

Survey of Productive Uses of Electricity in Rural Areas

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1 Background and Objective

Among the key priorities of the Africa Region are: (i) scaling up rural access to modern infrastructure; (ii) promoting non-farm income generation by enterprises. Further, the "four petals" of the Energy Sector Business Renewal Strategy also recognize the need to link increased energy access to supporting energy needed for social services, and to promote productive uses and income generation.

The World Bank's Africa Energy Unit is in discussion with a number of countries for the preparation of rural electrification projects. In keeping with the above, it is the intention that these projects should include a well-defined link between accelerated electricity (and ICT) access and enterprise-led rural non-farm income generation. This link has strong support from the officials of the client countries, who have often said that they want increased rural electrification and ICT access to increase rural non-farm incomes.

There have already been some projects that feature productive uses of electricity. For example, the Indonesia Second Rural Electrification Project (completed three years ago) included a Rural Business Services component that helped small business switch to electricity and with a positive impact on employment in very small enterprises. Further, a June 2002 GEF-FAO workshop focused on the productive uses of renewable energy.

The objective of the assignment is to survey and summarize the published literature as well as informal knowledge about the experience with promoting productive uses of electricity in the rural areas of the Bank's client countries. This should include projects not financed by the Bank, as well as relevant projects/analysis undertaken by non-energy experts, and to be done through the following two tasks:

- Discuss with a wide spectrum of relevant people their knowledge of the successes, failure and impacts of promoting productive uses of electricity in the rural areas of developing countries.
- Collect and classify the available formal and informal knowledge with a view to determining what additional elements could be included in future Bank-financed rural electrification projects.

An overriding theme of this endeavor is to go beyond anecdotal descriptions of productive use, and begin to establish a baseline of experience and knowledge. To this end, the survey would be structured around two broad questions:

- What has been the project experience?
- What are the major lessons and emerging themes?

2 Approach

Projects and initiatives were examined under three main types of supply:

- Grid-based systems
 - Utility-supplied business development services
 - CDD-financed grid extensions
- Independent mini-grids
 - Micro or mini-hydro (MH)
 - Biomass and Hybrid
- Independent stand alone systems
 - Multi-Functional Platforms
 - RE for home business and micro-enterprise
 - RE for agricultural systems
 - Targeted RE productive applications

For each of these categories, salient projects, private initiatives and studies were identified and briefly described in terms of:

- Experience with productive use
- Insights and lessons drawn from documentation or informal discussion

Also, projects underway and in the planning stage are cited and briefly described. Finally, experience and trends in other RI sectors are mentioned.

Based on the above, an attempt is made to draw out emerging lessons and institutional models and approaches, which could provide elements for future project development.

It has been suggested that an alternative way to address this issue would be to frame the inquiry by potential types of productive use and relate them back to energy options. While this approach was considered, it was felt that, even when starting with an end-use approach, one inevitably runs up against the distinction between grid and non-grid types of supply, simply because they are so critical to defining productive use options. From a project development viewpoint, it would seem that one of the early issues to be addressed is the extent to which grid-based options are conceivable, given such factors as economic circumstances, natural resources, population dispersion, etc. Thus, for purposes of this paper, productive end use activities are related to various sources of supply, although it is clear that typologies for productive uses should be a part of the future agenda.

Section 3 presents a summary of the results, which includes a list of the current literature on productive use, and a summary of the projects and initiatives. Section 4 summarizes emerging themes, with an emphasis on institutional models and potential fruitful areas of future endeavor. Appendix 1 presents a complete list of reviewed literature and studies and contacts. A Project Brief with notes and sources on each project or study reviewed is presented in Appendix 2.

3 Summary of Results

3.1 Literature and Studies

The following short list of publications provides what one might call recent foundation work, which may be built on or used in conceptualizing new projects:

Allderdice, April and John H. Rodgers, *Renewable Energy for Microenterprise*, National Renewable Energy Laboratory, November 2000. Excellent guide for understanding micro-enterprise context and incorporating energy decisions into micro-enterprise development.

Etcheverry, Jose, *Renewable Energy for Productive Uses: Enhancing Environmental Protection and the Quality of Life*, Research Paper (Second Draft) written for the Global Environment Facility, April 2002. Review of issues related to productive use, with selected examples of productive use energy projects; useful reference section.

Etcheverry, Jose, *Renewable Energy for Productive Uses: Strategies to Enhance Environmental Protection and the Quality of Life*, Draft Strategy Paper for Global Environment Facility, December 2001.

GEF-FAO, *GEF-FAO Workshop on Productive Uses of Renewable Energy: Experience, Strategies, and Project Development - Summary Report*, FAO Headquarters Rome, Italy 18-20 June 2002.

Martinot, Eric, et. al., *Renewable Energy Markets in Developing Countries*, from Annual Review Energy Environment, 2002. Particularly pages 319-320, providing several examples and extensive references.

Van Campen, Bart, Daniele Guidi and Gustavo Best, *Solar Voltaics for Sustainable Agriculture and Rural Development*, FAO Rome, 2000. Comprehensive source of PV applications, with examples and additional references.

Wiengart, Jerome M. and Robert F. Lee, *Wide-Spread Implementation of Renewable Energy Projects in APEC Member Economies: Road Maps for Success*, Alternative Energy Development, Inc. prepared for Asia-Pacific Economic Cooperation Energy Working Group, November 2000.

Weingart, Jerome M. and Daniele Giovannucci, *Rural Energy: A Practical Primer for Productive Applications*, Draft Paper, February 2003. Provides extensive list of references and internet addresses on RE applications.

Additional references on rural electrification are provided in Baumgardt, cited below.

The following studies involving sample surveys or case studies were obtained and reviewed. The Philippines, India and China studies address mainly households and businesses on grid-based systems. The Baumgardt ESMAP paper addresses both grid extensions and off-grid improvement through rural development projects. The Sri Lanka studies provide information on customers served by both hydro mini-grids (HM) and solar home systems (SHS), and the Misana UNDP study focuses on off-grid electricity and other forms of energy. The Mathieu (Nicaragua)

study (in Spanish) reports baseline information generated for the Nicaragua Offgrid Rural Electrification for Development Project.

Barnes, D. et. al., *Energy Strategies for Rural India: Evidence from Six States*, ESMAP/UNDP, August 2002.

Barnes, D. et. al., *Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits*, ESMAP May 2002

Baumgardt, Frank, *Bank Experience in Nonenergy Projects with Rural Electrification Components: A Review of Integration Issues in LCR*, June 6, 2002. Six case studies from Brazil, Peru, Mexico, Nicaragua and Panama, and contains useful additional references in rural electrification.

LGA Consultants, *Sri Lanka Energy Services Delivery Project – Independent Evaluation, Results and Best Practice Dissemination – Household Impacts Survey Results*, July 2002.

Lucas, H. et. al., *Poverty and Gender: a Review of the Evidence and Case Studies in Rural China*, Institute for Development Studies at the University of Sussex, UK, Energy for the World Bank EnPoGen and Government of Netherlands.

Misana, Saloma and G. Karlsson, *Generating Opportunities – Case Studies on Energy and Women*, UNDP, 2001. Cases of off-grid electricity and other energy from Bangladesh, Ghana, Kenya, Malawi, Mali, Nepal, South Africa and Uganda.

Massé, René, *Impact on Poverty and Gender of Rural Electrification Programs in Sri Lanka*, EnPoGen Survey of Sri Lanka, October 2001.

Mathieu, *Primeros Resultados de la Encuesta de Mercado de Electrificación Rural en Zonas Aisladas de Nicaragua, Emerza 2002*. Baseline study commercial demand for rural electrification.

3.2 Projects and Initiatives

The following table summarizes the projects and initiatives identified and reviewed in this survey. This is not exhaustive, but seeks to be indicative of the types and sub-types of supply. It builds on the initial work by Etcheverry, Martinot, Weingart, Baumgardt and Misana, as well as discussions with practitioners. Hopefully, it begins to provide an initial representation of what has been done in the past and what is being done now to address this issue.

Representative Projects & Selected Initiatives Addressing Productive Use

Type	Country	Project/Initiative
I. Grid-Based		
Utility-supplied Business Development Services	Indonesia	RE 1&2 (WB)
CDD-Financed Grid Extension	Brazil	Northeast Rural Poverty Alleviation Program (WB)
	Peru	Social Development and Compensation Fund (FONCODES) (WB)
II. Independent Mini-Grids		
Micro or Mini-Hydro	Sri Lanka	Energy Services Delivery Project (ESD) (WB/GEF)
	India	Renewable Resources Development Project (WB/GEF)
	Nepal	Rural Energy Development Program (UNDP)
	Peru	Micro-Hydro Dissemination (ITDG/IADB)
	Guatemala	RE-Based Small Enterprise Development (GEF)
Biomass & Hybrid	India	Biomass Cogeneration for Small Industries (DESI Power)
	Thailand	Biomass Cogeneration from Rice Mill (EU-ASEAN)
	Philippines	PV/Propane Hybrid Mini-Grid (Shell/CPC)
III. Independent Stand Alone Systems		
Multi-Functional Platforms	Mali	Diesel Powered Multi-Functional Platform (UNDP)
	W. Bank..	Greenstar Solar Powered Community Centers (Greenstar)
	Philippines	Biomass Productive Use Platform (CPC/Shell)
RE for Home Business & Micro-enterprise	Bangladesh	Solar Home System Promotion (Grameen Shakti)
	Nepal	Solar Home Employment and Lighting Package (HLF)
	Morocco	<i>Maison Energie</i> (UNDP)
	Sri Lanka	ESD Solar Home Systems/SEED (World Bank/GER)
RE for Agriculture	Mexico	Renewable Energy for Agriculture (WB/GEF)
	Chile	PV Pumping Systems for Irrigation (GTZ)
	China	Integrated Biomass Systems (Shell)
Targeted RE Productive Applications	Bangladesh	Battery Operated Lamp Enterprise (ESMAP)
	Senegal	PV Powered DC Motors
	Swaziland	Solar Packs (Netherlands)
	Argentina..	PV Powered Drinking Water Pumps (GTZ)
	Mauritania	Wind Power for Water Supply (WB)
	China	Solar/Wind for Herding Systems
	Ghana	LPG for Fish Drying
IV. Bank Productive Use Projects Underway or in Planning		
	Uganda	Energy for Rural Transformation (WB/GEF)
	Nicaragua	Offgrid Rural Electrification for Development (WB/GEF)
	Bolivia	Decentralized Energy, ICT for Rural Transformation (WB)
	Ecuador	Power & Comm. Sectors Modern. & Rural Services (WB/GEF)
	Brazil	Renewable Energy for Agricultural Production Systems (GEF)
	Honduras	Solar Net Village Program (ESMAP)
	Philippines	Village Power Fund (ESMAP)

3.2.1 Grid-Based Systems

Utility-provided Business Development Services. The Indonesia Rural Electrification Projects I & II pioneered the concept of Business Development Services (BDS). Initial surveys showed that a main constraint to increasing loads and profitability was insufficient information – price & technical – to potential users. Consequently, the project focused on outreach to small businesses through NGOs and developing a marketing strategy for the electricity supplier, which addresses issues of information, tariff barriers and quality of service. Impact studies show 66,000 enterprises reached and over 20,000 jobs created.

