Experience with PV systems in Africa

Summaries of selected cases

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Contents

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Njeri Wamukonya
Editor

Foreword

The majority of Africans have no access to electricity. In fact only around 30% of the population is connected to the electricity supply. Most of those lacking access are in rural and peri-urban areas where levels of economic development are still low and demand for employment and other services is highest. Analysis in most countries indicates that extending the central grid to these areas will not be financially feasible in the short term; decentralised systems will be the most viable options for providing electricity here. Due to increasing concerns about environmental degradation, the use of renewable energy technologies is being promoted by international organisations, various governments and NGOs. These technologies are expected to play an increasing role in electrification of Africa's rural and peri-urban areas, especially as the continent depends heavily on external support for electrification.

With the abundance of solar resources in most African countries, the use of photovoltaic (PV) systems for solar-based electricity production is an attractive option, but the investment costs have been prohibitive of widespread application. These costs are, however, gradually falling and Africa has gained some experience of PV systems for electrification, and the technology is still expected to be the dominant renewable energy technology for rural electrification in the future. Despite the obvious importance of, and the advantages to be gained from, sharing information with the aim of improving the efficiency of project implementation, most PV experience is hardly known outside of the individual counties.

The UNEP Collaborating Centre on Energy and Environment, therefore, in collaboration with experts from various African countries, has taken the initiative to analyse and document these experiences as a reference for stakeholders in electrification, including donors, private sector companies, governments and NGOs involved in implementing solar PV in Africa.

From the summaries of the cases presented in this document, it is evident that the levels of experience vary between countries. What is significant is the level of similarity in implementation approach between various countries. Hence, a lot could be learned and resources could be used more efficiently through information dissemination and the sharing of experiences. The governments in the respective countries have been involved, and are in many cases the lead agencies, in implementation. Institutional and financial barriers are prevalent in most cases. Also significant is the importance of focusing on service provision rather than only on the technology for electricity delivery. Consumers demand an energy service to meet their various needs, although the ability to pay among the majority is relatively limited. The role of governments in electrification is, however, changing with the increased participation of the private sector. The challenge is thus to create progressive public-private partnerships which satisfy the increased access-to-electricity agenda while meeting consumer energy demand in an affordable manner and contributing to sustainable development.

A publication with detailed reports on each of the cases will be published later in 2001 and distributed to a wide range of stakeholders. I would like to express my appreciation to all the authors for their efforts in preparing these summaries. I look forward to the final publication which I believe will contribute significantly to more sustainable electrification in Africa.

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March 2001

Overview

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As awareness grows about the multiplying hazards of conventional energy use, the role of renewable energy has shifted from the fringe to the mainstream of the sustainable development debate. Support for the development and utilisation of renewable energy is building up among stakeholders in government, industry and a growing host of NGOs, pursuing the sustainable energy and development agenda at national and global levels. In Africa, the promotion of renewable energy has been on the increase, especially as most nations shift their attention to rural electrification. Solar photovoltaic (PV) applications, in particular, are increasingly considered under the rural energy service infrastructure. Several case studies point to the technical feasibility of PV applications, but the potential market, though thought to be large, has been difficult to develop.

Various isolated small-scale initiatives using solar PV for electrification have been implemented in different parts of the continent. In some cases, these initiatives have been driven by government while in others the private sector has taken the lead.

Despite the experience gained in the different initiatives, however, dissemination of lessons across the projects, programmes and countries remains inadequate. A few isolated cases have been documented but the information is not readily available to potential users, decision makers and investors. As the energy sector becomes increasingly commercialised and privatised, the moral and social justifications previously used in advocating energy provision and increasing access to the majority are likely to be ineffective. Economic and financial benefits will become more important determinants. Needless to say, some incentives might have to be offered to the private sector to facilitate large-scale penetration of renewables in the shorter term. However, relatively little is known about the ability of renewables to deliver the level of services that will contribute to poverty alleviation in Africa, despite the fact that this is often the rationale provided for their use. Access to objective information upon which to base decisions is thus vital.

In recognition of this information gap and the need to fill it, the UNEP Collaborating Centre on Energy and Environment, is publishing a book on African PV experiences. Its objective is to document PV project and programme experiences in Africa as a reference for decision makers, energy planners and project implementers. Case studies from 13 countries are offered by people who have interacted, directly or indirectly, with the projects. A coherent account of the skills, knowledge and analytical tools that have proven most effective in the design, implementation and assessment of PV programmes and projects will be provided for each case.

The present booklet provides a summary of what will be in the final publication. Its aim is to inform potential beneficiaries of the imminent availability of the publication and to seek comments and inputs from stakeholders. The booklet contains fourteen case summaries, indicating key aspects, from Botswana, Namibia, Zimbabwe, Kenya, Uganda, Ghana, Mali, Swaziland, Zambia, Morocco, Senegal, South Africa and Lesotho. A notable element revealed by all the studies is the importance of a functional institutional framework. There have been some new developments in this area, which are summarised by Mark Davis at the end of the case-studies. A way forward with respect to the publication process is provided in the last section.

Solar PV dissemination efforts in Botswana

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A number of solar PV dissemination efforts are underway in Botswana and these are advancing appreciation of the technology in the country. Among these efforts are the National PV Rural Electrification Programme (NPVREP), the Motshegaletau centralised PV system, the PV Master Plan project sponsored by Japan International Corporation Agency (JICA), and the imminent Global Environmental Facility (GEF) PV project.

The NPVREP is a solar PV electrification programme targeted at rural areas and based on a credit scheme for system ownership. The programme is financed by the government and managed by a parastatal, the Rural Industries Innovation Centre (RIIC), which is active in rural energy technologies. In order to qualify for the credit scheme, potential rural consumers pay initially a P50 (US$9) commitment fee and a deposit of 15% for the system costs plus installation and insurance costs. The remaining 85% is paid in four years at an interest rate equal to the prime rate (currently 14.25%). In comparison, the potential rural consumers for grid electricity pay a commitment fee of P100 (US$8), a 5% deposit and monthly repayments on the balance over 15 years at an interest rate equal to the prime rate minus one percent.

Under the grid electricity scheme, for an average connection cost of US$ 933 the potential consumer makes a down-payment of US$52, with US$5 monthly repayments; for the PV system the down payment is US$140 and the monthly instalment is US$16. Besides the more affordable repayments, grid connected consumers enjoy ‘unlimited’ access to electricity. It is therefore obvious that the rural electrification policy currently favours grid electrification.

The Motshegaletau centralised PV station in Botswana’s Central District has a capacity of 5.7KWp, installed in 1998. It serves a primary school, a clinic, a bar and nine houses. The Botswana Technology Centre (BoTeC), a parastatal under the Ministry of Finance and Development Planning, initiated the project with technical support from the Botswana Power Corporation (BPC). The government, through BoTeC, financed the project at a cost of about US$80 000. After one year of operation, ownership of the project was passed to the Central District Council (CDC), a local government authority. The CDC acts as the service provider to the consumers on a fee-for-service scheme. Potential customers are expected to wire their houses and pay a P500 (US$90) connection fee. The tariff charged is the same as that for grid electricity – about US$0.06/kWh for the domestic sector.

The Japan International Corporation Agency project on the formulation of the Master Plan to promote solar PV rural electrification, kicked off in 2000, with a survey of willingness and ability to pay, in ten villages in seven of Botswana’s ten districts. This is the most widespread survey of this nature done in Botswana so far on solar PV technology. The survey is being followed up by a pilot project to test the market in three of the villages. The pilot project also aims to establish the most effective institutional framework for providing PV-based electrification services in rural villages.

The government of Botswana has recently been awarded a project-development grant by the GEF for an implementation project to remove barriers to PV dissemination in Botswana. The preparation of the project document is near completion, and the design phase will take some six to nine months and will probably be concluded during 2001.

