

GEF/FAO Workshop on Productive Uses of Renewable Energy:

Experience, Strategies, and Project Development

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**Workshop Synthesis and Report by
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Preface

In June 2002, an expert workshop on the productive uses of renewable energy in developing countries was convened in Rome by the Global Environment Facility and the Food and Agriculture Organization of the United Nations. Thirty-five workshop participants came from development agencies, non-governmental organizations, private companies, research institutes, and universities in fifteen countries. They shared their practical experience with productive use projects and formulated strategies and tools to help international project agencies prepare effective productive use projects. In the process they considered a range of issues, including priority applications, stakeholder participation, and project sustainability and replication.

This synthesis and report summarizes the presentations and discussions. The views expressed in this report are those of the author and do not necessarily reflect the views of all workshop participants or participating agencies.

The co-organizers gratefully acknowledge the support of the U.S. Agency for International Development and the Dutch government for preparation of the workshop and participant travel. And thanks are due to all workshop participants for their outstanding contributions and effort.

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PART A: WORKSHOP SYNTHESIS

Workshop Purpose and Motivation

The purpose of the workshop was to share practical experience with productive use projects; to clarify and understand the major issues related to applications, social impacts, participation, sustainability and replication; and to formulate strategies and tools to help international project agencies prepare a growing portfolio of quality productive use projects. This synopsis discusses the motivations that led the participating agencies to support productive use projects, the significant experience with productive use projects that now exists, the priority applications that support sustainable development and that can be supported by project agencies, project development guidelines, and tools for project development.

The motivation for an increased emphasis on productive uses of renewable energy is essentially two-fold. First, there is a growing recognition among the experts that rural electrification using any technology does not automatically create development benefits that are commensurate with the investment. Second, the pace at which rural populations are getting access to modern energy is simply unacceptable.

The importance of acting on the linkage between energy and development was reinforced by a recent paper, "Energy for the Poor," published by the UK's Department For International Development (DFID) which focuses on the links between energy services and the Millennium Development Goals (MDG) adopted by the UN. The paper concludes that it is not possible to achieve the MDGs without improved energy services and, in particular, energy is essential to poverty reduction efforts.

By focusing primarily on mechanisms for creating development benefits, it becomes clear that in rural areas small amounts of energy can bring about a big difference in productivity and incomes--especially in agriculture. Field experience indicates that renewable energy projects that address productive uses realize greater success than welfare-oriented initiatives. In particular, small amounts of energy can produce very significant increases in the income of a household if that energy is used (e. g.) for crop drying or water pumping. The introduction of rice-drying technologies has demonstrated this result, for example.

In addition to increased productivity and higher incomes, the new technologies simply reduce the drudgery of many people in rural areas. Significantly, at every step in the process of food production, processing, and consumption, there are opportunities for applications of renewable technologies.

The application of renewable technologies to productive uses in rural areas is a move beyond the typical rural energy projects that have characterized the past. In the past, the predominant technology in donor and MDB projects has been photovoltaics. The most frequent application of photovoltaics has been lighting for households, which yields a limited (though not inconsequential) set of development benefits when compared to productive use applications that could be served with renewables. Since affordability is frequently a major issue in any rural electrification effort, it is important to move beyond lighting.

The second major motivation for funding agencies is the unacceptable pace of access to modern energy. Using Ghana as an example, given current population figures (assuming no growth), the current coverage, and rate of new connections, it will take more than one hundred years to electrify the country. For Malawi, it will take more than 2000 years. Clearly new approaches are needed.

In short, the chief challenge is to increase economic power in poor countries, while identifying and applying energy technology to create real development benefits. To accomplish this there must be open access to expertise as well as policies that make markets work. Increased economic power translates to an opportunity for growth of renewable energy.

Experience with Productive Uses

At present investment portfolios contain only a few projects that are exclusively composed of productive uses components. However, there are a number of rural energy projects that do contain productive use components that can be the source for lessons learned. For example, the Argentine rural energy concessions that are best known for their institutional innovations support a number of productive uses associated with food processing, communications, lodging, in addition to community facilities such as clinics and schools. Routine project reporting does not capture the extent to which productive uses are being undertaken with support of concerned development agencies. There may be a need for additional evaluation and reporting as the economic development value of these productive use investments outweighs the value of the physical energy.

Among the more developmentally important projects are those associated with agriculture. Productive uses, such as crop drying or processing, are particularly important to small scale agriculture and are included in every agency portfolio that was examined. Especially noteworthy is the successful use of gasification technologies to provide controllable heat for the drying of food and fibre. Important water pumping projects and telecommunications applications are also under way. The chief technological innovations were in biomass gasification where different approaches

seem to yield similar benefits. In these projects, institutional innovations mainly involve the use of public-private partnerships and increased support to small enterprises and sometimes micro-enterprises.

It is useful to distinguish two types of productive use applications. The first is characterized as self-supply or as providing service to the local community and the second is characterized by a focus on and production for external markets. The former type can improve lives while the second moves beyond that to the support of integration of the rural area into the national or international economy.

In India, projects involving biomass gasification in silk and other textile production and processing have been demonstrated to yield a payback in less than six months. Fuel wood as well as conventional fuels, including diesel and kerosene, are displaced and productivity is increased. The units are small-scale and many local entrepreneurs benefit from the projects.

Spice (cardamom) drying, also with gasifiers and no reliance on electricity, yields a higher quality product in a shorter drying period. In this application, the investments pay for themselves in one season. More than eighty-five percent of the beneficiaries are small producers who own less than two hectares. The drying of rubber, again with gasifiers, also demonstrates the capability to displace conventional energy and deliver a payback of less than one year based on fuel savings. Projects to improve the drying process for mushrooms and other edibles have also shown improvements in product quality and storability, while increasing productivity.

Gasifiers are also used to dry bricks before firing in a kiln. Conventional technology involves both simple atmospheric drying and the use of various fuels depending on weather conditions. The use of the gasifier reduces fuel consumption and associated smoke and decreases the drying time (increasing productivity) while improving working conditions.

The communications needs of rural areas have always been problematic for a number of reasons, including the lack of electric power. Renewables technologies, mainly photovoltaics, have long been a cost-effective source of energy for many communication projects. However, trends in both energy technology as well as costs of information and telecommunication equipment are creating a new round of potential opportunities in many countries.

A new model for telecenters seems to be emerging in Guatemala, Honduras, and Bolivia. The approach is to combine public-service centers with a for-profit telephone service from telecommunication providers. The cost of hardware is a critical issue. The need is to lower costs and achieve full usage of shared systems to secure sustainable access in rural areas where about eighty percent of the revenue comes from

voice telephone calls. Moreover, telecenters are likely to be sustainable only where they are the main source of telephony. Internet-only service does not appear to be feasible as it is necessary to attract users with the familiar service of telephony first. However, many rural parents are convinced their children will be better off if internet service is available and it is often a usage that is not fully accounted for in the design and market assessment phases. In any case, high-cost, donor supplied systems are not economically feasible for replication. Systems that use laptop computers with lower power demands also require a smaller investment in energy producing hardware.

To ensure that women share in the benefits of new productive use applications, project design must approach that issue directly. When design is gender sensitive, significant benefits for women have been produced, including: increased income, time-savings and enhanced self-confidence from improved ability to support household income and greater control over self-generated finances. One project that has produced benefits for women is the ENSIGN project (Financing Energy Services & Income-Generating Opportunities for the Poor). ENSIGN was implemented in eight countries in Asia in a UNDP-financed project by the Asia-Pacific Development Center. Energy-linked micro-enterprise portfolios were developed in each country that addressed the identified needs of both urban and rural populations. In both areas, process heat and motive power were more crucial to income-generation than lighting. Activities receiving financing included garment making, embroidery, felt and leather goods manufacturing, welding, baking, cold storage, beauty salon, grain processing, and fish drying and powdering.