Insight/Lessons:

- An effective outreach program, such as BDS can improve load use and help generate economic activity & employment. Although the grid-based activity implies an extensive area and variety of clientele, the concept of customer-responsive service as a means to better utilization of capacity is transferable to other supply situations.
- Although the Indonesia utility recognized the need for marketing and outreach, efforts toward “mainstreaming” in the organization have not taken hold as hoped. It may be that the concept of “outsourcing” to NGOs is the only viable way to at least start this, given the organization and “mind set” of many utility companies.
- 1992 Survey of businesses gave a profile (more recent information not obtained):
 - Family owned & operated
 - Less than 20 employees
 - Based at home or adjacent to home
 - Electricity for lighting by most
 - Alternative uses for driveshaft power common

CDD-Financed Grid Extensions. Several examples of grid extension investments made through CDD type project have been cited by Baumgardt. These investments are in principle demand-driven, with opportunities for integrating them with other productive activities. The two main ones cited are:

- **Brazil Northeast Rural Poverty Alleviation Program**, which involved a major investment of \$155 million in grid extension.
- **Peru Social Development and Compensation Fund (FONCODES)**, which invested \$34 million in grid extension.

Insights/Lessons

Brazil:

- Case study show a change in the socio-economic outlook of community that received water, electricity and infrastructure, with productive uses including irrigation, production of industrial fodder and operation of cereal mills.
- Second case study shows electrification-induced irrigation subprojects, using electric pumps, a forage grinder and a cereal processing subproject.

Peru

- Projects were successful in extending to poor, with 5% going to non-poor households.
- However, payment culture has been a problem, with only 58% of beneficiaries reported to be paying for service. Productive uses not reported.

Sample Studies. Sample studies (Philippines, India) of grid-based electrification show that increased income-generating activity is positively correlated with electrification; also that electrification increases chances of HH engaging in productive use. However this does not mean that electrification is the sole cause, but an important factor, along with other elements, such as transport, water (for certain industries) and a supportive business climate.

- Philippines study focused on HH:
 - 71% engaged in variety stores, with 11% in tailoring/dressmaking, rest in food stands, hairdressers and others.
 - Average HH benefit value (increased income) for a current business is \$ 34, and \$ 75 for a new business. Disaggregated figures by activity not published.
- India study included 900 commercial establishments, showing the following uses:

- Artisan: tailor, carpenter, barber, blacksmith, potter
- Rural Industrial Unit: flour and oil mill, brick mill, stone crushing
- Irrigation pumping: the study assesses trade-offs between electric and diesel, given heavy subsidization of electricity.

3.2.2 Independent Mini-Grids

A distinction is made between Mini/Micro-Hydro systems and Biomass-based systems because their locations are determined by the availability of the resource, and they have different management structures and relationships with productive uses.

Mini and Micro-Hydro Systems. MH systems have been developed on a large scale in suitable environments of, among others, Sri Lanka, India, Nepal, Peru and Guatemala. They all show a potential for powering a broad range of productive uses, including small industrial units (common ones are tools for carpentry, welding and auto repair), battery charging, small scale agricultural grinding, milling and drying and ice-making for fisheries.

Insights/Lessons:

Sri Lanka ESD Impact Study

- Most MH customers are in the middle income range
- About 20% households said they use MH power for income generating activities. Need to get the survey data in order to assess the type of activities and relative incomes from each type.
- Study notes that families' perception of increased income focused more on savings in energy expenditures, rather than generating income.
- Study concludes that HH not taking advantage of availability of 230 AC power.

Sri Lanka EnPoGen

- Economic activities using MH were principally grinding mills for chillies and flour, radio repair shops and carpenters.
- Health facilities benefited greatly, however one case study indicated hospital was being provided electricity free of charge.
- Monthly consumption and payment for electricity is significantly lower for MH vs. grid connected schools, however this is also a function of variations in school size and services.

Both studies conclude that while MH can provide more and regular power than PV for productive uses, this power remains an underutilized capacity, especially during the daytime. Key situational issues cited in this regard are:

- The organizations responsible for supplying electricity may not be market and customer-oriented.
- Areas conducive to MH are often remote and with limited productive capacity and difficult access to markets.
- On the positive side, the prerequisite for community organization provides a potential mechanism for promoting productive use, supplying micro-credit, etc.

Nepal Rural Energy Development Program

The UNDP Nepal program seems to have addressed the above concerns, with positive results. It stipulates that each household should be involved with one income-generating activity. The project provides skills training and reports that more than 80% of the trainees started a business in

the community. New activities included bakeries, preparing broiler chickens, agricultural processing mills, sawmills, photo studios and producing incense sticks.

Biomass and Hybrid Mini-Grids. Numerous types of systems reflect different scales and productive use applications:

- **India DESI Power Biomass Cogeneration**, providing power to a “technology village” consisting of several small rural industries, employing over 100 people.
- **Thailand Rice Mill Cogeneration**, based on a large, export-scale rice milling operations, which generates heat for drying and electricity for husking; excess power is sold to the main grid.
- **Philippines Hybrid Mini-Grids.** (CPC/Shell “Sunstation” supplies power to a mini-grid in a pilot province, Aklan, for Rural Energy Services Companies (RESCOs). The pilot did not focus on productive use.
- Martinot, et. al. also report wind-solar-diesel hybrid that provides 24-hour power for seaweed drying, woodworking and sewing in Philippines.

Insights/Lessons

The DESI Power model exemplifies how one can tie development of a mini-industrial park to the establishment of a RE power source. It requires however, significant expertise, investment capital and a good knowledge of the market potential for rural industries. The Thailand case also requires a high level of resource availability, market potential, investment capital and management capacity. Examples of hybrid systems in the Philippines are in pilot phase.

If one can identify favorable circumstances, biomass cogeneration in theory holds significant potential. Throughout ASEAN, a largely untapped demand exists for rice and wood biomass cogeneration, while almost all countries have biomass cogeneration being implemented at sugar and palm oil mills that could benefit from improved efficiency (Weingart, p. 47).

3.2.3 Independent Stand Alone Systems

Four broad types of stand alone systems exhibit differing characteristics and management arrangements, with varying productive use implications:

- Multi-Functional Platforms
- PV for Home Business and Micro-Enterprise
- RE for Agriculturally-Based Systems
- Targeted RE Productive Applications

Multi-Functional Platforms (MFP). Three types of systems have been identified, based on power source, ownership, finance and income-generation:

- **Mali diesel powered MFP (UNDP)**, which provides motive power and electricity for a variety of immediate village needs, ranging from cereal husking, battery charging, welding, carpentry tools, water supply and lighting. Income is generated by these functions, and spinoffs such as increased production and marketing activity, and managed by women’s groups. Project subsidizes initial investment and women take charge of O&M.
- **West Bank, Ghana others Greenstar Community Center**, PV powered small structure, which serves as multi-functional center, and whose prime income (at least in the beginning) is e-commerce of digital local culture and handicrafts. Greenstar invests

in community by providing initial investment, then takes fee for website and declining % of e-commerce sales, such that the community eventually takes full ownership.

- **Philippines Biomass Productive Use Platform (CPC).** This is an pilot now being installed with Development Marketplace support. It is an attempt to apply the Mali MFP with a renewable resource, coconut shells. Tied to a large coconut coop, initial products are geotextile for soil conservation, organic fertilizer, dried copra and refined oil for high quality soap. The goal is to create a vertically integrated network of small producers tied together and linked to larger markets for the products.

Insights/Lessons

All three models have the advantage of tying the introduction of electrical and improved motive power to productive use applications at the village level. The models differ in the source of energy and the mode of promoting and supporting the end uses. The diesel MFP appears to be a way to rapidly introduce basic technology improvements that have almost immediate financial and other benefits, grounded in the current economic activities of the village. In contrast, the Greenstar and CPC/PUP initiatives aim to literally create a new set of revenue generating activities through partnering and tapping into a wider market area.

RE for Home Business and Micro-Enterprise. Numerous initiatives are increasingly being taken to tie PV systems to productive uses. Several of the more typical are:

- **India Grameen Shakti**, an outgrowth of the Grameen microfinance group and offers improved credit terms for SHS, with concessional loan from GEF/IFC. The program includes intensive outreach and a training program through 52 branch offices. A variety of artisan, rural industry and agricultural uses are reported.
- **Sri Lanka SEEDS/ESD Project**, similar to the Grameen Shakti model, wherein a well established microcredit organization took interest in promoting SHS. The loans to end users are initiated by the solar companies.
- **Nepal Home Employment and Lighting Package (Himalayan Light Foundation)**, which offers participating villagers skill training, tools to set up an income generating activity and solar electricity system. Marketable products are mainly handicrafts, with marketing support by HLF.
- **Morocco *Maison Energie***, which is part of a larger natural resource management program; the *Maison* consists of the commercialization of various forms of solar energy, including PV equipment, solar water heaters and ovens and improved meeting areas (*foyers*).

Other off-farm productive uses and cases are described in Van Campen, et. al. (pp. 31-37).

Insight/Lessons

Experience of Grameen, HLF and *Maison Energie* indicate that a certain number of income generation activities can be promoted, with a concerted and targeted effort, linked to micro-credit and through organizations with strong community links. Although the Sri Lanka EnPoGen survey of impacts are not encouraging, this may in fact confirm the importance of livelihood support interventions if the surveyed communities did not benefit from these interventions.

Several surveys provide some insights:

Sri Lanka ESD Impact Study

- 60% of surveyed HH cited increased income as a benefit, but this included indirect income from saving on fuel and batteries.

- 8% indicated direct income enhancement from opening shop for longer hours or small businesses such as sewing and business kiosks

Sri Lanka EnPoGen Study

- The study showed low levels of household business activity, attributed to very low (12 V) voltage.
- The study calculated monthly savings from alternative sources at Rs. 335 vs. monthly installment of Rs. 650-1,250.

