Productive uses of renewable energy
A Review of Four Bank-GEF Projects

Kamal Kapadia
Consultant

January 2004

INTRODUCTION

Promoting the productive uses of energy is an important aspect in the design and implementation of rural energy projects generally, and renewable energy projects more specifically. Projects with a "productive use" focus or component have developed in recognition of the fact that the provision of energy in itself is not the end-goal, the development service it enables is. Promoting "productive uses" in essence, is an attempt to make the energy input work directly and effectively for rural economic development.

This paper aims to analyze the World Bank's approaches to promoting productive uses of renewables, with a view to providing recommendations to the Bank on strategy on this given topic. It is by no means a comprehensive review of productive use projects and experience. The goal is to highlight the need for more rigorous study of some of the issues raised. This would help improve the chances of project success.

The introductory section explains what exactly productive uses of energy are, and why promoting productive uses is considered important.

The second section consists of an analysis of four Bank/GEF projects that either have an explicit goal of promoting productive uses of renewables, or have such a component built into a larger project. These case studies are used to highlight different approaches within Bank and GEF projects to promoting productive uses of renewables. It is difficult to determine the types of outcomes these projects will lead to since they are in early stages of implementation and no impact studies exist. However, using an analytical framework consisting of four parameters, namely the impact of the project on productivity and welfare, equity, and the environment, and opportunities for scaling up productive applications, I analyze the limited experience for possible outcomes is analyzed. This is with a view to highlighting some issues relevant to project design and implementation that need further attention. These issues have to do with governance and political trade-offs in multi-sectoral projects, technology selection, and the role of the GEF.

The last section draws from the case study analysis to provide recommendations on how the Bank and GEF can address these issues.

Promoting Productive Uses of Renewables: Definition and Rationale

What are "productive uses" of energy?

Quite simply, "productive uses" of energy involve the utilization of energy – both electric, and non-electric energy in the forms of heat, or mechanical energy - for activities than enhance income and welfare. These activities are typically in the sectors of agriculture, rural enterprise, health and education. Examples of such activities are pumping water for agriculture, agro-processing, lighting, information and communications, and vaccine refrigeration. Box 1. provides a more detailed list of productive activities.

It should be noted that the distinction between "productive uses" and "consumptive uses" is by no means clear-cut. Replacing electric lights with kerosene lamps in a house may not appear to be a productive use, as it is difficult to measure economic gains that result from this1. However, there is no doubt that these gains exist. They range from improvements in health as people stop inhaling harmful fumes from kerosene lamps, to less economically tangible, but equally important benefits that people get from having better lights by which to read and work.

Why promote productive uses of energy?

While this paper is about the productive uses of renewable energy, the rationale for its promotion is no different than that of promoting productive uses of energy more generally. There is nothing unique about renewables in this context, except that it offers environmental benefits over fossil-fuel sources and that there are international financial resources available for renewable energy development. The rationale then for promoting the productive uses of energy – be it a fossil fuel source or a renewable energy technology – is based on three goals:

To maximize the economic and social benefits that access to energy can catalyze

Till recently, most rural energy projects have focused on the delivery of electricity, or other energy services based on the assumption that economic development will follow. Indeed, there is no dearth of evidence to support the transformational effects that electrification, and easy access to clean and efficient forms of non-electric energy (in the forms of heat and mechanical energy) can have on rural communities. A Bank-funded literature review on infrastructure and poverty linkages (World Bank, 2002) provides hundreds of documented examples of how access to reliable electricity and other modern energy sources increase economic opportunities for the poor in multiple ways.

However, enough evidence also exists to support the fact this causal relationship does not always hold. While access to reliable and modern forms of energy is a prerequisite for economic development, it is not always a sufficient condition. Energy is only one input to the development process, and in and of itself is not enough to spur rural economic development. Bose, in her socio-economic study of electrification and development in India discusses the complexities involved in making electricity work for development. While acknowledging that the "potential impact of rural electrification on an underdeveloped, largely agrarian economy is widely acknowledged to be nothing short of revolutionary", she also points out that these outcomes do not always materialize (Bose, 1996: 2). Barnes also demonstrates how "rural electrification by itself will not act as a stimulus to development without supporting programs or favorable socio-economic conditions." (Barnes, 1988: 203)

It is easy to understand why this is so given that what people really need is not energy or electricity per se, but energy for a particular application or need, such as lighting, or pumping water, or running a motor. The energy input in such a context is therefore only one aspect of a set

[1] While this is true, increasingly sophisticated methods are being developed for measuring economic gains and consumer surplus benefits of electrification – in education, health and at the household level. See Barnes' work on measuring social and economic benefits of electrification in the Philippines in ESMAP Report No. 255/02 (2002).

of factors that need to come together for a person, or community to experience economic development. For example, supplying electricity to a community that does not have a reliable and regular supply of water is unlikely to make a large difference to agricultural productivity. Further, even if water is available, that community may not have easy access to markets, or may not have access to credit to purchase other inputs like pesticides or farming equipment.

Some of these other factors may in themselves improve once a community has access to reliable and modern energy. For example, rural health services may be of poor quality because it is hard to attract doctors to rural areas. If electricity were made available, doctors may be more inclined to live in remote locations. However, whether or not doctors are willing to work in remote locations also has to do with other factors like whether or not they are paid well, and whether medicines and other supplies are available at rural health clinics.

The fact that the delivery of electricity, or energy services does not always lead to economic development implies that some additional intervention, or efforts are needed in this area. Focusing on productive uses involves the development and implementation of these interventions, since the end goal of a productive use project is economic development, and not simply delivery of an energy service. In essence, energy projects with productive use components are more likely to lead to rural economic development than projects that simply focus on the provision of electricity, or other forms of energy.

The Bank has developed some innovative approaches to enable productive uses of energy. We discuss the positive aspects and limitations of these approaches in Section 2 of this report.

<u>To facilitate the achievement of the Millenium Development Goals</u>
The Bank is committed to help achieve the Millenium Development Goals (MDGs). Access to energy is an essential component of all the MDGs, however, is not an explicit goal in itself. From the Bank's perspective, incorporating a 'productive use' focus into energy projects allows the Bank to do energy projects that are more likely to help achieve the Millennium Development Goals. The linkages between energy and energy technologies, productive applications and the MDGs are laid out in **Box 1**. Energy is an essential input to all the 'applications' listed. The ability to carry out the activities listed under 'applications' leads to a variety of positive development 'impacts', all of which are essential for achieving the MDGs.

Take for example the goal of improving maternal health. In developing countries, the risk of dying during childbirth is one in 48 (UNDP, 2003). Improving maternal health calls for many interventions, such as providing women with access to better nutrition, education, training of rural midwives, and critically, access to improved rural health facilities. Energy plays an integral part in improving rural health facilities. A health facility needs electricity for lights, for the refrigeration of vaccines and medicines, for conducting laboratory examinations like blood tests, and for communication facilities, like a telephone. It needs heat or electricity for sterilization of equipment, for heating water (and space, in cold countries). Trained staff is also more likely to want to work and live near a health facility that has access to electricity.

Renewables specifically play an important role in helping achieve the goal of ensuring environmental sustainability. In this context, projects that promote the productive uses of renewables offer an obvious area of *synergy between development and environmental goals,* and therefore between the World Bank and GEF's goals. Promoting the productive uses of RETs will help meet local and national development needs of a country, in ways that are beneficial to the local and global environment.

<u>To improve economic sustainability of rural electrification projects and renewable energy markets</u>

Since demand for electricity in rural areas of developing countries typically tends to be very low (often under 50kWh a month), it becomes difficult to justify (on economic grounds) extension of the grid to many rural regions. This is because the size of electricity demand or load is an important factor in determining the economic viability of a grid extension scheme. The higher the demand (and willingness-to-pay) for electricity, the better the viability of the scheme.

Combining grid extension projects with interventions designed to promote productive uses of electricity helps stimulate demand, and thereby expand the potential area that can benefit from grid extension, by improving the economic viability of the grid extension scheme. This works in two ways: first, productive activities typically require larger quantities of electricity than household uses do, and second as productive activities stimulate an increase in income, people are likely to consume more electricity – for both household and productive activities.

Similar arguments hold for rural renewable energy markets:

First, since the goal of the intervention project or program is to increase productivity and augment income, rural people are likely to find it easier to *access finance* for purchasing RET (along with other equipment needed for income-generating activities, like a water pump, or threshing machine). In general, rural credit agencies are often reluctant to provide loans to rural people for purchases that do not obviously appear to lead to increased income. Solar home system markets are a good example of this, where the benefits often tend to be financially intangible, and many rural financing agencies are unwilling to lend for what they perceive to be ostensibly 'household' or 'consumptive' purposes. Lending for productive activities, however, is what rural credit agencies are set up to do.