Priority Applications

There was no explicit effort to identify priority applications during the Workshop. However based on the project experience that was presented and discussed, the constellation of applications most frequently mentioned were those associated with food and fiber production and processing. If this category is understood to include the pumping of potable water, then the application receiving the second largest amount of attention was telecommunications. Rural non-agriculture energy needs received relatively much less attention. This ad hoc ranking is not in any way based on a formal analysis of rural needs or potential markets, but might fairly be described as resulting from the experience and expertise of the participants. In the absence of formal analysis, the judgment of experts should be given fitting weight in terms of priority setting at this stage.

However, there are data to support the focus on food and fiber. For example, in some Latin America and the Caribbean countries 10 to 30 percent of the population are malnourished and development has been further hindered by natural disasters in recent years. In light of these facts, a new FAO initiative in the region focuses on the use of

wood fuel in the production and processing of food by small and medium industries (SMI), artisans, and households. Among the small and medium food industries fueled by wood in Latin America are bakeries, processors of coffee, cereals, cassava, animal and fish products, sugarcane, salt, tobacco, as well as fruit and vegetable preservation. Energy is a key factor in product quality and safety, productivity, and profits. Additionally, many development agencies, even outside the UN organizations, take some guidance from the MDGs and the first of those goals is to eradicate extreme poverty and hunger.

The following project sketches cover priority applications:

Argentina. From 1990-1993 a GTZ project provided market development work to promote the use of Photovoltaic (PV) water pumping. The project installed fifteen PV water pumping stations of 1-3 kWp each. The success of the project was such that between 1994 and 1999, more than 3000 small PV pumps (100-200Wp) were sold by industry in Argentina. In terms of institutional development, several water companies started offering water pumping services as well.

Mexico. Three much needed priority projects failed to survive for a variety of reasons. (1) Donor projects for drinking water in the 1980s were not internalized by the community. After an operational test, the intended beneficiaries who were fishermen left the area and resettled elsewhere. (2) A mini-grid system for village power collapsed after two years because the government contract that provided operation and maintenance expired. There was no tariff and metering system implemented to sustain it. (3) An eco-tourism hotel initially won a "green label" prize for its solar hot water and use of photovoltaics for lighting and water purification. The hotel succeeded but the nature of the clientele changed to guests who did not place a premium value the environment. Management responded by permitting the environmental component of the hotel to collapse.

Philippines. A water pumping project is under development to provide potable water to 200,000 people (40,000 households) in 40 municipalities. The willingness of people to pay for water is sufficient to offer the prospect of economic success based on 100% cost recovery using pre-paid smart water cards. Project financing comes from commercial bank loans to municipalities with project revenue providing the loan service. Considerable effort was expended to get the project designed and developed, including the cost of building the community organization that is part of the total cost of the project. It is planned that the first community will be on-line in August 2002. The project developer is covering all the logistical and organizational costs until the revenue stream starts to flow.

There are important development needs in agriculture, forestry, agro-industry, and fisheries that should be seen as clear opportunities for productive use projects. The

renewable resources and technologies are largely available. International development agencies are forming new partnerships and industry is getting more involved as well. There is a substantial--yet still emerging-- understanding that people need product options ranging from the simple to the sophisticated to support food and fiber production and processing. There are efforts under way to link renewable energy systems to integrated, diversified and organic farming systems so that farmers can better understand their options.

With respect to energy for cottage industry or rural non-agricultural enterprises, there is a realization of the need but little information regarding the actual energy needs associated with the variety of applications to be found. Many of the energy-using equipment were developed with the intention of connecting to the grid for power and re-engineering is needed to facilitate the application of renewables to the task. Developing mechanisms for linking renewables to rural non-agricultural enterprises is a significant and important challenge.

Project Development Guidelines

The two critical issues that project development guidelines must address are: (a) the capturing and conveying lessons learned; and (b) ensuring that projects are designed with an eye to their replication. There are a variety of lessons learned that need to be documented and incorporated into guideline documents and made readily available for project developers. These lessons learned are derived from specific project experience and focus on practical problems such understanding the energy technology cost implications of non-energy decisions during the design phase of the project. For example, the desire to make communications services, including radio and video broadcasts, available to low income rural inhabitants brings with it a need for low cost approaches and low cost technology. In such cases, low-energy technologies are inherently important because lower energy demand almost always means cheaper power supply solutions, always an issue with photovoltaics. Potential suppliers and customers may need technical assistance for project design and implementation.

A particularly vexing problem that arose in many contexts is the need to pursue a multi-sector design to achieve progress on productive uses (e. g., energy and agriculture) and at the same time experience clearly shows that multi-sector approaches take more time and are more costly to initiate.

One aspect of the problem is inter-sector communications difficulties that arise out of the differing perspectives of those working in the sectors involved. Frequently energy has been viewed skeptically by other development sectors due to a tendency of those who design energy projects to measure project accomplishments in terms of numbers of installations rather than their impact on measures of development. For example, it is

more likely that the number of improved cook stoves deployed would be measured rather than incremental improvements in health from better indoor air quality that the proper use and maintenance of the stoves could provide. Energy practitioners too often seek to document their work using metrics that are once removed from development indicators. The experience of FAO has shown that from the project design phase forward, it is important to make clear that the task is not to provide electricity, but to provide the services people need for development. Providing energy services that improve the productivity of agriculture can both increase rural incomes and reduce emissions through organic farming or reduce methane emissions from rice production or cattle. Yet, the energy sector focuses on urban and industrial activities rather than the rural and agricultural. At the same time the agricultural sector sees no role for energy and the forestry sector is focused simply on wood matters. While workshop participants recognized this problem, there was no resolution nor could that have been expected. Yet the need for experienced-based guidelines is apparent.

Replication of successful projects represents the second critical reason to create a set of project development guidelines. While the use of renewable technology to provide rural energy service dates to the 1970s or before, the emphasis on productive uses other than water pumping and simple crop drying is fairly recent. The diversity of needs in rural areas and other factors as well make it extremely difficult to develop a standard model that can simply be replicated by others.

While information may exist regarding such matters as prototype strategic frameworks on policies, listings of candidate technologies, standard sources for economic and demographic information, and useful techniques for prioritizing community needs, the type of guideline information listed here is not readily available. As a result, improved replication depends on action to gather and organize a list of design issues that can evolve into project guidelines.

Among the needed information was information to support the development of a project in order to improve the chances that there would be sufficient support to permit a project to weather the storms associated with institutional changes that are endemic to development and to cope with the technical failures that do occur. In particular projects need to withstand or accommodate institutional transitions such as the normal shift in focus from installation of hardware to after sales service or the shifting of project responsibility from one level of government to another.

Additionally, it is understood that the benefits of energy services often vary by gender. That is, gender-specific analysis will show the differences in benefits of reduced labor or other social benefit measures. In most cultures, women and men use energy differently and careful project design will document such differences. Women tend to be small-scale, marginal producers, yet their income is often critical to family survival and is used for basic needs like food, clothes, school fees. Women often face social and

cultural constraints in accessing new technology as well as credit—e. g., women receive only 10% of small business credit in Africa. The best means of producing a project that successfully accounts for gender in a way that is replicable is not readily available in a form useful to project developers.

