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PREFACE

During 1983–84 the Pacific Island Energy Studies Project initiated field studies of rural electrification projects in various Pacific nations. Field study programs were undertaken in Papua New Guinea, the Cook Islands, the Federated States of Micronesia, and Fiji. In late 1984 the field researchers—together with rural electrification experts familiar with projects elsewhere in the world—met in Honolulu to discuss study results. The following papers synthesize these discussions into a general policy framework.

No single field study or expert opinion led directly to the policy suggestions. Indeed, the range of experiences was so broad that study conclusions were sometimes contradictory. Thus, the suggested policy framework should be seen as a starting point in the formulation of a local RE policy rather than as a ready-made prescription for RE policy.
EXECUTIVE SUMMARY

Rural development is accorded a high priority in the national development strategies of the Pacific island nations. The supply of electricity to areas outside of towns and administrative centers is consistent with these strategies and is desired by rural people.

Early rural electrification (RE) projects generally have fewer customers, lower-growth rates, and greater operational problems than originally anticipated. They have provided a less reliable and more costly service than planned and have often worked counter to other development objectives by draining income from rural areas.

To control the costs of RE, more attention must be paid to estimating specific end-use applications. Although site visits are a prerequisite to obtaining realistic estimates of end-use demand, we propose that rural welfare should be regarded as a legitimate objective of RE and that communal end uses plus household lighting should form the planning base for welfare projects. Also, rural economic projects requiring electricity must be accompanied by provision of credit, skill training, transportation, and marketing services, in addition to electricity, if they are to generate rural income.

The choice of RE technology depends on the quality of service requirements, as well as the quantity. A reliable electricity supply is critical to achieving both economic and welfare objectives. 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 engines, photovoltaics, microhydro plants, and reciprocating steam engines. In technology selection, more attention should be paid to local conditions, social acceptability, and maintenance.

The ability of rural people to pay for RE is an important policy question. Evidence suggests that rural people can contribute substantially toward front-end costs through cash remittances from urban relatives, labor, and physical resources. The remainder of these costs can be requested from overseas donors. The recurrent cost component constitutes the main problem. The large operation and maintenance costs of RE are not likely to be met from the incomes of rural people or from overseas sources. Governments must accept the need to provide recurrent subsidies to RE programs. What percentage of the national annual budget is proper for RE is a difficult question. Determination of an appropriate RE subsidy level should be in direct relationship to the costs and benefits of other rural development priorities.
Rural people should have significant input into the planning of their electricity projects. A lack of consultation or information may cause rural residents to lose interest in using and maintaining electricity facilities. Rural people alone, however, cannot maintain RE facilities. Technical support services are also needed. Planners must coordinate their inputs of administrative and technical people in the Pacific islands at four levels of administration: the international Pacific region, the nation, the district, and the community. 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.
Introduction

Rural electrification (RE) programs, like all rural development programs, have one or both of two basic objectives: to increase rural welfare and to increase income-producing rural activities. It is important to remember, however, that electricity is but a means to an end. Poorly conceived RE projects can degrade, as well as improve, rural welfare and reduce, as well as increase, rural incomes. The contribution of each end-use opportunity for electricity to development in social services and economic activities must be examined closely. RE projects should be planned to achieve specific end-use goals that clearly increase welfare and economic objectives. Obviously, the chosen end-use goals for RE must reflect the priorities and preferences of rural residents because the success of RE ultimately depends on these people and their willingness to use and maintain electrical facilities. Identifying RE target groups and including community leaders of these groups in the decision-making process for proposed RE projects are the keys to achieving an electrical service that reflects rural realities and interests.

To assist in the formulation of RE project descriptions that provide details on end-use applications and target groups, this paper summarizes the findings of PIDP's impact studies of early RE projects in Fiji, the Cook Islands, the Federated States of Micronesia, and Papua New Guinea. It outlines the social and economic changes that have been associated with each end-use opportunity for electricity. It identifies the main users of each end-use application for electricity and suggests factors that have particular end uses by rural people. This information is provided first for welfare and second for income-producing RE projects.

Rural Electrification and Rural Welfare

Potential End Uses

Improved welfare is perceived by rural residents to be the foremost benefit of RE. Household lighting is the most important single way in which electricity is being used by rural residents. Some electrified rural households use a few electrical appliances in addition to electrical lighting. Electrified rural villages sometimes also use electricity in communal facilities, including meeting houses, churches, health clinics, and schools. Electricity is rarely used for public lighting.
Benefits of Household Lighting

Through the substitution of electricity for kerosene and benzine lighting, rural households in the Pacific islands have anticipated and realized a number of social and economic benefits. These benefits, in the approximate order of frequency with which they have been cited by rural households, are: (1) cheaper lighting, (2) cleaner lighting, (3) more convenient lighting, (4) better quality light, and (5) higher status. Each of these benefits requires elaboration; otherwise they may be misconstrued.

Rural households that have switched from the use of kerosene and benzine in pressure lamps for lighting to electric lighting have generally saved money, although the opposite has been true for rural households that have switched to electric lighting from the use of kerosene in standing or hurricane lamps. Electric lighting is cheaper than kerosene and benzine pressure lamp lighting because rural households are often charged a flat, heavily subsidized electricity tariff, whereas they are required to purchase kerosene and benzine at or close to economic cost. The subsidy in the electricity tariff results in rural households using an energy form for lighting that is more expensive for the nation. Removal of the subsidy RE might render kerosene and benzine cheaper energy forms than electricity for lighting for both rural households and the nation. Whether rural households would be willing to spend more money on electric lighting because of the nonfinancial benefits they receive is a matter that requires further research.

The nonfinancial benefits of residential electric lighting include a healthier home environment because electric lighting is cleaner than kerosene and benzine lighting. Electric lighting is also valued by rural households because it is more convenient than kerosene and benzine lighting in the sense that it is readily available at the flick of a switch. Nevertheless, most electrified rural households continue to use kerosene and benzine lamps in addition to electric lights because electric lights are available in only a few locations, for a few hours per night, and on an uncertain basis because of the unreliability of power supplies.

When available, electric lights are favored over benzine and kerosene lamps, however, because they provide better quality light. Household members use the better quality light provided by incandescent bulbs and fluorescent tubes in two main ways. They work on their handicrafts and they read and write. However, our studies suggest that they do not necessarily increase the total time that they spend on handicraft and study activities. Members of electrified rural households reported that they had merely changed the time at which they carried out these two activities—from day to night.

Although the precise patterns in which rural people reallocate time as a result of the availability of residential electric lighting remain unclear, it is evident that these time reallocations are made mainly by women and children. The reason is that the activities performed by women and children of the rural Pacific are centered on the home more than are the activities performed by men. Women and children are responsible for the performance of home duties. Women are the principal makers of handicrafts, and children study as part of their formal education program. Therefore, these groups are the principal users and beneficiaries of household electric lighting.

Not all of the perceived benefits of household electric lights are related to tangible uses. Perceived status and prestige have also been strong determinants of rural Pacific islanders’ positive attitude toward RE. Electric lights are highly visible symbols of progress and development. Both users and nonusers of electric lights perceive them to have tangible and intangible advantages over other forms of lighting. Our studies suggest, however, that
some households with access to RE have not adopted residential electric lighting either because wiring costs are too expensive or because household members are concerned about safety.

The Double-edged Impact of Electrical Appliances

While lighting is the most important single way in which electricity is being used by rural households in the Pacific islands, some households also use electricity to run a few electrical appliances. These households occupy the higher socioeconomic positions within the community or have urban relatives who provide them with electrical appliances and money. The pattern of ownership of electrical appliances has been similar among these households regardless of their country of origin. Irons, jugs (e.g., electric kettles), and fans have been the most popular appliances, followed by freezers and video machines. The consequences of the use of these electrical appliances may be far-reaching and affect the lives of both owners and nonowners in sometimes undesirable ways.

Electric irons have two advantages over the commonly used alternative, benzine irons. They are more convenient, and they are cheaper to run because of the large subsidy in the electricity tariff. Of course, rural Pacific islanders, like all people, take pride in their appearance, and many rural households that did not use irons prior to the introduction of RE may now be using them to improve their appearance. For these reasons electric irons are often highly valued by rural Pacific islanders.

On the other hand, electric irons sometimes are a point of contention among community members. The reason is partly technical and partly behavioral. Electric irons have large power requirements relative to the electrical output of many of the early RE facilities, and their owners use them at their prerogative and usually at about the same time. The result is systems overload and consequent systems breakdown, much to the displeasure of all members of the community, particularly those members with access to electric lights but without access to electric irons. Similarly, the convenience of electric jugs for the boiling of water can be lost abruptly if their pattern of usage is not controlled, because they can quickly overload small RE facilities. In contrast, electric fans to improve thermal comfort require relatively small amounts of electricity. Nevertheless, the additions they make to total electricity requirements need to be taken into consideration when designing an RE system.

In addition to irons, jugs, and fans, freezers are owned by a small minority of electrified rural households. Again, as a result of the subsidy, electric freezers are often cheaper to run than kerosene freezers. Freezers enable rural islanders to stockpile perishable foods, particularly protein goods. Instead of giving away or exchanging that portion of a slaughtered pig or chicken carcass or a day's catch of fish that they cannot eat themselves, members of rural households with access to a freezer begin to stockpile these products. This enables them to increase the regularity of their protein intake and hence improve their nutritional status and general health. Additionally or alternatively it enables them to accumulate protein surpluses until they have a large enough amount to make the sale of these products in nonlocal markets worthwhile. While households with freezers gain from this fact, households without freezers apparently lose. They are obliged to continue to give away their excess protein products, but they no longer receive in exchange the protein surpluses of households with freezers. While this conclusion remains tentative, we believe the protein implications of the use of freezers by some households and not by others requires careful nutrition research.
Video machines, like freezers, are owned by only a small proportion of electrified rural households, that is, those households with relatively high incomes or urban relatives with jobs. Video machines provide a novel source of entertainment, which their owners often share with nonhousehold members for a small fee. The impact of video on rural people is double-edged, however, and can easily have a negative as well as a positive impact. Teachers in the rural Pacific have reported that access to video machines sometimes interferes with their students' study practices and their performance at school because they stay up late at night watching video films. Further, these films can raise expectations that cannot later be met and can erode local cultural values. Clearly, the use made of video machines in the rural Pacific requires more attention, especially given that the size of the video industry in Pacific island countries and the number of video machines owned by rural Pacific islanders is increasing rapidly.