Background

The initial introduction of PV systems in Botswana was made by private sector companies which started PV dissemination as far back as the 1970s; the major clients have mainly been Botswana Telecommunications, Botswana Railways and the defence and police forces.

By the end of 2000 it was estimated that about 80% of households were still not connected to the grid. In an effort to address the situation, the government has initiated a policy of promoting decentralised electrification mainly through PV. To date, however, an autonomous and sustainable diffusion of PV system use has not been realised, for reasons including a lack of proper organisation for system design, delivery and maintenance, and a shortage of technologically capable personnel. Local manufacturing is limited to balance-of-systems, involving charge controllers, inverters and recently light fittings and module support frames. Modules, sealed type batteries and lights are imported.

The government has made efforts to disseminate PV technology in the past through assessing the technical feasibility, social acceptability and economic viability of PV solar home systems (SHSs) in Manyana, a village near the capital, Gaborone. Subsequently, it financed a feasibility study to assess commercial feasibility of SHSs in Manyana, as well as in two other villages, Molepolole and Takatokwane, under a credit scheme. This survey, conducted in 1996, indicated a significant potential market for such systems in those villages. It was after this study that government embarked on the National PV Rural Electrification Programme.

Motshegaletau Mini-grid Solar PV System Project was carried out to establish the feasibility of mini-grid solar PV systems and how the cost of implementation would compare with that for existing diesel mini-grid systems – electricity for remote government institutions is now mostly supplied from stand-alone diesel gensets.

The PV Master Plan being developed under the JICA project is intended to boost the current efforts to disseminate and commercialise PV use in rural Botswana through creating sustainable management and maintenance structures for PV systems, and training engineers and technicians. The Plan is expected to be in place by the end of 2001, and implementation will be over ten years from 2002.

Outputs

The expected main output of all these efforts is to achieve a self-sustaining market for both solar PV systems and solar PV mini-grids like Motshegaletau, through establishing a policy framework, including legal, institutional and financial aspects. Such a policy framework will facilitate the realisation of widespread solar PV dissemination in Botswana, thus improving access to electricity by rural communities which cannot be served by the national grid system.

Since its inception in 1997, the NPVREP project has achieved 300 SHS installations, in 86 villages countrywide, with a capacity of 42.75KWp. The project contributed to the drive for the Botswana Bureau of Standards to develop a Code of Practice for installation of PV systems.

The Motshegaletau project has demonstrated the feasibility of PV mini-grid systems. Being modular, such mini-grids can be upgraded to meet increased power requirements. The system, except the powerhouse, can also be dismantled and moved to another village in the event that Motshegaletau becomes connected to the national grid.

The survey regarding willingness and ability to pay, referred to earlier, indicated a potential for PV electricity use of up to 1MW for households in rural (unelectrified) villages with populations below 1000. Public institutions such as schools, clinics, village authorities and other government departments require another 0.5 MW.

The start of the JICA pilot project already reveals a market; still outstanding is the creation of an executing body to implement PV rural electrification. Since the NPVREP employs a system ownership model, the JICA project will test the feasibility of a fee-for-service model, projecting full recovery of costs for an implementing agency in under five years. The fee-for-service under the Motshegaletau System is set at the tariff for grid electricity (US$0.06/kWh). Under the circumstances, the payback period on the investment would be long, typically equal to or more than the lifespan of the modules. An example from a similar solar mini-grid system in the Philippines shows that tariffs for rural ESCO fee-for service models can be as high as US$1.5/kWh or more, implying that the government of Botswana heavily subsidises current consumers in the Motshegaletau project.

Key achievements

The current pace of PV uptake under the NPVREP is slow, with an average of 75 systems installed annually. The implementation of the NPVREP is to be boosted through enhanced project management to be provided under the African Rural Energy Enterprise Development (AREED) project. Key issues to be addressed include refinement of the financial management (such as management of arrears) and improved marketing. AREED is a UNEP initiative supported by the UN Foundation and implemented in collaboration with the UNEP Centre on Energy and Environment and E & Co, a not-for-profit organisation based in the United States.

Although a number of private households may have an interest in accessing electricity from the Motshegaletau Centralised PV station, only three private households are connected to date – the other houses belonging to the District Council and the Village Development Committee. The cost of wiring has been identified as one of the barriers, and BoTeC has considered introduction of 'ready boxes' or simple socket points to reduce the wiring costs. With assistance from BPC, prepayment meters have been introduced and are proving popular in rural areas, as they relieve the consumers of the burden of travelling long distances to pay at designated pay points. The recent evaluation of the project by BoTeC is expected to establish the feasibility of replicating such mini-grid PV systems in other villages.

The JICA Project has entered its pilot phase, and PV systems and installations will be provided by JICA, with potential consumers having to pay the required deposit and monthly instalments. System sizes will range from 50Wp to 1000Wp and monthly repayments by households will range from P40 for the 50Wp system to P1200 for the 1000Wp system. A security deposit equivalent to three months' instalments (refundable on surrendering the system) will also be required. Public facilities are to pay 1.5 times the monthly payments made by households. About 100 sets of 50Wp systems will be supplied to each of the three villages selected for the pilot phase, to be made available to both households and public facilities. Revenue will be collected by an executing body that will be formed in time for the commencement of the contracts and installation of the systems. The time frame of this pilot project includes two weeks in February 2001 for introducing pilot project to potential beneficiaries, the contracting period between potential users and executing body in May to June 2001, and system installation and commissioning between July and September 2001. There is no subsidy from the government for the pilot project, but the 300 50Wp system sets to be provided (inclusive of installation and light fittings) to consumers will be financed through funds from the Japanese government.

Lessons

Evaluation of the NPVREP in 1999 indicated that the programme is relevant for meeting the needs of rural communities not connected to grid electricity, although the evaluation also noted that PV system users want more than lighting: they want to power appliances, and hence require larger systems. The JICA survey also confirmed this finding for both households and public facilities.

Although government has tried to address the problem of affordability through the credit scheme it appears that there are other barriers to the widespread use of PV systems – hence the need for the barrier removal project sponsored by GEF.

The NPVREP has not realised its full potential due to unclear strategies for achieving a higher rate of uptake. The capacity to sustain system maintenance countrywide requires more resources than is currently available; installed systems often fail after a short period and this has tended to discredit the technology.

Most of the system components (such as modules) are imported, and depreciation of the local currency against major currencies, especially the US dollar, makes the systems relatively expensive. Consultations with users and potential users indicates that overall costs including installation and insurance are considered too high. It is notable that systems can be procured more cheaply directly from suppliers than through the government credit scheme.

An interesting extrapolation from consultations indicates that often governments expect to improve rural development through commercialisation. Apart from other considerations, the two are, however, in conflict, as commercialisation requires full cost recovery, while rural development will require some subsidy.

BoTeC has found through monitoring of costs that replication of the Motshegaletau mini-grid station can be done more cheaply through a more efficient system design and installation. The estimated reduction in costs could be as much as 40%.

Both the Motshegaletau Project and the JICA survey indicated fee-for-service to be attractive only when the customer base is large (typically above 1500). It will, then, not be attractive to the private sector, particularly in Botswana where rural villages are small, unless many villages are supplied by one service provider, an arrangement which would favour the concept of allocating concessions to service providers.

It also appears feasible for the national utilities or parastatals like RIIC to initiate the fee-for-service since they can absorb long payback periods. Utilities are important for initiating fee-for-service, particularly if villages supplied from PV systems eventually become grid-electrified, when the utilities will only have to move the systems to unelectrified villages, without much risk.

