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AN ASSESSMENT OF EVALUATIONS
OF AID
RENEWABLE ENERGY PROJECTS

"A Search for Cost-Effective Replicable Technologies"

by

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PURPOSE AND SCOPE

The purpose of this assessment was to determine which of the renewable energy technologies utilized in AID projects are: a) the most cost-effective; b) the most easily replicable; and c) capable of making the best contribution to the development of private enterprise and/or the achievement of national economic goals.

The assessment was carried out through the study of AID project documents, primarily project evaluations and audits, and therefore does not include the experience of other donors. The key question initially posed was whether the project had succeeded in producing energy, regardless of the detailed reasons for project success or failure. This restriction in scope meant that "hardware" type projects were emphasized and that subtleties in training, information, morale and multiplier effects were generally neglected. The restriction to a particular set of AID documents also often meant that little hard energy production information was available and that few usable cost data could be gathered. In addition, the documents in the evaluation literature, in general, did not permit an adequate analysis of underlying economic constraints, implicit engineering difficulties, or regional macroeconomic or social considerations that may determine the viability of a particular renewable technology in a specific environment. More importantly, they usually did not adequately document the great shortage of managerial resources on the part of both donor and recipient--a key factor in project and program success.

PROJECT EXPERIENCE

Relatively little energy appeared to be produced (or conserved) in most of these projects. A number of them, however, achieved important secondary goals of demonstrating renewable energy technologies under field conditions and exploring how problems of training, replication, and coordination with other economic development projects should be attacked. The results varied widely from technology to technology.

RENEWABLE TECHNOLOGY COMPARISONS

Photovoltaic Systems

PV systems appear to be cost-competitive only for specialized, high value uses (not including water pumping) in areas of high cost or non-existent electric power. The reliability of the PV units themselves, not necessarily that of the total system, seems to be high, fulfilling earlier hopes for this technology.

From the policy viewpoint, however, another issue should be noted. Even though power for specialized uses (i.e., isolated

clinics) is important, PV systems are not entirely trouble-free. The difficulties are usually balance-of-system problems, but will require that investments be made to establish the management and labor infrastructure to keep the total system running and enable the technology to gain widespread acceptance. If such infrastructural investments have to be made for a technology with a limited range of uses (such as PV), there is the danger that there will not be enough resources available for other types of technologies/projects that could possibly satisfy a larger number of existing needs or have multiplier effects of some kind. Present indications are that PV would fare poorly under such criteria.

Wind Energy

Wind machines of the conventional type are a feasible technology where wind regimes are sufficient. This is especially true for direct water pumping (as opposed to electricity generation). The basic technology is well established but more modern systems have often had to be tested on site--sometimes with discouraging results.

For the more conventional systems, the need for regular maintenance and repair facilities when introducing systems at new sites would also seem apparent--although this element has frequently been neglected or omitted.

For development planners, care should be taken to ensure that the available wind resources are sufficient to merit the investment of scarce resources. This means that there should be a large number of potentially good wind locations and users so as to justify and support the infrastructure required to install and maintain the equipment. Otherwise the money might be better spent in areas where it would do more good for more people.

Solar Water Heating

Solar water heaters have been characterized as a technology that is now cost-effective. This technology, by itself, will not solve a country's energy problems but it can have a quantifiable impact when used in institutions, multiple dwellings, and larger homes. Installation, maintenance, and repair networks should not be difficult to establish because the skills required are very similar to those needed for ordinary plumbing and other household maintenance. This technology therefore seems a uniquely good choice for economic, trouble-free operation without the investment of undue amounts of scarce local resources.

Other solar technologies, such as crop and fish dryers, kilns, ovens, stills, etc., have proven unpromising because they are either too complex or they merely attempt to improve techniques that already work reasonably well (i.e., solar crop dryers).

Biogas

Household-level biogas projects have, generally, not been successful in most countries. The high level of maintenance and support required has been the most frequent stumbling block. In countries where this has been provided, such as Nepal and India, household programs have been successful, although such infrastructure is probably too expensive to develop in most countries.

The major policy issue therefore now appears to be whether development resources should be devoted to industrial and large-scale biogas production and use, areas where the economics may be more promising. Many dairy farmers, for example, have adopted biogas technologies on their own. It is probably a misapplication of scarce managerial resources to divert assistance efforts to such industrial applications because the marginal results achieved beyond what the private sector would do on its own will probably be small.

Small-scale Hydro Power

Small-scale hydro installations produce a highly valued energy form through the use of a well-established technology. In certain instances they can rival large-scale hydro power installations for cost effectiveness, especially if environmental and social factors are taken into account. Given an appropriate site and the necessary design, installation, and maintenance/repair resources, small-scale hydro can be a practical source of electrical power and have a major developmental impact. This is not, however, a simple, self help type technology: amateur efforts have produced unnecessary failures and should be avoided. Donor efforts to promote this technology should be strengthened, especially since studies suggest that electricity use can be supply-driven.

Wood/Waste Gasification (Producer Gas)

Gasification has become increasingly popular during the past few years despite certain technical problems related to the use of wood-based fuels in internal combustion engines. Eventually, when fossil fuels run out, this or a related technology will probably become very prevalent but the short term feasibility of the technology is still somewhat questionable in light of the additional labor, management and -often- land resources required for the farming or material-gathering that is necessary. It also seems difficult to justify, at this time, a dual maintenance network for petroleum and biomass-based fuels - all for the same internal combustion engines.

Wood/Charcoal Stoves

Early stove designs and projects experienced technical, marketing, and consumer acceptability problems. Based on the records examined as part of this project, the overall success rate of stove programs appears modest despite certain bright spots. Re-

cent improved metal stove projects have shown more promising results, especially in areas in which they have been able to obtain local support. In situations where wood fuel is either scarce or expensive and stove artisans can develop an acceptable volume of business, the stove option may have formidable advantages: stoves save energy at the point of use and are efficient in the use of available human resources as well. Some metal stove programs have, in addition, stimulated local industry at the artisan level. A key factor is the extent to which users are able to keep their stoves repaired and in good working order. This aspect has been treated with undue optimism in the past.

Fuelwood

Earlier optimisim has been dampened in regard to fuelwood plantations. AID evaluations of fuelwood projects appear to indicate that tree production projects have had mixed success rates and have been expensive.

Nevertheless, in order to safeguard the environment on a long term basis, it is imperative that measures be taken to promote and assist forestry efforts. Whether or not this includes fuelwood plantations is another issue, but technical difficulties encountered in managing natural tropical forests suggest that forest plantations may be an essential option. Since fuelwood is a byproduct of plantations, agro-forestry and other fuelwood efforts are therefore often cost effective when considered as part of forestry schemes with larger economic and environmental goals. The data suggest, however, that qualified technical backstopping on an ongoing basis is an essential condition for success.

Other Technologies

The appendix treats animal and human traction and a group of miscellaneous technologies--including some which are very large-scale, such as geothermal. It is probably not appropriate for AID to become involved in exceedingly specialized (and sometime costly) technologies (i.e., peat). It also seems questionable whether it makes sense to try to alter established entrepreneurial charcoal-making systems in order to promote new technologies that the entrepreneurs may perceive as less profitable. If new technologies seem to provide only marginal or nonreplicable contributions to the energy picture, careful analysis should take place before investing scarce resources to promote them.