Second, as people's incomes rise, their demand for energy services is likely to rise too. This creates attractive market conditions for RET dealers and vendors. RET companies are more likely to establish and expand their operations in rural areas if they see an increasing demand for their energy services, and customers returning to purchase larger systems and more services. These customers could be rural people, but could also be the government or NGOs that purchase larger systems for schools, health clinics, and communications facilities. Large contracts with the government can create attractive conditions for RET companies.

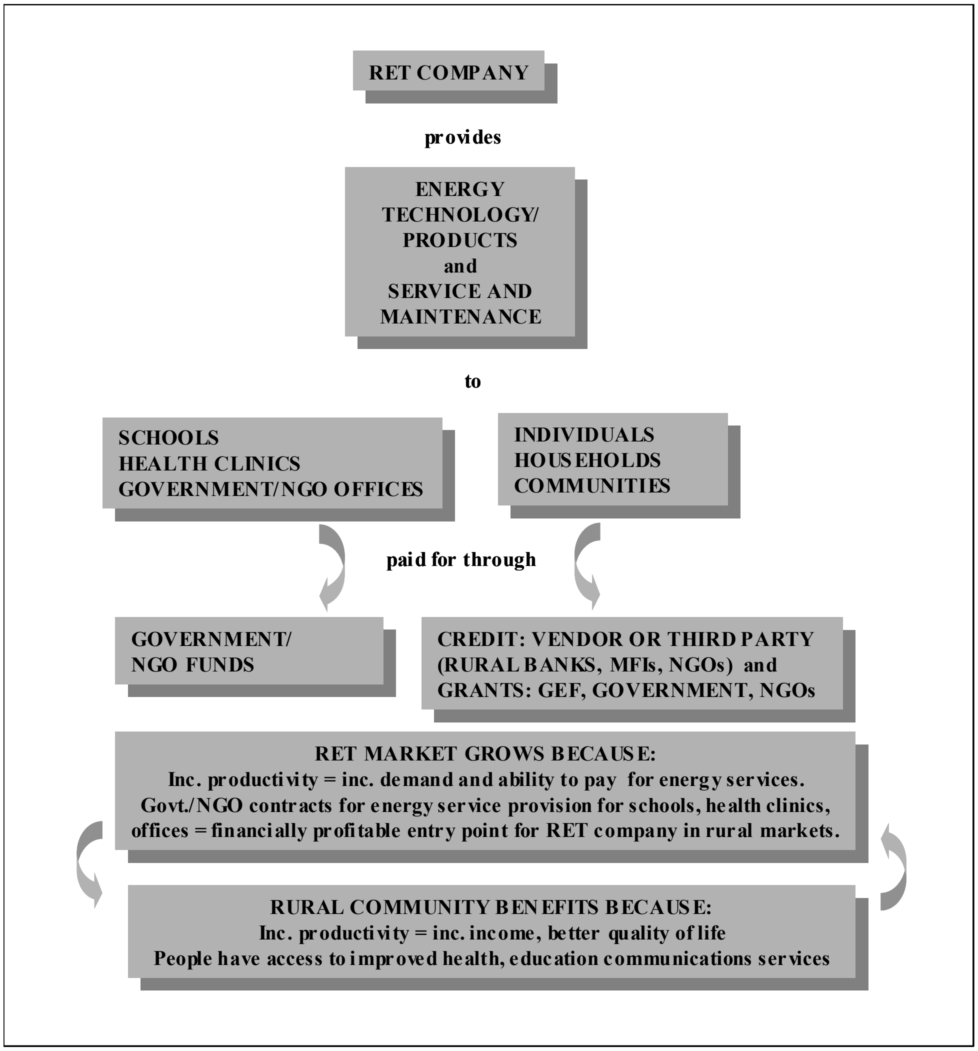
Box 2. attempts to demonstrate how a framework of promoting productive uses of renewables can improve rural welfare and help RET market growth in mutually reinforcing ways.

Box 1. The linkages between energy, productive applications and the Millennium Development Goals. List of applications are reproduced from White's report on the GEF/FAO Workshop on productive uses of renewable energy (2002). The list of impacts is taken from Brenneman's literature review on infrastructure and poverty linkages (2002).

ENERGY TYPE	TECHNOLOGY/FUEL TYPE
ELECTRICITY	GRID Fossil/renewables MINI-GRIDS Diesel generators Small hydro Small wind Biomass - combustion/gassification Hybrid - diesel with PV/wind/biomass STAND-ALONE SYSTEMS Solar PV Biogas Diesel generators
NON-ELECTRIC ENERGY	SHAFT/MECHANICAL ENERGY Wind Water wheels HEAT ENERGY: REGIONAL Piped NG/producer gas HEAT ENERGY: COMMUNITY Biogas Biomass gassification/combustion Solar thermal HEAT ENERGY: STAND-ALONE LPG Biogas Solar thermal Passive solar design

APPLICATIONS	
HEATING AND COOLING Air conditioning Commerical 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 fibre processing Gypsum processing Grain mills Sugar production Saw mills Silk production Silkworm rearing Textile dyeing and weaving WATER RELATED Desalination Pumping for irrigation Pumping for potable water Purification ENERGY PRODUCTION AND CONVERSION battery charging Gaseous fuels Liquid fuels	COMMUNICATION Broadcast Cinema Distance education Internet Navigation aids Receiver Tepephone Video MISCELLANEOUS Brick making Carpentry Cathodic protection Electrc fences Environmental monitoring Fish hatcheries Handicraft production Power for medical equipment Sewing Welding Wood-work workshop - hand tools LIGHTING Community center lighting Health clinic lighting School lighting Workshop Lighting Home lighting

IMPACTS	MILLENIUM DEVELOPMENT GOALS
Increasing productivity of businesses owned by or that employ the poor Facilitating establishment of businesses that employ the poor Lowering costs of energy Increasing literacy and time for reading because of improved lighting Increasing household income and decreasing time spent on collecting traditional fuels, this increasing time for children to spend on education and increasing likelihood of school attendance Empowering women Reducing respiratory illness because of cleaner fuels Improving delivery of health care Reducing household accidents like burns or poisoning Reducing incidence of food and water-borne illnesses due to increased boiling of water and refrigeration of food Reducing fertility Reducing time and efforts to gather wood/biomass Improving access to information (via radio, telecom, etc) Improving standards of living	Eradicate extreme poverty and hunger Achieve universal primary education Promote gender equality and empower women Improve maternal health Combat HIV/AIDS, malaria, and other diseases Ensure environmental sustainability Reduce child mortality Develop a global partnership for development



Box 2. Schematic representation of how ‘productive use’ projects can enable RET market growth.

DESIGNING AND IMPLEMENTING RENEWABLE ENERGY PROJECTS WITH PRODUCTIVE USE COMPONENTS: ANALYSIS OF DIFFERENT APPROACHES

This section reviews approaches followed by four different Bank/GEF projects to promote the productive uses of renewable energy. It should be pointed out that there are more than four rural energy projects in the Bank's portfolio that have a 'productive use' component built into their design. However, these four projects were selected because they are all under implementation, represent a variety of different approaches and project scales, and offer useful insights for developing new projects that promote the productive use of renewable energy.

It should also be noted out that there are NGOs like Winrock and Intermediate Technology Development Group (ITDG) that have been doing projects for several years that could be categorized under the generic description of promoting productive uses of renewables. They emphasize the importance of project design and implementation approaches that are participatory and based on an in depth understanding of peoples' needs. The Bank has implemented projects with the involvement of these organizations: of the four projects reviewed here, the Renewable Energy for Agriculture Project in Mexico was developed from work initiated by Winrock. In Sri Lanka, ITDG played a key role in developing the village hydro sector, and is now a stakeholder in the Renewable Energy for Rural Economic Development Project, also reviewed here.

Traditional grid extension projects have also begun to include components to promote productive uses. While analyzing grid extension projects is not the focus of this study, we draw on lessons from a grid extension project in Bangladesh where applicable.

Since the inclusion of productive use focuses or components in renewable energy projects in the Bank and GEF is a recent phenomenon, it is not possible to conduct any sort of impact evaluation. Of the four projects reviewed, the project in Uganda has just entered the implementation phase, the project in Sri Lanka has completed one of 5.5 years, the project in Mexico is about mid-way through its time frame, and the project in China is nearing completion. However, no impact studies exist for any of these projects yet because none of the projects are completed.

Given this, a detailed analysis of project design or performance is not possible. This section therefore is focuses on three goals:

1. It provides a description of different approaches taken by different projects,
2. It uses a conceptual framework based on four parameters –impact on productivity and welfare, on equity, on the environment, and scale-ability - to analyze current problems these projects face (based on discussions with project managers), and *potential* problems these projects may face (based on study of project documents and other literature).
3. Based on this, this section points to some aspects of productive use projects or component that need further attention, and provides recommendations on some possible ways for the Bank to address these issues.