Solar PV systems: Insights from Swaziland

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Solar radiation in Swaziland is estimated to be around 4-6 kWh/m^2 per day in some areas. Despite these favourable conditions, the country's experience with solar photovoltaic (PV) is rather modest, mainly due to high investment costs and lack of awareness. On the other hand, even with an ardent grid extension programme, the cost of grid-based service will remain prohibitive for a large part of the population. It is estimated that less than 5% of the rural population have access to Swaziland's national grid.[1] To meet the basic electricity needs for the others, off-grid systems are considered a viable alternative. Off-grid systems, in particular PV systems, are applied in public services remote from the grid, such as telecommunications and lighting for schools and clinics. The total installed capacity of PV is estimated at 56 kW, and growth is being experienced in solar home systems (SHSs).

PV sales

The PV market has been expanding slowly over the past decade and about 1000 residential PV systems have been installed. There is one major supplier of PV systems and several others who sell them as a marginal side-line. In a 1998 survey of 120 PV residential users, 86% of the respondents declared themselves happy with their systems, but 64% wanted to expand them. The major commercial user has been the Swaziland Posts and Telecommunication Corporation. In 1999 there were 31 PV powered repeater stations and 8 PV powered terminals,

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1 The population of Swaziland is estimated to be about 980 000, and the total number of households 172 416, with a split of about 67% rural and 33% urban.

but the use of PV systems is being slowly phased out due to PV module theft and advancement of the grid extension programme.

Lessons learned:

- Private PV users are generally satisfied with the service rendered by their systems. Given that grid extension may not reach all areas of Swaziland within the next decade, and the relatively high connection costs, there seems to be scope for wider use of PV systems.
- No matter how much the development of the commercial market is encouraged, PV systems can only serve a limited part of the society. For many, the costs of a PV system, even with a credit facility in place, will remain too high.
- The supply of PV systems is still largely through urban retail outlets. People from rural areas come into towns to purchase systems but there is no support network in the rural area where the system is used. This creates problems insofar as maintenance and after-sales service is concerned. An improvement of the rural infrastructure is necessary.
- Basic technical standards are recommended in order to protect end-users from sub-standard products and incompetent suppliers. At present the quality of the systems is difficult to assess and people tend to buy the cheapest option.

Government PV programme

As early as 1991, the government, through the Ministry of Natural Resources and Energy, undertook various activities aimed at stimulating the use of solar energy in the country. In particular, the Ministry implemented a PV demonstration project from 1992 to 1995, primarily aiming to create awareness of solar energy among the rural population and to meet basic electricity needs. The Ministry also intended to learn from the demonstration experience and hence help clarify the role of the government in future activities. The programme included the provision of electricity to schools, clinics and water pumping schemes. The installed capacity of the PV programme is about 12.2kWp.

Lessons learned:

- The programme demonstrated that PV systems are a technically feasible option for provision of electricity in rural areas.
- The awareness and promotion of solar energy requires systems to work efficiently. No matter how much effort is put into information activities, if people cannot see a system that works, and works properly, the efforts will be undermined.
- Projects should be demand-driven. PV systems for electrification of public institutions should only be installed at the request of, and with the approval of, the community involved.
- Projects should have a clear exploitation plan whereby the ownership, responsibility for maintenance, etc, are clearly defined.
- Solar refrigeration needs more research and development

World Bank solar market development programme

In order to assist in the development of the solar PV market in Swaziland, the World Bank made available, through International Competitive Bidding, a US$100 000 loan to a private sector supplier. The supplier was given targets to meet in terms of equipment installed and various other activities for PV market stimulation (see Table 1). Issues such as awareness raising and the setting up of a finance/credit mechanism were also addressed. The project commenced in January 1999 and was completed in July 2000.

Table 1: Targets vs. actual sales of PV components

Commercial sales	*Target*	*Actual sales*
Portable lanterns	25	1
Single modules (10-60Wp)	25	120
One/two light systems (10-20Wp)	25	20
Four light kits (40Wp)	25	170
TV kit for colour TV, VCR (80Wp)	25	25

The project exceeded the targets set in terms of some types of equipment sales but was less successful in establishing a finance/credit mechanism.

Lessons learned:

- Diversification of equipment is important. Often users buy a 12-14Wp module to add to an existing battery, building up the system when additional finance is available. Hence, suppliers must be able to incorporate buyers' preferences.
- It is difficult to arrange financing for residential solar PV systems since banks and other financing institutions consider it a high-risk business. Although experience in previous PV financing schemes in Swaziland has shown that repayment was close to 100%. However, much work still needs to be done to build the confidence of financiers and investors.

Solar village project

UNESCO in co-operation with the Ministry of Natural Resources and Energy and the community of Mphaphati, have established a 'solar village' at an area called Mphaphati, 80km from the capital, Mbabane. The 'solar village' is a concept being promoted and supported by UNESCO, and villages have been set up in Namibia, Malawi, Mozambique, Lesotho and Angola. The aim is to establish a sustainable demonstration project and to fulfil basic electricity requirements using solar PV. The project began in 1998 and has since been completed. In Mphaphati, four systems have been installed: for classrooms, eight staff houses, street lighting/security systems, and a water pumping system. All systems are operating well and no theft has been experienced so far. A full evaluation of the project is yet to be undertaken.

Lessons learned:

- Preliminary evaluation rates this project as a success. This success has been attributed to the involvement and participation of the community since commencement of project. At the start of the project, the community formed a Solar Committee to manage the systems and the revenues generated by charging users a monthly rental fee (to the teachers in particular) and by running a small cinema.

- From previous experiences, it is important that a maintenance contract be signed with the supplier in order to ensure support after the project's handover to the community. Additionally, system users and the Solar Committee have been trained in basic maintenance and use of the systems.

PV power experience in Zimbabwe

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Zimbabwe has a population of about 11.9 million (1997 census). The national electrification level is 22% but rural electrification is much lower: 5%. Improving the rural status has been one of the main goals of various donor-funded electrification projects. The main initiative are summarised in this paper.

Zimbabwe has had several projects on photovoltaic (PV) power dissemination, including the Global Environmental Facility (GEF) PV Pilot Project launched in 1992. Prior to this the country had an installed capacity of 73 743Wp. The major suppliers for PV systems before the GEF project were private companies, which viewed this work as a 'hobby' with minimal commercial value. Most of the companies were managed by groups such as members of the Solar Energy Society with interests in renewable energy.

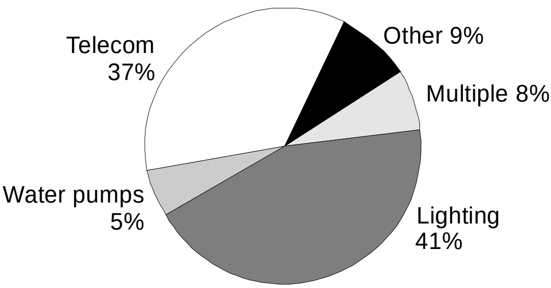

Figure1: Installed systems by use
Source: Dept of Energy

The main objective for solar PV system delivery was the electrification of remote communities. Initially the beneficiaries of PV lighting systems were mainly professionals employed in rural areas where systems were provided as an incentive for staff retention. Lighting and telecommunication were the major PV applications, although systems were also used for water pumping.

The pilot projects

• GEF-PV project

The signing of the United Nations Framework Convention on Climate Change rekindled interest in solar PV projects in Zimbabwe. The GEF PV pilot project was meant to reduce emissions from combustion of kerosene for lighting, and was designed to deliver systems for lighting by providing financial support to rural households. It also supplied PV systems for income-generating projects such as small-scale irrigation – although without active promotion for these applications. The project design excluded financial support to the equipment supplier. A major indicator of the project success was considered to be the number of systems disbursed as opposed to the number of systems remaining in service after project completion. The project therefore took a commercial approach with limited barrier-removal and developmental components. This deduction is based on the fact that the barriers persisted after the project had ended, despite creation of a revolving fund. Notably, the incentive provided to entrepreneurs through the project resulted in the emergence of 'fly-by night' entrepreneurs who disappeared after installation, leaving the customers without back-up service. Most of these supplied low quality products.