All of the aforementioned electrical appliances are high priority appliances among rural Pacific islanders. Indeed, these electrical devices are usually acquired by rural households within the first two years after electricity becomes available to them. Thereafter, growth in appliance ownership is substantially slower but continues to increase. After the introduction of RE 15 years ago, our surveys show that electric water pumps, sewing machines, washing machines, food processing equipment, and cooking devices were also found in a few electrified homes. Evidence suggests, however, that growth in appliance ownership drops off markedly at about two years after RE is introduced for one or more of the following reasons:

1. Spare parts for appliances and people with the skills to maintain and repair them are scarce, thus dampening interest in the acquisition of additional appliances.
2. Rural households do not perceive electrical appliances, other than the initial irons, jugs, fans, freezers, and video machines, to be of special advantage to them.
3. Rural households lack money with which to buy electrical appliances and are dependent upon the generosity of their urban relatives for electrical appliances.
4. Rural households are restrained from owning additional electrical appliances because they lack adequate and reliable power supplies.

Advantages of Electric Lighting and Power Points in Communal Facilities

While households with higher-cash incomes or urban relatives with wage employment tend to benefit most from the private use of RE, the community as a whole benefits from the use of electricity in communal facilities. Lighting is the main way in which electricity is used in churches, meeting houses, health clinics, and schools. In meeting houses and schools, however, the use made of electric lights may not be as expected. When fitted with electric lights, meeting houses are used on different nights by village women's groups as a venue for their handicraft activities, by youth groups for their meetings, study sessions, and social functions, by school children for indoor sports, and perhaps also by village leaders for their meetings. Because the electric lights in meeting houses are used for some of the same purposes as residential electric lights, community lighting is perhaps a means of dampening the demand for residential lighting. In rural schools, on the other hand, electric household lights are often used as a means of enticing teachers to teach in remote areas. Electric lights installed in classrooms are occasionally used during the day but are rarely used at night for study classes or adult education, because the skilled personnel required to run these activities are generally not available. It is also noteworthy that the use of RE for public or street lighting is not common in the Pacific islands. Rural Pacific islanders apparently do
not perceive the need for public lighting unless it serves a specific purpose such as navigational lights for fishermen or roadside lights for motorists.

In addition to electric lights, sometimes power points are available in communal facilities. In meeting houses power points are used by private individuals mainly to run video machines, projectors, and electrical musical equipment. In schools they tend to serve little purpose because relatively few vocational training activities require electrically driven equipment. In health clinics, particularly in remote areas, the availability of a power point enables emergency radios and small refrigerators to be installed, both of which are major assets to the community. Communal owned ice-making machines are also valuable assets to fishing communities. Communal ownership of other electrical equipment is not common.

Rural Electrification and Rural Incomes

Although early RE facilities in the Pacific islands are commonly used to improve the quality of rural social services, they have rarely increased rural incomes. Generally, income-producing end uses for RE are limited. Local entrepreneurs have used electricity to run freezers and video machines. A few nonlocal entrepreneurs have also established economic projects in electrified rural areas using local labor. These projects mainly include agricultural processing projects but also a few tourist projects.

Nonlocal entrepreneurs have often employed village men to work on their income-producing RE projects, and most of the local entrepreneurs who have established economic projects based on RE are men. Men are the main users and beneficiaries of income-producing RE projects because, in the rural areas of the Pacific islands, men tend to be better educated than women, and men more than women have sought work in towns and gained new skills associated with modern, electrically powered technology. Most of the local entrepreneurs are relatively young men because their formal educations have equipped them with the necessary management skills to run a business. Older men, in contrast, have not necessarily acquired management skills because on-the-job training has been the main way in which they have acquired their new skills and learned how to use electrical equipment. Cultural values and attitudes still restrict the mobility of women and the formal educational opportunities available to them.

Overall, early RE facilities have not significantly increased rural incomes. At the time of their introduction few rural businesses existed into which electricity could be incorporated, and the mere presence of RE has rarely stimulated the development of new businesses. Evidence suggests two reasons for this. First, would-be entrepreneurs have lacked the complementary inputs to electricity—adequate credit, reliable market outlets, reliable transport services, and the availability of people with the skills required by these industries. Second, would-be entrepreneurs are reluctant to depend on unreliable RE projects for their power supplies.

Conclusions

On the basis of the contribution of the various end-use opportunities for electricity to development in both rural social services and economic activities in the Pacific islands, we propose the following changes:

1. Household and communal end uses should be regarded as legitimate means of improving quality of rural life.

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2. Communal end uses plus household lighting should form the planning base for RE welfare projects.

3. A cautious approach should be taken to the provision of power points for private use to run electrical appliances, and, indeed, RE welfare projects should be planned without private power points. If sufficient capacity exists, however, power points could be provided on a private basis.

4. Rural economic projects that require electricity must be accompanied by provision of credit, skill training, transportation, and marketing services in addition to RE.

5. The electricity supply in income-producing end uses should be under the control of the business enterprise itself.

To obtain a realistic estimate of the demand for rural electricity, site visits need to be made, and rural residents need to be consulted, including village leaders and members of each of the social groups that will be the main users of electricity once provided. With regard to RE target groups, we have observed that: the main potential users of welfare RE projects are women and children with regard to household end-use applications but can include men if communal end uses are introduced, and the main potential users of income-producing RE projects are men and, in particular, young men.
RURAL ELECTRIFICATION ISSUE PAPER 2
TECHNOLOGY SELECTION

Introduction

The choice of rural electrification (RE) technology depends upon several factors. These factors relate to the technology's dependability, ability to provide the required amount of energy, organizational requirements, maintainability, and cost. They are discussed in this paper to help planners identify the conditions under which each of the many RE technological alternatives would be recommended.

Selection Criteria

A technology's dependability is the foremost criterion that should be considered in the selection process because a reliable electricity supply is critical to achieving economic and welfare objectives. Only combinations of those RE technology alternatives that have been extensively proven in the Pacific islands should be considered for widespread introduction. These alternatives are identified in the next section of this paper and evaluated in the last section on the basis of the criteria described below.

The choice of RE technology depends upon quantity of service requirements as well as quality. The technology's ability to provide the required amount of energy will depend on the following site-specific factors: the size of the electrical demand by end use, the physical availability of the resources required by the RE technology, and the actual availability of the requisite physical resources for RE after conflicting or multiple claims on the same resources have been taken into account. Planners should choose for further evaluation those RE technological alternatives that have electrical output characteristics that closely match the estimated electrical demand characteristics. This will enable achievement of cost-effective RE.

The third criterion that should be considered in the technology selection process is the technology's organizational requirements. Planners should be mindful that many of the RE technology alternatives are, by their nature, community-scale technologies, and that the success of community-scale technologies depends on the ability of rural residents to provide the necessary community organization. Planners should thus consider community-scale RE technologies only in those locations where rural residents are willing and have demonstrated their ability to work cooperatively. In locations that lack community organization, only those RE technology alternatives that can be provided on an individual basis should be
selected for detailed evaluation, even if these alternatives are not the best ones on the basis of electrical input and output data.

The fourth criterion to be appraised is the technology’s maintainability. To sustain RE projects, substantial technical support services are required; local people need to be trained in plant operation and simple repairs and in revenue collection and recording procedures. These essential complementary inputs should be identified and described in detail for each of the RE technological alternatives that have been determined to be compatible with local electrical needs and social structures.

The technology’s cost is the fifth criterion that needs to be considered, not because it has less importance than the four preceding criteria but rather because the full costs of a technology can be determined only after data are available on the technology’s required electrical capacity, physical and human resource requirements, and essential complementary inputs. Both the front-end and recurrent costs of the technology should be appraised.

Application of the Dependability Criterion

If the criterion of dependability is used, the many RE technological alternatives can be divided into three groups as shown in Table 1. Group A includes four RE technology alternatives that have not yet been tested in the Pacific, either because they are not yet sufficiently well developed technically or because they are not relevant. They are unlikely to feature in the RE programs of the Pacific island countries in the foreseeable future.

Group B includes five RE technology alternatives that are at the experimental stage. Although these technologies have been tested in the Pacific (and other regions) and may hold promise, uncertainties exist regarding their general appropriateness to Pacific conditions. For example, dual coconut and diesel oil engines are in this group because the price of coconut oil is subject to fluctuation, which makes the economics of this alternative uncertain, and because this alternative has been found to have serious maintenance problems when implemented on a pilot basis in Western Samoa, Kiribati, and Vanuatu. These problems need to be resolved before its widespread use in RE should be considered. Similarly, gasifiers cannot yet be recommended for widespread use because pilot gasification projects implemented recently in Papua New Guinea and Vanuatu have been only moderately successful. The uncertainties associated with the use of the biogas-to-electricity option, on the other hand, are of a nontechnical kind. They include lack of sufficient

Table 1. A preliminary screening of RE technology alternatives using the dependability criterion

<table>
<thead>
<tr>
<th>GROUP A (Untested and recommended against)</th>
<th>GROUP B (Tested, hold promise, but uncertainties exist)</th>
<th>GROUP C (Proven, but caution is suggested)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar turbines</td>
<td>Dual coconut oil and diesel engines</td>
<td>Town grid extensions</td>
</tr>
<tr>
<td>Sea wave power</td>
<td>Gasifiers</td>
<td>Photovoltaics</td>
</tr>
<tr>
<td>Solar ponds</td>
<td>Biogas to electricity</td>
<td>Diesel engines</td>
</tr>
<tr>
<td>Ocean thermal energy conversion (OTEC)</td>
<td>Wind generators</td>
<td>Microhydro plants</td>
</tr>
</tbody>
</table>
<pre><code>                                  | Dendro thermal                                   | Reciprocating piston steam engines        |
</code></pre>

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quantities of the requisite raw materials and difficulties of resource management because of life-style constraints that do not permit adequate performance of the daily operation requirements of biogas digestors. The potential of wind generators remains unknown because of limited wind data for many areas. Similarly, lack of primary data on all aspects of dendro thermal plants makes them an uncertain option. Given these uncertainties and considerations, we suggest that the Group B RE technology alternatives be considered experimental and, for the near term, restricted to demonstration plants in carefully chosen settings.