Many of the successes with productive uses involve small projects, thus the apparent need is for many small projects rather than a few large-scale projects. Yet funding mechanisms tend to be geared toward projects such as conventional poles and wires rural electrification. The lack of well understood pathways for developing projects with a high likelihood of successful funding poses problems for both funding and implementing institutions that are mainly unresolved.

The documentation as to the design and implementation of productive use projects provides scant information on steps that have been taken to increase their potential for replication. Given the extent of the need for productive use projects, efforts should be made to include discussions of replication in project documents.

Tools for Project Development

There are a variety of tools available for use by those who are preparing conventional energy projects that simply do not exist for those who are preparing projects that incorporate productive uses of renewable energy.

As a result, the lack of standardized tools is an impediment to reducing project preparation time and costs.

Among the needed tools that was frequently mentioned is a market analysis method that answers somewhat different kinds of questions than are usually seen in rural energy project papers. In particular, there was clear recognition of the need to improve analytic skills with respect to identifying and valuing the stream(s) of benefits in a productive use project. Conventional cost-effectiveness analysis that identifies the least cost solution to water pumping is simply not the right tool for the task. In productive use projects it is important to understand the benefits and how changes in the structure of the project would alter not only the timing and size of the benefits, but who receives the benefits as well.

A thread that was noted earlier ran through the discussion of these projects: the need for improved analysis of energy demand, willingness to pay, and associated market information. The issue is not simply one of applying known tools, but developing better field tools for segmenting and measuring the market for productive use applications. Additionally, the need for more data on the nature and extent of energy use in many existing process was seen as a necessary first step in providing modern renewable energy to such processes.

PART B: WORKSHOP REPORT

Introduction to the Workshop

1. Welcome address by FAO

Mr. Dietrich Leihner

2. Purpose and outcomes of the workshop

Eric Martinot, GEF

Workshop Purpose

The workshop purpose is to share practical experience with productive use projects; to clarify and understand the major issues related to applications, social impacts, participation, sustainability and replication; and to formulate strategies and tools to help international project agencies prepare a growing portfolio of quality productive use projects.

Planned Workshop Outcomes

- (1) New **motivation** by participating agencies to prepare productive use projects, including motivation to work with productive and social sectors such as agriculture, education, and water.
- (2) Descriptions of **significant experience** from productive use projects.
- (3) Identification of **priority applications** that provide sustainable development benefits and can be practically supported by international project agencies.
- (4) Recommendations for **project development guidelines** for international project agencies in formulating and preparing productive use projects.
- (5) Identified **tools for project development** that are specific to productive-use projects, including means to reduce project preparation costs and timing.

(6) Identified **knowledge gaps** and recommendations for research agendas to close those gaps.

3. The challenges and opportunities of productive-use projects

Gustavo Best, FAO

The application of renewable technologies to productive uses in rural areas requires that we move beyond the conventional projects that have characterized the past. In rural areas, small changes in technology can bring about a big difference in productivity and incomes--especially in agriculture. The introduction of rice-drying technologies have demonstrated this result, For example. In addition to increased productivity in higher incomes, the new technologies simply reduce the drudgery of many people in rural areas. There are opportunities for applications of renewable technologies at every step in the process of food production, processing, and consumption.

The chief challenges faced by development agencies are associated with the need to increase economic power in poor countries, while reducing the cost of technology investments and risk. To accomplish this there must be open access to expertise as well as policies that reduce market imperfections. Increased economic power translates to an opportunity for modular growth of renewable energy and the capability to reduce health problems associated with indoor air quality as well as improving the capacity to deliver education services – two of the keys to development.

An additional challenge is a lack of inter-sector communication. The energy sector focuses on urban and industrial activities rather than the rural and agricultural. At the same time the agricultural sector sees no role for energy and the forestry sector is focused simply on wood matters. Rural agencies and farmers organizations rarely have energy related capabilities. Power utilities have a limited role at present. To address these challenges, concerted action by all is required.

There are important development needs in agriculture, forestry, cottage and agro-industry, and fisheries that should be seen as clear opportunities for productive use projects. The renewable resources and technologies are largely available. International development agencies are forming new partnerships and industry is getting more involved as well.

Session 1 – Experience from Successful Projects

Chair: Cahit Gurkok, UNIDO

Teodoro Sánchez, Intermediate Technology Development Group, Perú

Aldo Fabris, consultant, Argentina

Jorge Huacuz, Electricity Research Institute, México

Jurie Willemse, E&Co, South Africa

Anand Rangarajan, World Water Corporation, USA

Art Lilley, Community Power Corporation, USA

In many ways, the characteristics of successful productive use projects seem to be quite similar the characteristics of other rural energy projects. In short, the differences appear to be small and mainly are matters of strategy, rather than technology, policy, or financing. Productive use is not mainly an engineering issue, but rather a logistics and organizational issue. Most of all, you need people in local areas who understand local needs.

A very important distinction was made among productive use projects. One type of project can be characterized as self-supply or as providing service to the local community. A second productive use type is characterized by a focus on and production for external markets. The former type can improve lives while the second moves beyond that to productive integration of the rural area into the national or international economy.

Frequently mentioned as a necessary step for success is the ability to perform somewhat different kinds of analysis than is usually seen in rural energy project papers. In particular, there was clear recognition of the need to improve analytic skills with respect to identifying and valuing the stream(s) of benefits in a productive use project. Conventional cost-effectiveness analysis that identifies the least cost solution to water-pumping is simply not the right tool for the task, for example. In productive use projects it is important to understand the benefits and how changes in the structure of the project would alter not only the timing and size of the benefits, but who receives the benefits as well.

At present investment portfolios contain only a few projects that are exclusively composed of productive uses components. However, some existing rural energy projects do contain productive use components and can be the source for lessons learned. For example, the Argentine rural energy concessions support productive uses associated with food processing, communications, lodging, as well as community facilities such as clinics and schools.

A very interesting productive application is the use of efficient woodstoves in peri-urban areas among those who prepare food for sale to others. This market segment was able and willing to pay more for an efficient stove because it was an important component of their business. This commercial segment of the market provided a market entry point for an effort to introduce efficient stoves in the local market--including the household segment.

While the use of renewable technology to provide rural energy service dates to the 1970s or before, the emphasis on serving productive uses is fairly recent. As a result of both the diversity of needs in rural areas and for other reasons as well, there is no standard model that can simply be replicated by others. The diversity of models or approaches to the problem is instructive.

For example, a comparison of the strategy or implementation models presented by Mr. Huacuz and Mr. Willemse shows considerable contrast. The E+Co model presented by Mr. Willemse is focused on the development of energy enterprises that are intended to provide sustainable energy services. The main issues involve financing and the successful operation of the business enterprise. Such enterprises need long-term support to help them implement their business plans. Public agencies, including those participating in the Workshop, need to find low-cost means to support such enterprises. In the E+Co model, the critical success factor is the entrepreneur: A second-grade entrepreneur with a first-grade business plan will not be successful. On the other hand, the implementation model shown by Mr. Huacuz certainly includes financing and institutional development and the technology choices and engineering practices, etc. are explicitly included as well. Clearly it is a matter of focus or emphasis as no one would advocate omitting technology and engineering. At this stage, it is important to resist any force that would prematurely seek convergence on a best-practices model.

Another characteristic of a replicable model emerged from the discussions – the ability to withstand or accommodate institutional transitions such as the shift in focus from installation of hardware to after sales service or when responsibility for the project shifts from one level of government to another. Additionally, common causes of failures are inadequate user training and technical failures in complex systems (e. g., mini-grid PV hybrid systems).