FAO survey described in Van Campen, et. al. (p. 31)

Businesses created or improved with PV (%):

- | | |
|------------------------------------|-----|
| • Retail shops | 28% |
| • Rural cinema (TV/video-business) | 19% |
| • Battery Charging | 16% |
| • Telecommunications shops | 12% |
| • Repair/technical shops | 16% |
| • Handicraft/sewing workshops | 21% |
| • Tourism (hotel, lodge) | 16% |

RE for Agriculturally-Based Systems. The experience in developing countries has been largely through experimental and pilot projects. Three experiences provide an overview of the range of applications:

- **Mexico PV Power for livestock and related enterprises (WB/GEF)**, a demonstration project, including pumping water for livestock, micro-irrigation, ice production for fishermen and milk cooling tanks. Target is 300 units; about 1/3 accomplished to date.
- **Chile PV Power for irrigation (GTZ)**, part of program of 10 pilot installations in Ethiopia, Chile and Jordan carried out 1998-2002, objective to clarify whether PV systems are cost-effective to irrigate cash crops and assess organizational and technical requirements.
- **China Integrated Biogas Systems (Shell Foundation)**, integrated biogas, pig production, latrine and greenhouse (“4-in-1”) system. Effort to introduce new source of income (vegetables and flowers), as well as supply methane gas for cooking, reducing demand for firewood. Installed in 50 households.

Insights/Lessons

The Mexico experience with livestock is showing promising results. Success so far is attributed to linkage with ongoing program of Bank assistance and functioning agricultural extension program. One barometer of success is that there is a demand for financing of the system by other (non-pilot) farmers. Water pumping functions for these livestock enterprises are very simple and low maintenance (no storage or batteries – daytime pumping only) – farmers themselves have introduced micro-irrigation as another productive use. Ice production and milk cooling are somewhat more complex because of the need for batteries for night/dark operations. Important conclusion is that Source of energy not such a problem, especially for pumping – main need is in training, TA on how to most effectively use technology – irrigation, marketing, management, record keeping, etc.

The Chile experience with irrigation showed that PV for irrigation can be considered an option, but certain conditions must be met for it to be competitive with diesel pumps. Overall, the PV investment is about 3 times that of diesel, although this can be heavily influenced by the subsidy

and import duty regime. The study showed that, if one considers the significantly lower running cost and better reliability of PV, then PV begins to look more attractive with a longer term assessment. The study shows that PV systems tend to be economically viable with a real discount rate below 12% and a degree of utilization, and an irrigated area of up to 4 ha. Because of the need to maximize utilization, there is generally need to change the way the farm is managed, around new irrigation scheduling and appropriate cropping patterns. This scheduling and cropping pattern requires management at the farm level, as well as a capable agricultural extension and applied research service to prescribe, train, monitor and improve on recommended irrigation schedules and cropping patterns.

The China experience with biogas showed that profitability to the farmer appears to be marginal, although time saved to women previously collecting firewood and health benefits are significant. The 4-in-1 system was downsized to “3-in-1”, excluding the greenhouse, because farmers felt the greenhouse component was beyond their resources and expertise. The study concludes that to be successful, the scheme has to “second and third tier enterprises”, focusing on the biogas system construction business and technical support to farmers in techniques of vegetable production, marketing and management. Other organizations, such as WWF and The Nature Conservancy, are implementing similar concepts.

Targeted RE Productive Applications. There are numerous creative initiatives to find productive uses that are directly powered by RE energy. These are cropping up all the time, but a few salient cases are mentioned below:

- **Bangladesh: Battery Operated Lamps (ESMAP).** Rural women trained to produce DC battery-operated DC 12 V or 8 V lamps as a micro-enterprise, responding to a potential market of about 20,000 HH within 300 km² outside grid. Activity tied to diesel powered battery charging station, which also powers mini-grid for about 100 shops and HH.
- **Senegal/Sahel: PV Powered DC Machines (Alternativas).** Food processing, village workshop and home business applications developed using PV-powered DC motors. Over 10 years experience of work with local stakeholders to develop design to ensure technology is firmly grounded locally. Used for food processing, fans, sewing, drilling, irons, etc.
- **Swaziland: Solar Power Packs (Netherlands Energy Research Foundation).** Long term program to get energy services to a highly scattered population, without extension of the grid. Phased approach is to: (i) identify successful solar delivery modes in one area (year 1-2); (ii) implement successful modes in other areas (year 3-9); and (iii) country wide dissemination (year 10+). Phase I = 2001-2002.
- **Argentina, et. al: Solar Powered Drinking Water Pumps (GTZ).** Program to demonstrate technical maturity of PVP and clarify prerequisites for its broad utilization. Program lasted from 1990-1998. In 1990, several thousand PVP were already installed but efforts and information were scattered. Program sought to fill this information gap. Installed 90 PVP systems, nearly half of all systems operate in the 1-2 kW_p power range. Operative ranges cover water discharge rates of 4 to 100 m³ and pumping heads between 10 and 125 m.
- **Mauritania: Wind Powered Water Supply Pumping (World Bank).** Very limited approach that was not scaled up. Systems apparently failed due to failure of maintenance system. These systems are or will be replaced by solar power systems or conventional motors powered by fuel or electricity.

Other examples include:

- **China: PV/Wind Hybrid Systems in Inner Mongolia (GTZ)**, which have provided herdsmen access to TV/Radio. Access to regular weather information has enabled them to reduce risks by helping to plan for sheep shearing, protection of newborns, moving hay indoors and avoiding unnecessary watering of fields (Van Campen, et. al. p. 19).
- **Ghana: LPG for Fish Drying (UNIFEM)**, which provided women with an alternative to using wood-fired techniques and provided women with micro-credit (Misana, et. al. pp 41-42).

Insights/Lessons

Bangladesh battery-operated lamp enterprise is providing additional off-farm income and employment to women, earning about additional \$2 for each 2 lamps sold, which is daily wage of skilled laborer. Purchasers are using lamps for productive use mainly by extending working hours. Enterprise has provided foundation for future endeavors in solar-based battery charging and solar home systems.

Principal premise of the Senegal solar powered DC motors is that, at least for now, we should focus on the “old economy” and depend on rugged and efficient motors produced at high volumes and affordable prices. This permits to expand a new motor market to semi-continuous machines like mills, shellers, drills, lathes, saws, irons, etc. This low intensity motive technology rests on local manufacturers and entities, who all participated in the development and dissemination process.

Cost analyses for the Argentina and others solar powered water supply showed that PVPs with ratings of up to about 4 kWp are cost-effective vis-à-vis diesel pumps. The smaller the demand and correspondingly the pump, the more attractive the PV option, though prices vary from region to region. One disadvantage of PVP dissemination is high initial cost and foreign currency outlays. Dissemination is also greatly dependant on the existence of a maintenance structure already in place, together with spare parts. Despite the hurdles, PVP pumping is seen as a well-defined option for large scale water supply projects and strategies.

The premise of the Swaziland solar power packs is that people will be more inclined to invest in technology if they see the immediate benefits. The proposal does not seem to have financial analyses. Hopefully these will be done during the pilot phase to assess the willingness to pay.

Failure of the Mauritania wind energy initiative seems to be that it was simply not possible to put in place a dependable system for maintenance. The systems are now reverting to either solar (lower maintenance requirement) or diesel or electricity, for which there is a network or capable suppliers and maintenance capabilities.

3.2.4 Bank Productive Use Projects Recently Underway or in Planning

- **Uganda: Energy for Rural Transformation Project (World Bank/GEF)**
- **Nicaragua: Offgrid Rural Electrification for Development (World Bank/GEF).** Support to off-grid pilot projects (mini-hydro and mini-grids), solar battery charging stations and Solar PV Market development. Addresses productive use directly with components on Micro-finance and Business Development Services. A baseline study of productive uses has been carried out.

- **Bolivia: Decentralized Energy, Information and Communications Technology for Rural Transformation (World Bank).** APL under design, which combines rural electrification with information and communication technologies (ICT). Explicitly aims to harness rural infrastructure services such that they promote social and productive uses. Project will finance mini-grids and SHS. Includes component: Development of Social and Productive Applications. All O&M will be financed through tariffs, hence need to promote access to financial services for productive applications to be explored in Phase I.
- **Ecuador: Power and Communications Sectors Modernization and Rural Services Project (World Bank/GEF).** Effort to address regulatory reform in both power and communications sectors, so as to foster an improved environment for providing both services coincidentally. A move toward “bundled services”, with a heavy focus on regulatory environment.
- **Brazil: Renewable Energy in Agricultural Production Systems (GEF).** PCD stage - Project will promote wide range of renewable energy sources, technologies and applications for productive uses in agriculture and agroprocessing, within the context of conservation agriculture. Aims to develop an operational framework to “optimize” energy, environmental and social aspects agricultural production systems. Optimization framework will be tested in the corn and livestock based agricultural system in the Santa Catarina State.
- **Honduras: Solar-Net Village Program.**
- **Philippines Village Power Fund.**

3.3 Other Sector Experience

3.3.1 Rural Transport

For the rural transport, the notion of productive use is similar to that of rural electrification – it is a means to many possible end uses. In this case, the direct productive use might be usefully termed as riding in or on a motorized or non-motorized mode of transport. The rural transport sector is faced with a similar challenge as rural energy: how to get access to the most basic level of service to the most people, given limited public funds for subsidization. There have been numerous attempts to find the quantitative “linkage” with economic growth and poverty reduction. These have generally required extensive data collection, modeling and assumptions about all the other factors involved in economic activities benefiting from improved transport.

On the practical side, the approach has been to first, define who is responsible for different parts of the network. Second, take a service-level view towards the idea of access, that is, for different parts of the network, provide a service corresponding to the demand (defined in terms of traffic) and what people (or local governments or communities) are willing to pay for, including continuous maintenance. This means that the type of road service might include an improved track with all-weather accessibility. Thirdly, assist communities to ensure that various forms of transport services (ranging from non-motorized to motorized) become available to actually take advantage of the infrastructure. For example, introduce local bicycle production through NGOs and rural enterprises.

3.3.2 Rural Water Supply and Sanitation

RWSS has addressed the issue of productive use mainly through a more concerted approach to promoting the health benefits of improved water supply and sanitation. Studies have shown that merely improving water supplies does not necessarily bring about significant reductions in water-related diseases. Rather, educational efforts to alter perceptions and behaviors, combined with improved supplies and sanitation infrastructure, have much better pay-offs.

Consequently, RWSS programs are increasingly including “software” aspects, which focus on community education strategies to promote desirable household behavior. An entire body of knowledge has been generated in this regard by organizations such as UNICEF and WHO. RWSS projects tend to be “community-based” and are therefore akin to the mini-grid and multi-purpose platform type of rural energy programs.

3.3.3 ICT

The ICT people have been addressing the productive use issue by actively crossing the sectoral boundaries, particularly with rural energy, but also advancing collaboration with microfinance.

4 Emerging Themes

4.1 Pre-Conditions

A recurring theme in all documentation and discussions of productive use is the need for rural energy services to be designed so as to respond to users’ needs (“demand-push”), rather than the other way around (“supply or technology-pull”). Related to this is the view that energy must be understood as an input to income-generating activities. In this connection, practitioners express agreement that demand will only be generated if a set of particular conditions are present, which would enable small businesses to thrive. Among the conditions mentioned are:

- Knowledge and skill by small and micro-business, households and farmers on how to use new-found electrical and motive power for profitable enterprise.
- Technical and financial management capacity of small and micro-business, households and farmers, including availability of credit and micro-credit to finance productive tools and equipment. Micro-credit programs seem mature in S. Asia and seem to be developing in LAC.
- A policy and institutional environment conducive to business development, willingness to promote decentralized services, etc.
- Access to markets for additional or new products produced or services offered as a result of new electrical, heat or motive power.