• Japan International Corporation Agency Project

The Japanese government supported a project implemented in 1998 and whose main objective was the assessment of the ability to pay by rural households and the preferred delivery mode for PV systems: 'cash and carry' or payment for service. The project was preceded by a survey that identified an area for a pilot project, and a service provider. Even though the households had indicated their desired applications for PV power, the systems delivered were considered too small.

Private sector initiatives

Some private companies have successfully run credit schemes for the supply of PV lighting systems outside the conventional 'lay-by' or hire purchase schemes. These schemes are not documented and it is difficult to assess the success of such schemes.

Impact of the initiatives to date

The greatest impact of PV projects in Zimbabwe has been raising awareness on PV technology. There is increasing consideration for PV technologies amongst the options for power supply in rural areas – although not at the same level as grid electricity.

Most importantly the need for a functional institutional and regulatory framework to ensure good practice and customer satisfaction is now seen as a critical element to the success of PV projects. The absence of such a framework was the main factor contributing to the limited success of projects, particularly the GEF one.

Providing electricity services using energy service companies in Eastern Province, Zambia

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Zambia has a population of 8.8 million (1998), most of whom are rural dwellers. The national level of electrification is about 18%, but only 2% in rural areas. Increasing access to electricity is one of the principal objectives of the Zambian government, and t o achieve this goal it is encouraging participation of the private sector in rural electrification.

The energy service companies (ESCOs) project is being implemented by the government of the Republic of Zambia through the Department of Energy (DoE) of the Ministry of Energy and Water Development. It is funded by the Swedish International Development Cooperation Agency (Sida). The Stockholm Environment Institute is the main project consultant. The project was initiated in 1998 and will be completed in 2003.

The main outputs are expected to be three operational privately owned ESCOs based in the Eastern Province of Zambia, and a financial and organisational framework for such companies to be integrated into the national rural electrification strategy. Important aspects of such a framework are information on the ability of the ESCOs to cover the cost of providing services, minimising the risks of the operations, and achieving secure access to suppliers of hardware and expanding their scope of service delivery.

Background

The overall objective of the project is to develop a model through which rural people can access energy services on a sustainable basis. The model is based on the premises that a private company can operate profitably as provider of rural energy services, that people would pay their dues, and that the generation and distribution systems are well maintained and technically operational in the long run. These aspects are essential in any attempt to introduce energy services and systems on a larger scale in rural areas. Training in technology, business management and logistic planning is also essential for achieving success in these areas.

The two main motives behind the design of the project described here were as follows:

- Earlier PV projects had a tendency to be short-lived, and PV dissemination without a carefully designed plan for post-project operation was generally not successful; in fact, such projects had to some extent discredited the technology, making revival difficult.
- A shift in perspective on energy technology was an important driving force. It had become increasingly apparent that people in rural areas were less interested in a specific technology (solar power, micro hydro, diesel, etc), and more interested in what could actually be achieved with the technology –such as lighting or access to radio broadcasts. This is the origin of the word 'service' in the name of the project, and in the name of the subsequently formed companies.

The area selected for launching the project was Eastern Province of Zambia, based on the area's low level of electrification from the national grid. Further, a strong agricultural base is expected to generate enough income in the rural communities to pay for these energy services. Surveys carried out in 1998 showed that rural households use a substantial part of their income to pay for kerosene, candles and batteries.

Outputs

The most important output of this project will include:

- guidelines specifying the necessary financial and organisational inputs needed for an ESCO operating in rural communities in Zambia, using PV systems as a source of electricity supply;
- three ESCOs operating on the basis of the developed guidelines in the Eastern Province.

Other `hidden outputs' (not easily measurable in quantitative terms) could be an increased understanding of factors that influence the successful dissemination of PV systems in rural areas of Zambia in particular and eastern and southern Africa in general.

Achievements

Since the project started in 1998, three ESCOs have been established. The first, Nyimba Energy Service Company (NESCO) is just becoming operational with 100 systems installed at the customers' premises. The other two (Chipata Energy Service Company and Lundazi Energy Service Company) are to be supplied with 150 systems each during the first months of 2001, bringing the total number of systems in the project to 400 (with a total output rated at 20kWp).

The cost of setting up the ESCOs has been shared between the government, Sida and the companies themselves, which are all offshoots of already established local commercial activities and hence already have a management structure. The ESCOs typically have five to eight employees, of which two are electricians specially trained in maintaining PV systems. The contractors install the systems, although the ESCO technicians also participate in the process.

To ensure a potential for expansion of the customer base and comparison of performance in different localities, the ESCOs have purposely been established far apart – enough to avoid competition, as the purpose of the project is to demonstrate the viability of the concept. It was not considered necessary to award the ESCOs concessionary rights to serve the rural communities with electricity, as there were no other actors based in the area to begin with.

At present, the ESCOs are subsidised during the project as no interest or amortisement is paid on the investments in PV equipment. The intention is not to give away equipment for free, but rather to provide a grace period during which the actual risks involved will be quantified. At present, financial and insurance institutions active in Zambia have no experience of micro-scale distributed power generation in rural areas, and it is envisioned that the project will yield such information. In fact, substantial experience has been gained regarding the conditions for operating companies providing energy services in rural Zambia, notably a greater understanding of the economic and institutional problems and possibilities.

The initial hypothesis – that local consumers would be able to bear the full cost of the services obtained from PV systems, including the actual cost of the systems – has so far not been substantiated. The discussion on how best to cater for payment for the initial capital has to continue, and could constitute a mix of public and private ownership models.

Present status

At present, the project combines public ownership of the systems with private supply of maintenance. This ensures that the ESCO has an incentive to provide services on a continuous basis and the private business operations should vouch for efficiency in operation and management.

The ESCOs have full control over the operations, and receive benefits. The ESCO customers, on the other hand, are only covering costs of maintenance of the installations, including battery replacement every three years.

The project will yield important insights on issues of risk (non-payment, damage, theft), long-term technical performance, actual costs of maintenance and collection of payments, logistics of the project set-up, etc. This information is crucial if private venture capital institutions are to sustainably serve the energy market in rural areas of Zambia.

The guidelines governing ESCOs in rural communities will have to be streamlined into the existing energy sector legislation, and taxes and subsidies will need to be harmonised to ensure competitiveness.

Lessons learned

The issues of equipment ownership and capital payback have been important since the project started. The rightful owner of the systems is, at present, the government, through DoE (because Sida provided the funds for the equipment procurement via the government).

The project group decided to postpone the final decision as to if and when the ESCOs should acquire ownership of the systems. The present position is that the DoE remains the owner of the systems during the lifetime of the project. There is, however, the option that the ESCOs would start leasing the systems after having been operational for one year. For instance, the ESCOs could lease the system for a period of five years, after which they would have the option to buy the system at a residual, subsidised price. The rationale behind this set-up is that no one, at this point, really knows what the actual cost of providing the services is, and what clients are able and willing to pay for the services.

Another reason for postponing the decision on ownership of the systems is that this would constitute too large a financial burden for the ESCOs. Interest payments would be enormous if the ESCOs would get a commercially based credit for the entire amount – the base rate in Zambia is currently about 35% and a sustainable interest rate for a revolving fund would be about 40%.

Lesotho's experience with PV systems

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Lesotho is amongst the countries with the lowest level of electrification in the Southern African Development Community region. Only about 3% of households have access to grid electricity in a country with a population of about two million and an estimated 369 000 households. A number of factors contribute to this situation, including scattered settlements and mountainous terrain, making it uneconomic to extend the grid to many rural households.

This low level of electrification through the grid presents immense opportunities for off-grid electrification. Many households rely on disposable dry cell batteries or automotive batteries for their electricity demands despite the high costs associated with these options.

