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Evaluating electrification experience

A guide to the social evaluation of small hydroelectric units in lesser developed countries

NRECA Small Decentralized Hydropower (SDH) Program

Evaluating electrification experience:

A guide to the social evaluation of small hydroelectric units in lesser developed countries

by AMARU IV Cooperative
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Small decentralized hydropower program

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Under the agreement, begun in May 1980, NRECA provides a broad range of technical assistance to developing countries. NRECA provides assistance by:

- designing and implementing regional workshops in Africa, Asia, and Latin America
- developing and conducting in-country resource surveys and site assessments
- providing engineering, supervision, and specialized assistance
- developing specialized publications such as state-of-the-art reports, inventories of manufacturers, and assessment methodologies
- conducting special studies on issues pertaining to finance, management, evaluation, and other subjects
- providing training services in such topics as operation and maintenance, resource assessment, equipment fabrication, and institution building
- carrying out specialized services such as tours of U.S. manufacturing plants and small hydro sites and seminars on private sector involvement
- creating specialized products such as productive-use plans for energy from small decentralized hydropower.

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The Small Decentralized Hydropower (SDH) Program of the United States Agency for International Development (USAID) will stimulate a new kind of project for AID missions. The technological focus of the SDH Program is the promotion of small hydroelectric generating equipment with less than 1000 kW installed capacity in developing countries.

The SDH Program entered into a cooperative agreement with the International Program Division of the National Rural Electric Cooperative Association (NRECA) for technical assistance. NRECA, in turn, contracted with the AMARU IV Cooperative, Inc., a social science consulting firm, for assistance in formulating a framework of social evaluation for small decentralized hydro operating units. To develop an evaluation framework, a team of AMARU researchers reviewed precedents in the evaluation of AID-sponsored rural electrification programs and analyzed the local social and institutional factors which distinguished electrification by small hydro equipment from electrification by two other technologies, isolated thermal autogenerators and power distribution networks.

This analysis was based on a review of the literature and extensive interviewing of individuals connected with small hydro projects. To collect case histories, the team designed a data inventory to survey the technical, social, cultural, economic, and institutional features of local rural electrification. Neither the literature nor the interviews provided as much information as the team wanted about local social and institutional arrangements. The literature on small hydro installations was especially disappointing. Technical descriptions of equipment installed were more common than accurate accounts of the end uses of electricity or their sociocultural context and consequences.

Despite the lack of complete data for any one locality, the coding and analysis of data from many sites allowed some conclusions concerning local social factors important for the success of small hydroelectric systems. These findings are preliminary observations only. Field work will be needed to verify the patterns and to discover other significant social factors in particular cultural settings.

Based on the conclusions of this study, NRECA with the assistance of its contractor, the AMARU IV Cooperative, Inc., has developed recommendations to USAID for establishing procedures for the social evaluation of small hydropower units in developing countries.

Summary recommendations

1. The purposes justifying the installation of each small hydropower unit in the field—that is, the objectives of each project—should be framed in terms of a development strategy appropriate to the level of development in the host country's rural areas and to other social characteristics of that country. Refinement of the objectives will influence the scale and form of small hydropower technology which is selected and will also identify some characteristics to be sought in a user-community.

2. The project purposes or objectives should be made explicit at the project design stage and appropriate indicators should be selected at the same time, to be used later in evaluating how well the project accomplishes its social objectives. Early selection of indicators will allow baseline data to be collected easily and systematically as the project begins.

3. A user-community application procedure should be used to select sites for small hydro units and to screen candidate communities for social and cultural characteristics important for project success. This is especially important if local involvement in construction and operation is to be achieved.

4. Regular evaluations should be conducted as soon as one year after local operations begin. Regular evaluation can identify problems in the local institutional arrangements for maintenance, management, and use of the small hydro units, as well as indicate whether the purposes established for the project are being achieved.

5. These evaluations need be neither elaborate nor costly. The same procedures should be used for all projects in order to gather comparable information. In this way, experience from operating small hydro units can help in improving the design of new projects. At the same time, the procedures must be flexible enough to accommodate the social and cultural differences among developing countries.

6. The evaluation procedures should involve observation, examination of selected records, and systematic interviewing within the user community.

At the end of this report, NRECA and AMARU IV Cooperative present a draft User-Community Application Form and Evaluation Protocols which can help USAID in responding to these recommendations.

Findings from literature review and interviews

Institutional mixes

The systems in which the functions of ownership, maintenance, and management were all invested in the same group of users were the most successful. In cases where these functions were invested in different groups (for example, owned by the power company but locally maintained) the systems were more vulnerable. An institutional mix of functions often led to breakdowns in communication, competition among groups, and other problems. This has great significance for the SDH program, as the program will involve a number of different institutions—AID, consultants, the host country national government, regional governments and/or utility companies (possibly), and the user community.

Local involvement

The systems that were the most successful were the ones in which the local community was actively involved from the conception stage. Most numerous are examples of successful hydro projects initiated by an outside agency but with communities heavily involved in planning and building the system which the community eventually operated and maintained. The Pakistan Appropriate Technology Development Organization micro-hydro projects are examples.

Community involvement can mean different things to different people. An agency or outside group might bestow a unit on a community and call it "local control" even though the community did not ask for or even want the hydro unit. Local involvement might be defined by some as forced local labor to build the system. Indeed, the centralized nature of AID's SDH program assumes non-local control, at least during initial stages. For the most part, requests for SDH assistance to AID come from national agencies via the AID Missions. Add to this various layers of regional governments and/or utilities companies that may be involved, and local initiative can be lost. Since one of the SDH program objectives concerns integration of the hydro program with other development programs, most of which will not be locally initiated, the issue of community involvement becomes even more complex.

There are cases, such as Pakistan, where non-local initiation can be successful. But there are many more instances where such systems have failed. SDH program officials will need to clarify the issue of local control and ensure that its requirements are met.

Integration into the cash economy

The most successful units were in communities that were well integrated into existing cash economies. To use electricity, people need a variety of appliances, including light bulbs, that are produced and sold within the modern commercial-industrial sector. If users do not have the cash to buy these appliances, and if they do not have access to these items

(transportation, markets, etc.), a hydroelectric system will do them little good.

In a number of cases, individuals and communities could not use "bestowed" electricity because they could not afford appliances. This could apply equally to systems designed for production and/or public use of electricity if businesses and communities cannot afford or do not have access to electric machinery, equipment, and lighting devices. Hookups can also be bestowed, and the system subsidized (that is, allowed to operate at a loss), but how much subsidization can be reasonably given?

This is a critical issue for the AID SDH program, which has a primary objective of helping poor communities. It raises a number of questions:

—Would direct motive applications such as water mills be more appropriate if the poor cannot afford to use electricity?

—Should less poor communities that can afford appliances be selected?

—Should non-household use of electricity be used to reach the poor—such as the electrification of enterprises that create employment or social uses (street lighting, schools, etc.)?

Scale

Within the range of "small" hydro, there appears to be definite scale breaks in the institutional arrangements necessary for the operation and maintenance of units. It is possible to make rough estimates of where scale breaks occur.

Units of about 25 kW installed capacity are apparently operated with very little occupational specialization. Units in a range from about 25 kW to 125 kW can be operated by a small, possibly part-time staff of as few as two to four specialists. The recurrent costs of employing even a few occupational specialists may be high for systems that serve households and public facilities alone. Institutions that are able to merge the function of hydroequipment operation and on-site repair into other jobs may be able to absorb this personnel cost more easily, and this is the approximate range of installed kW capacity common among the hydro units operated by specialized institutions such as processing plants or isolated hospitals.

Systems of about 125+kW installed capacity require small versions of the administrative organizations that operate, distribute, and collect user fees for large electric systems. The staff must be permanent, full-time, and possess well-developed engineering and management skills. Unless such systems serve a micro-region or several industrial users or are linked to a larger power transmission system, they may also be expensive to operate without subsidies.

Capital installation costs appear to have similar scale breaks, largely because of the associated civil works of the larger systems. Clearly there are popular microhydro units which are within the reach of individual rural farmers or small communities. A great deal more work needs to be done to

analyze the capital costs of "small hydro" with clear specifications of the scale ranges.

These findings and others reported in a data summary indicate that local social factors should be taken into account in selection among alternative sites for small hydro operating units.

An improved framework for evaluation

Review of the precedents of rural electrification evaluations for AID programs revealed extremely limited reference to pre-project status information in any evaluation commissioned. Both to improve the information available for decisionmaking in the design of small hydro projects and to establish a strong, internally consistent framework and basis for evaluating a project's success, three essential operations should be followed in the small hydro projects of AID country missions. These three essential operations are--

(1) Clarification of the purposes and objectives to which small hydro technology will be put in order to select among several alternatives those objectives most suited to a particular developing country.

(2) Community application procedures to select among alternative local sites and to create a pre-project status report that can be used as a baseline for evaluation after operations begin.

(3) Regular onsite evaluations using standardized protocols for observing, interviewing, and abstracting records of relevant changes brought about by the electrification.

Clarifying objectives

Small hydro operating units can meet a number of goals and objectives. Broad goals include improvement in the quality of life and economic development. SDH projects, like other rural electrification programs, can be designed to serve simultaneously many kinds of end users. The technology can also be applied to serve a more limited end use.

The SDH program has embraced a number of distinct objectives, not all of which are always compatible. The program assumes that "renewable energy resources are necessary for development...". The goal of "increasing utilization of renewable energy technologies in the developing countries" must be coupled with the mandate of AID to reach the "poorest of the poor," and especially the rural poor.* Chapter 1 discusses seven major types of purposes. These include end-use objectives (productive uses, social benefits), economic objectives (least cost), geographical objectives (remote areas), national objectives (decreased dependence on fossil fuel), and the objective of reaching a particular economic strata, the rural poor.

In evaluating SDH programs, both at the pre-project and post-project stages, goals and objectives must be clearly defined and understood so that appropriate criteria can be drawn up to evaluate potential user communities and to measure program accomplishments. Evaluation

* This "New Directions" mandate is set forth in the 1973 amendments to the Foreign Assistance Act of 1961.

criteria can be created to deal with any single objective or a multitude of objectives.

The objectives must, however, be clearly stated and understood. Each distinct objective will require its own set of evaluation criteria. For example, a SDH project designed to "benefit a poor community in a remote area through productive uses of electricity" will require three sets of criteria to satisfy these three objectives. At the pre-project stage, sites will need to be selected that have a large concentration of poor people, that have at least a minimum number of industries and businesses, and that satisfy the criteria of remoteness as defined in the host country. If assumptions are made about local participation (whether ownership, management, labor to build the system, or all of these), then potential user communities will need to be evaluated on the basis of their ability and willingness to perform these functions. If the SDH system is designed to be self-supporting, then communities must be matched to a technology they can afford.

At the post-project stage, evaluation criteria will need to be formulated to ascertain whether or not poor people have benefited, whether productive uses of electricity have been made, whether the community has been able to successfully manage the system and whether the system is solvent.

For objectives that contain inherent contradictions or that contain so many objectives that are all unlikely to be satisfied, choices and/or compromises will have to be made. For example, it may not be possible to meet the objectives of small hydro country strategy (national) and decentralized local control (community) in countries where laws and institutional structure require centralized management at the national level. Local participation could be part of the program in various forms, but there could be severe problems if the system had to satisfy both objectives. Similarly, if an SDH project designed to benefit poor people also has the objective of non-subsidization, there could be problems because, in many cases, poor communities may not be able to cover operating costs. Program officials will then need to decide whether to subordinate the non-subsidization objective or select a more affluent community of users.

Discussions in the Chapter 1 are intended to set forth considerations which must be taken into account in selecting the strategy and design of a SDH project most appropriate for a particular country. The selection and clarification of purposes will be made by the AID mission, host country and those assisting them.

To summarize, goals and objectives must be clearly delineated in order for evaluation criteria to predict accurately the success of an SDH project and to measure adequately project outputs. Where conflicts between objectives may occur, priorities will need to be established among objectives.

Community application procedure

Evaluations of potential sites and user communities to determine their suitability for small hydro systems is important for at least three reasons. First, careful evaluation and site selection can go a long way toward

ensuring the success of the project. Secondly, in most national or international small hydro programs, there will be more potential sites than funds to cover installation of SDH systems, and choices will have to be made among the sites that are available. Informed choices can be made by a good evaluation procedure. Finally, a good pre-project evaluation can provide valuable baseline data for a post-project evaluation.

Technical evaluation of hydro sites has long been standard practice, ranging from fairly informal procedures consisting of a few measurements and calculations to elaborate, detailed feasibility studies. Evaluation of user communities is a more recent phenomenon. In the vast majority of cases of existing small hydro systems, the users have themselves initiated the purchase and installation of the unit. Hundreds of SDH systems are being used successfully by businesses and private voluntary agencies around the world. A small number of SDH systems have been installed by villages and municipalities on their own initiative.

Where small hydro units have been installed and maintained on local initiative, evaluation of the user community has not been a significant issue, since the users have demonstrated their desire and need for the SDH unit by virtue of their willingness to install and pay for the system. However, when small hydro programs are initiated by governments and by bilateral and multilateral funding agencies, SDH units may be "bestowed" on local communities with, or without, their active support. In many of these cases, while there has been technical evaluation of the hydro sites, there has been no corresponding evaluation of the user community to determine its suitability for a hydro unit. Assumptions have been made by outside agencies that the community wants, needs and will use the system, and that the system will be used for the purpose planned by the donating agency.

In contrast to units that have been locally initiated, systems that have been bestowed on communities have a mixed record of success. While some have been enthusiastically received, many others have experienced severe problems, and a number have been discontinued. In some cases, user communities have been unable to manage or maintain the systems, necessitating outside personnel to perform these functions, often with increased costs and delays. In other cases, communities have been unable to use the electricity supplied by the SDH system through inability to pay the cost of hookups, service charges and electric appliances, including light bulbs. In a number of cases, there was an expectation of industrial and/or commercial demand for electricity, but this was not realized because these establishments did not exist, were not developed, or could not or would not use the electricity supplied by the SDH system.

To avoid these kinds of problems, a pre-project social evaluation of the user community is strongly recommended. This evaluation could take many forms. A useful tool suggested is a "community application form" that would screen potential applicants for those characteristics necessary for the successful operation of an SDH system. The criteria to be used in evaluating user communities will depend on the defined purposes of the SDH project: the community application form should reflect the goals and objectives of the SDH program. However, there are certain requirements

common to all SDH systems, whatever their purposes and whatever type of user community. These include installation and construction of the system, management, maintenance and repair.

The design of the User-Community Application Form recommended in this report was drawn from the experiences of local groups that have built and operated their own hydro systems. The Application Form reflects the kinds of issues these user communities had to deal with in building, maintaining and using their SDH units. It should be self-administered by the user community. The act of preparing the questionnaire itself can be a means by which the user community develops or enhances the management and planning skills that will be needed to successfully operate a small hydro unit.

Many characteristics which would help predict the suitability of one group of potential beneficiaries over another are tested in the application form. However, certain social, institutional and cultural characteristics need to be further delineated. To achieve this, surveys in particular sociocultural settings will be required. Fieldwork is essential, as the literature does not contain information about a number of important characteristics which would predict the suitability of a group of end users. This will vary by global region, country, area, and ethnic or occupational group. For example, a community which collectively operates a traditional irrigation system will be pre-adapted to understanding the hydrodynamics of the technology. While this cannot be raised as a worldwide screening characteristic, since there are many potential small hydro sites near populations which do not have such a tradition, this trait could be used to select groups within broad regions where the trait is present.

Regular evaluations

The final procedures suggested include an evaluation one year after operations have begun at the small hydro unit and at subsequent intervals. This evaluation is to be conducted by the respective AID mission. However, by using the same procedures in different countries, information for a higher-order comparative impact evaluation will be generated. This operation is described in some detail. Field preparation is outlined and a model protocol is provided in the final section of this report.

A post-project evaluation of the SDH system can provide program officials with valuable data. It can assess whether program goals and objectives are being met and can point out problem areas that need to be corrected. Since many SDH installations will be pilot projects, careful evaluation of these units can be helpful in the planning and installation of future SDH systems.

An on-site evaluation of the SDH system should be undertaken one year after installation. A year is not very long period of time in which to gauge the impact of electricity on a community. While there are usually some immediate effects, the full impact of electricity will not be obvious for a number of years. The post-project evaluation after one year, however, is advisable because most SDH projects will still be under the supervision of the sponsoring agency, and an early evaluation can allow needed

modifications while agency personnel are still available. Further evaluations can be undertaken at later periods. Followup studies should be conducted at intervals for a number of years.

The site visit evaluation should consist of three parts: observational data, examination of records and interviews, and if possible, photographs should also be taken. The evaluator should be able to perform a fairly comprehensive investigation in two to five days. An illustrated evaluation procedure detailed in the "Protocols" section is designed for use in a village-level multi-purpose electrification system. Evaluation formats for specialized institutions or single-purpose electrification can be designed from this generalized format by selecting out, and possibly expanding, those aspects of the evaluation which apply to the specific site. Items to be investigated will, of course, vary among cultural groups and global regions. For example, the use of such aplicances as rice cookers and fans will be restricted to certain geographical and cultural areas.

Preface: How to use this guide

This guide is intended to assist in the design of AID Small Decentralized Hydro projects so that a framework for social evaluation can be built into project design and so that designers may understand and select among alternatives. The guide contains a discussion of issues which will occur in the formulation of AID Project Identification Documents (PID's) and Project Papers. The guide also provides models for community application forms and for onsite evaluations.

The guide is primarily intended for use in the design of Small Decentralized Hydro projects by AID country missions. The document reflects the special concerns and procedures of that development agency. However, it holds interest for others concerned with promoting small hydro technology. The program is now beginning to build units in the field. This guide is a discussion of issues based on small hydro experience in the developing world. AID will augment that experience with its own projects.

The guide is bound in two volumes. Volume I, the main work, is divided into four chapters and a final section which contains a draft User-Community Application Form and Evaluation Protocols and a bibliography of the references cited. Volume II, appendix materials, includes the case history data inventory which was used to collect a base of information, a data summary, samples of some manufacturers' guides and questionnaires. Volume II is available upon request from NRECA.

Chapter 1 discusses the general objectives of reaching the rural poor and seven categories of objectives. These are discussed in Chapter 2 and include (1) serving "remote" areas, (2) small hydro country strategies, (3) decentralized local control, (4) lowering power costs through renewable hydro energy, (5) direct hydropower motive applications, (6) "productive uses," and (7) social benefits. Discussions of each are drawn from an analysis of the literature and from interviews.

Chapter 3 reviews evaluation procedures currently used within USAID. Also presented are reviews of evaluations performed for AID-sponsored programs which used central power transmission technology. Evaluations of rural electrification in Bolivia and in the Philippines were selected as examples. This chapter is intended to explain the different kinds of evaluations practiced and contracted by AID and the role of each within the agency. The "evaluation of evaluations" for Bolivian and Philippine rural electrification illustrates the style and social indices of current procedures. Evaluation procedures of small hydro units must be different from those designed to sample more massive electrification, yet fit within the conceptual framework used to appraise electrification as an instrument for social change.

Chapter 4 and a final section present a model Community Application Form and Evaluation Protocols. The application form included in this study will have to be modified for each country context. The procedure of having potential beneficiaries select themselves through application is particularly appropriate for screening social, economic and other factors important in

the successful operation of such units. This procedure, with modified applications, might also be used for other types of AID projects. The form also culls baseline, or before pre-project status, data.

Chapter 4 also includes protocols for on-site evaluations after a small hydro electrification unit is built and operating. The protocols are for observations, abstract of relevant records and key informant interviews. Together, these protocols form a simple evaluation procedure with numerous cross-checks for accuracy of the indices built into the operation.

Appendix A presents the case history data inventory which was developed to abstract information concerning rural electrification experience from the literature and to record interviews. This data inventory is suitable for collection of information from existing small hydro sites. Materials in the inventory can also be used to expand the lines of inquiry of either the community application form or the on-site evaluation protocol when the model documents are adapted to country use.

Appendix B summarizes the results of the analysis of cases and "sets," which are partial cases concerning small hydro electrification where data was too fragmentary to constitute a "case."

Appendix C contains several small hydro equipment manufacturers' questionnaires and guides for filling out the questionnaires. They support Part A, the TECHNICAL section of the recommended community application form.

The bibliography of references lists literature cited in the text by author's surname and date.

We hope that researchers who visit small hydro sites will use the data inventory and the proposed site visit evaluation methods in order to expand the now scant data base on the local social aspects of this important technology. Field work to collect good case history material will be important to test the hypotheses of this study and to document why variations occur in different sociocultural settings.

Both NRECA and its contractor, AMARU, would be interested in receiving copies of any case histories collected with the use of the forms proposed and in corresponding with any one who uses them in the field.

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Chapter 1

Understanding objectives: The purposes of the small decentralized hydropower project of AID

The Project Purpose of the Small Decentralized Hydropower (SDH) project is "to demonstrate the application of small decentralized hydropower to provide energy to meet rural needs" (AID/DS/EY 1979, p. 44). Among its outputs will be operating units in the field. These demonstrations will require reports and reviews, field trips, trip reports and general AID participation. The demonstration projects will be subject to "pre-project and post-project efforts (to determine) the effects of enhanced electrical power availability on the local economy, social and political structures" (ibid, p. 11). The specific goal of the SDH program is "to develop local water resources for electricity production in remote or rural areas of the LDCs" (ibid, p. 12). This represents a clear choice between two basic options for hydropower: genera-tion of electricity is selected over direct motive applications. This project purpose refines the choice of possible demonstration sites.

Other purposes are set forth in the original project paper which represent further choices and refinements, including—

> "coordination with rural electrification, irrigation and water resource projects and rural development projects" (ibid, p. 14) especially, in "rural areas where future development projects are expected, (and) where no alternative electricity supply network exists or areas where diesel generators may be the sole source of power," (ibid, p. 14); (to make) "a significant impact on development" (ibid, p. 9).
>
> replicability (ibid, p. 12)
>
> "implementation of SDH in such a way as to maximize local participation of labor and materials suppliers" (ibid, p. 12)
>
> "user acceptance of SDH systems" (ibid, p. 12) as predicted by such selection criteria as
> —existence of a local skills base which can be trained to operate the facility
> —existence of a mechanism to pay for the generation costs through sale of electricity
> —cultural acceptance of the concept of hydropower by the community

In addition to these statements of subpurposes and selection criteria in the project paper, additional implicit purposes or objectives emerge from discussions with AID.

To suggest a preliminary framework of evaluation, the various purposes to be achieved by the small hydro demonstration units in the field must be thoroughly understood.

Overview of potential objectives

In this section, various potential purposes or objectives are discussed, in an effort to clarify policy choices which must be made and compromises which may be required.

Outputs

All the purposes or objectives described in this section require that a project result in small hydros being in place, functioning reliably with a system for repair, acquisition of spare and replacement parts, and a cleaning routine for the upstream system and other maintenance and/or fee collection procedures in place, and perhaps some form of backup system also in place. The technological and social institutional characteristics of these outputs will vary according to the purposes defined for specific projects.

Categories of objectives

Discussions with individuals involved in the SDH program, with advocates of small hydro systems, and examination of the literature indicate several purposes for small hydros. These purposes are distinct enough to require separate evaluation criteria. The distinct purposes or justifications for small hydro are listed below. Key words are underlined.

Geographical objectives:

1. Serving remote, geographically isolated (that is, rugged terrain) rural areas with local multipurpose electrification, especially population centers which cannot be served by centralized public power sources in the immediate future, due to the high cost of transmission lines from power generating sources to the locality.

2. Applying a country strategy in those countries which have a good small hydro potential, where there is either no or very expensive macrohydro capacity or excessive capacity compared to given market demand, and especially those which have no indigenous fossil fuels. One variant of this strategy presumes that small hydros will be linked on a public power grid and provide one of several sources of power.