- For off-grid services, a closer attention paid to the interaction between the energy technology (heat, motive, electricity) and the wide range of potential productive uses and products.
- Availability of a minimum of other complementary infrastructure services, such as transport, water supply and ICT services.

4.2 Institutional Models

In view of the fact that widespread productive uses may not spontaneously occur, projects are beginning to take a more proactive role in promoting such use. This necessarily takes one into the domain of farm and non-farm enterprise development, which require particular expertise in micro-enterprise and farm management and an understanding of the local economy and business development prospects and marketing. It also requires attention to the policy and regulatory environment, which affects prospects for private sector initiatives and investment. Within this context, there seem to be several institutional approaches emerging, which could be applied in part or in combination, depending on the situation and type of service provided:

Business development services from energy provider (Indonesia BDS), in which the project assists the electricity provider to improve its outreach to potential clients, thereby increasing loads and profitability, and in the process providing impetus for general economic growth. The BDS could be provided through competitively awarded outsourcing contracts or directly by the supplier (in Indonesia, the outsourcing of these services through NGOs was successful in reaching a large market segment, but did not lead to a “mainstreaming” of this more commercial mentality within the utility company). This approach would seem to lend itself best to grid extensions or larger established min-grids.

Micro-enterprise development from project or micro-financier (Grameen Shakti, Sri Lanka SEED Nepal PV/HELP, Peru Micro-Hydro Dissemination, Guatemala Renewable Energy-based SME, Morocco *Maison Energie*), in which the project or micro-finance organization works directly to assist microenterprises come into being or achieve the requisite knowledge and resources to take advantage of new motive or electrical power. In this way, they seek to generate a critical mass of productive activity that would achieve a higher degree of utilization of daytime, as well as nighttime power. The productive uses are mostly based on local crafts and products, but some are beginning to try to tap into the “new economy” through internet sales.

Allderdice and Rogers (NREL) provide an excellent practical guidebook on how to evaluate the application of technology to micro-enterprise, and present three institutional approaches for combining energy with microfinance for the benefit of micro-entrepreneurs: (i) end-user credit for individual systems; (ii) financing and promoting productive application in community-scale systems; and (iii) supporting energy entrepreneurs.

Multi-functional platforms and direct applications, combined with micro-enterprise or finance support (Mali Diesel MFP, PV Powered DC motors, Mexico PV Powered livestock pumps, Bolivia Decentralized Energy/ITC), in which a set of economically beneficial activities are tied directly to the platform or power source, and these activities are grounded on the existing village economy and local, mainly agricultural markets.

Business Partnerships with Vertical Integration (CPC Biomass PRE/PUP, India DESI Power and Greenstar Community Centers), in which a promoter aims to help the community generate revenue by providing access to new markets, such as the internet, or in the case of the CPC, a network of small or micro-enterprises.

Cross-Sectoral Collaboration and Bundling (Uganda ERT, Ecuador PROMEC and Bolivia Decentralized Energy/ICT, Nicaragua Offgrid Rural Electrification for Development), which aims to capture demand-supply synergies between energy and those sectors requiring energy services. PROMEC addresses regulatory reform through the creation of a single regulatory agency for Telecom and Electrification.

4.3 Technical and Economic Issues

The following are some technical and economic issues arising:

- i. It seems that there are possibilities for solar systems and SHS home business applications, but they must have a minimum power output; it may be useful to have guidelines on specific power output ranges for specific applications (see iv/ below). The Nicaragua and Bolivia projects will provide further results in this regard.
- ii. Micro-finance is consistently cited as an important part of promoting productive use, and a good guideline in this connection has been developed by NREL. New projects in LAC are working directly with micro-finance specialists.
- iii. Diesel MFPs seem to enjoy success in part because they bring about a more efficient and profitable way of doing what villagers are already engaged in.
- iv. Similar advantages can be attributed to the PV powered DC motors, which can be even simpler and more reliable than diesel. This warrants further analysis, as it would seem to inform the ongoing debate on the value of low voltage solar systems beyond lighting and very small appliances, related to i/ above.
- v. The Greenstar and Biomass cogeneration models involving “new economy” marketing and vertical integration require extensive community screening, preparation, local expertise and financing. Once established, they probably are sustainable and have spin-offs, and may be the wave of the future, thus should be encouraged. However, one needs to see how they can be “scaled up” in a given country beyond the immediate plans of the sponsor.
- vi. PV vs. diesel for agricultural pumping: PV has higher initial cost but lower operating costs, hence the necessity to increase the load utilization to make it pay over time. If initial investment is subsidized, PV becomes more attractive and sustainable. A key question is, what level of subsidy will enable farmers to invest, while enabling widespread coverage beyond pilots. Even if PV becomes an attractive financial option, there is still need for technical assistance and management on how best to use the technology, as noted in i/ above. Further results from Mexico and Bolivia will be instructive.

- vii. The issue of “scaling up” requires that one addresses the policy and regulatory framework and how it affects the economics of any of these systems. For example, the relative costs of PV water pumps vs. diesel is clearly dependent on levels of subsidization and import duties.
- viii. Future baseline and monitoring studies may wish to establish a typology of productive use; building on the India Study, these might be identified by scale and number of employees, e.g.:
 - Artisans, such as: tailor, carpenter, barber, blacksmith, potter
 - Rural Industrial Units : flour and oil mill, brick mill, stone crushing
 - Rural Services, such as medical, education, ICT
 - Agriculture: water pumping for irrigation, livestock)
 - Water supply

4.4 Towards a Development Approach for Productive Use Components

The following are some items that could form part of a checklist to be used in scoping prospects for productive use components:

- Overview of current service supply, type and quality of coverage
- Policy and institutional framework for supply
- Rapid survey of productive use applications, by type of activity; existing, potential, perhaps using above-mentioned typology
- Order of magnitude of unmet demand
- Business development or support capacities for productive uses, including finance, BDS
- Complementary services, such as roads, ICT, water; potential for bundling
- Policy and institutional constraints facing productive uses, including pricing, subsidization, tariffs, etc.
- Other projects and initiatives promoting business enterprise and productive uses
- Existing studies and data on costs and returns and other performance indicators of productive uses (see below)
- Strategic approach to productive use – institutional reform, capacity-building, investment...

4.5 Some Examples of Performance Indicators for Productive Use

This section provides examples of the types of indicators generated that relate to productivity, efficiency and sustainability.

PVP for Irrigation (GTZ)

- Technically
 - High year round utilization of the pumped water is ensured
 - Well designed systems with an overall efficiency of 3 % or above and system sizes up to 2 kWp are applied (this depends greatly on country-specific conditions)
- Organizationally
 - Costs for operating staff are low

- Installation, maintenance and repair work can be performed by qualified local staff
- Additional costs for water storage capacity can be kept low (community labor support)
- Financially
 - Low interest credit lines are available
 - Import duties and other charges on PV modules, inverters and pumps are moderate or non-existent.

Diesel-Powered Multi-Functional Platforms

- Perceived Impacts
 - Milling & husking – mostly for household consumption, improved quality, reduced time
 - Crushing of shea nuts – shea butter sold in weekly market, improved quality, reduced time; ¼ consumed, ¾ marketed.
 - Lighting – nighttime use of platform, lighting of maternity
 - Battery charging – served mostly men, owners of radio & TV, reduced transport for those in village
 - Water – reliable supply, time saved, better hygiene
 - Welding – farming equipment and transport equipment; job creation for welders, savings in time and workdays for clients
- Financial Revenues (Platform)
 - Financial revenue tables from modules shown in tables (for periods ranging from 6 – 12 months)
- Productivity and Income Impacts
 - Increased rice areas planted and production; half of which is marketed, leading to increased monetary income of 50,000 FCFA per campaign per woman
 - Increased shea butter (triple). No figures on income.
 - Incomes to women operators
 - Women have created savings account, but keep at their own level funds for platform maintenance.
 - Strong increase in attendance at weekly market – before the platform women attended 1 to 2 markets per week; after 5 – 6 markets, citing reduction of domestic work and increase in income generating activities.

Morocco *Maison Energie*

- A total of 47 micro enterprises have been created, of which 17 are fully operational.
- Preliminary data shows that micro enterprises are offering a range of services:
- 50% of microenterprises are involved with commercializing PV equipment
- 56% offer battery recharging services
- 50% offer other services
- The micro enterprises have created 41 permanent employees

Philippines Measuring Social and Economic Benefits of Rural Electrification

- While higher income levels are correlated with electrification, this is not necessarily causation in one direction, because higher income HH are also likely to adopt electricity when it becomes available.
- Most of HH businesses found:
 - Small variety stores (71%)
 - Tailor & Dressmaker (11%)

- Food stands & restaurants (3%)
- Hairdressers & barbershops (1%)
- Other – carpentry, goldsmith, laundry... (18%)
- Statistical analyses on such questions as time spent on home businesses. Summary of How Typical HH benefits from Electricity shows a “benefit value” (increased income) of \$ 34.00 for a current business and \$ 75.00 for a new business (p.3).
- The above is an average figure. The actual benefit would vary with type of business. For example there are limits to the extent to which a home sewing business could work extra hours, because of fatigue.
- Did not find a statistical relationship between agricultural productivity and rural electrification. Context: year of survey (1998) was El Nino and a drought. In addition, with exception of one province, areas surveyed did not have any irrigation facilities.
- Electrification clearly increases the chances (by about 10%) that HH will engage in some form of home business. Once electrification occurs, about 25% of HH will engage in home business.

Senegal: PV-Powered DC Motors

- Cereal mill. Over ten years experience, shows marked advantages over diesel ICE driven mill. 100 kg millet flour/day with 200 Wp
- Cooling unit. Drive system plus compressor/condenser unit. Used to cool rooms for crop conservation, air conditioning and for a milk tank.
- Ceiling fan. 10’300 m3/h at 24 V 4’900 m3/h at 12 V
- Home businesses/appliances: sewing, drilling, etc. up to 1500 W and 4500 rev/min
- DC adapters change 220 V AC devices with PWM (most modern compact lights, TV, PV, etc. into battery-compatible DC elements, solving DC hardware availability & price problem.
- Flat iron : one wet shirt needs 20 Wh for ironing.