OTHER CONSIDERATIONS

Connections with the Private Sector

Interactions with private enterprise have been a key to the promising early results of metal stove programs, and the impor-

tance of private enterprise in fuelwood/forestry program success is increasingly evident. Wind energy system maintenance requirements suggest that a strong private input would be useful in most situations.

Renewable energy systems suited to water pumping--wind, gasification, the electrical technologies--can have the most obvious impact on local agricultural production. A potentially low-cost technology like small-scale hydropower could revolutionize agricultural and (actual or potential) industrial productivity in many locations.

The "Needs-Driven" Problem

A number of prominent failures among fuelwood and stove projects may have obscured evidence that local needs for supplying (or conserving) cooking fuels have been well met by successful biomass fuel initiatives. Likewise, crucial water pumping needs have been well addressed by wind (where suitable), small hydro, and--more recently-- gasification options. The ultimate cost-effectiveness of these technologies for water pumping may not as yet have been ascertained. Photovoltaics, on the other hand, may be more useful in meeting specialized basic human needs in the form of power for health clinics, for example.

RECOMMENDATIONS

Technologies

A. Current AID emphasis on forestry/fuelwood programs is well placed because general economic and environmental imperatives will compensate for the often dubious cost-effectiveness of fuelwood production per se.

B. The small hydro option involves several unknowns, but appears very promising as a source of energy for productive sectors. It deserves high priority.

C. Stove programs, especially those that include metal stoves, have benefitted from past experience and now appear cost-effective in favorable environments; this option merits further development.

D. Wind and photovoltaics deserve backup support from AID with a primary role being assigned to private industry.

E. Solar water heating could be usefully supported, especially through technical assistance to new industries. Other direct solar (non-PV) options should be dropped.

F. Gasification of wood and wastes merits further developmental support, where resources permit.

G. Biogas can be relegated entirely to local enterprise for

undertaking feasible, large-scale projects.

H. Animal and human traction should continue to be treated as part of agricultural project planning. Various other options have not been successful and should be dropped (e.g., improved charcoal production and peat exploitation). Geothermal power is a special case-- being inherently large scale-- and deserves a separate analysis.

Data

Many more project data would be available if interviews were held with past project staff and contractors. Such a study would be cost-effective if significant renewable programs are to be pursued.

General Lessons Learned

A. All projects have organizational problems, but fuelwood projects seem to have been the most refractory.

B. A simple technology (e.g., solar dryers), can form the basis for an impossibly complicated project.

C. Continuity is essential in a successful project--but the effective involvement of people (project staff and energy users) is even more essential.

APPENDIX

INTRODUCTION: WHICH ARE THE BEST TECHNOLOGIES?

AID interest in renewable energy technologies for development dates back at least to the traumatic oil crisis of 1973-1974, but there has been a crescendo of grant and loan activity in the years since the later petroleum price hike of 1979. The chief goal of the present assessment is a specific but important one: on the basis of actual project results, which technologies are economically practical -- in the widest sense of the word "economic"? In other words, which kinds of technologies are cost-effective, i.e., which can get along without subsidies sooner or later? And a related question: which energy technologies appear to be most replicable, preferably through the agency of local enterprise? Finally, which technologies can contribute most to the economy, especially in production sectors such as agriculture and rural industry?

ASSESSMENT METHODOLOGY

We search for answers to these questions here by reviewing existing AID project evaluations and other relevant documents for all present and past AID projects involving renewable energy. Since this is a short study with a limited level of effort, we will not be dealing with so much the cause as the fact of project and, therefore, technology failure or success. In particular, we will not be assessing management issues like the procurement of waivers or project approvement delays, which anyway are not energy-specific -- even though these factors are very important in practice in day-to-day assistance management. We are also limiting the discussion mainly to official AID project evaluations (PES's) and selected audits, and only when necessary to other AID or contractor documents or experience with other donors. (Since we are trying to deal with facts rather than hopes, however, the neglect of such documents as Project Papers is not as serious as one might think.)

In our assessment, we mention reasons and forms of successes and failures in order to clarify the status of the project. Note, however, that the main point pursued in this report is not primarily on why or how projects have succeeded or failed-- which is a critical aspect of the usual evaluation of an individual project. Rather, the focus here is more on whether the project succeeded or failed -- as a producer of energy, a stimulus to future production, or even on its own special terms-- for whatever reason. We also address the much harder but more cogent question of whether this type of technology looks promising for continued AID support.

Often this choice of goal for our study means that we are not following the main line of most project evaluations. Most evaluations -- very properly -- seek to compare project accomplishments to the goals stated in the Project Paper or to expected end-of-

project status or to the terms of the grant agreement. These latter goals are often only marginally related to energy production or to technology promise.

SCOPE OF THE ASSESSMENT

The scope of the term "renewable energy" project -- subject to the provisos above -- is taken here as very wide, with such items as animal traction aspects of an agricultural project included, at least on an a priori basis, even though such efforts may not rate as "energy" concerns at an organizational level. All conceivably relevant forestry projects may not have been considered here, but all those we have specifically identified as having a fuelwood (or other energy) component have been investigated.

A key limitation on this present study is that it is focused on the actual production or dissemination of renewable energy technology hardware or fuels, such as stoves or fuelwood. This choice has the advantage that the success of hardware/fuel-oriented projects is much easier to measure than that of project design, training and institution-building projects. The disadvantages of this approach are that (1) the "software" projects could conceivably be more effective engines of development than the hardware projects, and (2) a very significant portion of AID resources appears to be spent on such efforts. (The interrelationship of the different types of projects is discussed briefly below in Appendix A.)

Another problem in the approach taken here -- given the available data -- is that little hard information on probable energy product costs is available in most project documents. "Technical" success alone gives no idea of cost-effectiveness. To evaluate scientifically the overall favorability of an energy option, it would be necessary to attach some cost figures to these projects and their associated technologies. However, the proportion of costs to be associated with more or less measurable energy outputs appears difficult or impossible to discern. In any case, a detailed cost analysis of this large number of projects goes outside our mandate in this study.

The treatment is as exhaustive in breadth as we have been able to make it during the brief period of the project. However, some identified evaluations were not available for one reason or another, while others not in the AID library system nor found in the files of the regional bureaus or AID/W may not have been identified.

REPORT ORGANIZATION

Project experience is discussed first, with an attempt at an overall evaluation of the relative chances for success of the individual renewable technologies. This is followed by brief

sections on connections with development -- especially with privatization and energy for productive sectors -- and on the "needs-driven" aspect of project design. Then we assess some comparative priorities for energy projects and suggest some conclusions and general "lessons learned."

A bibliography is included, as well as appendices on the "hardware-software" problem and on details of stove and fuelwood project assessment results.

PROJECT EXPERIENCE

The universe of projects considered in this analysis and the documents reviewed are given in Table 1. The treatment below is by type of technology. The discussion begins with treatments of such fields as photovoltaics, wind, solar thermal, biogas, and small hydro. Stoves (wood or charcoal) and fuelwood, which both involve a large number of projects, are then treated. Activities that may not happen to be defined in organizational terms as "energy" -- like animal and human "power" -- plus other miscellaneous technologies are then briefly discussed. Many projects of course treat a number of renewable technologies and will be multiply referenced.

References are to AID project numbers and to AID project document ("PD") numbers -- or to other references (e.g., CARE, 1984) given in the bibliography. The text below does not mention all the projects or all the documents reviewed. Some projects have little or no relevance to energy, for others the data garnered from the documents were too sketchy or uninformative. Some projects essentially repeat the experiences of others and are included only implicitly in forming our conclusions.