Political objective:

3. Providing an autogenerating source to facilitate decentralized local control of power.

Techno-economic objectives:

4. Offering the alternative of lower cost renewable energy as a substitute for thermal fuels.

5. Offering direct motive hydropower applications in various appropriate technologies capable of reaching a maximum among the poorest of the

poor.

End use objective:

6. Offering a technology for electrical generation which can be more directly applied to productive uses.

Social objective:

7. Strikingly absent from most discussions of the intended purposes of small hydro has been social benefits. This is unfortunate because a well-established use of small hydros is the localized electrification of isolated institutions delivering social services to rural residents. Documentation of social benefits at the household or village level has suffered from inadequate evaluation techniques—a flaw which could be corrected. Social benefits are therefore discussed below as a seventh potential purpose.

Combinations of objectives

Some of these objectives could be combined by skillful design in a single project. The management and ownership of a small hydroelectric system could be decentralized to the locality and also be designed for application to productive uses. With careful institutional and technical quality controls, such a model could fit into a country strategy for the use of dispersed hydro potential and could one day be linked physically into a larger grid and institutionally into a second-level user-owners' association—all of which would be based on the renewable energy of hydropower.

Each objective could also stand as primary, for each has distinct technical and institutional potential for realizing to the fullest the intended objective.

Commonalities of assumptions among objectives

Least cost—The objectives could assume that small hydro would be the least cost solution to achieve the purpose—if not immediately, over the long term future. Least cost solution can be screened by economic feasibility criteria, and later verified by evaluation.

Means to end—All of these diverse objectives address the goal of raising the standard of living, or providing some concrete benefits through the provisions of additional energy. They vary in the tactic selected to meet this goal.

Feasibility criteria—For site selection, all the objectives except No. 2 (the small hydro country strategy grid option) require proximity to the hydropower source as a primary site qualification.

All of the objectives except Objective 5 (direct motive power) and Objective 7 (social benefits) assume some degree of monetarization and integration into modern distribution systems because the form of hydropower to be delivered is electricity. Electricity requires commodities for its application: appliances, tools, even light bulbs. These apparati and

electricity itself are normally sold for cash rather than bartered, exchanged or distributed by the state. Some of the objectives (No. 1 as a village local electrification) assume sufficient income would already be available, or would be generated by increased production (No. 4) in order for potential users to afford these costs. Each objective requires careful screening to test the assumption made about the socioeconomic integration of the user community.

Contradictions among objectives

1. To achieve the objective of serving remote populations, what characteristics weigh for or against the selection of sites? Several issues are at stake. For how long will a prospective site remain "remote"? Will it be isolated for the anticipated life of the small hydro unit to be installed? If not, might it be better to consider the site as one generating unit for a future grid? According to one rural development theory, the positive impact of rural electrification may be lessened if an area's level of development lacks other development investments. Yet are remote, inaccessible places to be abandoned for decades until the widening area of developing infrastructure diffuses to them? If a project is to be located in a remote site, might it be better justified if it served a larger community of users--a village or microregion--rather than only one or a few isolated sites of production? If the area is isolated, how could a remote production unit (saw- mill, oil presser, etc.) distribute its energized production beyond the locality and so demonstrate economic development?

2. To achieve the objective of a small hydro country strategy, selection criteria would need to be mounted at the national, rather than at the local, level. Localities would be selected in terms of their hydro potential and situation relative to eventual linkage to a grid, rather than for their isolation as in Objective 1. This strategy might be more easily implemented by a central planning authority able to sequence hydrogenerating and grid construction, to standardize procurement of equipment, spare parts and repair services and to regulate the overall country system. Such centralized decisionmaking might be structured to allow some local participation, but at certain critical junctures the ideal of decentralized local control (Objective 3) would have to be subordinated. As a country strategy, especially where undertaken to replace dependence on fossil fuels so expensive in foreign exchange, pre-existing norms and demands surrounding electricity might prohibit the productive use purpose (Objective 4) as a primary concern. To gain user acceptance, the end use of the electricity produced might have to be the same or similar to that already established elsewhere in the country, hence primarily to serve households for lighting and convenience appliances.

3. To achieve the objective of decentralized local control some institutionally responsible group would need to be identified and organized/educated, which again indicates local electrification with its larger clientele rather than a project oriented to productive uses and a more narrow base of beneficiaries. Whether decentralized control could be effective if generating sources were linked in a grid and owner-user associations were submerged as components of a larger institution is also an issue.

4. To achieve direct application to productive uses (see below) the best course of action would be to orient hydro units to units of production and to design the small hydro to meet the specific, limited requirements of the productive use of electricity.

A credit program to allow production units to purchase necessary equipment for the maximal use of electricity could be added to the project. If other intentions are mixed into this purpose, such as reaching the poorest of the poor, or democratic decentralized local control, only a minority of productive uses could be selected. The more common pattern worldwide is for small-scale industrial or processing operations to be owned and managed as private enterprises, and for economy in electrified irrigation, to require at least medium-sized irrigation units. In order to guarantee that an electrification scheme benefit the poor, the institutional structure of the production units would need to be evaluated. Design and evaluation would have to address the issue of whether benefits would accrue disproportionately to local entrepreneurs or larger landlords.

5. Superficially, it appears the objective of lower cost renewable energy can be automatically achieved with small hydro. However, the literature concerning the costs of small hydro electric power outlines important controversies. The leading controversy concerns the capital or investment costs. A further controversy in the literature and among experts questions the reliability of small hydro alone, without auxiliary generating capacity from some other source--most typically, diesel fuel. Long term costs are also a function of the quality of each manufacturer's small hydro equipment. A socio-institutional aspect of total costs involved in small hydro, frequently overlooked by enthusiastic voluntary agencies which view small hydro as a highly "appropriate technology," is the cost of labor to maintain the system and to pay for its capital costs through regular collection of user fees or through unpaid labor for civil works. These factors are discussed in the sections on Costs, below, and may require more indepth studies to determine scale economies.

6. For many areas of the world, direct applications of hydropower as motive energy would be more appropriate. The principal consideration for this determination would be costs and the socio-economic level of the intended beneficiaries. If hydropower as electricity reaches economies of scale at the multipurpose village level and if sites to be served will each cost in the hundreds of thousands or millions of dollars, then only a minority of the potential village sites could ever be served.

In terms of the world population of people living close to untapped hydropower, many do not display sufficient integration into the cash economy to afford electricity. It is difficult to justify the conversion of hydropower into electricity in their local socioeconomies. For these populations, the vast majority would not be in a position to benefit in any substantial way from hydroelectric power. For them, direct hydromotive power applications would be more immediately suitable, increasing the efficiency of some critical productive or processing activity to produce a surplus with which they could begin to enter the cash economy. In any economic analysis, the cost of direct motive hydropowered devices and hydropower rather than electricity would be lower. More beneficiaries could be reached for the same investment dollar.

Benefits and beneficiaries: or, the poor are not targets, they are people

Some of the objectives described in this chapter have intrinsic beneficiary populations. For example, for the "remote" objective, the beneficiaries would be the people of that remote place. The social characteristics of the people living there would need to be determined. A safari hotel might be in a remote place, but its guests would not be the poor. For the small hydro country strategy, the beneficiary would be the country as a whole at one level, measured by how much the fossil fuel bill was reduced. But it would be important to trace how those savings at the country economy level were invested and whether energy costs remained as "inflation-free" as promised by the capital investment.

For a "productive use" strategy, the beneficiaries would be the owners and workers in industries and agrarian production or processing endeavors. It would be important to determine whether the socioeconomic position of workers actually improved if they were not also owners. It would also be important to determine as part of the project design how to select among the poorer farmers for those who could use the inputs successfully. As part of evaluation, tests can be made to measure whether or not these farmers, rather than others, were actual beneficiaries.

For a social benefits objective the clients of a social service institution electrified by a small hydro would be the beneficiaries, or there might be some more general social benefit, such as clean water pumped by electricity.

In the conventional phrasing of indices, objectively verifiable indicators might be, respectively, "production of X at remote place Y increased by n%; n% of the households of remote place Y are hooked up" or "country Z saved n% on its fossil fuel bill; electric rates change Z-country wide by only n% or "4 sterilizers and 2 X-ray machines electrified and lightbulbs in every classroom in the small hydro service area."

Indices of this type require a second conceptual element in order to assess whether or not a project has reached and has assisted "the greatest number of low income people, especially in agricultural production and especially...women" (AID Handbook 3, Part I, p. 38-1). If the objective was to use the small hydro's power to increase agricultural production through pumping irrigation waters, objectively verifiable indicators of increased production in bushels per hectare or indices of number of pumps electrified are insufficient in and of themselves. In order to know whether the material benefits of a project have reached low income people, the distribution of those quantities must be broken down. In the International Bank for Reconstruction and Development-International Development Association credit for electrified diesel pumps in Bangladesh known as Northwest Tubewells, the larger landlords were better able to benefit from the irrigation waters produced than the poorer farmers with smaller and more scattered plots. Even though the smaller farmers were organized into groups to use the five hectare capacity pumps, not all the members of

"ground pumps" benefited equally (Personal Communications, former World Bank/Bangladesh staff).

Indices and objectively verifiable indicators need to be further developed to specify exactly how, and how many, low income people have been reached. If household connections are involved in a reasonable percent of lower income households, and if clinics are electrified, some measure of the way service to low income patients was increased or improved can be devised.

For indices to be expressed as percentage increases, baseline data needs to be clearly assembled to allow such comparisons. Feasibility studies can serve not only in the selection among alternatives in project design but as baseline information for evaluation. If a project is bringing electricity into a previously unelectrified area, zero baseline cannot be assumed. The functions that electricity will power may already be present, so more correct measurement indicators will be based on expansion of those functions or on other sources of power replaced. The users of any potential benefit from small hydro will be people of varying income and occupations. The baseline data must describe the consumer of electricity.

A focus on the functions of electrification in project design feasibility studies helps to determine reasonable outputs. It also helps identify the categories of persons who may be disadvantaged or displaced by electrification. It supplies further evidence of whether or not the poorer people have benefited. One electrified grain mill can produce two unemployed millers.

If the end-user community is a specialized institution, measures of how electrification has increased production, services or job opportunities within the institution may not be sufficient. It may be necessary to evaluate the impact of the institution before and after electrification by small hydro on a larger population in its area of influence, in order to evaluate how many low income people have been affected by the changes brought about by its electrification.

If the end-user community is a village, status differences are unlikely to be erased by electrification, but the poor people of that community may display measurable gains or losses as a result.

In short, indices must be focused on people, on their behavior, and on basic information such as their gender and relative wealth or poverty.

Chapter 2

Analysis of selected objectives

A geographical objective: serving remote areas

The purpose of serving remote areas via small hydro systems is a consideration that does not dictate any particular social, institutional or technological characteristic of the small hydro system. As figure 1 illustrates, small hydro technology serving remote areas could take several forms: an isolated local autogenerating source, one of several power sources synchronized to a larger grid, or a single power source for an isolated grid in a microregion. All of these forms could fulfill the purpose of serving remote areas via small hydro systems.

Similarly, ownership, maintenance and end use decisions in remote areas can vary widely. Ownership of an autogenerating system can be private, local, regional, or national. To further complicate matters, maintenance and end-use decisions can overlap between various owner groups, as demonstrated in figure 1.

Small hydros could be used to serve remote areas as an integral part of grids. For national or regional grids, the role of small hydro technology is reduced to interconnection and load management. For an isolated micro-regional grid, however, the same variety of institutional options occur as for an autogeneration plant with only short transmission-distribution lines.

For discussions of the multiple factors in the various arrangements see especially the sections, Power Transmission Systems, Local Decentralized Control, End Uses and Costs.

Examples of all these arrangements were encountered in the case histories described in Appendix B. Though the microregional grid is apparently rare, some proposed systems have selected this option. Synchronization examples came from Europe and are not reported in the case and set data summaries.

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A second geographical objective: a country strategy for small hydro

The purpose of implementing a country power sector strategy featuring small hydros hinges in part on physical geographical and infrastructural traits. The geographical objective would be to maximize a small hydro potential in the locations where that potential was strongest, or to use hydro sources to serve population concentrations, areas targeted for special development, or remote areas. Economic and policy decisions also come into play.

Selection criteria at the country level include--

(1) Good small hydro potential.

(2) Poor large hydro potential, whether on hydrologic resource grounds or on economic grounds--that is, an excessive potential hydro capacity on a major river which is too expensive to develop, given the country's economic situation or a limited market demand.

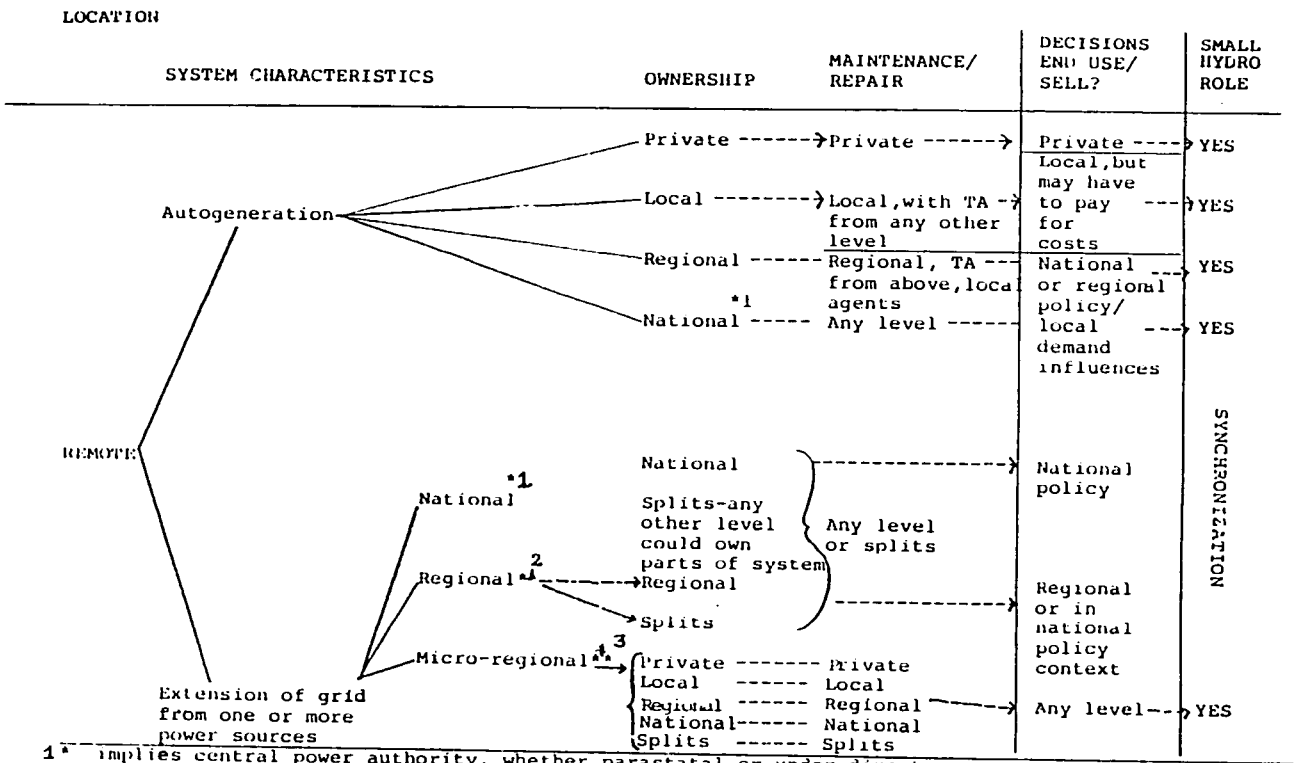
(3) If the grid option is favored, relatively short distances among potential small hydro sites within a region or country-wide.

(4) Existing reliance on imported fossil fuels, posing problems for foreign exchange, or a policy determination to develop indigenous power sources and to export the nation's fossil fuels.

(5) Accessibility of potential sites, which limits the scale of hydro potential utilization and/or influences choice of equipment.

A growing scarcity of firewood and deforestation due to the use of wood for cooking fuel would not be a good country selection criterion. A small hydro in Nepal (Molinari 1980, p. 2,4) and a large hydro in Kenya (World Bank, forestry discussion) were justified with the vain hope that the electricity produced would be substituted for firewood for cooking. Both failed in this objective. Not even the rich adopted electric stoves. The case histories (see Data Summary-Household Uses) confirm the rarity of electric stoves even for the cases involving a well-serviced grid though various auxiliary cooking appliances (such as rice cookers, blenders, toasters) appear once electrification is well established. For small hydros, the objective of substitution for wood cooking fuel is particularly unsuitable, because of the peaking of loads when many households cook simultaneously. The suggestion of introducing a kilowatt-conserving storage cooker or subscribed rate tariff has merit for the problem of peaking (Mackay and Yoder, 1980, p. 4) but only after conversion to electric cooking has been achieved. Electricity substitution for wood fuel in cooking is rare throughout the developing world (see Devers 1980).

Figure 1



1 * implies central power authority, whether parastatal or under direct government control or utility
2 * region, state, province -any middle governmental unit
3 * implies service of an isolated small area, on a localized grid but cut off from central grid

In adopting a small hydro country strategy, policymakers in lesser developed countries have made distinct choices:

(1) The decision to link small hydro electrogenerators to power transmission grids (see below) is one basic choice, largely determined by economic factors and the proximity of sites to each other. The countries of Jamaica, Haiti, Peoples Republic of China, Uttar Pradish-India, have made the choice to link at least some of the small hydros with larger grid units.

(2) The economic strategy of replacing fossil fuels by power from small hydros influences the power sector policies of Jamaica and Haiti, both of which import petroleum, and also Venezuela and Indonesia. The last two are petroleum exporting nations which are considering adopting an economic strategy of small hydro/ indigenous alternative energy to conserve their resources of fossil fuels as foreign exchange-earning export commodities. Ecuador has already adopted this economic strategy.

(3) The goals of serving remote areas which cannot be economically linked to power transmission systems is a rationale for the small hydro country strategies of Tanzania, Nepal, Thailand, Sri Lanka, Ghana, Papua New Guinea, Liberia, the Peoples Republic of China, India, Pakistan and Peru.

(4) For countries with an aggressive rural electrification program, a small hydro component may figure in the strategy of completing area coverage. The Philippines and India are examples (see Duckworth and Wray 1980 on the Philippines).

The economic substrategy of substituting small hydros for fossil fuel generators is particularly attractive for international financial institutions which judge a project's merits according to strict cost-benefit analyses and rate of return. The cost of installing a small hydro can be compared with evidence of the actual fuel costs (operating expenses) and replacement capital costs of fossil fuel generators. An experimental matrix for site identification is described below:

A matrix is created using country data for--

(1) Demography/population distribution and concentration
(2) Topography
(3) Rainfall patterns.

This matrix yields a theoretical set of potential small hydro sites. From this set of potential sites, all sites without existing electrogeneration plants based on fossil fuels are eliminated. Technical and financial feasibility analysis is then concentrated on those sites where hydropower can substitute for generating systems which are found to be more costly to operate and replace than the capital costs of small hydro. To assure the reliability of a small hydro system, the thermal unit is to be left in place, as a back-up. Therefore, perennial water is not an environmental prerequisite: the capital costs of a small hydro which can operate only part of the year can be justified in terms of the savings in fuel costs for the thermal unit (personal communication, J.J. Fish; based on Moore 1979).

Although this geographical-economic small hydro strategy is governed by strictly economic factors (lower operating costs or fuel savings), selection criteria implicitly choose local populations already experienced in the use of electricity and in its management--a factor which may favor success: a set of institutions will be in place to deal with electricity as an input or as a commodity and will only have to adapt to the novelty of another generator type. It can also be presumed that some mechanism for appliance procurement is in place and the location has access to skills for repair and maintenance.

A county small hydro strategy could adopt any of a broad range of institutional arrangements for small hydro. These factors are discussed under Decentralized Local Control, below. Several important factors at the country level can be briefly discussed here.

Whether or not the grid option is selected initially as a part of the country's small hydro strategy, the eventuality of grid linkage would need to be incorporated into the institutional and technical design of a project from the onset. Small hydros could be built to serve as isolated autogenerators for a time, but be designed to go on a grid at a later date. The costs of retrofitting a small hydro not so designed could be as high as building a new unit.

Centralized planning has been preferred for carrying out the technical preparation for physically linking multiple small hydro sites, for proper sequencing of their construction and that of the grid, and for technical quality control in synchronization (see Taylor 1980 on China; Marshall 1980 on Uttar Pradesh).

A country hydro strategy presumes that many small hydros will be built. It is important to make an early determination of what single manufacturing source will provide the country small hydro equipment and spare parts. A country strategy built up from various tied aid sources—for example, American Pelton wheels in the north and Chinese turbines in the south--may be overburdened in its mature stage with the administration of spare parts procurement. (For an example of this problem, see the discussion of Pakistani small hydro management problems by scale in the data summary section.)

The ideal component of a total small hydro country power strategy, whether on grid or not, would be the manufacture of selected equipment within the country, through licensing agreements, concessions, or the development in-country of a patentable device and auxiliary equipment for local manufacture. The problems of procurement and additional costs when imported materials are involved are frequently cited in the rural electrification literature as an issue of backward linkages in terms of economic viability. Reliance on imported goods has ramifications for institutional arrangements and for the reliability of small hydros, especially for the isolated systems.

Political objectives: Decentralized, local control

Decentralized control of hydropower units is an important objective of the SDH program. The SDH program is different from general rural electrification schemes which usually consist of a large system managed from the city. The SDH projects will be locally built and operated. While "city people" may be called in to provide technical assistance, the local community will manage the system. These institutional factors are critical to the SDH program.

AID and decentralized control of electricity

The priority for local control of energy sources, while popular for a number of years among appropriate technology circles, is a new initiative for AID. Over the years AID has favored rural electrification schemes operated from large, centralized generating stations. Although public power has been wholesaled to consumer groups, especially cooperatives in the programs advised by NRECA, generation was a monopoly of a state power company or centrally administered public utility.

Tendler (1979) cites as reasons for this policy the belief that centralized systems are more efficient and economical, that 24-hour service is necessary, and that it is easier to deal with a limited number of national government authorities than numerous local or private groups. Tendler also makes substantive arguments in favor of autogeneration. She points out that large systems suffer frequent breakdowns due to inadequate maintenance by the public power utility and the resultant losses are greater than would be incurred by a small autogenerating unit, due to the larger area covered by the central system. She argues that a series of autogenerating plants may be more efficient in terms of total system loss than one large system.

Centralized systems have not always proven to be more efficient than small autogenerating plants. Autogenerating plants may experience problems of outages and maintenance, but their record is no worse than centralized systems. Tendler describes how businesses in Nicaragua had back-up diesel generators because electricity from the central system was not reliable. Similar experiences were reported in the case study sources (see Summary: Reliability).

The literature of rural electrification acknowledges both the advantages of local control (responsiveness to local consumers, identification of area needs) and the efficiency of centralized administration (skilled technicians, standardization of equipment, tie-in to national economic development plants, etc.) (World Bank 1975; McCawley 1978). A compromise between local autonomy and centralized control of electrification is one possibility that may be considered in the planning of small hydro rural electrification schemes.

Decentralized systems under local control

Decentralized local control must be distinguished from all other institutional arrangements used to install and run a small hydro unit. In the case of exclusively local control, the local end users would initiate, engineer, install, manufacture, purchase or otherwise procure, own, maintain, repair, manage and retail or otherwise distribute the electricity of the system.

Examples of this exclusively local control were discovered among isolated systems, including small hydros. These systems worked well and were particularly characteristic of the lower range of installed kilowatt capacity. Few failures were reported and these could be attributed to natural disaster which also struck centrally, expertly designed systems. "Acts of God" lie as far beyond the capacity of administrators and engineers as they do beyond insurance coverage.

Problems also arose in locally controlled systems from engineering problems and poor technological choices of equipment. In the cases reviewed, however, these problems were successfully overcome by seeking additional outside technical advice. This suggests that the decentralized, locally controlled model works well if the local group has access to technical assistance.