Sri Lanka EnPoGen Survey

- 56% of connected villages offer battery charging facilities
- There was a lag time of some 5-7 years following grid installation for new local services and facilities to materialize
- About 2 new agricultural product processing activities came about in 16 electrified villages
- Electric fences have been installed to protect homestead crops from wildlife, particularly among larger holdings.
- 94% of remunerated activities involve men
- Among women with home-based activities, 15% use electrical equipment, compared to 32% for men.
- 40% of non-connected families use batteries for radio & TV
- Certain productive uses, such as rice milling or welding, require at least 100 watts. The study does not mention other low consumption activities, such as sewing.
- Preliminary results indicate that most agricultural water pumps in electrified villages have become electric. However, it is too early to say that electrification has brought about a structural change in agricultural activities
- Value of land in electrified villages increased
- Non-agricultural activities (MH grid):
 - Grinding mill for chillies & grinding mill for flour (woman whose husband is salaried)

Cost Grinding mill for chillies (1997): Rs. 50,000
Cost Grinding mill for flour (1999): Rs. 14,000
Monthly income: Rs. 2,000, but recently reduced to Rs. 1,000 because 5 other mills opened up

○ Carpenter

Cost Electrical equipment: Rs. 20,000
Cost Wood carving machine: Rs 2,000
Borrowed Rs. 5,000
Monthly Income: Rs. 5,000 – 6,000
Monthly maintenance: Rs. 500

○ Welding Workshop (previous welder working outside village)

Used to make Rs. 6,000 per month, Rs. 3,500 for food lodging, travel
Investment in equipment: Rs. 75,000
Received Rs. 10,000 loan from Samurdhi Bank & borrowed Rs. 25,000 from friend @ 12% interest
Produces grill gates
Income is Rs. 3,000 – 3,500 per month
Uses electricity to home

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Appendix 2: Project Briefs

Argentine, Brazil, Indonesia, Jordan, Philippines, Tunisia, Zimbabwe: Drinking Water Supply with Photovoltaic Water Pumps (GTZ)

Overview

Program to demonstrate technical maturity of PVP and clarify prerequisites for its broad utilization. Program lasted from 1990-1998. In 1990, several thousand PVP were already installed but efforts and information were scattered. Program sought to fill this information gap. Installed 90 PVP systems, nearly half of all systems operate in the 1-2 kWp power range. Operative ranges cover water discharge rates of 4 to 100 m³ and pumping heads between 10 and 125 m.

Analysis focused less as alternative to hand, wind or grid-fed electric pumps, but in comparison of diesel pumps, which are the main competitor for remote sites with populations of 500 – 2,000.

Experience with Productive Uses

Conducted comparative economic studies, with initial capital outlay, running costs and pumping costs. The broad conclusion is that PVP can be economically viable if:

- Technically
 - High year round utilization of the pumped water is ensured
 - Well designed systems with an overall efficiency of 3 % or above and system sizes up to 2 kWp are applied (this depends greatly on country-specific conditions)
- Organizationally
 - Costs for operating staff are low
 - Installation, maintenance and repair work can be performed by qualified local staff
 - Additional costs for water storage capacity can be kept low (community labor support)
- Financially
 - Low interest credit lines are available
 - Import duties and other charges on PV modules, inverters and pumps are moderate or non-existent.

The standard system proved very reliable, with an average availability of 99%. Downtime was mainly caused a total of 22 hardware failures, of which inverters accounted for 70%. However, the PVP systems are not completely maintenance free and require an after sales service network.

Innovative tandem system permitted the PV generators to be coupled during low periods of insolation and provide enough power to keep one pump running at high efficiency.

Insights and Lessons Learned:

Cost analyses showed that PVPs with ratings of up to about 4 kWp are cost-effective vis-à-vis diesel pumps. The smaller the demand and correspondingly the pump, the more attractive the PV option, though prices vary from region to region.

Working against PVP dissemination is high initial cost and foreign currency outlays. Dissemination is also greatly dependant on the existence of a maintenance structure already in place, together with spare parts.

Despite the hurdles, PVP pumping is seen as a well-defined option for large scale water supply projects and strategies.

Source:

GTZ, *Resource-Conserving Drinking Water Supply with Photovoltaic Water Pumps (PVP)*, Case Study IEA PVPS, Task IX, January 2003.

Bangladesh: Grameen Shakti: Promotion of PV Solar Home Systems

Overview:

Concessional loan from GEF/IFC SME program enabled Grameen Shakti to offer improved credit terms to its customers thereby increasing demand for PV systems. Has installed over 11,000 systems as of January 2003.

Also promoting biodigesters for cooking, and using residues for pond and field fertilizer, and conducting research on wind energy

Experience with Productive Use:

Customers are mainly using PV systems for lighting and recreational purposes (TV). However, programme actively supports electrification for income generation activities, such as:

- Educational facilities
- Cellular phones for commercial purposes
- Illumination for rice mills
- Tailor shops
- Saw mills
- Grocery shops
- Poultry farms
- Health clinics
- Restaurants, bazaars
- Radio/TV repair shops
- Micro-utilities (selling power to neighboring shops)

Includes training program to ensure network of sales and support personnel and generate employment. Trained 300 technicians and 2000 customers Has 38 branch offices.

Insights and Lessons Learned

This is an example of linking an energy program with established micro-credit organization that already has strong community links and outreach capability.

Research and other information could provide wealth of information on the returns to renewables for various productive activities.

Sources:

Grameen Shakti, *Status Report*, www.grameen-inf.org/grameen/gshakti/programs.html

Etcheverry, Jose, *Renewable Energy for Productive Uses: Enhancing Environmental Protection and the Quality of Life*, Research Paper (Second Draft) written for the Global Environment Facility, April 2002, p. 18.

Bolivia: Decentralized Energy, Information and Communications Technology for Rural Transformation

Overview:

This is an APL under design, which combines rural electrification with information and communication technologies (ICT). Explicitly aims to harness rural infrastructure services such that they promote social and productive uses. Project will finance mini-grids and SHS.

Experience with Productive Use:

- Includes component: Development of Social and Productive Applications.
- All O&M will be financed through tariffs, hence need to promote access to financial services for productive applications to be explored in Phase I.

Insights and Lessons Learned:

- The project takes a broad view of “social and productive uses”, but will begin with modest objectives during the initial phase:
 - Develop at least three applications of social and/or productive use, drawn from most likely:
 - Health, education, income generating activities (specifically small-scale agriculture)
- During the design, there has been a trade-off between trying to address a range of cross-sector issues essential to project success, while keeping the complexity of the project to manageable proportions.

Sources:

Project Concept Document, *Bolivia Decentralized Energy, Information and Communications Technology for Rural Transformation*.

Brazil: Renewable Energy in Agricultural Production Systems (UNDP/FAO/GEF)

Overview:

Project will promote wide range of renewable energy sources, technologies and applications for productive uses in agriculture and agroprocessing, within the context of conservation agriculture. Aims to develop an operational framework to “optimize” energy, environmental and social aspects agricultural production systems.

Experience with Productive Use:

Optimization framework will be tested in the corn and livestock based agricultural system in the Santa Catarina State.

Insights and Lessons Learned:

This project will provide groundbreaking experience in the integration of energy considerations into agricultural production systems.

Sources:

Project Concept Document, Renewable Energy in Agricultural Production Systems, November 26, 2002.

Chile: Irrigation with Photovoltaic Pumping Systems (GTZ)

Overview:

Part of program of 10 pilot installations in Ethiopia, Chile and Jordan on private and public sector farms between 1998 and 2002. Objective to clarify whether photovoltaic pumping systems can be used to irrigate cash crops in a cost-effective and resource-conserving manner, as well as to examine appropriate organizational and technical requirements. Carried out in the Atacama Desert in northern Chile – one of the most arid regions in the world. Two configurations with drip irrigation were tested: (i) pumping into a storage tank; and (ii) pumping directly into the drip irrigation system.

Experience with Productive Use:

- Investment cost about 3 times that of diesel pumps. However, this can be heavily affected by subsidies and import duty regime.
- Diesel pumps have very high running cost and low reliability
- Farmers are initially deterred because of the high initial cost, however, do not necessarily see the significantly lower operating costs.
- The PVP need a high degree of utilization to make it viable, compared to diesel.
- Close cooperation with local NGO and agricultural extension and research organizations.
- Overall profitability was assessed with various configurations and discount rates.
- Generally PVP systems tend to be economically viable with a real discount rate below 12% and a degree of utilization above 60%, and an irrigation area smaller than 4 ha.
- However, irrigation was shown to have a high return no matter what the pumping method, so farmers have a tendency to prefer diesel, because of the lower initial cost, ignoring the long term benefits. Therefore the need for TA and financing.

Insights and Lessons Learned:

- Because of the needs for higher system utilization, the way the farm is managed needs to change – basically organizing the cropping patterns and irrigation scheduling.
- This requires the input of professional agronomic experts. This is in principle available from the National Agricultural Institute, but also there needs to be further applied research to ascertain optimum cropping patterns and watering schedules, to match requirements of PVP.
- The tank configuration enable stored water to bridge period of low insolation and provide the pressure needed for the irrigation system. Direct injection case can reduce the initial outlay by as much as 35% but must operate with variable system pressures and flows.
- The PVP systems are best suited for uninterrupted crop rotations or continuous cropping systems with high value-added cash crops (fruits, vegetables, herbs and spices).
- The main challenge for PVP is to achieve high utilization rates, given its high initial cost and low running costs, as opposed to diesel, which has a lower initial cost and higher variable cost.

Source:

GTZ, *Resource-Conserving Irrigation with Photovoltaic Pumping Systems(PVP) in Chile – Case Study*, IEA PVPS, Task IV, January 2003.

China: Integrated Biomass Systems (Shell Foundation)

Overview:

Integrated biogas, pig production, latrine and greenhouse system (“4-in-1”). Effort to introduce new source of income (vegetables and flowers), as well as supply methane gas for cooking, reducing demand for firewood. The 4-in-1 system was downsized to “3-in-1”, excluding the greenhouse, because farmers felt the greenhouse component was beyond their resources and expertise. Installed in 50 households. “4-in-1” systems are successfully operated in other parts of China closer to urban markets for vegetables.

Experience with Productive Use:

- Profitability to the farmer appears marginal, though the time saving to women collecting firewood and health benefits appear significant.
- Seems to have spurred other programs to build same units, e.g. World Wildlife Fund and The Nature Conservancy.
- Although the report says direct income effect is marginal, calculation of payback period, based on increased pig production and reduced firewood assumptions show payback periods of 2 – 5 years.
- Promising sign for the future is emergence of private company to construct 3-in-1 system
- Farmers expressed concerns about: (i) marketing ability for vegetables; (ii) lack of expertise in growing vegetables; (iii) need for suitable plot of land.
- One local official expressed desire to promote system by removing agricultural tax on vegetables they produce.
- Financing was major challenge because local banks were not familiar with technology – solution was to offer a loan guarantee fund.

