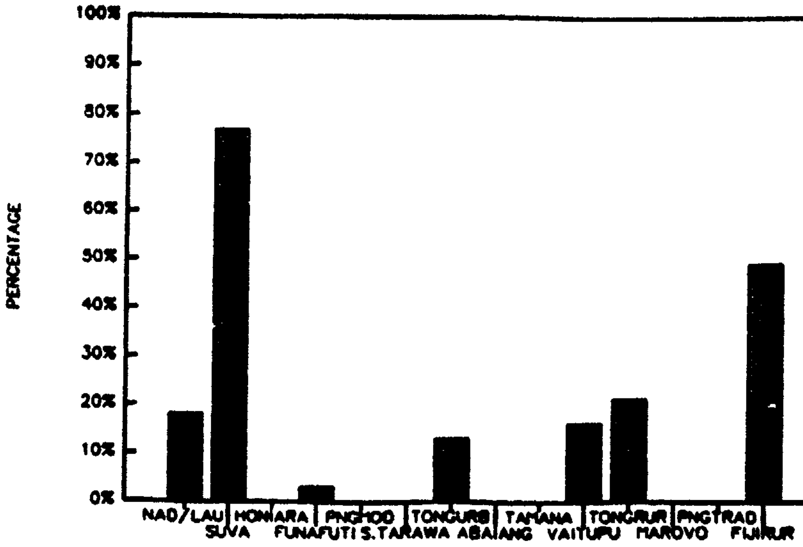
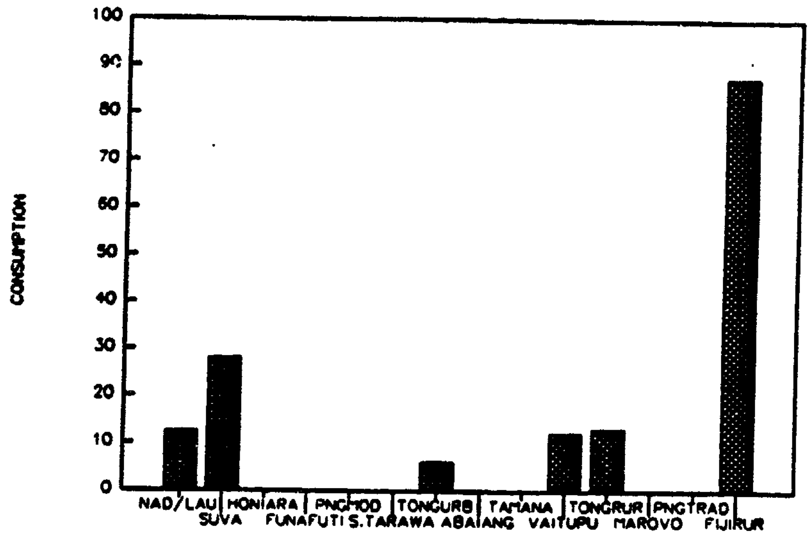


Figure 3.10 8/

Benzine Consumption
(Liters/Household/Year)



7/ Zero consumption of benzine for Honiara, South Tarawa, Papua New Guinea (modern and traditional sectors), Abaiang and Marovo Lagoon areas indicates that benzine was not used.

8/ Consumption of benzine on Fuanfuti was insignificant.

Figure 3.11 9/

Petrol Usage

(% Total Surveyed Households)

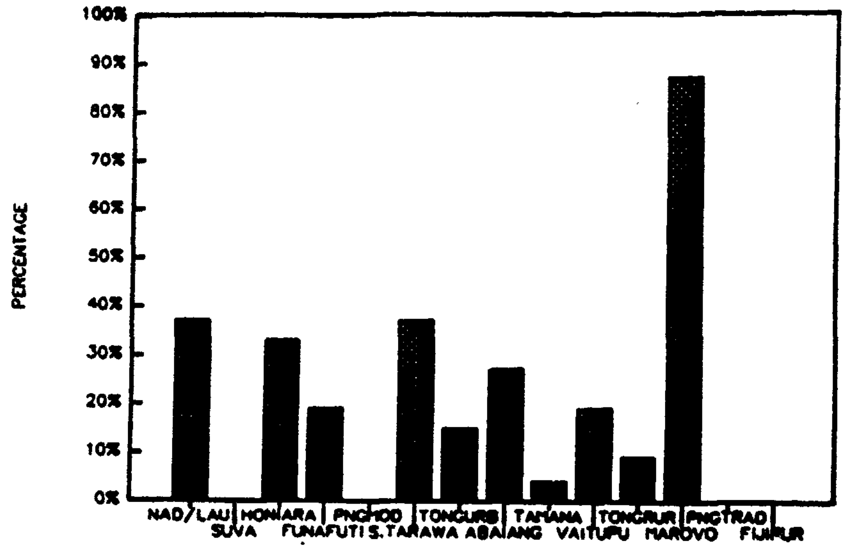
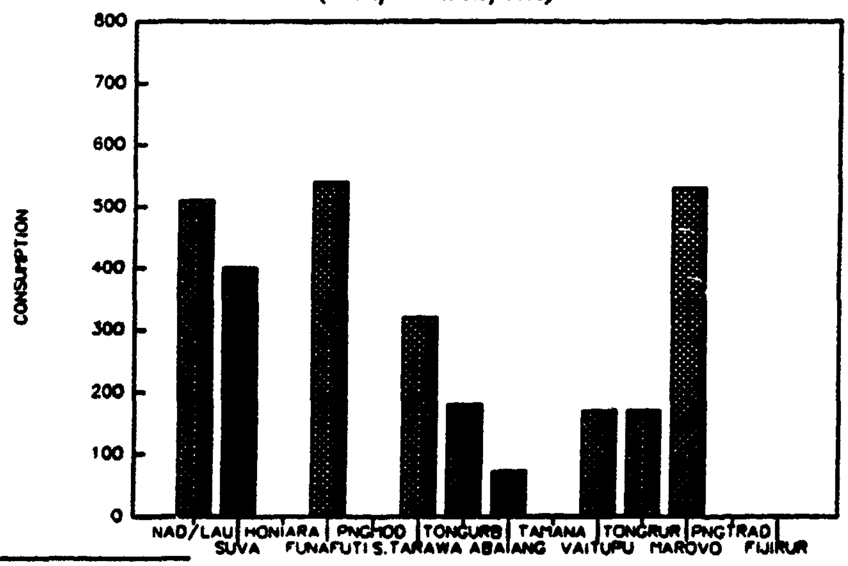


Figure 3.12 10/

Petrol Consumption

(Liters/Household/Year)



9/ Percentage of households consuming petrol in the Suva area and in rural areas of Fiji was not determinable from survey data.

10/ Petrol consumption by households surveyed in the Papua New Guinea rural areas was not determinable from survey data.

Figure 3.13

Diesel Usage
(% Total Surveyed Households)

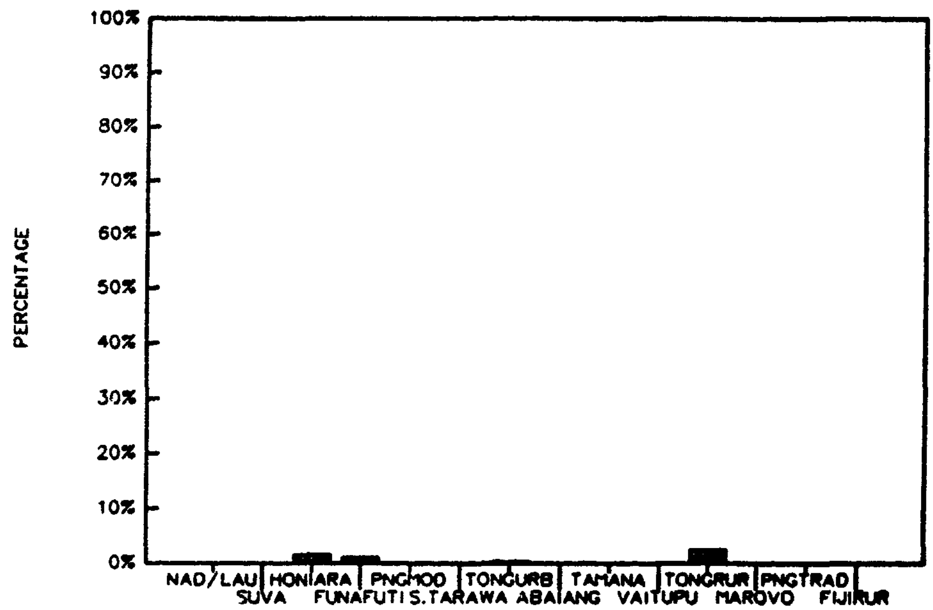


Figure 3.14

Diesel Consumption
(Liters/Household/Year)

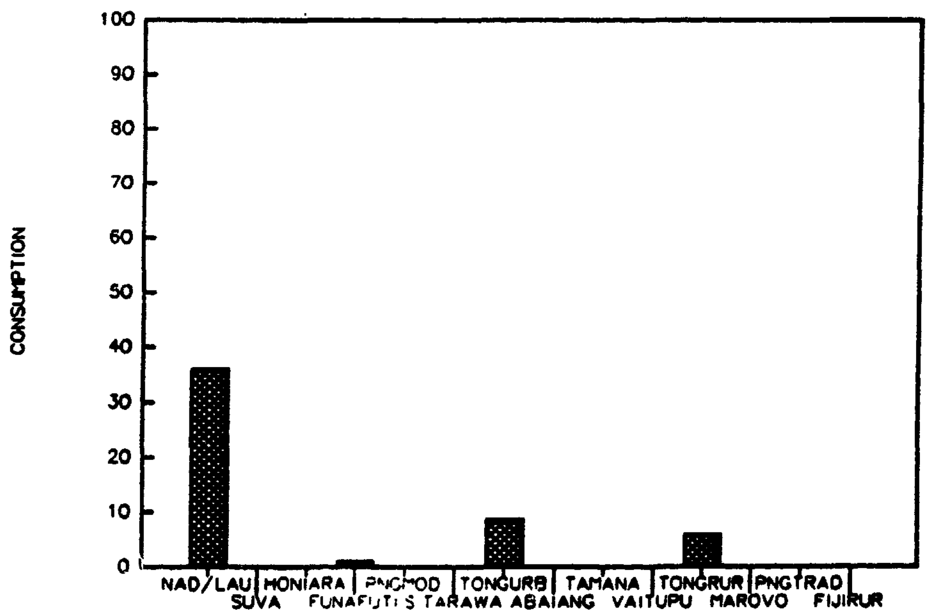


Figure 3.15 11/

LPG Usage

(% Total Surveyed Households)

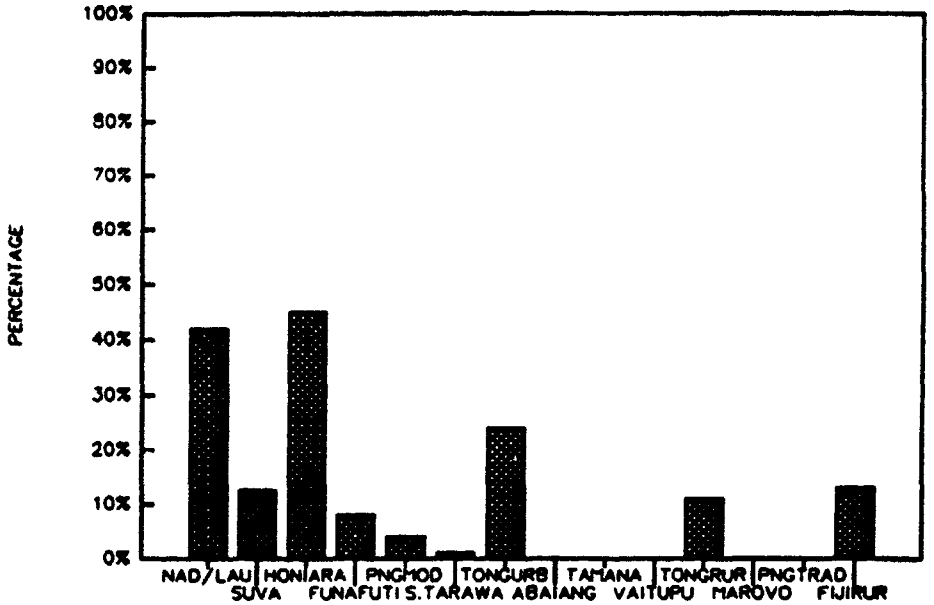
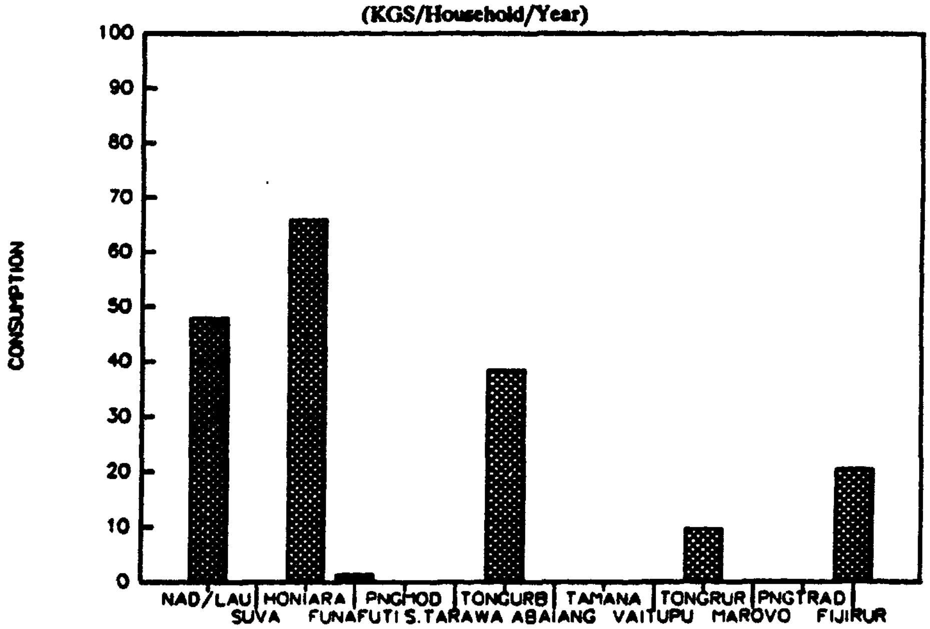


Figure 3.16 12/

LPG Consumption

(KGS/Household/Year)



11/ Survey areas of Abaiang, Tamana, Vaitupu, Marovo and Papua New Guinea (Traditional) did not use LPG.

12/ Total annual consumption of LPG on South Tarawa, Papua New Guinea (modern sector) was negligible.

Figure 3.17 13/

Electricity Usage

(% Total Surveyed Households)

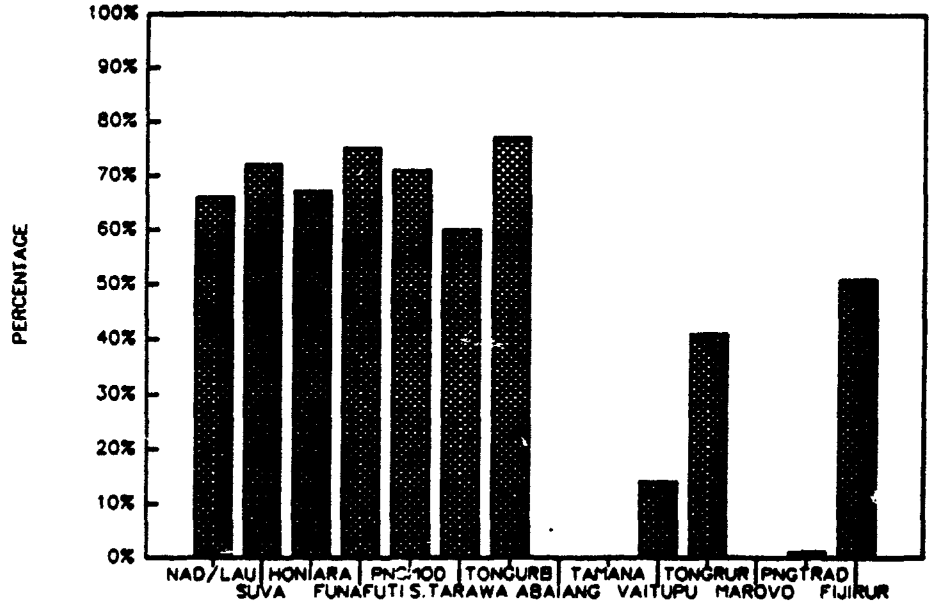
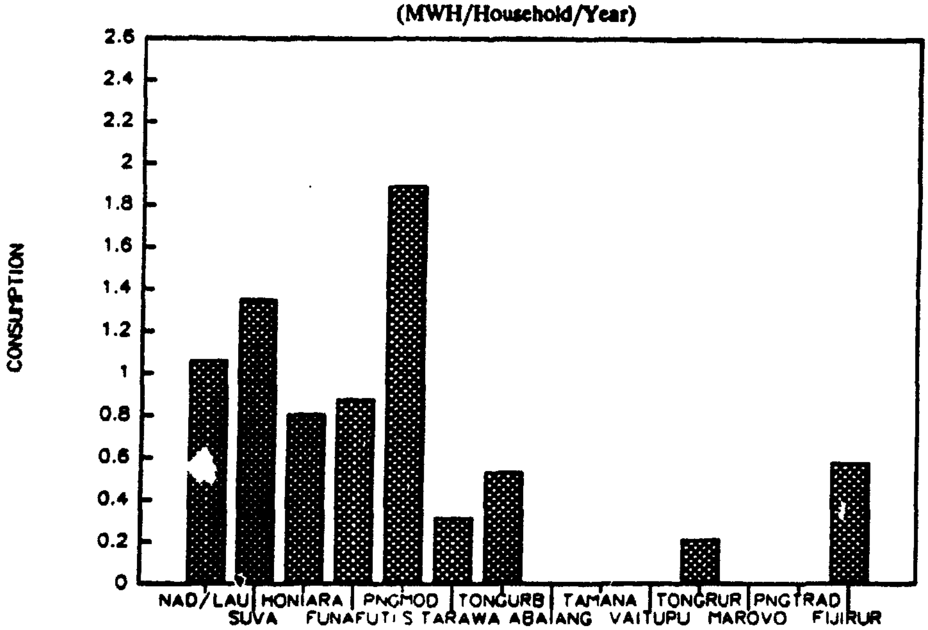


Figure 3.18 14/

Electricity Consumption

(MWH/Household/Year)

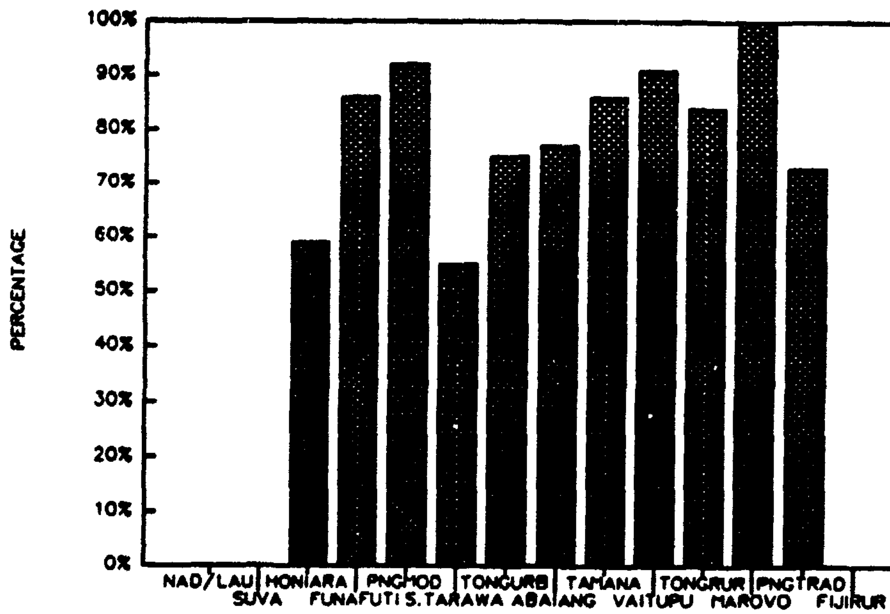


13/ Abaiang, Tamana and Marovo did not use electricity. Vaitupu used solar PV exclusively.

14/ Quantity of electricity consumed by households on Vaitupu was not determined.

Figure 3.19 15/

Battery Usage
(% Total Surveyed Households)



Presentation of Survey Summaries

Summary data from surveys are presented in a consistent format. This has involved conversion of measurement units to metric standards to enable direct comparisons of energy consumption across survey areas. Energy consumption has generally been expressed as liters, kilowatt hours, kilograms, etc per household per month, with the exception of wood fuel consumption which is expressed in the common form for this fuel i.e. kilograms (wet basis) per household per year. Values have generally been rounded off to two significant figures. No error estimates (confidence limits) have been presented but it should be kept in mind that both statistical sampling error and certain types of biasing associated with survey techniques and measurement units make the estimates of mean consumption levels and percentage ownership levels of energy devices approximations rather than precise values.

The information presented here is largely restricted to percentage ownership of energy-using appliances and mean values of energy consumption and associated expenditure for the survey populations. Readers should refer to the individual surveys to obtain information on data distributions. The range of information collected varies from survey to survey, so direct comparison between surveys is not always possible.

15/ Battery consumption for households in Fiji (Suva, Nadi/Lautoka and rural areas) was not determined.

At the end of each summary, a single table showing mean consumption of, and expenditure, on all energy forms used is presented. The values in this table are the mean consumption and expenditure levels for all households surveyed, not of the users of each energy form. The mean per-household total cash expenditure on energy has been calculated from the data in this table where possible.

Readers should consult the original references, shown in Appendix 1, to clarify their understanding of the survey methods and assumptions and how these effect the interpretation of the data. Some key points in data interpretation are outlined below.

(a) The sampling design must be understood to correctly interpret the results. Was the sample representative of the general population in the sample area or was it chosen in a way that restricted it to a one or more sub-groups (eg those households with/without electricity)?

(b) The size of the sample affects the precision of the estimates made. The larger the number of households surveyed, the more precise the estimates.

(c) When making comparisons of per-household consumption levels it must be kept in mind that the surveys were carried out at different times, ranging from 1977 to 1988 and the mean number of persons per household varies from country to country.

(d) Fuel consumption has been estimated in most surveys by asking households how much fuel per week they use, in familiar units such as containers of a standard size. The accuracy of such estimates is low. In rural areas (particularly on remote islands) availability of commercial energy forms may vary and weekly estimates tend to over-estimate consumption because it decreases or stops during periods of shortage. Most surveys in the Pacific have not actually measured fuel consumption over an extended period (exceptions are the Fijian surveys carried out by Siwatibau (1981, 1986), and the Papua New Guinean survey by Maleva (1981).

(e) Treatment of percentages and means differs from survey to survey. Always check the population on which mean values are based. For example, check whether mean consumption of LP gas per household is the mean for the households using LP gas or the mean for the entire sample including non-users. This is shown clearly in the summaries.

(f) When considering the potential impact of rural electrification, it is misleading to look only at the mean values for expenditure on energy forms and household incomes. This distribution of individual values around the mean is important and in most of the surveys mean consumption levels are substantially higher than modes (the mode is the most common value in a sample) because a few high values inflate the mean. What this means in practice is that fewer than half of the households will have consumption or expenditure levels at or the above the mean value.

South Tarawa (Kiribati) Household Energy Survey

DATE: October 1985

SURVEYOR: PEDP/Kiribati Government

COUNTRY: Kiribati

REGION: South Tarawa

Notes on Region Surveyed

South Tarawa is the most heavily populated atoll in Kiribati, with about 21,000 people, and a land area of about 1700 hectares (including recently reclaimed land and pond systems). It is the center of government and commerce, and home for the majority of Kiribati's public sector employees.

Number of Households Surveyed 244

Sampling Method

Stratified random sample based on random selection of houses within census enumeration areas. 60% of the households surveyed were electrified.

Summary of Survey Results

Mean Number of Persons Per Household	7.2
Mean Annual Cash Income Per Household	$A3045

Kerosene

Percentage of Households Using:

Kerosene	88%
Kerosene lamp	55%
Kerosene stove	65%

Consumption Per Household Per Month (liters/hh/month)

Mean for all hhs	15
Mean for hhs with lamp only	7.7
Mean for hhs with stove only	18
Mean for hhs with lamp and stove	22

Benzine (= White Spirit or Unleaded Petrol, Used in Lamps and Irons)

No households consumed benzine

LP Gas

Percentage of Households Using LP Gas 1%

Mean Consumption Per Household Per Month

Sample of hhs using gas too small for reliable estimate

Petrol

Percentage of Household Using:

Petrol	37%
Petrol motor vehicle	37%
Petrol motor boat	10%

Mean Consumption Per Household Per Month (liters/hh/month)

Mean for all hhs	26
Mean for hhs using petrol	69

Diesel

No surveyed households used diesel

Electricity

Percentage of Households Connected to Electricity Grid	60%
Mean Monthly Bill of Electricity Consumer (A$)	14.40
Mean Monthly Consumption of Electricity Consumers (kWh)	42

Dry Cell Batteries

Percentage of Households Using Cell Batteries	55%
Most Common Battery Size	D

Mean Monthly Consumption of Batteries

Mean for all hhs	7.3
Mean for hhs using batteries	13

Summary of Household Energy Consumption and Expenditure

MEAN OF ALL HOUSEHOLDS

Energy Form	Units	Consumption Per HH Per Year	Unit price	Annual Cost A$	Gross Energy Content (GJ)
Kerosene	liters	180	68c/litre	120	6.6
Petrol	liters	320	91c/litre	290	11
Electricity	kWh	310	34c/kWh	105	1.1
Batteries	dry cell	87	36c/dry cell	31	n.s.
Wood fuels	Kg as used	3100	0	0	48

n.s. = not significant

Total Expenditure on Energy as a Percentage of Annual Cash Income: (average)	18%

Abaiang (Kiribati) Household Energy Survey

DATE: October 1985

SURVEYOR: PEDP/Kiribati Government

COUNTRY: Kiribati

REGION: Abaiang Island

Notes of Region Surveyed

Abaiang is a large atoll in the Central Gilberts island group, with a population of about 4,300 and a land area of 1748 hectares. It has little commercial or industrial development, with most households having mainly subsistence lifestyles supplemented by income from copra and remittances from off-island relatives. None of the villages surveyed were electrified.