Photovoltaics

Evaluations of photovoltaic units that have been installed in AID projects report generally favorable results -- at least on the basis of limited operational experience. An installation in Burkina Faso (698-0410.13, 931-0234, PD-AAU-248, p.3) reports a reliabilty of 96% in meeting a load composed of a mill operation and a system of water pumps. PV units for transceivers and aircraft beacons in Zaire claim efficient operation after a year of service. No problems are claimed for the operation of two PV units in a "integrated village energy system" in India, as a source of power for radio, TV, street lights, and water pumps (386-0465, PD-AAR-453, p. 23). Water supplies have not been optimal, because of inefficient pump design, but required maintenance has been minimal (ARD 1985b, p. 2-16). The PV units in the Djibouti project (603-0013,PD-BAW-773, p. 17) were reported as functioning -- if not cost-competitive with other means of water pumping at most sites. In addition to PV's role as a candidate in a large multi-fuel water-pumping test in Botswana, PV units were also installed in schools, clinics, and for street lighting (633-0209, ARD,1985e, p. 30.) Where reliabi-

lity problems were reported, in a solar laboratory installation in Mali, the difficulty seems to have been more with the pumps than with the photovoltaic system (688-0217, PD-AAL-385, pp.14-5).

These few observations seem to back up the optimistic outlook taken by a recent review of renewable energy sources in Africa (AID, 1984, pp B-3,4). They indicate excellent reliability even in hostile environments, with cost-competitiveness with diesel or batteries in remote situations, for uses such as communications and refrigeration -- if not for water pumping. Good backup by manufacturers on maintenance problems that did occur was also a positive note. A cautionary note is provided, however, by a PV refrigerator project in Zaire (936-5710, PD-AAR-438, pp. 2-3), where the system operated well initially, but then broke down and no competent repair facilities were available. (Nine units supplied by another donor also either broke down or were insufficiently cold.)

Photovoltaic systems therefore appear to be a good candidate for further assistance -- in the specialized end uses where they make economic sense -- if account is taken of the total systems maintenance problems inherent in pumping or refrigeration.

Wind

One of the most prominent examples of the use of wind energy is the installation of 37 wind pumps (eight purchased locally) in a joint Netherlands-AID project in Cape Verde (625-0937.03, PD-AAQ-043, pp. 20, 43-4, PD-AAQ-970, pp. 8, 12, 54). They proved to be a reliable method of pumping -- if somewhat expensive, at least for the imported units. As part of the effort, maintenance workers were trained and sent back to their individual islands with a motorcycle and a tool kit. In Djibouti, a number of existing windmills were repaired and refurbished by the institute funded under the project and were reported operating well (603-0013, PD-BAW-773, p.17). In the solar laboratory in Mali (688-0217, PD-AAL-385, p. 22), the windmill pumps operated well at low speeds; they were assessed as fragile -- but readily repairable.

In Botswana, windmill pumping was tested but its use was categorized as economically marginal ((633-0209, ARD 1986, pp. 1-3). Siting difficulties in Honduras apparently restricted implementation there to two units out of a planned twenty-five (522-0166, PD-AAP-216, p. 11) -- it was difficult to find locations combining suitable local energy requirements, a favorable wind regime, and an adequate water table.

A recent review of wind in Africa says that there is no large use of imported windmills except in South Africa, and that local production is confined to Cape Verde, Kenya, Morocco, and Tanzania (VITA 1983 pp. 3-4). This picture is consistent with that of a generally promising technology -- but one for which motive resources -- i.e., wind -- are often lacking, as in most of Africa (AID 1984, p. 10). The need for adequate maintenance

for wind systems, moreover, can pose problems in self-help projects (621-01610, Lutheran, 1985a, p. 20) -- that is, where the emphasis is on an almost complete reliance on local resources. Note that the Cape Verde and the Djibouti projects have taken care to institutionalize maintenance.

Wind machines, at least those of the old-fashioned, horizontal-axis, multi-blade type, are a well-established technology. They can be useful in areas of high average winds -- with the proviso that repair and maintenance must be institutionalized in areas where little mechanical capability can be expected of end users.

Solar

With the exception of photovoltaics (discussed above) and solar hot water heating, results of work with direct solar technologies have been disappointing. For solar thermal pumping, one review summarizes the situation by attributing to them "serious and continual operational problems" (AID 1984, p. 12). The complexities of such systems, especially those requiring elaborate collector mechanisms, predispose them to failure, especially in unfavorable technical environments. The SOFRETES solar pumping unit tested in the Cape Verde project (625-0937.03, PD-AAQ-970, p. 13) was reported a failure. A solar pumping experiment slated to be part of the Senegal pump program (685-0208, PD-AAQ-773) was, as of September 1984, 33 months behind schedule and termination was recommended.

Perhaps more discouraging is the undistinguished record of simpler solar apparatuses like solar kilns or solar food dryers. The best reports on solar kilns are for timber drying operations in India (931-1333, PD-AAP-995, p. 5-70, 71) and in Sri Lanka (383-0044, PD-AAP-551, p. 15-3), but the favorable evaluation in Sri Lanka involves only one unit, as does the noncommital report from India. In Morocco, a solar oven project was forced to order mirror units from abroad because of the structural flimsiness of local manufactured units. Solar ovens tested in Lesotho were found to be expensive and not adapted to local cooking habits (632-0206, ARD 1984b, p. 59, 76). In Cape Verde, the solar oven was in "irregular use," while the solar still was successfully used -- to distill water for batteries.

Most surprising, perhaps, are the difficulties experienced with the relatively simple technologies involved in food or crop dryers, which often consist only in the use of simple materials applications like plastic sheeting. There is no diffficulty in manufacturing such units, for example, rice dryers in India (386-0465, PD-AAR-453, pp. 12ff.) or kits to make domestic food dryers in Lesotho (632-0206, PD--AAN-617, p. 36). Tests in a state-owned rice mill in India, have, in particular, stimulated great interset among other mill operators; similarly, promising results are announced for a simple farmer-oriented drying system (ARD 1985b, pp. 2-13,14). However, an evaluation of development work in Mali (688-0217, PD-AAP-385, P. 19) stressed that it is indeed possible to make serious design mistakes even with conceptually

simple systems. A disastrous experience in Senegal with fish drying also emphasizes the pitfalls of "simple" technologies, where a scheme for improving natural solar fish drying collapsed from faulty design, neglect of economics, and lack of monitoring (625-0937.7, VITA 1983, p. 27).

Solar hot water heating is the bright spot in the picture. One test solar heater was installed in Botswana (633-0209, PD-AAP-559, p. 18), four were installed (or renovated) , with fifteen more under contract in Jamaica (532-0065, PD-AAN-263, p.37), five units were installed in dormitories in Morocco, with five more under construction (608-0158, PD-AAN-304, pp. 23-4). Payback periods for the Morocco units were said to be 7-10 years. The AID (1984, p. 6) African review also notes that this technology is becoming commercial, with large firms entering the market. General knowledge of the state of the art in this field (for example, widespread utilization in Israel and Cyprus) and some studies of demand and supply in developing areas (see, for example, Schipper 1982, passim), however, must be relied on to strengthen the meager evidence from AID evaluations.

It is accepted that solar hot water heaters make sense, even at low oil prices, because of the relatively low temperatures required -- which implies high efficiencies in the technology. They therefore deserve consideration for funding in support of industry or essential infrastructure services in developing areas. Other direct solar technologies look much less attractive; in particular, the apparent simplicity of solar drying schemes has proved to be misleading in the context of practical development schemes.