One strong implication of this lack of a single best-practice model is that it can be both more complex and more expensive to design and implement a productive uses project. Donors, lenders, and others must be aware of this fact.

Several specific projects provide valuable illustrations of productive uses success and failure.

Argentina. From 1990-1993 a GTZ project provided market development work to promote the use of Photovoltaic (PV) water pumping. The project installed fifteen PV water pumping stations of 1-3 kWp each. The success of the project was such that between 1994 and 1999, more than 3000 small PV pumps (100-200Wp) were sold by industry in Argentina. In terms of institutional development, several water companies started offering water pumping services as well.

Mexico. Three examples of failed approaches provide many lessons learned. (1) Donor projects for drinking water in the 1980s were not internalized by the community. After an operational test, the intended beneficiaries who were fishermen left the area and resettled elsewhere. (2) A mini-grid system for village power collapsed after two years because the government contract that provided operation and maintenance expired. There was no tariff and metering system implemented to sustain it. (3) An eco-tourism hotel initially won a "green label" prize for its solar hot water and use of photovoltaics for lighting and water purification. The hotel succeeded but the nature of the clientele changed to guests who did not place a premium value the environment. Management responded by permitting the environmental component of the hotel to collapse.

Philippines. A water pumping project is under development to provide potable water to 200,000 people (40,000 households) in 40 municipalities. The willingness of people to pay for water is sufficient to offer the prospect of economic success based on 100% cost recovery using pre-paid smart water cards. Project financing comes from commercial bank loans to municipalities with project revenue providing the loan service. Considerable effort was expended to get the project designed and developed, including the cost of building the community organization that is part of the total cost of the project. It is planned that the first community will be on-line in August 2002. The project developer is covering all the logistical and organizational costs until the revenue stream starts to flow.

Session 2 – International Agency Programme and Project Experience

Chair: Aldo Fabris, consultant, Argentina

Gustavo Best/Peter Steele, FAO

Cahit Gurkok, UNIDO

Patricia Flanagan, USAID

Lawrence Agbemabiese, UNEP

Richard Hosier, UNDP/GEF

Stephen Karekezi, AFREPREN, Kenya

The underlying rationale that supports international agencies shifting to productive uses and away from projects and programs that mainly feature household lighting, is the renewed challenge to make real progress on poverty alleviation.

Field experience indicates that renewable energy projects that address productive uses realize greater success than welfare-oriented initiatives. In particular, small amounts of energy can produce very significant changes in the income of a household if that energy is used (e. g.) for crop drying or water pumping. Additionally, energy can be the key to reducing women's workload.

There are three basic approaches to projects that have been taken by agencies over the years:

- Improved rural energy services can be viewed simply as a means of freeing women from tedious work. In this approach, investments in improved service do not generate additional income for households or firms.
- Improved rural energy services are used to create profitable business activity and local individuals or groups are required to make an investment to create the business and generate the income.
- Improved rural energy services are provided to citizens as public infrastructure that is financed by taxes, grants, etc.

While there are few UNDP and UNDP-GEF productive use projects, many rural/renewable projects in fact contain some support for productive uses. Routine project reporting does not capture the extent to which productive uses are being

undertaken with support of concerned development agencies. There may be a need for additional evaluation and reporting as the economic development value of these investments outweighs the value of the physical energy.

Information on specific projects illustrates the approach taken. Over the past six years, UNDP – initially with assistance from UNIDO – has worked with communities in Mali to develop a Multi-functional platform that uses a diesel engine to supply shaft power to perform tasks such as pumping, grinding, milling, and generating electricity. The units are owned and operated by women’s groups and the savings in labor and improved school work by girls as well as increased income has resulted. UNDP intends to roll out a larger program both nationally and regionally.

Additionally, UNDP has supported the development of water mills as income generating centers. Grinding, oil extraction, and similar shaft-power applications are supported. Income levels have increased by a factor of two to three where the mills have been deployed. MNES has launched a new national program using water mills. A UNDP/GEF funded project in Mauritania used small wind machines to power irrigation, for other household uses and community uses. The project faltered because the business model was not sustainable without on-going donor grants.

UNIDO’s approach to rural energy project design and implementation promotes four kinds of institutional arrangements:

- Business support services
- Industrial partners
- Financial partners
- Research, extension, and forward linkages to markets for transformed goods.

Productive uses, such as crop drying or processing, is particularly important to small scale agriculture and, therefore, is a component of USAID’s program. A selection of projects supported by USAID can be found in *Energy For Life* (The background paper for the workshop included brief descriptions of a small selection of these projects.)

The extensive experience of FAO has shown that it is helpful to distinguish between project objectives and project impacts. From the project design phase forward, it is important to make clear that the task is not to provide electricity, but to provide the services people need for development – for example. Providing energy services that improve the productivity of agriculture can both increase rural incomes and reduce emissions through organic farming or reduce methane emissions from rice production or cattle. (Note: This theme was addressed again in Session 4 in terms of the Millennium Development Goals (MDG) and the selection of measures of accomplishment.)

The Uganda Energy for Rural Transformation Program is one of the first World Bank financed projects (Bank and GEF funding) to combine rural electrification with applications of electricity to health, education, agriculture, water, and SMEs to increase development impact. The project will be implemented in phases over ten years and has recently been approved. Potentially support will include risk-sharing of commercial debt, assistance with low-cost designs. Both pre-investment subsidies and transparent capital subsidies will be provided. Discussion of this project focused on issues encountered in planning the project. Particularly vexing is the simultaneous need to pursue a multi-sector design to achieve progress on productive uses (e. g., energy and agriculture) and at the same time experience clearly shows that multi-sector approaches take more time and are more costly to initiate. (While workshop participants recognized this problem, there was no resolution nor could that have been expected.)

A variety of bilateral donors have supported a mixture of productive use components in rural/renewable energy projects over the years. Water pumping projects probably have been the most common, but there have been significant efforts on crop drying and communications as well. Many projects of bilateral donors exhibit the same traits as were reported by the UNDP and UNDP-GEF projects. That is, while there may be a very small number of productive use projects, there are many instances of productive use components in their rural energy projects. Existing reporting mechanisms make it difficult to isolate the efforts and to learn from them.

Session 3 – Trends for Promising Applications in Agriculture, Rural Industry, Health, Education, Water, and Telecommunications

Chair: Teodoro Sánchez, ITDG, Perú

V.V.N. Kishore, TERI, India

Ron D. White, consultant, USA

Daniel Guidi, consultant, Italy

Chris Rovero, Winrock International, USA

Jeremy Woods, Kings College London

Probably the clearest trend that could be discerned was the increased success in the application of renewables to agricultural and rural industrial tasks. In particular, the use of gasification technologies to provide controllable heat for the drying of food and fibre. Water pumping projects and telecommunications applications were also presented. The chief technological innovations were in biomass gasification where different approaches seem to yield similar benefits. Institutional innovations mainly involve the use of public-private partnerships and increased reliance on micro-enterprises.

That the need is for many small projects rather than a few large-scale projects, such as conventional poles and wires rural electrification, poses problems for both funding and implementing institutions that are mainly unresolved.

A thread that was noted earlier ran through the discussion of these projects: the need for improved analysis of energy demand, willingness to pay, and associated market information pertinent to project design and implementation. The issue is not simply one of applying known tools, but developing better field tools for segmenting and measuring the market for productive use applications. Additionally, the need for more data on the nature and extent of energy use in many existing process was seen as a necessary first step in the process of providing modern renewable energy to such processes.