The renewable energy technologies, which include solar home systems, solar water heaters, passive design concepts and energy-efficient woodstoves were first formally introduced to the country in the late 1970s by the Thaba-Tseka Integrated Rural Development (TTIRD) project funded by the Canadian International Development Agency. Adoption of these technologies by households was slow or non-existent. In the early 1980s the USAID-funded Renewable Energy Technology Project took over some of the activities of TTIRD. The main focus of both these projects was on research and development, and some prototypes of solar water heaters and energy-efficient buildings were developed and disseminated. Two clinics and a few households were provided with solar PV for lighting purposes. Despite such efforts, adoption of these technologies was, at best, slow.

In 1993, the Lesotho Department of Energy (DoE) commissioned a study whose main objective was to identify the setbacks that inhibit wide adoption of renewable energy technologies. Furthermore, the study had to identify the technologies with the highest potential within the prevailing socio-economic conditions. It concluded that solar PV had the greatest chance of success. The study further indicated that factors inhibiting its adoption are: (a) the high initial cost of the system; (b)a lack of information on the part of the users; and (c) inadequate technical capacity in the country. The programme of renewable energies was then structured upon the recommendations of this study.

Strategies to promote PV

Pursuant to this study, the DoE geared its renewable energy project towards two approaches, namely PV and energy conservation in buildings using passive design concepts. The programme focused on information dissemination, capacity building and establishment of a financing mechanism.

- **Information dissemination**

The DOE adopted different channels to raise public awareness of the technology, firstly radio advertisements in which the public were informed on capabilities of solar PV and its limitations. The public was also informed of who the suppliers (those accredited by the Department) were and where they could be found. The other channel of dissemination adopted was newspaper advertisements over a period of six months.

The DoE also prepared some information leaflets on PV use for distribution in the fairs/exhibitions in which the Department participated. In addition, it manned a stall in which applications of PV for household purposes were demonstrated during the exhibitions. These activities have been going on four years and are still operational.

Demonstration units were also installed in businesses in rural-areas. Ten systems in all ten districts of the country were installed in rural centres, one per district. The business owner had to pay 50% of the cost of the system after installation over a period of six months, with the remainder paid by a donor agency. In return, the entrepreneur marketed the PV by informing customers about services available from the system. An additional benefit to the business was an increase in hours of operation.

Another promotional approach was installing PV systems at remote rural clinics and schools. About four schools and eight clinics were provided with PV for lighting purposes. In schools, this not only provided a visible example of what PV involves but it also enabled studying beyond normal working hours. In the clinics, health-care services could now be provided at night.

- **Capacity building**

Capacity building is viewed as one of the critical factors necessary for successful widespread application of PV technology in the country. Hence, the Department approached the Ministry of Education to incorporate PV topics into the curriculum. This was done at two levels. The first saw the inclusion of PV into the curricula of technical and vocational schools at craft level over a two-year period. The topic was integrated onto the electrical installation course, and instructors were trained by the DoE on the subject of PV.

The other level was incorporating the PV topics into the science curriculum of secondary schools, aiming to inculcate its concepts into the minds of students at an early stage of their education. This curriculum is now being implemented on a pilot basis.

Further to this school-oriented training, in 1996-1999 the Department undertook training of individuals in the business of electrical installation. The aim was to improve the quality of service offered to customers.

- **Financing**

As a means of addressing the issue of high up-front costs of the PV systems, a financing scheme in the form of a revolving loan fund was proposed. The fund was intended to provide a fallback position for the bank in case of default. The success has been limited, and this remains one of the biggest challenges facing the government. The reason for failure on the financing part is mainly due to lack of confidence on the part of financial institutions, which consider loans for PV system as high-risk business.

Lessons learned

Following the dissemination campaigns undertaken by the DoE, enquiries from the public regarding solar systems increased. No statistics are available, but local solar dealers indicated that more business resulted.

Another lesson learnt is that solar systems have higher chance for success if linked with productive uses. This was deduced from the rate of repayment after installation of demonstration units at business centres. As a result, the government is now focusing on facilitating access of PV systems for income-generating activities.

An important conclusion is that PV is not for the 'poorest of the poor' but can contribute towards meeting some of the electricity requirements of a certain niche of rural households. The thermal energy needs, on which the larger share of energy is spent, will not be met via PV. In addition, linking PV with productive income-generating activities in rural areas increases the chance for sustainability of service by elevating them from being merely a consumer good.

Kenya's PV market: a showcase for commercial development

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Kenya is still a largely rural country with only 25% of its 29 million people living in urban areas. Its GDP reached some US$9.98 billion in 1998 (Economic Survey 1999) with a growth rate of 1.8% and an average per capita income standing at US$296 in 1999.

Of the approximately four million rural households, more than 95% are without access to grid electricity. Rural households use candles and kerosene lamps for lighting and dry cells for radios and torches. Lead-acid batteries are also used to power DC electrical lights, TV sets and radios. These lead-acid batteries are routinely recharged at distant shopping centres where grid electricity or generator power is available.

Since 1973, the government, under a Rural Electrification Programme (REP), has undertaken distribution of electricity in areas where the financial viability seems doubtful to the utility. Seventeen years later, only about 62 000 (2%) of rural households have been connected to the grid, at a cost of US$600 million. Major constraints to the REP have been: high infrastructural capital costs, high revenue collection costs, low income from existing operations, insufficient generating capacity and high connection costs for scattered households.

PV has not been considered for rural electrification, as it does not qualify under the Least Cost Extension Programme (LCEP), a method used by the government to decide on which power generation options to use.

Commercial PV market

Kenya has an active commercial solar home systems (SHSs) market, with cumulative sales in excess of 150 000 units and current sales of over 20 000 systems per year. To date more than 3.2MW of amorphous and crystalline silicon have been installed and the PV industry is worth US$6 million new installations per year (500 kW/year). The demand for PV has grown exponentially since the mid 1980s. There are hundreds of PV businesses in terms of manufacturers, vendors, installers, and after-sales providers active in the market. Presently there are more than 15 companies based in Nairobi that supply this market.

- **Institutional focus: Solar for Schools Project**

The Solar for Schools Project is an awareness initiative implemented by Solarnet, an NGO. Off-grid rural boarding schools receive a 50% subsidy to install solar electric systems and endeavour to use these systems as demonstrations during school visiting days. To date ten schools have been evaluated and two of these are installing the systems.

Market development

Since the introduction of PV into the region, the local market has evolved through the following stages:

1985-1989: Market transformation from being driven by donors (relief agencies, NGOs and church organisations introduced initial systems in the region) to driven by the commercial market. General growth in PV sales was around 5-10% during this period. Typical systems used crystalline modules of about 40Wp (Acker and Kammen, 1996).

1990–1998: 10-14Wp amorphous silicon (a-Si) modules entered the market in 1989, capturing the majority of SHS sales within five years (van der Plas and Hankins, 1998). Since then, total a-Si sales in Kenya have increased dramatically, from 10kWp in 1989 to 270kWp in 1998. The relative percentage of complete system sales declined, while the number of over-the-counter, customer-installed systems increased.

1998 onwards: Small a-Si systems still dominate the market (by number). Average system size currently stands at 25Wp, implying that most people are buying small systems. Potential demand is currently estimated at 25MWp. Given income structures, the effective demand is about 14Wp, with more that 50% being 20Wp or smaller systems.