Biogas

Methane production from animal and crop wastes is an Asian technology that has so far apparently not transplanted particularly well to the other continents. The success of a biogas unit in generating electricity for water pumping as part of the Indian "energy village" (385-0465, PD-AAN-204) must be considered in the context of a large-scale ongoing national program. Similarly, AID has contributed to the large government biogas program in Nepal, where several hundred family units have been installed yearly; the household program, however, is operating at a loss, reportedly because of expenses connected with a seven-year guarantee (ARD 1985b, pp. 2-11, 12). Biogas experimentation as part of a Guatemalan project (596-0089, PD-AAL-648, pp. 55, 66) was criticized as encompassing too many candidate designs and as ignoring the poor economics of household applications. Isolated demonstration units have been built in Rwanda (698-0410.22, PD-AAL-384, p. 15) and were under construction (and delayed) in Cape Verde (625-0937.03, PD-AAQ-048, p.28). Tests in Lesotho predicted high costs -- in particular because of the cold weather problem (632-0206, ARD 1984b, p. 63). One review (AID 1984, pp. 10, B-6) saw problems in Africa with both operation and maintenance, and recommended them rather for larger, industrial applications.

There is little doubt that earlier views of biogas as a simple technology have not been verified in practice. Technical assistance is often needed during and after construction, and indeed the well-known Indian and Chinese programs have institutionalized technical (and credit) assistance (see, for example, Ramsay, 1985, pp.153-155).

Biogas therefore has not shown itself to be a promising village technology in situations oriented toward self-help and small households. Special situations like dairy farms or in agricultural processing in some areas, see ARD 1985b, p, 2-12], where the economics may indeed be favorable, could provide cost-effective opportunities.

Small Hydro

Small hydroelectric facilities occupy a peculiar niche in the hierarchy of possible AID energy interventions. In Lesotho, micro-hydro projects were criticized as something that local inhabitants could neither understand, operate, nor maintain (931-1071, PD-AAL-654, p.27) and that demand was insufficient in any case. Such observations might well be made elsewhere. On the other hand, hydropower makes no pretense, even at the village level, of being an easy, primitive technology; its prime advantage is that it is known to work and that costs are relatively predictable. In India, for example, for a project with two sites reported as 90% complete at the time of the evaluation (386-0465, PD-AAR-453, pp. 59ff.), one could have confidence a priori that known Indian expertise in hydropower would be a strong positive factor in a the project. Similarly, in Thailand, AID has participated in a government program that has successfully completed 15 projects providing energy at locally favorable capital costs of $1000-$4300 per kilowatt and plans for some 50 units per year over the succeeding few years (ARD 1985b, p. 2-7). A hydro project in Zaire was reported as a technical success, although the lack of load promotion to increase electrical usage was criticized (660-0097, PD-AAR-792, pp. 25, 49).

A major program has been carried out by AID in investigating possibilities for small hydro facilities (936-5715, PD-AAP-702, passim). The need for careful planning in this area is evident, since the problems that amateurish implementation can cause are illustrated in the description of a small AID-fiannced hydro project in Liberia, where questions raised about the integrity of the construction of the dam were a matter of some local interest (see NRECA 1982 pp. 9-10). Economics is a serious problem, also: the usual hydro rule of thumb is the bigger, the better, and most interest in small hydro in the United States, it should be noted. developed on solid environmental, not shaky economic grounds.

Small hydro projects have not yet had time to prove (or disprove!) themselves on a large scale in the context of rural economic development. The advantages of a proven technology must be balanced against unknown maintenance and cost/load factor

problems.

Gasification

A related option is the pyrolysis of wastes or wood to produce charcoal, oil-like (but corrosive) liquids, and/or gases. A project in Indonesia made some minimal efforts in this direction, but resultswere not reported (497-0268, PD-AAD-917). There also exist projects on using pyrolysis to generate "producer gas" for use in internal combustion engines -- and hence as a power for irrigation pumping. A rice husk pyrolysis unit developed in Thailand with AID assistance was reported as a techniclal success but too complicated for easy replication (ARD 1985b, p. 2-15, 16). A project in the Phillipines to gasify charcoal to replace diesel fuel in irrigation pumps ran into technical problems -- which, however, were reported later resolved; however, numerous difficulties of a financial and economic nature remained (ARD 1985b, pp. 2-14, 3-3,4).

Gasification projects have yet to demonstrate proven practical success sufficient to move on to wide-scale usage.

Stoves

The improved stove option is dealt with in a large number of project evaluations -- the details of these evaluations are reviewed at more length ion Appendix B.

The project experience reviewed in Appendix B reflects certain features peculiar to the stove option. The stove is an appliance, and the success of an appliance may appear to be less problematical than the production of fuels -- but the questions of consumer acceptability, maintainability, and cost-effectiveness can be daunting. These problems immediately suggest why metal stoves may be often more promising than earthen stoves: Consumer use patterns may already be established, and appliance reliability tends to be high. Nevertheless, there seems to be some geographic variability, in particular with earthen stoves appearing to be a more promising option in Latin America than in Africa.

Established patterns in stove use for charcoal may also favor charcoal stoves over wood stoves as an option -- as does the fact that a higher-cost fuel makes fuel savings from improved combustion more of a consumer priority. New-style metal woodstove projects like the Mali example may soon test this conclusion, however.

On the record examined here, the success rate appears modest, although there are some bright spots. The limited data suggest that stove production and dissemination projects in untried markets and for low-cost fuels may face difficult implementation problems: future project planning must study the complex of problems encountered in this past decade.

Fuelwood

Evaluations of projects invoving fuelwood are relatively numerous. The existing literature reviewed here is summarized in the Appendix. On the basis of the project evaluation review given in the Appendix, where does the analysis stand with regard to such statements as that made in a report of the Asia forestry consultant (936-5519, PD-AAQ-909, pp.34-35) that "agencies have spent many millions in planting trees and distributing stoves, yet success has been less than anticipated"?

We can begin to address this question by making a rough sorting out of "successes," "failures," "suspects," and "don't-know's" for the projects reviewed. Out of the 23 projects mentioned in the Appendix, about 6 are failures by any standards, and 7 are rated as successes in the evaluations (and appear to us to be so); for 3, the evaluations are positive but appear to be too optimistic, while for 7 the data are either too sketchy or seem ambiguous. Cost-effectiveness is difficult to evaluate. Even making a generous allowance for the defects of the marketplace in the typical subsistence economy, however, the rarity of spontaneous efforts toward tree production in the Third World implies a high cost situation. We therefore have a combination of mixed technical success combined with high apparent costs. Our somewhat negative assessment is consistent with general pessimistic comments of fuelwood production efforts, such as a recent regional assessment (AID 1984, p.9) that regards widespread production of fuelwood crops to displace petroleum as "unlikely."

Fuelwood projects -- as energy initiatives -- therefore display, on the basis of the data reviewed here, a decidedly spotty record of achievement, suggesting caution in further program planning.