Where there is a need, a demand, a local capability, access to equipment and technical assistance and some means to pay, decentralized local control can be organized. The nature of that organization will vary in relation to the scale of the system.

Any mix of institutions in the essential functions of—
- Initiation
- Engineering
- Installation/construction
- Manufacture, purchase, procurement
- Ownership
- Maintenance/repair
- Management
- Decisionmaking authority for pricing policy

makes the system more vulnerable.

Institutional mixes

As these functions can be split and among a variety of institutions at several levels of government, and at different locations relative to the small hydro site, points of institutional weakness leading to systems breakdown are numerous. Ample examples of tensions in the mixed systems are given in the data summaries.

One factor seems most critical in the institutionally mixed system for failure, and one other, for success.

Failure factor--However the functions of the system are divided among different responsible agencies, the system can break down if one group or

institution does not perform or is incapable of performing its assigned function. Perhaps because the cases examined all came from lesser developed countries, functional authority areas were not redundantly assigned. If one group moved in to take over the function of another institution and restore the system's process it was usually the most local group—end users—taking things into their own hands.

Success factor—Local involvement in some function appears to be a factor in systems' success. This local involvement does not have to be "control" in the proprietary or political sense.

Some of the institutional factors discussed in the case histories are briefly reviewed below:

Initiation—A small hydro (or other isolated autogenerating system) can be initiated by many different kinds of entities from the project identification missions of international lending institutions to a single local person. Small hydro projects have been or are being identified and initiated by bilateral assistance programs of Norway (Philippines, Tanzania), France (Nepal, Indonesia), Peoples Republic of China (Philippines, Guinea, Tanzania), and Cuba (Jamaica). The United States has done this in Liberia, through the Peace Corps; Peru, Ecuador, Guatemala, Panama, Costa Rica, Togo, Zaire, Sierra Leone, Liberia, Ghana, Swaziland, Morocco, Egypt, Nepal, Indonesia, Sri Lanka, Bangladesh and possibly Thailand and Papua New Guinea through USAID. International organizations such as the World Bank (Papua New Guinea, Haiti, Jamaica, Sri Lanka, Indonesia, Ghana), and the Organization of American States (Surinam, British Caribbean, Bolivia) have initiated projects. Initiation by national governments is common, especially in South East Asia. In Latin America the local governments of municipalities, townships or counties have been active initiators since early in the century. Private businesses (mines, fish packing plants, agrarian enterprises, small factories), missionaries, private voluntary organizations and private individuals have initiated electrification by small hydros.

Engineering, installation, and procurement—Engineering is commonly provided, or arranged and supervised by the initiators. Some governments have provided the technical assistance of public works engineers to more local level governments, for example in Peru and Pakistan.

At the stage of installation and construction, local involvement figures most prominently. Local manufacture is rare. Purchase and procurement of equipment can be the responsibility of any level; it may be tied to the extra-national capital source, subject to international competitive bidding, arranged by special governmental offices, or be transacted by mail order with the several companies that offer equipment lines.

Ownership—Ownership of an isolated small hydro can be private, local, regional or national. In some situations, ownership patterns entail management and maintenance entities that overlap with the owner group. For example, some locally owned systems are managed and maintained entirely by the local community, regional systems by regional power authorities, etc. Similarly, decisions on end use and sale of electricity to

outside individuals and groups could be made by the owner(s) solely in terms of their own needs and policies.

More often, however, there is overlap of functions and decisions regarding end use between various owner groups. For example, a local group may need technical assistance from private, regional or national groups in maintaining or even managing the system. Similarly, regional and national groups may request local groups to maintain or manage the system and may consider local needs and demands in formulating policies for electricity use.

Ownership of a small hydro system can be owned "free and clear" by the steward group (whether private, local, regional or national). In this case, decisions regarding end use and sale of power to outside individuals or groups can be made by the owner(s) according to their own interests and policies. If, however, the system is "mortgaged"; i.e., capital and/or other costs must be paid back, other factors influence these decisions. An owner may need to sell power to repay a loan, at least for a certain period of time. The end use of the hydro system will be influenced by profit considerations that enable payback. Direct productive use may be dictated because it is more profitable than household or municipal uses.

Maintenance—The function of maintenance and repair--and occasional retrofitting or replacement of original equipment—is the most vulnerable of all functions, leading to the assumption that small hydros are less reliable than either thermal autogeneration or central power systems. Local control of maintenance and repair is generally successful where training has been made available during construction (Pakistan) or equipment manufacture (China) or when the local group has access to outside, expert technical assistance (for example, Philippines, Thailand, Nepal, Papua New Guinea). Cases where local maintenance is undermined by a dependence upon procurement by some outside higher level agency are frequent.

Management and pricing decisions—The function of management is related to decisionmaking for pricing or end use policy and in turn to ownership. Where the costs (capital or operating) of a system are higher or where ownership at whatever level is mortgaged, tariff rates become more elaborate with consequent complication of the management system.

Local control is most often constrained by finances. The ability of a local group to pay for (or pay back) the capital costs of the equipment or to pay the true costs of electricity (including labor for maintenance, management, and parts or replacement) can lead local groups into problems. Systems which are authentically locally controlled, fee collection systems for electric usage are simplified--electric use is a right of the user community and costs are covered by some other revenue mechanism. Unconventional rates are sometimes set, such as charges per month per lightbulb or per installed kW. The free use of electricity is often associated with outright purchase of the equipment, both in communal user settings in China and among private user-owners.

Institutional characteristics of existing small hydro units under local control

There are hundreds of locally controlled, decentralized autogenerating systems currently in operation worldwide. The exact number is unknown and documentation on most of these units is nonexistent. Many small hydro units have been in operation for decades with apparently excellent results.

Of the many kinds of local owner-steward groups, two basic types can be distinguished across cultural differences in exact institutional arrangements. These are specialized institutions, both private and public, and village scale multipurpose systems.

Private/public specialized institutions—Many existing hydro units have been put in place and are kept operating by private companies or by private religious or voluntary agencies. More recently a number of small hydro units in developing countries have been installed by regional or national institutions such as rural schools or hospitals.

The record of small hydro units used by private companies, voluntary agencies, missionary groups and other specialized institutions has been excellent overall. There is little doubt the technology works well. These institutions are the clients of the manufacturers of small hydro equipment. Except for the recent entry of governments to provide electricity for outlying specialized public institutions, this sphere of small hydro activity worldwide is private.

The specialized institutions are organized, corporate units prior to their assumption of the owner-steward functions of small hydroelectric generation. Detailed information on how procurement and maintenance functions are assigned was not encountered in the literature review, though it can be inferred that some of the institutions have mechanics or engineers on their staff (for example, mines, processing plants, hospitals) and others include educated, often expatriate members (for example, private voluntary agencies, religious orders). The specialized institutions do not usually sell electricity but rather incorporate the energy into their general operations. As a courtesy or as a privileged convenience to their member staff, specialized institutions may also produce limited electricity for household or group quarters. If the specialized institutions do not sell electricity, they are usually exempt from regulation or prohibitions of autogenerating which exist in several countries. No case was found where the electricity of a specialized institution's small hydro was fed into even a microregional grid, though one case involved transmission to fairly distant end use sites.

Village scale multipurpose systems—Settlement or community level small hydro systems are not well reported in the literature, as the analysis of the case histories indicates. Information was found on only a few such small hydro sites, though there are references in the literature to more, especially in the Andean countries (General Electric 1962; Doughty 1964 and see Brownrigg 1980).

The Andean village level multipurpose systems, where a local government acts as the owner-steward group, may be more successful because these settlements share with the specialized institutions a characteristic corporate organization and clearly defined decision-making structures. While any settlement may be considered a distinct unit, village social and political organization does not necessarily share common goods or services. Incorporation (common ownership of goods such as land or the right to services such as labor) may be invested in other social groupings (households, lineages) rather than the village as a whole. In the Andean countries, however, some villages share goods in common, from the public square that dominates the Spanish-grid nucleated settlement pattern to irrigation systems and common pastures; labor and other contributions may be due from the residents to the local government for the construction and improvement of their public goods. In other world areas where local level government is a strong tradition, the owner-steward functions of small hydros have been vested in that government (examples: the traditional village councils of Papua New Guinea and of the 3-15 kW systems in Pakistan).

Recommendations for SDH program implementation of local control

Decentralized systems under local control can work successfully. The numerous examples of specialized institutions demonstrate this point. The analysis of village-level systems, however, indicates special problems. In order to establish locally owned, maintained and repaired systems, the Small Decentralized Hydro Program must deal with certain factors in every country where the program works:

Governmental tolerance—The governmental entity, whether at the national, regional or local level must allow this kind of arrangement. The Uttar Pradesh state in India, Bolivia and Indonesia are examples of countries where the local autogeneration of electricity for sale is prohibited. If AID is committed to local control of the hydro systems, it must assure that such control is possible under governmental regulations. AID missions must also seek host country government channels for assistance to hydro systems which will deal with local groups. For example, if a country's ministry of energy is involved in state generation of power, though no national laws prevent community ownership and local consumer sale of power, that ministry may prefer to build and own the small hydro to advance its own institutional agenda. A ministry or interministerial coordinating committee or state bank, however, may be better able and more willing to advance credit to a local government or specialized institution to build its own small hydro plant.

Local involvement—Local people must be involved in the project, not only as consumers after the project is complete, but from the onset. Initiation of small hydro projects by USAID risks the structural dangers of "top-down" development and technocracy. Yet it is at the stage of initiation where the local groups can be most easily involved. Their involvement at this stage will also help to assure that project designers use certain selection criteria discussed in AID's SDH project paper:

Existence of a current or future local demand for electrical power

Existence of a local skills base which can be trained to operate the facility,

Existence of a mechanism to pay for the generation costs through sale of electricity, and

Cultural acceptance of the concept of hydropower by the community, (AID,DS/EY, 1979, p. 14).

If there is no felt need for the hydro unit, there is less chance that it will be successful. The concept of a community application process is discussed elsewhere in this report (see Commnity Application Form, Improved Framework for Evaluation) as a simple mechanism to involve local people in the stage of initiation/site identification. Local involvement, whether or not the hydro unit will be owned or otherwise controlled by a local group, is critical to success, and it is easiest and most appropriate to involve local groups at this stage.

Capability—There must be sufficient management and technical expertise in the local community to enable successful operation of the system. Such expertise does not have to be a prerequisite for the selection of a local group, but it must be part of the total program if the project is to succeed. Training programs, where this expertise is deficient, must be an integral part of the SDH package. In cases examined this training usually involves a specialized group—a private voluntary agency or governmental agency with engineering and mechanical skills. Local involvement is most common during installation/construction in order to reduce costs of associated civil works. For optimal engineering of the local system, technical assistance would also be involved at this point. The training aspect of technical assistance should be coordinated with the engineering and civil works construction supervision in the locality.

Design—The unit must be designed with standardized spare parts readily available for procurement. A mechanism for the communication of procurement needs and distribution to the community must be firmly established and evaluated for its turn-around time efficiency.

Suitability—The system must be suited to the demands of the local community and designed with a clear understanding of those requirements. Whether this entails nighttime household lighting only, industrial productive uses, or a multi-purpose system, the design must assure that the system accurately meets the needs of the local group. Over-designed isolated systems, such as Dessatu and Colombia-Andes, place a cost burden on the local community that cannot be met without outside subsidy—a situation which defeats the SDH ideal of self-sustaining systems.

Affordability—Costs of service and hook-up charges must be set at a rate that will allow maximum participation of the intended users. Hence, thought must be given during the planning stages to the ultimate uses of the powerplant. Decisions concerning the installed capacity, distribution and metering arrangements, load governing, tariff structures, and above all, the types of end-uses (whether for industry, business, lighting, irrigation, or agricultural processing) will impact on the economic viability

of the project. For example, an oversized plant will likely result in costs which are unsupported by the revenues from sales of power. If the system cannot cover operating costs, it will not survive without outside assistance. If higher rates are imposed later in order to pass along deficits incurred by an outside assisting agency, the community will resist the imposition. If rates are unrealistic, and costs are later assumed by an outside authority, that authority can exercise the option to decommission the system--a situation which will crush the long term accrual at the community level of development infrastructure based on electrical power and may actually set back the progress of a local area.

Clear institutional function and authority areas--However the functions are divided the division of functions must be clear and unambiguous. While projects are still under supervision, the performance of functions must be evaluated.

Further discussion

Small decentralized systems will require user community organization in all stages. It will be particularly important to--

Establish the need for a system and the end uses of energy,

Determine what forms of social organization are appropriate for performing what functions, and

Fit the technology together with the institutional, economic and social arrangements.

These requirements, which will change the process of pre-project analysis, are discussed briefly.

To establish the need for a system an energy survey or study is required early in the process. It should sample the regional diversity of a country as a whole, or focus in an area selected for other reasons, i.e., "where future development projects are expected, where no alternative electricity supply network exists or areas where diesel generators may be the sole source of (electric) power" (AID DS/EY, 1979, p. 14). The survey should establish how energy in general and electricity in particular is used, and how electricity is likely to change the use of energy. The costs of each form of energy need to be carefully analyzed to see if electricity could replace any of them and under what conditions. One cannot assume that electricity is "vital to economic development" (ibid, p. 6) or that "energy consumption and income generally go hand in hand" or "educational institutions can be established which can operate in the evenings" (ibid, p. 24, cf. above, evaluation of Bolivia AID impact evaluation).

The best predictor of how electricity will be used after a new system is installed is how electricity is used in the nearest electrified area where people from the site's locality have experience. Their experiential models may be a nearby electrified market center where they take goods for sale; it may be another country, where local villagers migrate for wage labor opportunities. The phenomenon of migrant laborers returning to

impoverished rural homelands with television sets rather than cash occurs from Yemen to Ecuador.

There is a certain degree of technological determinism in systems for the production of energy that shapes social and institutional organizations. Although some organizational infrastructure is necessary for system success, it could take many forms. How to find those forms of social and institutional organization capable of the functions and at the same time compatible with the goal of equitable benefits is the main challenge to small decentralized systems.

One way to approach the problem is to visualize parts of the entire system and determine what social and institutional organization would be needed to put them in place. One can then test these by the criteria of whether or not the candidate organization could also accomplish other social and economic goals. Existing forms of social and institutional organization must be examined for their potential adaptation to creating and maintaining an energy system—with corporate hydro ownership being added to their other forms of incorporation. Whether or not new forms of organization are required must be determined after existing forms in a particular setting are examined.

Surveys can also identify appropriate institutions, or forms of social organization in which to lodge the functions and activities of acquiring the generating system, of installing the system, of maintaining the system, of distributing and using the electricity generated by the system, and, if necessary, of collecting fees for use or otherwise arranging to repay capital installation costs. When appropriate forms of social organizations are identified from surveys, a list of local groups which fit the description, can be invited to make user community applications.

The critical problem is finding the most appropriate form of social organization to acquire and install/construct the system. For this objective, which is short-lived, a temporary, goal-oriented action group may be most appropriate, rather than a complex, permanent organization such as a cooperative. A larger group is required to acquire a small hydro system than is needed to install it. Even fewer are needed to manage it. Though consumers may be numerous, once the system is installed and operating and as long as the service is reliable and reasonable, consumers do not require a permanent organization.

For maintenance small hydro systems do not need much organization; nor are they costly to maintain. A small staff can operate even the larger turbines and stand by for any necessary repairs. The choice of the organization to maintain the system should be made on the basis of efficiency. Because of institutional and organizational problems, maintenance by a cooperative or other large local interactive association may be more detrimental than beneficial to routinized system operation.

A techno-economic objective: Lower costs, renewable energy

The SDH project paper (AID/DS/EY 1979) and most of the literature on small hydro costs agree that—

(1) Initial capital costs of small hydro are greater than for other generating systems
(2) Operating expenses are lower
(3) Exact costs are site specific
(4) Interest in small hydro stems from rising fossil fuel prices.

Beyond this there is little agreement and pronounced variation among estimates and reports of costs.

High cost estimates

The World Bank estimates the investment cost of low head, "minihydro" at $3500, in 1980 US dollars per kW installed, ranking its costs more than three times higher than large, high head hydro and higher than all other generator types except solar photovoltaic and wind (1980, p. 43, table 19). This figure is much higher than the estimate used by AID.

There are a number of assumptions behind this higher estimate. The cost of transmission and distribution lines is included as a dummy figure for small hydro, as for all other generator types. This affects the absolute estimated cost per kW installed, but not the relative costs of small hydro compared to other systems. In fact, the Bank does favor grid for small hydro (World Bank 1975). Costs for a back-up system are included even for the "single consumer model" or multiple plants with at least one in reserve for the "village supply" model. (Moore 1980, Annex 4). The economic limit of minihydro lies in the "low hydro capacity factor, 20% instead of 55% for large hydro" (ibid, p. 2). "The penalty that limits the minihydro potential is the low system load factor. If the village system has reserve capacity the hydro capacity factor for the 3 x 50 kW plant is only 15%." (ibid, p. 3)

The SDH program however, assumes the high costs of transmission lines can be avoided by selecting "remote" sites close to the place where the electricity will be consumed. It also assumes that dependable turbine-generator sets are selected so that maintenance costs are kept to a minimum.

The World Bank includes in the cost the expert engineering and construction work that will "ensure their proper functioning and to protect them from floods" (Fallen-Bailey et al. 1979, p. 49). The location-specific technology means "each project may require expert services for its own design and siting (Pak and Taylor 1976, p. 4)." This cost factor has been estimated by comparing the ratio of expert engineering fees to installed kW capacity on those hydro projects which the Bank has supervised. The Bank's experience however has been with larger dams with high heads and civil works. The engineering costs for small hydro installations would probably not be in the same ratio as these larger installations. The Bank is aware

that case studies of small hydros would be useful to clarify their assumptions and their estimates (personal communication, J.J. Fish).

To develop a standardized data base, the Bank does not assume local labor will be either contributed or inexpensive. "Shadow wages may not always be zero and may change from season to season (ibid, p. 5) ...If an economist from one country were interested in the labor input to civil works associated ...in another country, it is of no use to be told that the labor input was ignored because the shadow rate was zero" (ibid, p. 6).

As with other decentralized alternative energy sources (AES), according to the World Bank, the total costs of a small hydro project should also include the interest payments, the market value of land, equipment and associated transportation costs, spare parts and maintenance inputs, all raw materials inputs, appliance needed to utilize the outputs from the AES and provision for any traditional function displaced by the project (ibid, p. 4-5).

In calculating benefits, the World Bank's Pak and Taylor warn that these are "frequently overestimated in physical quantity:"

> This is sometimes the result of using the plant capacity as the estimated output, regardless of anticipated periods of slack demand, when energy cannot be stored.... In theory it may be possible to achieve high utilization rates (if) concrete ways of utilizing the surplus energy outputs and of maintaining high rates of capacity utilization are clearly identified. (ibid, p. 3-4).

Low cost estimates

Lower cost estimates are achieved by eliminating from consideration one or more of these factors, for example transmission (Alward, Eisenbart and Volkman 1979, p. 27-31), or the cost of equipment from international sources.

It is difficult to compare the data in the sets for costs, given the numerous currencies and dates involved. Where actual cost figures were given, the calculations usually omitted one or more of the critical factors.

The issue of costs

Two basic lines of criticism of rural electrification projects are occurring in the development community. One focuses on the allegation that rural electrification systems do not pay for themselves and require subsidies. This criticism is a particularly sensitive issue for small hydroelectric systems for which costs are disputed. Costs to AID for small hydro units will clearly be lower than those of other rural electrification projects, but whether costs will be low enough not to require subsidies remains an open question.

The other criticism of rural electrification is that they do not reach or benefit the "poorest of the poor."

The design and evaluation of small hydroelectrification could be framed to answer either criticism. The objective of a non-subsidized, small hydroelectrification and the objective of fulfilling New Directions mandates could also be reconciled. The objective of productive uses (see below) has been raised as one possible mode of resolution.

The anti-subsidy position originates from international financial institutions. The model of subsidies is seen as coming from the United States and as requiring a developed industrial economy which can afford the subsidy, conditions absent in most developing countries (World Bank 1975).

The anti-subsidy position, which is also pro-productive uses (see below) maintains that electricity can be priced to pay for the real capital installation and operating costs, including power losses and thefts, and that this higher than usual tariff structure can be affordable if electrification can create new cash income sufficient to cover the higher rates. At the level of benefit to the economy of a country, rather than to local users, import substitution by indigenous renewable energy for imported energy could cover costs, but only if it occurred in the context of a country strategy.

Ideally the demand forecast, a common element of economic feasibility studies for all power projects, could be projected to estimate both the cash value of production attributable to electricity as an input and the distribution of this increased income among groups of a locality. Such modeling would require studies of local economies to perfect its predictability. It is doubtful that savings through substitution of fossil fuel imports would be passed along equitably, except where surcharges for rising costs have already begun to price out the poor.

New directions

Rural electrification in the United States can be viewed as a unique experiment in federal transfer benefits to rural Americans. Some commentators regard the subsidization of rural electrification by other sectors of a lesser developed country's economy similarly—as an equity benefit. Financing the extra costs of grid extensions into rural areas through charges embedded in the rates of urban and industrial users has been given development-lending support under the New Directions mandate as an income redistribution technique. Nevertheless, rural electrification has been critized as reaching neither the rural nor the poor (Tendler 1979, p. 15; Sen 1980, p. 13; World Bank 1975b; USAID and Development Alternatives 1979; Mandel et al. 1980, p. 10).

The SDH small units must be least cost solutions and not subsidized in order to demonstrate fully the lowering of costs. At present--no matter what small hydro's long term potential—front-end costs appear higher and less economical in certain ranges. The question of how the user group can produce sufficient income is a valid one. The more narrow definition of productive uses discussed below can be justified. The objective that, the end users amortize the capital costs of small hydrogenerators and other installment costs as well as pay for nonvolunteer maintenance,

management and repairs can be built into electric rates. The development loan financing the installation and initial operating costs can also be set to be paid back over period of time long enough to allow the end-users the time they need to accomplish the transitions from subsistence to surplus to market-oriented economies, or to accrue the long-term, more indirect economic benefits of electrification.

Power transmission systems

The reliability of isolated small hydros, their capacity and maintenance requirements must be closely examined. The "quick fix" of avoiding the costs of grids may not reduce costs over the long run. Tendler has commented on the problem of outages in the weighing of the alternatives of isolated autogeneration (thermal diesel generations) versus power transmission systems:

> Most analyses of the costs of central station electricity versus autogeneration ... do not take into account the lack of maintenance and the costs of the resulting downtime in the system. Like the cost-benefit analyses of roads, these comparisons assume that maintenance will be forthcoming. AID's long experience with these types of projects has shown that maintenance is not forthcoming, more often than not, and that losses from its absence are considerable (1979, p. 44-45).

Tendler cites relative management skills as critical for appraisal of the alternatives. She expresses the view that most developing countries perform better in generation than in distribution because the distribution requires management skills that may be in short supply. She concludes that autogenerating units may perform better because complex distribution systems are unnecessary.

Tendler also opposes the criteria that systems need to provide 24-hour service, best realized by grid systems, because impact studies of use of electricity by rural people show peak demands concentrated in the evening:

> The "higher-priced" autogenerated (diesel fuel) electricity... may...reflect the real cost of rural electricity to the economy instead of just "inefficiency." And the sparer consumption opportunities may sometimes fit better the needs of rural areas. Thus it can not be assumed that full service supply is always more desirable than partial supply, given the considerably greater investment costs of the former and the fact that autogeneration may satisfy most of the needs of the rural poor for electricity in many rural areas (1979, p. 56).