The four parameters selected are fundamental to any development project. To achieve the Millenium Development Goals, projects need to explicitly help improve productivity and welfare, reduce global and local inequities, improve global and local environmental quality. Further, since the goals are so ambitious in their scope, and development funds comparatively limited, it is essential that projects be designed to be self-sustaining and scaleable. Again, since actual experience is limited, not all projects offer insights on how their particular design or approach does, or may affect productivity and welfare, equity, environmental quality and whether it is conducive to scaling up. It is therefore not possible to produce any sort of 'matrix' of outcomes. Instead, the approach taken is to use relevant examples from experience that exists to demonstrate why certain aspects of project design are identified as needing more attention, and to offer recommendations on ways to proceed with these issues.

Box 2. Summary of projects reviewed

	Uganda Energy for Rural Transformation	Mexico Renewable Energy for Agriculture	China Passive Solar heating for Rural Health Clinics	Sri Lanka Renewable Energy for Rural Economic Development
Goals	1. To develop Uganda's rural energy and ICT/communications technologies sectors. 2. To facilitate a significant improvement in productivity of rural enterprises and quality of life of rural households.	1. To provide un-electrified farmers with reliable electricity supply for productive purposes in a least-cost and sustainable manner. 2. To increase their productivity and income by supporting the adoption of productive investments and improved farming practices.	1. To stimulate health sector and other community facility planners to adopt passive solar building designs. 2. To strengthen capacity of architectural and engineering design institutes to design and build energy-efficient passive solar buildings. 3. To demonstrate the life cycle cost advantages of energy efficient passive solar buildings in China. 4. To reduce CO2 emissions.	1. To invigorate the rural economy, empower and build assets for the poor and promote rural economic development and well being. 2. To support private sector and community-based devlp. models, and help develop initiatives for productive use of electricity to increase rural household incomes and improve the delivery of rural social services, such as health and education.
Costs and funding sources	*Total = $ 439.3 (phase 1 total = $123.3M)* IDA = $165.2M Others (inc. GEF, bilateral. Govt. and commercial sources) = $274.2M	*Total = $31.3M* IBRD = $13.6M, GEF = $8.9M, Govt of Mexico = $1.8M, Beneficiaries = $6.9M	*Total = $1.6M* GEF = $775,000 Others = $809,000	*Total = $133.7M* IDA = $75M, GEF = $8M, others (including commercial, govt. sources) = $50.7M
Time-frame	10-yr program, 3 phases. 1st phase launched 2003.	4 years, launched in 2000.	2 years, launched in 2000.	5.5 years, launched 2002.
Number and types of RET installations	1. Health – 1358 systems (majority solar PV) 2. SHS – 7496 systems 3. Other targets to be identified during Phase 1.	1. 1,150 solar water pumps 28 states 2. 55 wind-powered pumping 3. 24 solar-powered milk storage tanks.	1. 30 township health centers with passive solar design features incorporated.	85,000 household SHS and 1000 community, commercial and institutional solar PV systems 60-65MW of grid-connected mini-hydro capacity 30MW of grid-connected wind energy 12-15 MW of grid-connected biomass energy.
Implementing agencies/ organizations	Rural Electrification Agency and Board, Ugandan Ministries of Finance, Health, Education, Agriculture, Information and Communications, local NGOs.	National Govt. Agriculture Extension agency – Alianza.	Ministry of Health.	Development Finance Corporation of Ceylon, with involvement of private sector, NGOs, rural credit agencies, provincial governments. and Ceylon Electricity Board.

Description of Projects

Uganda: Energy for Rural Transformation (Uganda ERT)

The Uganda Energy for Rural Transformation project is an innovative, cross-sectoral project focused on productive uses. This is not a renewable energy project per se, a key feature of this project is that it is 'technology-neutral', in that selection of energy technology is based on selecting technologies to match energy needs of communities and regions in the most economically efficient way. The project also aims to address issues of scale-up of rural energy services by focusing on developing appropriate policy, institutional and regulatory capacity in the country. While initiated by the energy sector in the Africa region, the primary strategic choice is to stretch the project beyond the energy sector to focus on rural transformation. The premise is that energy and information and communications technology (ICT) together can help in rural transformation by: 1. improving agro-processing potential by providing electricity essential for agricultural production, storage and processing. 2. increasing access to market info through information and communications technologies.

The project has 3 phases: the first phase involves developing the requisite framework (regulatory, financial and institutional) and limited investment. The aim is to create the capacity for commercially-oriented, fully sustainable delivery of rural/renewable energy and ICTs. The second stage intends to continue building momentum for investment, and continue capacity building. This will involve mainstreaming of successful pilots, and fine-tuning of the framework. The 3rd and final phase will focus on rapid scale-up and consolidation of institutional build-up.

The cross-sectoral aspect of the project means that the energy/ICT component will be implemented through non-energy sectoral agencies in the country. These include:
1. Health –to facilitate the goals of the Uganda national minimum health care package by providing energy for medical equipment, staff quarters, lighting, cold chain, sterilizing and telecom. At the national level, the Ministry of health will promote and execute energy-related investments in their sector. Consultant assistance will be provided in energy package design and implementation.
2. Education –links mainly to post-primary education, where energy and ICT have potential for significant impact – e.g. powering equipment for vocational training, lighting for night classes and staff housing.
3. Water – this project is linked to the rural water strategy to provide energy for water pumping.
4. Small and Medium Enterprises – links in form of technical assistance where enterprises with motion-intensive processes will be assisted to switch over to electricity, and heat-intensive enterprises like fish smoking lime production and eating houses will be assisted in inc. energy efficiency of operations.

The project also provides supports for the solar home system industry, which already exists in rural Uganda.

Mexico: Renewable Energy for Agriculture (Mexico REA)

Only 5% of Mexico's population lacks access to grid-based electricity, this is still quite large in terms of absolute numbers, though, amounting to 5 million people. This includes 600,000 livestock farmers. The Mexico Renewable Energy for Agriculture project, initiated by the agriculture and rural development sector in LAC is a separate WB/GEF project, but closely linked to a larger existing Bank-funded agriculture extension and development program. Some 460-480 solar powered water-pumping systems have already been installed, and the mid-term review of the project is planned for the latter half of 2003. The systems were initially planned to provide water for cattle, but are also used being used by ranches for growing forage and some crops, and for horticulture in some areas. Other planned applications include refrigeration for milk and fish, and ice-making for fishermen.

An important aspect of this project is that the training and capacity building for farmers and field-level project implementers is focused on production and not on technology. Training is also provided on installation and maintenance of the systems, but the primary focus is the productive use training.

This project aims to scale-up a USAID/USDOE-funded demonstration project, which resulted in the installation of 108 solar-powered water pumps, and identified a number of barriers to the use of renewable energy for productive agricultural uses. The current World Bank/GEF project aims to remove these barriers by a) implementing a nation-wide promotion campaign to increase farmers' awareness of renewable energy systems; b) building the capacity of technicians and agricultural extensionists through training; c) introducing technical specifications and certification procedures for farm-based renewable energy equipment; d) carrying out studies on the potential market and applications for renewable energy in Mexico's agriculture sector; e) installing renewable energy systems (such as solar- and wind-powered pumps, solar-powered refrigerated milk storage tanks, etc.) on selected farms as demonstration units to reduce other farmers' perceived risk; f) supporting the proper operation of these renewable energy systems through the provision of on-going technical assistance to participating farmers by trained extensionists; and g) testing innovative vendor financing mechanisms for farm-based renewable energy systems in four states.

The most important strategic choice has been to manage and implement the project through a national government-level agriculture and rural development initiative – Alianza par el Campo Program, which promotes improved agriculture productivity and production. Alianza is established, well-run, and supported by government and farmers. Another strategic choice is to finance the non-grant component of these installations through vendor financing; the results of this approach are yet to emerge.

China: Passive Solar Heating for Rural Health Clinics (China PSHRHC)

While passive solar design is not as much a renewable energy 'technology' as is it an architectural design and building technique, it performs a similar function as renewable energy, in that it reduces the use of conventional fossil fuels, and in this particular context performs the very productive use of substantially improving quality of health services in rural China.

The GOC is currently undertaking a major program of reconstruction and rehabilitation of rural health clinics under the Three-Items Construction Program and the Health VIII Project. Many of the earlier health clinics constructed under this program experience severe heating problems, especially in the cold provinces of Qinghai, Gansu and Shanxi, where coal is expensive and not locally available. Due to erratic supply and high costs, the clinics are often too cold to provide adequate health services. The technical consultant hired for this project reported that temperatures inside many of the clinics were the same inside as outside during the winter months. Clinics where coal is burnt in poorly-designed stoves have very high carbon monoxide and particulate matter levels indoors, even in operating theatres, where coal is burnt to boil water to sterilize medical equipment.