Only combinations of those five RE technology alternatives in Group C, which have been extensively proven under Pacific island conditions, should be considered for widespread introduction. These alternatives are grid extensions, photovoltaics, diesel engines, microhydro plants, and reciprocating steam engines. However, even with these alternatives, caution is suggested. Evidence from early RE projects based on these alternatives indicates that more attention needs to be paid in technology selection to the technology's ability to provide the required quantity of energy, organizational requirements, maintainability, and cost. These four selection criteria have been used to evaluate the Group C RE technology alternatives in Table 2.

An Examination of the Five RE Technologies Proven in the Pacific

As indicated in Table 2, the grid extension alternative requires no site-specific physical resources and can provide electricity in whatever amounts are required with little or no environmental impact. Modest grid extensions have few organizational requirements. They can usually be implemented relatively quickly and can serve individual and community objectives. Further, grid extensions are relatively easy to maintain. Evidence suggests, however, that this alternative is often expensive with high front-end costs, is vulnerable to natural disasters, and can often present formidable technological problems where high-voltage lines must serve small, scattered rural settlements. In consequence, grid extension over more than a few kilometers may not prove to be economically competitive with the other four (decentralized) RE technological alternatives.

Of the decentralized RE technology alternatives, photovoltaics (PVCs) have characteristics that are similar to those described above in relation to the grid extension alternative. Photovoltaics can provide electricity on any scale wherever sunlight, their physical resource requirement, is available on a regular basis, which is in most locations in the Pacific islands region. They are an environmentally benign technology and have flexible organizational requirements because they can be introduced on either an individual or a community scale. Although relatively easy to maintain, PVCs require a network of trained people at the regional level to carry out support functions. The major drawback of photovoltaics is high front-end costs. However, because their recurrent costs are relatively low, photovoltaics will probably have the lowest life-cycle costs if the total demand for electricity is only a few kilowatts and made up of end uses that require small amounts of electricity for only a few hours per day. Despite their cost disadvantage in locations where the electrical demand is more than a few kilowatts, photovoltaics are often favored by rural residents because they are the least demanding of the five proven RE technology alternatives with regard to their planning, implementation, and management.

Diesel engines are responsive to a range of electrical demand conditions and are not site specific. However, diesel engines are noisy and generally not suitable for use adjacent to residential areas. In larger sizes, diesel engines are necessarily a community-scale technology and require community organization and cooperation, which may be difficult or impossible to achieve. In addition, diesel engines have proved difficult to operate and
<table>
<thead>
<tr>
<th>Selection criterion</th>
<th>Grid extension</th>
<th>Photovoltaics</th>
<th>Diesel engines</th>
<th>Microhydro plants</th>
<th>Reciprocating steam engines</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ability to provide the required quantity of energy</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Local physical resource requirements</td>
<td>None—dependent upon imported resources</td>
<td>Sunshine</td>
<td>None—dependent upon imported resources</td>
<td>Water</td>
<td>Wood or agricultural wastes, e.g., coconut husks</td>
</tr>
<tr>
<td>Environmental constraints on use considerations</td>
<td>Implications of right-of-way access</td>
<td>None—environmentally benign</td>
<td>Noise</td>
<td>Implications of changes in stream flows</td>
<td>Impact of use of biomass resources on watersheds and soil stability</td>
</tr>
<tr>
<td>Environmental implications of use of resources</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land for civil works</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local financial manager and nonlocal financial supervisor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manager of fuel delivery (discontinuous)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local operation and simple repairs officer (continuous)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skilled maintenance officer to do routine check at least every 6 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local financial manager</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonlocal financial supervisor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Organizational requirements</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Rate of implementation</td>
<td>Fast</td>
<td>Fast</td>
<td>Fast</td>
<td>Slow</td>
<td>Slow</td>
</tr>
<tr>
<td>Scale of technology</td>
<td>Individual/community</td>
<td>Individual/community</td>
<td>Individual/community</td>
<td>Community</td>
<td>Community</td>
</tr>
<tr>
<td>3. Maintainability</td>
<td>Easy</td>
<td>Easy</td>
<td>Hard</td>
<td>Easy</td>
<td>Hard</td>
</tr>
<tr>
<td>Operation and maintenance human resource</td>
<td>Inspection of grid yearly visit</td>
<td>Simple repairs officer (discontinuous)</td>
<td>Manager of fuel delivery (discontinuous)</td>
<td>Local operation and simple repairs officer (continuous)</td>
<td>Local fuel suppliers (continuous)</td>
</tr>
<tr>
<td>Skilled inspector to visit at least every 12 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local financial manager and nonlocal financial supervisor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Responsiveness to range of demand conditions</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Time of day that energy is available</td>
<td>Flexible, depending upon demand</td>
<td>Normally limited to a few hours per day</td>
<td>Flexible, depending upon demand</td>
<td>Variable, depending upon stream flow and storage pond facilities</td>
<td>Flexible, depending upon demand</td>
</tr>
<tr>
<td>Types of energy produced that can be used</td>
<td>Electrical</td>
<td>Electrical</td>
<td>Electrical and low-grade heat</td>
<td>Electrical and mechanical</td>
<td>Electrical, mechanical, and low-grade heat</td>
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Table 2. (continued)

<table>
<thead>
<tr>
<th>Selection criterion to sustain at local level</th>
<th>Grid extension</th>
<th>Photovoltaics</th>
<th>Diesel engines</th>
<th>Microhydro plants</th>
<th>Reciprocating steam engines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essential complementary</td>
<td>None</td>
<td>Training program in simple repairs</td>
<td>Training in operation and simple repairs</td>
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<tr>
<td>Training in financial management</td>
<td>Secure arrangements for fuel delivery</td>
<td>Training in financial management</td>
<td>Training skills for small industries</td>
<td>Training skills for small industries</td>
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<tr>
<td>Training in maintenance</td>
<td>Training in financial management</td>
<td>Training skills for small industries</td>
<td>Organization for fuelwood supply service</td>
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4. Cost

<table>
<thead>
<tr>
<th>Expected lifetime major equipment components</th>
<th>Very high capital, low recurrent</th>
<th>High capital, medium recurrent</th>
<th>Low capital, high recurrent</th>
<th>High capital, low recurrent</th>
<th>Medium capital, high recurrent</th>
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<tr>
<td>Planning and implementation human resource requirements</td>
<td>20 years</td>
<td>10 to 20 years</td>
<td>10 years</td>
<td>20 to 40 years</td>
<td>20 to 25 years</td>
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<td>Linesmen and local labor for construction of grid</td>
<td>Surveyor</td>
<td>Electrician</td>
<td>Diesel engineer</td>
<td>Electrical engineer</td>
<td>Forestry expert</td>
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<tr>
<td>Electrician</td>
<td>Electrician</td>
<td>Local labor for construction of powerhouse and distribution lines</td>
<td>Surveyor</td>
<td>Electrician</td>
<td>Steam engineer</td>
</tr>
<tr>
<td>Surveyor</td>
<td>Local labor for construction of powerhouse and distribution lines</td>
<td>Local labor for civil works and construction of distribution lines</td>
<td>Local labor for civil works and construction of distribution lines</td>
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</table>

Operation and maintenance human resource requirements

| See under maintainability | See under maintainability | See under maintainability | See under maintainability | See under maintainability |

5. Summary

<table>
<thead>
<tr>
<th>Conditions under which technology is likely to be cost competitive</th>
<th>Point of demand for electricity within a few kilometers of grid</th>
<th>Remote from grid, total electrical demand is a number of small discrete demands</th>
<th>Remote from grid, continuous power supply required</th>
<th>Remote from grid, electricity required continuously</th>
</tr>
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<tbody>
<tr>
<td>Likely electrical end uses</td>
<td>Social and productive</td>
<td>Social</td>
<td>Mainly social but also productive end uses requiring small amounts of electricity for a few hours each day</td>
<td>Social and productive</td>
</tr>
<tr>
<td>Major potential constraint on use</td>
<td>Distance over which extension is to be made</td>
<td>(High) cost</td>
<td>Operation and maintenance requirements</td>
<td>Physical characteristics of site, which determine water availability and complexity of civil works that affects length of implementation phase and cost</td>
</tr>
</tbody>
</table>
maintain in the rural Pacific. Diesel engines place considerable demands on both local operators and host RE agencies. For successful operation and maintenance, diesel-based RE projects require a continuous, dependable supply of fuel and lube oil, adequate fuel storage and handling facilities, trained local operators, and the assistance at least biannually of a skilled maintenance officer. These requirements have often not been met in existing diesel-based RE projects. Additional visits by skilled maintenance officers are required, and local operators will need to be better trained and equipped with tools, operator manuals, and spare parts. The evidence also suggests that rural residents have difficulty meeting the recurrent fuel costs of diesel sets. This is a principal reason that many diesel-based RE projects operate only intermittently. Indeed, because of low-utilization rates, diesel-based RE projects have high capital to recurrent cost ratios, contrary to popular belief.