This argument is the reciprocal of Pak and Taylor's concern for system capacity and lack of storage. Except where water may be diverted during the day for irrigation, a small hydro installation water power would be continual in the diurnal round; small hydrostations—unlike diesel generators which can be turned on and turned off—would waste their installed capacity and "free fuel" in an isolated generating setting. Storage capacity would add to installation costs, but linkage to a grid of power transmission lines would allow small hydros to sell their excess during off peak hours and pull electricity during evening peaks. Since many of the discussions in the literature concerning isolated versus central power generation assume the

type of autogenerating system is based on fossil fuel, cost comparisons are simply not valid for small hydros.

Linkage to grids might drive up capital costs for small hydros still further, adding the high costs of transmission lines, though this cost needs to be compared on a case for case basis with other capital costs for standby storage capacity. Linkage to grids may also drive down operating costs, allowing the small hydro system to profit from the sale of electricity by marketing far beyond the immediate rural area.

Cost is a major factor in the decision to extend a grid or to construct an autogenerating facility. Because small hydro is not intrinsically a technology for isolated generation these decisions are relevant for the SDH program and each small hydro unit to be built as a demonstration project.

In its 1975 publication on rural electrification, the World Bank discussed the relative cost factors involved in autogeneration versus grid. Using 1972 data based on a four kilometer transmission line grid extension and kilowatt capacity of 25 and of 50, the Bank concluded that costs were lower for the grid extension relative to fuel, operation and maintenance but substantially higher in capital costs. In this example, billing and administration costs were treated as equal for both kinds of system. The analysis concluded that autogeneration is most economical at low levels of demand or in very remote areas.

This analysis does not break down fuel type and defines autogeneration as diesel, steam and small hydro; the figures reflect diesel fuel costs before prices began to escalate. However, even when petroleum products were relatively inexpensive autogeneration with diesel was considered a more economical system under conditions of low demand and in remote areas. Venezuela, a country with indigenous petroleum resources, decommissioned hydro installations at one time because diesel was more economical. Venezuela is now reactivating the hydrosystems as more cost effective (M. Lizarralde, OAS, personal communication).

Local labor and materials

Costs can always be lowered if labor is exploited. Behind the assumption that the demonstration units of the SDH program can reduce costs by using local labor and materials there are assumptions which require examination.

The case histories and other sources on small hydro units in operation give ample evidence of the contribution of local labor to small hydro construction. But these ethnographic examples worked well where the labor was bartered for equity ownership, where there were pre-existing traditions of contributing organized labor for facilities for the common good, and where the subsequent charges for the use of electricity were inexpensive, subject to local political concensus decisions, or free. These background social factors and pricing arrangements are not necessarily the situation any given small hydro unit would face. A rural community may be individualistic without traditions of collective self-help. Indeed, where the "level of development" would allow the most immediate transaction of electric usage into cash or increased income, the model of volunteerism for

the local commonwealth is unlikely to coexist: labor, like other market commodities, would be monetarized. Also, if a locality is to assume the true capital costs of small hydro installation, pricing decisions would have to address that debt burden realistically.

Even if the local labor is contracted rather than contributed, it cannot be assumed that labor is always abundant in rural areas. The agricultural cycle, cyclical health conditions, and ritual celebrations govern labor supply in rural areas. For rural communities which export their labor in wage migration, demand in far away places impinges on the local supply. In many areas the conditions of labor contracts require the provision of advances, food, medicine and housing, driving up the administrative costs in order to meet expectations of workers.

In some countries, labor contributions are still forced, tributary in nature and backed by fines or imprisonment for non-compliance. Their ideology holds that because poor rural people cannot afford to pay taxes or otherwise contribute cash for governmental infrastructure, their labor will be their tax equivalent. These systems reach the "poorest of the poor" but not necessarily to make them beneficiaries.

Quality is also an issue. Complex civil works may be beyond the capacity of the local labor force and local materials. The contributions of local materials and land need to be similarly appraised.

A second techno-economic objective: Appropriate technology

The appropriate scale and form of hydropower applications needs to be examined if the "poorest of the poor" are to be reached. For the level of development prevailing in rural areas of lesser developed countries, the most appropriate hydropower technologies may be the very small hydro units for direct motive power applications.

Electrification in the micro-range

Just as there is a range from hydro generating equipment which produces only a few watts up to still "small" 1000 kW hydro units, there are ranges in the kinds of rural people who can realize maximum benefits from different kW capacity systems and who have the skill requirements for the management and maintenance functions of operating the systems.

The evidence of cases from Asia reported in the literature suggests that hydroelectrification in the range below 15 kW are more fully appropriate if systems are to be locally built, owned, operated and maintained. (See Data Summaries, particularly PNG and Nepal cases and the ATDO assisted small hydros in Pakistan). Just above 15 kW, there seems to be a scale break where more occupational specialization in small hydro is required both on the part of the local personnel and on the part of those who offer technical and institutional backup.

In Latin America, however, there are autonomous settlements and specialized institutions which have successfully operated systems up to about 150 kW for decades. In Latin America, the larger systems have hired the personnel whose skills were needed to operate the equipment. However, C.CH.L.G.Cia.Ltda (Bogota) has a standard line of Pelton and propeller D.C. battery chargers with a 3/4 kW capacity. They also manufacture Peltons and Kaplans up to 100 kW. The kW capacity range most in demand among their customers is less than 5 kW. In Africa, most of the cases of small hydros reviewed involved ex-patriates, so no regionally appropriate range of kW scale can be reported.

Direct motive power

Direct hydromotive technologies offer another option: the production of mechanical energy without entropy loss through conversion to electricity. The mechancal output is measured in horsepower, rather than watts. The capital costs are lower than for comparable energy capacity electrogenerators.

An important aspect of direct motive hydro technologies is their broad distribution in the lesser developed world, though in technological forms which could be improved and made more efficient with simple innovations. A socioeconomic characteristic attached to some traditional hydromotive technologies is the barter or the consumption by the producer of the goods produced by their application (ground grains, water for irrigation). These same products could be sold in rural areas more closely

integrated into the cash economy. Hydromotive power can be a technology bridging transitions from one form of economic organization into another.

Water mills

An important class of hydropower use is water mills. The origins of the horizontal water wheel have been traced to Asia Minor in the second century B.C. From there the technology spread north to play a major role in the medieval industrial revolution in Europe, south into Africa and east to Afghanistan, India and China. As many as 50,000 of these archaic design water-powered mills are still operated in the foothills of the Himalayas (Gimpel 1979, p. 10 and see Ermec 1978; ATDO 1980). The vertical water mill was invented a few centuries later; the floating mill dates precisely to the year 537 A.D. Beyond their established use in grinding grain, water mills have been applied to a variety of mechanical operations: to drive machines for tanning, fulling, sawing, smithing, etc. (ibid). These mills provided the energy life for Europe's transformation from an agrarian society to a pre-industrial one. The improvements which increased the efficiency of these mills spread beyond Europe with peasant settler colonists, for example, to North and Latin America. Yet, in the Asian heartland of water mill technology, designs stagnated until recently in the more archaic forms.

A recent experiment in technology transfer bridged a twenty-one century gap. At a mill in the Katmandu Valley of Nepal, C.B. Joshi of the Research Center for Applied Science and Technology ("RECAST") applied the innovation of a closed chute and curved, spoon-shaped blade based on a Roumanian 19th century horizontal wheel design. The grinding efficiency increased and with the higher speed of 120 to 160 rpm, the mill was able to power a small electrogenerator. Representatives from the Agricultural Development Bank of Nepal, French foreign assistance, UNDP, UNIDO, and the World Bank as well as fascinated Nepalese have come to see the "electric mill." The experiment has been repeated to modify a traditional African mill near Nairobi in Kenya.

The experimental Baghdadi generator can produce 100 watts off a water mill, sufficient for lighting the miller's home and for charging batteries. Belaju Yanta Shala works, in cooperation with the Swiss (SATA), have developed a prototype electrogenerator for water mills. It has a large potential local market among the estimated 20,000 water mills of Nepal. One small hydro plant in Nepal has already been established for the dual function of producing direct hydro motive power by day and electric light at night.

The notion of introducing the concept of electricity in this limited fashion while at the same time improving upon a familiar use of hydropower has great appeal as a model of rural development. See figures 2 and 3 for examples of such devices.

Other kinds of direct motive power are also undergoing technical development. Stevens-Guille (1978) reports on progress with hydraulic rams and Aguilar (nd.) on improved water pumping. The top of the line turbines are unknown in many areas of the world.

A theme in the literature contrasts the strategy of rural electrification to "village energization" (Smith 1980 and see also Ermec 1978). The village energization approach also addresses the problems of productivity and the needs of the rural poor, but in terms of building upon their current technological knowledge, rather than introducing at once the more complex technology of electricity. The suitability of this approach is argued by Gimpel:

> One of the major problems facing the world today is the situation prevailing in the two million villages of the developing countries, which lack food, health and energy. Attempts to introduce sophisticated western-type technology have generally met with insuperable difficulties. When machines break down, there are not enough locally trained engineers to repair them.... It will only be possible to raise standards of living in the Third World if the rural population remains in the rural areas and these areas are made productive. It has too often been forgotten that there are in the Third World traditional technologies which have deep roots among the people, and that these must be developed and encouraged. We need to rehabilitate the techniques which once flourished but are now often despised even by the workers who operate them, affected by the influence of western values. Such techniques can easily be modified and transferred from one Third World country to another. Examples of inventiveness from many different parts of the world demonstrate the remarkable traditional knowledge of irrigation, the ingenious ability to harness animal and water power and the capacity to cultivate land intensively. (Gimpel 1979, p. 9)

Figure 2

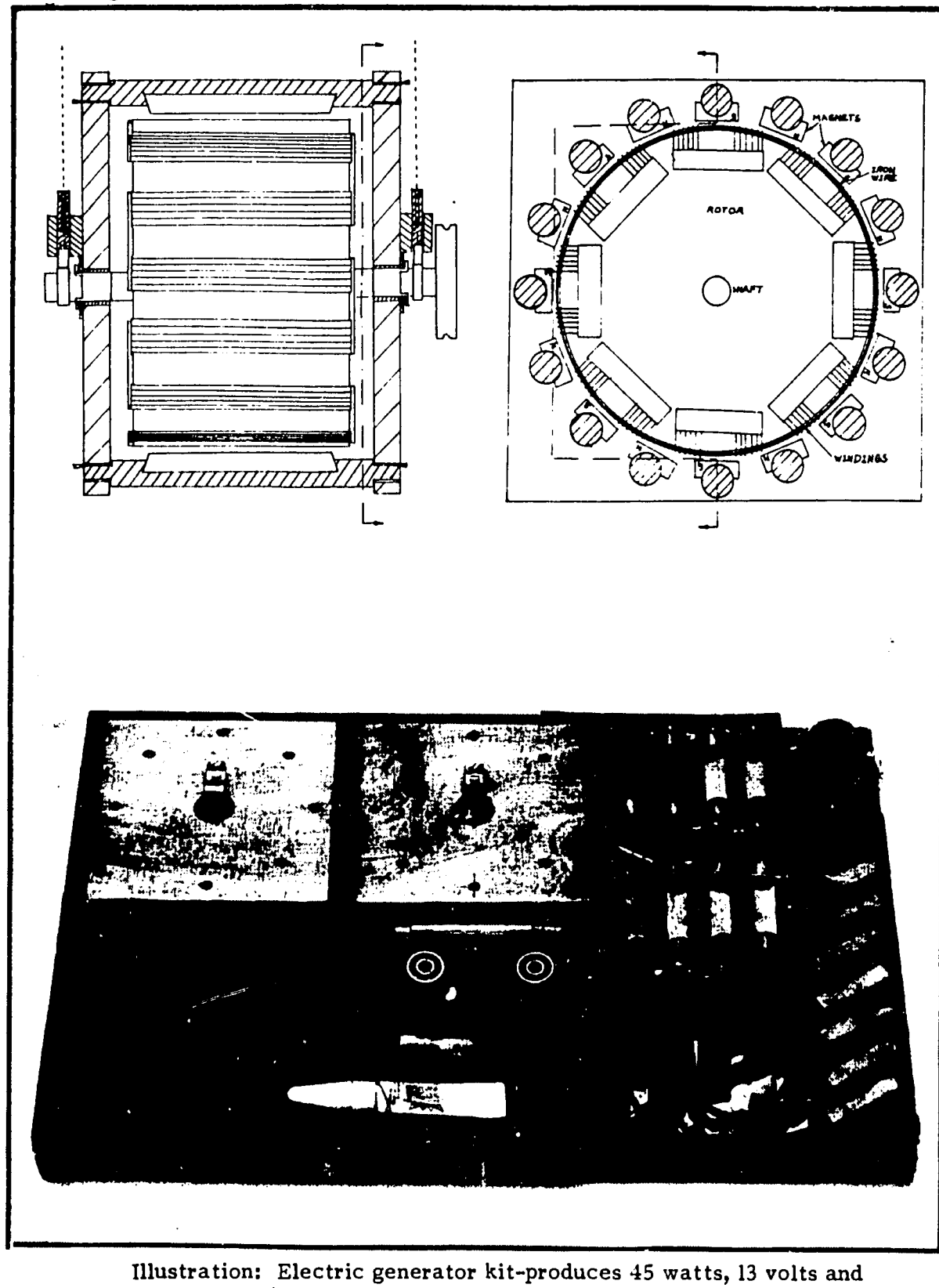


Illustration: Electric generator kit-produces 45 watts, 13 volts and 3.5 amps at 600 rpm by Jean Gimpel, from Models for rural development, a catalogue compiled by Julia Elton and A. Ali Baghdadi for the Acton Society (London, U.K.) 1979 page 27.

Figure 3

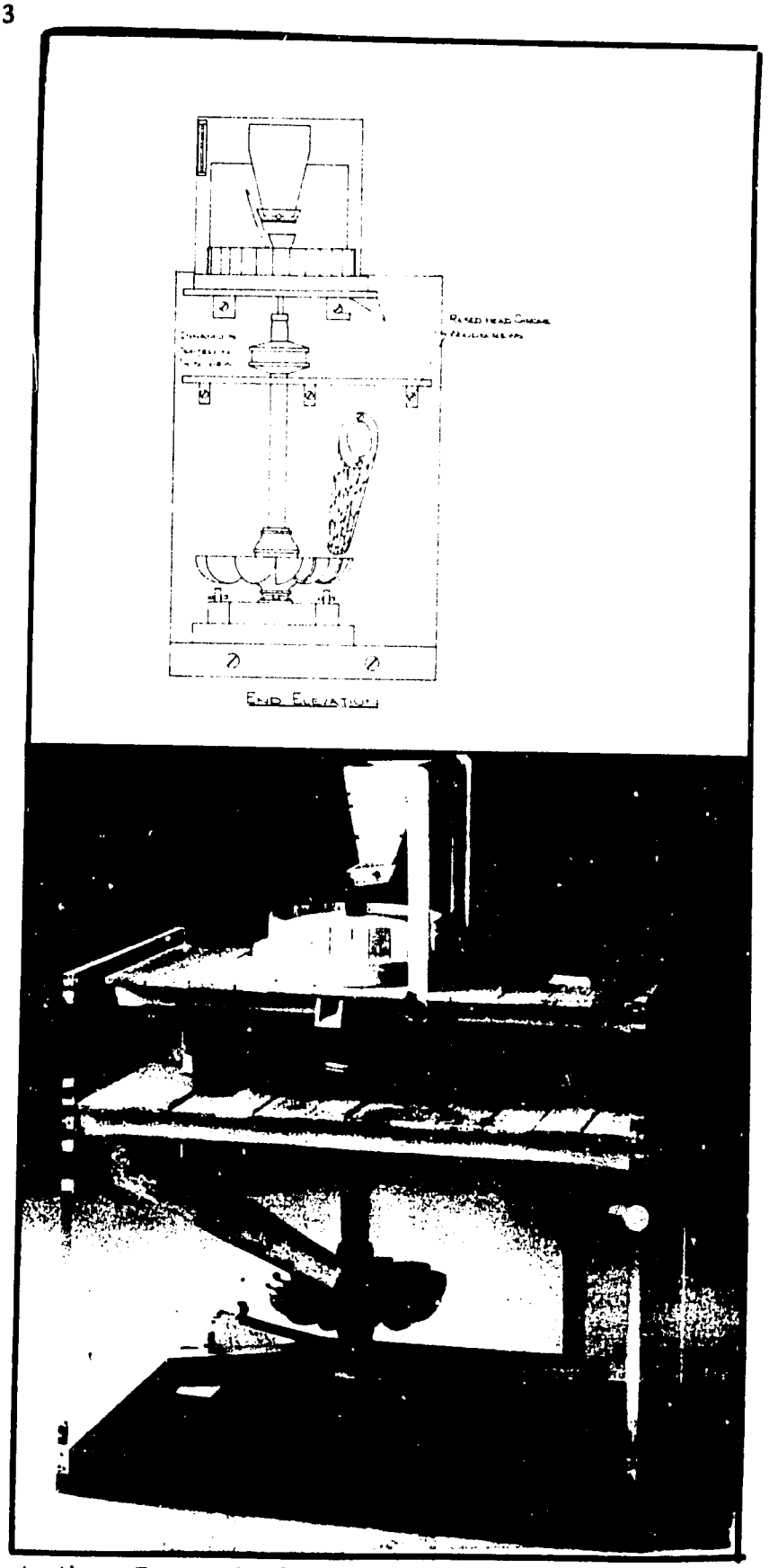


Illustration: Roumanian horizontal water wheel model of Jean Gimpel, from Models for rural development, a catalogue compiled by Julia Elton and A. Ali Baghdadi for the Acton Society Trust (London, U.K.) 1979 page 17.

An end use objective: "Productive uses"

The objective of "productive uses" can be understood as a response to criticism of rural electrification both by opponents of the subsidy mode and by advocates of rural electrification programs as a subsidized form of equity or benefits transfer.

A recent USAID impact evaluation of Philippines rural electrification (Mandel et al. 1980; see above) put forward the following line of reasoning. Key phrases are underlined for emphasis:

> For "people struggling for survival"..."the only possibility of deriving benefits from electrification is indirectly through the use of electricity to create job opportunities, to improve community life and to improve social services (ibid, p. 11-see below, Social Benefits). The existence of such possibilities depends largely on the role of electricity in overall economic development (ibid, p. 11).
>
> The introduction of electricity into an area does not automatically produce significant economic diversification and growth. The contribution of electricity to the development process depends on the level of development of the area, the availability of capital and other financial and human resources...(ibid p. 13).
>
> A significant difference between individuals who use electricity for productive purposes and those who use it exclusively for household purposes is their access to capital...At the community level, too, the availability of capital is critical to determining the industrial response to rural electrification" (ibid, p. 6).

Therefore, to achieve the purpose of creating job opportunities, a productive use electrification strategy must 1) "incorporate the additional resources needed to ensure the utilization of electricity" (ibid, p. 15) and 2) select communities for their "level of development."

The "level of development" selection criteria has been advocated by many commentators and appears to have been used in the USAID/Lima Project Identification Document of the Small Hydro Program.

The narrow definition: "Productive use" which generates cash and creates employment

The arguments summarized above require a definition of "productive uses" in very narrow terms: the end use of electricity to produce something that can immediately be sold for cash or to create new employment opportunities. Excluded from this strict definition are several end uses of electricity which can also be considered "productive":

- Increased efficiency of household production
- Forward linkages to employment from leisure
- Increased production of goods without concomitant immediate increases in either income or employment.

Increased efficiency of household production. Increased production within a domestic unit of goods or services intended for consumption within the same unit is discarded in the narrow view of "productive uses." Although, theoretically, time saved with more efficient, labor-saving electrical appliances could be "sold" as wage labor or otherwise used to produce additional income, the careful time economy studies required to prove or disprove this theoretical assumption have not been made. The actual use of time freed by what are generally called "convenience household appliances" will vary culturally, and both within and among socioeconomic strata of a national society. Significantly, the exclusion of this kind of "productive use" is a women's issue, as it is largely in the sphere of their gender-assigned work where the efficiencies would be achieved and time would be freed.

Linkages of leisure. Automatically excluded from the narrow definition of production as cash income or new employment are the leisure uses of electricity, though these have been demonstrated to be part of the equation of "affordability," given a certain level of development and disposable cash income (Munasinghe 1978). Munasinghe's study of the leisure costs of electricity supported his recommendation to increase the reliability of electricity. However, his Cascavel data also reveal both the value Brazilian working class consumers place on their leisure use of electricity and what they would be willing to pay for non-interruption of the pleasures of electricity, predominantly, the enjoyment of television in evening hours by men. The economic rationale for the respondents' preference for higher rates and more reliable power was analyzed to be sound: outages reduced the total number of hours each television could be used until it had to be replaced. Brownouts thereby increased the capital costs per hour of leisure viewing.

This example, embedded in a national culture where television is a media for political integration and cultural expression as well as for communications which unite its diversity, suggests another problem in an overly narrow definition of "productive uses." While the Cascavel laborer's watching of television is clearly a leisure and a domestic, consumer-oriented use of electricity, he and his peers by the thousands are supporting such income-generating ("productive") activities as the importing, manufacture, assembly, distribution, sale and repair of sets, an entertainment industry producing programs, and commercialized advertisements. These forward linked sectors each carry a load of the Brazilian national GNP and create employment.

Increased production without immediate increases in income or employment. Other problems with the narrow definition of productive uses appear at the opposite end of the continuum of developing countries--not a Brazil, where much of the population participates in the cash, employment-based economy, but a Nepal or Guinea, where a great proportion of the population is in a largely subsistence economy. Here, the input of electricity might lead to a quantifiable increase in the production of some good—for example more food—but a lag could be expected before this increased production turned into increased income.

Electrified, more efficient producers must learn to depend upon the new phenomenon of a surplus and must establish channels for marketing their surplus. A "level of development" consideration is whether other facilities exist, such as some way to convey a surplus to an existing market center—though not necessarily by truck or along a highway.

The best illustrations of a productive use strategy for the end use of rural electrification come from India and China. The experience of these countries bears an important lesson for the advocates of productive uses. That lesson can be simply stated:

> If productive use is the purpose of an electrification project, only productive uses need be served. Any other end uses can be treated as incidental or unintended, adding to the total benefits of the project, but neither counted as part of the project's financial or economic feasibility nor equated in judging its success.

Specific productive uses. Productive uses encountered in the case histories and elsewhere in the literature review are detailed in another section (See summary case histories—productive uses). In designating to what productive end use electricity can be put in any given potential small hydro site, correlation studies should first be made in the closest electrified areas. Information from the potential site can also be collected to determine which culturally and economically compatible "next development innovations" are suitable targets for electricity. The end uses of electricity vary culturally. In that electricity comes from the modern sector, it seems particularly associated with certain industrial goods worldwide, for example, as a fuel substitution for small appliances among consumers who already use similar, non-electric appliances. Prominent examples are individuals' replacement of transistor or battery-powered radios with plug-in radios and wood or charcoal irons with electric irons, and industries' replacement of steam or motor-powered machines by electricity. No master list of productive uses, garnered worldwide, can be used to predict adoption in a local setting.

Examination of the Bengali experience with electrified tubewells reveals the kind of social-institutional problems which can occur when the productive end use, as well as the electrification, is innovative in a particular cultural setting. Although through the Indian rural electrification program, tubewell irrigation was diffused beyond its original adoption area in an improved (electrified) form, the areas in India which received the adaptation were culturally continuous with areas where tubewell irrigation was well established; this facilitated adoption of the technology. This was not true in Bangladesh and problems of social and institutional character resulted (personal communication, former World Bank Northwest Tubewells loan staff).

Policy options

The issues surrounding productive uses for electricity mask a critical option for the planning of small hydro technology. Small hydro has an established use as an input to production among rural industries, as confirmed by an inquiry to manufacturers, farms, industries and other users from the

private sector. From the coffee mill in Honduras which operates on a Pelton turbine supplied by Small Hydroelectric System, Inc. of Acme, Washington to mines in Tanzania, small hydros have been a favored electrification technology by rural industries for a half century.