Three prototype passive solar health clinics built under an ASTAE-supported project have been monitored for a number of performance indicators like indoor temperature, reduction in energy use, indoor air quality etc, and based on the satisfactory performance of these designs, the current projects aims to develop capacity within agencies designing and building health clinics to incorporate passive solar components into their designs, and build 30 such centers.

This project consists of 5 major components:

1. Design and technical assistance where an international passive solar consultant will work with 3 design teams and the architectural consultant for the Health VIII project to develop standard design prototypes.
2. Construction of demonstration clinics
3. Monitoring and evaluation
4. Outreach, promotion and training
5. Capacity building for architects, engineers, officials and administrators, including workshops for training local trainers.

Sri Lanka: Renewable Energy for Rural Economic Development (Sri Lanka RERED)

The Sri Lanka Renewable Energy for Rural Economic Development Project's objectives include the invigoration of the rural economy, empowerment and asset building for the poor and the promotion of rural economic development and well-being. Over 50% of rural Sri Lanka lacks access to grid-based electricity. The Project will support provision of electricity and socioeconomic improvements in rural areas through:
(i) grid-connected and off-grid hydro, wind and biomass renewable energy technologies; (ii) financing and grant mechanisms for solar home systems and other solar energy applications in rural areas through private companies, NGOs and MFIs; (iii) technical assistance for income generation and social service delivery improvements based on villages' access to electricity; and (iv) technical assistance to promote energy efficiency, development of carbon trading mechanisms and integration of renewables into government policy, provincial council development strategies and sector reform initiatives.

The project attempts to build on the success of a prior World Bank/GEF-funded project – the Energy Services Delivery (ESD) Project. The ESD project was a successful renewable energy commercialization project. It resulted in the creation of vibrant markets for solar home systems, and grid-connected and off-grid village hydro systems, and the installation of a demonstration wind farm. Approximately one dozen solar and micro-hydro developers now operate in rural Sri Lanka, assisted by 6 financing agencies which extending credit for solar PV and mini-hydro installations. There is also a well-functioning quality assurance system in place, and a transparent tariff setting mechanism that the Ceylon Electricity Board utilizes to enter into power purchase agreements with renewable energy project developers. This project has generated considerable awareness about renewable energy in the country, and is supported by the national and some local government agencies (International Resources Group, 2003).

Both the RERED and ESD project before it operate almost entirely through the private sector, NGOs and non-governmental rural banks and credit agencies. Some provincial-level governments also participate in the project by providing a matching grant to residents of these provinces who purchase or connect to RETs.

Discussion on nature and types of interventions pursued
It is immediately apparent that there is no one model or approach to designing interventions that promote the productive uses of renewables.

The four projects reviewed illustrate this; they operate at different scales and through different types of institutions. Both the Mexico and China projects operate entirely through government agencies. While the Mexico project is largely a demonstration project, the China project is focused on capacity building and incorporation of passive solar design into the health clinics building standards. The Uganda ERT project involves large-scale transformation in the energy sector, including the creation of a new rural electrification agency, and works largely with government agencies. It also intends to support market-based efforts for RET dissemination. Finally, the Sri Lanka REREDP is mainly a market-based project: the stakeholders are private sector players, NGOs and community organizations. However, it is anticipated that the health and education components of the REREDP will be implemented through government agencies.

In spite of these differences, some aspects of project design are common. Again, I restate the caveat that making judgments on these projects should be reserved for when more is known on actual impact of these projects. However, the limited evidence and experience that exists seems to suggest that there are sound reasons for these common aspects. Discussing them helps to illustrate the fundamental building blocks of energy projects designed to promote productive uses.

The projects involve multi-sectoral activities

Promoting productive use applications of energy necessarily seem to involve non-energy sector agencies or organizations. This is hardly surprising, since energy, or electricity is only one of the inputs needed to stimulate or improve a productive application, and other inputs, such as delivery of water, ability to purchase equipment such as a water pump, would necessarily mean that agencies or organizations involved in rural water management, and agricultural development would need to be involved.

In the case of Mexico, a governmental agricultural development agency – Alianza – is the implementing institution. In Uganda, the program aims to develop coordination between the government agencies responsible for the design and implementation of health, education, information and communications, and agricultural development programs, and a new rural electrification agency that will be created under the auspices of this project.

Different types of intervention are pursued for health and education applications vs. for stimulating agricultural productivity and SME development

While multi-sectoral activities seem to be generally required, the types of interventions pursued for stimulating use of energy in health and education sectors are different from those pursued in for promoting agricultural production and SME development.

When it comes to health and education applications, involvement of government agencies, or large NGOs seems to be key, if they are to be provided with energy services on a large-scale. This is largely because provision of health and education in rural areas is a public service, and all decisions related to improving the quality and type of services of schools and health clinics are taken by a public agency, often with the involvement of large NGOs like WHO, or UNDP. Investment decisions not made by individuals or individual schools or health clinics, further since these institutions provide either free or highly subsidized services, they do not have funds at their disposal. Even in Sri Lanka, where both the ESD and RERED projects have been implemented entirely through non-governmental organizations in the private and NGO sectors, promoting the use of renewable energy systems for rural schools and health centers necessitates the involvement of the relevant government agencies.

Project managers have noted that a key component in promoting the use of energy for health and education purposes is creating awareness in health and education agencies, and NGOs working in these fields about the opportunities available to them to provide energy to their rural schools and health facilities. For the most part, these agencies do not consider they have any options open to them to address these needs themselves, or even in coordination with the energy agency in the country. Sectoral boundaries are notoriously difficult to break through, both within in countries and in the Bank. Education and capacity building in non-energy sectoral agencies are therefore important components of these projects.

In general, the approach followed by Bank projects has been to hire consultants who understand how both the energy and health, or education aspects of the project. Their task is to work out the details of the above-mentioned needs, performing a cross-linking task between health and education agencies, energy companies, and the Bank.

Improving agricultural productivity, and stimulating small and medium enterprise (SME) development does not necessarily require investments from a governmental agency, largely because rural people themselves are likely to invest in equipment and technology if they perceive that investment yielding an increase in their incomes, and if they have access to finance. This is does not mean that non-energy agencies or organizations do not need to be involved. It simply highlights the point that agricultural production and SME development are commercial activities, unlike health and education provision, which are non-commercial public services.

Different interventions have been pursued to promote productive uses of energy in agriculture and SME development:

- In Mexico, the government agency Alianza includes the provision of solar water pumps into their agricultural productivity improvement projects for livestock farmers, it is simply a technical component that is added into a bigger project. The project involves training of technicians to maintain the systems, as well as training farmers on increasing agricultural productivity.
- In Sri Lanka, a thriving market for SHS and village-hydro projects has already been set in place by a previous World Bank/GEF-funded project. The REREDP recently solicited proposals for innovative productive use projects. Most proposals have been submitted by rural development NGOs, and are focused around creating productive use applications in communities that already have electricity from village-hydro systems installed under the prior project. Here, the approach is to enable people to make more economically productive use of energy technologies already installed.
- Both the ERT project in Uganda and the RERED project in Sri Lanka draw on the help of organizations that provide business development services. Again, this is not to underplay the importance of co-ordination at the planning level. These examples demonstrate that different interventions have been utilized at multiple levels – for example in Uganda, the ERT aims to create cross-dialogue and activity between the rural electrification agency and agricultural ministry at the central level. At the same time, it solicits the assistance of an organization called the Private Sector Foundation, which provides business development services at the grassroots level. In Sri Lanka, the largest rural credit agency involved in the REREDP routinely extends business development advice and services to its rural members.
- Of course, such organizations and services are not widely available in many developing countries. However, capacity to promote productive uses in the agricultural and SME sector can be developed within rural energy agencies as well. The rural electrification program in Bangladesh provides an example of how this works. The Bangladesh rural electrification is modeled on the US Rural Electric Cooperative approach. Since Bangladesh is a poor and largely agricultural country, rural demand for electricity tends to be low; this undermines the financial viability of rural electrification cooperatives. In order to increase demand and spur rural economic development, every rural electrification cooperative, (called *Palli Bidyut Samities*), has a "member services team", headed by an Assistant General Manager. The task of this team is to encourage and assist PBS members to use electricity for productive purposes. They do this by identifying potential applications, providing information on these to PBS members, and providing other support services like helping members obtain credit to start small businesses, or purchase farm equipment like water pumps.

In general, the kinds of funding and financing support extended for promoting the use of renewables for increasing agricultural productivity and micro-enterprise development are for:

- surveys and studies on energy demand, and existing and potential productive activities,
- consultants and NGOs to develop cross-sectoral projects and provide business development advice and assistance to rural people,
- capacity development on productive uses in rural electrification agencies,
- lines of credit – for equipment suppliers and consumers,
- monitoring and evaluation.