Market status

Kenya is notable for having mobilised its local entrepreneurial skills in the development of the PV industry. PV dealers can be found in virtually all major towns across the country. Some salient characteristics of the market are as follows:

- All solar modules are imported and have varying warranties. Over 90% of the systems use locally manufactured solar or modified solar batteries. 70% of these are modified automotive batteries.
- Mean system size stands at 25Wp with an average purchase expenditure of US$418.
- Over 90% of the a-Si systems do not use charge regulators.
- Some customers save up to US$10 monthly on kerosene, dry cells and battery-charging expenditures.
- There is no rational tax regime for PV products as only modules enjoy special tax arrangements of 0% duty and 5% VAT. Other balance-of-system components attract relatively higher duties (15-25% duty and 15% VAT).
- There are 10-15 importers of modules, lights, charge controllers, inverters etc. There are three major battery manufacturers and a major lights and charge control manufacturer. Another 4-5 small-scale manufacturers of lights and charge controllers, inverters, etc, are in business countrywide.
- Generally, independent operators with some knowledge of AC electricity provide technical assistance, as only a few trained solar technicians exist.

Sales methods and financing mechanisms

A major factor influencing the actual demand for SHSs in Kenya is the inability of customers to pay the high up-front costs. The systems bought on a cash basis constitute the largest portion of systems installed in Kenya to date. This market seems to have reached a saturation point.

Hire-purchase schemes have been tried in the past and are making a comeback, at commercial lending rates (averaging 40%) and a maximum repayment period of 24 months. Several retailers offer a cash deposit system to customers, who get the system upon full payment.

Even though financing appears to be the best option in facilitating mass rural electrification by solar electric systems, few initiatives exist. In an effort to develop a sustainable financing mechanism to further assist the commercialisation of PV in the country, ESMAP, through a local company Energy Alternatives Africa, conducted a pilot Solar Finance Project (1997–99). The approach was based on the co-operation of a finance partner, credit group and a technical partner. The objectives of the exercise were to: increase access of solar systems through financing, spread-out up front costs, offer savings through bulk purchase to offset cost of credit and enable use of better equipment. Two approaches were used: K-REP – a rural development bank, and the Co-operative Bank of Kenya. Each group used its standard existing system of disbursement. In total, 70 systems of sizes ranging from 24Wp to 60Wp were installed. Costs varied between US$500 and US$1 100 per system.

The major problems encountered included cohesion among loan groups, changing preferences and local politics. Lack of technical capacity among local installers was evident from the low installation standards. The most notable achievement was the rise in bank managers' acceptance of the viability of PV business. Lessons learnt included the following:

- Banks are not accustomed to consumer credit. Interest rates need to be less than market rates.
- Low or no defaults on loans experienced in the case of cooperatives.
- For smooth implementation, there must be existing infrastructure.
- SHSs are not a productive asset.
- Substantial technical training is needed as technical capacity is weak.
- Time and dedication is essential to implement such projects; steady and adequate project preparation support is necessary.
- Even if economically viable, initiatives are not always financially viable.

- Adequate financing mechanisms as well as information dissemination channels need to be developed. (With respect to financing for suppliers, two proposals have been short-listed for financing under the US$5 million initiative of the World Bank/ GEF targeting entrepreneurs.)
- Policy barriers need to be removed and duty/tariffs rationalised.

Market impediments

Despite the high potential demand for solar home systems, constraints impede market growth. These include:

- lack of government support;
- high consumer prices partly resulting from high tax and duties component, and relatively high transactions costs among dealers and distributors;
- missing credit lines;
- lack of standards leading to poor installation standards and practices;
- low quality of available local balance-of-system components; and
- low consumer awareness of the limitations and potential of PV.

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Uganda's experience with PV systems

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The level of electrification in Uganda is among the lowest in Africa. Less than 6% of the population of about 22 million have access to the grid, and in the rural area the situation is worse with only 1% connected. An additional 1% provides itself with electricity via decentralised systems. The government of Uganda has set a goal to raise the rural electrification level to 10% by 2010 and recognises the need to use both grid and off-grid methods to meet this target. It is expected that PV systems will meet 20% of the electrification. In view of this, the experience with the Uganda Photovoltaic Pilot Project for Rural Electrification (UPPPRE) is explored here.

The UPPPRE pilot project, started in June 1998, is being implemented by the government. Its main goal is to establish sustainable mechanisms for commercialising PV systems. These mechanisms include financing, consumer awareness, marketing infrastructure and capacity building. The project has established credit windows with financial institutions for PV vendor companies and consumers, and raised public awareness about solar home system. As a result, the private sector companies have installed close to 1000 PV systems, including over 40 community service systems (in health, education and water supply sectors) in rural areas in the two years the project has been under implementation.

Prior to the UPPPRE project, the major initiatives in solar electrification were through donor community assistance to government institutions mainly for health and communication services, NGOs, together with a few commercial sales. Therefore, to the extent that donor and NGO funds were not targeting individual households and commercial establishments, the UPPPRE project was initiated to address this gap.

Lessons learnt

During the last two years of the project, a number of lessons have been learnt. These are discussed below.

Financing

- Short-term consumer lending by micro financial institutions (MFIs) does not remove the high cost barriers on PV systems. The monthly loan payments are high and, therefore, a disincentive to borrowing.
- The policy and institutional set up of the MFIs has contributed to the poor access to loans. Since female users had more problems in acquiring the 50Wp or larger solar home systems than men, the Uganda Women's Finance Trust (UWFT) was selected as one of the MFIs that would provide credit to women. However, the UWFT has loaned virtually nothing to potential consumers. Very few vendors have accessed credit through the Centenary Rural Development Bank (CERUDEB) that had been selected to administer the loans.
- Lack of collateral by end-users as well as vendors has curtailed access to loans, Potential consumers for solar systems do not generate regular monthly incomes, yet the participating banks want monthly repayments. (A 50Wp system costs about US$800). The source of income for such clients, especially women, is mainly from agriculture-related activities, which provide seasonal income.
- Lack of operational bank accounts hinders rural men and women from accessing loans from the banks.
- Ugandan PV companies remain weak in marketing. This is demonstrated in two main ways. Firstly, they are not capitalised enough to procure stocks in appreciable amounts. They procure in the range of 20–50 50Wp systems (or equivalent in components) at a time and hence the unit costs remain high. Secondly, most of them are not creditworthy enough to access loans from financial institutions. Even with the financing established by the project at CERUDEB,

where the interest rate (12%) is much below the market level (28%), many of the companies have failed to raise the required collateral. While the project has tried to assist the companies by providing partial risk guarantee through CERUDEB, it is apparent that the companies will need other forms of contingent finance to raise their capital base.

Marketing

- PV marketing is not an easy undertaking. The original assumption that the PV companies would take advantage of the public awareness and vigorously market their wares in the rural areas, including opening branches/agencies, did not materialise. The main problem the companies have cited is the high transaction costs associated with potential customers. The transaction costs get intensified where decisions to invest take longer than necessary, as in cases where wives have to consult with their husbands.
- Although the project has tried to encourage companies to use commissioned agents who are well established in the rural areas, companies are still reluctant, due to lack of accountability by agents and unavailability of monitoring mechanisms.
- Public awareness can be an important marketing tool. Data available has shown that the cash or short-term credit models used by the companies are doing much better than the consumer credit by financial institutions. This is mainly because the companies provide the short-term flexible loans on the basis of a signed contractual agreement without requiring interest or collateral. In additional, the procedures are much shorter than in formal financial institutions. The companies have good customer relationships and are within easy reach. This indicates that a certain market, based on cash sales, exists, as long as people are well sensitised about PV.
- Public awareness activities enabled the solar companies to understand that there are various categories of solar system consumers. Through these activities solar companies addressed strategic needs of women and men by providing advice and systems that could be used for income-generating activities.

- There is need for a PV distribution infrastructure in the rural areas. A recurring problem has been the lack of follow-up marketing of PV equipment by companies. The fact that the product is not in the proximity of the market makes it difficult for both the supplier and the consumer to conduct a transaction.