The particular suitability of small hydro to a productive use strategy is its flexible size: a hydro generating unit can be installed to meet exactly and only the needs of a particular productive use. A small hydro program designed to facilitate the distribution to and use by existing rural industries would encounter fewer difficulties than attempts to introduce new productive uses or accomplish multipurpose village electrification. There is a strong precedent. The major financial questions would be repayment of credits, not collection of routine billings. Maintenance would be a less likely problem because a rural industry or better-capitalized farm is likely to have among its employees individuals with mechanical ability and tools.

The problem of implementing such a strategy within New Direction mandates to reach the poor, rather than a few favored rural entrepreneurs, might be solved by selecting worker self-managed enterprises, production cooperatives or other more democratically organized industries or agrarian production units as beneficiary institutions. Rather than form a cooperative for electrification alone, a cooperative could be formed capable of producing and marketing a product to be manufactured or grown with the input of electrification.

A precedent can be found among existing small hydro systems. In San Pedro de Cajas, Tarma, Peru, members of that peasant community formed a corporation which completed a hydroelectric plant in 1957. Its primary productive use was lighting to extend the hours of weaving, the export cottage industry of this town. Marketing, transportation and credit/consumer cooperatives were also formed to handle other functions spurring their successful community economic development. (See General Electric Laboratory 1962.)

From one perspective, it is not realistic to expect that small hydroelectrification can immediately accomplish a purpose recently deemed essential for rural electrification projects in general, that is, that small hydro projects can be justified in terms of how productively the resultant electricity will be used. Small hydroelectrification has great economic potential because of its cost-free fuel, but this will only be fully realized when small hydro technology has proliferated. It is unfair to burden the development of hydro as a form of renewable energy with an objective which in turn depends on poorly understood additional factors and conditions.

The limitation of productives uses to those which can be "objectively verified" to produce immediate new income and new jobs is too narrow. Increased production can be measured in hours saved or bushels harvested, as well as in cash and as wages.

A strategy constrained by the narrow definition excludes the poorest of the poor: people living in communities which have not yet broken out of the subsistence mode. It further excludes individuals unused to making and

unable to make capital investments. It favors the local entrepreneurs of the world. It values, as a mark of project success, the explicit stratification of the neediest into a marginal class who benefit from electrification only through the jobs created by productive end uses.

An end-use objective: Social benefits

Some New Directions critics fault rural electrification programs because they have not reached poor households (Tendler 1979, p. 15; Sen 1980, p. 13; World Bank 1975b; USAID and Development Alternatives 1979; Mandel et al. 1980, p. 10, etc.). However these same critics express the view that electricity has improved the lives of the rural poor through social benefits, "the public use of electricity—like village hospitals and village lighting" (Tendler 1979, p. 21; see also Tendler 1980, p. 18, Sen 1980, p. 7 but cf. Mandel et al. 1980, iv, v, 9).

Whether the public social benefits which incidentally accrue through rural electrification are more cost effective than projects purposefully intended to produce social benefits such as rural sanitation and water supply, health or education remains to be quantified in any major comparative evaluation.

The social benefits objective has, in general, suffered from a lack of suitable evaluation measurements. However, indices could be constructed to compare the social benefits incidental to rural electrification with the deliberate benefits of projects which had them as a primary purpose. For example, the amount of water, measured in pints, of clean sanitary water pumped in a village which was the beneficiary of a rural electrification project could be compared with the amount pumped as a result of a deliberate water and sanitation project. The hours of extended use of school or clinic facilities made possible by rural electrification could be compared with the hours of use of unelectrified facilities built under education or rural health projects. Further evaluation could compare the costs with the observed benefits.

Recognition of the role electricity can play in the delivery of public social benefits has already been incorporated in the design of joint NASA/USAID projects to electrify isolated clinics and schools with solar cells. Small hydros with auxiliary diesel power already electrify isolated mission schools and hospitals in Tanzania. Electrification of schools and a hospital are already on the SDH agenda for Panama and for Zaire.

Private household use of electricity also produces real social benefits to the household and to the community, beyond mere "convenience" factors cited in impact evaluations. Examples include reduction of infant mortality by diverting time freed by electrical appliances into child care—a phenomenon observed by comparing the electrified and non-electrified villages in Tumbes, Peru and El Oro, Ecuador. This behavior may also underlie the correlation of lower fertility and electricity use found in the Philippines (Herrin 1979).

Increased literacy due to increased education or even increased practice reading under electric lights (Valunjkar 1968) and the extended allocation of time for ritual or social activities are also measurable benefits. In the Latin American and Philippine case histories examined, evening peak loads provided a lighted setting for social activities. In the Tarabuco, Bolivia case materials, the sleep-wake patterns of Tarabuco were demonstrated to vary by at least one hour compared with unelectrified nearby villages. The

later hour to retirement was used in social activities. Since productivity ultimately depends on social organization, the benefits of devoting more nonworking hours to activities which can lead to greater social cohesiveness should not be underestimated as an indirect production support (ACLO-CESSA 1979).

Chapter 3

Evaluation in the Agency for International Development

Evaluation in USAID is complex and many faceted, involving the collaboration of many different institutional entities. This section will describe the entities which undertake the various phases of evaluation and will identify the types of evaluation now recognized by AID as part of its project design, implementation and post-project analysis. These include evaluation activities of the field missions, regional bureau units, and the Program and Policy Coordination Bureau.

Design stage

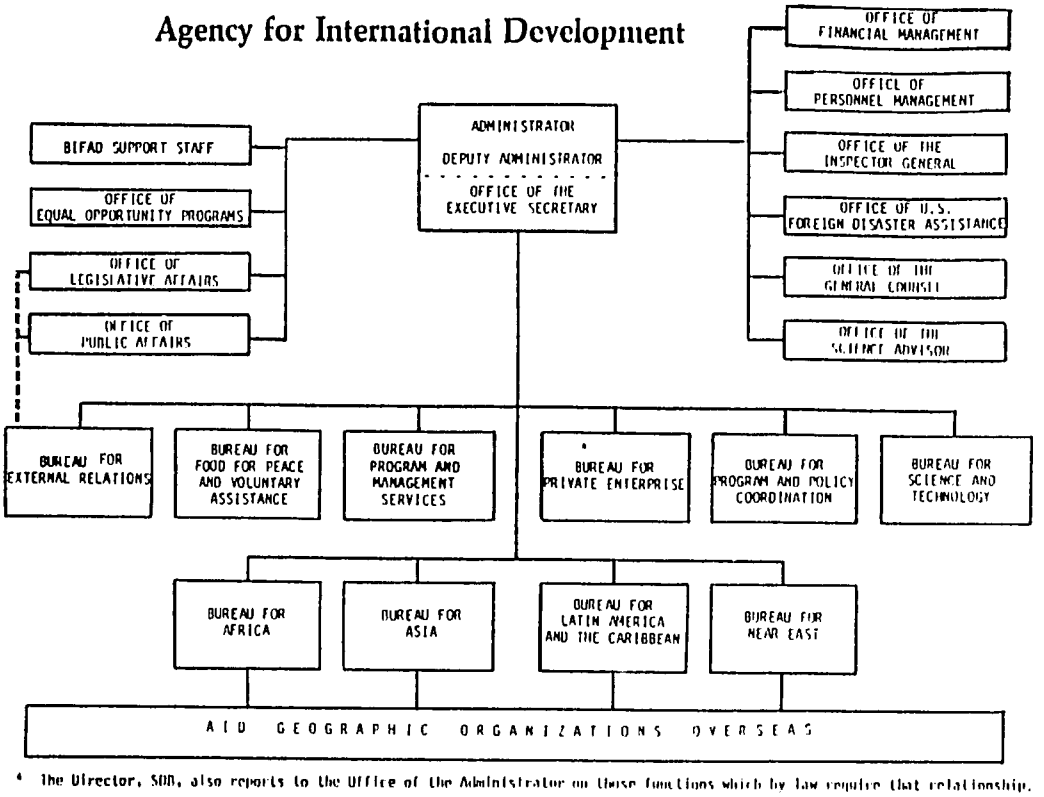
There is no systematic evaluation or critique of the design of AID projects, aside from reviews of the project identification documents and the project papers themselves. After a project is signed, if it is a prototype, model, or experimental project, it should have included in the design a comprehensive evaluation design (prepared in the project design process) which will serve the mission as a guide for future funding and continuation of activities. In all projects some attention should be given to evaluation design.

Social impacts analyses are usually lacking in any evaluation, primarily because they are omitted from the "social soundness" scope of work by the project manager. The logical framework which currently is part of the project design process should serve as a tool for evaluation. It is extremely rare to find any concern with control sets as a part of evaluation design. Often, baseline data do not exist or are incompatible with project needs. Therefore, no baseline for the objectively verifiable indicators listed in the log frame are available. Furthermore, these indicators tend to be selected by their quantifiability and ease of access, but beg the question of the social value of the project. It is relatively easy to determine the number of loans in a loan program or the number of trainees in a training program but it is almost impossible to use the log frame indicators-as these are now phrased--to assess impacts. As one AID evaluator put it, "You know you've trained 500 midwives but you don't know how or if it impacts on target populations."

The project evaluation summary

Evaluation in AID is primarily the responsibility of the field missions. Missions regularly submit Project Evaluations Summaries (PES's) based on in-house or contracted evaluations, stating whether the mission agrees or disagrees with outside evaluation reports, if there are any. The PES's also say what action is to be taken to remedy any problems. The PES is submitted to the project officer in Washington from where it is distributed to 25 to 30 people. A review is then organized, which can range from informal comments by telephone to the meeting of a project committee or a full bureau review with the participation of the Assistant Administrator, if the project is controversial. Then the results of the review are cabled to the mission.

Figure 4 AID organization chart



* The Director, SDB, also reports to the Office of the Administrator on those functions which by law require that relationship.

Each AID Bureau has a chief of evaluation, usually in the Development Programs office. This person and his/her staff receive copies of the PES's produced by all missions in the region. The Bureau evaluation staff has several functions. The first is to prod project officers to evaluate the PES's, which tend to have relatively low priority when compared to project design work and budget considerations. A second function is to look over new projects, to give advice based on past experience and to scan the evaluation plans of new projects. The third function of the Bureau evaluation unit is to initiate evaluation for the Bureau, if a project has region-wide impact or if there is some question about mission competence. A fourth and final function is to act as liaison between the regional bureau and the Policy and Program Coordination Bureau (PPC) which also has evaluation activities.

The Program and Policy Coordination Bureau

The Program and Policy Coordination Bureau (PPC) also initiates evaluations, most notably the "Bennet evaluations"—the impact evaluations mandated by former Administrator Douglas V. Bennet Jr., in his Memorandum of October 24, 1979. Prior to the 1960's, all evaluations had been classified top secret, because they were a part of development strategy. There was a growing realization in the late 60's and early 70's that some things labeled development activities were dynamic and unpredictable. By 1974-75, a new effort at evaluation was mandated which required in-depth evaluation at least every three years.

An evaluation task force under the Carter administration concluded that no central policy lessons had been learned from previous efforts. There was a need, said the Task Force, to find out more precisely what had been the yield of policy actions in order to inform inter-regional policy budget decisions.

PPC's approach to evaluation is that these efforts ought to respond to a need—not be "supply in search of demand." PPC is now hoping to discontinue the function of central review of routine evaluations and concentrate upon summary and impact evaluations. PPC also sees for itself a training role, the facilitation of evaluation as a part of public administration in developing countries. In this area, it is reported that most donors including AID have no idea how good or poor the evaluation function is in developing countries. Many assume that all developing countries have little or no evaluation capability, but this capability appears to vary widely. For example, India has 900 evaluation professionals.

Thus, in AID evaluations, the field missions, the Bureau evaluation staffs and PPC each have separate functions, which slightly overlap and require coordination. There is suspicion and jealousy among these entities, and between the field and Washington. This partly reflects the view of developing countries that evaluation efforts are "wasted development monies," and that they have had enough study teams. The missions also sometimes resist evaluation efforts because evaluations may be a source of embarrassments. Furthermore, evaluation results are sometimes not clear and may take a long time to analyze. Often, the mission personnel feel that Washington staff simply do not realize how difficult it is to operate

under the constraints of the developing country environment. Finally, the missions often feel that evaluations are basically subjective, and that it is very difficult to find indicators of impact which can be agreed upon.

The field missions initiate and staff (either in-house or with contract personnel) routine evaluations and many special evaluations. Routine evaluations, according to the Draft of the revised AID Evaluation Handbook, are done periodically during the life of a project according to an evaluation plan established in the Project Paper (PP). These evaluations rely fairly heavily on the use of the logical framework matrix (known as the log frame) which specifies benchmarks to be met. They are designed to reveal unanticipated results and problems. These evaluations are not intended to be mere monitoring reports, but are to bring together data collected by monitoring operations so that issues are identified and management decisions can be made. (AID/PPC/E, 1980, p. 5).

Special evaluations are done when some particular question needs to be answered. These often deviate from the log frame since unanticipated issues have called for the special study. They are done by teams made up of mission, Washington, and host country personnel, sometimes with outside contracted assistance. The mission has to submit on a regular basis a plan for its evaluation activities. This is coordinated by the Regional Bureau into the Bureau evaluation plan which will try to save costs on fielding teams to various missions. Special evaluations may also be initiated by the Bureaus, especially where there are problems which touch more than one mission within the region.

A third type of evaluation is the impact evaluation, a post-execution evaluation effort originating in PPC. This type of effort asks what the effects of the completed project were on the target population and the non-beneficiaries. It also asks questions about endurance and replicability. These evaluations, in the Bennet form, were limited by certain requirements: time, readability, publication, using in-house personnel (within AID, but not within the mission). Although the effort originates in PPC, the process of conducting the evaluation requires mission concurrence.

A fourth type of evaluation done in AID is the Summative Evaluation. This is the process of looking at types of projects and attempting to find out the lessons learned from a policy impact standpoint. These efforts are sector-wide. The efforts of the Bennet evaluations are part of a summative evaluation plan. Projects are selected because they typify certain sector efforts. PPC has sponsored a number of research papers dealing with sector approaches such as rural roads (AID/PPC/E 1980, p. 5-6).

These four types of evaluation constitute the state of the art within AID. AID is moving away from the idea that evaluation is simply a monitoring process which checks on the expenditure of resources and planned activities and services. Audits and feasibility studies are now specifically excluded from the AID definition of evaluation as are Contractor Performance evaluation ratings.

Other issues of relevance

Cost-Benefit Analysis is a tool used in evaluation as well as feasibility and design studies to compare costs and benefits. These studies try to assess the internal rates of return of capital investment in a project and benefit/cost ratios for various features within the projects. For example, in one irrigation project, costs were determined to include capital costs of construction, the costs of maintenance and operation of the systems and the opportunity costs expended to use the system. The benefits included the difference in production with and without irrigation, the employment generation component, and other factors. Issues which are usually not treated by cost/benefit analyses are differential impacts on various socioeconomic groups, community development benefits, and environmental impact. These costs and benefits are generally very difficult to quantify and often the data does not exist to allow before and after comparisons.

Cost/Benefit Analyses and calculation of a project's internal rate of return are design stage considerations for international financial institutions (see World Bank 1975; Pak and Taylor 1976 and Costs, below). While themselves rarely evaluated, these analyses guide supervision of projects and may lead to their cancellation or a revision of method for future projects.

The term "social impact analysis" is not used in AID's evaluation terminology. The closest comparable procedure is the impact evaluation, described above, which is conducted only on selected projects. This is also the case with community development assessments. Environmental impact is rarely assessed post-project, because the only Congressional mandate for it is at the project design stage.

In short, evaluation of AID rural electrification projects, including small hydro projects, is neither as comprehensive, as systematic, or as informative as it could and should be, as many AID officials recognize. What is needed is a design for impact monitoring as well as process and cost monitoring. Project design should include a way of collecting the socioeconomic data which will be needed for later evaluation. For example, evaluators need data on social impacts such as—

Proportion of community houses which are electrified;
Domestic, public, and private uses of electricity;
Spin-offs such as a larger and more productive labor pool, making businesses move viable;
Displacement of women by men in productive activities which move from the domestic to the public sector.

Improved social evaluation can increase the value of AID's small hydropower program and reduce the risks of unintended, unwanted social consequences. As one AID official says, "We go at the same speed down the highway whether its an icy road or a clear highway."

Analysis of evaluations and cases of rural electrification

As a first step in developing a methodology for evaluation of the impact and effectiveness of small scale decentralized hydropower systems in developing countries, and of the suitability of potential users, electrification studies made by or for AID were reviewed along with some feasibility studies for AID's rural electrification projects.

Little relation was found between survey instruments which had been used to collect base line information for feasibility studies and the survey instruments, or other evaluation techniques, used for post-hoc evaluations. While many of the characteristics of user (or potential user) populations and indexes included in various survey instruments would be useful in the evaluation of electrification, applying such lengthy expert instruments to small hydroelectrification projects would unduly increase the cost of these projects. A lower cost framework for evaluation is necessary. This framework is detailed in the next chapter. Its primary instruments are a community application form to provide pre-project baseline information and survey protocols to be administered by AID mission personnel to provide post-hoc evaluations.

Critical examination of two cases of rural electrification reveals a great contrast to small hydroelectrification alternatives. Each uses central power distribution systems, is administered by central governmental power authorities, has country coverage as a goal, shows a bias to urban consumers and divides sharply the administration of power generation from power distribution. While a country program for small hydroelectrification might have several of these characteristics, it is possible for small hydro to have none of these characteristics and still be an effective project. What is important in the critical examination of the evaluation of these cases are the styles and expectations which surround rural electrification within AID and its client countries.

Evaluation of evaluations

The improved framework for evaluation outlined in the final section of this report draws upon assumptions or theoretical postulates used in recent evaluations of rural electrification. An earlier study by R.R. Nathan Associates, Evaluating AID Rural Electrification Projects, presents a valuable summary of much of the evaluation documentation. Recommendations of this and other comparative or critical studies of evaluation procedures (see AMARU 1981, p. 1-40 for references) have been incorporated into the impact evaluations of rural electrification performed recently by USAID. The impact evaluations represent a new style in evaluation using criteria to which electrification by small hydros can respond.

Evaluations of rural electrification in Bolivia and in the Philippines were selected for critical review because both programs had been subjected to an AID impact evaluation. In addition, the Philippines was selected because it is one of the oldest, most ambitious and, for some, a successful

rural electrification country program. The results of this "evaluation of evaluations" are presented on the following pages.

Country: Bolivia

Project titles, numbers, and dates:

Rural Electrification I-511-L/T-046—1973
Rural Electrification II-511-T-049—1974
Amendment to RE I & II—1974

Project funding (US$ millions):

Rural Electrification I:			
U.S. loan funds	10.8	1.0	11.8
Government of Bolivia	1.2	3.6	4.8
	12.0	4.6	16.6
Rural Electrification II:			
U.S. loan funds	6.5	3.0	9.5
Government of Bolivia	2.2	1.1	3.3
	8.7	4.1	12.8

AID impact evaluation

Reference document:

Bolivia: Rural electrification. Project impact evaluation, July 1980.

Team members and authors:

Edward Butler, Team Leader/Senior Rural Development Officer (USAID, Bureau for Near East)
Karen M. Poe, Anthropologist (USAID, Bureau for Program and Policy Coordination)
Judith Tendler, Economist (Consultant)

Local help to team:

Juan de Dios Yapita—Aymara interpreter
Alcira Bascope—Quechua interpreter

Schedule of evaluation: 3 weeks

2 weeks in the field, 3-4 days per region
1 week in La Paz, reviewing additional information, writing draft

Criteria for site selection:

1. Length of service-only those with the longest time in operation were visited; report does not indicate dates the systems were energized.
2. Ecological and cultural variation-sites representative of the traditional divisions of Bolivia: Highlands, Valleys, Lowlands.
3. Easy access fo sites in consideration of limited time available.

Departments visited:

Santa Cruz, La Paz, Cochabamba, Sucre; (Potosi and Tarija, where grid extensions are under construction, were not visited).

Evaluation objectives:

1. To determine the social and economic benefits attributable to the use of electricity;
2. To determine if the utilities had the capacity to load up the electric distribution system after termination of AID funding; and
3. To identify and analyze the key factors contributing to or inhibiting the achievement of the intended social, economic, and institutional objectives.

Outputs funded:

USAID has funded the design, engineering, and construction costs to extend electric transmission, distribution and connection services to rural areas adjacent to the departmental capitals of La Paz, Cochabamba, Santa Cruz, Sucre, Tarija and Potosi and had financed a limited amount of technical assistance to strengthen the management capabilities of the weaker electric utilities (Tarija, Potosi, and Sucre?).

Purpose of the loan:

According to the 1973 loan document cited in the report, the purpose of the loan is to improve the economic and social conditions of the inhabitants of the rural areas adjacent to major population centers of Bolivia by providing them with electrical transmission, distribution and connection services on a self supporting basis. The target population was the 48,000 rural consumers projected to receive electricity by 1977, and 81,000 by 1986.

Background:

In 1979, all systems except La Paz were energized. Population benefitting was 42,000 or 12% less than projected for the first year after completion of construction. The service was well established in Santa Cruz and Cochabamba. Areas indicated above were under construction. La Paz had not yet begun construction.

The impact evaluation:

The Project Impact Evaluation on the Bolivian rural electrifi-cation projects is an impressive document in its depth and coverage of issues considering that time spent in the field was only three weeks.

The evaluation team had three objectives which were stated in very broad terms. The broadness of the questions gave the team freedom to focus on whatever aspects it found to be relevant. Though there are advantages to broad general questions, there are also disadvantages to not having a more clearly defined instrument for conducting an evaluation.

The first question or objective was to determine the social and economic benefits attributable to the use of electricity. The evaluation touches on a number of concrete benefits of an economic nature; however, none is explored in detail or in a systematic way. In terms of economic benefits, the report questions the assumptions made in the feasibility and project papers as being inadequate to the Bolivian reality.

The main assumption was that availability of electricity would generate a number of productive rural enterprises - irrigation pumps, agro-industry, etc.

The systems were designed and constructed to accommodate demand for these types of productive enterprises. The team found no evidence of these types of enterprises resulting from the availability of electricity and questioned the validity of the assumption.

> Specifically it was expected that electricity would stimulate the development of rural industry and irrigation, improve health services, make life more comfortable for rural residents and help deter the exodus from the countryside. (ibid, p. 3)

The two rural electrification projects "assumed incorrectly" that all of the above goals will result from simply providing basic electric infrastructure.

The report indicates that the team found small scale uses of electricity such as tailors and hat makers using electric sewing machines and irons, restaurants using refrigeration and blenders, etc. However, these types of activities were not contemplated in the design, nor were they considered important productive uses of electricity. The team questions the assumption and bias of the project in only considering industrial types of activities as productive uses. There is clearly little real knowledge of the beneficiaries in the feasibility study and project papers which in part may be explained by the fact that both were done before such profiles were required and that they focused only on economic and financial analysis.

The team also found that rural population density was underestimated. One consultant used old census (1950) data without adequate field checks or consideration of the socioeconomic changes since then. As a result the consultants used a "rule of thumb of one connection per 20 households in an area through which primary distribution lines would be passing, the actual ratio was 1:6." (ibid, p. 8)

The team "had the impression that central-system electric power was more a response to economic growth than the cause of it." (ibid, p. 8)

The team also addressed the question of what factors were responsible for the lack of productive uses of electricity. These were identified as—

1. Technical and organization design
2. Costs to users
3. Promotion policies
4. Broader economic and policy reasons for the low level of productive uses:

(a) "Bolivians' perception of the system as providing electricity not power"

(b) Machine-based technologies of production in many cases may not have been competitive with existing labor-based techniques

(c) Proximity to cities and cheaper products and services.

The rest of the report on the impact of the rural electric system is devoted to exploring the factors—mostly of design and institutional—that are responsible for the lack of productive uses of electricity in the countryside. In a number of appendexes, the most important issues are dealt with in some detail.