Analysis of project approaches: issues that need more attention and some possible ways to address them

This section highlights issues that are not adequately addressed in project documents, but which could affect project outcomes in significant ways. These issues have been identified based on an analysis of the approaches described above, using parameters of possible project impact on productivity and welfare, equity, environmental quality and scalability.

The role of governance and political trade-offs in determining multi-sectoral project outcomes

In general, if a country has vast areas that lack access to modern energy services, this is symptomatic of crises in the rural electrification agency of that country. However, the crisis in the rural electrification agency is only a symptom of broader-level failure in governance. This failure in governance in a country is a systemic problem, often infiltrating other agencies dealing with rural development like health, education, and agricultural development agencies. If the implementation of an energy project requires the involvement of a non-energy agency, then the success of the project is at least in part dependent on the performance of that agency. In this context, one has to keep in mind the realities of how agencies providing rural agriculture, health and education services are performing, and the kinds of resources they have at their disposal. While there is little doubt that health, educational, and communications facilities should have access to energy, it is important to recognize the limitations of what can be achieved. This is because these limitations can have substantial influence on project outcomes. We use the case of the Uganda ERT project to explore how these limitations could affect the impact of the project on productivity and welfare, and on equity.

The Uganda ERT project aims to improve the quality of rural health services by involving the Health Ministry in project implementation. A very recent OED Implementation Completion Report to Uganda for a District Health Project (June 23, 2003) suggests that the health sector is in poor shape. It rates the project outcome as Unsatisfactory. It highlights problems in the health sector, and reports that in general, pace of reform was extremely slow and incomplete, implementation of project activities were fragmented and uncoordinated, e.g., facilities were constructed, but not staffed or equipped properly, non-payment of salaries of health workers and salary arrears seriously undermined health worker performance, and the program indicators in designated districts either stagnated or deteriorated (World Bank, 2003). Under such circumstances, to what extent can an energy project improve the delivery of health services?

The issue of equity comes to the fore when implementing such a multi-sectoral project. If a large proportion of rural health clinics are functioning poorly, there will be a tendency to provide energy to those that are performing relatively better to begin with, as one is most likely to see the greatest positive impacts from such installations. This is especially likely to be true if the evaluation of the energy project depends on certain health indicators. However, what does this mean for those regions that have poorly performing health centers? To ensure that projects are equitable, care must be taken to include populations that are more marginalized to begin with. While equity is always an important goal, it is not always commiserate with the ways in which the success of projects is measured.

No doubt, different agencies in different countries very likely vary greatly in performance. However, the following issues are likely to hold in many countries: Non-energy agencies are unlikely to want to invest in energy components. For one, irrespective of what an agency wants to do, there will always be a political trade-off to be made when it comes to using a limited budget. Should that agency do fewer schools, but also invest in the energy components? Or should they build more schools, and ignore the energy needs? From a politician’s standpoint, building more schools means reaching more people (even if the service is of poorer quality overall), and this choice is likely to win out. Limited budgets can greatly influence what is possible. A consultant report for the Bank on the energy requirements of the health sector in Uganda points out that while total required health care costs per capita is estimated at US$ 14, the government spends slightly more than US$ 2, with donor contributions adding on another US$2 (Bro, 2001: 11). This is a health care system that is severely short of funds. The health ministry of a country could avail of World Bank loans for energy investments (which is what it is doing in Uganda), and other donors could also contribute. However, this money too has an opportunity cost, and countries have to determine their own investment priorities for the total multilateral debt they take on.

The Bank of course recognizes that governance is a key component of any development effort. Many programs are underway to improve governance in various sectors, including the energy sectors of many countries where power sector reforms are underway. Given the difficulties identified in implementing multi-sectoral projects, what steps can increase the chances of success of an energy project designed to promote productive uses?

First, project appraisal documents on multi-sectoral projects should explicitly discuss the status of all sectors involved. To its credit, the Uganda ERT project appraisal document acknowledges that the health projects could fail for a number of reasons not connected to energy, e.g., lack of medicine, lack of trained staff, etc. However, it has not discussed how these risks could be minimized, nor takes on concerns about equity.

Second, facilitating cross-sectoral coordination within the Bank itself could help in the design of projects that are more likely to succeed. For example, a well performing agricultural extension program would be a good partner for a rural energy project aimed to enhance agricultural productivity. The Bank is the premier storehouse of information and knowledge on where good projects exist, and how they work. However, this knowledge rarely crosses over into other sectors. One possible way to begin this process of exchange and coordination would be to create job positions at the interstices of sectors. The task of people who hold these positions would be to monitor project development in both sectors, and help coordinate activities and projects. For example, the Bank could have a 'energy-ARD facilitator' whose task is to ensure that agricultural and rural development projects are coordinated with energy projects in a given region. These positions would reflect the role of energy (and possible other inputs like water) in the MDGs – as one input to improving agricultural productivity, and health, education and communications services.

The concerns about equity could be addressed if every sector and every project makes explicit the steps it plans to take to include marginalized groups, and project baseline studies and evaluation criteria include equity goals. This may be difficult to actually implement, since the Bank rarely chooses project beneficiaries, these decisions are made by the implementing agency in country. However, loan disbursement could be made conditional to the implementing agency meeting certain equity requirements.

The process of technology selection

Since this paper is about promoting the productive uses of renewables, the question that arises is when are renewables appropriate options, and how does one select between technologies? In theory the answer is fairly straightforward: When it comes to promoting productive uses of energy, the per unit cost of energy is very important. It would be impossible for a rural farmer to compete in any agricultural market – local or international - if the cost of a key input to the agricultural process - energy - is substantially higher than what their competitors are paying. It therefore follows that energy demand for a community, or region, should be calculated based on the types of household and productive uses that exist as of the time of the project, and on those that are projected to be stimulated by the intervention. The appropriate technology would then be the least-cost option to meet these needs – be it the grid, or a solar PV system, or a diesel-powered mini-grid, or any other technology. Of course, selecting between renewables also calls for an assessment of what resources are locally available for technologies such as biomass energy systems, small hydro and wind systems, and solar PV systems.

In practice, technology selection is far from straightforward. This is because the process of technology selection is influenced by factors other than costs. We discuss two of these factors, using two of the cases reviewed to show how technologies selected may not always be the least-cost options (thereby reducing economic and welfare benefits that a project could deliver), nor conducive to scaling up productive applications and rural access. One factor is the reason why renewables have become a popular choice for meeting rural energy needs, and the other is the issue of path dependency.

Renewables became popular technology choices for meeting off-grid energy needs in developing countries primarily in response to state failure to provide what people in the developed world consider a social entitlement – access to the grid. Because they are decentralized options, NGOs and private players could offer high quality energy services directly to rural populations, who would no longer have to wait for the state to bring them the grid, an event which may well never come to pass anyway. Of course, renewables offer the added advantage of being environmentally-friendly. As a result, both public and private 'green' money has been invested in supporting rural RET markets.

However, the key issue here is do renewables provide the same quality of service as the grid, and are they really least-cost options from the perspective of a developing country as a whole?

The answer to these questions depends on which technology is being used and in what context. There may be many situations in which certain RETs are the least-cost option, compared to, say, the cost of grid extension, such as on islands, and in mountainous regions. However, RET markets are far from limited to these regions. In countries like Kenya, Uganda where less than 1% of the rural population has access to the grid, solar home systems markets are widespread. Even in Sri Lanka, where about 50% of the rural population lacks access to the grid, SHS markets exist in almost all off-grid areas.

While a country-level economic comparison of grid extension vs. RETs is beyond the scope of this paper, it is highly unlikely that in countries where grid coverage is as low as 1%, RET markets are universally a more cost-effective way of meeting people's electricity needs than the grid is. For example, the average delivered cost of electricity from a solar PV system is on the order of $0.70 to over $1.39/kWh[2]. Of course, while RETs may be more expensive than grid extension for many of the regions in which they exists, they are still far superior options to not having the grid at all. However, the point remains that in many circumstances, people may be paying a lot more for energy services than they would if the grid existed. This of course, affects economic productivity. As explained earlier, if rural people are to compete in local markets, and developing countries in international markets for products such as agricultural commodities, then the cost of energy matters.

While the discussion so far revolves around grid. vs. renewables arguments, another factor affects the way in which choices between renewables get made. This is the issue of path dependency.