Animal and Human Traction

The fields of animal and human traction involve energy, to be sure. However, in organizational terms they usually fall under the egis of agricultural or watershed programs. We should mention a few features of some of these projects because they could compete with more conventionally "energy-type" efforts. Indeed, handpumps may be a desirable alternative to pumps operated by other renewable energy sources. In a project in Sri Lanka, for example, there was some criticism of the reliability of handpumps distributed under an AID project, but it was noted that a private firm had gone successfully into large-scale pump sales after the project conclusion (383-0044, PD-AAP-551, pp. 13-4, 5). The possible substitution was suggested of handpumps for planned solar pumps in Senegal (698-0135, Ulinski 1978, p. 15). Human or animal traction was mentioned as a viable alternative for rural water pumping in the Botswana experiments (633-0209, ARD 1986, pp. 1-3). Perhaps the greatest lesson for energy initiatives from animal traction projects could be as an analogy, for example, note the astounding difficulty in introducing plowing by

yoked oxen or even by single donkeys in the same regions where the introduction of concentrating solar collector arrays has been pursued! (See, for example, projects in Togo, 693-0218, PD-BAN-681, p. 5, and Mauritania, 682-0201, PD-AAM-487, p. 12.)

Miscellaneous Technologies

Other renewable technologies include potentially important options like the improvement of charcoalmaking. A project in Liberia reports that demand outstrips supply of its new and improved charcoal kilns (669-0163, PD-AAP-979, pp. 12, 40). This type of technology may be considered to be well-established. But the normally complex market situation -- with producers often having no incentive to cut down on wood consumption -- suggests that extreme care must be taken in implementing such schemes.

Water wheels for direct motive power for milling, a time-honored technology, have been reported successfully promoted with AID help in Nepal; it was noted that the standard hydro load factor problem does not arise in this application (ARD 1985b, pp. 2-9,10).

A wind energy option not mentioned above involved sailboat construction for fishermen in Sri Lanka; unfortunately the fishermen disliked the boat design (383-0044, PD-AAP-551, p. 14-2).

Other options are those like peat and geothermal, which are marginally renewable (peat) or at least almost inexhaustible (geothermal), but are more similar in potential and application to AID initiatives in conventional energy than to most renewable energy programs. Indeed, the peat project in Burundi, which at last reports was failing to achieve its goals by a wide margin, probably undertook too much in trying to develop its energy resource to replace household fuels in an unfavorable market and with insufficient attention to marketing and distribution of both fuel and appliances (695-00103, PD-AAP-251, pp. ii, 5). Geothermal energy was investigated in a project in St. Lucia: the local geothermal resource was reported as promising, but more research was said to be needed (538-0137, PD-AAR-849, p. 1).

CONNECTIONS WITH THE DEVELOPMENT PROCESS -- PRIVATE ENTERPRISE AND PRODUCTIVE SECTORS

After many years of trying to assist development by demonstration effects that may have demonstrated technical feasibility but did not stimulate practical imitation, there is much current enthusiasm for the co-opting of the private sector into assistance programs through both carefully targeted demonstrations and through planning around existing markets. Programs such as the "Energy Initiatives for Africa," for example, are concentrating on problems like getting the wood from the Dinderesso forest in Burkina Faso to a market and on growing trees on private farms in Rwanda (698-0424, EDI 1984, p. 7). There is little documented evidence of widescale involvement of the private sector in past

projects. Exceptions include the improved jiko project in Kenya and the private sector invovement in Djibouti. However, there is often some involvement, and it must be recognized that private sector impacts are often not very visible. In fuelwood projects, especially, it is often difficult to guess at the future of seedlings that are disseminated to private individuals. Finally, many private enterprises are involved in renewable energy systems which are not connected with any AID project.

Are some of the renewable technologies more compatible with an increased role for local private enterprise? Just looking at the large number of different biomass fuel regimes emphasizes the complexity of this question, but some observations can be made about the specific technologies.

In some places, well-established fuelwood/charcoal markets exist. There, as in the case cited in Mali (625-0937.7), the problem may be to avoid fighting the market: e.g., trying to lower stove costs without considering the impacts of lower profit margins on wholesalers . In other situations, growing wood competes with more economic land uses and trying to privatize is an uphill battle at best.

For stoves, the metal portable stove appears to be the most promising for privatization. The experience in Cape Verde -- and the other reports from a few other African countries quoted above-- seem to suggest that a straightforward windmill technology might be very favorable for local production -- and follow-up maintenance. Biogas seems to be unattractive: its success in India has been highly subsidized.

Small hydropower seems to represent a technology singularly inappropriate for local implementation in most inchoate industrial environments. The same could be said about photovoltaics. However, note that the appliances that go with photovoltaics (and with wind) may cause most of the maintenance problems, and a strong program of stimulating pump production and repair may make sense anyway for many rural development schemes.

In regard to rural development, are any of the technologies examined obviously better fitted for supplying energy for productive uses? A number of them, wind, for example, and wood or waste gasification schemes, which are relatively new, could provide economic motive power for water pumping -- depending on windspeeds and on the cost of biomass. Small hydroelectric power could revolutionize many localities presently lacking reasonably-priced electric power -- complaints levied against such projects because of "low load factors" therefore embrace an Alice-in-Wonderland logic, we believe. Any biomass project -- wood, grass, or "energy cane" -- which produces cheap fuel and other byproducts (alcohol or building poles) is going to stimulate the local economy in various ways -- many of which will be unpredictable. The stimulation from successfulforestry/fuelwood projects is probably best documented -- on the other hand, the number of failed projects is large, and these do little for local develop-

ment in general.

SUPPLY AND NEEDS-DRIVEN ORIENTATIONS

There are obvious advantages to the promotion of technologies that may be highly responsive to what the local inhabitants perceive as important areas of need. In a sense, most if not all AID renewable technology project planning is self-consciously aware of the goal of being "needs-driven" -- meaning responsive to basic energy and other developmental needs of rural communities. Some types of technologies, however, are more compatible with such goals. Furthermore, there are a large number of possible economic and social needs which a rural community could perceive as priority items.

Water pumping is one of the greatest perceived needs in many areas. The test program undertaken in Botswana investigated the outlook for many of these renewable technologies. The current interest in gasification is especially centered on this area, since a direct replacement for diesel fuel is possible; obviously biogas could also be used to replace petroleum fuels in internal combustion engines for this use. Wind in favorable environments is a good candidate, as shown in the Cape Verde project. And in principle, any of the electric technologies could be needs-oriented in this context because of the wide availability of electric pumps. However, photovoltaics, with its decentralization possibilities, is especially attractive; PV economics, though, has been assessed as marginal in a number of projects.

The second large area is for cooking fuels, and especially for woodfuels -- a difficult and ambiguous category for needs analysis. The need for such fuels and the social and environmental pressures on supply are all too well known by now. However, many efforts at fuelwood or charcoal projects -- to say nothing of stoves and indeed biogas -- have come to grief over the lack of a perceived local need. Without encouraging the further compilation of massive sociological reports on local attitudes, we must nevertheless point out that the question of "need" is complex, including gender gaps, local politics, and other convoluted issues. Within this context, the improved stove is perhaps one of the most straightforward options for meeting cooking fuel needs -- by cutting down directly on consumption. Fuelwood supply projects, when carefully designed, meet the supply problem head on.

Other common needs in the context of rural development include transport, energy for processing crops, power for lighting and communications. None of the renewables considered here -- except animal traction -- are well adapted to the transport need. Solar power is already widely used for drying -- the difficulties with improved, "modern" solar-based systems has been noted.