Comment on evaluation findings—A brief, general section at the beginning of the report deals with social impact and touches upon what may be the most productive way of evaluating impact at the household level. There is, however, no attempt at analysis of communitywide impact. Perhaps given the scope and time available to the team, it was not possible to try to determine the social aspects involved in the electrification projects or their impact on communitywide forms of social organization. There is not even a community profile except for the repetition of the cliche that towns are made up of "blancos" (whites and mestizos) and "indios" (Indians) are the rural dispersed population. Allusions are made to the facts that the areas called "rural" that are adjacent to the cities have very special characteristics, that these areas are integrated into the cities economically and socially, and that they are the main areas responsible for the departmental capital cities' urban growth of the last 20 years.

The impact evaluation report focuses clearly on those issues that have an influence on availability of electric power, such as rates, costs, ease of connection, etc. It discusses the impact of each issue on number of people included and excluded, on economic and social activities, and on the future of the electric utilities.

Social impact

Other than policy and institutional factors in the rural electrification projects, the report does explore in a general way the "social impact" of electrification.

> The preponderant positive impact of the rural electrification project was social. (ibid, p. ii)

"Social" seems to be defined as in social life, socialization, conviviality, etc. It is closely related to the assumption in the project paper, and later statement in the report, that electricity contributes to the standard of life.

> Electric light was more convenient and cleaner for her (the campesino woman) to use, than traditional kerosene lamps and candles since the wind could not blow out the light bulbs and there were no spills of wax to clean up. She no longer had to worry about the small children being burned. The bright light also made it easier for the older children to do their homework; they no longer complained about headaches from the kerosene fumes and eye strain from the dim light. (ibid, p. 4—Comment in parenthesis added)

While all of the statements above may be true, they seem to disclose more of an observer's bias than what the beneficiaries may have felt or thought. A more valid indicator of the value placed on electricity by the rural population is their willingness to pay several times the original cost of connection to obtain electricity once the loan fund for that service is exhausted. Another indicator was people organizing themselves and making petitions for their communities to be included in the project. Acts of vandalism by people not connected in an effort to force the utilities to take electricity to their communities is also a very good indicator.

On page 4 of the report, there is a brief quote from field notes about the changes in the daily round of a household and a statement of how light has affected the daily activities of a household. Again, it is difficult to sort out what is happening and what are simply observer's conclusions and maybe even suppositions.

However, in terms of finding a way to systematically assess impact at the household level, the daily round may be the best. It would have to be done before and after, or at least the daily round before electrification has to be reconstructed. To assess impact on a unit larger than the household, seasonal or annual rounds should be looked at.

Regional impact

The nature of the system—an extension of central power to adjacent areas around the major cities; the passive nature of the beneficiaries; the lack of any participation by the beneficiaries in the project, except as users, are all very important characteristics of these types of rural projects.

The oft-repeated assertion by the team that the central system power projects were more a response to economic growth than a cause for it is a key to understanding the impact of the projects.

Rural-urban distinctions—The first issue that all of these considerations raise is that of urban-rural distinctions. In some cases like Cochabamba, just how "rural" was the population that benefited from the project? The assumption is that anything outside the major cities in Bolivia is rural. It does follow the traditional native's view of the urban-rural distinction. This assumption is never questioned either by the project or the evaluation. A great number of areas considered rural are in fact extensions

of the urban centers. In Cochabamba where this is more evident, a number of so-called rural areas are part of the economic and social urban areas. Many of the communities have become "dormitory" type suburban communities where the greatest part of the economically active population resides after working in the central city.

How important rural or agrarian occupations are for the majority of the population of these areas can be questioned. It is possible that "rural" occupations are only sources of supplemental income. A small farmer may be only a part-time farmer, or his wife and children may attend to a dairy farm while the husband works in the city in unskilled occupations, in construction, transport, etc.

The lack of a socioeconomic profile leaves all these issues unanswered. It is possible that in each of the regions, the situation differs; however, all the capital cities have experienced growth in the last 20 years that has changed the nature of the social and economic organization not only in the cities but more importantly in the adjacent areas.

One of the appendexes deals with the rural to urban migration:

> A striking change is occurring in the rural Bolivian countryside; people are moving from dispersed settlements to nucleated rural settlements. It is not possible to attribute each case of nucleation to rural electrification since this process began to coalesce in the 1960's, the decade after the land reform. However, there is evidence that the process is being accelerated by the provision of electricity. (ibid, p. B 1)

Changing settlement patterns—The formation of new towns and the resettlement along roads, which at the same time are now along the electrical line, is striking. The process responds to economic and social changes long in the making.

What were once self-sustaining communities have become part of a regional economic and social area. Forms of social organization and economic activities characteristic of a community are no longer viable, which is evidenced in changing rural settlement patterns. New roads have been a magnet for people who have moved from towns or from more isolated places to sites along the road. This process is most clearly seen in Cochabamba. In areas of colonization in Santa Cruz, settlements are usually temporary until the colonists consolidate their holdings. Here again the location of houses tends to be along roads and near other services such as schools, water, and medical posts.

The distribution of electricity in the projects was designed to follow existing roads, and in many cases the decision to build a house may have been influenced by the last factor. Not only would the house be near the road, it would also have easy access to electricity.

Though a contributing factor, electricity cannot be seen as the main or only factor in changing settlement patterns. This fits, however, the team's impression that it is more a response to economic growth than a cause for it.

Rural vs. urban production—These factors help explain why there were no significant productive uses as was expected in the project papers. The answer may be that there are no significant economic or productive activities in the areas served by the Bolivian "rural" electrification program because all of these activities take place in the nearby cities.

In addition, productive activities in the countryside may not be competitive with those of the nearby cities.

> The lack of productive use may also have resulted from the fact that the rural systems were expanded out from the city along existing road networks. Roads radiating out from cities result in decreased urban-rural transport costs and thus facilitate the supply to rural areas of mass-produced articles which cannot be produced as cheaply in rural areas. (ibid, p. 12)

To justify the project, much was made of the assumptions that provision of electricity would lead to productive uses without exploring the areas' characteristics or potential. A more realistic view was apparently held by "the Bolivians":

> Despite the concern for productive use expressed in project justifications, the Bolivians saw the rural systems as having exclusively social and political justifications. These investments were meant to carry light, not energy for production, to the rural population. The Bolivians viewed rural electrification as redressing the past imbalance in public-sector attention in favor of the cities. From the point of view of load management moreover, the utilities felt no pressing need to seek out productive users in rural areas since the urban base of the rural system provided a reasonable industrial load and its desirable characteristics. (ibid, p. 11)

An exception was Sucre which had a promotional campaign and was negotiating credit with the Banco Agricola for the purchase of water pumps. This was in part due to the previous experience of the other systems, but more importantly to the lack of urban growth of Sucre when compared to the other cities.

Centralized system characteristics—The identity of the "Bolivians" cited in the impact evaluation is an interesting question. The views cited fit well with ENDE's perception of its role and function in Bolivia as being the big power utility and not wanting competition from smaller, independent systems. The role of ENDE is not explored in the evaluation report. However, the provision of electricity to areas adjacent to the cities was carried out in the traditional working manner of an urban utility. It did not require any participation from the "rural" residents except as consumers.

In terms of lessons for independent decentralized systems, it is important to note that in the extension of the central system, the role of the beneficiaries is a passive one. They were treated and dealt with as any central utility would its urban consumers.

The lack of services for a number of rural consumers and their subsequent organization to request that they also receive electricity were ignored as potential bases for area or community participation. A number of issues related to central vs. decentralized systems are explored in detail in the evaluation report. Questions of rates (in this case the urban consumers subsidizing the rural ones through equal rates but higher costs for the rural systems) and their implication for the future use of electricity and for the utilities' future attention to the rural areas are analyzed in the evaluation report.

Conclusions

The central-system rural electrification projects of Bolivia present a clear case of urban bias in design, execution and uses. It illustrates the factors that should be important in small and decentralized systems.

1. By treating the areas adjacent to the cities as simply an undistinguished number of potential consumers, it ignores rural differentiation, and more important rural forms of social organization that could have been mobilized to insure better results from the electrification systems.

2. The systems did not and do not require any response other than passive consumption from the rural inhabitants.

3. The systems do not have any room for local initiative or participation in any aspect of the system except consumption.

4. A system designed with an implicit assumption that the rural consumers are not any different than the urban poor can not expect responses from the rural consumers that are different from that of the urban consumers (use of electricity for lighting purposes only).

5. The provision of electricity alone is not enough to make a radical difference in the life of rural areas. Improvement in social services, education, health, etc., will not materialize only because of electricity, but needs a concerted effort by other agencies and institutions responsible for these services. Electricity allows schools to hold evening classes for adults but, as the impact evaluation noted, only if there is at least one teacher.

The complexities involved in considering all the cities together, each having special characteristics and special ties to the adjacent areas, is apparent in the evaluation report. It did force the evaluation into an examination of issues and problems common to all the areas; however, it made it very difficult to get into specifics in more depth. Thus, the evaluation report concerns regional issues and institutional characteristics rather than impact on community organization, household organization, or localities. Some generalizations made in the evaluation report are based on one area and may not be applicable to the others.

The project and the evaluation make clear that in the small system alternative, the beneficiaries have to be taken into account since they play an active role in all phases of placing the systems. In a small system then,

issues of social and/or institutional organization become key issues in determining the success or failure of the systems.

Country: The Philippines

Project titles, numbers, and dates:

Power Survey Grant, 1965
Feasibility Study Grant, 1967
VRESCO Loan, 492-H-025, August 1968
MORESCO Loan, 492-H-026, August 1968
Technical Assistance Grant, 492-11-220-248, April 1972
Rural Electrification Loan for Engineering Services, 492-H-027, November 1971
Rural Electrification Loan for Equipment, 492-H-028, May 1972
Rural Electrification Loan II, 492-T-034, August 1974
Rural Electrification Loan III, 492-T-036, March 1975
Rural Electrification Loan IV, 492-T-043, August 1976
Rural Electrification Loan V, 492-T-047, January 1978

Project funding as of December 30, 1979 (US$ millions):

U.S. grant funds	$ 2.95
U.S. loan funds	89.20
Other donor funds	132.00
Government of Philippines funds	158.00
Total	$382.15

AID impact evaluation

Reference Documents:

The Philippines: Rural Electrification.
AID Project Impact Evaluation No. 15. PN-AAH-976. December 1980; and draft, July 1980. (Note: cited in text as Mandel et al., 1980.)
Memo from Willy Baum ASIA/PD/SA to Gary Wassermann A/AID (cited as Baum 1980).

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Local help to team:

Team Members: Robert Salazar and Josephine Alviar
Volunteers: Dave Aguila, Deputy Administrator, NEA; Emy Villanueva, Pete Villarte, Manuel De Los Reyes (all NEA)
Local cooperative officials

Schedule of evaluation:

April 1979—field visit. July 1980—draft, December 1980—final, literature review, and interviews in Washington:
3 days in Manila--briefings at USAID mission and NEA
3-4 full team visit to pilot study sites
3-4 partial team visits to each cooperative service area
Discussions in Manila
Drafts

Criteria for site selection:

1. Length of service- cooperatives energized at least 4-5 years
2. Distribution of power use among residential and non-residential customers
3. Variety in the characteristics of the cooperatives examined-
   (a) Range of rate levels
   (b) Self-generating and distribution-only
   (c) Service area with high incidence of poverty as indicated in the Manila mission's FY 1982 CDSS
   (d) Service areas where major agricultural crops grow
   (e) Geographical dispersion
4. Logistical considerations

Cooperatives and provinces visited:

Intensive examination:
BATELEC I, Batangas
CANORECO, Camarines North
VRESCO, Negros Occidental
CENECTO, Negros Occidental
DORELCO, Leyte
Brief visits:
CASURECO II, Camarines Sur
LEYECO II, Leyte

Evaluation questions:

At what stage should electrification be introduced into a poor developing country? What other resources are needed to maximize its benefits? To whom should it be delivered? At what cost? (Mandel et al. 1980, p. 1)

Outputs funded:

USAID assistance financed feasibility studies, the pilot projects MORESCO AND VRESCO, equipment, engineering consultant services and extensive technical assistance provided by NRECA. (ibid, p. iv)

Goals and measurements:

> According to the PPs (Project Papers) for more recent loans, the goal of rural electrification is an improved standard of living for rural people, and the purpose is increased production and improved daily amenities. Verifiable indicators included increased real incomes, job opportunities, access to social services, and agricultural production.
> (Brown, 1980, p. 4)

The 1977 AID project loan document, the last in a series, contained a log frame which specified concrete measurements of goal achievement (see Philippines-Rural Electrification V, p. 18). These measures included among others, 20% increase in real income, ready access to social services such as medical treatment and educational programs, agricultural production increase of 20%, households having at least one labor-saving or convenience electrical appliance, etc. The means of verification were to be statistical data from a number of agencies, NEA and the International Division of the U.S. Census Bureau, plus independent analyses and project evaluations.

Background:

By 1980, the backbone system had been completed and 117 cooperatives had been registered, of which 101 were energized, serving 844 municipalities, 9,088 barrios and 1,159,434 households (Ibid, p. iv).

The impact evaluation:

In April 1979, an AID evaluation team from Washington visited the Philippines to conduct a "project impact evaluation" of the rural electrification program. Their methodology included review of the literature, discussions with key informants and on-site interviews in the service areas of cooperatives. More details on the methodology appear in Mandel et al. (1980, appendix A).

The interviews were, by the teams' definition, "relatively unstructured but intensive," lasting about one hour each:

> The objective of the interviews was to understand the conditions of rural life for the interviewee, how the individual responded to the introduction of electricity in the area and what that individual perceived to be the effects of electrification upon himself and upon the community.

The interviewees selected by the team were cooperative staff or board members, businessmen, school directors, shopkeepers, both landlord and tenant farmers, farm laborers, fishermen, carpenters and casual workers. Both users and non-users were interviewed in each energized cooperative service area.

As far as can be determined, the structured interviews constituted the only data used in the evaluation. The report mentions that the team received some data from NEA, but it is not used in the evaluation. Relevant literature is not cited in the report. The exact questions addressed to respondents are not given, only the general lines of inquiry cited above as questions framing the evaluation inquiry. There is no indication whether the same questions were asked of each interviewee to obtain comparative data. Fifty-one socioeconomic case studies are attached to the evaluation, reporting information from interviews at three sites by the team's anthropologist Dr. Hickey. Since other team members worked at different sites, there is no indication how this additional interview material was handled. Considering that the evaluation was based on interviews this omission is a critical point:

> The case studies do not seem to support the discussion and opinions presented in the body of the report, and the conclusions do not seem to relate directly to the discussion contained in the body of the report. It is almost as if the conclusions were arrived at independently of the case studies. (Baum, 1980, p. 4)

According to the report, the team investigated two issues:

1. Whether the benefits of rural electrification have reached the rural poor, and
2. the degree to which the cooperative form of organization has stimulated development.

The conclusions were that:

1. The impact of rural electrification on both the process of development and on the rural poor were very limited, although there were some examples of "positive effects," and
2. cooperatives do not display popular participation in many cases and the cooperative form itself has not stimulated development.

The rural electrification program in terms of inputs and outputs, however, was judged to be a success.

Other evaluation documents are available for the Philippines. Two others, the Xavier University Evaluation of the MORESCO Pilot Project and the 1977 and 1980 NEA Survey Evaluation are based on contrasting methodologies.

Xavier University evaluation

The Mindanao Center for Population Studies at Xavier University in the Philippines received a grant from AID to evaluate the Misamis Oriental Rural Electric Service Coop (MORESCO) in Mindanao. The results were published in 1976.

The purposes of the study were to determine:

Whether or not the rural electrification program reached the poor,

If so, the nature and extent on the program impact,

The impact of rural electrification on the community as a whole, and

The extent to which rural electrification has supplied the means for the development of business and industry, as well as for an increase in agricultural employment.

An "exploratory sample" of 411 households containing 2,478 individuals were interviewed. This sample is broken down as follows: 203 users, 118 nonadopters, 40 inaccessibles and 50 disconnecteds. In terms of residence, 130 were in urban centers, 118 in rural coastal areas and 163 in rural inland regions. In addition interviews were also held with teachers/principals, religious leaders and business people. A "probability sample" was also used to "establish the pattern of income distribution in the area."

There is no detailed analysis of methodology or a list of questions that were asked. Some of this information is scattered throughout the text—businesses were asked specific questions regarding capitalization, products, etc. However, there is an indication that respondents were at least asked the same sorts of questions so that comparisons could be made.

The study defined the goal of rural electrification in the Philippines as "to improve the quality of life of the rural poor." The study defined the MORESCO area as poor and determined that 62% of the users were poor. This was based on cash income, but according to the researchers, adding other income or classifying the heads by occupation did not change the statistics.

The benefits of electrification, based on interviews, were assessed as follows:

1. Pure and safe water due to electrified pumps that bring fresh water to the surface. Reduction of gastro-intestinal disease.

2. Better services at clinics due to improved lighting and more efficient sterilization procedures. Also new equipment such as x-ray machines.

3. Increased use of educational facilities at night. Less eye strain, better study habits. Vocational courses can now use equipment (electric saws, stoves, sanders, etc.)—before electrification, these courses were all theoretical because equipment could not be used.

4. Convenience of electricity for home lighting cited very frequently by respondents.

5. Decrease in gastro-intestinal disease due to better refrigeration which prevents spoilage and pest contamination.

6. Cheaper power outlays for lighting. Electricity is considerably cheaper than kerosene and batteries.

7. Increased quality of life due to electric household appliances—radios, hot plates, electric sewing machines, and others.

8. Increased agricultural production due to electricity for pumping water. Also, electricity enables some farm work to be done at night—sorting, getting produce ready for market, etc.

9. Productivity has increased in business and industry and new industry has been attracted to the area.

10. Employment and income have increased due to new business and productivity of farms.

11. Women can take daytime jobs because they can do chores at night.

12. Enlivened downtown area. New entertainment activities—movie theater.

13. Users of electricity feel life situation has improved (satisfaction index) and are more optimistic about their own and their children's futures.

14. Increased religious activity—night services possibly increasing church attendance.

15. Birth rates lower for users.

This study is very useful in that it lists a number of additional factors that may be significant in analyzing the benefits of rural electrification: women taking daytime jobs, health/sanitation/nutrition changes due to electric water pumps, refrigerators, etc., and nighttime school activities.

The ultimate value of the Xavier University study may be not that it provided direct casual relationships but that it points out potential benefits and areas of investigation which could be subjected to more rigorous analysis.

NEA evaluations

The ultimate goal of the Philippines National Electrification Administration (NEA) program is total electrification by 1990. According to the AID report, this has been shortened to 1987. Other objectives of the program, cited in various places, are to enhance the quality of life, provide low-cost, adequate and reliable service to a majority of households in rural areas, and reach the poor.

The NEA conducted two nationwide surveys: one in Jnauary-March 1977 and one in January-February 1980. The results of the 1977 survey have been published, while the 1980 results are still in raw data form. Assistance in the evaluations was provided by USAID/Manila and the U.S. Census Bureau.

1977 survey—The Survey consisted of a questionnaire, containing 115 questions plus data on respondents administered to approximately 4,000 household heads (or wives in their absence). The survey was nationwide and included NEA coop areas (14 coop areas with 1,021 electrified and 1,980 nonelectrified households) and non-coop areas (309 electrified and 696 non-electrified households).

The 1977 survey concentrated on rural* households. It was identified as the first of a series of nationwide surveys and as exploratory and designed to provide baseline data for future comparison. The main areas of investigation were (from NEA report):

Sociological characteristics of the household
Housing conditions and facilities
Coverage, use, and cost of electricity
Substitute power sources and cost in nonelectrified and electrified households
Availability, accessibility and use of community facilities
Household income
Perception of the impact of electricity on the community
Attitude towards and reactions to electricity cost and service.

While the survey's stated objectives were to "describe and measure the socioeconomic impact of electricity on rural households," the major emphasis of the survey was a comparison of the NEA electric cooperatives vs. non-cooperative electrification programs. Data in all categories mentioned above was tabulated for coop vs. non-coop areas. In some cases, tabulated data was also given for electrified vs. nonelectrified households (regardless of management form of the supplier), but in most cases it was not. Therefore, in order to compare electrified and non-electrified households, one has to re-work the figures or go back to the raw data.

A series of profiles were drawn up for (1) cooperative households, (2) coop electrified vs. non-coop electrified households, (3) coop non-electrified vs. non-coop non-electrified households, and (4) electrified vs. nonelectrified households. Socioeconomic criteria used were net income, education of household head, house-lot ownership, quality of building materials/improvements, household items (TV, fans, refrigerator, water pump, livig room set, etc.), source of drinking water and employment of household head.

The survey also measured the outreach of electric service, comparing coop and non-coop areas and the percent of the poor and food producers reached by coop and non-coop utilities. Coop and non-coop areas were also

*The NEA surveys include as "rural" all areas that have been or will be taken over by NEA; that is, all households and businesses except those in metropolitan Manila, Davao, Cebu, Iloilo and Angeles. Therefore, many urban areas are included. However, a rural/urban classification is used only in that part of the survey that measures geographical coverage (outreach) of the electrification program.

compared for cost of electricity, quality of service and attitudes toward electric cooperatives.

Benefits of electricity were gauged according to use in the home—both for household functions and for household-based businesses (productive)—and for lifestyle changes. Data on alternative power sources was also obtained. Respondents were asked if they thought electricity improved their lives, improved peace and order, increased educational activity and increased economic activity. Family planning and migration data were also tabulated.

As mentioned above, the survey emphasized how electric coops compared with non-coop electrification programs. Using that criteria, the survey probably achieved its purpose, although some of the conclusions drawn can be questioned. However, since NEA is apparently going to take over all non-coop electrification programs except the five areas mentioned, it is a moot point.

Other issues that might be of use in evaluation of rural electrification were not dealt with. Causality was not really measured. Nor was there much attempt to isolate factors which would induce people to either electrify their home or increase usage. Respondents were asked if they would electrify given a certain rate and whether they would continue/discontinue service if rates were raised. But variables that would affect this decision, notably the cost of other power, were not taken into account. Nor do the yes/no answers to these questions evaluate the importance of electricity in people's lives--would they sacrifice other things to keep electricity; was electricity a luxury item that really was not important and could be easily dropped; etc. Benefit was restricted to educational activity, peace and order, and economic use.

A total of 52 of the 115 questions dealt with income, regarding sources, profits and losses and other issues. However, this data was not evaluated in the survey and the reason for asking the questions is unclear.

From reading the questionnaire, it is apparent that there is data available in raw form that could be useful in making other evaluations on the effects of rural electrification, if NEA or others wanted to do so. Data could be correlated in a number of ways that could yield some useful information, particularly for electrified vs. nonelectrified households. A sophisticated factor analysis could also be applied.

A major problem in the NEA surveys is the definition of "rural." If urban factors, such as transportation, employment bases, facilities, etc., are not taken into account, it really is very difficult to measure the impact of electricity.

1980 survey—The 1980 survey contained some significant revisions. In this survey, NEA placed more emphasis on the impact of electricity on the poor and on business. There was also an attempt to design a "before and after" survey of nonelectrified areas. Since all areas are to be electrified by 1990, NEA attempted to get baseline data on these areas so that they could more effectively measure the impacts of electricity after 1990. Another

area of interest was whether length of service improves socioeconomic status, and the survey compared the socioeconomic status of households with different dates of electrification. The sample size was increased to 5,000.

The 1980 survey, like the 1977 survey, is designed to provide baseline data for future evaluations. The NEA plans to conduct surveys every 3-5 years. To be able to compare the 1977 and 1980 survey results, NEA selected a design that was compatible with the 1977 material. Thus, while changing the emphasis in the 1980 survey, NEA continued to break down data into coop and non-coop categories so that the data could be more effectively compared.