_Microhydro plants_ are not generally applicable because of siting requirements and have a number of potentially negative environmental implications. The organizational requirements of this RE alternative are relatively high as a result of two factors: it requires a concerted effort and a relatively long time to construct, and it is necessarily a community-scale technology and thus has a number of organizational requirements that rural residents must be able to satisfy. Once in place, however, microhydro plants have relatively few operational and maintenance problems and can usually provide electricity continuously. Microhydro plants can also be used as a source of mechanical energy.

_Reciprocating piston steam engines_ are similar to microhydro units in three ways. First, they are dependent on the availability of local physical resources for steam raising and thus are not generally applicable. Second, there are many potential environmental constraints on their use. And third, they are necessarily a community-scale technology and present operating and maintenance challenges. They can, however, provide a combination of electrical, mechanical, and low-grade heat energy on a continuous basis. Steam engines can often be readily integrated with existing cash income-producing activities in the rural Pacific. The waste products from agricultural processing activities can be used as fuel for steam engines, which in turn can provide low-grade heat for crop drying in addition to electricity and, if required, mechanical energy.

Conclusions and Recommendations

The preceding discussion of the five RE technological alternatives that should dominate the RE programs of Pacific island countries in the near future can be summarized as follows:

- Under selected conditions for RE projects in urban hinterlands, grid extensions may prove an extremely attractive alternative.
- In rural areas remote from urban centers and with modest electrical needs to meet welfare objectives, photovoltaics should be the starting assumption for RE technology selection.
- In some remote rural locations, diesel engines may prove cost-effective mainly for RE welfare objective projects but will be demanding in their operation and maintenance.
- Microhydro plants are best employed under conditions where electricity is required relatively continuously, that is, where electricity is to be used for both welfare and income-producing purposes, where the requisite civil works can be kept simple, and where community organization is strong.
- For combination welfare and income-producing RE projects, reciprocating steam engines should be considered in addition to microhydro, especially in those locations with a need for low-grade heat for crop drying.
Overview

Because the dominant RE pattern in the Pacific consists of schemes to improve the quality of rural life, the consideration of a few economic principles should benefit all parties. The following discussion is divided into two substantive sections. The first section deals with the initial financing of small RE projects. In the second section, the discussion shifts to economic issues relating to subsidies for recurrent operating and maintenance costs. In practice, these policy areas cannot easily be separated either from the economic climate of the village in which the system is installed or from the characteristics of the technology that has been selected.

When considering RE economics, planners should pay particular attention to life-cycle costing in the project analysis. Life-cycle costing is simply an approach to the project analysis from the broadest long-term viewpoint. Based on our studies, five costing pitfalls are common in an RE cost analysis:

- The failure to reflect indirect subsidies to liquid fuels
- The tendency to overestimate the actual operating use and, at the same time, to underestimate the operating and maintenance costs of some technologies (for example, diesel sets)
- The omission of foreign exchange shadow price to foreign sources (including banks) for all alternatives
- The high delivered costs of existing fuels and energy supplies (particularly batteries and lighting fuels)
- The failure to recognize the opportunity cost of aid

When these considerations are taken into account, the commonly used solution of a diesel set should become considerably less attractive as a rural electrification option.

Initial Financing for Front-end Costs

Electrification of rural areas implies the provision of power to small population centers or remote villages. Insofar as rural development (as contrasted with income generation) is a stated goal of the government, outside front-end funding for this sort of grassroots electrification should properly come from the national treasury (or foreign sources) and should be designed to overcome the costs of being “rural” or “remote.” This principle suggests that a
rural subsidy policy should first take the form of a capital subsidy (say, for building a transmission link). To the degree that rural also implies small-scale and high unit cost of power supplies, it may also be necessary (depending on the choice of technology) to offset some proportion of the direct, recurrent costs. The guiding objective should be to insure that rural people are not penalized for being rural.

As suggested in the substantive country reports and in RE Issue Paper No. 5, foreign assistance is likely to be available for imported RE-generating equipment of all sorts. When bilateral or multilateral aid financing is sought, the usual caveat about inappropriately "tied" procurement assumes considerable importance. It benefits no one to have aid-acquired equipment rusting in the village. Inappropriate technology based on foreign aid availability may easily have counterproductive or negative consequences for the ongoing RE program. Furthermore, unless the equipment is to be used for "economic" (income-generating) purposes, the international borrowing of money for RE should be carefully considered on the premise that the use of foreign exchange funds may have a higher return in other developmental sectors.

Whatever the source of RE funding, the local community should be required to contribute directly to each RE project. Fieldwork suggests that RE projects with substantial local content stand a greater chance of long-run success than wholly outside-funded turnkey projects. Indeed, we suggest that wherever possible, RE should be approached from basically a self-help perspective.

While the size and type of local resources will obviously vary from village to village, from 25 to 40 percent of front-end costs may be available locally. This range is substantially higher than has been previously used in financing RE schemes and is based on the following categories of local resources:

- Contributed local labor and land
- Local construction materials
- Cash raised from urban or foreign remittances
- Cash raised from local savings

Obviously, the cash contributions of the villagers are the most problematic. The outstanding issue is the amount of cash the local community can be expected to raise. While it is extremely difficult to generalize about the cash-generation potential, the two guiding principles should be: (1) the cash is a community responsibility and (2) it should be related to specific components of the supply system.

To be cost effective, RE schemes should encourage the maximum household participation from the start through two mechanisms: high penalty payments for late joiners and low initial costs for individual households. High penalty payments for late joiners can be economically justified on the basis of increasing marginal costs; moreover, in RE schemes elsewhere in the world such payments have proved quite successful in encouraging initial participation. Ironically, given our suggestions about community cash contributions, our studies suggest that even relatively modest lump-sum household installation expenditures (for example, in meeting house expenses) can pose substantial barriers to both early participation and high-system utilization. The distinction here is between the lesser ability of the poor households in the village to raise cash for connection and wiring costs and the greater capacity of the general community to mobilize resources for the overall scheme. As a general guideline, we believe villagers should determine how they will collectively meet...
system costs. In any event, substantial outside, subsidized funding will be inevitably necessary.

In those RE schemes where direct income is generated, the RE project should be managed by the primary sponsor or company. In this circumstance, the terms of and conditions of selling electricity to the public should be directly negotiated by the investor, the government, and local representatives.

Subsidies for Meeting Recurrent Costs

For technologies having high recurrent costs for fuel (diesel, biomass projects, etc.), the inability of rural people to meet operating expenses is often a formidable barrier. Unlike one-time cash remittances or payments in labor or land, recurrent cash resources are in chronically short supply in most island communities. Remote villages, which simply lack the overall ability to meet high recurrent expenses, have only two choices: either the system will be subsidized or it will not operate. Non-operation is obviously not only undesirable for the villagers but also counterproductive for the government or aid donor, which has invested in non-functional capital at the expense of other development priorities. In numerous cases, RE equipment has been idle because of the local people's inability to meet recurrent costs. The issue is to find an acceptable subsidy formula to meet recurrent expenses.

The determination of an appropriate level of subsidy is primarily a question of social policy based on political priorities. Within this framework, the choices are almost infinite, but a few issues should be explored in some depth. The first critical matter is to ensure that RE tariffs (and implicitly RE subsidies) are related to anticipated benefits. RE Issue Paper No. 1 suggested that the primary quality-of-life benefits of electricity are household lighting and communal activities. Therefore, tariff policy should primarily support these end uses. In contrast, other electricity uses should be treated under the urban tariff scheme and charged on a per unit (metered) basis at the appropriate urban rate.

The primary policy questions inherent in the subsidy issue are the source of the subsidy funds and the extent of the subsidy.

Subsidy questions must be an explicit part of any overall RE program. The case studies clearly show that in the Pacific the general pattern of RE pricing has recognized only a portion of recurrent subsidies, with many attributable operating and maintenance costs hidden in the budgets of government departments or electricity supply agencies. Also the subsidy policies vary widely among technologies, for example, diesel versus solar versus hydro. Such hidden and unequal subsidization encourages the misallocation of development funds and may result in projects that do not reflect a government's actual priorities.

Of the two major subsidy questions, the source-of-funds issue is perhaps the easiest. For RE quality-of-life purposes the source of recurrent subsidy funds should be the national treasury. The alternative—cross subsidization from other electricity consumers—results in suppressed consumption and, for electricity-intensive industries or activities, may represent a substantial disincentive to urban or industrial development. Of course, such problems may be overcome through differential tariffs, but the costs of establishing and administering an

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1. The encouragement of electricity demand via a product subsidy may be in direct conflict with national energy conservation policies.
2. Foreign aid subsidies generally take the form of initial capital costs.
elaborate differential tariff scheme may be quite significant for small Pacific island electricity systems.

Earlier this paper suggested that high rates of system utilization should be encouraged both through substantial penalties on late joiners and through provision of initial funding for house wiring. If these measures are successful, most households in the village should have (unmetered) lighting early in the RE program and communal uses should be part of the initial base load. These two end uses then can be considered as community-wide RE benefits, with tariffs collected on a community rather than household basis. We suggest that the government subsidize all communally used electricity as part of its rural development strategy and that the villagers be collectively responsible for meeting the household lighting costs of the system.

In practice, RE tariff policy is likely to be considerably more complicated than suggested by this simple model. In particular, two troublesome questions are, How can charges be equalized between the larger (lower-cost) villages and the smaller (higher-cost) villages? and How can the more affluent members of the community, who wish to have (and are willing to pay for) private electrical appliances, beyond lighting, be accommodated?