The needs question is especially treacherous because sometimes the most basic needs are being very poorly met. Health care

needs, for example, are basic. Communications needs are often not fully appreciated in their absence. In such contexts, the provision of electricity may not be a luxury but a high-priority option. PV, mini- or micro-hydro, wind electric, could all contribute in such a picture. The role of photovoltaics for remote health clinics has already been noted.

The present analysis of evaluations has added little to this conventional picture of needs and energy options. At most, the not unexpected result is that fuelwood and stove programs may be much more effective in satisfying cooking fuel needs than they may appear on paper, and that PV and wind -- in moderate wind regions -- may be rather expensive solutions to the need for irrigation water.

RECOMMENDATIONS: COMPARATIVE PRIORITIES FOR RENEWABLE ENERGY TECHNOLOGIES

Assessing what our review of project evaluations implies about relative priorities for energy technologies requires an overall guess at "demonstrated" cost-effectiveness as an energy (or conservation) source. Furthermore, we must consider the impact on privatization and productive uses just considered above.

In addition, many energy projects will constitute a part of larger projects directed toward a wider scope of problems and possibilities. Therefore goals of multi-use projects, such as the output of industrial and agricultural economic goods (e.g., building materials), and less specific goals such as environmental preservation -- e.g., watershed and therefore agricultural protection -- must often be taken into account.

This multi-goal aspect, we believe, lends important support to assigning high priority to fuelwood projects -- despite the difficulties and disappointments detailed in Appendix C. Environmental conservation has to be pursued anyway, if agriculture is to be preserved in the long run, and so forestry projects with fuelwood components must remain important, whether or not the fuelwood subprojects alone ever become "economic" in the narrow sense of the word.

Although experience with AID small hydro projects has been limited, the positive advantages of this proven technology -- which produces high-quality (-negentropy) energy -- make it a prime candidate for futher replication. Realistic provision for professional maintenance and systems operations needs to be emphasized , however, in future projects.

For stoves, earlier optimism has given way to searching out targets of opportunity, such as the situation in Kenya (assuming it is successful in the long run). Fixed stoves may also thrive in situations where social acceptability already exists, for example in Latin American locations where the improved stove concept is now familiar in many areas. New programs could be

very productive if they learn from experience. The option deserves further AID attention.

For wind and photovoltaics, the technologies are feasible -- in the right locations and for particular end uses. Though their total contributions to the energy picture may turn out to be small, they could be very cost-effective as a development tool. The role of private industry should be large in both of these to be sure that supply and maintenance constraints are satisfied.

Solar hot water heaters, on the other hand, are a specialized end use that can also contribute measurably to energy savings in the economy. Here, emphasis might well be placed on technical support to the private industrial sector that could increase profit margins by the use of this technology for low temperature process water applications. Other direct solar options have had a poor history of cost-effectiveness and adaptation to user needs and continuing them is not recommended.

Biomass gasification may turn out to provide reliable low-cost energy for important uses like pump engines. On the other hand, there have been technical problems, and field testing has not yet been convincing. A developmental role for AID is suggested, the extent of which should depend on the availability of current end use alternatives.

Biogas has proved itself technically viable in protected economic environments like India and China. The limited amount of evidence, however, for AID projects -- plus general observations on the efforts of other donors -- suggests that technical and cost factors are not generally favorable for household digester units. It is recommended that AID support be limited to technical assistance to larger agricultural and industrial projects for which local enterprise has taken the lead.

Animal and human traction projects should be handled as part of AID agricultural programs, since the farming system is such an integral part of the energy use. Other options may require specialized consideration. Charcoalmaking projects have been poorly planned from a market point of view, and any new project should be viewed with the utmost caution. Peat development experience has been limited -- as is the resource -- but that experience has not been such as to encourage new efforts. Geothermal power involves a larger scale than most renewables and there is little experience on which to judge it here: new initiatives should be examined on a case-by-case basis.

RECOMMENDATION ON POTENTIAL IMPROVEMENTS IN THE ANALYSIS

The present study has taken a first cut at an overall evaluation of the renewable energy technologies as observed in AID projects. The project evaluations have been an invaluable source of data. They are, however, slanted toward different goals from ours here: problems and promises rather than concrete energy accomplish-

ments. A vast untapped source of potential information in this area lies in the staff of contractors and government agencies who have performed past evaluations. An effective way of improving the analysis with a modest expenditure of resources could be undertaken through a study based on interviews with such staff and with other relevant experts.

CONCLUSION AND GENERAL LESSONS LEARNED

This review of AID project evaluations has tried to elucidate some of the relative advantages of different types of renewable energy technologies. Looking, however briefly and with imperfect data, at a large number of projects has helped us to identify some general technology characteristics independent of individual project implementation problems, planning errors, unforseen weather or political changes, and so on. It has suggested to us conclusions on the high priority of forestry projects, and has confirmed current thinking about the relative difficulty of disseminating different types of woodfuel and charcoal stoves, for example. It has also not discouraged us from speculating -- in the absence of data -- on the underestimated potential of small hydropower installations.

Some general lessons learned are that -- although all projects have organizational problems -- fuelwood initiatives seem to have the most complex and refractory ones. Organizational and planning time spent on this aspect will not be wasted for these projects. Another lesson is that technologies that look especially simple -- like solar drying or improved stoves -- may be deceptively difficult to carry out in practice. Finally, a conclusion that is difficult to document, but has the ring of truth to us, is that there is none of these technologies -- not even concentrating solar collectors -- that cannot be made to work successfully by a good project team; and there is no successful project that can be guaranteed to remain a success without continual attention after implementation.

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SUBAPPENDIX A

"HARDWARE" VERSUS "SOFTWARE" PROJECT GOALS

The projects reviewed in the text have been treated with an emphasis on concrete results -- energy produced, or at least a good foundation laid for the future production of energy. In fact, however, little or no energy is generated in the average project -- sometimes by default but often by design. The laying of "good foundations" for future energy production is indeed often the explicit goal of energy projects and is often the only practical measure of success. Even if such a lesser measure is accepted, we have seen that many projects fail to achieve such "foundation-building" goals. But even when projects fail to achieve stated goals of energy production or training or institution building for future production, they might well provide a spark of leadership or otherwise serve as a stimulus to other efforts. This last kind of achievement is much more difficult to trace, however, and is usually lost in an analysis like the present one.

Along these lines, many of the "hardware" projects considered have really been designed primarily as demonstrations -- or as training exercises. Such projects as the solar laboratory in Mali (688-0217) are fairly typical of this type. Failures in demonstrations can be detected, but identifying a success is much more difficult: just because a technology works doesn't mean a useful demonstration effect occurs! Applying evaluative measures to training programs is very difficult indeed -- if the measures are to go beyond the fact of training and get to the concrete, long-term results that are supposed to come out of it later. Institution-building is another area that is difficult to assess. Sometimes the institution building is the main output of a demonstration program -- but its benefits, if any, may lie in the relatively far future.

Feasibility study projects are an essential feature of any assistance program, but the best test of a feasibility study -- or the kind of pre-feasibility survey program mounted to assess micro-hydro potential, for example (9936-5715) -- may be in the money it saves by issuing negative findings on potential sites! There is obviously even a place for such indirect efforts as the Philippine "Project Design Project" (492-0343), which funds the process of designing new assistance efforts.

While these considerations are obvious in one sense -- and have application to all AID initiatives -- they have some particular bearing on the renewable energy option. Technologies in this field have been relatively untried -- therefore demonstration programs have been given deservedly greater weight.