The socioeconomic criteria listed on the questionnaire for the 1980 survey was essentially the same. However, data was obtained for all household members and the list of household items was expanded. In addition to asking questions asked in the last survey about source of energy for household functions, respondents were asked about energy sources for income-generating functions. In many cases the functions were the same—lighting, cooking, TV, ironing—but respondents were asked to differentiate between household and business uses. This data can be useful for evaluating productive uses. The list of energy sources was expanded from wood, kerosene, charcoal and LPG/batteries to include such items as wood shavings, candles, coconut oil and coconut husks. The availability of these fuels was also determined. Respondents were also asked how much they spent on rice, meat, milk, tobacco and other items.

The stated purpose of the household survey is essentially the same as in the first survey, except that in the 1980 survey additional factors were added, including change in socioeconomic status since the last survey, comparison of newly electrified households with households that have been electrified for several years and quantification of other sources of energy.

The business establishment survey looks at several items: (1) a comparison of businesses that have been electrified for more than a year with those that are not electrified; (2) identification of productive uses of electricity; (3) baseline information for measuring employment and income trends; (4) alternative sources of energy used; (5) a determination of the extent that capital formation or availability of credit impedes business expansion of old businesses.

The 1980 survey also included a municipal data questionnaire and a neighborhood data questionnaire covering such items as hospitals, educational and recreational facilities, costs of power and new businesses established.

The data for the 1980 survey is still in raw form. An examination of the questionnaires shows some of the same problems as in the 1977 survey. However, the before and after investiga-tion incorporated into the survey should yield some very useful information for evaluation of the effects of the rural electrification program.

Conclusions

In selecting the most efficient and informative evaluation technique, several models were studied. Impact evaluations, as used by AID, are not recommended because they are too subjective and impressionistic. Evaluation of the demonstration units of the SDH program should contain quantifiable data. Though subjective impressions of people working in the field may be insightful, such impressions represent hypothesis, not proof.

The survey performed by NEA in the Philippines contains excellent material. The survey questionnaire used can serve as a guide on certain issues. Although a survey as extensive and expensive as those of the NEA are not practical for the SDH program's demonstration projects, which will be limited to less populated areas, some of the material can be useful, particularly in areas that overlap with case history information. Examples include household structure, co-resident group, productive uses and small business survey, among other items.

The Philippines case also demonstrates a mechanism for the collection of baseline data which is appropriate to incorporate into the SDH evaluation framework. The Philippine Electrification Cooperative Team (PECT) collect certain baseline information on an area before it is electrified. Establishing some baseline data on items such as potential use, number of consumers and rural industries helps planners design or modify the system being installed to meet the needs of the local community. Surveys by the PECT teams also represent an important form of community involvement which, by predating a project, prepares users for acceptance and further involvement.

Chapter 4

An evaluation framework for small hydro units

About the framework

The Small Decentralized Hydropower Project will stimulate a new type of project for AID missions. SDH will help prepare a number of Project Identification Documents and Project Papers for particular operating units in the field. The suggestions made in this section constitute a generalized framework for evaluation for those field projects centered on operating units.

There are a range of options at the level of project purposes or objectives. In the first section, several different options are explored. In refining a project design, the first step must be to clarify the purpose of the project. The general assumption is that "renewable energy resources are necessary for development..." but the goal of "increasing utilization of renewable energy technologies in the developing countries" must be formulated in the context of New Directions. The actual selection and clarification of purposes will be made by the mission and host country. A strategy must be selected for how economic development will be achieved by a particular operating unit in a particular place.

Because it is difficult to evaluate achievements in the absence of baseline or "before project" data, evaluations properly begin as a part of feasibility studies. While baseline social, institutional cultural and economic information concerning the potential beneficiary population can be collected as part of formal feasibility analyses, part of this information should be provided by the applicant "user communities"—those local areas, villages or institutions which will be electrified by the proposed small hydro. The community application procedure is also discussed below.

Many characteristics which would help predict the suitability of one group of potential beneficiaries over another are covered in the application form. However, other social, institutional and cultural characteristics of the population to be served could also be delineated. Further surveys in particular sociocultural settings will be required. Fieldwork is essential as the literature does not contain information about some characteristics which are important.

Characteristics which would predict the suitability of a group of end users will also vary by world region, country, region and ethnic or occupational group. For example, a community which collectively operates a traditional irrigation system will be pre-adapted to understanding the hydrodynamics of the technology. This cannot be raised as a worldwide screening characteristic because there are many potential small hydro sites near populations which do not have such a tradition. This trait could be used to select groups within broad regions where the trait is present, however.

The procedures suggested culminate in a procedure for evaluation one year after operations have begun at the small hydro unit. This evaluation is the

routine type, to be conducted by the respective AID mission. However, by making the procedures to be used in different countries conform, a higher order comparative impact evaluation will be facilitated. This operation is described in some detail; field preparation is outlined and a model protocol is provided.

Use of evaluations. Evaluations are a tool to improve project and program design. For evaluation to feed back, it must be performed while the project is still under development agency supervision to allow for the implementation of the recommendations generated by evaluation.

The more comparable the data gathered in evaluations of similar projects, the greater the net gain in experience applicable to future design. The more reproducible the data gathered--that is, documenting phenomena which can be seen and collected by more than one independent observer--the stronger is its comparability and consistency.

Evaluations do not need necessarily to be lengthy procedures which burden development efforts with the statistical rigor associated with some forms of social research. However, fieldwork at already existing small hydro sites is critical to the demonstration of the method proposed here. The focus of this social scientific effort will be on (1) perfecting country-specific protocols which include both cross-cultural, comparative and culture-specific information procedures framed in site-specific vernacular languages; (2) the development of a computer program using factor analysis techniques to screen and rate the application forms of qualifying communities; and 3) comparative analysis of small hydro project information across time within user communities, and among different sites within each country program, as well as world- wide.

Introduction to the procedures. A user-community application form can serve both as a screening device for the selection of small hydro sites and user communities and a "pre-project" status report which contains certain baseline socioeconomic data.

One year after the small hydro plant and its initial distribution lines are built and operative, the user community will file similar data, updating its profile with a report on the one-year-after-project status.

In the method proposed here, both screening and regular programmatic evaluations rely heavily on the analysis of data provided by the user community. Some potential user communities may require technical assistance to formulate their applications It is therefore imperative to this evaluation framework that information originating from user community sources be verified--by spot checks among those communities applying and screened as qualifying, and by evaluation site visits one year (or at other intervals) after small hydroelectrification.

The following pages include a discussion of the rationale of the community application procedure, an outline of the user-community application forms, procedures for on-site evaluation visits and examples of protocols to be developed for use in routine evaluations.

Community application procedure

The appropriate technology approach holds that technology transfer is triggered by a "recognition of need, followed by an expression of need and a request for assistance from potential beneficiary end users" (VITA 1980, p. 1). The concept is formulated in community development theory as the expression of felt need.

Electricity is a need very commonly perceived by the rural poor of the underdeveloped world, if only as a desire for the special prestige associated with electrified places. After a survey of 23 Andean communities, a General Electric team concluded the desire for electrification was "universal" (1963). When rural electrification produces those who "have" among the "have nots," problems can result. In Bolivia, a social tension associated with the rural electrification system is the frustrating of communities' desire for electricity by the centralized planning of grid extensions. The "vandalism" of electric installations reported from Bolivia turns out to be naive attempts by rural people to take into their own hands the decision of where to extend distribution lines and, literally, to try to divert high tension wires (personal communication, Ivo Kraljevic, AMARU). Along the highways where electric wires pass, Bolivians build second and third stories in a cargo cult-like attempt to touch the wires and so tap its passing power for their own use (personal communication, Karen Poe, USAID).

In Indonesia, the pilot project area for small hydro was selected in part to serve its politically influential residents, raising an image of favoritism and inaccessibility of the program which may burden future projects with a negative image. In Mozambique, FRELIMO made a political decision not to destroy a major hydroelectric installation after they controlled its area, on the grounds that once their revolution succeeded that power could be used for their own development design, rather than be sold to South Africa (CCLAMG sources). Recently in Peru, high tension wires transmitting power to the capital city, Lima, have been dynamited in two less well electrified rural hinterland areas.

These incidents suggest that people's perception of electrification as positive or negative depends on people's estimation of their actual or future access and their opinion of how fairly distribution decisions are made. A user-community application procedure, especially for grant or subsidized programs, introduces a fair contest to find and develop first those sites judged to have the highest natural hydro potential and also the highest human resource potential.

In the Philippines, potential user-communities have been required for some time to form a PECT team which, through surveys, develops a community profile. Technical assistance is available from, and forms are standardized by, the NEA, but the actual work of developing the statistical profile is carried out by volunteers. This community profile, or PECT, is used to make the decisions concerning which areas will be electrified and in what order. The pace of rural electrification has been fast enough in the Philippines to assure potential users that their organizational work in

developing the PECT teams and in forming local institutions capable of carrying out distribution functions are not in vain, and will in due order be rewarded.

A different set of technical decisions are involved in the selection of small hydro sites than are involved in extensions of a national grid. However, both electrification systems frequently share a common problem in having more potential sites and consumer demand than program funds. Rather than place the identification of potential sites solely in the hands of technicians reviewing hydropotential or scouting sites in air overflights, certain information important for technical feasibility from community applications can be used to inventory potential sites.

Several small hydro equipment manufacturers send standardized questionnaires to potential customers. Few offer on-site technical assistance. Rather, their business depends on matching requirements stated by customers with the appropriate model. The more sophisticated manufacturers have proprietary computer programs to analyze the data and select the best model from their line. This mail order aspect of the small hydro commercial sector, which is more experienced than the development sector, suggests interesting options to reduce engineering costs. Hydraulic engineers, who are concerned with programmed modeling for the careful studies required for large hydro sites, could also develop master-programmed analyses if more small-hydro site-specific data were available (personal communication, Robert Meredith).

Technical data supplied by potential users should not be the only technical criteria for definitive site selection. Enough disasters are reported in the fragmentary small hydro case histories to confirm that on-site technical assistance by engineers is a recommended procedure. But collection of data of this type as an aid to developing a computerized criteria for analyzing site potential would be verified and perfected by on-site technical feasibility studies. Such a mode of site selection will serve to eliminate poor sites and to sequence sites with the best potential to be developed as first priorities, if other feasibility criteria are met.

Social and institutional criteria need to be taken as much into account in selecting small hydro sites as do technical criteria. The potential community of users, be they the local government of a village or some entrepreneurial entity or an isolated social service institution will, by fulfilling the requirement of completing a user community application form meet two essential social/institutional feasibility criteria: they will express a "felt need" and desire for assistance and they will demonstrate minimal organization capacity.

In terms of management and maintenance, among the more successful cases of rural electrification appear to have been triggered by some form of community involvement. The people of Huaylas district petitioned on moral grounds and entered into litigation with the Santa Corporation to win the improved electrification of their village. Before this "good electricity," they had organized themselves to provide successive improvements in their local diesel-generated system—an organizing ability which has been displayed in many rural towns and villages worldwide.

Through the user-community application procedure, the act of petitioning marks the willingness of potential users to get involved.

Prior electrification by some other autogenerating source also displays this feasibility-screening trait, on economic and technical as well as social/institutional grounds. User-communities that wish to substitute hydropower for some other fuel, or to improve their local autogenerating systems will not require a perennial flow. The costs of capital installation for a small hydrogenerating plant can be compared with anticipated lowering of fuel costs already established by their use patterns (personal communication, J.J. Fish, World Bank). Since an institutional capacity for the management and maintenance of an electric system is already in place, a judgment can be more firmly made about the applicant's capability to form a suitable institution. Since the trait of already having some autogenerating capacity has technical, as well as social ramifications for selection criteria (e.g., no perennial flow, only enough to net a fuel savings equal to or exceeding capital investment costs), these traits need to be analyzed in tandem.

Models

The rural electrification social feasibility studies and evaluation studies examined which were based on more formal field data—rather than the authors' impressions or secondary sources—reported the results of a sampled household survey. This methodology reflects the dominance of household consumption in rural electrification projects. As such, the method is adequate to the task. For the innovations of the Small Decentralized Hydro Program to be evaluated successfully, for user-communities to be involved and eventually emerge as responsible stewards of small hydro systems, and for small hydro end users to move beyond hooking up households of passive consumers, a new technique is required.

For this approach, important models can be found in energy survey methods and integrative human ecology studies rather than in the rural electrification feasibility and evaluation study tradition. One model is the Peace Corps Energy Survey; though this document is deficient in its coverage of households, it is intended for administration by an expatriate without special training and could be adjusted for self-administration by settlements and institutions in lesser developed countries. Another model to examine is the energy section of the recent VITA survey of Guinea (1980).

One country-specific energy survey examined (Planning Rural Energy Projects, Burrill, Forman, Gomez 1980) specifies survey instruments to be used by "planners" with interrogation directed to local individuals.

The critical difference between the survey instruments cited above and the community application form outlined here is self-administration by the respondent community. Each applicant user-community may vary in its methods of answering the questions. However, the activity of preparing an application will enable user-communities to plan and make decisions themselves. Information the user-communities provide can serve as a baseline pre-project survey.

Theory

Boyden (1979) summarizes the integrated ecological approach to the study of human settlements, a method which develops the principles of the Odum model (see Thomas 1973 for a sample analysis of a remote rural community) for complex settlements, such as the city of Hong Kong.

Basically, the ecological study of extrasomatic energy use in a human ecosystem involves analysis and description of the following:

—the inputs of energy supplies;
—the outputs of energy supplies;
--the uses of extrasomatic energy use (i.e., intended effects) within the settlement;
—the side effects of extrasomatic energy (Boyden 1979, p. 39-40).

The patterns of use of extrasomatic energy...are of far-reaching ecological and human significance. They are, of course, a reflection of the kinds, number and size of machines used, as well as of the organization of that society. In turn, the pattern of machine use is the result of various cultural factors, including, in particular:

--the technology of the society (that is, that state of knowledge relating to the design, manufacture and use of machines); and

--the dominant value system, the economic system and the power structure of the society as they affect decisions and actions relating to the applications of technology.

These are all important considerations for screening the suitability of a particular settlement for the new energy input a small hydro would represent. The operation of collecting such information from the community itself represents a transfer of social science technology rather than a simplification. The method involves conceptual models, such as energy flow, for analysis but relies on check lists for its data, with the knowledge that for different kinds of settlements, filling the data cells would require quite different research operations. Many items in the master "life conditions checklist" are directly relevant to the process of a small hydro unit. For example, "the availability and quality of water" is important in determining technical feasibility and in testing for environmental effects and possible disbeneficiaries impacted by a small hydro project. Social items such as "community experience in degree and kind of community interaction" and "subsistence (job) opportunities (availability and distance from residence)" affect, respectively, how well a settlement can mobilize to construct and operate a small hydro system and, as a comparison of pre- and post-electrification situations, how economic impact can be measured. Behavioral data gathered as a "time budget"—sleeping and resting patterns, small group behavior, goal-directed activity—are important because all of these are subject to measurable change when the energy of a small hydro is fed into a human ecosystem.

The user-community application form and social evaluation protocols

Following this final section of the report is a tentative or illustrative User-Community Application Form and Protocols for a Site Visit Evaluation, the latter intended for use one year after a small hydro installation has begun operations.

The user-community application form is in four parts. Part A is a face sheet, to be signed after the application is complete. It will constitute the formal petition. Part B will elicit technical data. Part C will ask a set of "Socratic questions" posing to the applicant user-community problems they will have to solve in order to successfully install, operate and otherwise manage a small hydro system.[1] Part D will be a survey of the user-community and the proposed end uses. There are different formats for settlements and specialized institutions.

Part A, the face sheet, will show the name of the applicant user-community, and general information about the group's legal status, type organization, and population. This face sheet will be printed with the text of a formal petition, legally screened and approved by the administrating agency within the country. The final element of the application form face sheet will be a signature, by the recognized representative of formal associations (head of tribal council, mayor, president of the board of directors, etc.). If the petitioning group has no formal organizational status (such as the residents of a remote hamlet which lacks a political authority recognized by the central government or the members of an unincorporated society), then the signatures or marks of the petitioner shall appear on the face sheet.

Part B will require data which will screen the technical feasibility of the site and give site specifics important for recommending optimal ranges of equipment and civil works.

This section will have to be developed by engineers. Analysis and scoring of this section of the application may require development of a computer program similar to those of the major small hydro equipment manufacturers, programmed to recommend specific equipment from the range of options to be used within the particular country. In the sample below, the types of information most frequently asked on manufacturers' in-house questionnaires are given.

Many potential rural user-communities will need assistance to complete this section. A written guide explaining the required measurements and line drawings or photographs of each step and proper instruments could be

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[1]In Plato's dialogues, the philosopher Socrates taught his students by asking probing questions, which required them to re-examine their own reasoning. "Socratic questions" are those which test and re-test the problem-solving capabilities of the respondent.

developed. A variety of didactic guides are available from manufacturers (e.g., C.CH.LG Ltda., Bogota, Colombia) Microcentrales hidroelectricas para independencia energetica and Leroy-Somer's Guide de l'acheteur; the hydropotential section of the Peace Corps Energy Survey; C.D. Basset's "Harnessing the Small Stream" in Cloudburst: a handbook of rural skills and technology (original 1947) and in publications available from the National Center for Appropriate Technology, Intermediate Technology Development Group and Volunteers in Technical Assistance.

Part C may require some didactic information to be prepared to enable the user-community applicant respond to the "Socratic questions" in this section, which will pose problems for the applicant to solve. A short explanation noting that some small hydros will require civil works construction of a certain type with certain materials may be required before potential user-communities can answer the questions that address this situation; i.e., "Do you plan to build the necessary associated civil works? If not, will you need to contract outside labor?", etc.

The goal of this section is to allow the applicant user-community to solve some problems they would face if they were to undertake the small hydro project—in the abstract and in terms of their own resources. If outside technical assistance is provided on-site for the preparation of applications, it is important to instruct the agent only to rephrase these questions and give examples of problems encountered elsewhere, rather than to give examples of solutions. The potential user-communities must think through problems for themselves--in advance and in the abstract. If the answers are to be taken into consideration in selecting one application over others, the reasoning presented in their solutions must be evaluated. If answers are unduly influenced by outside assistance, the test will be invalid. In the rating of this section, attention should be placed on similarity of answers—it may be that too strong a model for the organization is being projected in publicity campaigns. It may also be that there is an already well-established model generally accepted in the cultural setting which should be taken into consideration in all subsequent community organizing.

Part D consists of survey questions for all applicants, for specialized institutions, and for settlements. The survey information required from specialized institutions should be within their capacity to assemble without any technical assistance. If the applicant is a settlement, some technical assistance or orientation may be required. Training should be made available, with short courses in conveniently located centers, but the community should decide for itself to take this option. If the community has no person with the requisite literacy and census-taking skills available, a group of university students—otherwise not associated with the small hydro program in the country--can be trained to offer their services for pay to communities which require extraordinary assistance.

This section of the survey will constitute hydro project baseline data. It must be finalized to match exactly the requirements for evaluation indices, as the user community will resurvey itself for comparable information one year after small hydro plant operations have begun and at subsequent intervals as part of its obligation for participation in the program.

Following the User-Community Application Form, three kinds of protocols are sketched. These protocols are designed as evaluation instruments to be used at least one year after the small hydroelectrific plant has begun operations or at some other period, numbered in years, after small hydroelectrification.

These protocols are designed to be administered by one evaluator accompanied by a guide or language translator, to perform the evaluation during a visit to the locality where the small hydro was used. The site visit will take at least two days. If the system is large, embracing a town of several thousand, a longer visit by a single evaluator, or a team of evaluators visiting for a short period, will be required to complete the on-site data collection.

The sampling technique proposed for administering each kind of protocol is not based on randomized or stratified procedures. The thrust of these protocols is to provide data from key informants. Data for project evaluation by a variety of criteria is proposed with cross-checks among different kinds of documentation and including independent means to verify the same phenomena across the content of all protocols.

There are three kinds of protocols. One calls for observational data, which can be documented by graphic representations such as photographs, a map, and sketches, or by logs of observations. The second type of data base is founded on specialized records. Copies or notes can be taken from existing records to back up the required analyses with examples. The third type of data is from a series on interview protocols.

Not all of the interview instruments would apply in every place. For example, if no households are served by electrification, the household observation would not be used and the household appliance questionnaire would not be used. The specified samples are small, requiring that the evaluator seek out certain kinds of people rather than apply standard statistical sampling techniques (see Mandel, Allzier, Wasserman, Hickey, et al. December 1980, A-3). The kinds of respondents designated are likely to know the information each will be requested to supply. Cross-verification is achieved by asking more than one individual the same set of questions.

An exact protocol will have to be developed for each country in a suitable language to obtain the information required. For a protocol which is suitable for worldwide comparative use, on-site field tests in different cultural settings will be necessary to perfect these instruments. It is not necessary to wait until the first hydro is built under the program to make this adjustment—a protocol can be tested at existing small hydro sites.

The advantages of the instruments suggested here are (1) flexibility—parts can be applied where relevant to the actual uses of electricity generated by a given small hydro, and (2) reproducible data: the hard documentation of observation and records informs, and is in turn informed by, interviews.

The information generated by these protocols will require analysis. A procedure for basic analysis and for the formulation of recommendations

for changes in procedures at the same site evaluated, or to improve the design at new sites, will need a special operation. Analysis and reporting should take no more than one man-week of effort after the site visit. If a sufficient number of small hydro sites are built, a program for computer assisted analysis can be developed.

Before an evaluator is sent to administer the protocols, the beneficiary community of users will have supplied its own updated profile. The document will update information presented on the community application form, except that the problem solving questions will be phrased in the present or past tense. For example, "How do you plan to collect fees...?" will be rephrased as "How are you presently collecting fees...?"

The evaluator who will visit the site will make a preliminary analysis of the situation to be found there by comparing the original community application form reporting the before project status with the most recent update submitted by the community of users. The evaluator will take notes on the important differences (changes) and unexpected similarities reported on these two documents. These notes will serve to formulate additional questions for the General Interview. Questions can also be formulated to probe the matters noted.

If the original community application form and status report are not available for the community to be evaluated, the evaluator will administer a status report questionnaire prior to administering the other evaluation protocols.

The evaluator will also study the logical framework, project paper and any monitoring records before the site visit. If other sites have been evaluated, the evaluator will study protocols completed at other sites.

User-community application form

Part A—Face sheet

A-1 Name of applicant _____
(formal name of group, institution, settlement, pre-cooperative, etc.)

A-2 Address _____

_____

A-3 What kind of organization are you:

(Here, supply multiple-choice checklist appropriate for the country, for example:)

Social institution Public/Private	Business	Settlement
Hospital Clinic School University etc.	Commercial establishment Mine Plantation etc.	(Here list formal political-geographic hierarchy of kinds of places)

A-4 What is the legal or corporate status of your group?

(Here, supply checklist of possibilities appropriate for country. For example, for a settlement in Peru, recognized peasant community, municipality, etc.; for Ecuador, parish council; for India, village panchayat, incorporated cooperative, incorporated business, mission group operating under state contract, etc.)

A-5 How many people are in your applicant group?

a. For settlements, answer with total population: ___
b. For businesses, missions, special institutions, answer with the total number of your "staff": ___
c. And clients served: ___

A-6 (Here, place formal petition with waivers and understandings concerning selection process.)

Signatory _____
(recognized representative)
Or signatures of petitioners organizing as a group for the purpose of application

Title/Office _____

Date _____

Part B—Technical

For the proposed site:

B-1 Head (m): (a) gross, (b) net

B-2 Flow quantity (m^3/s):
(a) Stream maximum ___
(b) Stream minimum ___
(c) Turbine design ___

Civil features:

B-3 (a) Dam/weir
(b) Headrace
(c) Forebay
(If needed, length? size?)

B-4 (a) Penstock
(b) Powerhouse
(c) Tailrace
(d) Access road

B-5 Tailwater level variation (m)

B-6 Diagram of the site (include topographic maps)

Other site characteristics:

B-7 Altitude above sea level (m)

B-8 Water quality (sand, chemicals, silt, vegetation, etc.)