In India, projects involving biomass gasification in silk and other textile production and processing have been demonstrated to yield a payback in less than six months. Fuel wood as well as conventional fuels, including diesel and kerosene, are displaced and productivity is increased. The units are small-scale and many local entrepreneurs benefit from the projects.

Spice (cardamom) drying, also with gasifiers and no reliance on electricity, yields a higher quality product in a shorter drying period. In this application, the investments pay for themselves in one season. More than eighty-five percent of the beneficiaries are small producers, that own less than two hectares. The drying of rubber, again with gasifiers, also demonstrates the capability to displace conventional energy and deliver a payback of less than one year based on fuel savings. Projects to improve the drying process for mushrooms and other edibles have also shown improvements in product quality and storability, while increasing productivity.

Gasifiers are also used to dry bricks before firing in a kiln. Conventional technology involves both simple atmospheric drying and the use of various fuels depending on weather conditions. The use of the gasifier reduces fuel consumption and associated smoke and decreases the drying time (increasing productivity) while improving working conditions.

The communications needs of rural areas has always been problematic for a number of reasons, including the lack of electric power. Renewables technologies, mainly photovoltaics, have long been a cost-effective solution for many installations, but trends in both technology and costs of information and telecommunication equipment are creating a new round of potential opportunities in many countries.

A new model for telecenters seems to be emerging in Guatemala, Honduras, and Bolivia. The approach is to combine public-service centers with a for-profit telephone service from telecomm providers. The cost of hardware is a critical issue. The need is to lower costs and achieve full usage of shared systems to secure sustainable access in rural areas where about eighty percent of the revenue comes from voice telephone calls. Moreover, telecenters are likely to be sustainable only where they are the main source of telephony. Internet-only service does not appear to be feasible as it is necessary to attract users with the familiar service of telephony first. However, many rural parents are convinced their children will be better off if internet service is available and it is often a usage that is not fully accounted for in the design and market assessment phases. In any case, high-cost, donor supplied systems are not economically feasible for replication. Systems that use laptop computers with lower power demands also require a smaller investment in energy producing hardware.

Growth of the internet, attractive distance learning models, and telecom sector reforms are contributing to the perceived opportunity to design productive use projects with the technology. Better market information for rural enterprises as well as improved know-how for health clinics and a simple demand for improved contact among families and friends are among the uses of improved communications and information flows.

The desire to make services, including radio and video broadcasts, available to low income rural inhabitants brings with it a need for low cost approaches and low cost

technology. Low-energy technologies are inherently important because lower energy demand almost always means cheaper power supply solutions, always an issue with PV. Both potential suppliers and potential customers are in need of technical assistance with respect to design and implementation of the energy supply.

Throughout the Workshop, there were discussions of how best to define a productive use project. Annex One focuses on a definition, but in the context of this session a series of related questions was suggested as a starting place:

- What is the product?
- Will the project reduce the cost of production?
- Will there be an improvement in productivity
- Will it be acceptable to users?
- Is it bankable?
- Who are the people to benefit?
- Can the diffusion occur without major government intervention?

Session 4 – Social Benefits, Constraints, and Participation Strategies

Chair: Elizabeth Cecelski, ENERGIA

Rachel Polestico, Xavier University, Philippines

Roberto Cuevas, Miguel Trossero, and Omar Masera, FAO-Rome

The topics of this section were also discussed in each of the other sessions, since they are part and parcel of good project development. Given the importance of the topics, the organizers also elected to have specific topical presentations in this session as well.

In the Philippines, rural energy surveys showed that the major energy needs were for cooking, lighting, and mechanical power to replace human labor. Thus the technologies promoted include biogas and rice hull stoves for cooking, photovoltaics for street and home lighting, photovoltaics for battery charging and water pumping as well as solar dryers.

Social benefits of these technologies included:

- More convenient cooking, lighting, drying and electrical needs.
- Reduction in the work burden of women (cooking, lighting, home appliances).
- Improved health due to better sanitation (biogas), clean air (PV lighting), better food preservation (solar drying).
- Environmental services such as sanitation, methane burning, reduction in wood cutting.
- Equity by supplying energy to remote areas without grid access.
- Establishing a link to science education by showing practical research and applications to communities.
- Support to "social entrepreneurs" - activists who have gone into selling renewable energy sources, organic food cottage industries, etc.

The major constraint to dissemination of renewable energies in the Philippines is cost. One approach to cost reduction and cost-related constraints involves the increased participation of beneficiaries – specifically:

- Households are willing to contribute to costs as benefits increase and costs decrease
- Use of local materials and labor, bring cost down
- Use of micro-credit improves cost-recovery
- People need product options ranging from the simple to the sophisticated

- Linking renewable energy systems to integrated, diversified and organic farming systems so that farmers can better understand their options
- Introduction of renewable energy systems should not only be done by technical people but should incorporate community organizing techniques, training of local technicians and end users, as well as community-based M&E
- Renewable energy can be very well integrated with other development initiatives such as environmental rehabilitation and preservation, lessening the burden of women, participation of the very poor, and the promotion of peace

In some Latin America and the Caribbean countries 10 to 30 percent of the population are malnourished and development has been further hindered by natural disasters in recent years. A new FAO initiative focuses on the use of wood fuel in the production and processing of food by small and medium industries (SMI), artisans, and households. Among the small and medium food industries fueled by wood in Latin America are bakeries, processors of coffee, cereals, cassava, animal and fish products, sugarcane, salt, tobacco, as well as fruit and vegetable preservation. Energy is a key factor in product quality and safety, productivity, and profits. For example, tortillerias consume 1.4-2.0 kg of wood fuel per kg of corn used, and bakeries consume 0.9 kg/kg of flour.

Part of the project development process is the creation of prototype strategic frameworks on policies, technologies, economic and market information, as well as prioritizing community needs. Directives to improve sustainable and efficient use of bio-energy will be developed to improve the capacity of the users to contribute to environmental protection.

The project design and implementation strategy is to proceed through several steps beginning with characterization of needs, development of strategic frameworks for participation and collaboration, project design, implementation, and evaluation. It was noted that this could be an opportunity for joint gender and energy work together in FAO, given the respective roles of both women and men in the sector.

Food industries are concerned not only with energy efficiency, but also with product quality and safety. In some cases, consumers demand the traditional quality and characteristics of wood fuel-made food products, even in the cities. Food processing and preservation require significant energy inputs and the energy use patterns and competitiveness of the SMIs may need improvement.

In a recent paper, the UK's Department For International Development (DFID) has identified the links between energy services and the Millennium Development Goals (MDG) adopted by the UN. The paper concludes that it is not possible to achieve the MDGs without improved energy services and, in particular, energy is essential to

poverty reduction efforts. (ENERGY FOR THE POOR; Underpinning the Millennium Development Goals)

Frequently energy has been viewed skeptically by other development sectors due to a tendency of those who design energy projects to measure project accomplishments in terms of numbers of installations rather than their impact on measures of development. For example, it is more likely that the number of improved cook stoves deployed would be measured rather than incremental improvements in health from better indoor air quality that the proper use and maintenance of the stoves could provide. In short, too frequently there is little documentation of the impacts of energy technologies on social indicators. At the same time, such benefits do flow from energy projects, for example:

- Education: Women in electrified households in India read more than women in non-electrified households (World Bank)
- Rural development/agriculture: In the Mali Multi-Purpose Platform Project, mechanization of crushing and milling operations has helped triple women's shea butter production (independent impact evaluation)
- Health: Clean cooking fuels in India could avoid 500,000 deaths per year of women and children due to indoor air pollution (WHO estimate)

Additionally, the benefits of energy services often vary by gender. Gender-specific analysis will show the differences in benefits of reduced labor or other social benefit measures. In most cultures, women and men use energy differently and careful project design will document such differences. Women tend to be small-scale, marginal producers, yet their income is often critical to family survival and is used for basic needs like food, clothes, school fees. Women often face social and cultural constraints in accessing new technology as well as credit – e. g., women receive only 10% of small business credit in Africa.