Number of Households Surveyed

50

Sampling Method

Households were chosen at random from within each of 5 subjectively selected villages. One of the villages was atypical, as it housed most of the salaried public servants on the island. Household cash incomes and levels of commercial energy use in the 4 "typical" villages are substantially lower than the results presented below, which are the means for all 5 villages.

Summary of Survey Results

Mean Number of Persons Per Household	5.7
Mean Annual Cash Income Per Household	A$624

Kerosene

Percentage of Households Using:
Kerosene 100% Kerosene lamp 100% Kerosene stove 8%

Mean Consumption Per Household Per Month (liters/hh/month)	
Mean for all hhs	4.7
Mean for hhs with lamp only	4.3
Mean for hhs with lamp and stove	11

Benzine

No household consumed benzine

LP Gas

No household consumed LP Gas

Petrol

Percentage of Households Using:

Petrol	27%
Petrol motor vehicle	27%
Petrol motor boat	0%

Mean Consumption Per Household Per Month (liters/hh/month)	
Mean for all hhs	**6**
Mean for hhs using petrol	**22**

Diesel

No surveyed household used diesel

Electricity

There is no reticulated electricity supply on Abaiang. One household had a petrol generator used for household lighting, and another had a small photovoltaic panel charging a battery for CB radio operation.

Dry Cell Batteries

Percentage of Household Using Dry Cell Batteries	77%
Most Common Battery Size	D
Mean Monthly Consumption of Batteries (dry cell batteries per month)	
Mean for all hhs	7
Mean for hhs using batteries	9

SUMMARY OF HOUSEHOLD ENERGY CONSUMPTION AND EXPENDITURE: MEAN OF ALL HOUSEHOLDS

ENERGY FORM	UNITS	CONSUMPTION PER HH PER YEAR	UNIT PRICE (A$)	ANNUAL COST (A$)	GROSS ENERGY CONTENT (GJ)
Kerosene	liters	56	0.68/liter	38	2.1
Petrol	liters	72	0.91/liter	66	2.5
Batteries	dry cell	84	0.36/dry cell	30	n.s.
Wood fuels	Kg as used	4000	0	0	61

n.s. = not significant

Mean Percentage of Household Cash Income Spent on Commercial Energy Forms: 21% 16/

16/ Mean expenditure per household on commercial energy forms was some three times higher in Tabuaro village, which housed a large proportion of government salary-earners, than that in the other villages. Mean cash income was also some three times higher so the percentage of expenditure used to purchase commercial energy forms was about the same in Tabuaro as it was in the other villages.

Tamana (Kiribati) Energy Programme Formulation Survey

DATE: October 1985

SURVEYOR: N.Wardrop, for UN Integrated Atoll Development Programme/Kiribati Government

COUNTRY: Kiribati

REGION: Tamana Island

Notes on Region Surveyed

Tamana Island is a small island in the Southern Gilberts, with a land area of 473 hectares and a population of about 1400. The environment is harsher than that of the islands in the Central Gilberts, with the chance of prolonged severe droughts.

Number of Households Surveyed	99

Sampling Method

Stratified random sample of entire population, about 40% of households surveyed.

Summary of Survey Results

Mean Number of Persons Per Household	5.8
Mean Annual Cash Income Per Household	A$520

Kerosene

Percentage of Households Using:	
Kerosene	98%
Kerosene lamp	98%
Kerosene stove	6%

Mean Consumption Per Household Per Month (liters/hh/month)	
Mean for all hhs	3.8

Note: If extrapolated to obtain an estimate of the entire island's kerosene consumption, the result (about 12,000 liters/year) is much higher than the recorded imports of about 7,000 liters/year).

Coconut Oil

Percentage of Households Using Coconut Oil for Lighting:	35%

Mean Volume of Coconut Oil Used for Lighting:

The mean production of coconut oil per household, for the 46% of households that produced oil, was estimated to be about 3 liters per month. However, less than half, on average, was used for lighting in those households that used coconut oil for lighting. Mean consumption per household per month was therefore less than 1.5 liters in the 35% of households using coconut oil for lighting, and the mean usage for lighting for all households was less than 0.5 liters/hh/month.

Benzine

(= White Spirit or Unleaded Petrol, used in Lamps and Irons)
None of the surveyed households used benzine

LP Gas

None of the hou :eholds used LP Gas. It is not imported into Tamana.

Petrol

Percent of Households Using:	
Petrol	4%
Petrol motor vehicle	4%
Petrol motor boat	0%
Mean Consumption Per Household Per Month (liter/hh/month)	
Mean for all hhs	0.1
Mean for hhs using petrol	2

None of the surveyed households used petrol to run generators.

Diesel

None of the surveyed households used diesel.

Electricity

There is no reticulated electricity on Tamana. One household had a photovoltaic lighting set.

Dry Cell Batteries

Percentage of Households Using Dry Cell Batteries	86%
Most Common Battery Size	D
Mean Monthly Consumption of Batteries	
Mean for all hhs	11
Mean for hhs using batteries	13

Summary of Household Energy Consumption and Expenditure

MEAN OF ALL HOUSEHOLDS

Energy Form	Units	Consumption Per HH Per Year	Unit price	Annual Cost Aust.$	Gross Energy Content (GJ)
Kerosene	liters	46	68c/litre	31	1.7
Petrol	liters	1	91c/litre	1	0.04
Batteries	dry cell	132	35c/dry cell	46	n.s.
Wood fuels	Kg as used	5900	0	0	92

n.s. = not significant

Mean Percentage of Household Cash Income Spent on Commercial Energy Forms: 15% 17/

17/ As an Abaiang Island, there were a number of households of salaried government workers in the sample, with incomes greatly exceeding the mean. Income of households other than salary earners was estimated to average about $300 per year.

Vaitupu (Tuvalu) Household Energy Survey

DATE: March 1986

SURVEYOR: PEDP/Tuvalu Government

COUNTRY: Tuvalu

REGION: Vaitupu Island

Notes on Region Surveyed

Vaitupu is an atoll island with a total population of 800 people in about 150 households. Most of the households make a living through subsistence agriculture and fishing supplemented by copra production. There are a few salary earners (teachers and other public servants) and a few small businesses.

Households Surveyed	120

Sample Method

Households selected at random

Summary of Survey Results

Mean Number of Persons Per Household	6.3
Mean Annual Cash Income Per Household (A$)	1341

Kerosene

Percentage of Households Using:	
Kerosene	100%
Kerosene lamp	100%
Kerosene stove	27%
Mean Consumption Per Household Per Month (liters/hh/month)18/	
Mean for all hhs	5.0
Mean for hhs with lamp only	4.7
Mean for hhs with stove only	0
Mean for hhs with lamp and stove	5.6

LP Gas

No households used LP Gas

18/ The low precision of estimation of kerosene consumption (most households were estimated to use one or two 750 ml bottles per week) meant that an accurate comparison could not be made between the 14% of households with, and the 86% of households without, solar photovoltaic lighting systems. All that could be said was that the households with solar systems still used a substantial amount of kerosene.

Benzine (= White Spirit or Unleaded Petrol, Used in Lamps and Irons) and Petrol, Non-Transport Uses

Percentage of Households Using:	
Benzine or petrol for non-transport uses	16%
Benzine lamp	2%
Benzine iron	1%
Benzine cigarette lighter	16%
Mean Consumption Per Household Per Month (liters/hh/month)	
Mean for all hhs	1.0
Mean for hhs using benzine/petrol for non-transport purposes	6.0

Petrol

Percentage of Households Using:	
Petrol	19%
Petrol motor vehicle	12%
Petrol motor boat	11%
Mean Consumption Per Household Per Month (liters/hh/month)	
Mean for all hhs	14
Mean for hhs using petrol	87

Diesel

No households used diesel

Electricity

There is no reticulated electricity on Vaitupu
14% of households had solar photovoltaic lighting kits.

Dry Cell Batteries

Percentage of Households Using Dry Cell Batteries	91%
Most Common Battery Size	D
Mean Monthly Consumption of Batteries	
Mean for all hhs	35
Mean for hhs using batteries	39

Summary of Household Energy Consumption and Expenditure

MEAN OF ALL HOUSEHOLDS

Energy Form	Units	Consumption Per HH Per Year	Unit price	Annual Cost Aust $	Gross Energy Content (GJ)
Kerosene	liters	62	0.55/litre	34	2.3
Benzine	liters	12	0.65/litre	8	0.4
Petrol	liters	170	0.65/litre	110	5.8
Batteries	dry cell	430	0.30/dry cell	130	n.s.
Wood fuels	Kg as used	4800	0	0	75
TOTAL					83.5

n.s. = not significant

Mean Percentage of Household Cash Income Spent on Commercial Energy: 21%

Tongatapu (Tonga) Household Energy Survey

DATE: November 1984

SURVEYOR: PEDP

COUNTRY: Tonga

REGION: Tongatapu Island

Notes on Region Surveyed

Tongatapu Island is Tonga's largest island, with a population of about 60,000. About 20,000 people (hereafter termed "urban") live in the Tongan capital, Nuku'alofa, with the balance of the population (hereafter termed "rural") grouped in small towns and villages scattered around the island. Most land is held in the form of 3.3 hectare holdings, called "api's". Approximately 98% of rural households either own an "api" or have at least temporary access to one and most rural households make their income through a combination of cash and subsistence farming. Fewer than 50% of urban households own agricultural land and a large proportion are wage and salary earners or small business operators.

Number of Households Surveyed

Urban	276
Rural	329

Sampling Method

Thirteen towns or villages were selected to represent the range of rural environments. The urban population was also sampled on a stratified basis so that established households and recent "squatter" arrivals were both represented. Households were randomly selected within these sampling areas.

Summary of Survey Results

(U = urban and R = rural shown separately)

Mean Number of Persons Per Household	7.0 (U)	7.0 (R)
Mean Annual Cash Income Per Household (Pa'anga)	3000 (U)	2250 (R)

Kerosene

Percentage of Households Using:

Kerosene	76% (U)	84% (R)
Kerosene lamp	48% (U)	76% (R)
Kerosene stove	47% (U)	34% (R)

Mean Consumption Per Household Per Month (liters/hh/month)

Mean for all hhs	8.0 (U)	6.4 (R)
Mean for hhs with lamp only	5.6 (U)	5.5 (R)
Mean for hhs with stove only	11 (U)	9.7 (R)
Mean for hhs with lamp and stove	18 (U)	11 (R)

Benzine

(= White Spirit or Unleaded Petrol, Used in Lamps and Irons)

Percentage of Households Using:		
Benzine (not calculated)	6% (U)	19% (R)
Benzine lamp	13% (U)	21% (R)
Mean Consumption Per Household Per Month (liters/hh/month)		
Mean for all hhs	0.5 (U)	1.1 (R)
Mean for hhs using benzine	3.1 (U)	3.6 (R)

LP Gas

Percentage of Households Using LP Gas (Used only for stoves)	24% (U)	11% (R)
Mean Consumption Per Household Per Month (kg/hh/month)		
Mean for all hhs	3.2 (U)	0.8 (R)
Mean for hhs using LP Gas	13 (U)	7.5 (R)

Petrol

Percentage of Households Using:		
Petrol	15% (U)	9% (R)
Mean Consumption Per Household Per Month (liters/hh/month)		
Mean for all hhs	15 (U)	14 (R)
Mean for hhs using petrol	99 (U)	150 (R)

Diesel

Percentage of Households Using Diesel:	0.3% (U)	24% (R)
Mean Consumption Per Household Per Month		

Sample of diesel users too small for accurate estimate. 8 rural users averaged 240 liters/hh/month.

Electricity

Percentage of Households Consuming Reticulated Electricity 19/	72% (U)	36% (R)
Mean Monthly Electricity Bill of Connected Households (Pa'anga)	12.24 (U)	9.51 (R)
Mean Monthly Electricity Consumption of Connected Households (kWh/hh/month)	61 (U)	48 (R)

19/ 5% of urban and 13% of rural households did not have access to the grid.

Dry Cell Batteries

Percentage of Households Using Dry Cell Batteries	75% (U)	84% (R)
Most Common Battery Size	D	
Mean Monthly Consumption of Batteries (batteries/hh/month)		
Mean for all hhs	12 (U)	18 (R)
Mean for hhs using batteries	16 (U)	21 (R)

Summary of Household Energy Consumption and Expenditure

MEAN OF ALL HOUSEHOLDS

Energy Form	Units	Consumption Per HH Per Year	Unit price Pa'anga	Annual Cost Pa'anga	Gross Energy Content (GJ)
Kerosene	liters	96 (U) 67 (R)	0.60 0.60	58 40	3.5 2.5
Benzine	liters	6 (U) 13 (R)	1.17 1.17	7 15	0.2 0.5
LPG	kgs	38.4 (U) 9.6 (R)	n.a.	n.a.	1.92
Petrol	liters	180 (U) 170 (R)	0.50 0.50	90 75	6.1 5.7
Electricity	kWh	530 (U) 210 (R)	0.197 0.197	100 42	1.9 0.8
Batteries	DRY CELL	140 (U) 210 (R)	0.35 0.35	49 73	n.s. n.s.
Wood fuels	Kg as used	3600 (U) 5100 (R)	(20/)	110 13	53 75
TOTAL					64.7 (U) 84.5 (R)

U = urban, R = rural, n.s. = not significant

Mean Percentage of Household Cash Income Spent on Commercial Energy:	15% (U)	14% (R)

20/ A proportion of the urban wood fuel is purchased at the market, and a further proportion from the coconut processing factory. Households also pay significant sums for hire of motore transport to carry wood fuels to the home. Average annual expenditure on purchase and transport is shown.

Nadi-Lautoka (Fiji) Domestic Energy Survey

DATE: 1982

SURVEYOR: University of the South Pacific

COUNTRY: Fiji

REGION: Nadi-Lautoka

Notes on Region Surveyed

The Nadi-Lautoka area surveyed covers an area of about 100 km^2 and contained about 67,000 people at the time of the survey. The survey covered urban, peri-urban and rural households. Rural households were primarily cash crop farmers. The urban households are mostly wage and salary earners employed by a wide range of businesses. About 70% of the population is Indo-Fijian.

Number of Households Surveyed

Electrified	727
Non-electrified	99

Sample Method

Electrified households were selected at random by choosing one in nine of the domestic consumers from the Fiji Electricity Authority records. Non-electrified households were selected by choosing, as randomly as possible, one in every 10 of such households. Knowledge of the overall ratio of electrified to non-electrified households in the sample area was used to construct a "composite" sample weighted to enable average household energy consumption to be calculated.

Summary of Survey Results

(E = electrified households, NE = non-electrified households)

Mean Number of Persons Per Household
Not estimated in the survey. Average household size was found to be 5.5 in urban areas and 6.1 in rural area in the 1976 Census.

Mean Annual Cash Income Per Household

Data on percentages of households in different income categories was collected. 52% of electrified, and 36% of non-electrified households had incomes of F$5,000 or more. Only 7% of electrified, and 15% of non-electrified households had incomes below F$2,000.

Kerosene

Percentage of Households Using:

Kerosene lamp	15% (E)	97% (NE)
Kerosene stove	82% (E)	95% (NE)
Kerosene refrigerator	0% (E)	13% (NE)

Mean Consumption Per Household Per Month (liters/hh/month)		
Mean for all hhs, for all uses of kero	**15 (E)**	**19 (NE)**
Mean for kerosene lighting, users only	**5.2 (E)**	**8.2 (NE)**
Mean for kerosene cooking, users only	**18 (E)**	**9.5 (NE)**
Mean for kerosene refrigeration users only		**17 (NE)**

<u>Benzine</u>

(= White Spirit or Unleaded Petrol, Used in Lamps and Irons)

Percentage of Households Using:		
Benzine lamp	3% (E)	64% (NE)
Benzine iron	2% (E)	28% (NE)
Mean Consumption Per Household Per Month (liters/hh/month)		
Mean for all hhs	0.2 (E)	6.8 (NE)
Mean for benzine light users only	7.3 (E)	9.4 (NE)
Mean for benzine iron users only 21/	3.0 (E&NE)	

<u>LP Gas</u>

Percentage of all Households	47% (E)	8% (NE)
Mean Consumption Per Household Per Month (kg/hh/month)		
Mean for all hhs	5.7 (E)	0.4 (NE)
Mean for hhs using LP Gas	11 (E)	5.0 (NE)

<u>Petrol</u>

Percentage of Households Using:		
Petrol motor vehicle	42% (E)	4% (NE)
Mean Consumption for Private Vehicles (liters/hh/month)22/		
Mean for all hhs	43 (E)	2.6 (NE)
Mean for hhs using petrol	100 (E)	64 (NE)
Mean Consumption for Taxis (liters/hh/month)23/		
35% of all households used taxis regularly		
Mean fuel use for all households	4	
Mean fuel use for hhs taxis	11	

21/ Ironing estimate is approximate only and includes kerosene for ironing.

22/ The consumption of diesel and petrol by households through their use of taxis was estimated indirectly through expenditure on taxis.

23/ Some proportionofth taxi fuel would have been diesel.

Diesel

The use of diesel was not examined directly in this survey. The consumption of diesel by households for but transport was estimated indirectly through expenditure on bus fares.

Mean Consumption Per Month For Buses (liters/hh/month)

67% of households were regularly bus users

Mean use for all households	3
Mean use for hhs using buses	4

Electricity

Percentage of Households Consuming Electricity

Not applicable, because of sampling design. In the entire Nadi-Lautoka area, 66% of the households were electrified.

Mean Monthly Consumption for Households Consuming Electricity (kWh/hh/month)

Electrified urban hhs	131
Electrified peri-urban hhs	87
Electrified rural hhs	76

Dry Cell Batteries

No information was collected on batteries

Summary of Households Energy Consumption and Expenditure

MEAN OF ALL HOUSEHOLDS

Energy Form	Units	Consumption Per HH Per Year	Unit price	Annual Cost Fiji $	Gross Energy Content (GJ)
Kerosene	liters	180 (E) 230 (NE)			6.6 8.4
Benzine	liters	3 (E) 82 (E)			0.1 2.8
LP Gas	kilograms	68 (E) 5 (NE)			3.4 0.3
Petrol (Private vehicles)	liters	520 (E) 31 (NE)			18 1.0
Electricity	kWh	1200 (E) 0 (NE)			4.3
Batteries	dry cell	n.s.			n.s.
Wood fuels	Kg as used	800 (E) 900 (NE)			12 14
TOTAL					47.4 (E) 26.5 (NE)

n.s. = not significant

Suva (Fiji) Urban Energy Study

DATE: 1982

SURVEYOR: S. Siwatibau

COUNTRY: Fiji

REGION: Suva area

Notes on Region Surveyed

Suva is the capital of Fiji. the survey covered the urban area and suburbs (electrified households) and the urban area (non-electrified households) The population of the survey area in 1982 was over 100,000, of whom about 53% were Indo-Fijian, 37% or Pacific island and 10% other races.

Number of Households Surveyed

Electrified	1011
Non-electrified	301

Sampling Method

Electrified households sampled by surveying every tenth consumer from electricity consumer billing records. Non-electrified households sampled by surveying every tenth non-electrified households in all "squatter" areas, which were known to have a high proportion of non-electrified.

Summary of Survey Results

(E = electrified households, NE = non-electrified households)

Mean Number of Persons Per Household	5.5 (E)	5.8 (NE)
Mean Annual Cash Income Per Household (F$)24/	5,000 (E)	2,000 (NE)

Kerosene

Percentage of Households Using:		
Kerosene lamp	7.3% (E)	94% (NE)
Kerosene stove	77% (E)	87% (NE)
Kerosene refrigerator		3.6% (NE)
Mean Consumption Per Household Per Month (liters/hh/month)		
Mean for all hhs		
Mean for lighting		6.9 (NE)
Mean for cooking with kero only		24 (NE)
Mean for cooking with kero + wood		20 (NE)
Mean for kerosene refrigerator		22 (NE)

24/ This is a very approximate estimate made from data collected on income classes.

Benzine

(= White Spirit or Unleaded Petrol, Used in Lamps and Irons)

Percentage of Households Using:

Benzine lamp	**0.8% (E)**	**64% (NE)**
Benzine iron		**65% (NE)**

Mean Consumption Per Household Per Month (liters/hh/month)

Mean for all hhs, E & NE combined	**2.3**	
Mean used for lighting, users only		**8.0 (NE)**
Mean used for ironing, users only		**5.2 (NE)**

LP Gas

Percentage of Household Using LP Gas	16% (E)	0.7% (NE)

Mean Consumption Per Household Per Month (kg/hh/month)

Mean for all hhs	1.3 (E)
Mean for hhs using only LP Gas for cooking	8 (E)

Electricity

Percentage of Households Connected to Electricity Grid

Not applicable because of sampling design. It was estimated that of all households in the Suva are, 72% were electrified.

Mean Monthly Electricity Bill (Fiji$)

Mean for households using electricity	21.95

Mean Monthly Consumption of Electricity (kWh/hh/month)

Mean for households using electricity	146

Mean Consumption of Electricity By Refrigerators:

The electricity consumption of refrigerators was metered in 49 volunteer households. Consumption ranged from 39.1 kWh per month (mean of two refrigerators with external volume $0.1m^3$) to 141.3 kWh/month (mean of three refrigerators with $0.7\ m^3$ external volume). The most common size was $0.4\ m^3$ external volume, with a mean consumption of 65.9 kWh/month for 17 refrigerators in this size range.

Dry Cell Batteries

No information was collected on use of batteries

Summary of Household Energy Consumption and Expenditure

MEAN OF ALL HOUSEHOLDS

Energy Form	Units	Consumption Per HH Per Year	Unit price (F$)	Annual Cost (F$)	Gross Energy Content (GJ)
Kerosene	liters	250	0.43	110	8.9
Benzine	liters	28	0.47	13	1.0
Petrol (Private Vehicles)	liters	400	0.476	190	14
Electricity	kWh	1261	0.15	189	4.5
LPG	kg	15.4	0.8		
Wood fuels	Kg as used	580	(25/)		8.7
TOTAL					37.9

n.s. = not significant

25/ 9% of all households purchased wood at an average price of $8.60/tonne fresh weight, with average moisture content 36% (% of oven-dry weight basis).

Marovo (Solomon Islands) Energy Consumption Survey

DATE: 1987

SURVEYOR: PEDP

COUNTRY: Solomon Islands

REGION: Marovo Lagoon, Western Province

Notes on Region Surveyed

The Marovo Lagoon area was chosen as being representative of rural coastal areas in the Solomon Islands well away from major towns, in which transport is mainly water-based. People live in small villages of 5-50 households, usually spaced at intervals of 2-5 km along the coast. None of the villages surveyed were electrified.

Number of Households Surveyed

108 households in six rural villages, and further 17 households in a government center with somewhat different energy use patterns

Sampling Method

The villages were selected to represent both major religious denominations of the region,a nd both coastal and mainland locations. None of the villages were electrified. All households in each village wee surveyed.

Summary of Survey Results

(for rural villages, not including government center)

Mean Number of Persons Per Household	7.7
Mean Annual Cash Income Per Household (SI$)	980

Kerosene

Percentage of Households Using:	
Kerosene lamp	100%
Kerosene stove	3%
Kerosene refrigerator	0%
Mean Consumption Per Household Per Month (liters/hh/month)	
Mean for all households	4.4

Petrol

(Petrol was used for powering outboard motors and chainsaws)

Percentage of hhs purchasing petrol for their own equipment	26%
Mean consumption for own equipment (liters/hh/month)	65
Percentage of hhs purchasing petrol for other hhs' equipment	69%
Mean consumption for equipment owned by other hhs (liters/hh/month)	55
Mean consumption for all households (liters/hh/month) (including 13% of households who did not use petrol)	44

Dry Cell Batteries

Percentage of Households Using Dry Cell Batteries	100%
Percentage of hhs using batteries in torches	69%
Percentage of hhs using batteries in radios or cassette players	42%
Most Common Battery Size	D
Mean Monthly Consumption of Batteries (batteries/hh/month)	12

Summary of Household Energy Consumption and Expenditure

MEAN OF ALL HOUSEHOLDS

Energy Form	Units	Consumption Per HH Per Year	Unit price (F$)	Annual Cost (F$)	Gross Energy Content (GJ)
Kerosene	liters	53	$1.33	69	1.5
Petrol 26/	liters	530	$0.93	490	17
Batteries	dry cell	140	$0.60	84	n.a.
Solar		n.a.			
TOTAL				640	

n.a. = not available

26/ Outboard motors and chainsaws

Honiara (Solomon Islands) Household Energy Study

DATE: July 1987

SURVEYOR: PEDP/Solomon Islands Government

COUNTRY: Solomon Islands

REGION: Honiara

Notes on Region Surveyed

Honiara is the national capital and largest city of the Solomon Islands. Its population was about 32,000 in 1987, and growing rapidly. Many recent arrivals live in leaf houses in "temporary housing areas" with few or no services.

Number of Households Surveyed

Electrified	190
Non-electrified	95

Sampling Method

Stratified random sample based on random selection of four households within local areas containing 40 households as marked on the 1986 census maps. Most of the non-electrified households were located in clearly defined "temporary housing areas" around the edges of the established city.