Institutional issues

- The project has been physically supporting the industry association, Uganda Renewable Energy Association (UREA), including provision of office space. This has been found to have a negative impact on the growth of the Association towards self-reliance.
- Linkages with other projects, other donors, and NGOs are essential for enhancing the delivery mechanisms of a project. The institutional arrangement of the project did not include establishing structures in the pilot areas. However, the link with the Private Sector Development Project, which already had a functioning network in the rural areas, enabled the project to reach the rural areas.
- Priority-setting by users in most cases placed PV as a luxury, due to other pressing needs on household income. However, in cases where public awareness programmes had shown other benefits to users, there was a great shift in looking for strategies to cope with acquisition of the systems (such as opting for hire purchase options directly from the companies).

Policy concerns

PV can make a large impact in rural electrification if the service can be used to generate income and not just as a consumer good. It has been demonstrated that the required cash or monthly payments greatly limit the level of PV system dissemination. Levelling the playing field between grid and off-grid electrification by extending subsidies to off-grid could make PV systems more affordable. The government has recognised this need in the Rural Electrification Strategy and Plan for 2001 to 2010. It is evident however, that finance is not the only barrier. Institutional barriers significantly inhibit penetration of PV systems.

The transition from pilot projects to large-scale programmes: The case of Namibia

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In Namibia, out of an estimated population of about 1.8 million, only about 30%, most of whom live in urban areas, have access to electricity. In rural areas, the electrification rate is estimated to range between 8% and 15%. In 1993, the Ministry of Mines and Energy (MME), supported by the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), launched a programme to promote the use of renewable sources of energy. As part of this programme, a market-oriented dissemination strategy for solar home systems (SHSs) has been developed and tested to provide electricity services to those households unlikely to be connected to the grid in the foreseeable future.

As stipulated in the White Paper on Energy Policy, the Namibian energy policy is aiming at effective governance, security of supply, social upliftment, investment and growth, economic competitiveness and efficiency and sustainability.

In line with these objectives, government undertook considerable efforts to narrow the gap in development between urban and rural settlements, by extending the public grid as far as possible. However, due to limited government budgets and the dispersed nature of the settlements, only a limited number of rural households have so far been connected. In ex-post analyses it became obvious that the specific electricity consumption per capita in newly electrified villages remains rather low. Electricity is mainly used for basic needs including lighting, radio and TV, and, only to a very limited extent, to cooling and other domestic applications. This low specific demand and the dispersed structure of settlements are the limiting factors for the economic viability of rural electrification programmes based on grid extension.

Dissemination strategy for solar home systems

As a consequence, rural electrification by extension of the grid had to be complemented by decentralised technologies and the MME decided to develop and test an appropriate dissemination strategy for SHSs based on the needs and means of rural families. Towards this goal, the following steps have been undertaken:

Energy inventory study: In-depth inventory studies were carried out to analyse the actual energy demand and supply situation of the target groups and the local administrative structure. The lighting needs are mostly met using candles, kerosene and gas lamps for lighting, dry-cell batteries for radios and tape recorders, and car batteries for television. The car batteries are normally re-charged in rural centres far away from the settlement.

Information: With the target groups and their needs (demands, expectations, anticipations) being identified, public awareness campaigns were launched via the mass media, and expositions of material on-site and discussions with potential users were conducted.

Demonstration: In order to demonstrate to the rural population the mode of functioning of a PV system, suitable sites for pilot installations, such as churches, schools, teachers' houses and rural clinics, were identified and equipped with solar systems free of charge.

Training: In order to create an effective regional supply and maintenance network, local technicians were trained in PV technology and were established in the various regions as retailers and installers of SHSs supplied by the municipality-based PV companies. Training material and courses were provided by the renewable energy project in collaboration with national and regional institutions.

Set-up of a financing scheme: With the initial investment for a SHS (approximately US$1000 for a 50Wp system in 2000) exceeding by far the financial capacities of most rural households, it was essential to provide appropriate credit facilities. The experiences gained by setting up a revolving fund in 1995 administered by the Namibian Development Corporation (NDC), a financing institution focusing on development projects, have been encouraging. With the revolving fund in place, financed jointly by the Namibian government and foreign donors, rural customers can benefit from credits provided by NDC to purchase a SHS. In the initial phase, only a 50Wp system was available through the project. According to demand in the present phase of the project, four different system configurations are offered to the customer, ranging from an installed capacity of 50Wp up to 250Wp. This project was referred to as the 'Home Power' project.

Other initiatives

In two villages, in Caprivi and Erongo regions, 190 households were electrified with 75W PV systems in July 2000. The project was implemented with financial assistance from the Indian government though a bilateral agreement between Namibia and India. Unlike the Home Power Project, the households did not pay for the systems, although they are expected to meet the operation and maintenance costs. For these the households are expected to contribute to a fund managed by the village committee. The amount will be based on ability to pay. The institutional framework for this to function is yet to be developed. The status of these villages in the national electrification context needs to be clarified.

A new solar PV technology for rural electrification known as the 'power can' was launched in March 2001. The power can is developed by SunTechnics, a German-based company, and modified to suit Namibian conditions by SunTechnics Namibia and the Namibian University. The power can is similar to the SHS. There are two main sizes – 50Wp and 200Wp. It will be operated on a fee-for-service basis where the consumer uses the plug to buy credits. The new utility company, Premier Electric, will use the power can to electrify some of the off-grid areas.

Lessons learned from pilot projects

The principles of private ownership, locally available service and reliable material provided a high degree of customer satisfaction, leading, as per mid 2000, to an excellent payback rate within the revolving fund scheme of nearly 100% with only minor arrears. On the other hand, the high up-front investments are a limiting factor for the wide spread utilisation of SHSs, limiting potential customers to the well-off. In order to provide basic electricity services to as many customers as possible, this 'high-end' approach has to be complemented by other 'lower-end' approaches such as government supported off-grid programmes.

From pilot to programme

In recognition of the need to adopt the 'lower-end' approaches to facilitate achieving the government's goal of electrifying 25% of the rural population by 2010, the Namibian power utility, NamPower, launched an extensive Rural Electrification Master Plan (completed by the end of 2000) in which both grid- and off-grid electrification are taken into consideration. The Master Plan clearly identifies areas suitable for each type of electrification. The cabinet endorsed this Master Plan in March 2001. NamPower is presently evaluating various options of large-scale implementation strategies for off-grid electrification. To test the acceptability of the fee-for-service model, three regions have been selected where a service provider will install 50 SHSs per year. This provider remains the owner of the systems and charges the end-user a fee for service. For this purpose, the revolving fund will be transferred to the respective service provider in due time. However, the option of purchase of a SHS on credit by making use of the revolving fund will remain. After a three-year period, an evaluation to establish which model to adopt will be undertaken.

While the Master plan will provide guidance on future electrification strategies, it is worth noting that there are previous initiatives that will have to be integrated into the plan. Thus, to enable large-scale programme-oriented establishment of off-grid electrification, the MME is developing the regulatory framework for off-grid electrification. The first phase, which involves development of guidelines for developing such a framework and undertaking off-grid electrification in the short term, is underway. To realise this phase, the MME is receiving financial and technical assistance from UNEP Collaborating Centre on Energy and Environment, Denmark, under the Sustainable Energy and Advisory Facility Programme.

Overview of the South African off-grid concession process

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In South Africa, government initiated a process in 1999 whereby public-private partnerships are being established to enable energy service delivery to rural areas beyond the reach of the national grid. The intention is to establish five or six concession areas, each serving about 50 000 households. A subsidy will be available to assist in covering the costs associated with the supply of off-grid basic electricity services to households. This article provides an overview of the experience so far in the programme.

Over the past eight years South African communities have gained access to the benefits of grid electrification at an unprecedented rate, with approximately 67% of all households connected to the grid by the end of 1999. Although the grid extension programme is expected to continue for some time, there are between 1.5 and 2.5 million households located in regions and settlements that would be expensive to electrify, and for whom the most cost-effective option for basic electricity supply is off-grid electrification using either solar home systems (SHSs) or isolated mini-grid systems.