Consequently specific approaches are needed to reach women. Significant benefits for women have been produced, including: increased income, time-savings and enhanced self-confidence from improved ability to support household income and greater control over self-generated finances. One project that has produced benefits for women is the ENSIGN project (Financing Energy Services & Income-Generating Opportunities for the Poor). ENSIGN was implemented in eight countries in Asia in a UNDP-financed project by the Asia-Pacific Development Center. Energy-linked micro-enterprise portfolios were developed in each country that addressed the identified needs of both urban and rural populations. In both rural and urban contexts, process heat and motive power were more crucial to income-generation than lighting. Activities receiving financing included garment-making, embroidery, felt and leather goods manufacturing, welding, baking, cold storage, beauty salon, grain processing, fish drying and powdering.

Another approach that is being used is the Energy, Poverty & Gender (EnPoGen). The World Bank (ASTAE) and ESMAP initiative will generate valuable, replicable good practices for application in future World Bank rural electrification projects. The objective is to develop a management tool for assessing end-user needs and monitoring and evaluating the social development-related impacts with a focus on poverty and gender implications. The effort integrates participatory community assessment and social impact survey methodologies. A feedback loop provides information for community members, service providers, project planners and implementers, and policy makers, as well as conveying information between participatory assessments and surveys. It is useful not only for post-project evaluation, but also for project design and on-going project implementation and assessment.

Social benefits, project constraints, and participation strategies were also considered as a part of project discussions in other Workshop sessions. In those projects the participation of women ranged from being project managers to beneficiary entrepreneurs. Among the more unanimous conclusions were those concerning the difficulty of involving women in projects conducted in male-dominated societies.

Session 5 – Strategies for Project Sustainability and Replication: Economic, Financial and Institutional Viability

Chair: Richard Hosier, UNDP/GEF

Erik Streed, USAID

Todd Johnson, World Bank

Eric Martinot, GEF

Judy Siegel, Energy and Security Group, USA

An understanding of the need for increased sustainability of projects and the need for improved project replicability can be found in the data on rural electrification. Using Ghana as an example, given current population figures (assuming no growth), the current coverage, and rate of new connections, it will take more than one hundred years to electrify the country. For Malawi, it will take more than 2000 years.

Obviously some new approach at a new scale of activity is required.

Productive use projects are more sustainable, from a financial perspective, than conventional energy projects because:

- Income generation is a component of the project and income from the project can pay for its continued operation, maintenance, and expansion.
- Production is easier to finance than consumption.

Financial sustainability can be addressed both in terms of internal financing and external financing. Internal financing, that which is generated as a result of the project activities, is dependent on the factors that normally affect a business, e. g., size of markets, availability of raw materials, labor availability, and a supportive legal environment. Market research and training in business skills are examples of actions that can be taken to improve internal financing. External financing, on the other hand, can mean a variety of grants and loans – including micro-finance.

The documentation on the design and implementation of productive use projects provides scant information on steps that might be (or have been) taken to increase their replicability. Given the extent of the need for productive use projects, efforts should be made to include discussions of replication in project documents.

Sessions 6 and 7- Tools for Development of Productive Use Projects, and Observations, Summaries, Conclusions

Session 6 Chair: Judy Siegel, Energy and Security Group

Session 7 Co-Chairs: Njeri Wamukonya, RISOE and Jeremy Woods, KCL

Both the structure and the content of the text below is the author's summary of the output of sessions six and seven. Session 6 was conducted as a brainstorming session with the participants divided in to two sub-groups for convenience. By design, no closure was sought. Session 7 involved discussion based primarily on observations and issues provided by the co-chairs.

While the largest part of the brainstorming and discussion dealt directly various challenges encountered in project design and preparation, perhaps the most important point was at the conceptual level. That is, productive use projects represent a major change of direction. Their goal is to increase production rather than consumption. The need for new tools, innovative institutions, and new technologies emerges from this substantial re-definition of the rural energy problem.

The remainder of this section is organized into four parts: Design, Implementation, Replication, and Issues.

Design

Productive use projects need to be designed as development projects, not renewable energy projects. The goal of the projects should be to increase income or to improve other measures of economic development (e. g., Millennium Development Goals) rather than access to electricity or the more rapid diffusion of renewable energy technologies.

Energy options should be considered only after taking into account the quality and quantity of energy services that are needed and the opportunity to add value or increase productivity. To best accomplish this step, the project design should be multi-sector or cross-sector. That is, it should include a specific connection between the energy-related activities and a development activity such as food or fibre processing.

Both to control costs and to ensure enduring local participation in the project, the capacities of the local economy to contribute to the project should be clearly assessed.

Local participation in the development of the project as well as the use of in-country goods and services can contribute to project success and lower costs. Established user-oriented methodologies for project design and implementation are available. The FAO rural-centric organization and associated capabilities recommend it as a model and makes a strong case for others to seek to operate in conjunction with FAO on rural projects.

While it is essential to focus on productive benefits and added value, the GEF environmental mandate must also be integral to the design. The overall goal is to achieve real economic development benefits in a truly sustainable fashion, including being in harmony with the natural environment.

In the design phase of the project, consideration must be given to establishing an exit strategy for the proponent. There are numerous instances of unplanned or poorly planned exits causing serious problems with projects, such as failures in after-sales service or insufficient provision of user training. When plans call for a hand-off or a transition between agencies or levels of government, that alone can be sufficient to disrupt or destroy a project.

Implementation

Following on the notion of inter-sector project design, the energy institutions and experts need to communicate fully with other sectors during implementation as well. Consideration should be given to formalizing the relationships between the energy entity and other institutions, e. g., forming partnerships between institutions.

In implementation it is essential to locate the project within the context of existing development plans and to understand how the situation may have changed since the project was designed. Project implementation most often requires the ability to adapt the project to unforeseen events and conditions.

Given the scarcity of well-documented successful experience with inter-sector projects, a template or framework should be developed to provide guidance for project developers and others. During implementation, project management should follow available best practices, such as always having a baseline and continually evaluating against it. Additionally, it was widely recognized that project evaluations should be conducted by an independent organization or expert.

Achieving local ownership of the project should be a high priority. Meaningful participation by the community in decisions is essential. It is equally important to understand that energy experts may not make good entrepreneurs and may not have other skills needed for project success and sustainability.

With respect to funding and financing, project participants must understand the need and desirability of phasing out any start-up subsidies that are involved.

Replication

The project plan should include an explicit component for replication and/or scale up. It is important to capture the lessons learned, both positive and negative. The emphasis should be on transferring methodological, structural, and implementation lessons rather than, for example, descriptions of the technology used.

The goal should be to develop information that would permit others to adapt the project to another institutional setting and achieve replication. Where project success depends heavily on institutional design or adjustments, then that point should be clear in the plan and discussions meant to facilitate replication.

Issues

At the end of the Workshop, as expected, there were a number of unresolved issues that need further work and discussion.

1. Financing.

To what extent can the rural credit entities incorporate productive uses of renewable energy into their portfolios, rather than have renewable energy people trying to do (for example) micro-finance?