Energy had often had no bureaucratic home of its own -- therefore institution-building, and to some extent, training programs have been relatively important compared to those in other development fields.

A related consideration is that energy -- as a secondary good -- aften finds an appropriate home as a part of an integrated program for rural development. The importance of by-products and co-products for such options as biogas have often been stressed (see, for example, Ramsay 1985, pp. 142, 160). The contribution and function of energy components in such projects may often by neglected in standard evaluations.

SUBAPPENDIX B

STOVE PROJECTS

Stove projects -- woodfuel or charcoal -- should by rights be characterizable in terms of fairly definite measures of success. Every unit of stove hardware placed into service should by rights represent a data point for assessments. In practice, of course, the reality is complicated by questions like continuousness of usage, maintenance capabilities, and feasibility of replication.

One recent project that has to all appearances overcome some of these latter obstacles is the program to introduce improved charcoal "jiko" stoves in Kenya (615-0205, PD-AAQ-333, p. 5, IDA 1983 pp. 5, 6, 83; ATI 1985a, b, passim). This project claims to have been responsible for the distribution of some 84,000 jikos through training and loans to local artisans. Charcoal savings on the order of 50% are reported as potent motivators for purchase and use. The use of established stove designs as a model and the encouragement of use of scrap metal to keep costs down have been credited as reasons for success.

Positive if somewhat less dramatic results for metal charcoal stoves are reported from Guinea (675-0208, VITA 1985 pp. 3 ff.), where interested artisans were trained, and local metalworkers were reported producing independently of the project as the profit potential became clear. (Consideration of this project could benefit, however, from a further independent evaluation.)

A project in Mali (625-0937.7, VITA 1983, pp. 20-21) trained stove workers in an improved charcoal stove technology, but ran afoul of conflicts of interest between the artisans and the entrepreneur-dealers, who had no stake in fuel conservation.

Central America has been a center for the development of earthen woodfuel stoves. The successful production of 250 Lorena stoves under Peace Corps Volunteer auspices was reported in a project in Honduras (522-0157, PD-AAN-988, p. 16) as saving fuelwood (and also as a source of pride!). Indirect evidence of stove success may be traced in an evaluation of a project in Guatemala, where the project (596-0089,PD-AAL-648) was criticized for continuing to plan earthen stove demos after other agencies had successfully disseminated proven stove technology.

In Africa, success with high-mass stoves has been less favorable. An evaluation of a renewables project in Rwanda (698-0410.22, PD-AAL-384) mentions the testing of sand and clay stoves. Indirect evidence on this case comes from a later evaluation in Burundi (695-0105, Seyle 1984, p. 31) where it was decided not to implement the stove portion of the program since "the Rwanda project had had difficulty." The failure of the particular stove designs to provide light and space heat was mentioned as disadvantages.

In Mali, where a project introduced Lorena stoves into a number

of households (688-0217, PD-AAL-385, p.23-24, 31), only 39% of them were later reported in regular use -- practical problems with hole size, crumbling materials and rainwater had proved discouraging, despite the theoretical attraction of an eight-month payback period. The experience in another project in Mali was reported as very negative, with the model chosen being accused of being less efficient than the classical three stones (625-0937.9, PD-AAP-706, pp.84-6)! Local cooking patterns and needs had evidently not been taken into account, so that even though the local inhabitants were familiar with relevant ("banco") technology, none of the project-built stoves were in service at the time of the evaluation. In Lesotho, despite enthusiasm on the part of the project staff for the development of a stone stove ("paola") patterned after local windbreaks (632-0206, ARD 1984b. pp. 6, 33), a later evaluation ("PES of 1-20-84", pp.9-10) notes a lack of usage and suggests that most cooking locations are outside -- instead of inside, as earlier envisaged -- and therefore not useful for space heating.

More positive results were reported in a contractor's report for Senegal (625-0937.7, VITA 1983 pp. 2-3, 6-7) where 60% of the 6000 banco stoves constructed under the program were still in use. However, the need for yearly repairs was noted, with a questioning of the will or capability to carry them out. In the Gambia, a pilot effort at training local workers in banco stove construction reported that most of the test stoves, examined later, were still in good condition, but that users were discouraged by the tendency of the stoves to develop cracks as time went on (635-0205, PD-AAM-117, p. 14).

After a project decision against mud stoves in Botswana, one portable metal wood stove was designed and 1500 were reported distributed (633-0209, ARD 1985e, p.5; PD-AAP-559, p.18). However, the opinion expressed in a later evaluation (PD-AAR-147, executive summary) must also be considered: the problems with the production, marketing, and distribution of the metal stove were held to be unresolved and perhaps insurmountable. More positive results are reported for a relatively new metal fuelwood stove project in Mali (629-0434, Fisher, 1986, pp. 1-3). Field tests with 455 stoves have been carried out, and 20 production centers using local artisans are due to be set up by June 30, 1986.

In Asia, we found little hard evidence bearing on the stove issue from official AID documents. A stove demonstration program was being carried out as part of a larger renewables project in Thailand (493-0304, PD-AAQ-512, pp.65-6). In Nepal, 190 improved stoves were reported distributed as part of a larger rural program, but other details were not given.

There have been some other general remarks made that may be useful in assessing the overall stove program. A project evaluation in the Sudan (650-0041, PD-BAU-878, pp.3,12) asserts that there have been no successful woodstove programs in Africa -- except possibly Botswana. Another review (AID 1984, pp. 7, 9)

notes that the inefficiency of government extension efforts is limiting the spread of stoves ("it could take decades"), but also remarks hopefully about the possibility of selling businessmen -- e.g., brewers -- on larger stoves. For Africa, at least, the superiority of portable stoves over stationary is also asserted. (For Latin America, the limited evaluative reports we have could be interpreted as indicating that the earthen stove may be attaining a degree of success.)

The AID projects reviewed here encompass only a small portion of the improved stove projects pursued worldwide by all assistance agencies. For a better understanding of the pros and cons of the stove option, a more extensive look is doubtless needed at the large number of non-AID projects.

SUBAPPENDIX C

FUELWOOD EVALUATIONS

Obvious measures of the success of any forestry program are the number of trees planted and the number of seedlings raised in nurseries. In practice, such measures are easier to come by than more significant data like long-term survivability or information on the successful stabilization of production and marketing of products.

Therefore, figures such as the 16,611 acres reforested (out of 19,500 scheduled) in fuelwood species in a project in Sri Lanka (383-0055, PD-AAS-123, p.26) and 500 hectares (out of 4000 scheduled to be reforested , with 1.6 million meters of windbreaks planted in Honduras (522-0168, PD-AAP-927, p.10) give obviously only minimal information on "success". Sometimes survival rates in the acceptable range are given, for example for the Madhya Pradesh Social Forestry project in India, where it was reported that the project met the target of 11,800 hectares planted in 176 community plantations, with over a 70% survival rate. Or the data may be couched in terms of nursery production or distribution of seedlings to farmers -- a project in Haiti [521-0142, PD-AAN-733, part IV, p.20] reported 35,000 fast-growing trees distributed to 60 individuals and several groups, with a success rate of about 65%. Or brief uninformative statements may be made, e.g., that the woodlots are "going well," as in an evaluation of the forestry component of a project in Thailand (493-4304, PD-AAQ-512, p.69). In the Sudan (650-0041, PD-BAU-878, pp.9-10, a positive outlook is claimed for a grants program to increase nursery production aimed at planting of shelterbelts and woodlots -- but it is noted that there appears to be no plan for dissemination. A project evaluation in Guinea (698-0410.35, PD-AAP-629, pp. 2,4) reports success in achieving project goals ahead of schedule -- nurseries, three demo plots established -- and claims that some interest has been generated in the private sector in seedling production (one potential entrepreneur!).