Insights and Lessons Learned:

- Characterized the economy surrounding the systems as having three levels:

- Farm enterprise business
- Biogas systems construction business
- Produce transport and market business
- Sustainability and replicability will depend on the establishment of “second” and “third” level enterprises, with government support and creating the right environment, and at the “first” level technical support to the farmers in techniques of vegetable production, marketing and management.

Sources:

Barnett, Andrew, et. al., *Integrated Biogas Systems for Poverty Reduction and Natural Resource Conservation in the Baima Snow Mt. Nature Reserve Yunnan Province, Southwest China – Validation Report for the Shell Foundation (Review Draft)*, May 2002.

China: Energy, Poverty and Gender: a Review of the Evidence and Case Studies in Rural China, IDS University of Sussex (World Bank/ESMAP)

Overview

Series of case studies, using qualitative and quantitative techniques in five poor and non-poor rural counties in two provinces. Section 1 is largely conceptual on energy, poverty and gender, while Section 2 reports results of studies.

Experience with Productive Use

- Found clear correlation between powered production or transport equipment and living standards
- Powered equipment included grinders and fodder cutters, oil press, noodle maker, electric saw for construction.
- Small number of powered machines, often hired to neighbors and in exchange for labor. Many were owned by people with salaries;
- While those without electricity spoke of plans to engage in productive activities enabled by electrification, such as milling and grinding, breeding chickens, those with electricity seemed more concerned with quality of life issues (lighting, TV, reduced domestic task labor) not production. Viewed as an enabling device to go off and seek casual labor.
- Constraints cited include lack of credit, and a lack of a set of infrastructure – roads water and electrification – as essential to developing alternatives to migration in search of income.
- Biogas, although used elsewhere, seen as prohibitively expensive.
- Women use fans for cooking fires. Women spoke of need for electric fans, but were prohibitively expensive (Y40).

Insights and Lessons Learned

Even villages with grid electricity were not expanding their productive uses significantly, because the communities remained largely isolated and without “complementary inputs” and other basic infrastructure.

Source:

Lucas, H. et. al., *Poverty and Gender: a Review of the Evidence and Case Studies in Rural China*, Institute for Development Studies at the University of Sussex, UK, Energy for the World Bank and Government of Netherlands.

Ecuador Power and Communications Modernization and Rural Services Project (PROMECA) (World Bank)

Overview:

Effort to address regulatory reform in both power and communications sectors, so as to foster an improved environment for providing both services coincidentally.

Experience with Productive Use:

A move toward “bundled services”, with a heavy focus on regulatory environment.

Insights and Lessons Learned:

Too soon to tell.

Sources:

World Bank, *Ecuador Power and Communications Sectors Modernization and Rural Services Project – PAD*.

Guatemala: Renewable Energy-Based Small Enterprise Development in the Quiché Region (GEF)

Overview:

Helped develop a micro-hydro electric system and PV systems. Has actively involved local women in project decision-making and led to new initiatives to create their own associations for future projects.

Experience with Productive Use:

Energy use for income generating activities such as coffee drying and weaving are being explored by project.

Insights and Lessons Learned

Introduced way of using river for micro-hydro development which has spinoff income generating opportunities.

Sources:

Etcheverry, Jose, *Renewable Energy for Productive Uses: Enhancing Environmental Protection and the Quality of Life*, Research Paper (Second Draft) written for the Global Environment Facility, April 2002, p. 20.

India: Decentralized Energy Systems (DESI Power)

Overview:

DESI (non-profit of TARA and DASAG India) sets up independent rural power producers (IRPPs) at village level as joint ventures between local communities and enterprises. First DESI Power Plant was installed in 1996 – 80 kW biogasification plant. TARA purchases electricity to run the operation in its “technology village” which consists of several industries employing over 100 people.

With investment capital from the Dutch Ministry of Development Cooperation, intends to set up six independent Rural Power Producers around the company.

Experience with Productive Use:

The industries in the technology village consist of:

- A large handmade paper recycling unit
- Several enterprises producing microconcrete roofing tiles, mudblocks and other cost effective material
- A charcoal briquetting unit
- A paper products unit.

Insights and Lessons Learned:

Example of tying energy supply with technology development and market development operations.

Sources:

www.devalt.org/TARA/desi_power.htm

Etcheverry, Jose, *Renewable Energy for Productive Uses: Enhancing Environmental Protection and the Quality of Life* – Research Paper (Second Draft) written for the Global Environment Facility, April 2002, p 16.

India: Energy Strategies for Rural India: Evidence from Six States (ESMAP)

Overview:

Survey of 5,000 HH and 900 artisans & industries.

Experience with Productive Use:

Provides Table on Energy Consumed by Artisans and Rural Industries Surveyed
Artisan Activity

- Tailor
- Carpenter
- Barber
- Blacksmith

- Potter

Rural Industrial Units

- Flour mill
- Oil mill
- Brick mill
- Stone-crushing

Irrigation Pumping

- Electric vs. Diesel Pumps. Electric is heavily subsidized, but service is poor. Farmers express willingness to pay for better service (because it is already much cheaper than diesel) but are suspicious that higher prices won't bring better service.
- General shift away from diesel towards electric pumps.
- Price based on pump size not electricity consumed.
- HH in rural areas pay higher prices (double or triple) than agricultural customers.
- Govt policy to reduce agricultural subsidies to be not less than 50% of cost of supply
- Low tariffs do not provide incentive to improve efficiency of pumpsets.

D. Barnes, et. al., *Energy Strategies for Rural India: Evidence from Six States*, ESMAP/UNDP, August 2002.

Indonesia Rural Electrification Projects I & II (World Bank)

Type of Service: Grid-Based

Overview:

- Focus on outreach to small businesses through NGOs, developing marketing strategy of supplier: information, tariff barriers, quality of service.
- Main constraint believed to be insufficient information – price & technical – to potential users
- Program deemed effective in promoting use, increasing consumption and creating jobs – 66,000 enterprises and 22,000 new jobs. Need to get more disaggregated information on the types of users.

Experience with Productive Use:

- Intensive consumers of energy identified in PAD:
 - Food & beverages
 - Light engineering
 - Garments
 - Wood products subsectors (furniture, bamboo & rattan, handicrafts...)
 - Rice mills & other agro-industries
 - Small tools & metal products
 - Roof tiles and building materials
- Survey of businesses in 1992, profile of businesses – Update??:
 - Family owned & operated
 - Less than 20 employees
 - Based at home or adjacent to home

- Electricity for lighting by most
- Alternative uses for driveshaft power common

It would be interesting to see to what extent this profile has changed as a result of the project. Judging from the aggregate results, it ought to have..

Insights and Lessons Learned:

- Risk identified is to attempt to carry out too many tasks trying to solve a wide range of problems confronting business. Addressed this by sharply focusing role of NGOs and providing better support with training and promotional materials.

Sources:

World Bank, *Indonesia Rural Electrification Project – Implementation Completion Report*, Report No. 15210, December 1995

World Bank, *Indonesia Second Rural Electrification Project – Staff Appraisal Report*, Report No. 12920-IND, February 1995.

World Bank, *Second Rural Electrification Project – Implementation Completion Report*, Report No. 20676.

Finucane, James, Personal Correspondance, February 12, 2003.

Mali: Multi-functional Platform using Diesel Gensets (UNDP)

Overview:

Platform built around a 10 HP diesel engine that can power various tools, such as cereal husker, alternator, battery charger, pump welding and carpentry equipment, etc. It can also generate electricity and be used to distribute water. Capable of driving up to 12 ancillary modules. Among these are grain mill, de-huller, shea butter press and electric alternator, which can drive water pump and power up to 250 light bulbs, battery charging, drive a sawmill or weld metal.

Pilot phase has installed 65 platforms (Mali), aims to equip 450 villages in Burkina Faso, Guinea, Ivory Coast and Senegal. Managed by womens’ groups.

Experience with Productive Use:

Impact Study, June 2001:

- Perceived Impacts
 - Milling & husking – mostly for household consumption, improved quality, reduced time
 - Crushing of shea nuts – shea butter sold in weekly market, improved quality, reduced time; ¼ consumed, ¾ marketed.
 - Lighting – nighttime use of platform, lighting of maternity
 - Battery charging – served mostly men, owners of radio & TV, reduced transport for those in village
 - Water – reliable supply, time saved, better hygiene

- Welding – farming equipment and transport equipment; job creation for welders, savings in time and workdays for clients
- Financial Revenues (Platform)
 - Financial revenue tables from modules shown in tables (for periods ranging from 6 – 12 months)
- Productivity and Income Impacts
 - Increased rice areas planted and production; half of which is marketed, leading to increased monetary income of 50,000 FCFA per campaign per woman
 - Increased shea butter (triple). No figures on income.
 - Incomes to women operators
 - Women have created savings account, but keep at their own level funds for platform maintenance.
 - Strong increase in attendance at weekly market – before the platform women attended 1 to 2 markets per week; after 5 – 6 markets, citing reduction of domestic work and increase in income generating activities.
 - Data on extra family activities by women for two villages:
 - Tendeli: cotton spinning, small trade, trade of fish, marketing of shallot, millet beer sale, sale of cotton, sale of pepper, sale oil, sale food items (local bread, peanuts, paste, cakes)
 - Maourlo: millet beer sale, processing and sale of honey, making acacia balls, sale of soumbala, sale of tobacco, sale of peanuts, sale of leaves of sorrel, small livestock breeding and sale of pigs, collective women’s farm, working on men’s farms (300 CFA/day) and making of soap from pourgher.
- Social welfare Impacts
 - Increase in girls’ attendance and performance in schools
 - Increase participation of women in public life

Insights and Lessons Learned:

- Seems to be an extremely promising initiative. Incomes of participating women increased from US\$ 40 to US\$ 100 and freed up 2 -6 hours of her time per day. Positive cash flows from the first day after installation.
- Although managed by women, there is a strong incentive to provide services that the whole community can use – e.g. welding and battery charging which men mostly use, and public lighting.
- The absence of a micro-credit scheme tends to constrain the women from fully realizing benefits.

Sources:

The Multifunctional Platform <http://www.ptfm.net/mfpwhat.htm>.

www.gvep.org/knowledge/experience/MaliUN.pdf

Diagana, Mousa, *Impact Study of the Multifunctional Platform on the Living Conditions of Women*, MLI/99/001 Project.

Mexico: Renewable Energy for Agriculture Project (World Bank/GEF)

Overview:

- Demonstration project
- Target: 300 units – about 1/3 accomplished to date

Experience with Productive Use:

- Pumping water for livestock, but farmers using for micro-irrigation; also ice production for fishermen and milk cooling tanks.
- Water pumping functions very simple and low maintenance (no storage or batteries – pumping during the day only)- PV pumps limited to shallow wells, small irrigated area coverage.
Ice pdn. & milk cooling require batteries for night/dark operation – somewhat more complex and environmental considerations.