Summary of Survey Results

(E = electrified households, NE = non-electrified households)

Mean Number of Persons Per Households	7.1 (E)	7.5 (NE)
Mean Annual Cash Income Per Household	not determined	

Kerosene

Percentage of Households Using:		
Kerosene lamp	8% (E)	100% (NE)
Kerosene stove	24% (E)	28% (NE)
Consumption (liters/hh/month)		
Mean for all hhs using kerosene	8.3 (E)	8.3 (NE)
Mean for hhs with kerosene stove (most also with kerosene lamp)	11 (E)	13 (NE)
Mean for hhs with lamp only		6.5 (NE)

Benzine

(= White Spirit or Unleaded Petrol, Used in Lamps and Irons)

No households consumed benzine

LP Gas

Percentage of Households Using:	64% (E)	7% (NE)
Mean Consumption (kg/hh/month)	13 (E)	7.8 (NE)

Petrol

Percentage of Households Using:	
Petrol	about 33%
Petrol motor vehicle	about 33%
Petrol motor boat	1%
Mean Consumption per Household Per Month (liters/hh/month)	
Mean for hhs using petrol	61

Diesel

Three surveyed households used diesel; their consumption averaged 57 liters/hh/month

Electricity

Percentage of Households Connected to Electricity Grid	~67%
Mean Monthly Bill of Electricity Consumers (SI$)	26.07
Mean Monthly Consumption of Electricity Consumers (kWh)	~100

Dry Cell Batteries

Percentage of Households Using Dry Cell Batteries	52% (E)	78% (NE)
Most Common Battery Size	D	
Mean Monthly Consumption of Batteries		
Mean for hhs using batteries	13 (E)	15 (NE)

Wood Fuels

(Included Wood, Coconut Residues, Other Biomass Residues)

Percentage of Households Using Wood Fuels		
For some or all cooking	91% (E)	98% (NE)

Summary of Household Energy Consumption and Expenditure

MEAN OF ALL HOUSEHOLDS

Energy Form	Units	Consumption Per HH Per Year	Unit price (SI$)	Annual Cost (SI$)	Gross Energy Content (GJ)
Kerosene	liters	49	1.33	65	1.8
Petrol	liters		(27/)		
LPG	Kg	66	1.89	120	3.6
Electricity	kWh	1200	0.295	240	0.9
Batteries	dry cell	96	0.60	58	n.s.
Wood fuels	Kg as used	1900	varies		29
TOTAL					35.3

n.s. = not significant

Total Expenditure on Energy as Percentage of Annual Cash Income: not determined

27/ Sample too small to estimate.

Papua New Guinea Household Energy Survey

DATE: June to August 1987

SURVEYOR: Deutsche Gesellschaft fur Technische Zusammenarbait (GTZ)/ Papua New Guinea Government

COUNTRY: Papua New Guinea

REGIONS: Various (see below)

Notes on Regions Surveyed

Three distinct regions were defined. Villages included within each of the three regions are specified below:

REGION 1 (Highland)	REGION 2 (Midlands)	REGION 3 (Coastal)	
Ialibu	Aiome	Konos	
Kaintiba	Angoram	Losuia	
Maramuni	Lake Murray	Tufi	
Menyamya			
Telefomin			
Wabag			
Woitape			
Number of Households Surveyed			276

Sampling Method

The survey was based on a disaggregated sample of limited total size. Sub-dividing the sample quickly results in sub-samples sizes in which multi-way cross tabulation no longer leads to meaningful figures. Cell sizes become too small from the viewpoint of statistical analysis.

A number of common and specific sub-sample categories were used.

Sector	Modern 28/	Traditional 29/	Total
Region 1 (highland)	80	47	127
Region 2 (midland)	33	31	64
Region 3 (coastal)	21	64	85
Total	134	142	276

Summary of Survey Results

(T = Traditional Sector, M = Modern Sector, All = All households surveyed)

Mean Number of Persons Per Households	6.2 (T)	5.8 (M)	6.0 (All)
Mean Annual Cash Income Per Household (KINA)	661 (T)	5785 (M)	

Kerosene

Percentage of Households Using:			
Kerosene	83% (T)	83% (M)	83% (All)
Kerosene lamps	79% (T)	77% (M)	78% (All)
Kerosene			20% (All)
Consumption (liters/hh/month)			
Mean for all hhs using kerosene	5.5 (T)	9.9 (M)	7.9 (All)
Mean for hhs with kerosene stove			17.2 (All)

Benzine

(= White Spirit or Unleaded Petrol, Used in Lamps and Irons)

No households were reported to consume benzine

LP Gas

Percentage of Households Using:	0% (T)	4% (M)	2% (All)

28/ The "modern" sector includes all people living int he government station proper. The majority are public servants but also, to a lesser extent, self-employed persons (trade store propiretors) and private employees whose households are located within the station. The income level and living standards of non-governmental households are comparable to those of public servants. Providing services for the households living within the government station, their professional existence is often directly linked to the very existence of the station.

29/ Households belonging to the "traditional" sector live outside the government station. Their existence is based on activities in the private sector or on trading goods, for example running village trade stores, marketing surplus from gardening and field work. Their lifestyle is generally very traditional and no assimilation to the other sector is evident.

Petrol

Percentage of Households Using:			
Petrol motor vehicles			2.2% (All)
Petrol motorbikes			<1% (All)
Petrol motor boat			2.8% (All)

Mean Consumption Per Household Per Month (liters/hh/month)
Mean for hhs using petrol not available

Diesel

Four surveyed households owned a truck. Consumption of diesel fuel per household not specified.

Electricity

Percentage of Household Using Electricity	1% (T)	71% (M)	34% (All)
Percentage of Households With Own Generator			1% (All)

Mean Bill for Electricity Consumers (Kina/month)
Metered consumers 30/ 13.2 (All)
Flat rate based bills 31/

Mean Monthly Consumption for Electricity Consumers
157.5 kWh (metered consumers only) 32/

Dry Cell Batteries

Percent of Households Using Dry Cell Batteries	73% (T)	92% (M)	82% (All)
Most Common Battery Size	D		
Mean Monthly Consumption of Batteries			
Mean for hhs using batteries (Kina/mth)	7.4 (T)	13.4 (M)	10.7 (All)
Mean number of batteries used per hh	19 (T)	34 (M)	27 (All)

30/ Metered consumption was encountered only in Ialibu and Wabag amounting to only 39% of all electricity consumers sample.

31/ Based on 36 responses.

32/ Only 39% (37 hhs all in region 1) of consumers were charged on actual metered consumption.

Wood Fuel

(Wood, Coconut Residues, Other Biomass Residues)

Percentage of Households Using Wood Fuels

For some or all of cooking	98% (T)	95% (M)	96% (All)
Percentage of hhs purchasing woodfuel 33/			

Summary of Household Energy Consumption and Expenditure

MEAN OF ALL HOUSEHOLDS

Energy Form	Units	Consumption Per HH Per Year	Unit price (Kina)	Annual Cost (Kina)	Gross Energy Content (GJ)
Kerosene	liters	66 (T) 119 (M)	1.03 1.09	68 109	2.3 4.2
Petrol	liters	n.a.	n.a.	n.a.	n.a.
LP Gas	kgs	n.s.	1.6	n.a.	n.a.
Electricity	kWh	1890 34/ (M)	0.12	227	6.8
Batteries	dry cell	329 408 231	0.39 35/	129 161 89	n.s. (All) n.s. (M) n.s. (T)
Wood fuels	Kgs	n.a.	n.a.	121 36/	n.a.
Solar		n.s.			n.a.
TOTAL					n.a.

n.s. = not significant　　n.a. = not available

Total Expenditure on Energy as Percentage of Annual Cash Income: 23.9% (T) 5.1% (M)

33/ Majority of Government workers who do not have access to tribal lands.

34/ Metered consumption only (37 out of 95 respondents).

35/ Price of batteries varied from 0.25-0.65 Kina according to region.

36/ Average expenditure for all households purchasing fuelwood. Costs vary significantly across regions with Region 1 (K11.1/hh/mth) and Region 3 (K5.6/hh/mth).

Funafuti, Tuvalu Household Energy Survey

DATE: May 1987

SURVEYOR: PEDP, Ministry of Works & Communications, Tuvalu

COUNTRY: Tuvalu

REGION: Funafuti

Notes on Regions Surveyed

Funafuti is the seat of national government and is the port of entry all visitors and imported goods arriving in Tuvalu. A total of approximately 420 households live on the island.

Number of Households Surveyed	169

Sampling Method

Random sample of households chosen from amongst the total population resident on Funafuti.

Summary of Survey Results

Mean Number of Persons Per Household	7.7 37/
Mean Annual Cash Income Per Household (A$)	4966 38/

Kerosene

Percentage of Households Using:	
Kerosene	97%
Kerosene lamps	65%
Kerosene stoves	85%
Kerosene lamps & stoves	55%
Consumption (liters/hh/month)	
Mean for all hhs using kerosene	23.8
Mean for hhs with kerosene stove	23.8

Benzine

(= White Spirit or Unleaded Petrol, Used in Lamps and Irons)

Percentage of Households Using:	3%

LP Gas

Percentage of Households Using:	8%
Mean Consumption (kg/hh/month)	1.5

37/ Range 2 to 17.

38/ Median A$4000

Petrol

Percentage of Households Using:	
Petrol motor vehicle	41%
Petrol motorbikes	59%
Petrol motor boat	64%
Mean Consumption (liters/hh/month)	
Mean for hhs using motorbike	16
Mean for hhs using motorboat	156
Mean for hhs using petrol for transport purposes	110 39/
Mean for all hhs	45

Diesel

Two surveyed households reported consumption of diesel fuel.

Electricity

Percentage of Households Connected to Electricity Grid	75% 40/
Mean Monthly Bill for Electricity Consumers	
Number of metered households	323 41/
Mean bill (A$/month)	22 42/
Mean Consumption for Electricity Consumers	
kWh/hh/month (metered consumers only)	73

Dry Cell Batteries

Percentage of Households Using Dry Cell Batteries	86%
Most Common Battery Size	D
Mean Monthly Consumption of Batteries	
Mean for hhs using batteries (A$/mth)	5
Mean number of batteries used all hhs	7.2

Wood Fuel

(Wood, Charcoal, Coconut Residues, Other Biomass Residues)

Percentage of Households Using Wood Fuels	
Percentage of hhs using woodfuel	93%
Percentage of hhs purchasing woodfuel	n.s.

39/ Includes one houehold using petrol for an automobile.

40/ Source: Tuvalu Electricity Authority.

41/ Total number of households connected on Funafuti.

42/ Assuming A$0.30/kWh.

Summary of Household Energy Consumption and Expenditure

MEAN OF ALL HOUSEHOLDS

Energy Form	Units	Consumption Per HH Per Year	Unit price A$	Annual Cost A$	Gross Energy Content (GJ)
Kerosene	liters	277	0.66	183	9.9
Diesel	liters	1	0.48	n.s.	n.s.
Petrol	liters	539	0.60	323	18.9
LP Gas	Kg	1.4	0.66	5	0.1
Electricity	kWh	875	0.30	262	3.2
Batteries	dry cell	86	0.24	21	n.s.
Wood fuels	Kgs	2858	n.s.	n.s.	42.9
TOTAL				535	74.8

n.s. = not significant

Total Expenditure on Energy as Percentage of Annual Cash Income: 10.8%

A Survey of 5 Rural Areas of Fiji

DATE: 1983

SURVEYOR: S. Siwatibau

COUNTRY: Fiji

REGION: 5 Rural Areas

Notes on Regions Surveyed

Areas studies were as follows:

A. Somosomo, Taveuni - All establishments within 1 km of the main road between Welagi and Soqulu.

B. Baulevu, Vita Levu - All establishments within 1 km of the existing FEA grid between Verata and Tovutovu.

C. Ovalau - All establishments within 1 km of the existing FEA grid between Cawaci and Tokou including PAFCO.

D. Sigatoka Valley, Vita Levu - All establishments within 1 km of the existing FEA grid from Lawai to the northern extremity.

E. Queens Road, Namosi/Rewa, Vita Levu - All establishments within 1 km of the existing FEA grid between Orchid Island and Nabukavesi.

Number of Households Surveyed

	Total Households in survey area	Total Households Surveyed
Area A.	460	49
Area B.	685	50
Area C.	693	57
Area D.	n.a.	51
Area E.	499	48
Total households surveyed		255

Sampling Method

Household numbers, total population and racial composition of each area obtained from 1976 census data. This was updated from local health center records. Sample households were randomly selected. A total sample of 48 to 57 households covering all the settlements and distributed according to population density was taken in all areas.

Summary of Survey Results

Mean Number of Persons Per Households		
Area A.	6	
Area B.	6.2	
Area C.	5	
Area D.	6	
Area E.	6	
Mean for all households		5.8

Mean Annual Cash Income Per HH (F$)

Income data was collected though could not be used for the determination of mean annual income per household.

Kerosene

Percentage of Households Using Kerosene for Cooking:		
Area A.	100%	
Area B.	74%	
Area C.	67%	
Area D.	39%	
Area E.	65%	
Percentage of all households		69%

Mean Consumption for HHS Using Kerosene for Cooking (liters/hh/month):		
Area A.	26	
Area B.	18	
Area C.	31	
Area D.	37	
Area E.	32	
Mean for all households		20

Percentage of Households Using Kerosene for Lighting:

Area A.	68%
Area B.	30%
Area C.	39%
Area D.	61%
Area E.	42%
Percentage of all households	48%

Mean Consumption for HHS Using Kerosene for Lighting (liters/hh/month):

Area A.	9
Area B.	12
Area C.	12
Area D.	3
Area E.	25
Mean for all hhs	5.8

Mean Consumption for HHS Using Kerosene (liters/hh/month):

Area A.	35
Area B.	30
Area C.	43
Area D.	40
Area E.	57
Mean for all hhs	25.8

Benzine (= White Spirit or Unleaded Petrol, Used in Lamps and Irons)

Percentage of Households Using Benzine for Lighting:

Area A.	52%
Area B.	36%
Area C.	26%
Area D.	55%
Area E.	29%
Percentage of all sampled households	39%

Mean Consumption for HHS Using Benzine for Lighting (liters/hh/month):		
Area A.	12.5	
Area B.	14.2	
Area C.	9.4	
Area D.	3.2	
Area E.	20.8	
Mean for all sampled hhs		4.6

Percentage of Households Using Benzine for Ironing:		
Area A.	83%	
Area B.	38%	
Area C.	37%	
Area D.	63%	
Area E.	27%	
Percentage of all sampled households		49%

Mean Consumption for HHS Using Benzine for Ironing (liters/hh/month):		
Area A.	5.4	
Area B.	6.4	
Area C.	6.0	
Area D.	3.4	
Area E.	6.4	
Mean for all sampled hhs		2.7

Mean Consumption for HHS Using Benzine (liters/hh/month):		
Area A.	17.9	
Area B.	20.6	
Area C.	15.4	
Area D.	6.6	
Area E.	27.2	
Mean for all sampled hhs		7.3

LP Gas

Percentage of Households		
Area A.	15%	
Area B.	8%	
Area C.	19%	
Area D.	12%	
Area E.	10%	
Percentage of all sampled households		13%

Mean Consumption for HHS Using (kg/hh/month):		
Area A.	11.8	
Area B.	6.0	
Area C.	17.9	
Area D.	14.1	
Area E.	13.0	
Mean for all sampled hhs		1.7

Electricity

Percentage of HHS Using Electricity		
Area A.	31%	
Area B.	70%	
Area C.	63%	
Area D.	31%	
Area E.	56%	
Percentage of all sampled HHS		51%

Mean Monthly Electric Bill (Fiji$)		
Area A.	9	
Area B.	10	
Area C.	25	
Area D.	10	
Area E.	15	
Mean for all sampled Households		14

Mean Monthly Consumption of Electricity (kWh/hh/month) 43/		
Area A.	60	
Area B.	67	
Area C.	167	
Area D.	67	
Area E.	100	
Mean for all HHS		48

Wood Fuel

Percentage of HHS Using Wood		
Area A.	100%	
Area B.	84%	
Area C.	56%	
Area D.	80%	
Area E.	77%	
Percentage of all sampled HHS		79%

Consumption for HHS Using Wood (kg/hh/month)		
Area A.	n.a.	
Area B.	114	
Area C.	n.a.	
Area D.	n.a.	
Area E.	109	
Mean for all HHS		86

Dry Cell Batteries

No information was collected on use of batteries

43/ Assuming F$0.15/kWh.

Summary of Household Energy Consumption and Expenditure

MEAN OF ALL HOUSEHOLDS

Energy Form	Units	Consumption Per HH Per Year	Unit price (F$)	Annual Cost (F$)	Gross Energy Content (GJ)
Kerosene	liters	309.6	0.53		11.02
Benzine	liters	87.6	0.63		3.13
LPG	Kgs	20.4			1.02
Electricity	kWh	567			2.07
Wood fuels	Kg as used	1032			15.48
TOTAL					32.72

n.a. = not available   n.s. = not significant

Feasibility Assessment for Photovoltaic Cells Replacing Kerosene Lighting in Papuan Villages (Gaire Village - Central Province)

DATE: 1981

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COUNTRY: Papua New Guinea

REGION: Gaire Village, Central Province

Notes on Region Surveyed

Gaire Village is a coastal village 50 kilometers from Port Moresby, the capital of Papua New Guinea. At the time of the survey it had a population of about 1500 people living in 150 households. Three categories of households were identified: those headed by businessmen, those salary earners (mostly employed in Port Moresby, and commuting to work or visiting home on weekends) and those headed by ordinary villagers, which formed the largest group.

Number of Households Surveyed 29

Sampling Method

The purpose of this survey was to estimate expenditure on kerosene and kerosene lamps to help determine the potential market for solar photovoltaic lighting. 5 households headed by villagers were selected. It was felt that the sample was representative of the three categories of households in the village. Expenditure on kerosene, and parts for kerosene lamps, was recorded daily over a one month period.

Summary of Survey Results

B = households headed by businessmen
S = households headed by salary earners
V = households headed by villagers

Mean Number of Persons Per Household	9.8 (B)	9.0 (S)	10.0 (V)
Mean Annual Cash Income Per Household			

This was not estimated, but background information suggested households headed by businessmen had incomes of several thousand Kina per year, those headed by salary earners had incomes in the range 2,000 - 7,000 Kina per year, and those villagers had incomes generally lower than 2,000 Kina per year. There was considerable income transfer between households associated with weddings, funerals etc.

Kerosene for Lighting

The survey was restricted to the consumption of kerosene for lighting. All surveyed households used kerosene lighting.

Mean Number of Kerosene Lamps Owned by Households

Mean for businessmen	28 pressure	0.6 hurricane lamps
Mean for salary earners	1.3 pressure	0.9 hurricane lamps
Mean for villagers	1.0 pressure	0.8 hurricane lamps

All except 4 families (one salary earners, three villagers) owned one or more pressure lamps

Mean Consumption of Kerosene for Lighting (Liters/hh/month)	
Mean for businessmen 44/	23 (range 11 to 60)
Mean for salary earners	12 (range 8 to 20)
Mean for villagers	9.2 (range 6 to 13)
Mean for entire sample	12 (range 6 to 60)

Mean Monthly Expenditure on Parts for Kerosene Lamps (Kina/hh/month) (Wicks, mantles, pumps, glass covers, etc)	
Mean for businessmen	4.19
Mean for salary earners	2.70
Mean for villagers	0.90

In addition to spare parts, lamps would have to be replaced about once every three years, at a cost of Kina 30 (kerosene pressure lamp) and Kina 3.50 (kerosene hurricane lamp).

General Observations on Lighting

Pressure lamps are often used outside the house for working on canoes during the nights, dances, fishing etc. It was noted that in the survey month (November) kerosene and lamp use for fishing was lower than the average during the months of fishing season (August to November).

44/ Use for businessmen includes use in trade stores attached to residences.

Appendix 1

List of Known Energy Surveys
Carried Out in Pacific Island Countries

Bowman, K. (1985) 45/ Rural electrification in Papua New Guinea: an assessment of a pilot micro-hydroelectricity project. Pacific Island Energy Studies, East-West Center

Seifried, R., Zimmermann, K. (1988) Energy Consumption Survey - Evaluation of Results PN78.2247.1-03.200 Deutsche Gesellschaft Fur Technische Zusammenarbeit (GTZ) GmbH (1988) Special Energy Programme - Papua New Guinea

Gamser, M. (1980) Household Energy Consumption in Port Moresby. Report 8-80, Energy Planning Unit, Papua New Guinea, Department of Minerals and Energy.

Lloyd, C.R. Kumar, M. and Metham, P. (1982) Household Energy Use in Fiji. Report of the Nadi-Lautoka Domestic Energy Survey.

Maleva, K. (1981) Feasibility assessment for photovoltaic cells replacing kerosene lighting in Papuan villages (Gaire Village, Central Province). Report 81/7: Energy Planning Unit, Papua New Guinea Department of Minerals and Energy.

PEDP (1985) Tongatapu Household Energy Survey. PEDP Report Tonga 85-1

PEDP (1986) Final Report of the Household Energy Survey, South Tarawa. PEDP Report Kiribati 85-6

PEDP (1986) Household Energy Survey, Abaiang. PEDP Report Kiribati 86-1

PEDP (1986) Household Energy Survey, Vaitupu. PEDP Report Tuvalu 86-1

PEDP (1988) Report of the 1987 Household Energy Survey, Honiara. PEDP Report Solomon Islands 1988-1

PEDP (1988) Household Energy Consumption on Funafuti: An Analysis of 1987 Survey Data. PEDP Report Tuvalu 88-2

Rizer, J.P. (1985) Pohnpei: Household income, expenditure and the role of electricity. Pacific Islands Development Programme, East-West Center

Siwatibau, S. (1981) Rural Energy In Fiji: A survey of domestic rural energy use and potential. IRDC, PO Box 8500, Ottawa Canada K1G 3H9.

Siwatibau, S. (1984) A preliminary report on a survey of five rural areas of Fiji for the Ministry of Energy and Mineral Resources. Published by PEDP.

45/ Less than 50 households surveyed

Siwatibau. S. (1986) Suva Urban Energy Study.

Tata Consulting Engineers (1984) Fiji rural Electrification Study. Final Report to the Asian Development Bank.

Wardrop N. (1985) Tamana Energy Project Formulation Study. Report submitted to UNDP Integrated Atoll Development Project and Kiribati Ministry of Works and Energy.

V. OVERVIEW: HOUSEHOLD AND RURAL ENERGY IN THE PACIFIC ISLANDS

AN OVERVIEW OF RENEWABLE ENERGY RESOURCES IN THE SOUTH PACIFIC ISLANDS COUNTRIES

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Abstract

The developing countries in the South Pacific region have small, highly dispersed populations, no conventional fossil or nuclear energy resources and rely almost exclusively on foreign aid in developing new conventional or renewable energy systems to meet increasing energy demands. Fortunately, these countries have renewable energy resources that can be utilized for electricity generation.

A preliminary assessment of these renewable energy resources and their current and potential contribution towards the energy needs in eleven South Pacific countries follow. Various forms of energy usage are discussed, with particular emphasis on electricity generation for rural and remote communities from renewable sources.

Background

The countries considered in this paper include Fiji, Tonga, Western Samoa, Cook Islands, Vanuatu, Solomon Islands, Niue, Kiribati and Tuvalu. These countries cover a vast area of ocean, lying between 4 N to 23 S latitudes and 155 W and 155 E longitudes. Actual land area is very small compared to ocean area; sea/land ratio varying, from 41 for W. Samoa to 34,615 for Tuvalu.

The number of islands in these countries vary considerably; Niue has one single island, Tuvalu has 9, Vanuatu around 80 and Fiji somewhere around 350. Island characteristics vary from large volcanic and mountainous (Fiji, Vanuatu, Solomon Is., W. Samoa), to raised coral (Niue, Tonga) and low-lying coral atolls (Tonga, Kiribati, Tuvalu).

Similar conditions which apply in these areas include mainly agriculture-based economies, large rural/village populations, rapid growth in electricity consumption, generally low GNP and heavy reliance on foreign aid. Lack of conventional energy sources (coal, oil, gas), almost total reliance on imported petroleum products for commercial energy uses and little or no expertise in new and advanced technologies of alternative energy sources draw these countries into a common predicament.

Current and Projected Needs for Energy

Energy supply is one of the major problems facing these countries. Apart from Fiji, which commissioned a 80 MW hydro-electricity system in 1983, and W. Samoa, which had around 20 MW of hydro-power in 1986, these nations depend exclusively on imported diesel fuel for electricity generation and on imported petroleum products for transportation, commercial and industrial uses. Furthermore, all forms of development invariably go hand in hand with increasing demand for energy. This was the case for most of the last decade, despite increases in diesel fuel prices. Electricity demands have been steadily increasing in most areas (ADB, 1986); over the period 1972 to 1985, growth in electricity generation has been: Cook Islands-7.5%; Kiribati-9.3%; Solomon Islands-8%; W. Samoa-8.1%; Fiji-5.5% (ADB, 1986). In Fiji, moreover, electricity generation increased by 5% from 1984 to 1985 (FEA, 1986). This increase was due to an increase in the number of consumers as well as an increase in the use of electricity.

Reliance on imported fuels ranges from 22% in Vanuatu to 77% in the Cook Islands. Biomass constitutes the bulk of local energy supply, used mainly for domestic and some institutional cooking, water heating, crop drying and, to some extent, steam and electricity generation. The transport sector depends totally on imported fuels.

Supply of electricity is further complicated by the fact that there are numerous (mostly small) islands in each country. Most of the inhabited, small islands are quite remote from the main islands, have small populations (less than a thousand) and the distribution of population does not justify a grid-based electrical network. Of the hundred or so inhabited islands in the Fiji group, for example, only 3 islands have reticulated electricity; these are the two main islands of Viti Levu and Vanua Levu and Ovalau. In 1985, the total domestic and commercial/industrial consumers of grid electricity were 50319 and 9288 respectively (FEA, 1986). Less than 40% of the population have access to grid electricity, even now.

Demand for energy in all its forms is expected to show a steady growth. For electricity, in particular, growth is expected to be larger, due to increasing, industrial and commercial developments, as well as stated government policy, to electrify, more rural and remote areas. For the latter, since extension of existing grids is impossible for various reasons, and since the demand for electricity does not justify construction of large centralized power stations, electrification of large parts of remote and island areas will be possible only by small scale renewable energy-based power systems or by small, diesel generator sets (which usually have a high operational and maintenance cost).