Many rural renewable energy markets in developing countries, whether supported by Bank funding or not, cater to household energy needs. This has resulted in the establishment of markets biased towards a particular technology – solar PV. To date, the development of rural solar home system (SHS) markets have received the largest share of private, multilateral and NGO investment, when compared to funds available for other RETs market development. A review of the 10 largest RET investments in the Bank's renewables portfolio (which adds up to 92% of total costs of all projects with renewables components), the vast majority supports solar

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[2] The range is based on discounting lifetime costs of PV systems (over 20 years), annualizing the discounted figure, and then dividing by total kWh generated over the system life. The range of capital costs used is from $8.32/W to $19.38/W. This has been calculated by Anil Cabraal, and represents actual costs of PV in countries where Bank projects operate. Maintenance and replacement costs have been assumed to be on the low side – on average at $10 per year. This is actually very conservative. Even in Sri Lanka, one of the most competitive rural PV markets, maintenance and replacement costs are typically higher than this. On the whole therefore, the calculated cost of delivered electricity presented here is a conservative estimate.

home system installations[3]. About ¾ of the GEF's renewable energy investments are for supporting off-grid rural RET markets. Till 2003, of 81 GEF projects supporting off-grid or mini-grid RET market development, 60 support either SHS, or solar PV installations for commercial, public and agricultural applications, compared with 24 biomass projects and 32 small hydro projects (Eric Martinot, personal communication by email, August 14, 2003).

Solar PV systems for household use - typically called solar home systems (SHS) – are good replacement for kerosene lamps and car batteries, providing substantially improved quality of electricity service. They tend to be typically small in capacity: in a global study of SHS installations, Nieuwenhout et al (2002), calculate that about half of all installations covered in their study fall in the range of 35-54W. In the same study, it was determined that 93% of the systems installed were used for powering lights alone, or for running lights, DC televisions and radios for a few hours every day. Of course, SHS provide considerable health benefits by displacing harmful emissions from kerosene lamps, the luminosity and quality of light is immensely better, making it much easier to carry out household chores and reading and studying activities. They can also provide for limited income-enhancing opportunities such as keeping shops open, or carrying out activities such as basket weaving or sewing, for a few extra hours every evening, and charging cellular phones for rural communications businesses. If they replace car batteries, they help save much time and effort involved in hauling acid-filled, short-lived car batteries to battery charging stations every few weeks.

However, while solar PV may be appropriate for household lighting and applications that use small amounts of electricity, it may not be suitable for promoting productive applications on a large-scale, largely because of the high costs of delivered electricity involved. The Mexico REA project helps to illustrate the limitations of scaling up productive use in agriculture using solar PV:

There are approximately 600,000 livestock farmers living off-grid in rural Mexico. The current renewable energy for agriculture project aims to install 1,150 solar water pumps. The Mexican government has expressed an interest in scaling up this project. Currently, the systems are paid for through a combination of Mexican government and GEF grants, and small contributions from the farmers themselves. The solar water pump costs $7,750: these bulk of these costs are shared the Mexican government ($4,650) and the GEF ($2,325) with the farmer paying the rest. At this subsidized price, the livestock farmer's income is predicted to increase by 19-44%, depending on the region they are in.

Suppose a subsequent scale-up project is planned, with the aim to bring solar-powered water pumping to 30% of these farmers over 5 years, that is, 180,000 solar water pumps are planned to be installed over 5 years. Should the GEF subsidy be gradually phased out at a rate of 40% per

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[3] It has proved very difficult to calculate the exact figures of how much investment is allocated for PV per se. The 10 largest projects with renewables components are in China, the Philippines, Argentina, Uganda, Bolivia, Bangladesh, Sri Lanka, India and Mozambique (in reducing order of total project costs). Some of these projects support other technologies, including the grid. However, within the renewables component of the projects, SHS dominate in terms of target numbers of households to benefit.

year, we are still looking at a total commitment from the GEF of $32M over 5 years for disseminating PV water pumps in Mexico.

Year of project	Number of PV water-pump installations	GEF Grant amount USD (reducing by 40% per year)	Total GEF Grant USD	PV of total grant (at start of project) USD
0	1,150			
1	2,852	2,325	6,630,890	
2	7,073	1,395	9,866,748	(32,679,921)
3	17,541	837	14,681,698	
4	43,501	502	21,846,332	
5	107,883	301	32,507,291	
Total	**180,000**			

If the GEF subsidy is discontinued completely, but the Mexican government continues to provide a subsidy of $4,650 per system as its currently doing, a solar water pump would still cost about $2,325. Even if the farmer could avail of long-term credit to pay for this, it is important to consider the size of investment that the Mexican Government will have to provide: If the government itself were to reduce the subsidy by 20% a year (to reflect reduced price of systems due to economies of scale and fall in PV prices), we are still looking at a total investment of $87M over 5 years. This is to cater to the needs of less than 18% of its off-grid population, or less than 1% of total population. This is not likely to be politically feasible.

Year of project	Number of PV water-pump installations	Mexican Govt. subsidy amount USD (reducing by 20% per year)	Total Mexican Govt. subsidy USD	PV of total subsidy (at start of project) USD
0	1,150			
1	2,852	4,650	13,261,779	
2	7,073	3,720	26,311,328	(87,146,456)
3	17,541	2,976	52,201,593	
4	43,501	2,381	103,567,796	
5	107,883	1,905	205,478,183	
Total	**180,000**			

Further, using farm models, the project predicts that farmers who participate in the project will augment their income by 19-44% depending on the region they are in. However, the predicted increase in income will arise only if the system is used entirely for providing water to the cattle. If a household diverts some amount of power to their house to run lights, television, radio, while this will no doubt greatly improve their quality of life, there will be a corresponding decrease in the predicted rise in actual income-in-hand. By no means does this mean that people should not be diverting electricity for household use, it simply indicates that in the context of projects promoting productive uses of energy, predicted rise in income needs to be examined carefully for inbuilt assumptions, especially if these increases form the basis for large-scale economic and financial investments from the bank, governments and rural communities.

Recent Bank-funded rural energy projects are designed to be 'technology-neutral', for example, the Uganda ERT project does not discriminate between solar PV or diesel-generators in its funding structure. In Bangladesh, for areas where the grid does not reach, the rural electrification program provides support and guidance for business plans for any energy technology installation or project. However, amongst renewable energy technologies for rural applications, because solar PV has received a disproportionate amount of support from donor agencies, multilaterals, governments and the private sector, there is no level playing field between technologies. That is to say, grants and funds have been pumped into establishing rural infrastructure, supply chains, developing technical capacity, and extending lines of credit for solar PV on a much larger scale than for any other RET. This of course, creates a certain path-dependency in new project development: that is, once a PV market exists, the tendency is to design projects that can utilize this infrastructure and capacity. However, as discussed, solar PV may not always be the most appropriate technology for promoting productive applications, especially if scale-up of rural access is an important goal.

The RERED project in Sri Lanka helps to demonstrate the problems associated with path-dependency, but also provides insights into how this can be overcome.

The RERED project in Sri Lanka was preceded by the Energy Services Delivery (ESD) Project. This is one of the Bank's most successful rural RET market creation projects. According to an independent evaluation of the project, "the Sri Lanka Energy Services Delivery (ESD) Project, a uniquely designed and implemented project, can serve as an excellent model for other rural electrification initiatives with renewable energy and energy efficiency components."(International Resources Group, 2003: ES1).

While the off-grid component of the ESD project was largely focused on the establishment and expansion of rural RET markets, the RERED project is focused on improving rural productivity and social welfare. To achieve the goal of improving rural productivity, the REREDP's approach involves to solicitation of proposals on productive use projects and approaches from NGOs, individuals, and companies. Several innovative proposals have been received to date. All these proposals received to date focus on developing productive use applications for technologies already installed under the previous ESD project. More significantly while 85% of the off-grid component of ESD investments, and 86% of the off-grid component of RERED project investments are allocated for solar home system market development and support, none of the productive use proposals received involve using solar PV for a productive use application. They are all concerned with using power from the village-hydro systems installed under the ESD project to stimulate income-generating activities. This is a significant issue: it implies that people in the country interested in promoting productive uses of renewables do not feel the technology which received the largest push offers such opportunities. Of course, since it is very early in the project, this outcome is far from conclusive.

On the positive side, the ESD (and RERED) projects have helped to create a number of village-hydro cooperatives. While off-grid small hydro capacity is very site-specific, the experience of cooperative management of decentralized energy systems can provide useful lessons in creating markets for other technologies like biomass-based systems, which is said to offer considerable potential for meeting Sri Lanka's energy needs (Energy Forum 2001, Wijewardene and Joseph, 2002). The first off-grid biomass combustion system has been approved for installation under the RERED project. The NGO implementing this project – Energy Forum - is a spin-off of ITDG, which spearheaded village hydro capacity development in the country.

The off-grid biomass project faced the 'path dependency' problems discussed earlier. The RERED project treats off-grid biomass development in the same way as it does other off-grid RETs markets (namely, solar PV and village hydro). It extends a GEF grant for the incremental cost of the system, and provides access to a line of credit to the community. However, these other RET markets have both evolved out of donor-funded initiatives, and received considerable support and grants through bilateral and NGO aid programs, and under the prior ESD project, whereas biomass systems have not. Energy Forum complained that it was unfair to make a rural community bear the costs of 'learning' for a new technology. They pointed out that biomass does not have a level-playing field with other technologies. The Bank and GEF considered this a valid point, and have approved a grant for this biomass demonstration unit. Once this first system is installed, Energy Forum has plans for experimenting with several different types of biomass systems, using different fuel sources, and in different regions.