2. Product Markets.

When projects improve the productivity of a rural enterprise such that the supply of goods reliably exceeds local demand, how are the links to external markets established?

3. Transition to Demand-Pull Projects.

How do we achieve the transition from the supply-push projects of the past to genuine demand-pull projects that are now understood to be necessary? In addition to the items covered in project design that are also germane here, participants discussed the need for better market analysis tools or frameworks. The market analysis needed for technology-push projects is insufficient to answer key questions about the needs of various market segments, including the poor and women. Rather than supporting

decisions regarding the setting of necessary subsidy levels for each income class, the demand-pull task is the production of analysis for matching needs with a productive technology. Market analysis that does not show the pros and cons of multiple technologies (conventional and renewable) is both not credible to users or project funders and not truly demand-pull.

4. Project Analysis.

Project analysis needs to be carried out using a more complete framework that includes consideration of the costs and benefits of inter-sector cooperation. Prototype methods need to be developed, tested, and made available. Consideration should be given to the use of Socially Responsible Rates of Return, given the nature and intent of the investment. Gender-specific analysis should become common practice as well.

5. Declining Support.

Present trends indicate a general decline in institutional and financial support for both project development and needed research. Both locally and globally, the trend is not positive and new initiatives to promote productive uses must compete with established activities for declining program funds. Therefore, it is prudent to seek to lower costs and increase the efficiency of the project preparation process. In the context of these declining funds, is there a role for networks or other new institutional arrangements in the facilitation of project development? Best practices, standard data, recommended methods, etc. that were derived from experience would seem to be a useful step toward lower cost as well as more efficient and effective project development.

Additionally it may be possible to bring more resources to the task if GEF were to work more with other funding bodies. The GEF relationship with implementing agencies is sometimes unclear and both project developers and GEF itself would benefit from making more information available and creating more transparency in those relationships.

6. What are the options for developing entrepreneurial activity as a part of productive uses? There were presentations in which the creation of private sector entrepreneurial activity was the initial goal of the project (AREED) as well as presentations in which such institutional choice was a second-tier decision and NGOs, private firms, or other institutions took an entrepreneurial role. Is there sufficient experience to define the conditions under which one or another approach is more likely to lead to sustainability or replication?

7. Productive use projects are likely to be small in scale and, therefore, do not fit well with the institutional needs of some lending and technical assistance organizations that were designed to promote conventional rural electrification. What changes need to be made to improve the matching of scale?
8. The benefits of productive use projects often vary by gender. Women and men use energy differently, yet many projects do not explicitly address the different needs or different institutional issues faced by women – e. g., dissimilar access to financing.
9. Existing productive use projects contain scant information intended to facilitate replication. Given the need to achieve replication, project guidelines should emphasize the transfer of methods and implementation lessons rather than simply convey technological issues encountered.

Annex 1 – Toward a Definition of Productive Uses

Throughout the Workshop the participants grappled with the development of a working definition of *productive uses*. While many interesting discussions took place, no closure was reached. Following the workshop some participants provided written material giving their view on the topic. This document is an attempt to blend the Workshop discussions with the written work received from Art Lilley, Njeri Wamukonya, Jeremy Woods, and Elizabeth Cecelski into a working definition of productive uses. None of these persons bears responsibility for this final product.

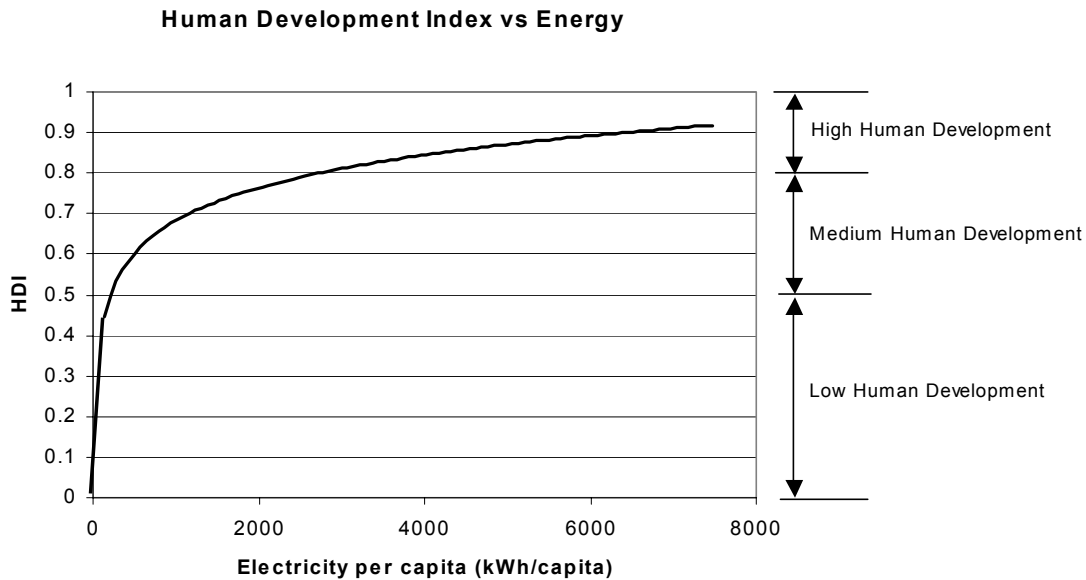
Working definition: In the context of providing modern energy services in rural areas, a productive use of energy is one that involves the application of energy derived mainly from renewable resources to create goods and/or services either directly or indirectly for the production of income or value.

The production of income or value is understood to be achieved by selling products or services at greater than their cost of production, resulting in an increase in the net income of the enterprise or the entrepreneur. Additionally, the definition recognizes that productive applications of energy can either be closely linked or more distantly related to the act of income creation.

This meaning of *productive uses* of energy in terms of poverty reduction or basic economic development is reasonably straightforward. However, the meaning of *productive uses* in the context of human development is more difficult to establish. At the same time, there is little debate that energy per se is important to human development as shown in the graphic below. In fact, the rate at which increments of energy improves the human condition is most dramatic for those at the lower level of human development.

The question becomes: under what conditions does the application of renewable energy to human development turn out to be a productive use? While there are social benefits that accrue from the implementation of a productive use project, when is the reverse true? That is, are there productive benefits that accrue from a project that is largely social in nature?

Human Development Responds Dramatically to Initial Electricity Additions



Source: UNDP Human Development Report 2001

The UNDP Human Development Index (HDI) provides the basis for an answer. The HDI consists of three components: GDP, life expectancy, and education. If an application is credibly linked to one of the major components of the HDI, then it should be considered a productive use. In part the rationale is that people are the most important asset of any productive enterprise and efforts to develop their skills and maintain their health are an important part of the productive process. A use of energy that brings about an increase in the GDP component is obviously a productive use because a direct relationship can be shown between income generation and GDP.

In the case of life expectancy and education, the link is indirect but no less productive. Therefore, an application that directly and obviously benefits life expectancy would qualify as a productive use. For example, energy for a vaccine refrigerator enables immunization against disease. A person immune to disease has an expectation of being more productive as a result of reduced lost time due to illness. People also should expect to work longer and produce a larger return on investments in training as well as increased productivity through more learning by doing. An application that improves education also qualifies as a productive use. For example, education should lead to improved capacity in reading, writing, performing mathematical computations, etc. These skills improve the ability to perform, especially in a modernizing economy.

On the other hand, while applications of energy for home lighting and entertainment may be said to improve the quality of life, their link to the HDI is far less obvious and virtually impossible to quantify. For these reasons, household applications of energy are not considered productive use, even though some may use the energy for income generation or educational purposes. The principal use is not productive in the context of this definition.