Energy from Renewable Sources

These countries do have the option of utilizing various renewable energy resources. Fiji, W. Samoa. Solomon Is. and Vanuatu have considerable hydro-power potential. Cook Islands and Niue have potential for micro-hydro schemes. Biomass energy is already used almost exclusively for domestic cooking and heating purposes in the rural sectors as well as steam and electricity generation for several industries. There is considerable potential for development of biomass-based steam and electricity systems, particularly for small-scale systems utilizing forest, crop and sawmill residues and wastes (Tata Report, 1985; Prasad, 1987). All the island countries have abundant sunshine and solar energy is thus a viable energy source in the rural/domestic sectors for electricity generation (using photovoltaic panels) and hot water (Tata Report, 1985). On a larger scale, solar thermal generating systems and solar photovoltaic systems can generate electric energy for larger communities. It has been shown (Prasad, 1982) that while the wind energy potential for the islands is not vast, suitable locations have adequate windspeeds for installations of water-pumping and electricity-generating systems. Biogas from animal and vegetable wastes can meet appreciable energy demands of the domestic sector, especially for livestock farmers. Other longer term renewable resources include geothermal energy (for which a few countries have surveys in progress), wave energy, tidal energy and ocean thermal energy.

Table 1 shows the status of current utilization of renewable energy and also indicates a crude assessment of its potential for meeting energy needs for 7 selected countries in the South Pacific region.

Table 1: Assessment and Current Utilization of Renewable Energy For Some S. Pacific Island Countries

Country	Hydro	Solar	Biomass	Wind	Wave
Fiji	1H; 2 (100MW) MH, MIH 3-DE	2; 10 D,C, IN, 12 13L; 3-SO	2-LS 7-C, I 13	1H; 2SS 3-SO	3-SO
Cook Is.	1 M; 12 3-LI	10-D, C, IN 2; 12; 13 3-SO	2; 9; 8 8-C; I 13	1-M 2-SS 3-SO; 5	1; 5 3-SO
W. Samoa	1-M (>30MW) 2, MH, MIH 3-SO	2; 10 D,C 2-IN; 12 3-LI	2; 9; 7 7-C, I 13	1-M 2-SS; 3-SO	1; 5 3-SO
Tonga	1-S, P-MH, MIH 3-SO	2, 10-D, C 10-IN; 12 3-SO	2; 9; 8 8-C, I 13	1-S 2-SS 3-SO	1; 5 3-SO
Solomon Is.	1-H 2 (>10 MW) 3-SO	2; 10-D, C 12 3-LI	2; 9; 8-C, I; 7 13	1-M 3-SO	1; 4
Vanuatu	1-M P:>10 MW 3-SO	2; 10-D, C 10-IN; 12 3-LI	2; 9; 8C 7 13	1-M; 3	1; 4
Kiribati	6	13-SS 3-LI	2; 9-D, IN, 8-SS, C 13	1-S 12	1; 4

Codes:

1	Potential exists	: H-huge; M-medium; S-small
2	Currently used	: LS-large scale; MS-medium scale;
3	Data available	: SS-small scale
4	Surveys underway	: D-domestic; C-commercial;
5	Sites chosen	: I-industrial; IN-institutional
6	No potential	: DE-detailed; SO-some; LI-little
7	Steam and Electricity Generation	: U-urban; R-rural
8	Steam Generation	: PV-photovoltaic
9	Cooking	: P-potential

10	Hot water systems	: MH-Mini hydro; MRH-micro hydro
11	Not used currently	
12	PV power generation	
13	Crop (copra) drying	

Resources for Hydroelectricity Generation

Countries which have potential to develop hydro-electric power stations of capacity greater than 10 MW are Fiji, Solomon Islands, Vanuatu and W. Samoa. Fiji has already developed an 80 MW hydro power station at Monasavu in central Viti Levu, the main island in the Fiji group. The station has enough generating capacity for Viti Levu until 1992 (Fiji--DP9, 1986). Currently, over 90% of electricity generated by the Fiji Electricity Authority is from the Monasavu hydro-electricity station. The Fiji Electricity Authority has firm plans to install around 5 MW of hydro power using micro and mini hydro electric schemes, ranging from 25 kW to 1 MW. These are to be located in the two main islands as well as in Taveuni and Koro. The government has set aside some 8.3 million dollars for the development of small hydropower plants between 1986 and 1990 (DP9, 1986).

Around 50% of the electricity generating capacity of W. Samoa was provided by hydro power in 1985 (Development Plan, 1985). With the completion of a 3.5 MW hydro-electric system at Sauniatu, W. Samoa's dependence on imported energy will decrease even further. Currently, hydro-electric power plants have a 70% contribution towards the electricity generating capacity in W. Samoa.

The hydro-power potential in all these countries is estimated to be greater than 1 GW. Micro-hydro (up to 10 kW) and mini-hydro (10-100 kW) power systems can be developed on the mountainous islands, for example Tonga (Eua) and the Cook Islands (Rarotonga). The Solomon Islands government has been considering 21 MW hydro-electric power system for some time but lack of funds seems to be a major problem, along with the fact that other power systems, notably biomass-electric units, appear to be more attractive economically.

Rainfall variation is similar for Fiji, Solomon Islands, W. Samoa and Vanuatu; the months from May to September having lower than average rainfall. Annual mean rainfall varies in the range 200 to 400 centimeters per year for all these countries. For an annual average rainfall of 300 cm, and assuming that only 10% of the rainfall is retained in a catchment area of 1 square kilometer, the potential energy stored per year is 4×10^{11} J/yr for an average height of 100 m.

Biomass Energy Resources

Substantial amounts of biomass energy are available in the majority of the South Pacific island countries being considered. These resources are in the form of natural forests and vegetation, coconut and timber plantations and the wastes and residues from agricultural crops and forest industries. From the sawmills of Fiji, for example, around 108,000 tonnes of wastes in the form of sawdust, shavings, wood chips and waste timber are generated every year (Fiji Forestry Department, 1984). This figure is expected to increase as the pine plantations are harvested and milled. At present, there are no commercial uses of sawdust, shavings and the logging, residues, yet the energy contained in these resources is considerable.

Biomass is the most widely used energy source for domestic purposes in many developing countries and more so in the South Pacific island countries. Reliance on biomass energy for domestic consumption ranges from 60% in the Cook Islands to 94% in the Solomon Islands. Biomass in the form of animal wastes (cow dung, pig and chicken excretions, etc.) and plant wastes such as sawdust, sugarcane tops, rice straws and husks, maize straws and husks, coconut husks, shells and leaves and many more plant residues, has a significant energy potential. The available energy in these wastes can be used in two ways:

(a) by direct combustion for cooking, hot water or steam generation for industries and electrical generation; and

(b) by conversion into biofuels such as biogas (methane), ethanol, methanol and other fuels.

The availability of waste biomass varies considerably in nature and amount from country to country. However, significant amounts of plant wastes are available in most South Pacific countries, especially coconut husks and shells. Animal wastes are available in considerable amounts in Fiji, Solomon Islands, Vanuatu, and W. Samoa where livestock are present in substantial numbers. Fiji, which is the only South Pacific country to row sugar cane, has large amounts of cane tops which are either burnt on farms or are simply left on farms as manure. A good portion of this material could be used for direct combustion.

The conversion of sugar cane, cassava and oil palms to biofuels, for example ethanol and methanol has attracted much interest in Fiji, Vanuatu, Solomon Islands and elsewhere. In Fiji, sugar cane and cassava are being used to produce alcoholic drinks and similar plans are underway in Vanuatu and the Solomon Is.

Direct combustion of biomass in open fires for cooking, heating (water) and other domestic chores is very inefficient and wasteful- the efficiency of open-fire stoves can be as low as 1% and generally falls in the range of 5 to 10%. A considerable portion of biomass energy goes towards drying crops, principally copra; in Vanuatu, almost 3 times more biomass was used for copra drying than for cooking in 1981, according to Country Reports, 1982. In Fiji around 35% of the total energy used is supplied by bagasse, a waste product from the sugar mills.

While biomass energy resources at present are adequate to supply current needs for many years (at the current rate!), there is concern regarding this increasing depletion of standing biomass. The growing demands for biomass energy are due to increasing population, better living conditions (with associated demands for more energy), and the increasing costs of other forms of energy, viz. kerosene, benzine and electricity. Furthermore, the forests and plantations are being removed at very rapid rates by the timber and sawmill industries. It is, therefore, imperative that this increase in the rate of depletion is matched by similar rates of replanting. Equally importantly, it is vital that there be a trade-off between the use of forest resources for timber and fuel, the conservation of soils and ecology, and for parks and animal reserves.

Direct Solar Energy Resources

There is a general abundance of solar energy resources in the South Pacific region. Even though the land compared to the sea area is quite small, the energy from the sun falling on the land area is vast since most of the islands enjoy a good sunny climate. There are local variations in insolation values over large islands through variations in cloud cover due to dense forests. The annual mean daily insolation values range from 17 MJ/m**2/d in Vanuatu to 24 MJ/m**2/d in Kiribati. Annual sunshine hours range from 2000 to 2500 per year (5 to 7 hours of sunshine per day on the average). As most of these island countries consist of many islands scattered around a large ocean area, and are not connected to electricity networks, solar energy can be a viable alternative to diesel generated electricity and heat. This is especially true when one considers the very high costs of transporting expensive diesel fuel.

Solar energy is beginning to make inroads into the domestic energy consumption. In Fiji, several thousand urban homes in Suva, the capital city, have solar water heating systems and some 10-20% of new homes being built have provisions for solar hot water systems. The Telecommunications department of the Ministry of Works and Communications in Fiji (and indeed similar departments in other countries) make extensive use of solar photovoltaic (PV) panels to power remote communications and navigational facilities, including telephone repeater stations and lighthouses.

The cost of production of PV panels has dropped from $1000 per peak watt in 1958 to around $5 per peak watt in 1989. By the end of this century, the production costs are expected to drop to $2 per peak watt.

The Department of Energy (DOE) in Fiji has used small PV units to provide electricity for lighting and other small appliances in remote villages and islands having adequate insolation levels. A hundred such units at a unit cost of $450 were bought by the DOE in 1984. It is noted that an increasing, proportion of the population in the remote and rural areas relies on PV panels for its lighting and entertainment uses. A few companies rent such units out for around $15 per unit for a month. A remote village in Rakiraki in Fiji has recently been provided with solar electricity through PV panels.

In the Cook Islands, the government has granted substantial subsidy for the installation of photovoltaic lighting units on islands which do not have electricity. Solar power is used in the Solomon Islands for water heating, desalination plants and for copra drying. Most of the countries are showing interest in renewable energy resources, in particular solar energy for the rural and remoter islands. This is reflected in the latest development plans in which sizeable sums of money are set aside for research, development and demonstration of solar energy systems. However, most efforts are directed towards solar electrification for individual homes in rural areas and remote islands as well as for hot water for individual homes and community installations.

An EEC funded PV lighting project provides 230 households with lighting (150 in Tuvalu and the rest in Tonga). PV refrigerator systems were also installed in Tuvalu, PNG and the Solomon Islands. The Energy Studies Unit of the University of the South Pacific has been actively involved in the energy field for 6 years and has carried out a lot of work on PV and wood gasification systems, among others.

For the next 10 to 15 years, governments are expected to promote the use of solar energy for domestic lighting, cooking and heating and for industrial hot water systems. Other important uses of solar energy can include refrigeration, water pumping, salt production, crop drying, battery charging for telecommunications and lighthouses and space heating.

Wind Energy Resources

The power in the wind varies as the cube of the windspeed. The power is given by half of the products of density of air, cross-sectional area through which the wind passes and the cube of the windspeed. Thus, across an area of 10 square meters, the power in the wind is 6500

W for a steady windspeed of 10 m/s. All this energy cannot, of course, be extracted and there is a theoretical upper limit of 59.3% as the maximum fraction that can be extracted by a wind energy conversion system.

In general, the wind energy potential in the areas covered is not great, particularly for electricity generation. According to available meteorological records, the annual mean windspeed of all the nine countries range from 2 to 6 m/s. However, most of this data is recorded at sites such as airports and major urban centers, places which are less than noted for their wind resources. Thus, without more valid data, and pending its availability, no firm conclusions can be reached regarding the potential of wind energy.

For wind-driven generators, windspeeds above 4 to 6 m/s are needed for cost competitiveness relative to other energy sources. It would thus appear that wind-driven generators would not be suitable for use in the wind regimes in these countries. However, sites may exist where the windspeeds are enhanced and may be several times higher than those of the surrounding areas. The tops of smooth hills, for example, and the coastal areas might have windspeeds of a magnitude adequate for the economic generation of electricity. In Fiji, for example, some areas such as Udu Point, have recorded hourly windspeeds of between 6 and 10 m/s on a regular basis.

Wind energy is currently used in several islands for pumping water for irrigation and for livestock. Water-pumping windmills operate well with lower windspeeds than their electricity-producing counterparts. For rural areas and remote islands, windmills could be used to generate electric power if electricity is not readily available or if its costs are too high from conventional sources. When used with a micro or mini hydro-electricity generating system, wind-powered generators could be used to pump water from a lower to an upper reservoir whenever there is enough wind for the generator to generate, forming a pumped-hydro electricity generation system.

It is noted that the Cook Islands, for instance, reportedly have higher mean windspeeds than elsewhere.

The annual mean windspeed in Aitutaki has been determined (by the New Zealand Meteorological Service to be between 5 and 7 m/s). Preliminary results obtained from the electronic wind monitoring system installed by the University of the South Pacific in 1982/83 suggest that the average annual windspeed could be between 6 to 8 m/s. The windspeeds also seems to be fairly well distributed throughout the year. In short, the wind regime at the site seems suitable for installing a wind-driven generator.

Geothermal Energy

There appears to be little or no geothermal energy potential in the South Pacific countries. However, interest in the search for geothermal resources has been stepped up recently and surveys are underway in Fiji, Solomon Islands, Vanuatu and W. Samoa. Vanua Levu in Fiji has several hot springs, the hot water from which is being used for domestic purposes. There do appear to be significant geothermal energy resources in Fiji (Country Report on Fiji, 1982). One problem appears to be that geothermal energy sources are remote from electricity demand areas, especially in Vanua Levu (ESCAP, 1985). However, little or no hard data is yet available in terms of the electricity-generating potential of the resource, although this may change as survey results come in.

Energy from Ocean Waters

If the countries lack for anything, it is not ocean area. The ratio of ocean to land area is a huge 171. Possible energy sou~~es from the oceans include wave, ocean thermal and tidal energy. While the available ocean r . ~es are truly vast, the resources are widely scattered, the technology for their conversion ir .. the research and development stages and is suitable for large systems where economy of scale applies, and their economics no' nown well enough for these island countries to contemplate harnessing at

PACIFIC REGIONAL ENERGY ASSESSMENT ISSUES BACKGROUND AND OBJECTIVES

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Background

Since the Bank carried out an initial series of Energy Assessments in six Pacific Island countries 1/ from 1982-85, their total imports of petroleum products rose from about 15-16 thousand barrels per day to 22.9 thousand barrels in 1989, with Papua New Guinea accounting for over half and Fiji for nearly a quarter of total consumption. With the exception of PNG, the demand profile for petroleum products is skewed towards light, relatively expensive products. The growth in demand suggests that not much has changed in the countries' dependence on imported petroleum, in spite of extensive efforts to develop indigenous energy resources. Although some large scale hydroelectric and small scale solar-based energy resources have been developed, petroleum fuels remain the main source for commercial energy. Expectations that were held for wave power, geothermal, wind power, ocean thermal energy conversion (OTEC), ethanol and large scale biomass conversion remain unfulfilled, in spite of the fact that considerable aid funds and scarce national staff time were allocated. While a few of these projects have already been formally evaluated most have not, and there is a need for a comprehensive review of the causes for the successes and failures that have occurred.

In the absence of a comprehensive evaluation, the preliminary perception in the Pacific Islands is that the largely technology driven, hit-or-miss approach to the development of indigenous energy resources has not been effective. This has already led to an increased interest in improving the reliability and controlling the costs associated with the existing supply systems for petroleum products and electricity. There is also a perception that improved energy supplies in rural areas, which had been the objective of many projects, cannot be used to reduce the imbalance between urban and rural incomes and development and slow urban migration. As a result, there has been a shift in emphasis away from small scale rural energy development towards improving the infrastructure serving the urban economy, where the scarce available technical and managerial resources could be more effectively employed. The important long term implications of such a shift in developmental priorities also point to the need for a careful evaluation of the past experience with rural energy projects and their potential for development in the future.

Recent Developments

The recent increase in petroleum prices, if sustained, will have important adverse consequences for the economies of the Pacific Island countries. These countries are heavily dependent on petroleum product imports for meeting their energy requirements. The direct effect

1/ The work was carried out under the Joint UNDP/World Bank Energy Sector Assessment Programme and covered Papua New Guinea (1982), Fiji (1983), Solomon Is. (1983), Tonga (1985), Vanuatu (1985) and Western Samoa (1985). The ADB participated in the Fiji and Solomon Is. Assessments.

of higher petroleum prices will be an increase in the cost of imports and a widening of the trade deficit. The principal indirect effects will include higher transport costs and associated negative impacts on tourism and manufacturing earnings.

For the island countries, the size of the price increase will be magnified as a result of their small size and geographical isolation. With the exception of Fiji and Papua New Guinea, the landed cost of petroleum products is already among the highest in the world, due to high shipment and trans-shipment costs. The underdeveloped condition of port and storage facilities and archipelagic nature of the countries add further to internal distribution costs. The small volume of purchases and limited number of companies servicing each country could also put the countries in a vulnerable position in relation to the risk of shortages and other disruptions in supply.

The impact of the petroleum price increases is also magnified by the high sensitivity of key economic sectors to changes in transport costs. Manufacturing will be adversely affected by higher costs for imported raw materials, capital goods and higher shipment costs for final goods. Foreign exchange earnings for tourism are expected to be depressed as a result of higher airline fares and a slowdown in the economies of the countries of origin. The competitiveness of the region's few agricultural commodity exports is also expected to suffer from higher transportation charges. At the household level, the impact will be felt in the form of higher cooking and lighting costs.

Given that the impact of the current oil price shock is going to be substantial, the long term economic consequences can be ameliorated through appropriate management of the energy sector. To provide a basis for decision making in this regard, the Pacific Regional Energy Assessment (PREA) is being proposed to explore the potential for strengthening the governments' capacity to manage the sector and, to the extent that it is economically and technically feasible, reducing the burden of petroleum product imports through the development of alternative sources of energy. The PREA will be based on a comprehensive review of the recent experience with energy projects in the Pacific and draw the appropriate lessons for guiding the development of the sector in the future.

The objective of the PREA will be to define a development strategy for the energy sector in each country (as well as a regional strategy, when it makes sense to tackle problems on a regional basis) which would serve as the basis for planning and prioritizing recommended policy measures institutional strengthening priorities and investments in the sector. Basically, PREA will:

(a) follow-up on and update the earlier series of Energy Assessments;

(b) expand the coverage to twelve countries by including all major independent countries in the region; and

(c) include including all major independent countries in the region, and (iii) include a regional overview, which will cover issues on a region-wide basis, as appropriate.

While the focus of the report will be on energy, the analysis will be set in a macroeconomic framework based on the World Bank's economic reports where available, supplemented with its the mission's own analysis where required. The PREA will also take

advantage of background material prepared for the recent Pacific Power Efficiency Seminar and Pacific Household and Rural Energy Seminar. 2/

Main Issues to be Addressed 3/

Petroleum Supply and Pricing: How can island governments assure that they obtain reasonable prices for petroleum products?

The value of petroleum products accounted for 10-22% of tota. .nports of the Pacific island countries in 1989, which is significantly below the levels experienced in the early 1980s, mainly as a result of the decline in real petroleum prices. With the exception of PNG, which is expected to begin exporting oil from 1992, this share is likely to increase again in 1990 as a result of recent developments in the world petroleum markets. As in the early 1980s, the main issue associated with the supply of oil relates to the potential for reducing the landed cost of petroleum fuels, which tends to be 20-30% higher than world market prices in the smaller countries, without compromising security or disrupting supplies.

While most countries have some form of price surveillance or control mechanism, these have proven to be cumbersome and often ineffective. Where price control has been dropped (e.g., Vanuatu), there has not been effective surveillance and prices have arguably been higher than they should. A potential approach to the reduction of costs, which the PREA will explore, is the improved surveillance of costs and review of petroleum supply contracts. Where appropriate, the PREA will also review the taxes on petroleum products with a view of finding ways to reduce distortions in relative prices and provide appropriate signals to the consumers.

Electricity Supply: How can the small, mainly diesel-based power utilities in the region respond to numerous challenges now facing them, including a change in the financing environment and growing pressures for rural electrification?

The financial for the power utilities in the region is undergoing a transition as a result of:

(a) the increasing size and financing requirements of power projects;

(b) the growing preference of donors for focussing their concessionary assistance on social programs rather than infrastructure development; and

(c) the growing insistence of multilateral lenders on satisfactory financial performance.

2/ The Pacific Power Efficiency Seminar was held in Suva, Fiji from September 3-7, 1990, in conjunction with the Second Meeting of Chief Executives of Pacific Island Power Authorities. Both seminars were organized by the World Bank/UNDP/bilateral Aid Energy Sector Management Assistance Program (ESMAP) in cooperation with the UN-pacific Energy Development Program (PEDP), the Pacific Forum Secretariat Energy Division (FSED) and the Asian Development Bank (ADB).

3/ This section is based on a preliminary overview prepared by the PEDP.

These changes in the financing environment have several important implications for the planning and management of power systems. These implications include: a need to raise the tariff to recover capital, as well as operating and maintenance costs; more stringent requirements for system optimization and project justification; alterations to equipment procurement and standardization policies, and increased lead times for project implementation.

Many of the power utilities in the region are ill-prepared to meet the requirements of the changing financial environment. Their tariffs tend to be based on historical costs, rather than financing requirements. Their management and technical capacity tends to be inadequate, which frequently reflects itself in an inability to meet the expectations of lenders and the public, as well as poorly maintained equipment. On the basis of the recent Pacific Power Efficiency Seminar, the utilities appear to be keen to improve their performance, and look forward to an assessment of their current condition and guidance for their future development, such as will be provided by the PREA.

Aside from financial and technical issues, a particular area which deserves to be reviewed is the improvement of the regulatory environment. In a few countries the power utilities are quasi-autonomous (PNG, Fiji) or private (Vanuatu) enterprises and the main issues revolve around the extent and manner of government involvement in pricing and investment decisions, In most other countries the utilities operate as government departments, with little managerial autonomy or financial accountability, and the main issues revolve around the need to develop them into more commercially-oriented, financially autonomous entities. A few countries have also expressed an interest in the PREA'S exploring the potential for private sector involvement in the development of the sector.

A related set of issues derive from the increasing pressures for the electrification of rural areas and outlying islands. These pressures are driven by the low (10-40%) share of electrified households in comparison to other countries with comparable GDP/capita, and the high expectations raised by the electrification of remote government centers and a few grant-funded pilot projects to supply electricity to small rural communities. Where the conventional supply of electricity from the grid or isolated diesel stations has the potential of commercial viability, the main issues to be addressed will relate to the prioritization of investments and the strengthening of managerial and technical capabilities to ensure the efficient design, installation, operation and maintenance of power facilities in rural areas. Where the conventional approach is not commercially viable, the viability of alternative organizational and/or technical approaches will have to be explored. This again points to the importance of reviewing the Pacific Islands' past experience with non-conventional approaches to energy supply in rural areas.

News and Renewable Sources of Energy: How can new and renewable energy sources (NRSE) be developed in a financially and technically sustainable manner in small, isolated countries with very limited technical and managerial capacity?

For all Pacific island countries, except for PNG with its petroleum resources, the development of new and renewable energy supplies offers the only alternative, albeit a limited one, to continued long term reliance on imported energy. These resources are poorly mapped and unevenly distributed. Some high volcanic islands have significant hydro and geothermal potential and a number of islands have good biomass cover. In the long term, ocean thermal and seawave could also become developable energy resources. In the near term, many of the smaller islands have no immediately exploitable energy source' other than solar. In addition to technical and economic limits, the development of all of these resources is severely constrained by the low density of population, low skill levels and remoteness of the islands.

The recent experience with NRSE in the Pacific indicates that the development of hydroelectricity has been relatively successful, at least in terms of producing energy, although cost and time overruns have been common. Large scale (over 1 MW) hydro resources have been developed in Fiji, PNG, Western Samoa and FSM (they are planned for development in the Solomon Is.) and have contributed to a conversion of the power grid from diesel generation to mostly hydro. In view of the large size and capital requirements of these projects, in relation to those of the countries' economy as a whole, the main issues here relate to:

(a) the need to strengthen the implementation capacity of the utilities to avoid time and cost overruns; and

(b) the need to smooth out the sharp increases in power prices often required to maintain a satisfactory financial position during the initial years of the projects.

The development of minihydro (less than 1 MW) schemes, for which some potential exists in about half of the countries, also offers the potential of economic diesel substitution in small isolated systems. The main constraint to their development has been the high costs (up to $10,000/kW for a recent project) associated with often difficult topographical and geological conditions, which require costly designs. In addition to the financial costs, the administration and supervision of such project puts a disproportionate strain on the scarce professional manpower available to Pacific island governments. In view of these issues, the PREA will explore the potential for reducing the cost of minihydro projects, Possibly through focussing further development on the microhydro (under 50 KW) range which could be implemented by local efforts with only limited technical requirements.

The experience with photovoltaic (PV) projects in the Pacific Islands has also been better than with other NRSEs. About 4000 small systems have been installed, typically involving 2-8 panels for household lighting, water pumping and refrigeration. Although there have been many problems with the reliability of the equipment (controllers, batteries and appliances), the current perception is that the technical problems can be overcome and that PV systems can be competitive with small diesel-based electric power systems for remote island communities. The main issues relates to management and financing. Most of the existing systems have been financed through grants or concessional loans whose availability cannot be expected to continue) and are operated on a non-commercial basis. The PREA'S review will therefore focus on the potential for improving cost recovery from PV systems to enable their expansion to continue in a financially sustainable manner.