Of course, one reason that solar PV is so attractive is that other less expensive RETs are limited because of their site and resource specific nature (e.g. small hydro, small wind systems and biomass systems), and, because all other RETs are more technically complicated to operate, finance and manage than solar PV systems (individuals vs. community). Further, in certain types of geographical locations, and for certain productive applications, solar PV may well be the least-cost option: for example PV is well suited for remote telecom and communications applications.

However, the real potential of other technologies – RETs and other decentralized options, are far from fully understood or explored. In response to this, the Bank has initiated some activity in this area. These include a global study of small-scale energy providers (irrespective of the technologies they use), a study of the potential of biomass energy in stimulating productive uses has also been commissioned. Also, rural energy projects funded by the Bank are now all 'technology-neutral'.

Finally, technology choice has serious implications for the environment. In developed and developing countries alike, the short-term economic basis that governs policy decisions and project design makes us biased towards polluting technologies that are creating environmental problems like climate change that will prove to be extremely costly to future generations. Irrespective of who caused the problem, large developing countries like India and China cannot continue to emit Co_2 at current rates, for the sake of the global environment. How is this relevant to promoting the productive uses of renewables? We will return to this issue in the discussion on the role of the GEF. We close this section on technology choice with a set of recommendations:

First, it is important to recognize that even technology-neutral projects face problems of path-dependency. This is not necessarily a negative thing – rural markets develop in certain ways in response to certain needs. However, rural markets for certain services can also develop because of external influences that may not always be the most efficient or effective way to meet people's needs – e.g., they can be established by donor-funded projects driven by a western environmental agenda, or as responses to failures in the state to meet basic needs of people. In either case, better options and approaches may be available, which are more economical for rural people, and more conducive to scale-up. At minimum, they warrant rigorous study and exploration of all technological options. Countries themselves ideally should carry out such analysis. Given power sector reforms underway in many developing countries, the rural energy agencies are already in a state of flux. The Bank could support capacity building efforts within these agencies to enable them to make their own technology choices.

Second, there is little understanding or experience with combining delivery of electricity along with non-electric energy (gas or other sources of heat energy) for both household and commercial needs in rural areas. What would models that address both these rural energy needs look like? What would be the effect on rural development impacts? How does combining both these needs affect the economics of various technologies? For example, the economics of biomass energy systems are very sensitive to the load factor; a higher degree of plant utilization involving both heat and electricity utilization greatly improves the economics of such systems, while also addressing two critical energy needs (heating/cooking and electricity-based applications) in rural areas. What sorts of incentives and policies are needed to create markets for both services? The Bank and/or the GEF could conduct such studies.

The purpose of this section is not to argue for or against any technology. Ultimately, understanding difficulties in making technology choices calls for a detailed understanding of the *process* by which technology choices get made, and of the inherent biases and differing priorities of the agencies and individuals making these choices. These priorities may not always be the same: for example, environmental motivations may influence the Bank's preference in energy technology selection, these motivations may not figure in the priorities of the energy agency of a poor developing country. Further, the remote rural communities selected to be 'beneficiaries' of an intervention bringing them electricity may prefer if the same money were invested in, perhaps, technologies that free up the amount of time they spend collecting fuelwood for cooking, rather than for electricity provision. Even if electricity is the priority, technology preferences may differ. McAllister draws on a number of references to show how in the context of South Africa, financial analyses may determine that one technology or another is 'optimal', however surveys indicate that the majority of rural inhabitants prefer grid-based prepayment systems (McAllister, 2002). Ultimately, the economic analyses used to justify certain choices are strongly influenced by who is making the choices.

Role of the GEF

About ¾ of the GEF's Climate Change portfolio consists of off-grid RET projects. While these may offer compelling development benefits, they offer relatively expensive carbon reduction benefits when compared to grid-connected renewables or energy efficiency projects. This trade-off is likely to hold to a large extent – investing in say, energy efficiency improvements in developing countries is likely to provide much more carbon benefit bang for the buck than subsidizing solar PV systems in rural areas.

How is this relevant to promoting productive uses of energy? In the section 1, we state that promoting productive uses of renewables provides an obvious area of synergy between Bank's and GEF's goals. This is true. However, should countries discover that for promoting productive uses and scaling-up rural access, grid and fossil fuel-based generators are the least-cost approach in most cases, the GEF may discover that promoting productive uses may mean the role of renewables in off-grid energy delivery shrinks rather than grows (there is no way to know for sure, of course).

This does not mean that the RET market in developing countries shrinks too – both the Bank and the GEF should closely examine the opportunities available in grid-connected renewables markets, and urban energy efficiency improvements. Energy efficiency and RETs like solar water heating technologies are clear win-win investment opportunities. Further, while not directly 'productive' for rural areas, near-commercial grid-connected renewables like wind, small hydro and biomass cogen help countries increase diversity in generation, brings technologies down learning curves, attract R&D investments, foster local and global environmental protection, generate new local industrial growth and employment, and enable the development of infrastructure and a knowledge base that can more easily be mobilized for rural applications. This is especially relevant in countries where no manufacturing or rural infrastructure exists for technologies like biomass-based energy systems. For example, it may be difficult to attract private investment for biomass systems for off-grid areas alone. However, the industrial and grid-connected market may prove attractive to companies, which can then be incentivized to invest in rural markets. They can partly offset the high risks associated with remote rural markets with the stable income stream guaranteed by a power purchase agreement with the local utility.

Kishore et al (*Energy Policy,* in press) demonstrate how biomass energy technologies can also have the lowest carbon abatement costs of any renewable energy technology. They illustrate how a 500kW biomass plant, with a carbon emission reduction credit sales price of $5/ton Co_2, can result in internal rates of return of 18% in grid-connected contexts. The same facility can yield an IRR of 16% in off-grid situations, where kerosene in households, and diesel and fuel oil in agriculture and industrial applications are replaced with energy from the biomass gasification unit. Of course, IRR of off-grid projects are sensitive to plant load utilization, further there are non-carbon emissions that have to be controlled.

The GEF's portfolio is currently skewed in favor of off-grid investments. A more balanced portfolio would help achieve relatively greater carbon reductions at lower costs, in ways that may or may not directly enhance rural productivity, but would provide other important developmental benefits to countries.

CONCLUSIONS AND SUMMARY OF RECOMMENDATIONS

Highlighting the limitations of current approaches to promoting productive uses of renewables is not to underplay the importance of promoting productive uses, or the role of renewables. Promoting productive uses of energy is important for achieving the Millennium Development Goals. Promoting renewables is also important for the same reason.

Using four Bank and GEF projects as case studies, this paper attempts to demonstrate that designing and implementing projects to promote the productive uses of renewables is not an easy task. Paying attention to the possible impacts of these projects on productivity and welfare, equity, the environment, and their potential for scale-up, provides some indication as to how these projects may help in achieving the Millenium Development Goals.

The Uganda ERT case study shows that problems with governance in the health sector, and issues of political trade-offs may have a negative influence on equity, and may not lead to economic and social benefits to the extent that they are planned for. The Uganda ERT, the Sri Lanka RERED and the Mexico ARD projects all demonstrate problems with technology selection, such as path-dependency which may be leading to sub-optimal technology choices. This too could have potentially negative impacts on productivity and welfare, and scale-ability, and may not always lead to the most cost-effective approaches for meeting environmental goals.

On the positive side, all the projects demonstrate that multi-sectoral projects, while fraught with difficulties, are essential for promoting the productive uses of renewables, and energy more generally. Their designs contain many innovative concepts that can be replicated. These projects also provide important insights on changes needed in the Bank and in countries to ensure that multi-sectoral projects that promote the productive uses of renewables can help the Bank achieve the Millenium Development Goals.

This paper concludes with a set of recommendations for the Bank and GEF on precisely these changes:

1. Establish mechanisms within the Bank to facilitate cross-sectoral project development. Incentives for cross-sectoral work for both staff and management are needed.
2. Help countries develop their own capacity to make technology choices for meeting rural energy needs. The Bank and GEF can assist this process by:
    a) recognizing problems of path dependency in their renewable energy portfolios, which have resulted in a disproportionate support for solar PV over other technologies;
    b) conducting studies on the technical, economic, and institutional feasibility of technologies like biomass energy systems, and developing criteria for selecting between renewables and non-renewables, and grid versus decentralized technologies;
    c) conducting studies on the technical, economic and institutional aspects of combining electric and non-electric energy service provision for rural areas;

d) training personnel in rural and power sector agencies to conduct such studies themselves and to use tools like GIS to help them make their own technology choices.