Inevitably, the only administratively feasible answer to the small versus the large village problem is through cross-subsidy among villages. We suggest that nationally the total RE costs (net of government subsidy) for the country should be divided by the total number of RE households regardless of village size. If this cost-per-household average is used, the communal obligation of any village can be quickly determined by multiplying the number of RE households located in the village. Precedents for such subsidy policies commonly occur in postal and educational services, where small villages are not penalized despite their diseconomies of service.

The next step in the tariff equation is to deduct from the community's total payment the contributions of private users using appliances other than basic lighting. These private users usually incur two additional costs for private appliance use: an initial charge to offset metering and circuit protection and a periodic payment equal to the prevailing urban tariff times appliance usage. Thus, private appliance users (who should be discouraged for technical reasons of capacity) would effectively make four kinds of contributions to system costs:

- A contribution (land, labor, or remittance) to initial financing of capital costs as part of the larger community
- A prorata contribution to the village (lighting) assessment as other villagers
- A one-time installation charge for the metering and circuit protectors of their own households
- A private consumption charge based on metered appliance use assessed at the urban tariff

This rural tariff subsidy scheme attempts to insure that inequities are minimized. First, it makes the basic welfare service (for example, household lighting) the responsibility of the community rather than the household and thus encourages within the village a degree of cross subsidy reinforced by traditional authority patterns. Second, it differentiates basic

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3. Although community assessments do not preclude an equal assessment for each household, the villagers should collectively determine how they raise the money to offset these basic charges.

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(communal and lighting) needs from private appliance use and causes price differentials to be based on type of electricity use rather than on the volume of electricity consumption.

A final element in the RE tariff system should be to ensure that rural people do not, as a result of low consumption and high costs, have to pay more per unit than urban consumers. The policy logic here is simply that it is contrary to the development strategies of all Pacific nations to penalize rural people simply for being rural. Evidence from our studies, however, suggests that this outcome may possibly occur. Under such circumstances, we would urge an additional government subsidy to equalize rural-urban tariffs. The consequence of this tariff subsidization scheme is to specify the extent of the government's RE subsidy commitment in a way that is logically and politically defensible.

In addition to these recurrent tariff questions, two other points are worthy of comment. First, many RE projects have often failed to recognize that rural people have income and expenditure patterns different from those of their urban brethren. While occasionally prosperous villages may be able to meet recurrent costs on an annual basis, villagers only infrequently have sufficient cash available on a monthly basis. Rural cash is available seasonally and tied to harvesting or shipping cycles. A payment schedule that recognizes this fact has a better capacity to meet costs than a scheme based on monthly payments. Second, experience elsewhere in the world suggests that villagers sometimes consider RE programs to be a convenient form of self-taxation. For example, in Thailand, villagers sometimes opt to pay higher than required electricity tariffs on the understanding that the surplus funds will remain in the village for other projects. Whether Pacific islanders would be attracted by this revenue-raising aspect of periodic RE payment is an open question, but this option should be raised for local discussion and decisions.

**Policy Issue Summary**

In conclusion, the 12 policy suggestions are as follows:

- **RE project planning should pay particular attention to life-cycle costing and should insure maximum system utilization.**
- **Foreign loan funds should probably *not* be utilized for social RE schemes designed to improve the quality of life.**
- **Where possible, initial capital costs should be financed by aid donors, but caution must be exercised to avoid inappropriate “tied” technology.**
- **The local community has substantial resources in the form of land, labor, construction materials, and remittance cash, which should form an integral part of any RE financing plan.**
- **Maximum system utilization can be encouraged through penalty payments for late joiners and through initial funding for house wiring.**
- **Rural people often may be unable to meet high recurrent costs and thus will require direct operating subsidies. The proper source of these social welfare subsidies is the national treasury.**
- **Operating subsidies should be related to end uses, with the government meeting the electricity costs associated with communal activities.**
- **Household-lighting costs should be the responsibility of the community at large.**
- **Private appliance use should be based on metered consumption charged at urban tariff rates.**
• Income-producing uses of RE should be directly managed by the sponsor or company. Costs to villagers under these circumstances should be jointly negotiated among the private supplier, the government, and the local representatives.

• As a general policy premise, attempts (including further subsidization) should be made to insure that rural tariffs do not exceed urban tariffs.

• Rural income patterns related to harvesting or shipping schedules should be recognized in tariff collection schemes.
RURAL ELECTRIFICATION ISSUE PAPER 4
RURAL ELECTRIFICATION AND OTHER RURAL PRIORITIES

Introduction

In planning rural electrification (RE) programs, governments must accept the need to provide recurrent subsidies. Subsidies are essential to meet the operating and maintenance costs of RE that cannot be met from the revenues raised from rural users. The percentage of a national recurrent budget that is appropriate for RE depends on the relative priority that is placed on RE and other rural infrastructure projects. This in turn depends on the criteria used to set priorities. We suggest that the determination of an appropriate subsidy for RE should be in direct relationship to the costs and benefits of other rural development programs.

To help determine the proper role and level of subsidization for RE, this paper examines how RE fits into a broader strategy of rural development. It considers the order in which electricity and other inputs to the rural development process are best provided to enhance rural welfare and income-producing opportunities. Account is taken of the development priorities set by rural Pacific islanders in Fiji, the Cook Islands, the Federated States of Micronesia, and Papua New Guinea, who participated in PIDP’s impact studies of early RE projects. Having identified the preconditions for RE, the paper then selects the most promising sites for RE projects within the rural areas of the Pacific islands.

Rural Electrification and Other Inputs to Improve Rural Welfare

Improved welfare is perceived by rural Pacific islanders to be the foremost benefit to be gained from RE. End uses for RE that clearly increase rural welfare include household lighting and community applications (lighting and electrical appliances) in facilities such as meeting houses, churches, health clinics, and schools (see Issue Paper 1). However, two things must be borne in mind: RE is only one among many development projects that can improve rural welfare, and RE will rarely be the most important welfare project.

Food, Shelter, and Thermal Comfort

In the domestic sector RE for lighting is less important than energy for tasks that directly help provide the basic needs of food, shelter, and thermal comfort. These tasks include crop production, crop drying, crop processing, cooking, space heating, and building materials collection and house construction. In the Pacific the energy requirements of these life-
sustaining rural tasks are supplied primarily by human labor and firewood. Firewood, supplemented sometimes with agricultural wastes, is used for crop drying, cooking, and heating.

Although some rural areas are suffering from severe firewood shortages, electricity is not an economical substitute for firewood. Moreover, the substitution of electricity or any other commercial energy form for firewood will not resolve the localized firewood shortages. These shortages reflect the fact that timber in general is in short supply because the wood used by Pacific islanders for firewood is the same wood that might have been used for building fences and houses. Because rural Pacific islanders maintain a complex set of relationships to the natural environment to satisfy their food, shelter, and firewood requirements, a recognized deterioration in the pathway from trees to firewood has adverse implications for future health and well-being. In firewood-short rural villages, then, the primary goal of a rural energy plan should be to improve the supply, distribution, and use of timber in the village economy. If the demand for firewood cannot be met because of absolute lack of land suitable for tree plantations and if agricultural wastes are not available, projects will be needed that focus on the supply, distribution, and use of kerosene or gas since these are cheaper than RE as a source of low-grade heat for drying, cooking, and space heating.

**Water, Sanitation, Health, and Education**

Water, sanitation, health, and education are other basic human needs. They are also needs that rural Pacific islanders have identified as being more important than RE. Pacific islanders living in electrified periurban villages have identified adequate water supplies and sanitation, in particular, as being of higher priority than RE, whereas Pacific islanders living in remote rural villages with access to RE have identified adequate basic services in health and education as being more essential than RE. An adequate basic health service has the following components:

1. A permanent health clinic located near people’s homes
2. Sufficient medical staff trained in at least primary health care to meet the local demand for primary health care
3. Adequate quantities of basic educational aids including books, maps, and writing materials

We suggest that these higher-priority community needs should be met before a village is considered for a full-scale RE project. We note, however, that a small-scale RE project specifically for water-pumping purposes may prove necessary and be a cost-effective means of satisfying a community’s water supply and sanitation needs.

**Other Complementary Factors**

A full-scale welfare RE project for household lighting and community end uses is best for villages where basic energy needs are being met and adequate basic health and education services exist. Evidence suggests, however, that social perceptions can play a significant role in the introduction of household RE uses. Concerns about safety and the suitability of houses made of bush materials for connection to an electricity supply might have to be overcome before household electric lighting can be introduced. This could necessitate a housing improvement program. Several Pacific islanders with access to RE identified improved housing as being more important than RE.

Problems similar to those just described might arise and need to be overcome with the introduction of RE into meeting houses and churches. Before the provision of electric

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lighting to a school would be worthwhile, teachers to run evening classes would need to be available, and rural residents would have to perceive the need for such additional classes. Similarly, the provision of electric lighting to a health clinic will be justified only if rural residents are willing to travel after dark to attend an evening health clinic. The provision of an emergency radio would be useful only if access to the village is by road or a short distance by air so that an emergency team could reach the area quickly after a call for help is made. In brief, essential complementary factors to RE must exist before RE will have a major positive impact. This fact applies to economic as well as welfare RE projects.

Rural Electrification and Other Inputs to Increase Rural Incomes

Early RE facilities in the Pacific islands are rarely used to increase rural incomes. Evidence suggests that the presence of RE has failed to stimulate directly the development of rural income-producing projects largely because would-be entrepreneurs have lacked the complementary inputs to RE required by rural industries. Given that RE projects for income-producing projects are critically dependent for their success on the availability of essential complementary inputs, we suggest that problems regarding these inputs, which include credit, skill training, transportation, and marketing, should be resolved before a rural area is considered for an economic RE project. Income-producing RE projects are best seen as part of a comprehensive rural industries development program.