The consumption of fuelwood, which accounts for over half of total energy consumption in some countries, now exceeds the rate of natural regeneration in some (mostly peri-urban) areas, resulting in deforestation with a consequent increase in erosion and destruction of mangrove areas. Options for addressing this issue include the enhancement of supply through the development of social forestry or fuelwood plantations, and the improvement of end-use efficiency through the introduction of improved woodstoves. The PREA will review the potential for these options, as well as the institutional and financial requirements.

In the 1970s and early 1980s there was considerable enthusiasm for biomass gasification based on fuelwood, wood waste and coconut waste. However, they have proven to be expensive to build and difficult to operate. In the Pacific, about two dozen gasifiers were planned, five were built, and perhaps one is still now operating. On the basis of this experience, unless recent innovations such as cheap ferro-cement design) prove to be practical, the use of gasifiers will have a limited future in the region. Nevertheless, in view of the continued and renewable supply of biomass available in most islands, it would be useful for the PREA to review the region's recent experience with the utilization of biomass resources and, after drawing the appropriate lessons, explore the potential for their future development.

Other than the above, investigations and pilot projects for the development of NRSES in the Pacific have not yet yielded the prospect of a significant contribution to overall energy supplies. Geothermal resources have been identified in a few countries, but only in areas far from suitable markets. Numerous small wind electric systems have been tried with little success, although many wind pumping systems have worked well. Dozens of small biogas systems have been built in the 1970s, mostly at piggeries. Although useful for pollution control, they never produced an appreciable amount of energy and have largely been abandoned. Perhaps a household-, rather than community-based approach deserves to be explored. The production of ethanol fuels, based on a large variety of feedstock (cassava, sorghum, sugar, molasses breadfruit, nipa palm, sago) have been studied, but their economics have been found to be unattractive. A seawave electric power project has been proposed for Tonga, but its costs appear to be higher than those of diesel-generated electricity. Ocean thermal energy conversion (OTEC) is of considerable interest to the island states, many of which have high temperature differentials close to shore, but its technical and economic viability remain to be demonstrated. For these NRSES, the PREA will review the available information and assess the need for any future work, if appropriate.

Energy Conservation: What can governments do to improve the efficiency of energy use in the economy?

The generally high prices of petroleum products and electricity create a favorable environment for energy conservation and electricity demand management. Although distribution losses in the electricity network generally are low by developing country standards, the optimal level of losses should also be low, given the high cost of electricity. Given the financial problems of the energy sector and vulnerability to the cost of imported oil, the enhancement of energy efficiency would seem to be a high priority in the energy strategy of the countries. There appear to be numerous cost-effective opportunities for saving substantial amounts of fuel and electricity in all sectors of the economy. The achievement of these savings may require changes in the policy environment and other incentives. The PREA will review the available options and recommend appropriate measures for the governments to pursue, while taking into account the limited implementation capacity of the energy offices.

Energy Sector Management: How can the government of a small country with very limited financial and manpower resources effectively plan for the development of the energy sector and establish and administer energy policies?

The ability of the energy offices of the Pacific Island governments to effectively manage the energy sector is generally limited, due to numerous reasons whose relative importance will vary for each of the countries:

(a) they have weak links with the core departments of the government finance, planning, aid coordination, civil service administration);

(b) their role and formal responsibilities are unclear, particularly in relation to the power utilities and energy pricing;

(c) they have difficulty in attracting and retaining skilled staff;

(d) there is heavy reliance on short-term expatriate staff and often therefore little institutional memory; and

(e) they are often responsible for both policy and implementation for small rural projects with the attendant conflict of interest and generally poor implementation, in the absence of suitable staff.

None of these factors is insurmountable in itself, but in combination they tend to overwhelm the senior officials and limit their ability to manage the sector effectively. The PREA will review these problems and develop options for addressing them, including the identification of regional approaches where appropriate.

Energy Related Training: How can energy sector training programs be established which address the needs of national staff:

(a) As suggested from the above discussion, there is an acute shortage of qualified professional and technical staff for meeting the requirements of the energy offices, power companies and other enterprises in the sector. An improvement in training programs would appear to address this problem, but there is only a limited understanding of the skills and experience required for the effective operation of the sector. Also, while there are already several training institutions in the region as well as numerous short-term courses and seminars world-wide to which Pacific Islanders are invited, many of these are of little relevance or inadequate in relation to the needs of the sector. To assist the governments in addressing this situation, the PREA will review the training needs of the sector and evolve appropriate options for meeting them.

Donor Assistance Programs: How can donor assistance programs in the energy sector be made more effective and responsive to the needs of the Pacific Islands?

The Pacific Island countries are highly dependent on donor assistance for funding the development of the energy sector. In view of the mixed record to date, it is important to understand the factors that can affect the success or failure of energy projects in the Pacific and draw the appropriate lessons for improving the effectiveness of foreign assistance in the future on the basis of ex-post project evaluations carried out by the Bank and the European Community 4/ on their own projects, factors which contributed to difficulties and failures in the implementation of projects include:

4/ See Project Performance Audit Reports of the Papua New Guinea: Upper Ramu Hydroelectric Development project (1979), Papua New Guinea: Second Power Project (1982), and Fiji: Monasavu-Wailoa Hydroelectric Projects I and II (1986), by the Bank's Operations Evaluation Department, and An Evaluation of Energy Projects in ACP Countries (1988) by SRA and Lahmeyer International for the European Economic Communities and the European Investment Bank.

(a) a tendency to build projects ahead of demand, due to over-optimistic forecasts, or for demand to fall behind projections, due to lower than expected economic growth;

(b) difficulties in attracting high quality consultants and contractors to work on small projects in remote locations;

(c) weak links between assistance to the energy sector and assistance to other sectors, particularly in relation to rural energy development projects;

(d) a donor preference for short-term funding commitments for specific stand-alone projects, rather than long term support for institutional development;

(e) a tendency for project ideas to originate from those interested in carrying out the work rather than from an objective assessment of the need for the project and a careful comparison of options;

(f) on occasion, no clear evidence of commitment of the recipient government, agency, utility, community, etc. to the project; and

(g) the physical remoteness of the islands, with attendant difficulties of supervision and lack of understanding of the characteristics of the area.

To the above points, a recent report by the PEDP (Pacific Energy Development Program) would add the following reasons for the relatively poor experience with NRSE technologies in the Pacific Islands:

(a) a limited understanding of the energy needs of the recipients;

(b) inadequate or no involvement of the local community at the planning stage;

(c) the choice of projects with management overheads which are disproportionate to the benefits, and which the small local energy offices cannot provide without assistance;

(d) unrealistically optimistic assumptions by advisors and promoters about costs, output, reliability and the skills required to manage the proposed projects;

(e) the choice of equipment which has not been thoroughly tested elsewhere, is poorly designed, or is not appropriate for the site;

(f) the lack of adequate training for local people in system operation and maintenance;

(g) the lack of adequate support for local organizations to plan, operate, maintain, manage, finance, expand and evaluate the projects in the field;

(h) inadequate initial support (commissioning, instructions, spare parts, etc.); and

(i) poorly chosen consultants.

The need to address the above issues brings us back to the importance of a comprehensive review of the recent experience with project implementation in the Pacific energy sector, such as will be done in the PREA. This will provide for recommendations on necessary measures to improve the effectiveness of donor assistance and reduce the probability of failures. It is expected that the major part of such a strategy will be the formulation of a sectoral development program which would serve as the basis for planning and prioritizing of policy measures, institutional strengthening and investments. The development program will assist the countries in guiding donor assistance towards the areas of highest priority and in ensuring that donor projects are defined with a full understanding of associated institutional and policy requirements. The country-specific and regional development programs are also expected to be useful to the donors for planning their assistance to the sector in a manner that is sustainable and consistent with each countries' developmental priorities.

Organization and Schedule

Organization

The PREA is designed to be an update and extension of the six Energy Assessments of Pacific Island countries carried out by the joint Undp/world Bank Energy Sector Assessment Program between 1982 and 1985. This time, on efficiency grounds, the Assessment will be carried out on a regional basis, that is, combining the country specific review of issues and options in the energy sector with a review of regional issues and solutions, where appropriate. To maximize the benefits, the PREA will be carried out in a cooperative manner with the Un-pacific Energy Development Program (PEDP), the Pacific Forum Secretariat's Energy Division (FSED) and Regional Petroleum Unit (RPU), the Asian Development Bank (ADB) and the South Pacific Facility of the Australian International Development Assistance Bureau (AIDAB). Other major donors in the region have been informed about this study and have expressed an interest in its results. The World Bank will have overall responsibility for the organization and management of the PREA, and for ensuring the quality of the report, with the assistance of the cooperating agencies.

Requests for participation in the PREA have been received from twelve countries: Cook Islands, Fiji, Kiribati, Marshall Islands, Federated States of Micronesia, Palau, Papua New Guinea, Solomon Is., Tonga, Tuvalu, Vanuatu and Western Samoa. On the basis of discussions with the cooperating agencies, who have agreed to bear part of the costs, the PREA will be able to cover all of the countries that have requested it. As the Solomon Islands had initially requested this assistance from the World Bank in 1988, the Solomon Islands portion of the PREA is already underway as a separate but coordinated activity of the ESMAP. 5/

Schedule

To familiarize the mission participants with the Bank's approach to energy assessments and brief them on the background and objectives of their work, the PREA will begin with a preparatory workshop 6/ to be held in Suva, Fiji on January 21 and 22, 1991. From Suva, four teams will travel to the countries under study for about one week each (two weeks for PNG) to collect information and discuss energy issues with relevant country officials. Upon their return

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5/ A preparatory mission visited the Solomon Islands in May 1990, and the main mission is there in October, 1990.

6/ To be hosted by the PEDP/FSED/RPU.

to headquarters, the teams will prepare the draft country energy assessments and the regional overview.

The draft report of the PREA, including the regional overview and the country reports, will be reviewed by a Review Panel prior to its distribution to the countries for discussion. Current plans are to present the preliminary results of the PREA as part of the Pacific Energy Ministers' Meeting, to be held in Honolulu in July, 1991. 7/

To familiarize the responsible country officials with the results of the report, the PREA will be conclude with an Energy Policy and Planning Workshop, to be organized by the Bank's Economic Development Institute (EDI) with the assistance of the PEDP/FSED/RPU and AIDAB. The workshop will be designed to strengthen the Pacific Island countries' senior energy officials' understanding of the fundamental concepts of energy policy and planning that will underlie the recommended energy sector development program. This is expected to improve their ability to follow-up on the recommended measures, both internally within their governments as well as externally in working with the donor community. Current plans are to hold this workshop in conjunction with the Pacific Regional Energy Meeting to be held in Apia, Western Samoa in September 1991.

7/ The Energy Ministers' Meeting will be jointly hosted by the PEDP and the East West Center of the University of Hawaii.

TECHNICAL, FINANCIAL AND ECONOMIC CONSTRAINTS AFFECTING CONSERVATION AND RENEWABLE ENERGY OPTIONS IN THE HOUSEHOLD AND RURAL ENERGY SECTORS

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ESMAP

Outline of Presentation

I. Introduction
II. Commercially Viable Conservation and Renewable Energy Systems
III. Issues in Financing Conservation and Renewable Energy Systems.
- High initial costs;
- Perceived technical and financial risks;
- Small-scale and dispersed applications;
- Technology transfer/imports.
IV. Policy, institutional and organizational constraints.
V. "Innovative schemes" for financing conservation and renewable energy systems - FINESSE.

Introduction

* The demand for energy in the developing countries is expected to grow at an annual average rate of 7% over the next decade (i.e., more than double).

* In some S.E. Asian countries the growth is in excess of 15% per year.

* Financial requirements to meet these needs are in excess of one trillion U.S. dollars or approximately US$100 billion per year.

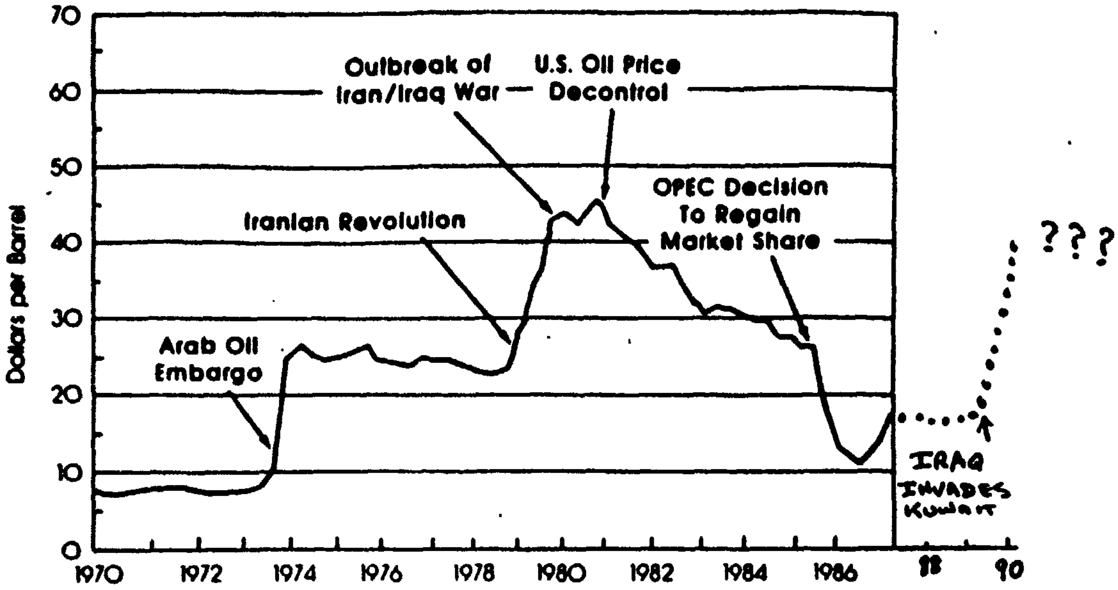
* To date the primary focus of energy assistance from the MDBs and development institutions has been on supply oriented large-scale fossil fuel and hydropower based projects, this, in spite of their attendant negative environmental implications.

* The World Bank currently estimates that over 80% of the expected doubling in power plant capacity in developing countries will consist of coal thermal and large hydro capacity.

* Despite the enormous investments in the energy sector, an estimated two billion people, or approximately half the population of the developing world, will continue to be without adequate energy supplies for economic growth and basic human needs.

* Alternative energy technologies -- Energy Conservation and Renewable Energy Systems - can play an important role in meeting the energy needs of developing countries while simultaneously helping improve the environment.

<u>Recent World Crude Oil Prices</u>



*Average quarterly cost of crude oil imported by U.S. refiners

<u>Definitions</u>

* Energy Conservation (EC) or saving energy - is the process in which <u>energy services</u> are maintained or even increased while energy consumption is decreased.

* Energy conservation does not have to translate to less or lower qualities of energy services.

* Commercially available energy conservation options for households and the rural sector include:

  - Design and process modifications;

  - Efficient cooking;

  - Efficient lighting;

- **Efficient refrigeration;**
- **Efficient air conditioning;**
- **Efficient hot water and process heat;**
- **Efficient small-scale power generation.**

Definitions

* Renewable Energy (RE) - is energy that is partly or wholly regenerated in the course of the annual solar cycle. The major categories of RE are:

  - Solar energy;
  - Wind energy;
  - Small-hydropower, and
  - Biomass fuels.

* Commercially available technologies for conversion of RE to usable forms of energy include:

- Solar PV	- electricity;	
- Solar Thermal	- process heat	- hot water; - drying; - electricity;
- Wind	- shaft power	- water pumping; - milling; - electricity;
- Small-hydro	- shaft power	- milling; - electricity.
- Biomass	- combustion - gasification - bio-gas - fermentation	- process heat; - shaft power; - gaseous fuels; - liquid fuels.

Applications for Renewable Energy

* RE systems have a wide range of potential stationary applications which can be divided into three major categories:

- **Large scale systems for grid integration or industrial applications:**
    - **Wind electric farms;**
    - **Solar thermal power;**
    - **Biomass power generation and co-generation;**
    - **Small hydropower.**

- **Medium scale systems for local grids/village electrification and commercial applications:**
    - **Centralized PV;**
    - **Mini hydropower;**
    - **Wind hybrids;**
    - **Biomass combustion and gasification;**
    - **Solar thermal.**

- **Small scale systems for isolated and individual household/institutional use:**
    - **PV;**
    - **Bio-gas;**
    - **Micro hydro.**

Comparative Conventional Energy Systems

* In all these potential applications, Conservation and RE systems must complete technically and economically against conventional options:

    - Large scale Systems:
        - Coal;
        - Fuel oil;
        - Natural gas;
        - Nuclear.

    - Medium scale systems:
        - Diesel oil;

    - Small scale/household energy systems;
        - Kerosene/LPG
        - Gasoline;
        - Woodfuel.

Costs of Conservation & Renewable Energy Systems

* Two major cost components for all energy systems;

(1) Initial capital or investment costs;

(2) Fuel and Operating & Maintenance costs.

* Conservation and RE Systems tend to have significantly higher capital costs when compared to conventional energy systems.

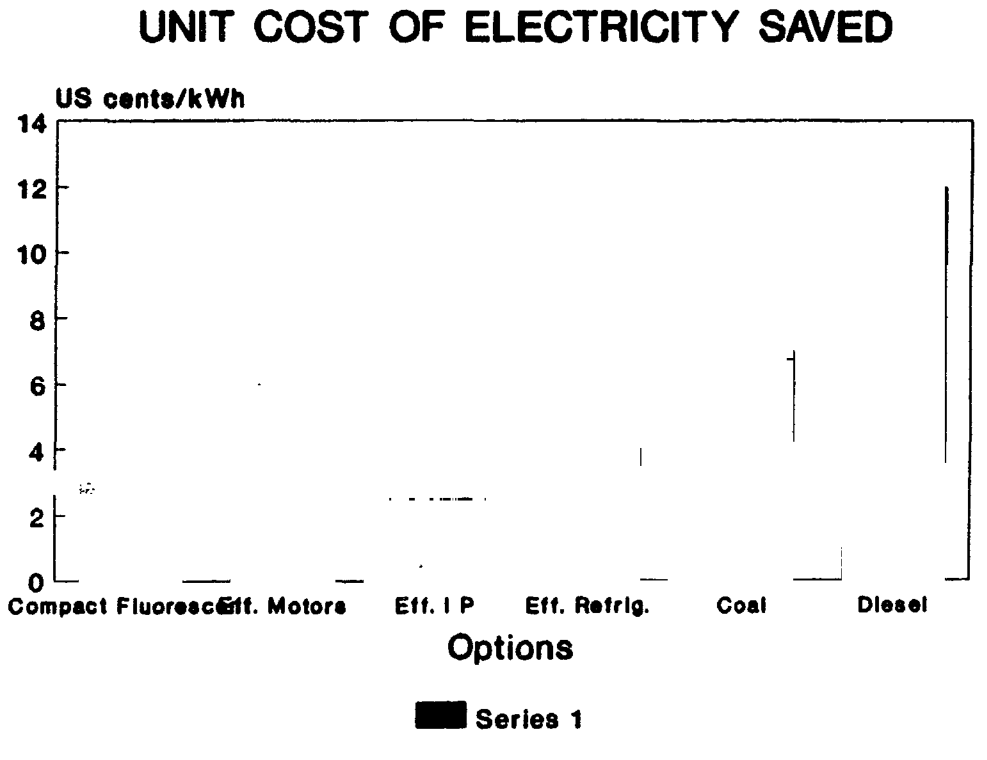
* In contrast, most Conservation and RE systems have lower fuel costs and minor O & M costs when compared to contentional energy systems.

* A comparison of energy systems must be based on the amortised costs of the resulting energy services provided by each system.

* Factors such as availability and reliability of Conservation and RE systems need to be accounted for in comparisons against conventional energy systems.

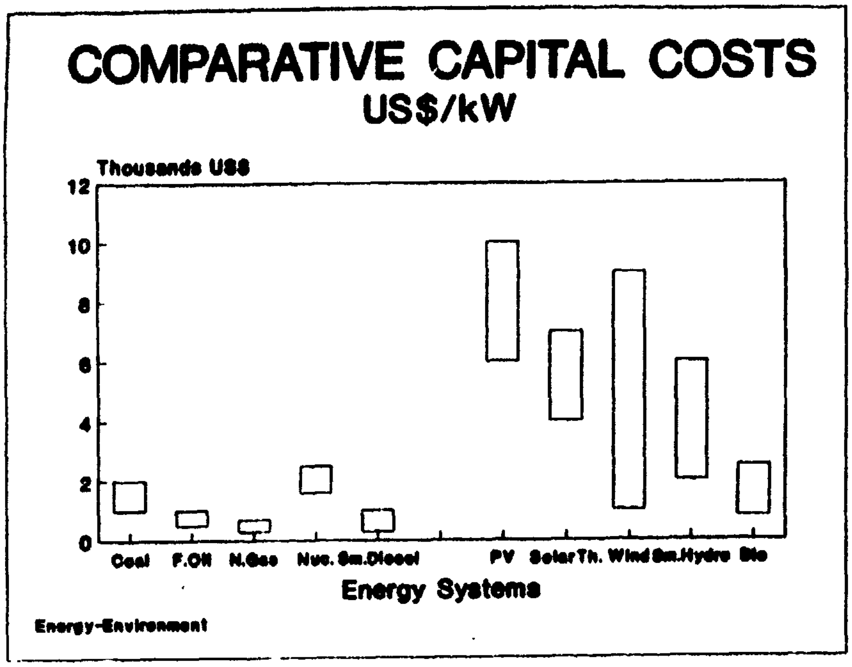
* The significant environmental benefits of Conservation and RE systems also need to be accounted for in comparisons against conventional energy systems.

Unit Cost of Electricity Saved

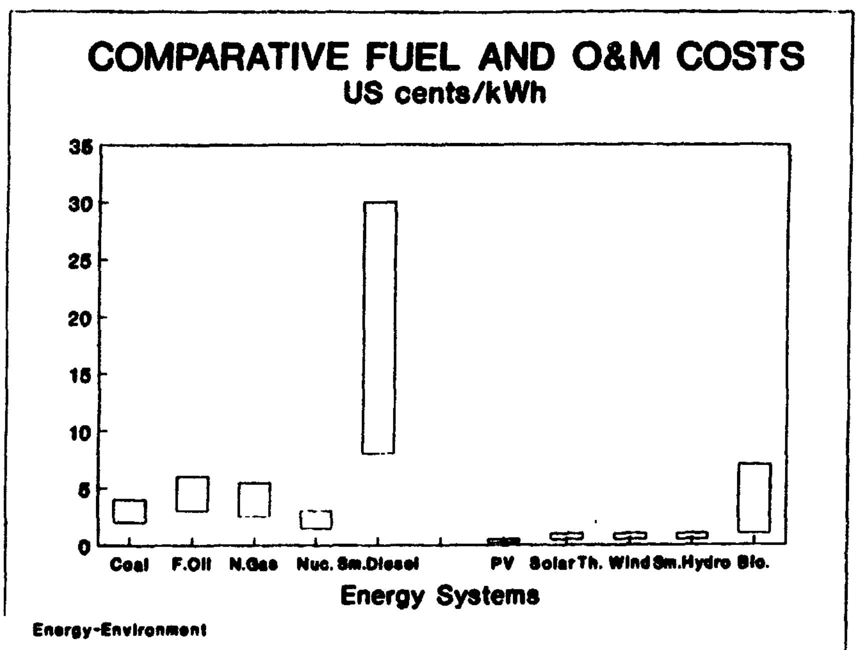


Source: A. K. Reddy, 1990.