Systems characteristics required:

B-9 Generator output-(kW, voltage, phases, frequency)

B-10 Load-(existing, forecast, load factor)

B-11 Isolated or parallel with existing power system or future power source?

B-12 Other information-(if local power source exists):
a. What are the present costs of fuel if existing generator
b. What is the reliability of existing system.

(See Appendix C for sample technical questionnaires.)

Part C—Problem solving

(This section gives examples of problem-solving questions.)

C-1 What do you want to use the small hydro's electricity motive power for?

(Insert checklist suitable for region with "other" category.)

C-2 How will you pay for the system?

(Insert checklist of conventional payment programs with "other" category.)

C-3 a. Will the electricity be sold?
b. If yes, on what basis will you select consumers and assess them rates?
c. If yes, who will collect the fees for use?
d. If yes, who, or what agency, will keep the accounts?
e. In what form will the accounts and records of operation of the unit be kept? etc.

C-4 a. Who in your group could repair the machine which will produce electricity/motive power? Give name(s) of individual(s) and for each, please explain—
b. What experience with machines does that person have?
c. Would that person be available to work in (number of years) when the system will be built and operating?
d. Would you pay that person to repair the machine?

C-5 Has your group (settlement or institution) ever built a major civil works or public building together?

(Insert checklist of regionally appropriate examples such as irrigation canal, road, potable water system, agricultural terraces, school, community center, mosque, shrine, etc. with "other" category.)

C-6 Please describe how you organized the effort of that construction:
a. Who designed it?
b. Who supervised the work?
c. Who did the work?
d. Were those who did the physical labor paid for their work?
e. If they were not paid, were they obliged to work as a public service, OR did they volunteer, OR did they receive benefits in kind?
f. How did the people who built the civil work described benefit from it?
g. How long did it take to build?
h. How much did it cost your group to build?
i. How did you cover these costs?
(After an explanation of the kinds of civil works which may need to be constructed "Depending on the characteristics of the site where

the small hydro is to be installed, certain civil structures may be necessary, such as...", then ask—

C-7 a. If such civil works are required, would you plan to build the necessary civil works yourselves?
b. If not, will you need to contract outside labor?
c. If yes, where will you contract such laborers?
d. If b above is yes, how much will you have to pay them?
e. Is there any time of the year when you would not be able to undertake this kind of construction, because no labor from your group or from outside your group would be available at that time of year?

(To these sample questions can be added others to test the problem solving capacity of the community making its application. While creativity and reasonableness of answers will indicate groups likely to assume important functions during the various stages of small hydro, answers will also indicate how much community organization and training will be needed to supplement existing skills within the community.)

Part D—Area survey

For all types of applicants:

D-1 a. Do you already have some electricity?
b. If so, attach separate form with questions concerning technical characteristics and reliability.)

D-2 a. Is there electricity in the area?
b. Where is the closest electrified place?
c. What is the power source?
d. Is there a transmission system?
e. If yes, how far away is the nearest spur?

D-3 a. Have you ever heard that the government plans to put electricity into this area?
b. If yes, please explain your knowledge of those plans.

D-4 a. When does it get dark?
b. Is there any seasonal difference in the time it gets dark?
(Note: Variables include not only latitude, but precipitation cycles and mountain shadows in highlands.)

D-5 a. During what hours do people regularly work?
b. About what time do people usually go to sleep?
c. At what times in a day do people usually eat meals?
d. How many days a week do people
i. work
ii. sleep
iii. eat meals described?

D-6 How far away is the plant site from the place where your group will use the electricity?

For specialized institutions only:

DSI-1 How will you use the electricity?

(Insert checklist with "other" category.)

DSI-2 a. Will you have to buy new equipment in order to use the electricity/direct motive power?
b. How much will this cost you?

DSI-3 Do you expect to use the electricity/direct motive power only in your enterprise for its functions, or will you also use the power for residences or group quarters nearby?

(If answer to DSI-3 is yes, treat specialized institution as a modified settlement and also include settlement section, below.)

DSI-4 What machines and work tools will you power with the electricity/direct motive power?

For each
i. What do they do?
ii. What do they produce?

(For additional details, see questions in evaluation protocol.)

DSI-5 (Here include a question to determine current levels of production under technological conditions prevailing at the time of the application.)

Note: Further detail on the population to be directly impacted through the electrification of a specialized institution may require additional questions. Population total is given on the face sheet. As a minimum, a profile of the age, sex, occupational characteristics, ethnic profile, and income source profile of the member-workers or client-patients of the specialized institution would be appropriate. Since variation will be great, this section will need to be country and region specific. The impact population associated with a shrine is very different from that associated at a mine.

For settlements only:

DS-1 Please prepare a diagrammatic map of the settlement. Note true distances and include locations of public central places (squares, markets, bazaars, etc.), residential areas, and any specialized sections (such as precincts for weavers, for scheduled castes) and all important public meeting places or places where educational, medical, or religious services are available.

(Insert checklists of "urban functions" appropriate for the region.)

DS-2 Give total number of households.

DS-3 Give number of households expressing an interest in household electrification.

DS-4 Describe housetypes and give number of each type in settlement, location in reference to the map DS-1, construction materials, and how built.

(Insert checklist prepared for the region, with "other" category.)

DS-5 Give average number of people residing together in a house or other dwelling/domicile unit.

DS-6 List businesses and commercial establishments in the settlement by number and type.

(Insert checklist appropriate for the region, with "other" category.)

DS-7 List public facilities, including water supply sources and outlets, and public buildings.

(Insert checklist appropriate for the region, with "other" category.)

DS-8 Describe the agricultural crops, if any, by type, noting for each if it is sold outside the region, and if so, in what form (bagged, loose, semi-processed and packaged) it is transported from the area.

DS-9 Note if any irrigation works are present in the area, and if so, map and describe the system, showing its location in relation to the settlement.

DS-10 Describe communications facilities (mail services, telegraph, telephone, radio, etc.)

DS-11 Describe linkages--roads, trails, railroads, ports, and other transportation infrastructure and the availability of each mode of transportation.

DS-12 Give occupational and socioeconomic data.

DS-13 Prepare an age/sex demographic profile of the population.

DS-14 Prepare a table of income source by activity and occupied population profile.

(Add on other settlement level data required for baseline in terms of the indexes which are selected for the final settlement level end of project status report. See AMARU Data Inventory, Rural Towns, in Appendix A for a model.)

Note: This section, DS, was not phrased as questions, rather operations to be performed. In actual community application forms, worksheets and graph paper for maps will be included. How to perform each operation (i.e., prepare a table of income source by activity) will be explained in a

guide. Many communities will require assistance in order to complete this part of the application form. However, by providing the communities which are applying with a description of the type of social baseline information needed at the time they apply, the work of social survey assistants to the communities at a later date will be given a more welcome reception.

Observations

0-1 It is recommended that the evaluator seek accommodations in an electrified household to observe use of electricity and to ask questions about appliances in that household.

0-2 The electrogenerator and its associated civil works, if any, will be observed in the company of a person assigned as the local technician. Photographs and sketches of the system will be made. These photographs and sketches will form an integral part of the evaluation. A technical evaluation protocol developed for each site and technology-specific small hydro equipment will be administered in conversation with the technician at the time the small hydro equipment and its operation are observed.

0-3 The distribution lines will be traced and noted on a map of the population center and service area. If no map of the locality is available (for example from census records) then a map of the locality will first be prepared working with a local respondent. Lines will be traced to all public, industrial, and commercial installations, even if the use of a hookup is limited to lighting. The main lines into residential neighborhoods will be traced and noted on the map. The evaluator will observe what household hookups are distributed on a sample house-by-house basis, and will observe if only certain residential areas within the settlement are serviced and if any of the surrounding rural area is served. Differences in house types between household served and not served will be noted, in terms of a typology of local housing construction materials and venacular architecture, number of rooms, etc. The evaluator will make an estimate by observation of how many households are served. This estimate will be compared with records.

0-4a Appliances will be observed. An inventory will be made of what electrical appliances are offered as wares for sale in the locality. Local stores as well as outdoor booths, markets, or bazaars will each be sampled. If a market cannot be observed on the days of the site visit, then those local merchants who do not sell appliances will be asked to describe what is offered for sale at these periodic markets or bazaars. Appliances will be inventoried by make, model, manufacturer, technical specifications (i.e., rating), sale rice, wholesale source, and frequency by type (total number observed in all the places sampled where these are for sale).

O-4b The use of appliances will be observed in a minimum of two electrified households, if any households are electrified in the settlement. One of these will be selected for having a greater number and variety of appliances. The other will be selected for having a minimum, perhaps only one lightbulb. Observations will be made within the hours electricity is available. If electricity is available both night and day, then observations will be made in

each of the households at two different times of day, once in the morning and once in the evening, at the same time of day in each household. At the same time these use observations are made, the evaluator will ask to see all appliances powered by electricity owned by the household, and administer the appliance questionnaire (Interview type 5) in conversation with an adult male member of the household, and at another time of observation, with a female adult member of the household. In both households, "backup equipment" and the fuel of each for the performance of each function to which electrical appliances are applied will be noted, for example, kerosene lamps for lighting alternating with lightbulbs.

O-5 The new and extended hours of public and commercial or service buildings will be observed, following the indications of what the extended use patterns are taken from Interview type 1. Observations might include street lighting, the number of persons present during the new or extended use of buildings in evening hours, and the kinds of activities observed. Attention should also be paid to the new or improved uses of public, commercial, and service areas during daylight hours, such as the use of specialized lights by dentists or physicians, the use of jukeboxes or television sets to attract daytime customers to commercial establishments on a day determined to be a typical workday.

O-6 The use of electricity will be observed at no less than two distinct production or processing plants, small craft shops, or other such workplaces if such exist in the locality. Any on-farm use of electricity, such as milking machines will also be observed. At the same time, Interview type 2 can be administered. Any substantiating documentation, such as photographs, ads, or newspaper accounts (see figure 4) will be collected.

Records to be examined

R-1 The billing records of the local agency charged with collecting fees for the use of electricity will be examined. In particular, the evaluator will discuss accounts in arrears. This examination of records will be made after the general lines of distribution of the system have been mapped (Observation operation 3). Certain installations noted when tracing the distribution lines will be checked against billing records for that connection. The billing records of the two households selected for observation of appliances (Observation operation O-4b) and interviews on appliances (Interview type 5) will be checked. Any differences between the evaluator's expectation of the relatively higher costs of the more amply electrified household as compared with the minimally electrified household and the actual billing records will be discussed with the billing agent. It is important for the evaluator not to discuss the observations made in these households with the billing agent, however, to assure confidentiality. Any unusual hookups observed during the mapping operation to public, commercial, industrial, or apparently ad-hoc users (such as street

craftsmen tapping a line) will be analyzed and discussed with the billing agent. Here, too, the evaluator must assume a manner of probing which does not specify the exact observations made, but rather to ask questions in a general manner based on prior observations. If the cases are regarded as unusual or irregular by the billing agent, it is important to learn whether that agent knows the details or is ignorant of the cases.

R-2 Birth certificates on file in a public registry will be examined. The total number of children born during the year immediately preceding electrification and during the first year (or the most recent year) of electrification will be noted from these records. If available, death records on children under age 5 years will also be noted in a similar fashion. This information will be cross checked against interview information on retrospective fertility histories (Interview type 4).

Note: While the demographic effect of lower birth rates has been correlated with electrification in several studies, neither the chronological trends nor the cultural mechanisms for this phenomenon are understood. There are several hypotheses—increased consumerism, increased investment in the education of each child, replacement of children's domestic tasks like drawing water by electrical devices leading to a lowered need for childhood labor, and changes in sleep/wake patterns affecting sexual activity. However, more data will be required worldwide to clarify the mechanisms for the correlation. Early data, such as only one year after electrification, will help establish trends and dependent variables.

R-3 The evaluator will request to see the employment records of each of the industrial and commercial users of electricity visited for observation operation O-6 and Interview type 2. These records will be used to verify the interview data concerning employment collected at the same places. If available, profit and loss statements for a year of electrical use and an earlier period, before electrification, will be examined, compared, and discussed.

R-4 The evaluator will also examine a sample of health records at a local clinic or hospital, if such an institution is present and electrified. A sampled week dating to the pre-electrification era and the same week (for example, the second week of the month of June) in a year after electrification will be compared. Any changes in the volume of patients attended and diagnoses of their ailments will be noted. Interview type 8 will be administered at this time.

R-5 The evaluator will examine the records of a school or special education class attendance for those programs which have been instituted in evening hours under electric lights, if any.

Interview information

A series of interviews will be directed to particular categories of respondents. The kinds of information to be collected from each is given below. It will be important to develop and use exact interview questions in the venacular language of the locality and to ask the same questions to all persons interviewed at all sites within a country. With minor changes to adjust the question to cultural variables, the same questions will be asked in all countries where the small hydro program is operating.

Interview type 1: Electricity impact at the community level

This interview collects general information. Interviewees will be two individuals, one selected among the juveniles or young adults unless a set of respondents is designated by the host settlement as the evaluator's local guides.

I1-1 a. What do people do at night now? ("now"—present time, after small hydro electrification)
b. What did people use to do at night? (before electrification)

I1-2 a. Where do people get together? (Probe for points of congregation: ritual centers, public squares, meeting places of all types both formal and informal.)

Once a list has been elicited, ask for each place:

b. Is (name of point of congregation) now electrified with at least lighting?

Ask for each type of place (school, church/mosque)

c. On what hours and on what days is this (kind of place) a gathering place?

d. What kinds of people gather at these times in that kind of place for what kinds of activities?

I1-3 a. What kinds and numbers of people are not using the (small hydro) electricity?
b. Why? (Note: This question is especially important in areas which had some limited, pre-existing form of electrification, such as diesel generators.)

I1-4 What kinds and numbers of people are using the (small hydro) electricity and what are they using it for?

I1-5 a. How reliable is the small hydro generated electricity?
b. Has there ever been an interruption in service, brownout, outage, or power failure since operations began?
c. How many times was there a power failure last month?
d. How many times was there a power failure in the last year?
e. What did people do when this happened?

Figure 5

Aprovechan conexión eléctrica

El ingenio no duerme y menos en Lima. Una prueba de la viveza criolla es este zapatero remendón que muy suelto de huesos ha "tomado prestada" una conexión eléctrica en la vía pública, para hacer funcionar el esmeril que usa para los acabados de "las medias suelas". Tanto tiempo habrá pasado inadvertido este hecho, que incluso no se inmutó cuando nuestro reportero gráfico, Gerardo Samanamud, le tomó la foto en su centro de operaciones del jirón Pachitea y Azángaro.

Illustration from El Comercio, Sunday, September 20, 1981, page 1 (Lima, Peru).

I1-6 Administer the set of questions based on the format of the community application form (the functional Before Project Status Report in this evaluation framework) and the status report filed prior to evaluation site visit.

Interview type 2: Industry

The second interview will be directed to industrial/productive users of electricity. Two individuals will be selected for interviewing at each production unit. One of these must be an owner, foreman, or manager. The other will be a typical laborer/employee working at the place where electricity is installed for a productive use. Each kind of respondent will be interviewed privately. Observation operation O-6 will be performed.

I2-1 When is electricity used at this (plant/workshop)? (Probe for time of day, days in week, etc.)

I2-2 a. Is the electricity ever used during the day?
If so, when?
If so, for what?
b. How many days during the week is it so used?
c. Is it used every week in a year?
If not used every week of the year, at what seasons in the year is it used for (purpose given above)?

I2-3 Is the electricity ever used at night or during darker hours at dawn or dusk?
If so, when, why, for what?

I2-4 a. How many people were employed at the (plant/workshop) before electrification by the (small hydro) system?
b. Of these, how many are women?

I2-5 a. How many people are employed now? ("now"—present time, after electrification)
b. Of these, how many are women?

I2-6 How often does employment turn over?

I2-7 a. How do people like working at this place?
b. How do they express this attitude?

I2-8 a. What happens when people are sick or have an accident and cannot work?
b. Are workers replaced (brought in to do the same job)?
If not, is a worker's place held for him, or is he given another job in the same place when he recovers?

I2-9 What kinds of employment or job categories are there?

I2-10 (Once the list of job types is elicited in I2-9, ask for each category—)
a. How much does a (type job) get paid (per payroll unit)?

b. How much does (type job) receive in other than cash compensation? (Note in kind, shares in the production, benefits including use of housing, etc.)
c. (Obtain the breakdown by age, sex, and, if relevant, education or ethnic group, of employees in each category.)

I2-11 a. Since the installation of electrification, have there been any accidents?
b. Before electrification, were there accidents of the same kind?
c. Were there more or fewer accidents of this type after electrification?

I2-12 a. What industrial/productive tools and equipment are run by electric power?
b. Are there tools and equipment of this same type (doing the same operation) presently available at the plant which do not use electric power?

For each kind of tool or equipment named:
c. Is the electrically-powered tool more efficient or less efficient than the alternative tool?
d. How do you know?
e. By how much more is the (electric or alternative tool—whichever is cited as more efficient by respondent) more efficient?
f. What differences do you observe in your work between their efficiency?
g. Are the backup tools ever used?
h. When and why are they used?

I2-13 a. Where did the plant buy its electric power tools and equipment? (Repeat, naming each type.)
b. How are these repaired?
c. By whom are they repaired?
d. Where does the plant procure spare parts for these electric tools and equipment?

Interview type 3: Daily round/electricity impact on individuals

This interview samples the impact of electricity on the daily lives of users. A user does not have to reside in an electrified household or work in an electrified place if interview type 1 has determined that significant public use of electricity exists in the area. The minimal number of persons interviewed will be six. One of these must be an older man, another must be an older woman, without children born to them in the past 5 years. One will be an adult man and another an adult woman, each of whom is married and in the childbearing years, preferably with at least one child age 5 or under. Finally, at least one male and one female juvenile between the ages of 10 and 20, each of whom is unmarried and has no child of his/her own will be interviewed. In communities where there are significant ethnic groupings or castes are strong, it may be necessary to include representatives of these groupings in each of the status/age categories specified above. The objective of this selection is to interview

representatives of each of the important age/status sets and other major groupings of the settlement.

I3-1 (Collect from each person interviewed a daily round (schedule of activities) for two kinds of days. The kinds of days must be determined in each cultural setting, for example, one ordinary work day and a day set aside for special purposes such as marketing, ritual, or recreation.)
(Ask each person to tell you, hour for hour, what he did on the most recent "ordinary" day and the most recent "special" day prior to the day on which the interview is held.)
(For each activity volunteered in response, ask—
And did you use electricity in this activity?

I3-2 (After collection of the daily rounds from each individual with the role of electricity or its absence pointed out by the evaluator's probe, ask each person the following open-ended questions:)

a. What changes has the small hydroelectrification made in your own life?
b. How was your life different before the small hydroelectrification?
c. What changes in your own life will the system make in the future?
d. Do you believe others have benefited more or less than you have from the new electricity source?
e. Why is that so?

Note: A reference model for this protocol can be found in the methodology of the recent Philippines Impact Evaluation (Mandel, et al. 1980).

Interview type 4: Retrospective birth history

This interview collects additional information concerning the effect of electrification on fertility. Two women in their thirties (30's) who have at least one living child will be interviewed.

There are several standard formats for the collection of retrospective birth histories. The women will be asked to recollect about when each conception occurred and its outcome—miscarriages, infants born dead, infants born alive who died later, and living children and the age at present of each. No marital status information will be collected.

Analysis will be a comparison of the number of children conceived, miscarried, born dead, born alive, died young, and still alive as an average rate for the fertility history during the years discussed prior to electrification and the years after electrification. See note under R-2.

Interview type 5: Appliances

This interview collects detail on the household uses of electricity. Selection of interviewees will be within the households selected for the

observation operation O-4b. Both will be electrified households, but one will have typically more, and the other, typically fewer appliances. The persons interviewed in each household will be a male adult or older juvenile and a female adult or older juvenile.

In some areas, the number of appliances in a single, well- equipped household may be large. A preferential list will be developed to obtain information about certain types of appliances by use category, especially--

An appliance which produces a service consumed in the household (e.g., iron);

An appliance which produces a good which could be consumed in the household or sold (e.g., sewing machine, blender);

A food processing appliance;

An appliance used for entertainment (e.g., radio, television, taperecorder or phonograph).

The household selected for the larger number of appliances can be chosen for the present of appliances representing these types.

For each appliance, ask--

I5-1 Is it new?

I5-2 Did you buy this appliance after the place was electrified by the small hydro system?

I5-3 a. Do you have another appliance or tool that performs the same function and operates with another fuel (including manual power)?
b. If so, do you ever use it?
c. If so, when and why do you use it?

Note: This is a cross-check on reliability of electricity and cultural preferences.

I5-4 What does the appliance do?

I5-5 What do you use it for?

I5-6 a. What does it produce or make?
b. If it does produce an item, what do you do with that product—do you use it yourself, share it with your family, or sell it?

I5-7 When do you use it?

I5-8 Why did you buy it?

I5-9 Where did you buy it?

I5-10 How did you pay for it?

I5-11 How many other people use it?

I5-12 Do you charge a fee to other people who use it?

Additional questions--

I5-13 What other appliances would you like to have?

I5-14 How soon do you expect to get them?

I5-15 Why don't you have them now?

Interview type 6: Business and commercial use of electricity

To survey the business and commercial use of electricity in stores, small shops and other places where goods and services are distributed, the Peace Corps energy survey protocol for a business or commercial establishment is excellent. At least two different kinds of businesses will be selected. In addition to a protocol modified from the Peace Corps energy survey, the business people will be asked whether in their perception business has been improved since electrification, whether they have expanded their line or taken on new help (employees or family) since the small hydroelectrification. The businesses surveyed may not need to be electrified, but must be in or near electrified districts.

Interview type 7: Education

To collect information on the impact of electrification on education, either a school teacher or an older pupil can serve as the source for the following information.

I7-1 a. Has student enrollment increased since electrification?
b. If yes, what is the source of the new student population?

I7-2 Is absenteeism up or down since electrification?

I7-3 a. Is school performance better; that is, are more students passing exams and being promoted to higher grades since electrification?
b. If yes, about how many more?

I7-4 Have any new programs begun since electrification, such as adult education or secondary school?

I7-5 Have the number of students studying in the evening, in classes or at home, increased or decreased since electrification?

I7-6 How do you believe electrification will increase the level of education in this place?

I7-7 If more people in this settlement were better educated, what would those people do differently than they now do?

Interview type 8: Health

This interview collects information concerning the effects of electrification on health. At least two individuals will be interviewed, one of whom is a health professional (nurse, paramedic, physician) and one of whom is the mother of small children. Ask each of the following questions.

I8-1 Has the health center kept extended hours of evening service since electrification?

I8-2 a. Is the health clinic/hospital etc. itself electrified?
b. If so, what is powered by electricity there?

I8-3 a. Have any water pumps been electrified?
b. If so, have you seen that people who use the electrified pumps suffer from the same number of intestinal problems as the people who do not use electrified pumps?

I8-4 a. Have any people begun to use refrigerators to store their food, powered by electrification?
b. If so, do you think it is a good idea to store food in refrigerators?
c. If so, do you think people who store food in refrigerators are healthier or not as healthy as people who do not store food in this way?

Comments on the protocols

A separate protocol will need to be developed if the small hydroelectrification is used by a specialized institution, expanding the units O-6, R-3, and Interview type 2 for specialized institutions which produce, process, or extract goods, or expanding the units which pertain to education or health if the specialized institutions electrified render these services.

The information which can be obtained from brief site visits by using the protocols described will yield indicators of the total impact of electrification on the beneficiaries' lives. After a series of site visits have been made to different installations, patterns will begin to emerge which can be used to adapt the experience of each place into models for other places.

While a detailed socioeconomic survey would yield more ample information, the goal of this evaluation procedure is coverage of all small hydro installations through an economical procedure, producing definite and comparable information.

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