It needs to be noted, however, that the principal cash-earning activities of rural Pacific islanders are agricultural in nature and that the agricultural sector is likely to remain the main source of rural income-producing opportunities in the near future. The potential end uses for RE in the agricultural sector are not great. This is perhaps why rural Pacific islanders with access to RE have sometimes identified adequate credit and extension services for agricultural projects as being more important than RE. Indeed, RE is technically appropriate only for a narrow range of rural agricultural tasks that require energy. For example, electricity is not likely to be used in the production stages of agricultural activities except perhaps for lighting used as heaters in chicken hatcheries. In the processing stages of agricultural activities electricity could be used in the following ways:

1. For lighting to allow evening work during the peak of the harvest period
2. For cold storage of produce until it can be transported to external markets
3. For electrical equipment in activities such as fruit juicing, fruit and vegetable canning, and arrowroot grinding

The energy needs of these agricultural tasks can also be met by energy forms other than electricity. Kerosene, for example, can be used for heating, lighting, and refrigeration, and mechanical energy can be used for grinding. The economic appropriateness of using electricity for these rural agricultural tasks will need to be determined by looking at the relative costs of competing fuels.

Site Identification

Clearly the proper sequencing of RE projects and other rural energy and infrastructure is crucial. Careful thought needs to be given to how RE fits into a broader strategy of rural development because RE is not an end in itself. It is important to appreciate also that different types of villages will be suited to different RE end-use applications. The villages of the Pacific can be divided into three basic types: periurban villages that are adjacent to towns and regional administrative centers, remote main island villages, and remote outer island villages. As a general rule, periurban villages are likely to have the preconditions for
combination income-producing and welfare RE projects. Remote main island villages are likely to have the preconditions for welfare RE projects and the potential to use RE for economic purposes in the future once the essential complementary inputs have been provided, and remote outer island villages are likely to be suited to welfare RE projects only. Certainly there will be exceptions to these general rules, and site visits are a prerequisite to obtaining realistic and justifiable RE end-use demand estimates.
Introduction

The establishment of effective institutional arrangements for RE is crucial to program success. Successful administration of RE programs requires a strong organization to define and coordinate numerous complex technical and planning tasks. These tasks pertain to the following RE program phases: (1) program planning; (2) project appraisal; (3) project selection (or rejection) and procurement of financing; (4) project implementation and handover; (5) project sustainment; (6) project monitoring, evaluation, and refinement; and (7) program refinement and ongoing research.

We attribute the failure of many RE projects in the Pacific islands to a failure to recognize and perform satisfactorily the tasks associated with phases 5 through 7. To make RE projects sustainable, we suggest that Pacific island governments will need to create specific RE agencies in their central administrations and establish at the district level the technical support services that community RE organizations require. In addition, we believe that the assistance of Pacific island regional and international organizations can be focused to improve the success of RE programs. In sum, we envisage that RE programs will require the coordinated inputs of people at four levels of administration: the international/Pacific region, the nation, the district, and the community.

A Suggested Organizational Framework for RE

We anticipate that RE tasks would be shared among the four levels of administration as summarized in Table 3. The suggested allocations take into account the nature of the task to be undertaken and the skill base of each administrative level. The allocations also reflect the need to involve local communities in the planning and management of their electricity projects to the fullest possible extent. This paper discusses each of the main phases of an RE program, task by task, and identifies the people required to carry out the tasks within each phase.

Phase 1: Program Planning

As shown in Table 3, this phase has two major tasks: policy formulation and project identification. The policy statement should precisely define the objectives, in priority order, that are to be met by the RE program and the conditions under which incentives or subsidies for RE will be provided. An RE policy strategy should be applicable to the entire
Table 3. Rural electrification: main phases, specific tasks, and recommended divisions of responsibilities

<table>
<thead>
<tr>
<th>Phase</th>
<th>Task</th>
<th>Main responsibility of:</th>
<th>Pacific island region</th>
<th>National level</th>
<th>District level</th>
<th>Community level</th>
</tr>
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<tbody>
<tr>
<td>1. Program planning</td>
<td>Policy formulation</td>
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<td>x</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Project identification</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>2. Project appraisal</td>
<td>Preliminary design</td>
<td>x</td>
<td>x</td>
<td></td>
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<td></td>
<td>Feasibility studies</td>
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<td>x</td>
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<tr>
<td></td>
<td>Preproject evaluation</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Project selection (or</td>
<td>Selection/rejection</td>
<td>x</td>
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<td></td>
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</tr>
<tr>
<td>rejection and procurement of</td>
<td>If selection, procurement of finance</td>
<td>x</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>financing</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td>4. Project implementation</td>
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a. An x in more than one column indicates that the task is performed jointly or by any one of the institutions.

country and preferably be considered by politicians and endorsed by parliaments. This will provide the strategy with status and visibility and create a basis for program development. To develop the policy, those individual RE projects need to be identified that are feasible within the established RE objectives and ground rules. RE project descriptions should identify specific end-use goals for RE (see Issue Paper No. 1), potential rural sites (see Issue Paper No. 4), and feasible RE technological alternatives (see Issue Paper No. 3).

We anticipate that RE policy formulation and project identification will be the primary responsibility of people at the national governmental level (see Table 3). This will enable a unified approach to RE to be achieved. Indeed, we propose that a national commitment to RE should be reflected in the creation in the central administration of a specific RE agency made up of one or more staff members, depending on the size of the proposed RE program. A staff member with previous involvement in rural development planning and a special interest in energy would be the best coordinator of the RE agency.
In addition, we envisage that Pacific islands regional organizations have a role to play in RE program planning. This role is to assist national planners through regional RE planning workshops and provision of a regional advisory service.

Phase 2: Project Appraisal

The individual projects within each Pacific island country’s RE program will need to be justified. This should be done within the second phase of an RE program: project appraisal.

Three tasks are associated with this phase. The first task is the formulation of a preliminary project design. This is an all-important task since the preliminary design criteria constitute the base upon which future decisions will be made. The preliminary design should be in accordance with the rural residents’ stated aspirations and expectations regarding RE and detailed enough so that cost estimates and decisions on other critical aspects of the project can be made in the feasibility report, the product of task 2.

Feasibility studies should deal with all components of the project including its physical resource requirements and their effects on environmental factors; its managerial and organizational requirements and the ability of rural residents to meet these requirements; its end-use goals and their anticipated impacts on rural residents; and its economic and financial costs and the ability of rural residents to meet those costs. Once collected, this information will need to be evaluated.

Preproject evaluations, the third task within the RE project appraisal phase, should assess the overall ability of the project to succeed in support of the previously established national and local objectives. It is our impression that in-depth feasibility studies have seldom been undertaken in Pacific island countries.

RE project appraisals should be carried out jointly by the RE agency and the rural residents. The appraisal team needs to be multidisciplinary and composed of people whose collective skills span four disciplines: ecology, sociology, engineering, and economics. At least one of these people should be a member of the national-level RE agency. The other people could be located at either the national or the district level. The rural residents who make up the consultative group should include the leaders of each village to be involved in the proposed RE project and representatives of each of the social groups who are to be the main users of the electricity. During the project appraisal stage care must be taken to explain honestly to rural people that an RE project may not ultimately be implemented in their area.

Phase 3: Project Selection (or Rejection) and Procurement of Finance

The decision to accept or reject a proposed RE project should be made on the basis of the findings of the feasibility studies and preproject evaluations carried out within phase 2. A project should be selected only if it has been clearly established that it meets the previously determined selection criteria. Of course, not all of the selected RE projects necessarily will be implemented. Funds procured for RE may fall short of the estimated costs of justifiable RE projects. In these circumstances, selected projects will need to be ranked using additional criteria such as density of potential consumers.

Selection of RE projects should be the task of the people within the central RE agency who are responsible for RE policy and project identification. These people should be responsible for acquiring and disbursing the funds for the RE projects under implementation.
At least some of the funds required by each RE project should be obtained from rural residents as a group rather than as individuals. Indeed, rural residents should be required to have available their cash contributions to the project before central RE planners seek other funds. This is one of the few means of determining that rural residents want electricity. The remainder of front-end costs can be requested from overseas donors. The subsequent recurrent costs of RE that cannot be met from the revenues raised from rural users will have to be provided from money allocated to RE out of the national recurrent budget. (See Issue Paper No. 3 for details on the financial implications of RE.)

Phase 4: Project Implementation and Handover

This is the most visible phase of an RE program. It has three major tasks: procurement of equipment, construction, and training. Procurement of equipment involves selecting, ordering, taking delivery of, and transporting to the field the necessary RE equipment. It is an especially important task since the purchase of unsuitable equipment or the absence of even one screw from the final equipment package can cause lengthy and costly delays in remote site construction. The construction time of an RE project could range from a few weeks to a few years, depending on the technology used and the size of the project.

During project construction two types of training programs need to be provided: one for junior members of the implementation team so that they will be qualified to fill middle-level positions in future teams and the other for previously identified local people so that they can fill technical and managerial roles in the completed project. Training of local people early in the RE program cycle will facilitate a smooth transition from project implementation to project operation and management. We believe that the identification of suitable local people for training should be a prerequisite for project selection.

People at all four levels of administration have a role to play in project implementation. Cooperation among the Pacific island countries for the bulk purchase of standardized RE equipment (particularly PVC sets) might prove worthy of consideration. The central RE agency could commission project implementation teams from either the public or private sector or both. These teams could include organizations operating at either the national or the district level. Private sector agencies that possibly could become involved in government-sponsored RE projects include solar systems firms (for projects based on photovoltaics) and mission groups (for projects based on the microhydro and diesel alternatives). Public sector agencies that might act as implementing agencies include national electric utilities, public works departments, and tertiary educational institutions. These institutions could provide the skilled labor, while rural residents provided all of the unskilled labor required for project construction. It could be anticipated that rural residents would provide free accommodation for members of the host agency implementation team. Evidence suggests that the appointment of two people, one from the implementing team and one from the local community, to act as project managers and to coordinate the inputs of their respective groups might be the key to the success of this phase, which includes project construction. These two project managers should be responsible for ensuring that the training needs of local RE operations and financial managers are met. We suggest that the contractual obligations of project managers should explicitly include the implementation of training programs.