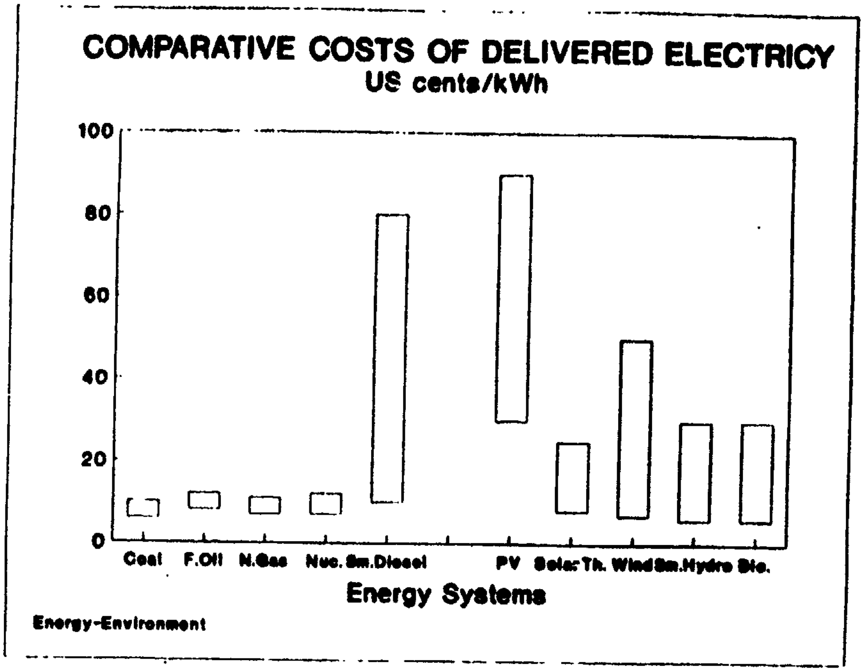
Comparative Capital Costs



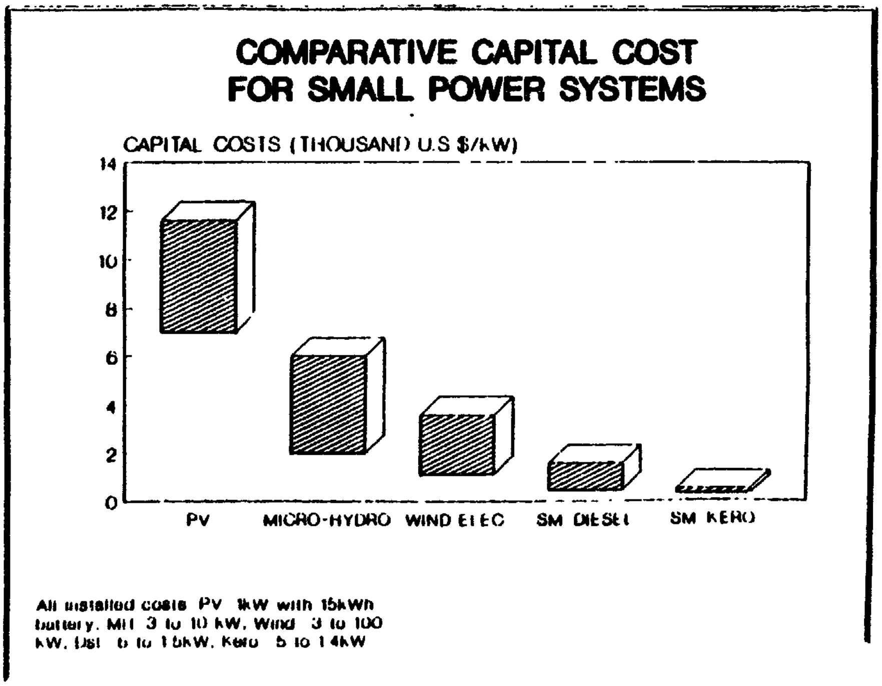
Comparative Fuel and O & M Costs



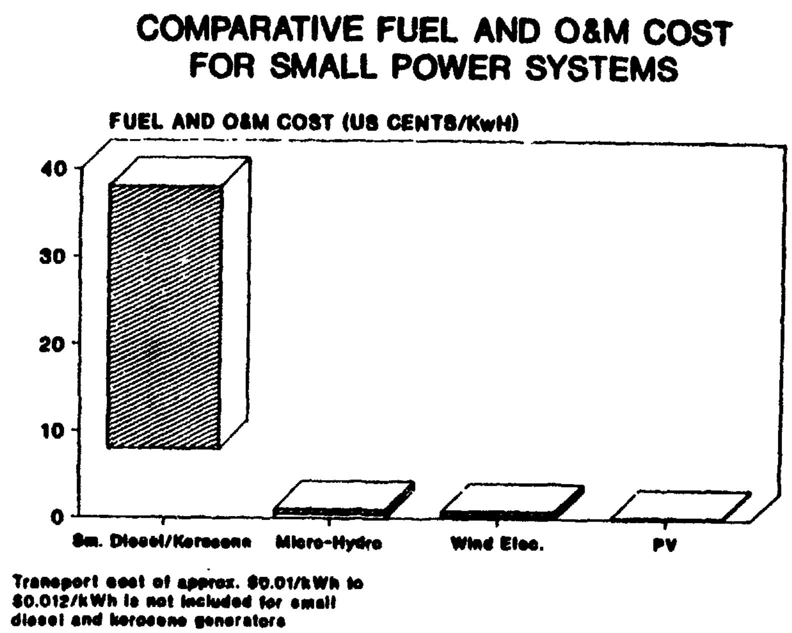
Comparative Costs of Delivered Electricity



Comparative Capital Cost for Small Power Systems



Comparative Fuel and O & M Cost for Small Power Systems



Cost of Delivered Electricity for Small Power Systems

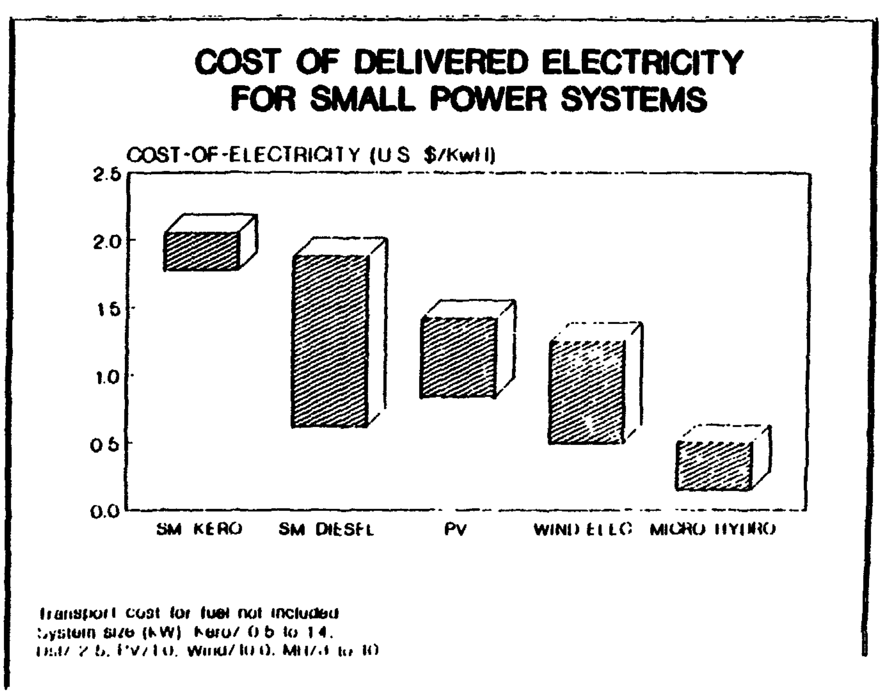


FIGURE I-4

Comparison of Current Wind Electric, Photovoltaic, Micro-Hydro and Diesel/Kerosene Generators for Small Electrical Power Applications

POWER SYSTEMS	WIND ELECTRIC	PHOTOVOLTAIC	MICRO HYDRO	DIESEL GENERATOR	KEROSENE GENERATOR
COST FACTORS ***					
CAPITAL INVESTMENT	3,500/kW (0.25 kW size) 1,370/kW (10 kW size) 1,144/kW (100 kW size) (including tower & foundation)	7,000/kW to 11,000/kW (installed cost with 15 kWh batt. storage)	2,000/kW to 6,000/kW (installed cost for 3 kw to 10 kW systems)	640/kW to 1,500/kW (2.5 kW size) 600/kW (3.7 kW size) (installed cost)	500/kW (0.5 kW size) 300/kW (1.4 kW size) (installed cost)
OPERATION AND MAINTENANCE					
MAINTENANCE & REPAIR	0.0020/kWh to 0.008/kWh	0.0005/kWh to 0.002/kWh	0.005/kWh to 0.01/kWh	200 - 400 per 1000 hours	200 - 400 per 1000 hours
FUEL COST (AT PUMP)	Zero	Zero	Zero	0.22/liter to 1.00/liter	0.22/liter to 1.00/liter
FUEL TRANSPORT COST	Zero	Zero	Zero	0.01/liter to 0.012/liter, per 100 kilometers	0.01/liter to 0.012/liter, per 100 kilometers
COST OF ELECTRICITY GENERATED	0.50/kWh to 1.25/kWh (10 kW size)	0.85/kWh to 1.42/kWh	0.15/kWh to 0.50/kWh	0.83/kWh to 1.00/kWh (2.5 kW size) 0.90/kWh (3.7 kW size)	2.05/kWh (500 watt size) 1.78/kWh (1.4 kW size)
OPERATING FACTORS**					
SYSTEM LIFETIME	10 to 20 years	20 years	10 years to 30 years	10,000 hours	5,000 hours
RELIABILITY	Good	Good	Good	Fair	Fair
CAPACITY FACTOR	Resource dependent, generally 20 % to 35 %	Resource dependent, generally 15 % to 25 %	Load and resource dependent, generally 25 % to 35 %	Load dependent, (should be >25% to operate eff.)	Load dependent, (should be >25% to operate eff.)
MODULARITY	Good	Good	Good	Good	Good
ENVIRONMENTAL IMPACT	Small	Small	Small to large depending on site conditions	Moderate to large depending on O&M experience	Moderate to large depending on O&M experience

Perceived Technical and Financial Risks

* Although many EC and RE systems are now reliable and warranted by their manufacturers, the perception remains in both the developed and developing countries that most of these systems are still experimental and unreliable.

* Other factors that contribute to the heightened perception of technical and financial risks associated with EC & RE systems include:

  - Lack of accurate information and wide-scale "track records" for most EC & RE systems;

  - Weak or undeveloped infrastructure support for EC & RE systems;

  - Unknown social acceptability of EC & RE systems;

  - The decentralized nature and lack of central control associated with EC & RE technologies.

Small-Scale and Dispersed Applications

* Although the potential of RE resources far outweighs that of conventional energy resources, it is highly dispersed and diffused and is presently most efficiently captured and utilized in relatively small-scale and widely distributed applications.

* The decentralized character of EC & RE systems is a major factor working against its commercialization and financing. Difficulties arise primarily due to:

  - Individual or community ownership, operation and maintenance of RE systems;

  - Investments need to be made by the end-users, who, for the most part, are not able to or accepted for participation in the financing process;

  - Disbursements of small loans to a large number of individual borrowers translates into higher risks and administrative costs;

  - Many of the potential end-users themselves do not have the financial resources or the credit worthiness and are not served or reached by the present lending network.

Technology Transfer/Imports

* Most EC & RE systems have evolved in the developed countries and are designed for applications in these environments. Some like compact efficient lighting, high efficiency motors and pumps, PV, wind turbines and hydro turbines require sophisticated manufacturing skills and significant production capacities.

* Imports of RE systems require the use of scarce foreign exchange. When this is coupled to the high capital investments associated with EC & RE systems, the impact is overbearing.

* The savings in fuel and electricity payments that result from EC & RE systems are in local currencies which may not offset the foreign exchange used to import the systems. This is not necessarily the case if fossil fuels are imported.

Policy Constraints

* EC & RE systems must presently complete in a distorted market due primarily to unfavorable and out-dated energy and economic policies. Some of the more restrictive policies include:

  - Non-economic pricing of conventional energies including direct and in-direct subsidies, and exclusion of social and external costs and benefits;

  - Un-regulated conventional energy monopolies which are guaranteed market access and allowed to restrict private sector initiatives;

  - Economic and infrastructure support for conventional energy systems that are not available for or applicable to EC & RE systems;

  - Taxes and subsidies that encourage the exploitation of fossil fuels and favor operating costs over long-term investments;

  - Import duties on EC & RE systems while fossil fuels are imported duty free;

Organizational and Institutional Constraints

* Several organizational and institutional constraints also exists to prevent developments of EC & RE systems.

  - Unwillingness of utilities to purchase surplus electricity from private co-generating industries or power generators at fair market prices;

  - Lack of information, technical and infrastructure support to assist the deployment of EC & RE systems;

  - No established standards or regulations to ensure acceptable performance and safety of EC & RE systems;

  - Difficulty of ensuring payments for services given the up-front costs and dispersed nature of EC & RE systems;

  - Reluctance of utilities to accept EC & RE systems as part of the range of energy supply systems available to them;

- The present state of many developing country utilities which are unable to cope effectively with even the conventional energy systems that are currently under their purview;

- The urban/grid development focus of most developing country utilities.

FINESSE

* FINancing Energy Services for Small-scale Energy-users.

* FINESSE is a recognition that:

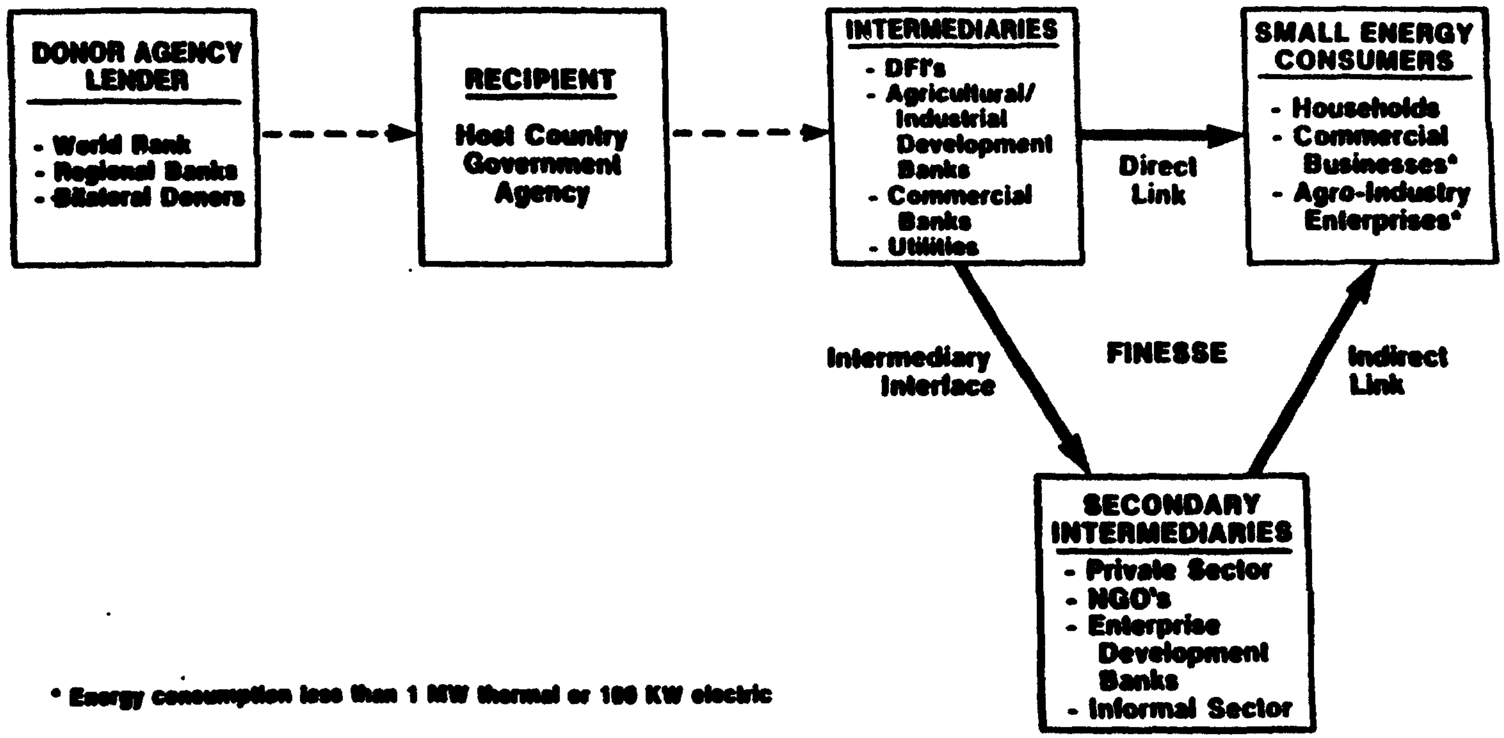
  (a) Alternative energy technologies - conservation and renewables - present viable and environmentally beneficial least cost options for a variety of developing country end-use applications;

  (b) The current focus of energy assistance and development is on large-scale, supply oriented power projects and virtually ignores the ultimate energy services (lighting, heating, cooling, refrigeration, shaft-power, etc.) that are the final objectives of consumers; and

  (c) The current policy, organizational, institutional and financing framework is biased against the equitable exploitation of alternative energy systems.

Exhibit 1

Illustrative Financing Process for Small-Scale Energy Consumers



* Energy consumption less than 1 MW thermal or 100 KW electric

Conclusions

* There are a number of EC & RE systems that are technically proven and commercially viable with sufficient "track records" to warrant their consideration in energy sector planning.

* EC & RE systems, in general, are significantly more beneficial for the environment than conventional systems.

* The high initial capital costs of EC & RE systems are a major barrier to their wider implementation.

* More accurate information on both EC & RE and conventional systems is necessary to help alleviate the perceived technical and financial risks associated with RE systems.

* The small-scale and dispersed nature of EC & RE systems makes their financing, implementation and management more difficult.

* Present energy and economic policies in most developing countries are unfavorable and unfair toward the adoption of EC & RE systems.

* There is a need for "innovative" financing, policy, institutional and organizational mechanisms to assist the deployment of viable RE systems in developing countries.

VI. HOUSEHOLD AND RURAL ENERGY NEEDS AND RURAL ENERGY DATA COLLECTION

IMPACTS OF RURAL ELECTRIFICATION ON RURAL AND HOUSEHOLD ENERGY NEEDS

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Consultant

Electricity is the key which opens the door into the modern world. Without an electricity supply, individuals and communities are condemned to an existence in which a high proportion of the benefits and conveniences of modern living are denied to them. Meanwhile, with technical progress, the gap between the electrified and the non-electrified world continues to widen.

The provision of an electricity supply to their rural areas is therefore a legitimate development objective. Indeed, development beyond a certain level is virtually impossible without electricity. The dilemma facing many Third World governments is that while they recognize the political and social pressures to accelerate their rural electrification programmes, the required resources for doing so are in scarce supply.

Policy making in the rural electrification area is thus a matter of difficult choices about priorities, about where, when and how best to carry out rural electrification. This demands clear thinking about how the benefits of rural electrification are distributed, how much consumers should pay for obtaining them, what criteria should be used in the selection of areas for electrification and what supply technologies should be used.

Rural Electrification and Development

There is no doubt that the arrival of an electricity supply in an area seems, at times, to be the trigger which sets off a surge of new economic activity and a marked rise in the standard of living. There are numerous examples which demonstrate this.

A study of the effect of rural electrification on small businesses in Bangladesh, for example, found that 98% of those surveyed believed that electricity had increased their income. The majority of these were small shops selling food, stationery and household utensils, and personal services such as tailoring, laundry and hairdressing. Most used electricity simply to provide power for two or three light bulbs; the next most popular use was for fans, which were used by about 50% of the businesses. The total usage of electricity tended to be about 25 kWh per month among newly connected businesses but was double this among those who had a supply for a few years.

The same study also reported that electrification led to the establishment of a significant number of new businesses. It concludes firmly that:

"These results show a clear correlation between supply of electricity and significant growth of commercial enterprises in rural markets. Though other factors ...may also contribute to this growth, there is no doubt that electrification of these markets is the most important intervention that has stimulated this growth in economic activity with a concomitant increase in employment" (Rahman and Huq, 1988).

Similar results are reported in a variety of other studies in different parts of the world. They suggest that rural electrification is particularly effective in stimulating activity in the service sector, an extremely important area of the economy as far as off-farm job creation is concerned.

Other analyses, however, cast considerable doubt upon the proposition that there is direct causal link between rural electrification and development. In one extremely comprehensive set of country studies carried out by USAID in the late 1970s, the overall conclusions was that "Electricity does not elicit major spontaneous development activities in poor, less-developed areas" (Wasserman and Davenport, 1983).

The study of Bolivia was particularly firm in its conclusions. It said:

"Providing electricity was neither a catalyst for economic development of rural areas or a precondition to it. The anticipated productive uses of electric power, primarily for irrigation and small industry, have not yet materialized... Where rural industry and irrigation has occurred, it has been accomplished with self-generating diesel systems in response to price incentives and other factors such as the availability of credit and technical assistance" (Butler et al, 1980).

It is, in fact, obvious that bringing an electricity supply to an area, is, in itself, not sufficient to cause development to occur. The extreme case is where a supply has been provided but no one has taken a connection:

"Numerous 'electrified' villages in India have no connected load: in one subdivision of Orissa State, a recent appraisal mission of an international lending agency found that of 64 villages 'electrified' between 1978 and 1981, only 10 had a connection. The 10 villages had a total of 52 connections, half of which were in a single village" (Smith et al, 1983).

Such arguments for and against rural electrification as a direct cause of development, taken separately, appear highly plausible. On the one hand, it seems undeniable that the arrival of an electricity supply in an area frequently brings improved living standards and a surge of economic activity. On the other hand, it is equally clear that electricity, in itself, cannot cause development.

The resolution of this apparent contradiction, in many cases, is likely to be that there has been a degree of confusion between cause and effect. Rather than electrification causing development, it may be the other way round, with development creating the conditions under which rural electrification programmes can be successfully implemented.

Rather than rural electrification bringing about increased wealth, economic dynamism, and increased literacy, it is arguably the presence of these which permits rural electrification programmes to be successfully implemented. The confusion between cause and effect arises because once an electricity supply is brought to areas which have reached such a stage of what might be called "electrification readiness" the form of their subsequent development is profoundly influenced. Thus, people in electrified areas spend their money on goods and services which use electricity. Businesses and productive enterprises use electrical equipment because it is effective and available. A study looking at the effects of rural electrification in India, Indonesia and Colombia said that "...it is virtually guaranteed that in a village with electricity, a new industry will start with electricity" (Barnes, 1988).

The fact that electricity use is widespread in a prosperous area does not necessarily mean that electrification has brought about this prosperity. It simply means that the availability of an electricity supply is a necessary but not sufficient condition for the modernization and development of the rural economy beyond a certain point. While this leaves rural electrification with a crucial part in the rural development process, it is still a considerable way short of saying that bringing an electricity supply to an area will necessarily cause it to develop.

Other Myths

Rural electrification is sometimes credited with a number of specific effects. Among these are that it slows the drift from the land; that it saves fuelwood, thereby preventing deforestation; that it helps the rural poor; that it increases agricultural production; and, even, that it reduces population growth. Despite the absence of any substantial body of evidence to support them, these myths have shown an extraordinary persistence.

Any idea that rural electrification might slow the drift of people from the land runs contrary to historical experience throughout the world. Whether as a cause or a consequence, rural electrification is invariably associated with economic development. History shows that, rather than halting the drift from the land, the overall effect of economic development is to bring about a reduction in the rural population. This can be seen in the demographic statistics of the industrial countries over the past couple of centuries and in the more recent experience of newly industrialized countries such as Korea.

As for helping the rural poor, it is true that many of the families who are connected under rural electrification programmes are poor by the standards of the industrial world and the upper income urban groups in their own countries. Often they live in one or two room dwellings with mud or straw walls, thatched roofs and earth floors.

In the areas being electrified, however, they are the elite. Electricity is not a basic need. Families only commit themselves to an electricity supply after they are able to satisfy their needs in food, water, accommodation and other priorities. Families who take an electricity supply have risen economically above the concerns of those who live at or close to the profound poverty of subsistence farming, share cropping, or work as hired farm labor.

The use of electricity for cooking in the rural areas is rare in the initial stages of rural electrification programmes. When rural families use an electric hot plate it tends to be mainly for snacks or making tea rather than cooking the main meal. Any impact on rural woodfuel consumption is therefore likely to be minimal. It also needs to be borne in mind that the main agent of deforestation is clearing the land for agriculture; this would continue even if the whole rural population cooked by electricity.

Rural electrification is frequently justified on the grounds that it increases agricultural production, particularly by encouraging farmers to use irrigation. The fallacy in this argument is broadly similar to that in which rural electrification is seen as directly causing rural development.

There are various factors which encourage, or enable, farmers to increase their output above that needed for their own subsistence. A key consideration is whether there are markets, and sufficiently attractive prices, for farmers to be able to recover any investments they make in increasing their output. Where there are guaranteed markets, farmers everywhere have shown that they are prepared to increase their production irrespective of whether they have electricity, by for example using diesel pumps. Where the right market conditions are not present, farmers if, indeed, they are prepared to take a connection, will tend to use their electricity simply for lighting and other domestic uses.

As for the rural birth rate, there is, of course, no evidence that it is reduced by rural electrification as such. It is obviously silly and trivialising to suggest that having electric light or television in the evenings prevents men and women going to bed together to produce more children. But in so far as an improvement in economic circumstances is often accompanied by a fall in the birth rate, the fact that a rural electrification programme has succeeded in an area can justifiably be regarded as an indicator that such a demographic transition may be under way.

Who Obtains the Benefits?

None of the above discussion is intended to suggest that rural electrification does not bring benefits. It clearly does.

The rise in domestic living standards which comes with an electricity supply can be quite dramatic. Electric lighting extends the day and provides opportunities for work and entertainment more effectively than any other lighting source. A survey in Peru found that for women, "having light at night enables them to sew, spin, knit, separate seeds etc, activities which only have been accomplished earlier with great effort under the light of kerosene lamp or a candle" (Valencia and Seppänen, 1987). The fact that electric light makes it easier for children to study is listed by families throughout the developing world as one of the major benefits of electrification; this, for example, was the verdict of 80% of the families responding to a survey of the social impact of rural electrification in Malaysia (Omar and Zin, 1988).

For local industries, electricity provides a supremely versatile and flexible source of power. For the owners of grain mills, an electric motor is cheaper, cleaner and far more convenient than diesel. Garages, workshops and agro-industries are able to stay open later, increase their output and carry out a wide variety of tasks which were previously impossible or prohibitively expensive. The use of electricity also improves the working conditions and productivity of the labor force.

Businesses can also benefit greatly. The owner of a bar or restaurant can attract new custom by installing better lights and a video set; shops can offer ice cream and cold drinks. Tailors, barbers, beauty parlors, and general stores can widen and improve the range of services they provide once they have a supply.

It is possible to put a cash value on some of these benefits. One kWh of electricity used in a 60 watt electric bulb produces the same amount of light as about 12 liters of kerosene burned in a wick lamp. In Tanzania, for example, one kWh of electricity on the domestic or small commercial tariff costs about 0.5 cents and 12 liters of kerosene costs about $3.70.

The use of a 500 watt power tool, in energy terms, increases the daily output of a worker by a factor of ten. In a ten-hour working day, the consumption of electricity is just 5 kWh. For a bar or cafe owner, a refrigerator and a cassette player can bring a major increase in sales for an electricity consumption of less than 2 kWh per evening.

An analysis of the economics of grain milling in Zimbabwe shows that the price of fuel is negligible as a proportion of turnover. For an expenditure on electricity of about US$0.45 per hour, it is possible to earn milling fees of about US$21.50 per hour; the fuel costs are just over 2% of turnover. Labor, repairs and maintenance cost a further US$0.80 per hour. Assuming a price of US$8,750 for the mill and a three year loan at 18%, repayments are about US$310 per month and are covered by the net return from about 16 hours operation per month, with the remainder as pure profit (Hancock, 1990). The electricity bill is totally insignificant in this context and could be increased by a factor of ten without seriously undermining the profitability of the enterprise.