Annex 2 – List of Productive Use Applications

The following productive uses were mentioned during the Workshop.

Heating and Cooling

Air conditioning
Commercial Stoves and Ovens
Ice Making
Milk chilling
Refrigeration of medicine
Water heating

Processing

Meat and fish drying
Edible flower drying
Rubber drying
Spice drying
Cereal grain processing
Coconut fiber processing
Gypsum processing
Grain mills
Sawmills
Silk production
Silkworm rearing
Textile dyeing

Water-related

Desalination
Pumping for Irrigation
Pumping for Potable water
Purification

Communication

Broadcast
Cinema
Distance education
Internet
Navigational aids
Receiver
Telephone
Video

Energy Production or Conversion

Battery charging
Gaseous fuels
Liquid fuels

Miscellaneous

Brick making
Carpentry
Cathodic protection
Electric fences
Environmental monitoring
Fish hatcheries
Handcraft production
Power for medical equipment
Sewing
Welding
Wood-working
Workshop – hand tools

Lighting

Community center lighting
Health Clinic lighting
School lighting
Workshop lighting

Annex 3 – Inventory of PV Applications for Sustainable Agriculture and Rural Development

The table below is taken from *Solar Photovoltaics for Sustainable Agriculture and Rural Development* (FAO, 2000), available at <http://www.fao.org/sd/egdirect/egre0057.htm>.

Inventory of PV systems for sustainable agriculture and rural development

TYPE OF PV APPLICATION	TYPICAL SYSTEM DESIGN	EXISTING EXAMPLES
<i>Applications in the agricultural sector</i>		
Lighting and cooling for poultry factory for extended lighting and increased production	50-150 Wp, electronics, battery, several TL-lights, fan	Egypt, India, Indonesia, Vietnam, Honduras
Irrigation	900 Wp, electronics, small DC or AC pump and water tank	India, Mexico, Chile
Electric fencing for grazing management	2 - 50 Wp panel, battery, fence charger	USA, Australia, New Zealand, Mexico, Cuba
Pest control (moth)	Solar Lanterns used to attract moths away from field	India (Winrock Intl.)
Cooling for fruit preservation	PV/wind hybrid systems or 300-700 Wp PV with DC refrigerators (up to 300 lt.)	Indonesia (Winrock Intl.)
Veterinary clinics	300 Wp, batteries, electronics, refrigerator/freezer, 2 TL-lights	Syria (FAO project)
Cattle watering	900 Wp, electronics DC / AC pump, water reservoir	USA, Mexico, Australia
Aeration pumps for fish and shrimp farms	800 Wp, batteries (500 Ah), electronics, DC engine, paddle wheel, for 150 m ² pond	Israel, USA
Egg incubator	panel up to 75 Wp, integrated box + heating element for hatching 60 eggs	India (Tata/BPSolar), Philippines (BIG-SOL project)
Crop spraying	5 Wp, sprayer	India (southern states), but cancelled from product package by BPSolar
<i>Applications in cottage industry</i>		
Tailor workshop	50-100 Wp system with DC lights and electric sewing machine	Several countries (i.e. NREL projects)
Electronic repair workshop	50-100 Wp for DC lights and soldering iron	Bangladesh (Grameen Shakti project) India, Indonesia
Gold jewellery workshop	60 Wp system with DC lights and soldering iron	Vietnam (SELF project)
Bicycle repair workshop	80 Wp system for DC lights and DC small drill	Conceptual: Vietnam - Ha Tinh Province (IFAD project)
Handicrafts workshop (small woodwork, bamboo, basket weaving, etc.)	60-100 Wp system for DC lights and DC small tools	Nepal, Vietnam

Trekking/eco-tourism lodges	Solar lanterns, SHSs and larger PV systems for lights and refrigeration	Nepal, India, Peru, Trinidad and Tobago
Pearl Farms	0.4 - 1 kW PV systems to power craft workshops with drills, pumps, lights & compressor	Examples in French Polynesia (Solar energy)
<i>Applications in the commercial service sector</i>		
Village cinema	100-150 Wp system with DC lights and Colour TV + VCR or satellite	Dominican Republic (ENERSOL project), Vietnam (Solarlab), Honduras
Battery charging stations	0.5 - 3 kWp systems with DC battery chargers for kWh sales to households and micro-enterprises	Morocco (Noor Web), Philippines (NEA), Senegal, Thailand, Vietnam (Solarlab), India, Bangladesh
Micro-utility	50 Wp, electronics, battery, 5 -7 TL ("rented out")	India, Bangladesh (Grameen Shakti project)
Rent-out of solar lanterns for special occasions (weddings, parties, reunions)	Solar lanterns (5 - 10Wp)	India (NEC) as part of a youth programme
Lights, radio/TV and small appliances such as blenders for restaurants, shops and bars	20-300 Wp, electronics, battery, appliance, inverter (if necessary)	many countries, incl. Karaoke bar in Philippines (NEA)
Trekking/eco-tourism lodges	Solar lanterns, SHSs and larger PV systems for lights and refrigeration	Nepal, India, Peru, Trinidad and Tobago, Mexico
Cellular telephone service	A 50 Wp System with 2 lights and a socket to charge cellular phone batteries	Bangladesh (Grameen Shakti project)
Computer equipment in rural offices	8- 300 Wp systems powering lights, fax, TV, etc.	Bangladesh, Costa Rica, Chile
Internet server for E-commerce	Integrated in multifunctional solar facility (> 1 kW)	West Bank (Greenstar project)
<i>Applications for basic social services</i>		
Health clinics	150-200 Wp, electronics, deep-cycle batteries, small refrigerator/freezer	Many countries (WHO standards)
Potable water pumping	1 - 4 kWp, electronics, pump, reservoir (generally no batteries needed)	Many countries, e.g. large project in Sahelian countries (EU-project)
Water purification	PV to power UV or ozone water purifiers (0.2-0.3 Wh/litre)	Many countries, e.g. China, Honduras, Mexico, West Bank
Water desalination	1 - 2 kWp needed to power reverse osmosis or other water desalination units for 1m ³ per day	Italy, Japan, USA, Australia, Saudi United Arab Emirates
Internet server for telemedicine	Integrated in multifunctional solar facility (> 1 kW)	West Bank (Greenstar project)
Schools and Training centres	PV systems for powering lights, TV/VCR, PCs	many countries: China, Honduras, Mexico, the Philippines,
Street light	35/70 Wp, electronics, battery, 1 or 2 CFL	India, Indonesia, the Philippines, Brazil

Annex 4 – List of Interventions

Information

- Compilation of relevant lessons learned
- Information programs to address specific barriers or audiences (e. g., bankers)
- Renewable resource base assessment
- Review of technological options
- Review of relevant existing policies

Technical Assistance and Training

- Best practices manuals
- Business skills training
- Conduct project-specific research and development
- Design guidelines
- Establish multi-sector contacts and working arrangements
- Laboratory testing
- Market analysis and advice
- Marketing assistance
- Project management training
- Technical training
- Test marketing

Policy Innovations

- Consumer protection
- Create new institutions
- Equipment standards
- Open restricted markets
- Reform existing institutions
- Strengthen transparency and anti-corruption measures

Financial

- Bank credit for small rural entrepreneurs or other institutions
- Loan guarantees
- Micro-credit to end-users
- Seed funds
- Subsidies and subsidy removal

Pilot Projects

- Design for scale-up and replication
- Project risk assessment and mitigation
- Independent project evaluation

Annex 5 – List of Participants

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