Phase 5: Project Sustainment

Once constructed, an RE project is not completed; it merely enters a new phase—an operational phase. To keep an RE project operational, five tasks need to be carried out: (1) project operation and simple repairs, (2) maintenance, (3) tariff collection and record
keeping, (4) tariff policy supervision and account auditing, and (5) load management of end-use applications for electricity. We believe that these tasks have not been carried out adequately in existing RE projects in the Pacific islands and that this is a principal reason why many of them have failed. More emphasis must be placed on this phase of RE.

We have identified three complementary training programs required by rural residents to sustain their RE projects. They are (1) a technical training program for local operations and simple repairs; (2) an accounting course for local financial managers that focuses particularly on tariff pricing, collection, and recording procedures, as well as on aspects of creative credit schemes; and (3) a simple load management program for the entire rural community that provides information on the potential and limitations of the power supply and how to use electricity efficiently and safely. We suggest that precise details on each of these essential complementary training programs should be formulated within phase 2 of an RE program and that the programs themselves should be conducted within phase 3. This will make it possible to hand over the newly constructed RE project to a suitably trained community RE organization.

While RE project sustainment is anticipated to be mainly the responsibility of rural residents, two kinds of continuing external support will be essential. First, a skilled mechanic must be available to perform the routine maintenance work on the RE facility and to overcome technical problems. Second, a financial advisor will be needed to provide tariff collection supervision (since the determination of tariffs is a complex and all-important exercise), to audit the accounts kept by the local financial officers, and to help collect any overdue bills. For logistical reasons these two people are best located at the regional level.

Phase 6: Project Monitoring, Evaluation, and Refinement

This is the last phase of an RE project but not of the RE program as a whole. It has four major tasks. The first task is project monitoring, which involves monitoring the use made of electricity and ensuring the timely provision of essential complementary inputs. It is an especially important task during the first year after the project becomes operational and community members are adjusting to their new energy system. Task 2 involves impact studies—examinations of the social, economic, and ecological changes that have occurred as a result of the RE project. These studies would best be conducted within the first five years after the RE project becomes operational. Task 3 is postproject evaluation and involves an examination of the data collected on local conditions both before (within phase 2) and after the RE project was introduced and the determination of the success of the project within the framework of its original objectives. It also involves the identification of reasons for any failures and the initiation of corrective measures as a step in refining future RE projects.

It is anticipated that people at the national, district, and community levels will be involved in this phase. The aforementioned engineering mechanic and financial advisor at the district level would be best placed to monitor the project with the assistance of community members. The more time-consuming impact studies would best be done by the same people who conducted the preproject feasibility studies and evaluations in phase 2. New project initiatives to correct any past mistakes would presumably be carried out by the project implementors and/or operation and maintenance officers.

Phase 7: Program Refinement and Ongoing Research

An RE program must be viewed as a dynamic effort. If it is to meet new challenges in the future its objectives and ground rules must be refined continually in the light of the lessons
learned from each RE project. RE policy procedures must be updated to meet changing rural situations and energy needs. The refinement of RE policies and plans (task 1) should be the responsibility of the people in the central RE agency at the national level. They should be the receivers of all reports on preproject and postproject evaluations. They should also be responsible for organizing research and development work (task 2) on outstanding RE issues.

**Summary**

Broadly, we propose that a national commitment to RE should be reflected in the creation of a specific RE agency in the central administration. This agency would be responsible for the majority of the tasks associated with an RE program and specifically for the formulation of RE policy guidelines, the procurement of the necessary financing for individual RE projects that have been selected on the basis of site appraisals, the monitoring and evaluation of operational projects, and the refinement of RE project and RE program policies by the findings of each completed project.

In addition, we suggest that Pacific island regional and international organizations can contribute to the success of a program for RE. Pacific islands regional organizations can help national planners by organizing regional RE planning workshops and by providing an advisory service. Procurement of equipment on a regional basis might also prove worthy of consideration. The role of international organizations would be to provide capital assistance to meet the high front-end costs of RE.

No program for RE will succeed, however, without the support and active participation of the rural people themselves. Indeed, local rural residents should have significant input into all phases of their RE projects. They should be required to nominate a person to act as the local RE project coordinator. The local coordinator will need to be someone who has the ability to act effectively as a link between the local community and outside RE resource people. The responsibilities of the local coordinator would be to ensure that the RE project is consistent with the community's development goals and priorities, to collect community members' cash contributions toward front-end project costs, to organize local labor for project construction, and to identify local people who will subsequently operate and carry out simple repairs on the RE facility and manage its financial aspects.

But rural people cannot implement sustainable RE projects alone. They require the assistance of engineers and finance managers. These people will best be located within district organizations from where they can act effectively as links between national and community RE organizations. Their responsibilities would include assisting national RE agencies in the construction of RE projects, and providing local training and end-use advisory services, carrying out routine maintenance on completed RE facilities, and supervising revenue collections. A schematic diagram of our organizational framework is provided in Figure 1.
Figure 1. Seven-phase planning and management framework for rural electrification projects.
RURAL ELECTRIFICATION ISSUE PAPER 6
INFORMATION NEEDS OF RURAL ELECTRIFICATION PARTICIPANTS

Introduction

Rural electrification participants are of three basic types: planners, field technicians, and rural residents. If these participants are to plan, implement, and successfully manage an RE project, they must work closely together and develop a shared perception of the RE development process. This paper discusses the information that each type of RE participant needs from the other two types, and elsewhere, in order to meet individual responsibilities.

Information Needs of Planners

In our suggested institutional framework for RE (see Issue Paper No. 5), the principal task of RE planners is to formulate and continuously refine policy guidelines and a master strategy for RE. The master strategy will describe the various types of RE projects that are to be considered by end use, potential rural site, and technology alternative. In order to do this, planners need four categories of information. First, they need national and regional development plans. These documents form a policy background required by planners in order to determine the priority allocated to RE, the objectives that should be met by an RE program, and interrelationships with other rural development initiatives. Second, planners need reports on rural extension services by sectoral activity. By consulting these reports, potential end uses for RE can be identified. Third, planners need regional infrastructure and village census data. The relative timing of RE and other rural infrastructure projects is crucial to maximizing developmental benefits. By analyzing data on the characteristics of rural regions and on villages within each region, sites that have the preconditions for successful RE can be identified. Fourth, planners need continuously updated technical reports on the various methods for generating electricity. To select suitable RE technologies, planners need to have a basic understanding of the characteristics of the various methods of electricity generation and detailed knowledge of their reliability, applicability, and maintainability under local conditions.

The potential sources of these four categories of information include the files of national and district government offices and external consultants. These secondary data sources should always be viewed with some skepticism, however, and will not be adequate in selecting sites for RE. Site visits are a prerequisite to obtaining realistic end-use demand estimates for rural electricity and the adoption and the support of rural residents for a proposed RE project. In our suggested RE organizational framework, these site visits will be made by multidisciplinary appraisal teams composed of at least one member of the central RE agency together with field technicians located at either the national or district level.
The planners in the appraisal teams from the central RE agency should make at least one site visit, because they ultimately will make the decision to accept or reject a proposed site for an RE project. However, it will be the field technicians in the RE project appraisal teams who will provide the planners with the primary data they require to make their decisions. In analyzing this field data, planners need to ascertain the basic aspects of local socioeconomic conditions. Such local insights are critical to the planning and implementing of successful RE projects and cannot be obtained without site visits. The procedures that field technicians should adopt in gathering this primary data need to be considered carefully.

RE planners should draw up guidelines for use by field technicians when they are collecting primary data from rural residents. We suggest that fieldwork should include the following elements:

1. Technicians should know well the purpose of their site visit and be sure to explain it to rural residents before embarking on their surveys or other work.
2. Technicians should avoid draining community resources while collecting information in relation to, or carrying out work on, an RE project; they should bring with them their food, cooking equipment, and other requirements that cannot be readily met by local resources.
3. Household interviews should be planned ahead of time and individual field interviews kept short.
4. To keep field surveys short, a number of subsurveys may need to be prepared, each of which focuses on a specific topic or potential end use of the electricity. Each subsurvey should be pretested to ensure that every question that is asked is intelligible to rural residents.
5. Surveys should be conducted in an informal conversational manner because rural residents generally dislike formal question and answer situations and may believe that whether or not they receive an RE project depends upon their answers to questions. Under such conditions, unrepresentative data are likely to be obtained.
6. Information collected in surveys should be checked immediately following the interview and arrangements made to fill any outstanding gaps in the database.
7. As much time as possible should be left to analyze site information, and the final report must be made available to rural residents, preferably with a community briefing by the interviewer.
8. Subsequent work performed by field technicians on accepted RE projects should be written up in the form of a progress report after each site visit and made available to the central RE agency.

Information Needs of Field Technicians

In order that RE planners can appraise the proposed RE projects, field technicians will need to collect several types of village data: (1) information on how rural residents plan to use electricity and their ability to pay for it, (2) information on the availability of the physical resources required by RE technologies, (3) information on the community skills that could be used in the RE project, and (4) the willingness and ability of community members to work together as required by the project. Sources of this information will be the potential end users of RE, village leaders, local school teachers, church and health officials, together with social conversations and each field technician’s own observations.
End uses for electricity can be divided into three basic classes: household, communal, and income-producing end uses. Surveys should look at each of these classes in turn. The survey on household end uses should begin by establishing what energy forms are currently in use and the activities that are performed with each energy form. It should then be determined how cooking fuel requirements—the basic rural energy need—are being met. Next, quantitative data should be gathered on how much fuel is being used for household lighting and how much money is being spent on lighting fuel. Expenditure data are an indication of the household’s eventual ability to pay for electric lighting. However, in order to determine a household’s ability to contribute towards the front-end cost of RE and to pay for subsequent electrical appliances, household income data (including remittance sources) will need to be collected. Information should also be collected about the house itself—its size, configuration, and material makeup. This information is essential for the design of a safe and utilitarian residential electric wiring system. These data can be in the form of a quick checklist of technically important characteristics.