Insights and Lessons Learned:

- Source of energy not such a problem, especially for pumping – main need is in training, TA on how to most effectively use technology – irrigation, marketing, management, record keeping...
- Success so far attributed to linkage with ongoing program of Bank assistance and functioning extension program
- One barometer of success – demand for financing by other farmers, users.
- Limiting factor in scaling up/replication is supplier network in country.
- “Blended Projects” with GEF grant to demonstrate & Bank loan for replication may be way to go.
- Waiting to get more information on financial and other benefits to the demonstration units.

Sources:

World Bank, *Mexico Renewable Energy for Agriculture Project – Project Appraisal Document*, Report No. 19912-ME, November 1999.

Morocco: Maison Energie Project (UNDP)**Overview:**

One of three components of a larger project, “Environmental Protection, Natural Resource Management, and Renewable Energy Promotion.” The Renewable Energy component includes the establishment of “Maison Energie,” which are designed to promote micro-enterprises, based on the commercialization of various forms of energy, including PV equipment, solar water heaters and ovens, and improved public meeting areas (“foyers”).

Initial investment of a Maison is \$ 10,000 – \$ 5,000 by program, \$ 2,000 from the community, and \$ 3,000 from a “promoter.” This includes stock of parts and accessories, transport and the establishment of a revolving fund.

The first phase currently in process aims for establishing 30 Maisons Energie, of which 20 are presently in operation. Overall goal is to establish 1,000 Maisons. Focus is on establishing micro enterprises with “youth.” Program has sponsored workshops for the youth promoters on starting up and managing a micro enterprise and establishment of network of collaborators.

Plans to establish website, networking support among micro entrepreneurs and guarantee fund with support of IFC.

Experience with Productive Uses:

A total of 47 micro enterprises have been created, of which 17 are fully operational.

Preliminary data shows that micro enterprises are offering a range of services:

50% of microenterprises are involved with commercializing PV equipment

56% offer battery recharging services

50% offer other services

The micro enterprises have created 41 permanent employees

Insights and Lessons Learned:

Example of promotion of energy in direct conjunction with promotion of income generating activities.

Need more information on the types of micro enterprises being developed.

Sources:

Dafrallah, Touria, *Microentreprises pour l'Amelioration de l'Approvisionnement Enegetique du Milieu Rural – Le Cas de Maroc Projet 'Maison Energie.*

Nepal: Rural Energy Development Programme (UNDP)

Overview:

By June 2000, 31 micro-hydro demonstration schemes were installed. Total objective is 64 micro hydro schemes with total installed capacity of 1,157 kW. Program includes skills training to promote agriculture and home-based business.

Experience with Productive Use:

Focus on gender equity – establishment of male and female community organizations and these organizations collaborate on specific projects with equal numbers of male and female representatives.

Insights and Lessons Learned:

Would be interesting to see the results for gender-oriented program. Could provide a model for gender-sensitive energy planning.

Sources:

Etcheverry, Jose, *Renewable Energy for Productive Uses: Enhancing Environmental Protection and the Quality of Life*, Research Paper (Second Draft) written for the Global Environment Facility, April 2002, pp. 19.

Nepal: Himalayan Light Foundation Home Employment and Lighting Package (HELP)

Overview:

Program which combines dissemination of solar electricity technology with income generation. Participating villagers are offered skill-training, tools to set up an income generating activity and a solar electricity system, which extends the working day. Marketable products can be made in the home apart from agricultural activities.

Experience with Productive Use:

Types of home industries include:

- Knitting
- Weaving
- Handmade paper products
- Thangka painting

Another income earning service is battery charging.

A feasibility study showed that there is an international market for Nepalese handicrafts, particularly thangka paintings.

HLF in process of setting up an e-commerce website for marketing of products.

HLF also conducts handicraft product training, which focuses on product styles and management issues, such as number of product needed to repay loan.

Pilot project shows perceived increase in income from:

- Increased hours for income-generating activities
- Reduced battery consumption (20% of income saved)

Insights and Lessons Learned

Example of effort to identify marketable products as well as marketing chains for products.

Sources:

www.hlf.org.np/help.htm

Nicaragua: Off-Grid Rural Electrification for Development (PERZA)

Overview:

Support to off-grid pilot projects (mini-hydro and mini-grids), solar battery charging stations and Solar PV Market development. Addresses productive use directly with components on Micro-finance and Business Development Services.

Experience with Productive Use:

- BDS and micro finance components to be implemented in close coordination, trying to “jumpstart” business relationships between BDS suppliers and clients and financing.
- Generating BDS services through grants and TA to qualified community-based BDS providers in pilot areas.
- Micro-finance through matching grants to micro and small businesses in the pilot areas and matching grants for institutional development to MFIs.

Insights and Lessons Learned:

- Three-pronged approach to pushing for sustainability: output-based subsidies to communities with economic potential; business support activities; and micro-finance.
- Initial surveys carried out by Mathur (Spanish) provide a baseline against which to monitor results.
- Coordination with UNDP-led small hydropower project specifically aimed at productive uses will provide synergies.
- Major problem in Nicaragua is the poor state of the banking system – hence, microfinance component

Sources:

World Bank, *Nicaragua Offgrid Rural Electrification for Development Project PAD*, Nov. 26, 2002.

Peru: Micro-Hydro Dissemination (ITDG Peru/IADB)

Overview:

Installation of 15 micro-hydro plants in isolated areas of Peru based on provision of soft loans and TA. Integrated approach, including technology development, training, pilot projects, research on institutional issues and advocacy work. The 15 plants represent 602 kW of installed capacity and provide electricity for some 1,800 people

Experience with Productive Use:

- Facilitated creation of small industries, such as carpentry and welding shops, and battery charging.
- Electricity also used to power education and health facilities and communications facilities.

Insights and Lessons Learned:

Sources:

Etcheverry, Jose, *Renewable Energy for Productive Uses: Enhancing Environmental Protection and the Quality of Life*, Research Paper (Second Draft) written for the Global Environment Facility, April 2002, pp. 16-17.

Philippines Rural Energy Services Companies (Shell/CPC & CPC/Development Marketplace)

Overview:

First of 10 planned RESCOs providing electricity to community of Alaminos, using: (i) Freestanding PV units; and (ii) Full time AC power supplied through local low voltage mini-grid (12 kWe PV/Propane hybrid).

Customers pre-purchase electricity service weekly to the service provider.

Use of NREL PC-based software to identify optimum low-voltage minigrid layout and configuration.

Under a Development Marketplace supported initiative, CPC is now installing and conducting trials on a biopower multi-functional platform system (Productive Use Platform – PUP) that will generate power from waste coconut shells in same location.

Experience with Productive Use:

Initial RESCO program had not productive use per se, and focused more on testing technology.

The Development Marketplace initiative involves setting up a Productive Rural Enterprise (PRE) that will attract investors who will have an interest in marketing a wide range of products resulting from the PUPs. Present range of products include:

- Geotextile (nets from coconut fibers to be used for twine and soil erosion protection)
- Organic fertilizer
- Dried copra
- Refined oil to make high quality soap

PUPs are designed to provide thermal, mechanical and electrical outputs that can drive a number of different appliances and productive uses. The first unit has been delivered in February 2003.

Insights and Lessons Learned:

The RESCO is one of 4 Shell Renewables Business Models, based on (i) type of system, (ii) finance; & (iii) mode of service delivery.

- Sunstations (low voltage minigrids, renewables & hybrids) – Fee-For-Service, local gov't financing
- Solar centers – Financed Sales
- PV Solar home – Fee for Service
- PV Solar home – Sales to Distributors

Market research and selection criteria applied before entering area, among others:

- Large number of unserved HH
- Potential service territories with 1,000 or more off-grid HH
- Current monthly expenditures of \$5 - \$10 for basic HH energy services
- Good local economy and stable social & political environment

- Strong potential for economic uses (renewable based) energy services
- Local commercial market unspoiled by grand aid projects. (Weingart, p. 39)

The PRE/PUP model is designed to create and own numerous micro-enterprises involved in trading, operations and manufacturing. The premise is that because the enterprises are vertically linked, this can provide wider avenues for tapping into markets and a more stable environment for small businesses to grow. It is an attempt to use the technology to break away from numerous tiny enterprises selling products to a limited market.

A theoretical list of appliances and productive outputs are listed for Thermal, Mechanical and Electrical Energy forms provided by the PUP. The PUP/PRE initiative merits close monitoring.

Sources:

Wiengart, Jerome M. and Robert F. Lee, *Wide-Spread Implementation of Renewable Energy Projects in APEC Member Economies: Road Maps for Success*, Alternative Energy Development, Inc. prepared for Asia-Pacific Economic Cooperation Energy Working Group, November 2000, pp. 31-46.

Community Power Corporation, *Development Marketplace Proposal, Presentations and discussions with Mr. Art Lilley, Feb. 28, 2003.*

Philippines: Rural Electrification and Development: Measuring the Social and Economic Benefits, ESMAF

Overview

Effort to assess quantitative value of electrification. Fieldwork on 2,000 electrified and non-electrified HH on island of Luzon (4 provinces). Provides complete profile of HH, including income levels and sources. Focus of survey was one educational returns, plus effect on entertainment, time spent on HH chores, health and home business productivity.

Experience with Productive Use

Salient productive use related results:

- While higher income levels are correlated with electrification, this is not necessarily causation in one direction, because higher income HH are also likely to adopt electricity when it becomes available.
- Most of HH businesses found:
 - Small variety stores (71%)
 - Tailor & Dressmaker (11%)
 - Food stands & restaurants (3%)
 - Hairdressers & barbershops (1%)
 - Other – carpentry, goldsmith, laundry... (18%)
- Statistical analyses on such questions as time spent on home businesses. Summary of How Typical HH benefits from Electricity shows a “benefit value” (increased income) of \$ 34.00 for a current business and \$ 75.00 for a new business (p.3).

- The above is an average figure. The actual benefit would vary with type of business. For example there are limits to the extent to which a home sewing business could work extra hours, because of fatigue.
- Did not find a statistical relationship between agricultural productivity and rural electrification. Context: year of survey (1998) was El Nino and a drought. In addition, with exception of one province, areas surveyed did not have any irrigation facilities.
- Electrification clearly increases the chances (by about 10%) that HH will engage in some form of home business. Once electrification occurs, about 25% of HH will engage in home business.

Insights and Lessons Learned

This study provides methodology for assessing productivity and income effects. The results indicate that there is a definite correlation between electrification and increased productivity and revenue from home businesses. Further investigation of this data could provide further insights into the other enabling conditions (socio-cultural policy, credit, etc.) that led this to occur.

Source:

Barnes, D. et. al., *Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits*, ESMAP May 2002

Senegal: Off-Grid PV Motive Power using DC Motors

Overview:

Food processing and village workshop applications developed using PV-powered DC motors. “Thermal bridge” technology design addresses problem of excessive heat build up. Work with local stakeholders to develop design to ensure technology is firmly grounded locally.