3. The GEF and the Bank must further recognize and evaluate the trade-offs common between environmental and development benefits (e.g., SHS vs. energy efficiency investments), and develop criteria for balancing these trade-offs.

This paper is the first attempt by the Bank to assess productive uses of renewable energy, recognizing that links to poverty alleviation, economic development, and financial/economic viability are the key to sustainable energy, including renewables, development.

REFERENCES

References Cited

Barnes D. 1988. Electric Power for Rural Growth: How Electricity Affects Rural Life in Developing Countries. Westview Press: Boulder.

Bose S. 1993. Money, Energy and Welfare: The State and the Household in India's Rural Electrification Policy. Oxford University Press: New Delhi.

Brenneman A. 2002. Infrastructure & Poverty Linkages: A Literature Review. Unpublished World Bank Report.

Bro C. 2001. Access to Energy in Rural Health Facilities – a Missing Link for Improved Health Care Service An assessment of the Energy Needs and its Contribution to Improved Health Care Service in Uganda. Consultant Report For the World Bank.

Cabraal, A. Solar PV in Bank Projects. E-mail to author. August 7, 2003.

Energy Forum. 2001. Report on Potential for and Viability of Community-Based Dendro/Biomass Electricity Generation. Energy Forum: Colombo.

ESMAP 2002. Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits. World Bank: Washington DC.

GEF. 2000. Medium Sized Project Brief. Passive Solar Heating for Rural Health Clinics. GEF: Washington DC.

International Resources Group. 2003. Evaluating the Potential for Scale-up of Off-Grid Renewable Power. Consultant Report for the World Bank.

International Resources Group. 2003. World Bank/Sri Lanka Energy Services Delivery Project Impact Assessment and Lessons Learnt. Consultant Report for the World Bank.

Kishore V. Bhandari P. Gupta P. In Press. Biomass energy technologies for rural infrastructure and village power—opportunities and challenges in the context of global climate change concerns. Energy Policy.

Martinot E. Grid vs. off-grid renewables projects. E-mail to author. August 14, 2003.

McAllister A. 1999. Electrification and Productive Enterprise in Rural South Africa. Consultant Report to NREL.

Nieuwenhout F. van Dijk A. Lasschuit P. van Roekel G. van Dijk V. Hirsch D. Arriaza H. Hankins M. Sharma B. Wade H. 2001. Experiences with Solar Home Systems in Developing Countries: A Review. Progress in Photovoltaics: Research and Applications 9: 455-474.

UNDP. 2003. UNDP website on Millennium Development Goals. Accessed at http://www.undp.org/mdg/ on June 15, 2003.

UNDP. 2003. Simple Steps, Effective Actions. A UNDP/GEF Handbook on methodologies for technology needs assessments. UNDP: New York.

Waddle D. 2002. Bangladesh: At the Crossroads of Sustainability. Draft Report.

Wijewardane R. Joseph P. 2002. Growing our own energy: complementing hydro-power for sustainable energy and rural employment in Sri Lanka. Renewable Energy for Development 13(1).

World Bank. 2003. Operations Evaluation Department Report to Uganda for a District Health Project. World Bank: Washington DC.

World Bank. 2002. Project Appraisal Document On A Proposed Credit In The Amount Of SDR 59.3 Million (US$75 Million Equivalent) And A Global Environment Facility Trust Fund Grant In The Amount Of SDR 6.4 Million (US$8 Million Equivalent) To The Democratic Socialist Republic Of Sri Lanka For A Renewable Energy For Rural Economic Development Project. World Bank: Washington DC.

World Bank. 2001. Project Appraisal Document On A Proposed Credit In The Amt Of SDR 38.30 Million (US$49.15 Million Equivalent) And A GEF Grant In The Amount Of SDR 9.50 Million (US$ 12.12 Million Equivalent) To The Republic Of Uganda For An Energy For Rural Transformation Project In Support Of The First Phase Of The Energy For Rural Transformation Program. World Bank: Washington DC.

World Bank. 1999. Project Appraisal Document On a Proposed Grant From The Global Environment Facility Trust Fund In The Amount Of SDR 6.5 Million (US$8.9 Million Equivalent) To The United Mexican States For A Renewable Energy For Agriculture Project. World Bank: Washington DC.

World Bank. 1997. Project Appraisal Document on a Proposed Credit in the amount of SDR 16.9 Million and a GEF Trust Fund Grant in the amount of SDR 4.2 Million to the Democratic Socialist Republic of Sri Lanka for an Energy Services Delivery Project. World Bank: Washington, DC.

References Consulted

Allderdice A. Rogers J. 2000. Renewable Energy for Microenterprise. NREL: Golden.

Barnes D. Foley G. 2002. Rural Electrification in the Developing World: Lessons from Successful Programs. Draft Report.

Barnes D. Floor W. 1996. Rural Energy in developing countries: A Challenge for Economic Development. Annual Review of Energy and Environment 21: 497–530.

Cabraal A. Cosgrove-Davies M. Schaeffer L. 1998. Accelerating sustainable photovoltaic market development. Progress in Photovoltaics: Research and Applications 6 (5): 297-306.

Fishbein R. 2003. Survey of Productive Uses of Electricity in Rural Areas. Consultant Report for the World Bank.

Goldemberg J. 1996. Energy, Environment and Development. Earthscan: London.
Intermediate Technology Development Group. 2003. About ITDG website. Accessed online at http://www.itdg.org/, on May 20, 2003.

Jimenez A. Lawand T. 2000. Renewable Energy for Rural Schools. NREL: Golden.

Jimenez A. Olsen K. 1998. Renewable Energy for Rural Health Clinics. NREL: Golden.

Karekezi S. and Kithyoma W. 2002. Renewable Energy Strategies for rural Africa: is PV-led renewable energy strategy the right approach for providing modern energy to the rural poor in sub-Saharan Africa? Energy Policy 30: 1071-1086.

Martinot E. Chaurey A. Lew D. Moreira J. Wamukonya N. 2002. Renewable Energy Markets in Developing Countries. Annual Review of Energy and Environment 27: 309-48.

Mulugetta Y. Nhete T. Jackson T. 2000. Photovoltaics in Zimbabwe: lessons from the GEF Solar project. Energy Policy 28: 1069-1080.

Munasinghe M. Munasinghe S. 1988. Policy Perspective and Evaluation Methodology. In Rural Energy Planning: Asian and Pacific Experiences, ed. Ramani K. pp. 293-309. Asian and Pacific Development Centre: Kuala Lumpur.

Villavicencio, A. 2002. Discussion paper on Sustainable Energy Development: the case of photovoltaic home systems. UNEP Collaborating Centre on Energy and Environment Risø National Laboratory: Roskilde.

World Bank. 1996. Rural Energy and Development: Improving Energy Supplies for 2 Billion People. World Bank: Washington, DC, 1996.

Winrock International. Website accessed at http://www.winrock.org/ on June 15, 2003.

Winrock International. 2002. Renewable Energy State of the Industry Report #8.

White R. 2002. GEF/FAO Workshop in Productive Uses of Renewable Energy: Experience, Strategies and project Development. Consultant Report for the GEF and FAO.

World Bank. 2001. The World Bank Group's Energy Program. Poverty Reduction, Sustainability and Selectivity. World Bank: Washington, DC.

World Bank. 2000. Fuel for Thought. An Environmental Strategy for the Energy Sector. World Bank: Washington, DC.

World Bank. 1996. Rural Energy and Development: Improving Energy Supplies for 2 Billion People. World Bank: Washington, DC.

World Bank. 1995. Rural Electrification: A Hard Look at Costs and Benefits. Oper. Eval. Dep. Precis No. 90. World Bank: Washington, DC.

People Interviewed

World Bank:

Mac Cosgrove-Davies
Nikhil Desai
Subodh Mathur
Trine Refsbaek
Gershon Feder
Anil Cabraal
Todd Johnson
Ted Kennedy
Ajay Mathur
Robin Broadfield
Xiaodong Wang
Dominique Lallement
Michael Carroll
Charles Feinstein
Douglas Barnes
Johannes Exel
Lucio Monari

Outside the World Bank:

Eric Martinot, Global Environment Facility
Asoka Abeygunawardene, Energy Forum, Sri Lanka
Gustavo Best, FAO
Elisa Derby, Winrock International
Lalith Gunaratne, Sri Lanka
Harish Hande, SELCO
Judith Lipp, Consultant, IT Power, UK
Daniel Kammen, UC Berkeley
Jayantha Nagendran, DFCC Bank, Sri Lanka
P. Venkata Ramana, Winrock International
John Spears, International Center for Sustainable Development Inc.
Dan Waddle, National Rural Electric Cooperative Association
Jerome Weingard, International Resources Group
Rona Wilkinson, Consultant, IT Power, UK
Neville Williams, SELCO