The survey of communal end uses for electricity should collect background information on the number and types of communal facilities in existence, their location, and by whom, for what purpose, and how often each facility is used. In addition, the community should be asked to nominate facilities for connection to the proposed electrical supply and to specify the ways in which its members envisage the electricity will be used in each electrified communal facility. The availability of communal funds to pay for electrical equipment and units of electricity used should also be ascertained.

Information similar to that described above should also be collected for each rural business that proposes to use electricity for income-producing purposes. In addition, surveys on income-producing end uses for RE must pay particular attention to the preconditions for rural business success: the availability of credit, transportation, skills, and markets. Also the use of alternatives to electricity in rural business should be explored, and the relative advantages and disadvantages of the various possible energy forms should be determined.

It is important to correctly identify the members of a rural community who should be included in the surveys on potential end uses for RE. Obviously, a sample of potential end users for each proposed application for RE should be interviewed. Women should be the target interviewees in the household surveys, and women and young people as well as men should be among the interviewees in the communal and income-producing end-use surveys. After individual interviews have been completed, field technicians may find it useful to relax into informal social conversations with rural residents. During these conversations, formally collected data can be confirmed, and potential new sources of information can be ascertained.

Physical Resource Endowment

Upon completion of the surveys on potential end uses for RE, field technicians will be better equipped to make realistic estimates of electricity demand. However, our experience suggests that even here the data collected in the surveys must be treated with caution. Generally we believe that the actual use made of electricity will be less than that stated by rural residents. Evidence suggests that, even without conscious effort, rural residents tend to be optimistic about the amount of electricity they will consume. Once the size of the demand for electricity has been ascertained, field technicians can begin to address the question of choice of RE technology. To reach a decision on the type of RE technology alternatives
that are feasible, the availability of the physical resources required by each alternative must be assessed.

To determine accurately the feasibility of the grid extension alternative, an actual site visit in combination with discussions with the electricity authority will be required. Site visits are often necessary to locate the position of the grid in relation to the proposed site because data on grid extensions often are not transferred onto the maps of the central electricity authority until years after the actual installation.

In addition to determining the distance over which the grid extension would need to be made, field technicians will need to identify and consult with the owners of the requisite land. Particular attention should be paid to the natural hazards that might occur as a result of the extension, and eventually a right-of-way agreement must be negotiated with local landowners. We believe this should be a formal process written down in an official document.

The principal resource need of the diesel alternative is a reliable fuel supply. Field technicians will need to determine the fuel transportation mode, frequency of transportation service, and storage capacity at both ends of the transportation link. Indeed, transportation is a topic that will need to be addressed in relation to all RE technology alternatives in order to determine how RE equipment can be conveyed to the site.

The real challenge faced by field technicians will be estimating the availability of renewable resources from which electricity can be generated. Information on the general availability of sunlight or hydro or biomass occasionally may be available in government offices. Even if such information is available, discussions with rural residents, and village leaders in particular, about these resources are often invaluable in providing localized information on matters such as the availability of sunshine throughout the year, the consistency of stream flows, and the use of biomass. Experience suggests, however, that it is wise to assume these resources to be less accurate than village information would indicate. Of course, actual measurements of these resources should be taken to accurately define their availability.

Skills and Social Organization

In addition to physical resource surveys, field technicians will need to undertake human resource surveys to identify the kinds of skills that could be used in managing and operating an RE system. Both men and women and old and young people should be included in these human resource surveys. If the proposed RE project is to be communal, then the community’s social structure should be examined, and the willingness and ability of the people to work together should be assessed. An effective way of determining the community’s ability to work together is by collecting information on the community’s previous involvement in community development projects and on the relative success of these projects.

Other good sources of information on the capabilities of rural people include local church officials, school officials, government field officers, and aid organizations. All of these groups are directly or indirectly involved with rural community relations. It is to be noted, however, that local church officials tend to favor change and may overestimate village resources in the hope that once the RE system is in place, community members will become committed to its continuance or that the government will step in to rescue the scheme. Compared with church officials, school officials tend to be more pragmatic about the potential of rural villages and are a prime source of information on rural capabilities.
because they often depend on rural people for money and labor for their schools. For an unemotional and independent view of rural local capabilities, government field officers and representatives from aid organizations should be consulted.

Information Needs of Rural Residents

It is important for field technicians to realize that rural people's knowledge of what an RE project encompasses and can achieve will be extremely limited. Field technicians must assume the primary responsibility for explaining to rural residents what they can and cannot expect. This is an overriding responsibility and cannot be ignored. Unless they are provided with this information, rural residents cannot make meaningful decisions between RE and other desired community development projects. The responsibilities of local residents to an RE project should be stated clearly by RE planners and relayed to rural people by field technicians. Rural residents' responsibilities might include making cash contributions to meet front-end costs, donating right-of-way access, providing unskilled labor for implementation, identifying suitable people to be trained to operate and carry out simple repairs on the RE system and to manage its finances, providing free housing and some food for RE field technicians, arranging fuel deliveries in the case of diesel projects, meeting certain equipment replacement costs, and paying recurrent bills for electricity. Whether each of these potential RE responsibilities is acceptable to rural residents should be determined by discussions. Field technicians should refrain from telling rural residents what they will and will not do; on the contrary, field technicians should see themselves merely as providers of information on the proposed RE project. Rural residents should be encouraged to make the necessary decisions. Our studies suggest that a perceived ownership of the RE project may encourage community involvement. We believe that rural people are generally very conscientious about their obligations and will meet them if they understand exactly what is involved.

In addition to providing village people with information on their responsibilities, field technicians must provide them with information on end-use opportunities for electricity and educate them in the safe and efficient use of electrical equipment. The ideas that rural residents have on these matters will be vague at best. Particularly in RE systems with limited power availability, potential users need to know the limits of power supply and how to avoid systems overload. Villagers also need to be educated about the power requirements of the various types of electrical equipment in which they show an interest and about what combinations of electrical devices can be connected to the power supply at any one time without exceeding the capacity of the RE facility. Furthermore, they will need to know the power rating of the different electrical devices, in combination with data on tariff rates, so that they can determine how much the various electrical devices will cost to run. It may also be useful to educate villagers about the likely life span of the different brands of electrical equipment and to encourage purchase of brands made of materials that are durable and do not corrode easily.

When field technicians conduct these consumer education programs, they may find that discussions are stimulated if rural residents are supplied with photographs of each piece of electrical equipment under consideration. They may find it useful also to have a resident from a neighboring electrified rural area participate in the information program. They certainly will find it useful to have rural residents visit an existing RE project (of comparable size and type to the one being considered for their own area) and to see for themselves what such a project encompasses and might achieve. However, even if rural residents have been well informed about the RE project, only after the project is in place will they begin to appreciate fully the time and resource adjustments necessary to use and sustain it. An RE
information officer will be required to keep in close contact with rural residents during the first year to answer questions that emerge only with implementation.

Summary

The process of planning, implementing, and managing RE projects is a partnership involving planners, field technicians, and rural residents. Effective communication channels among these groups are essential because each depends on the information and expertise of the others if the RE program is to be successful.
EAST-WEST CENTER

The East-West Center is a public, nonprofit educational institution with an international board of governors. Some 2,000 research fellows, graduate students, and professionals in business and government each year work with the Center's international staff in cooperative study, training, and research. They examine major issues related to population, resources and development, the environment, culture, and communication in Asia, the Pacific, and the United States. The Center was established in 1960 by the United States Congress, which provides principal funding. Support also comes from more than 20 Asian and Pacific governments, as well as private agencies and corporations.

Situated on 21 acres adjacent to the University of Hawaii's Manoa Campus, the Center's facilities include a 300-room office building housing research and administrative offices for an international staff of 250, three residence halls for participants, and a conference center with meeting rooms equipped to provide simultaneous translation and a complete range of audiovisual services.

PACIFIC ISLANDS DEVELOPMENT PROGRAM

The Pacific Islands Development Program helps meet the special development needs of the islands through cooperative research, education, and training. Its analytical research provides Pacific island leaders with detailed information on alternate strategies for reaching development goals.

PIDP also serves as the secretariat for the Pacific Islands Conference, a regional heads of government organization, and its Standing Committee, composed of eight island leaders. PIDP initiates its activities in direct response to requests from the Standing Committee and works in close cooperation with the Pacific island governments, ensuring that the focus of each project addresses the islands' needs.

Since 1980, PIDP has conducted research in eight project areas: energy, disaster preparedness, aquaculture, government systems, nuclear waste disposal, indigenous business development, roles of multinational corporations, and regional cooperation.

RESOURCE SYSTEMS INSTITUTE

The Resource Systems Institute (RSI) carries out policy-oriented research on issues in energy and minerals resource assessment, development policy, trade, and economic growth in the Asia and Pacific region. RSI's projects are conducted within the context of three major programs: Energy, Minerals Policy, and Development Policy and International Studies. The current research agenda includes projects on regional energy security, technical and economic assessment of land and marine resources, rural development, and trade and investment patterns. Projects are also under way that examine Pacific Basin economic cooperation, ASEAN regional cooperation, and international relations issues.

Research and related activities are undertaken by RSI project teams consisting of an international research staff, invited scholars, and graduate students. These project teams, working in cooperation with regional research groups, help realize the Center's goals of promoting better relations and understanding among the nations of the region through cooperative study, training, and research.