Experience with Productive Use:

- Cereal mill. Over ten years experience, shows marked advantages over diesel ICE driven mill. 100 kg millet flour/day with 200 Wp
- Cooling unit. Drive system plus compressor/condenser unit. Used to cool rooms for crop conservation, air conditioning and for a milk tank.
- Ceiling fan. 10’300 m³/h at 24 V 4’900 m³/h at 12 V
- Home businesses/appliances: sewing, drilling, etc. up to 1500 W and 4500 rev/min
- DC adapters change 220 V AC devices with PWM (most modern compact lights, TV, PV, etc. into battery-compatible DC elements, solving DC hardware availability & price problem.
- Flat iron (women’s activity): one wet shirt needs 20 Wh for ironing.

Insights and Lessons Learned:

- Principal premise is that we should for now depend on rugged and efficient motors produced at high volumes and affordable prices. This permits to expand a new motor market to semi-continuous machines like mills, shellers, drills, lathes, saws, etc.

- This low intensity motive technology rests on local manufacturers and entities, who all participated in the development and dissemination process.

Sources:

Cyphelly, Ivan and Patrick Jourde, *DC Rural Off-Grid PV Motive Power for Developing Countries*

www.alternativascomr.com

Sri Lanka Renewable Energy for Rural Economic Development

Overview:

Follow-on to ESD (appraisal May 2002)
 Grid-connected Hydro, Wind and Biomass
 Solar PV
 Community hydro, biomass & wind
 Energy Efficiency & DSM
 Cross-Sectoral Energy Applications

Experience with Productive Use:

Explicit productive use Component: *Cross-Sectoral Energy Applications*. No experience yet.
 Aims:

- Policy level guidelines in at least 2 ministries
- Develop and deploy standard energy packages
- Income generation through connections to some 500 commercial off-grid commercial establishments

Lessons Learned and Insights:

M&E scheme will track results. To be followed.

Sources:

World Bank, *Sri Lanka Renewable Energy for Rural Economic Development, PAD*, May 24, 2002.

LGA Consultants, *Sri Lanka Energy Services Delivery Project – Independent Evaluation, Results and Best Practice Dissemination – Household Impacts Survey Results*, July 2002.

Sri Lanka: ENPoGen Survey

Experience with Productive Use:

Some salient results in Productive Use:

- 5% of women, 8% of reported using *extra time* to carry out productive activities.
- 56% of connected villages offer battery charging facilities
- There was a lag time of some 5-7 years following grid installation for new local services and facilities to materialize

- About 2 new agricultural product processing activities came about in 16 electrified villages
- Electric fences have been installed to protect homestead crops from wildlife, particularly among larger holdings.
- 94% of remunerated activities involve men
- Among women with home-based activities, 15% use electrical equipment, compared to 32% for men.
- 40% of non-connected families use batteries for radio & TV
- Certain productive uses, such as rice milling or welding, require at least 100 watts. The study does not mention other low consumption activities, such as sewing.
- Preliminary results indicate that most agricultural water pumps in electrified villages have become electric. However, it is too early to say that electrification has brought about a structural change in agricultural activities
- Value of land in electrified villages increased
- Non-agricultural activities (MH grid):
 - Grinding mill for chillies & grinding mill for flour (woman whose husband is salaried)
Grinding mill for chillies (1997): Rs. 50,000
Grinding mill for flour (1999): Rs. 14,000
Monthly income: Rs. 2,000, but recently reduced to Rs. 1,000 because 5 other mills opened up
 - Carpenter
Electrical equipment: Rs. 20,000
Wood carving machine: Rs 2,000
Borrowed Rs. 5,000
Monthly Income: Rs. 5,000 – 6,000
Monthly maintenance: Rs. 500
 - Welding Workshop (previous welder working outside village)
Used to make Rs. 6,000 per month, Rs. 3,500 for food lodging, travel
Investment in equipment: Rs. 75,000
Received Rs. 10,000 loan from Samurdhi Bank & borrowed Rs. 25,000 from friend @ 12% interest
Produces grill gates
Income is Rs. 3,000 – 3,500 per month
Uses electricity to home
 - Restaurants
 - Retail shops
 - Battery charging
 - Woodworking
 - Radio repair

Insights and Lessons Learned:

- The limited power capacity of the MH has prevented Electricity Consumer Societies from allowing new connections for non-domestic uses. However, “even during the daytime when electricity is available in excess, neither ECS management nor financial institutions

- who subsidized the investment seemed concerned with incentive measures to promote productive uses of this feely available produced energy.” (section II.4.5).
- Lack of SHS income producing activities attributed to very low voltage (12V)
 - Monthly SHS savings from alternative sources was about Rs. 335, however, this was below monthly installment of Rs. 650-1,250.

Sources:

Massé, René, *Impact on Poverty and Gender of Rural Electrification Programs in Sri Lanka*, EnPoGen Survey of Sri Lanka, October 2001.

Swaziland Solar Electrification Program (Netherlands Energy Research Foundation)

Overview:

Aim is to get energy services to a highly scattered population, without extension of the grid. Phased approach is to: (i) identify successful solar delivery modes in one area (year 1-2); (ii) implement successful modes in other areas (year 3-9); and (iii) country wide dissemination (year 10+). Phase I = 2001-2002.

Experience with Productive Uses:

- Poor experience in sales of SHS led to refocus of efforts on productive applications, such as:
 - Small water pumps
 - Wireless communication
 - Small tools employed in productive processes
- Based on results of needs assessment (6 week process), approach will be to try to develop small “solar power packs” that are designed for one application and come as a kit for that application. Potential examples include:
 - Multi-media power pack
 - Cell phone pack
 - Water pumping system
 - Powering computers for domestic, schools, offices
- Development of application solar packs will take about 8 weeks for initial development
- Development of sales and delivery modes – cash, credit scheme, rent-to-own, pure rental scheme

Insights or Lessons Learned:

- Premise is that people will be more inclined to invest in technology if they see the immediate benefits.
- Proposal does not seem to have financial analyses. Hopefully these will be done during the pilot phase to assess the willingness to pay.

Sources:

ESMAP, *Swaziland Solar Electrification Program 2001-2010 – Phase I: 2001-2002 (Solar Energy in the Pilot Area)*, ESMAP Technical Paper 019, December 2001.

Thailand Biomass Cogeneration

Overview

Bangsue Chia Meng Rice Mill one of largest rice mills in China, producing 500 m tons of rice per day and over 100 m tons of rice husk per day. Cogeneration facility is 2.5 MW, commissioned in 1997, and has proved technically & economically feasible.

Experience with Productive Use

By its nature, cogeneration is tied to an existing productive use. Savings in electricity costs, gas/oil for drying and husk disposal costs. Revenue through sale of power to grid and sale of ash. IRR >30%.

Insights and Lessons

Thailand has established an attractive environment for biomass cogeneration projects:

- Resource abundance
- Government policies
- Increasing demand for power by private sources

Throughout ASEAN, a largely untapped market exists for rice and wood biomass cogeneration, while almost all countries have biomass cogeneration being implemented at sugar and palm oil mills that could benefit from improved efficiency (Weingart, p. 47).

Source:

Wiengart, Jerome M. and Robert F. Lee, Wide-Spread Implementation of Renewable Energy Projects in APEC Member Economies: Road Maps for Success, Alternative Energy Development, Inc. prepared for Asia-Pacific Economic Cooperation Energy Working Group, November 2000.

West Bank Palestine, Jamaica, India, Ghana: Greenstar Solar/E-Commerce Community Centers

Overview:

Greenstar sets up a solar powered community center that provides basis for e-commerce, health, education and environmental benefits. The e-commerce activity pays for the monthly operating cost and profit channeled to the community. A fully configured facility runs at \$ 115,000, with an initial capital investment of \$ 25,000. Scaled-down versions start at \$ 40,000, depending on quantities and configured services. Components include:

- Office business center
- Classroom
- Health clinic
- Solar array
- Water purification equipment
- Battery charger

Aim is for 300 over the next 5 years.

Experience with Productive Use:

- E-commerce involves setting up a web-site, or internet kiosk, through which community can display and sell local handicrafts, digital music and arts, acting as a kind of bridge to different cultures.
- Greenstar invests in the community – there is no indebtedness resulting from the facility. It sets up the website and manages shipment to the customers. For this, it takes commission from all sales. Over time, the license fee is reduced and the community takes full ownership of the equipment. The commission is reduced from 40% to 15-25% after the initial investment is recouped. The monthly maintenance costs are about \$ 750 for maintenance and \$ 950 for connectivity charges.
- Direct productive uses include refrigeration for the health clinic, water supply, battery charging and other spin-offs.
- Can include a micro-credit program for \$ 10,000 - \$ 15,000 for village lending

Insights and Lessons Learned:

- This is a variation on multi-purpose platform concept, grounded in the concept of opening the community up to a worldwide market through the internet.
- By doing this it also is exposed to the spinoff benefits of other productive uses as a result of the solar power.

Sources:

<http://www.greenstar.org>

Appendix 3: Terms of Reference

The World Bank Terms of Reference

Survey of Productive Uses of Electricity in Rural Areas

23 December 2002

Background

Among the key priorities of the Africa Region are: (i) scaling up rural access to modern infrastructure; (ii) promoting non-farm income generation by enterprises. Further, the "four petals" of the Energy Sector Business Renewal Strategy also recognize the need to link increased energy access to supporting energy needed for social services, and to promote productive uses and income generation.

The World Bank's Africa Energy Unit is in discussion with a number of countries for the preparation of rural electrification projects. In keeping with the above, it is the intention that these projects should include a well-define link between accelerated electricity (and ICT) access and enterprise-led rural non-farm income generation. This link has strong support from the officials of the client countries, who have often said that they want increased rural electrification and ICT access to increase rural non-farm incomes.

There has already been some projects that feature productive uses of electricity. For example, the Indonesia Second Rural Electrification Project (completed three years ago) included a Rural Business Services component that helped small business switch to electricity and with a positive impact on employment in very small enterprises. Further, a June 2002 GEF-FAO workshop focused on the productive uses of renewable energy.

Objectives and Tasks

The objective of the assignment is to survey and summarize the published literature as well as informal knowledge about the experience with promoting productive uses of electricity in the rural areas of the Bank's client countries. This will include projects not financed by the Bank, as well as relevant projects/analysis undertaken by non-energy experts.

The tasks are:

Task 1: Discuss with a wide spectrum of relevant people their knowledge of the successes, failure and impacts of promoting productive uses of electricity in the rural areas of developing countries.

Task 2: Collect and classify the available formal and informal knowledge with a view to determining what additional elements could be included in future Bank-financed rural electrification projects.

Reporting requirements

The consultant will report to Arun P. Sanghvi, with day-to-day contacts with Subodh Mathur.

Output and schedule: The assignment period is January 1 – March 31, 2003. It is expected that the consultant will produce a draft report by February 28, 2002.