We have similar positive evaluations that however give little idea of future prospects, for projects in Kenya (615-0205, PD-AAQ-333,p.6), Ecuador (518-0031, PD-AAL-791, pp.112-3), and in Central America (596-0089, PD-AAM-485, p.3). Such data should probably only be read as evidence of 'provisional success' or perhaps 'lack of failure' - note that one investigation undertaken a few years ago sought to locate and document the large number of abandoned woodlot projects in Central America!

From here one can proceed to projects with somewhat more convincing detail as to success -- or failure. In Senegal (685-0243, PD-AAN-118, pp.10-15), one project reported that the Forest Service nurseries had formed a good collaboration with self-help groups in the villages, and that it had taken only six weeks to meet 80% of a two-year goal. The two-year-old trees were said to be over two meters tall, and were reported to "look real good." Project success was evidently bolstered by the perception by the

villagers that the trees would be a source of cash as a pole crop. A project in Tanzania (621-0160, Lutheran, 1985, pp. ii. [not an official evaluation]) reported 6 tree nurseries operating in connection with local schools, with 189,000 tree seedlings estimated planted; the more relevant data from the point of view of replicability and continuity was the assertion that the project was becoming successfully institutionalized as a part of local church and school activities. Audits on a project in Haiti (521-0122) reported great success in the planting of trees, over 4 million in one subproject alone (PD-AAP-220, sec.3.2.2.2), but also pointed out low survival rates (45%) owing to incorrect planting, lack of protection from grazing, and lack of supplemental water (Pd-AAP-719, pp. 4,9). An interesting contrast was evidenced in three CARE subprojects in Somalia (649-0122 CARE 1985a, Seyler,1985 pp.12-15). At Qorioley, the apparent success of an irrigated project was clouded by the questionable long-term availability of water. At Hiran, a woodlot project was highly praised as having been very professionally implemented, with a survival rate of over 90%; on the other hand, the evaluator believed that the third project at Jalalaxi utilized more local labor and materials and was therefore much more replicable.

Success was reported for a project in Chad (677-0008, PD-AAJ-854, pp.8,16,20) because more than 56% of the scheduled hectares were planted, with an overall effective survival rate of about 70%. The target of 1725 farmers induced to participate in this agroforestry scheme was exceeded: actual was 3000. The recognition by the farmers of the established economic value of the species planted (Acacia albida) was apparently important: a subproject to plant live fencing of Prosopis was much less successful. A description of a project in Rwanda (698-0502.96, CARE,1986 [draft evaluation], pp.17,18,32,37) points out the hazards of relying on interview data alone for evaluations. Over 600,000 seedlings were reported produced, 530 hectares (out of a goal of 600) were forested, with a significant demand for seedlings (22,000) for agro-forestry outplanting; however, the report cautions that many of the trees reported alive by the interviewees were found on examination to be dead.

A number of projects reported more or less gross failure by any standards; many of these are in the Sahel. In contrast to the successful Senegal project reported above, another in that country (685-0219, PD-AAN-330, summary pp.1-2, p.105) detailed an abject failure where over $1000 per hectare was spent to plant a eucalyptus species that was evidently not adapted to regions of rainfall less than 800 mm -- resulting in yields per hectare of about 1.5 cubic meters per year instead of the projected 10! In the same country, a "self-help" project (685-0247, PD-BAF-196, pp. 2, 7, 12, PD-AAP-205 pp. 9,14, 24) apparently failed to organize the local populace, perhaps because an existing interest in fruit and shade trees was ignored, but also probably because again eucalyptus was not a correct species choice. In any event, survival rates varied from 0 to 50% in different sites. A project in Mali (625-0937.9, PD-AAP-706, pp.65,81) apparently suffered from management difficulties, with delays in construction,

lack of equipment, and inadequate implementation of production: the overall survival rate for the two woodlots actually established was only 30%. In the Gambia (635-0205, PD-AAM-117, pp.8,12), planting of woodlots was reported on schedule (on a very small scale), bu plantation areas had been cleared too soon and would all require replanting that should have been unnecessary.

Causes of failures varied. In efforts to establish community woodlots in Botswana (633-0077, DAI 1984a, pp.PES-7, pp.II-18, 24, 42ff.), an evaluation reported that government nurseries provided seedlings at very high costs, there was no extension or technical backstopping provided to interested communities, and there was a lack of tradition of joint community efforts toward common goals. One project in Niger (683-0205, PD-AAP-509, Sec. C1) attributed high seedling mortality and excessive planting costs to the failure of the Eaux et Forets to involve the community and to a lack of establishment of ownership rights in the tree lots. Another project there (683-0230) presents an informative contrast between contractor reports and AID evaluations. The contractor (ARD 1985d, pp.29, 41) reports the successful sales of woodlot trees in the pole market and discerns a demo effect as 53% of villagers surveyed have planted their own trees after observing the official windbreak plantings. The AID report (PD-AAN-806) stresses the uneconomic nature of the block plantings and asserts that the agro-forestry element may be counterproductive in that it exacerbates the agriculture-forestry dichotomy and promises unrealistic levels of wood supplies.

The forestry projects mentioned above are all of a national resource management or a local wood supply type. There is a lack of evidence for AID involvement in industrial applications (see, for example, Ramsay, 1985, chap. 10). In particular, the Philippines dendrothermal project, (originally part of AID project 492-0294), spun off to the National Energy Agency (per PD-CAC-742, p.ii), could be usefully evaluated. Furthermore, we have no data on newer efforts, for example in Jamaica, to produce non-woody biomass as an energy source.

What does this brief review of some of the salient points in AID forestry project evaluations (and related documents) tell us about the desirability of continued AID effort in this field? Before examining this question, we must try to clarify some complicating factors.

First of all, we are considering here forestry only in its energy aspect: the prime motivation for forestry project work, on the other hand, is almost certainly environmental -- in the larger sense of that word -- and economic. (We have seen evidence of a perceived importance at the village level of pole production and horticulture.) Therefore our conclusions will apply only to the fuelwood and charcoal aspects of forestry.

Second, we should by rights consider secondary, spinoff effects of projects: this consideration applies of course to all the

renewable technologies. Undoubtedly, it would be a weak and perhaps even frivolous tactic to ascribe benefits (see for example the Honduran project 522-0168, PD-AAP-927,p. 12) to the project because through it, "farm families receive technical assistance, loans, and grants." However, any stimulation of somnolent rural economies can be beneficial, and any evidence of increased entrepreneurship or and increased community consciousness slanted toward productive change could be useful: even dead and stunted trees could conceivably produce a "better luck next time" syndrome. In the Indian project quoted above (386-0475, PD-AAP-363, p.19), the positive nature of increased income and responsibility for the village councils -- as well as the increased employment of casual labor -- were noted as important benefits. Furthermore, forestry projects can act as a stimulus to land use upgrading. In the same Indian project, it was noted that 95% of the community planting had been done on lands that were previously considered completely unproductive. Unfortunately, there does not seem to be sufficient evidence from the evaluations to assess these spinoffs in any quantitative -- or indeed qualitative -- way. However, the tenor of the evaluations examined does not lead one to expect that this neglect is important for our conclusions.