When looking at these benefits, it is also important to bear in mind that they flow primarily to those with an electricity supply. It is the families who use electricity who enjoy better lighting and a reduction in household drudgery, whose children are able to do better at school, and who are able to make additional money by productive enterprises in the home. It is the shopkeepers with an electricity supply who draw the extra customers; it is the owners of grainmills, factories and workshops who benefit from their increased output.

This is not to deny that there are real and worthwhile wider social benefits from rural electrification. They are, however, modest in comparison with the benefits obtained by those who are actually using electricity for their own purposes. The thirsty customer benefits from being able to buy a cold drink on a hot and dusty day; but it is the shopkeeper who makes a profit from selling it.

When rural electricity supplies are subsidized, it is therefore to the users, rather than the wider community that the benefits primarily flow. In the case of domestic supplies, the main beneficiaries are the better-off families. The spin-off for the poor as a result of providing the wealthiest 10% of the rural population with a cheap source of light and power for their domestic appliances is negligible.

Nor does the use of rural electrification programmes to provide direct social services such as public lighting, or power supplies to schools, hospitals and public buildings, depend upon electricity also being sold at a subsidized price to private and business consumers. The contrary is the case; it is more difficult for the utility to subsidize public services if it is making a loss in supplying its paying customers.

The Question of Tariffs

Experience shows that it is difficult for rural electrification programmes to show a financial profit. The capital costs of supplying dispersed and distant consumers are high. And because the numbers of consumers and the amounts of electricity they consume are usually small, the financial returns tend to be low.

Rural electrification programmes have therefore tended to be subsidized, often very heavily. Such subsidies are frequently justified on the grounds that rural electrification causes development or that it has wider social benefits such as increasing agricultural production or reducing the pressure on woodlands. The dawning awareness that these wider benefits are largely mythological, is provoking a serious revision of thinking on the appropriate level for rural electrification tariffs.

Given that the benefits are large and that they flow primarily to the consumers, who happen to be the rural economic elite, there is little justification for channelling large amounts of state funding towards them in the form of subsidies. In general, rural electrification tariffs should therefore be pitched at a level which covers production costs. Anything less means that any increase in consumption worsens the financial position of the supply utility.

There is, however, considerable room for debate on the return which should be earned on capital. The build-up of consumption in a rural electrification programme can be quite slow. Attempting to burden a small number of initial consumers with charges which provide an adequate return on capital is likely to kill off any hope of a programme succeeding. There is therefore a case for accepting a relatively slow build-up to an acceptable rate of return.

In practice, domestic rural electrification tariffs are often extremely low. Charges of a few US cents per kWh are common; in at least one developing country, electricity is sold at less than 1 US cent per kWh. Such charges tend to cover only a small fraction of the production and distribution costs. The result is that utilities are so starved of funds that they cannot adequately maintain their existing supply systems, let alone undertake more comprehensive rural electrification programmes.

If the position is to improve in the future, it is imperative that rural electrification tariffs are raised to more realistic levels. Generating costs should, in general, be passed on to consumers. In many cases this will involve charges of 20 US cents, and more, per kWh. For customers, and utilities, accustomed to charges which are a small fraction of this, such tariffs may appear impossibly high. But in comparison with the benefits, they still represent extremely good value for money.

Many utilities, however, will still tend to find that, even with prices of 20 US cents per kWh, they are still unable to break even in supplying rural customers by means of isolated diesel generators. This is not surprising given that there are often severe diseconomies of scale for utilities in running small isolated power stations.

In such situations, the most appropriate solution is likely to be the encouragement of private sector suppliers. This will require a liberalization of the legal restrictions on the private production of electricity for sale which are in force in many developing countries.

Where to Electrify

Despite its many benefits, it is evident that attempting to provide an electricity supply to some areas is a complete waste of time, effort and money. There are numerous examples of projects which, at least with the benefit of hindsight, can be seen to have been doomed from the beginning.

Rural electrification is, for example, inappropriate when obtaining an electricity supply, and paying at least a substantial proportion of the costs, is not a priority in the local community. This is likely to be the case in an area where subsistence farming is the normal way of life and there is little commercial or industrial activity.

If an electricity supply is to be relevant, the area to be electrified must already have reached a level of economic development in which there is a substantial number of potential customers able to afford the connection fees, house wiring expenses and regular bills. On the demand side, potential consumers must feel that obtaining an electricity supply has a high priority for them. If farmers are to invest in electrical equipment, they must be convinced they will be able to sell their extra production at a reasonable profit. The same is true of entrepreneurs and business people. They must believe that there is a market for the extra goods or services which electricity will enable them to provide.

When electrification is expected to bring social benefits such as improved adult education or health services, the resources to provide these must be available. Evening classes need recognized curriculums and teachers willing to work the necessary hours. Health clinics need to be staffed, properly equipped and supplied with drugs. Often the costs and physical shortages of these are considerably greater obstacles to the effective functioning of health centers than the lack of an electricity supply (Wasserman and Davenport, 1983).

If the community is expected to pay for street lighting, pumped water, communal television or other facilities, there must be a local agreement that these are priority needs. This normally presupposes that a certain level of more basic infrastructure is already in place. It also implies that a local organization able to give voice to the community's wishes and ensure that the necessary payments are collected, either exists already or can be established.

In a well-known 1975 paper, the World Bank suggested that the following indicators will provide a guide to areas which are suitable for rural electrification programmes (World Bank, 1975). The list remains valid today:

* the quality of infrastructure, particularly of roads, is reasonably good;
* there is evidence of growth of output from agriculture;
* there is evidence of a growing number of productive uses in farms and agro-industries;
* there are a number of large villages, not too widely scattered;
* income and living standards are improving;
* there are plans for developing the region;
* the region is reasonably close to the main grid (if the demand is particularly strong, remote regions may be considered too)"

The exact weight to be given to these various factors will vary from place to place and will depend upon local physical, economic, and social conditions, as well as the type of supply being considered. But using such a list, each country will be able to draw up its own set of criteria which can be used in the selection of the most promising areas for rural electrification.

Restricting rural electrification to such areas also helps in the balanced development of the utility. It ensures that the available funds are used in the optimum manner, first electrifying the areas with the greatest potential return and leaving the less profitable until later when the utility is financially and technically better equipped to deal with them.

Community Management

In areas outside the reach of the utility, and where private sector initiatives are unlikely to be profitable, local communities may be prepared to take on the management of their own electricity supply.

The existence of a such a scheme could also provide hope of a supply for communities in remote areas which would otherwise not be eligible on financial grounds for a supply from the utility. They would have a choice and an opportunity to do something about obtaining and electricity supply if they wish, rather than having to wait passively for the indefinite future time when the utility deems them suitable to be fitted into its programme.

Much of the discussion about community management of projects has tended to focus on the choice of technology. But selecting the technology is only the first and, in some ways, the least important step. Whatever technical method of providing an electricity supply is chosen, it is essential that the institutional arrangements, required for its installation, operation, and repair, already exist or can be put in place.

If a significant national impact is to be achieved by means of local community managed generation systems, a strong central coordinating organization is required. This organization needs to have the technical and managerial expertise to develop and organize the installation of generating systems which are cheap, reliable and closely matched to local needs and conditions. It must have the ability to win the trust of local communities and enter into an effective dialogue with them. It must also maintain a constant drive to achieve reductions in costs, standardization, and simplification of the systems being offered.

Equally importantly, the coordinating body must have a guarantee of continuity. Rural electrification is a long term process. Communities which have been helped to obtain their own generating systems need to be able to rely on support not just in operating systems throughout their working life, but in replacing them. This is a process which stretches over decades. Support for it needs to be institutionalized on a permanent basis.

The coordinating body can, for example, be part of the national rural electrification agency. Alternatively, it can be another state agency such as the Public Works Department in Fiji or Pakistan Council on Appropriate Technology which is part of the Ministry of Science and Technology and is responsible for community-managed small hydro installations in Pakistan. It could also be an NGO, but it must be well-established and have guarantees of long term funding.

Particular care needs to be taken to ensure that local communities have the management capabilities necessary for the running of their own generating system. The demands of local management should not be under-estimated. They include operation and routine maintenance of the equipment; administration and keeping of accounts and records; issuing and collection of bills; and longer term management of funds for repair, extension or replacement of the system. Unless the capacity exists for carrying out all these tasks, the working life of the system is likely to be short.

Village electrification schemes should never be provided as donations. The local community must always make a substantial contribution to the initial costs of the scheme and should also be obliged to cover the operating costs. Where small hydro schemes are installed, the operating costs will be relatively low since there is no fuel to be purchased, and villages should make a regular contribution to the capital costs. Diesel schemes will require the purchase of fuel, lubricating oil and any other operating requirements.

Even the best equipment breaks down. If communities are going to operate supply systems on a long term basis, they have to be provided with a service which will regularly inspect installations and carry out repairs when necessary. These services have to be easily available to local communities in case of emergencies and must be able to carry out repairs within a reasonable period of time. At least a proportion of the costs involved should be met from village funds.

A system for providing prompt repairs is essential. If electricity supply systems are liable to lie idle for months waiting for spare parts or the availability of technicians, the community dare not allow itself to be dependent upon them for any important functions. Providing villages with generation systems without an adequate repair service is an infallible way of ensuring that whatever electricity is produced will be of marginal developmental importance. The availability of repair and maintenance services, in the final analysis, may well be the principal factor determining whether particular community managed schemes succeed or fail.

Technology Choice

The choice of the optimum electricity supply technology for rural electrification programmes depends on a variety of factors. Realistic assumption have to be made on all the key variables, in particular, the level of demand and the working life of the equipment. If they are not accurate, they can have a major bearing on the relative ranking of different options.

Where extension of the grid is feasible, it is usually the best option on both technical and economic grounds. Grid extension programmes probably cover 90-95% of the consumers connected under rural electrification programmes. This is not likely to change greatly in the future. Where the demand is within reach, the practical advantages of a grid-based supply are usually overwhelming.

The range of off-grid generating options is, in principle, wide. It includes diesel, small hydro, a variety of biomass-fuelled boilers, gasifiers, wind turbines, and solar energy.

In practice, the choice in any given location is much more limited. Purely practical considerations will usually eliminate several options immediately. Hydro, for example, is obviously ruled out unless there is a river with a suitable site for a power station within easy reach. Photovoltaic systems require clear sunny conditions throughout the year; wind turbines require a suitable wind regime. Biomass-fuelled systems require a secure source of biomass fuel.

The level of locally available skills is also an important consideration. There is no hope of keeping complicated pieces of electrical equipment in operation, be they diesel generators or wind turbines, if there are no technicians available to maintain and repair them. Similarly, there has to be an assured supply of spare parts for whatever option is chosen.

It is important that renewables are subject to the same technical and financial analysis as the conventional options. Where a renewable technology can demonstrate that it is the best available option, for example, where there is a good hydro site, it should, naturally, be chosen. But there can be little justification for lowering the standards of analysis in order to justify the use of expensive and inappropriate generating equipment simply because it relies on renewable energy sources.

In the majority of cases, the only suitable generating source will be a diesel engine. Fears that the world will not have sufficient oil to keep these running are greatly exaggerated. The world still has ample oil resources. In 1990, the "published proved reserves", the stock in trade of the oil industry, were over 60% higher than they were in 1970 (BP, 1970; 1990). The world's likely ultimate oil resources are sufficient to keep present levels of consumption supplied for at least the next century.

Nor is rural electrification likely to place a significant extra burden on oil imports. The energy consumption of even a major programme of small diesel installations in the range 10-25 kW will rarely account for more than a few percent of the total consumption of the transport fleet.

Such complacent utterances may appear inappropriate in the light of the spectacular increase in the price of oil which has taken place since the Gulf crisis. This is not related to the ultimate availability of oil; it has happened because the short term price elasticity of oil is low. People have to pay what is asked at the filling station if the alternative is not getting to work. Moreover, oil companies would prefer to have oil, at virtually any price, which they can sell to their customers rather than find themselves without stocks if supplies are disrupted.

But in the medium term, as the history of the past two decades has shown, it is extremely difficult for oil producers to maintain high oil prices. Fuel switching, conservation and new sources of oil are waiting to be deployed. The outlook is that these can, over a period of 5-10 years readily make up for even a catastrophic loss of production facilities in the Middle East. The medium term prospect for oil prices is that even in a worst case war scenario in the Middle East, that they will to the range $20-25 per barrel (Foley, 1990).

Pre-electrification

The initial demands for electricity are extremely small in many rural electrification programmes. Households tend to begin by using their electricity for lighting and a radio. At a community level, the main demand may also be for public lighting. Diesel engines may already be in use to meet larger energy demands such as grain milling or irrigation pumping.

With such low demand levels, it can be difficult to justify the costs of a grid extension or a diesel generator. This has led to the development of the concept of pre-electrification in which photovoltaic units are used to supply these low initial demands. At a later stage, when demand has risen, the idea is that the supply can then be provided with a grid extension or diesel generator. Pre-electrification, in other words, allows rural communities to obtain the main benefits of an electricity supply at a significantly earlier stage than is financially justifiable with conventional supply options.

In some cases, the pre-electrification supply has been provided by a centralized photovoltaic power station. This has, for example, been the case in the village of Notto in Senegal where a 9 kW station was opened in 1987. Another is the 8 kW station in Utirik in the Marshall Islands.

The overwhelming disadvantage of such power station is their huge capital cost of $250 000-300 000. In capital-scarce economies, this means they are totally uncompetitive with small diesel generators which can be purchased for less than a tenth of the price and have a much greater yearly output since their running time is not dependent upon the availability of sunlight.

Neither does the fact that photovoltaic power stations do not require imported fuel mean that they do not have foreign exchange costs. Virtually the whole initial capital investment, as well as the recurrent costs of maintenance, repair and battery replacement, involve the import of materials and foreign technical expertise. In most cases these will be considerably greater than those required to install and keep a diesel system in operation.

The centralized photovoltaic power station is also extremely inflexible in the face of increasing electricity demands. Some commentators see them as acting as a block on village development. The following comments were made with reference to experience in Senegal:

> "It becomes a rule that the level of consumption must remain fixed in order to ensure that it fits within the pre-defined characteristics of the installation. The distribution network is frozen, the number of consumers constant, the hours of service immutable. The corollary is that the percentage coverage provided in an expanding village falls with time. It is impossible for new businesses and small industries to set themselves up and obtain a connection. Water pumping, grain milling, television or other uses can only be provided at a community level because of the rigidity of the energy system provided for the village" (Diallo, 1988).

A more realistic approach to pre-electrification relies on the use of individual photoelectric kits. These can be used to provide power for domestic lighting or for community uses such as small scale water pumping or refrigeration. The costs of such units are difficult to establish with any accuracy, partly because they have been falling in recent years, but also because they have been subsidized by aid agencies. Broadly, depending upon location, specification and a variety of other factors, a unit capable of providing power for lights, a radio and perhaps a small fan will cost in the range $500-1000.

Such costs are likely to be competitive with those of providing an electricity supply by more conventional means. The difference is that once a conventional supply has been provided, the incremental costs of providing for virtually any likely increase in household consumption is zero. With the photovoltaic unit, on the other hand, any increase in consumption requires additional units.

Pre-electrification tends therefore to block rather than encourage the development of a growing and diversified electricity demand. The purchase of a domestic photovoltaic system not only mops up a large amount of cash, it also means that the family cannot go on to invest in other appliances such as an iron, hotplate, sewing machine, conventional refrigerator or hand tools unless it is prepared to abandon its investment in the solar equipment and take a conventional supply. This can mean that pre-electrification makes it more difficult, rather than easier, for a community to be provided with a conventional electricity supply.

Another problem with pre-electrification is sustainability. Agencies cannot make an open-ended commitment to the continued supply of photovoltaic equipment to whoever wants it. If pre-electrification programmes are to make developmental sense, they must be capable of becoming self-sustaining, which means, in effect, that they become self-funding.

In some cases, programmes have been very far from this and equipment has been provided virtually free of charge. There have been numerous accounts of such units being damaged by careless use. It also remains highly questionable whether people will be prepared to invest their own money in replacements when their present units reach the end of their useful life.

Any self-sustaining programme will thus require a system by which families which are provided with units pay a regular fee for their use. The resulting funds can then be managed to provide for repairs and replacement units, thus ensuring the continuity of the system.

None of this is to suggest that the purchase of photovoltaic equipment by individual families should be in any way discouraged. Photovoltaic kits for lighting and other purposes are undoubtedly attractive to those able to afford them. They can also be used by governments and public authorities to provide public services such as street lighting or power for health clinics.

What is much more doubtful is whether funds should be allocated for the dissemination of photovoltaic systems on systematic and widespread basis. In many cases, the present evidence suggests that the financial and managerial resources involved could be better used in the promotion of rural electrification by more conventional means.

Summary

Rural electrification clearly has a significant role to play in the raising of rural living standards and general modernization of the rural areas. Without it, development beyond a relatively low level of economic activity is effectively barred.

Rural electrification, on its own, will not bring about any such development. It can only fulfil its potential in areas which have already reached an appropriate economic level. In such areas, however, it can contribute to a dramatic expansion and diversification of activity, particularly in the service sector, and a marked rise in domestic living standards.

At present, many utilities are running at a substantial financial loss. The result is that they are unable to run their supply systems in a reliable and effective manner. There is an urgent need in many areas for a sharp upward revision of electricity charges to bring them into line with actual utility costs. When considering such tariff increases, it should be borne in mind that the benefits from rural electrification for families, businesses and small industry are extremely large. Moreover, these benefits flow primarily to those connected to a supply who are primarily from the upper income strata of rural society. There are few, if any, developmental or equity reasons why such consumers should not pay the full production costs of the electricity they use. Where private sector suppliers, because they do not have the inefficiencies or diseconomies of scale of utilities, can provide a cheaper supply they should be encouraged to do so.

Where community management of electricity supplies is being considered, it is important to look beyond the choice of technology and consider the management implications. Running a local electricity supply system is not simple and communities need to be provided with the support they need on a long term basis. Ensuring a reliable repair and maintenance service is a matter of particularly critical importance.

The use of centralized photovoltaic power stations does not, at present, appear to be justified on technical or financial grounds. A much better case can be made for the use of individual photovoltaic systems to provide electricity for lighting and other small scale domestic and community uses. But the use of resources for the systematic dissemination of such photovoltaic systems needs to be carefully weighed against the much greater versatility and flexibility of conventional supply options.

In summary, having an electricity supply is an enormous step upward in living standards for rural people. Assisting rural communities to achieve this is a worthy and legitimate target for governments and development agencies. But there are many challenges still to be met before this can be done in an efficient and cost-effective manner.

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HOUSEHOLD AND RURAL ENERGY DATE COLLECTION, MANAGEMENT AND ANALYSIS

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Introduction

The household sector is the largest single energy consuming sector in the LDCs, accounting from 40% to 90% of total energy consumption. Traditional biomass fuels continue to dominate the household sector. Little [reliable] data exist on the supply and demand patterns and trends of the production and consumption of biomass fuels. The ecological impact of continued biomass use fuel is not known, but the available evidence suggests that severe environmental damage may be occurring and that rural households, especially poor ones, must turn increasingly to undesirable fuels for essential tasks such as cooking.

Household consumption represents often a lower percentage of total modern fuel demand. However, consumption of modern fuels in the household sector has been growing at high rates, depending on the fuel. This growth places serious pressure on the already strained modern fuel supply system and contributes to load shedding, shortages of fuels and budgetary problems in a great many LDCs.

The energy issues are different for rural and urban consumers. Most rural people collect their biomass fuels without paying cash, whereas urban people and their non-household sector buy their [biomass] fuels. The issues will also differ per type of fuel, per end-use, and per income level.

Although we will focus in what follows only on energy demand the data requirements to address the above mentioned problems include the following other necessary data collection instruments, to wit: a survey of energy resources and a household energy market structure survey. However, for practical purposes we will here only deal with the energy demand survey.

<u>Background and survey design</u>

The design of a HE survey is usually guided by the following principles:

(a) to obtain the information required to achieve the objectives of the project as much as possible;

(b) execute the survey in a professional manner; and

(c) if need be, transfer the know-how to the relevant national staff through training and hands-on implementation of the survey.

The design includes the following main steps:

(a) determination of the objectives and scope of the project;

(b) conceptual design of the survey and sampling plan;

(c) determination of the scope of issues to be included;

(d) determination of the information requirements;

(e) development of an analysis plan [listing the tabulations, estimates, and analytical procedures];

(f) design of the questionnaire;

(g) enumerator training, pretest of the questionnaire and evaluation of the pretest;

(h) preliminary analysis of initial descriptive output;

(i) detailed analysis; and

(j) reporting and documentation.

From the above it is clear that it is essential before embarking upon any activity, including the formulation of a household energy strategy [HES], to first determine why one wants to start such an activity and what one wants to achieve in doing so. Thus, it is incumbent on an energy planner or a decision maker first to define the nature and scope of the issues that need to be addressed, and secondly, to formulate his/her objectives for a strategy or a set of policies that will positively impact on these issues. Once the objectives have been identified the type and nature of data requirements need to be identified. These data need to be reliable and relevant to the issues to be addressed. They also should enable the energy planner to analyze the underlying energy issues. The data requirements also need to selected with a view to replicability of their collection so as to enable monitoring of eventual changes as a result of new policies and technical interventions. The data need to record actors (male and female), activities, artifacts, and attitudes. Having determined what data are required, the energy planner needs to identify what instruments are needed to generate those data. Having collected the data with the identified instruments analysis can begin, followed by policy formulation.

There are several kinds of surveys: baseline, diagnostic and market surveys. A baseline energy demand survey aims to [a] provide baseline information about the level and pattern of national household energy demand on which to develop policies, and [b] enable the implementation of the policy to be monitored. Such a survey is a statistically representative sample of the target population in both cities and villages. A diagnostic survey aims to survey the impact of policy and technical interventions and/or to analyze one or more parts of the energy sector. These diagnostic surveys usually follow the baseline survey, once a set of policies is being implemented. It would be erroneous to repeat a baseline survey in such a case. A market survey can take the form of an inquiry into the adequacy of cooking equipment (including stove testing) as well as a consumer market-testing survey to determine market interest in options for improved biomass fuel stoves or stoves for modern fuels. In what follows I will only discuss the baseline survey. This survey should include:

(a) a strong socio-economic component;

(b) housing and area information;

(c) family occupation, income and expenditures;

(d) energy use for different end-uses;

(e) appliance ownership and utilization.

Data are also gathered on responses to:

(f) woodfuel scarcity and/or availability of fuels and devices;

(g) price changes of fuels;

(h) access to media and information channels;

(i) attitudinal information on fuel preferences, conservation and fuel switching behavior.

Questions about energy use should not be limited to the level of use, but should also include the pattern of use and the use for different end-uses. In addition, questions should be asked about the price of fuel, the equipment needed to use a particular form of energy as well as people's preferences and beliefs that influence fuel choice. Finally, the demand survey should try as much as possible to capture the dynamic aspect of energy use rather than the static picture. Ideally the survey should be repeated to capture seasonality factors. In short, the survey should provide relevant data necessary for useful energy planning.

Development and Execution of the Survey

The sampling procedures. There basically are two kinds of sample designs: [a] probability samples and [b] non-probability samples. In case [a] every element in the sample at different stages of selection is chosen with a known probability or randomness. In case [b] subjectivity enters into the selection, which is often purposive. Because subjectivity presupposes a good knowledge of the [energy] sector characteristics of the population to be surveyed it is best to avoid purposive samples, and to use it only when random sampling is not appropriate.

The basic issue of sample design is: how to select a sample. The standard procedure of sample selection is to list all households and to randomly select a sample of households from that list. However, often such lists do not exist and even when they do exist it can be costly to survey this sample which may be very scattered. Usually a stratified, multi-stage design approach is followed, which is more efficient from the cost and management point of view. This means that a population is divided into strata or groups and samples are selected from each stratum. This is done to reduce the variability of the characteristics within each stratum. The strata are made as homogeneous as possible within themselves re a variable which is correlated with the study variable. The sampling procedures and sample design can be different between the various strata. Because stratification control variations, it is possible to have a relatively small sample, with the same level of precision as a large unstratified sample. The following variables are often used for stratification: regions, rural-urban, size of town, agro-ecological zones, income level, availability of electricity.

For urban areas in Botswana, for example, the ESMAP team adopted multi-stage sampling design to capture important variations between towns. The sample was divided between small, medium and large towns; then by dwelling types, i.e.: high cost, medium cost, low cost and SHHA (= social housing projects). The final stage was by household (see Annex 1). If there is not a proper listing, but there is a list of villages, for example, one usually selects a sample of villages from that list, and from each selected village sample households may be selected after making a complete list of all households in the sample village. The households then are selected at random.

"In Botswana, to stratify the sample, the number of high, medium, low cost and SHHA areas in each stratum was calculated. These were then multiplied by 2.977 per cent [or the percentage sample, i.e. the number of households of the sample as a percentage of the total number of households] to derive the proportion of each stratum (H/C, M/C, L/C, SHHA) in the sample. The table below illustrate how the procedure was done for Gaborone".

Table 1

Gaborone Sub-Sample by Type of Dwelling

Gaborone	Dwellings	Sample fraction	Fraction (actual)
High cost	3229	99	120
Medium cost	4533	135	120
Low cost	3507	105	120
SHHA	8905	265	240
TOTAL	20274	604	600

An important question is: how big should the sample be? This depends on the acceptable margin of error. This depends, i.a, on the identification of the study variable for which the margin of error is referred to. Therefore, often several variables are studied and analyzed. In stead of asking, e.g., about total energy use, estimates on the use of individual fuels are also obtained. Taken separately, each fuel would require a different sample size based on a fixed margin of error, considered jointly their conflicting claims must be reconciled. Therefore, the larger the sample the higher its significance, esp. when there are several levels of stratification. However, budget constraints, schedule limit, and the availability of personnel and supervision are also important parameters in determining the optimum sample size. However, irrespective of cost and time constraints, the sample size must be large enough to cover the variation of the population, capable of being enumerated and analyzed within a reasonable time limit, and permit generalizations to be made about energy demand of the targeted population.

As far as non-response is concerned one should, ideally, use an existing listing and a household substitution procedure which allows one to replace the non-respondent household with one of the same socio-economic profile. However, as stated above, often listings are lacking. In such cases, often a number of households are added to the sample to make up for expected non-response, although non-response sometimes is dealt with by selecting, for example, the next house.

Questionnaire design; data collection takes place by using a pre-coded structured questionnaire. Usually several drafts are prepared and reviewed by the various partners [Ministries of Energy, Forestry, Rural Development, etc.] interested in the survey, before a final version is adopted. The design of a questionnaire is governed by five considerations.

(a) to prepare all questions so that they match the information needs of the project of which the survey is a part; these information needs are partly based on an a priori hypothesis on the impact of certain variables on energy consumption (see para 2.39);

(b) the questionnaire needs to reflect the local conditions in the country/area to be surveyed;

(c) the survey has to be easy for the enumerators to administer;

(d) questions require common simple wording to facilitate responses; and

(e) the designed length of each household interview should ideally be limited to 30-45 minutes.

The types of information to be collected include: the present and recent pattern of energy use by socio-economic group, including fuels used for each household end-use, how fuels were obtained, recent trends in fuels utilized, basic fuel preferences, appliances owned, utilized and preferred, and other influential attitudes, beliefs and practices affecting fuel and appliance usage.

For example, a recent HES questionnaire carried out by ESMAP in Zambia consisted of four parts and collected information on the following subjects:

(i) Socio-economic situation. This included questions about name, sex, age, occupation and educational level of the responding head of family, family size, type and quality of dwelling, cash income level and total monthly expenditures.

(ii) Household Energy Consumption. This section had questions on type, quantity, frequency, end-use and source of energy used by the responding household during the last year. Also, information was collected on price, seasonal variation, source of supply and availability, means and cost of transportation, and types of appliances used and frequency of use. Pictures and/or drawings were used to facilitate identification of cooking devices and appliances.

(iii) Household Cooking. This part included questions on cooking practices, consumption and preparation of major staple food, use of different kinds of stoves and the fuels used.

(iv) **Attitudes Towards Different Fuels.** This section had questions on the respondents' fuel switching behavior during the past two years, their willingness to switch to a new fuel, and the reasons for an actual or desired change.

If the survey also has a rural component, which the Zambian one had not, section (i) would have included questions relating to plot acreage, output of cereal and cash crops, animal herd size and use of open access land. In addition, a separate section on 'Local Energy Resources' would have been included covering fuelwood felling, planting, straw and stalk utilization and soil erosion situation compared to five years ago.

It is important that enumerators keep to the order of the questions during the interview, starting at the beginning, finishing at the end. However, because the questionnaire addresses different groups of respondents one does not need to ask all questions of each respondent. If, for example, the respondent replies 'No' to the question: does he use firewood", then the enumerator skips the part about firewood. This skip pattern is indicated in the questionnaire (see Annex 2)

From the questionnaire in Annex 2 , it is also clear that there are two types of questions: open-ended questions and closed questions. Open-ended questions call for the enumerators to write down the answer in the space provided for this purpose. These questions are not pre-coded. The answers can be a number (number of people living in the household), a name (of a market), or the question asks the respondent to specify his/her response (see e.g. Q C5). Closed questions provide alternative answers, one or more of which have been pre-coded. The answer to a question may be "Yes" or "No", for example, and the enumerator only has to write down the code for "Yes", if the respondents replied in the affirmative.

Recruitment and Training

Energy questionnaires are more problematic than of any other socio-economic surveys. There are problems of concepts, measurements and estimation. For example, classification of end-uses, heating appliances and fuels are issues that enumerators need to decide upon based on the definitions agreed upon by the survey design. For some of these problems uniform solutions have been found, while for others different methods apply, though it can be argued, none are as yet ideal.

The training of the interviewers, therefore, is a very important task for any survey, because the quality of the interviewers decides the quality of the survey. In most LDCs, socio-economic surveys and opinion polls are not as common as in the DCs. Consequently, there is hardly a supply of experienced interviewers in most countries. Therefore, interviewers often have to be recruited specifically for the project. This is not always easy, in particular in countries where the number of high school graduates and/or university trainees, the standard pool of interviewers, is limited. Sometimes, such as in the case of the Cape Verde, we even had to use elementary school graduates due to a lack of available high school graduates.

Because household energy issues mostly concern housewives one should try to recruit as many female interviewers as possible. This holds especially true for countries where men from outside the immediate family are not supposed to have contacts with female members of the household. In these cases, it is also necessary to employ male interviewers, because it is considered inappropriate to have a female enumerator to interview a male respondent. This situation occurs mainly in Moslem countries which apply the strict rules of 'purdah'. In addition to enumerators one also needs to hire supervisors, who ideally should have had previous experience with surveys. The enumerators are either recruited via radio messages announcing that the project is looking for candidates for survey work who satisfy a certain number of qualifications and/or via contacts with related professional organization such as Ministry of Planning (statistical service) and the University (sociological department).

Because most enumerators do not have any experience with surveys, or if they have, they are new to the field of energy, a customized and carefully designed training program needs to be developed. Depending on the complexity and size of the questionnaire the training program ranges from one to two weeks. During that period the training will cover the following topics:

(a) the objectives of the project; this usually also includes background information on the economy, the energy situation and why this requires the kind of project the trainees are involved in now.

  (i) the types of information to be collected.
  (ii) the conduct of the interview, and
  (iii) how to record, encode and edit questionnaires.

(b) the conduct of the interview; a carefully worded, but brief, introduction to the questionnaire will serve to prepare the respondent for the interview. Because many people are skeptical of surveys, and some even afraid, the introduction should essentially provide the respondent with a general background of the survey. This should include:

  (i) who you are, and what agency you represent;
  (ii) the purpose of your visit;
  (iii) how the household was chosen as respondent;
  (iv) what information the family will be asked to provide.
  (v) how this information will be used.

Further, during the training, information is provided on the interview itself and how to act as a good enumerator. This includes: gaining the confidence of the respondent; maintaining of neutrality during the interview [no leading questions!]; trying to control the interview, and avoiding expectations and misunderstandings.

The coding scheme and how to record, encode and edit the questionnaire; all enumerators should know that the questionnaire is pre-coded for computerization purposes. Appropriate boxes for answers are provided on the questionnaire form according to the possible number of answers (see Annex 2). To ensure uniformity and avoid mistakes enumerators should be trained in the proper legible and filling out of these boxes. For questions with the answer "other" the enumerator has to write the specification of the answer in the margin. Editing of the questionnaire forms should be done immediately after the forms are returned from the field. The supervisors must check for errors in data entry and computation.

Usually, these topics are written up in a questionnaire manual which discusses each of these points in detail. Also, the manual is used as a text book during the training course and serves as a guideline for the survey staff which they may consult in the field, in case of doubt.

In countries where more than one national language is spoken the questionnaire usually is translated into the relevant local languages. For example, in Zambia we had a questionnaire in English and the three main local languages; in Pakistan in Urdu and English. In these cases it is necessary to divide the enumerators into groups according to the language spoken in the different areas that are covered by the survey. This regrouping of the enumerators is necessary to allow them to practice among themselves in their respective languages.

Although the training course partly serves to motivate the enumerators its main focus is on the understanding and the handling of the questionnaire. This also requires that the enumerators are taken into the field to practice what they have learnt, in particular to test their ability in dealing with the questionnaire and the respondents. At the same time this field practice may serve as a test of the questionnaire itself.

Based on the results of the training course the final number of enumerators and supervisors are selected. This means that you wish to preselect more enumerators and supervisors than you will really need. Apart from the selection procedure there are also other reasons to preselect a higher than required number of trainees. It is usual to see that people drop out during or prior to the training course. The reasons for this are various and range from finding other more attractive employment, illness, and opposition by the family. The latter is often the case with female enumerators, when male family members (father or husband) object against working late or staying overnight in the field.

Information and Sensibilisation

The success of the survey is influenced by the measure of cooperation by the local authorities, and in particular, by that of the respondents. After all, people are not accustomed to surveys, which, moreover, often ask questions that many people consider to be improper. This holds not only for the obvious ones, such as on income and expenditure, but also on social related issues.

Therefore, it is important to inform the local authorities in the areas that one executes the survey well in advance of field execution. Official letters should be sent to heads of counties, prefectures and its subdivisions. In those areas where traditional chiefs also play a role, such as the village chief or the chef du quartier [ward chief], one preferably would pay them a visit to explain the purpose of the survey and ask them to inform their constituents about them.

These personal contacts may not always be possible, because of time constraints. Therefore, it may be necessary to mobilize the population's support, particularly the future respondents', for the survey through a media campaign. Depending on the amount of money available the following media can be used: targeted mailing, radio, tv, and newspapers. The mailing can take place to government officials, who in urban areas, often constitute a major part of the work force. Via the other media on may reach most other potential respondents. The media coverage should take place not later than one week prior to the survey and continue at the beginning of the survey. This means that the media campaign may last weeks, if the survey is carried in a staggered fashion, i.e. by moving from one area to another weekly.

Pre-test

The execution of the pretest is usually done after the completion of the training course, although in some cases it is combined with it. The purpose of the pretest is twofold. The first reason for pretesting is to determine whether the questions have been formulated in such a way that the respondent understands them and/or will be able to give a useful answer. The second reason (especially in the case of large and complex surveys) is to test the logistics of the survey. I.e. one wishes to establish that the time allowed per survey unit, the size and composition of the enumerators' group, and the number and size of cars are adequate to complete the survey on time.

As a result of the pre-test questions are usually dropped, whilst others are changed or new ones added. For example, the pre-test of the Indonesian UHESS demonstrated the importance of inter-household electricity sales, with the metered households selling to their neighbors. As a consequence questions relating to this important issue were added to the questionnaire.

Ideally, the group of enumerators is split into two groups. One group is basically left on their own, while in the second group a supervisor is present during the interview to observe the behavior of the enumerator and the respondent. The results of the two groups are later compared with one another and discussed with the enumerators. However, usually only one group is formed which executes the survey under close supervision of the supervisors and the survey designer[s]. The sample of the pretest should be ideally a sub-sample of the survey's sample. If the sample of the survey comprises: urban [large., middle, small] + (high, middle, low income) and rural (high, middle, low income) + [pastoral, agricultural] the same stratification should be applied in the pretest. However, in practice the pre-test is administered to a small group of either a small group of urban and/or rural households for financial reasons. Depending on the size of the survey and questionnaire the pretest requires several days to two weeks.

Field Work

Depending on the size of the survey there is one supervisor for every 3 to 6 enumerators. The latter form one team for which the supervisor is responsible. The supervisors accompany the enumerators to the field and assist them in case of problems. The supervisor is responsible for the proper identification of the housing units. In very few countries urban houses are numbered, whilst this certainly is not the case in rural areas. Therefore, identification of the houses to be interviewed are important. In Botswana the following solution was found:

> "Before an area was enumerated the sample households were first located and a brightly colored identification sticker placed on the front door or on somewhere easily seen. Another brightly colored sticker was placed in the same spot if the household was enumerated successfully. To signify "call-back" an alternate sticker was placed by the enumerator. The sticker system was particularly useful in the large villages where it was often difficult to identify dwellings where selected households were located"

The supervisor also is responsible that the questionnaire is properly filled out. To that end the supervisor needs to check each questionnaire at the end of each working day. If mistakes are found the enumerators need to be sent back to the respondent to get the full answer[s]. Apart from the supervisors, the survey designers also should make spot-checks to ensure that supervisors and enumerators carry out their work correctly. If need be, one should not hesitate to dismiss incompetent staff on the spot.

The respondent can be the head of the household or his/her spouse. In case of a special female section of the questionnaire the respondent should be preferably the [main] wife.

But any female adult household member who is knowledgeable about household matters may also be the respondent.

The teams should be organized in such a way that the logistics are optimal. In cities, usually one quarter is covered per day, for example, with figures that indicate the size of the quarter versus staff field requirements. For rural surveys, distance and accessibility have to be taken into account. This sometimes means that some teams have to wait for a car until one vehicle is available from other teams.

If a respondent is not at home one either makes several visits to get hold of him/her, or, in case of difficult communication, one applies the substitution procedure. Also, after two to three visits the house may treated as a non-response. Call-backs may be prove to be more difficult when houses cannot be properly identified, either because the respondents had removed the census number from their house, had changed the color paint of their door, or were known locally by a nickname instead of the official name that was given during the interview.

Office Work

The office work is usually carried out by qualified and trained staff under the direction of the survey designer[s]. The tasks performed consisted of the following:

(a) checking the questionnaires (major parts missing, not at home; readability and completeness of answers; proper coding);

(b) data entry into the computers. The software used in data entry and analysis should be taken into account during the design of the questionnaire. If SPSS is used, the questionnaire should be broken down into several files [less than 500 variables each due to SPSS/PC constraints]. Each file has the same survey and household identifier variables. The remaining variables depend on the files topics, which may be functional of fuel-specific: for example,

File One - General
File Two - Cooking
File Three - Lighting
File Four - Electricity
File Five - Kerosene
File Six - LPG and
File Seven - Biofuels

There may be some overlap between the files. To the extent that the file organization is successful, there should be a single file providing all of the variables relevant to any given substantive issue. Different agencies are likely to be interested in a different subset of files.

In many cases the variables are not directly from the validated survey data, but are derived from computations. Most conversions are straightforward and require simple linear transformations, but in some cases more elaborate procedures are required.

> For example, in the Indonesia UHESS, "the most complex data processing was for the estimation of electricity use by appliance. Three sources of information regarding appliance energy use were employed: (a) survey-based estimates of wattage and

hours of use available for every household; (b) crude technical estimates of expected appliance use for "average" appliances sold in Indonesia; and (c) statistical analysis of the relation between appliance use and recorded electricity consumption. The first source alone was insufficient. Top a rough approximation, hours of use times appliance wattage equals watt-hours of electricity consumption. However, there are appliances for which hours of "use" are not equivalent to "on-time" (e.g. automatic water pumps and refrigerators), the wattage information collected is not appropriate (e.g. it may be maximum wattage) or systematic mis-estimation occurs (e.g. it is more likely for households to omit lamps that exist than to include ones that don't)".

Calculation of extrapolation factors; Before any analysis can take place it is necessary to check if the sample as it is represents the true picture of the population. This is done by checking if the different strata are proportionally represented in the sample; if not (which is the most usual case due to overrepresenting of some minority groups or use of a particular fuel or technology for better significance) then a correction of the sample must be done by introducing appropriate weighing factors. This exercise assumes that the structure of the present population is already known which may not always be the case. However, an estimate of the basic information needed may be done, if one has carried out a listing prior to the survey as was the case in Zambia.

"As the results of this study were aimed at being significant at the level of the type of town, the following two steps were carried out:

(a) calculating the average number of households per Standard Enumerator Area (SEA) for the three types of towns taking into consideration the standard of the areas in the case of large and medium towns;

(b) estimating the total number of urban households for the three types of towns by multiplying the average number of households per SEA by the total number of SEAs.

Table 2

Estimate of number of Households for Urban Zambia by Type of Town (for towns over 5000 people)

Total number of SEA's	Average number of households per SEA	Total number of households in Zambia	Percentage (%)
Large towns	1538	186	56.8
Medium towns	907	907	26.5
Small towns	382	382	16.7
TOTAL	2877	178	100

Data cleaning or consistency check takes place after data entry. The information in each record is checked for consistency to minimize errors. Most errors have been already identified and corrected during field supervision. However, at the end of the field work errors may remain. For example, the skip pattern (which requires the enumerators to skip certain sections of questions) may not have been strictly applied. Further, control questions that have been built into the questionnaire need to be checked on their consistency. Further, the final end-use of various fuels needs to be checked with the answers about applications. Finally, income-related questions need to be checked with expenditure data.

Analysis of the data. The design of the questionnaire is based on certain hypotheses, and the questions are formulated in such a way to test the impact of certain variables of the level and pattern of energy consumption. For example, is there a relation between income level and household energy consumption? Is there a relation between household and/or city size and the pattern and level of energy consumption. Therefore, simultaneous with the questionnaire design, the survey designer[s] also will draw a list of tables that will shed light on specific situations and bear out, or not, the hypothesis that is at the basis of the questionnaire's design. Having such a list of required tables prepared beforehand facilitates analysis considerably. (for an example of such a list (see Annex 3). In fact, one should have one's plan of analysis ready well in advance, for without it, analysis will take a long time. One may, of course, go beyond the limits of the analysis plan and analyze the survey data at even greater length. However, given time and resource constraints, it is best to stick to one's analysis plan.

After identification of the important variables that effect energy consumption it is of importance to know which ones are more important than others. One can achieve this through further cross reference of these variables. For example, if income and city size have an impact on energy consumption, one could classify for each income group the energy consumption per city size. If there is not much difference between the energy consumption of income groups in different sizes of city then one may conclude that income is the more dominant factor. However, this is a method that may be used if the number of variables are limited. If there are many variables this method is too cumbersome, also because the frequencies of the variables may be too small to be statistically significant.

Therefore, regression analysis is used to express the functional relationship between a dependent variable (e.g. energy consumption) and a set of explanatory variables (e.g. socio-economic factors). This method also allows one to quantify the relative contributions of the different factors in the variability of energy consumption.

Survey Report

Apart from the findings on the energy sector of the country/area surveyed other results also are generated by the survey. The most important, for our purpose, are the problems encountered in survey implementation. For despite all the careful preparation of the survey design, the questionnaire, the training and the pre-test, problems will arise. In a rural survey of Chinese counties the following were encountered:

(a) The number of questions on certain topics was not satisfactory. For example, questions on oil products took up considerable space, though farmers used only limited amounts of kerosene for lighting and practically no petrol and diesel oil. More questions should have been allocated to the use of stoves in all counties and stove-linked beds in Kezuo county.

(b) Some of the questions in the survey were not well designed. In the case of straws, stalks, tree leaves, grass, weeds and dung, their major uses as manure, feed, raw material and fuel and other uses for meal and pig fed cooking, heating and other purposes were completed only if the households used them as fuels. This caused some confusion and in the future such questions should be answered by all households in the sample.

(c) All the units of measurement in the questionnaire were those traditionally used by local farmers. This caused errors in recording and data entry.

(d) County-town households used the same questionnaire as the rural households and this resulted in the asking of inappropriate questions in many instances.

(e) The sample for measuring household fuel consumption was too small (36 households in one county). And the duration of the measurement was too short (only three days). The fuel measurement survey was unreliable due to time-specific measurement error.

(f) No questions were asked concerning the heat efficiency of different stoves or on the methane generating rate of biogas pits.

(g) Not enough time was allocated for completing the survey, including data input and processing by computers.

(h) There were not enough computers (one unit for each county). The work of the Chinese expert team was hindered by lack of its own computer.

It is important that such problems are reported so that future mistakes can be avoided at the project and survey design stage.

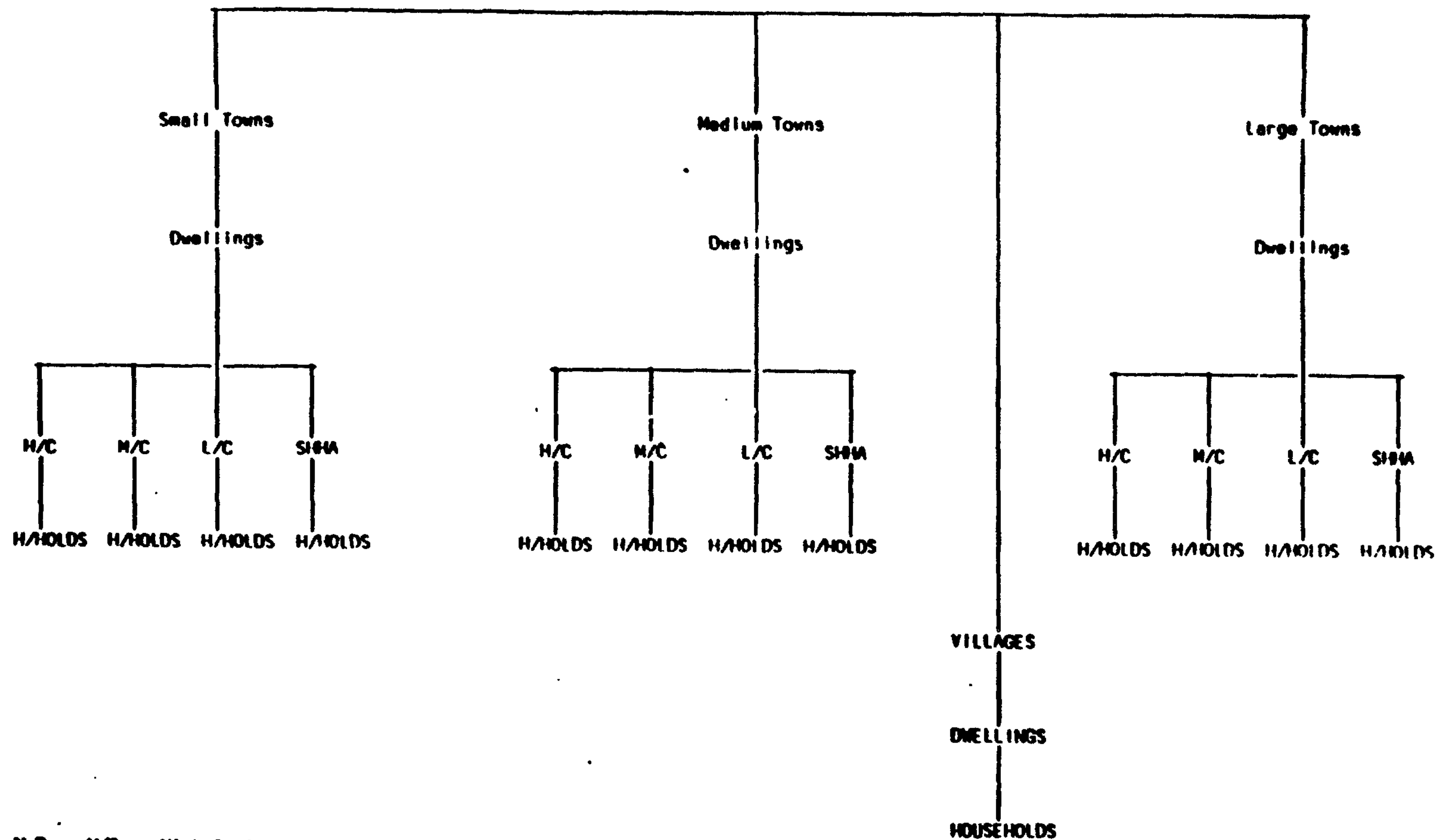
The household energy survey provides the data which will allow energy planners to make forecasts about the development of the <u>level</u> of energy consumption, how it will grow, for which segments and locations, and what the possible growth rate may be. Overall energy demand is relatively easy to project, for it is mainly influenced by two variables, viz. household income and household size. Using regression analysis, a demand projection using these two variables will yield a good approximation of total future energy consumption. However, this method is not good enough to project the <u>pattern</u> of demand. To do so, requires taking into accounbt other variables such as availability, fuel preferences, and relative prices (see for more information my companion paper on the determinants of fuel substitution). Data on relative prices, fuel preferences and availability should have been collected as part of the baseline survey. In addition, data should be collected from industry and government sources on estimates with regards to the extension of the grid, increase of power supply, increase of LPG and kerosene imports [or production] and growth of coal and/or natural gas production. Similar assumptions need to be made concerning the growth of crops and animal husbandry.

Having collected all required data overall energy demand can be estimated, while the pattern for different fuels will be arrived at by projecting their growth based on their availability, fuel preferences, and relative prices. Usually prices are held constant or a certain annual growth rate is assumed. Another approach is that of econometric modelling, where the growth of individual fuels is projected, taking into account the relevant variables and the interdependence among different fuels.

A successful survey and the subsequent review and analysis [based on survey results and other data] of the supply-demand situation as well as of the relevant issues and options would yield a comprehensive and realistic household energy strategy, consistent with the country's macro-economic and budgetary situation, based on available energy resources, demand management and interfuel substitution options, fuel pricing and institutional issues.

Annex 1

Table I : METHODOLOGY
MULTI STAGE SAMPLING
URBAN HOUSEHOLDS



N.B.: H/C = High Cost
M/C = Medium Cost
L/C = Low Cost
SHHA = Self Help Housing Association

FIREWOOD

CODES

1. During the past month, how often did your family use firewood?

Frequently	1		Q072
Seldomly	2		
Do not use	3		

2. During a normal month when your family uses firewood, roughly what percentage is used for each of the following activities?

	PERCENTAGE	
Cooking, Boiling Water, heating rooms	%	Q073
Space heating only	%	Q074
Home-based Business Activity	%	Q075
Other, Specify:____________	%	Q076
Total		

3. How does your family get firewood?

Collect Only	1		Q077
Purchase Only	2		
Both Collect and Purchas	3		

4. How many days ago did you last buy firewood? Q078

5. In which form was the firewood bought? Q079

Small individual log	1
Large individual log	2
Small bundle of split logs	3
Large bundle of split logs	4
Half cord	5
Cord	6
Bags of offcuts	7
Headload	8
Scotch Cart	9
Pick up load	10
Other, Specify: __________	11

6. How many of these units of firewood were purchased at that time? Q080

7. For how many more days will this firewood last, before more will be purchased? Q081

8. What was the price paid for a single unit of the firewood your family bought at the last purchase? $ Q082

9. Where does your family most often go to purchase firewood? Q083

Wood venders deliver door-to-door	1
Go out to buy it from wood venders	2
Buy it from wood shops	3
Buy it from service stations	4
Buy from farmers	5
Other	6

Specify ____________________

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For rural energy

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113. Total cultivated land by village/province/household
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