Although there have been significant sales of small SHSs (with estimated total sales of the order of 50 000) to date, there has been little formalised delivery of off-grid electricity to rural communities in South Africa as part of the national electrification process. About 2.5 million households have received a grid connection on payment of a relatively low connection fee of R100 (US$16.7 in 1999). Those beyond the reach of the grid have received no significant energy-related support.

Government, the industry, and policy makers have been seeking to identify a mode for large-scale off-grid electricity delivery for several years, and a number of different off-grid electricity supply models have been explored, generally with little long-term success or potential for replication. The most recent endeavour has been to involve the private sector in a medium-to-large-scale concession-type approach.

The off-grid concession process

Key elements of the strategy are:

- involvement of private sector companies as 'concessionaires' where each have defined geographical regions within which they are required to operate according to set performance standards;
- setting aside of electrification funds that will be used to buy down the capital cost of the off-grid energy services provided by the concessionaires; in the interim these funds will be disbursed/managed by the National Electricity Regulator;
- an expectation that the concessionaires are responsible for setting in place revenue collection and maintenance infrastructure to ensure long-term operational integrity of the off-grid systems;
- the allocation of responsibility to the grid electrification implementer (Eskom, the national utility) to monitor the basic performance of the concessionaire, and thus act as the primary public sector representative in the delivery programme (this is currently under discussion);
- using SHSs as the principal electrification technology, although provision is also made for the use of other technologies such as mini-grid or hybrid power supply units;
- a clear expectation that the concessionaires should also improve access to thermal energy services (liquefied petroleum gas and paraffin) within their concession areas.

Progress and key lessons learned

At the time of writing, only one of the concessionaires had started implementation (the Shell Eskom Joint Venture), and even this implementation has essentially taken place outside of the concession process (it started before the call for proposals; the parties have not yet signed the formal concession documents; and the concessionaire has not yet been able to access the subsidy funds). Nevertheless, the Eskom-Shell

JV has installed about 6 000 SHSs in the Eastern Cape. From this implementation experience, three main messages emerge:

- The lack of publicly available medium-term grid electrification plans leads to difficult community negotiations, and tensions between the grid service providers and the off-grid service providers.
- Consistent revenue collection remains a problem area, despite the use of pre-payment meters.
- There is a significant demand for the service offered at the tariff used (around R50 or US$6.5 per month). The demand is, however, not as high as may have been hoped for.

For all parties to the process, perhaps the most important lesson to learn has been that it is very difficult and time-consuming to allocate and define the public sector responsibilities for such a rural energy services concession process. The request for proposals from industry was issued prior to final agreement on the part of the local authorities, the Department of Minerals and Energy, the National Electricity Regulator and Eskom as to who would take responsibility for what aspects of the programme. In an environment where grid electrification is an important political issue, and has provided tangible evidence of delivery, it has been difficult for parties to, firstly, accept the role of off-grid electrification, and, secondly, to agree on their responsibilities towards the process. At the time of writing, it is twenty-one months since the private sector companies were selected, and no contracts have been signed. Although the Department of Minerals and Energy has provided the strategic impetus to the programme, it is not able to act as an implementation authority, or even to administer the funds. The Department has therefore sought to engage other public sector institutions to act, effectively on its behalf, in administering and running the programme. This has been relatively simple from a financial point of view, as the National Electricity Regulator already plays a key role in electrification funding, and has expressed its willingness to hold the off-grid funds, and to allocate these to implementers in accordance with rules and procedures that it has been able to adapt for the process. It has, however, been far more difficult to clearly identify the responsibilities and even the best roleplayers for the task of monitoring the concessionaires, defining more precisely the settlements within which they can operate, and effectively acting as the 'contractor' or 'concedante'.

In the first instance it was expected that local authorities would take on the role of monitoring and effectively contracting the concessionaires. However, this has not happened so far, for several reasons, including ongoing debates around the restructuring of the electricity distribution industry, concerns regarding capacity and concerns regarding the impact of off-grid electrification on the potential for future grid electrification in communities. At present, Eskom has been requested to take on the role of 'concedante', effectively acting as government's agent in the public-private partnership arrangement. A key reason to involve the utility has been its strong involvement in rural grid electrification and in electrification planning. Eskom is also expected to play a dominant role in a future restructured electricity distribution industry. Eskom is thus well placed to reduce the risks associated with grid encroachment into areas where off-grid technologies have been used. On the other hand, there is significant potential for competition between Eskom and the private sector concessionaires – they compete for the same customers (albeit with different technologies), and Eskom itself is a potential off-grid service provider (and a joint venture partner in one of the concessions). Concerns have thus been raised regarding the risk of Eskom's access to confidential commercial information, and its impartiality. In an attempt to include some safeguards for the private sector, the National Electricity Regulator has been included as a signatory to the proposed concession contracts. Furthermore, the Regulator will be the primary agent responsible for tariff reviews and financial monitoring associated with the concession process of off-grid electrification.

The way forward

The South African off-grid electrification process is clearly still in its infancy. While it is clear that the public-private partnership approach has been able to draw in a number of important resources and roleplayers for most of the concessions, delivery has not yet started. The current debates around public sector roleplayers and responsibilities are important, but this author feels that for the key responsibilities and challenges to successful, sustainable implementation will lie on the shoulders of the private sector concessionaires. As the process moves into its implementation phase, issues such as local-level consultation, market development and awareness, revenue collection, maintenance, capacity development, rural infrastructure and logistical constraints will require innovation and commitment. Indeed, with hindsight, it is unfortunate that a mechanism was not found to encourage and allow the private sector operators to commence on a far smaller scale almost immediately after selection. Then the time lost during the above described negotiation period would have been put to good use. The process remains exciting, and the jury will need to wait for some time before there is evidence or real opportunity to pronounce on success, or failure.

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PV project experiences in Morocco

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In 1995 about 90% of rural households in Morocco were not connected to electric grid. Under its new policy of decentralisation and accelerated rural development, the Department of Energy adopted, in August 1995, the goal of national electrification by 2010. A long term programme, referred to as the Global Rural Electrification Project (PERG), was developed in co-operation with the National Electricity Office (ONE). The PERG is managed by ONE and financed by ONE, the beneficiaries and communities.

This programme involves both grid extension and decentralised electrification. As a result of the innovative financing system, the number of villages electrified per year went up from an average of 50 to 1 044 in 1997. In 1998 the programme was expanded to electrify over 1500 villages per year, in an effort to achieve the universal electrification goal.

A large PV programme targeting the implementation of 200 000 solar home systems (SHSs) has just started. The market for the next five years is projected to be about 10MWp.

During the last decade, public and private operators have worked alongside each other in developing the PV market. Presently public and private operators are establishing an appropriate service approach. The fee-for-service model is being tested using selected service providers. It is expected that every service company selected will, by 2010, install ten to twenty thousand 50Wp SHSs and provide maintenance and after-sales service. The National Electricity Company is contributing US$400 for each system, with the balance, approximately US$100, being met by the users.

The private sector involvement is strengthened with the 'maison energie' (energy house), a new concept of ESCOs developed to improve energy distribution in rural areas. The services offered include PV electrification and maintenance, gas distribution, sale of improved furnaces, and energy and environment conservation awareness campaigns. About 150 ESCOs are under establishment.

The total installed PV power in Morocco is estimated at around 4MW peak. PV is mainly used for electrification of rural homes (more that 20 000 SHSs installed), for pumping drinking water (more than 300 PV pump systems), and professional systems (telecommunications, TV emitters and receptors, and traffic signals in isolated areas).

PV technology is particularly adapted to the significant but widely dispersed demand for small amounts of electricity in rural homes that will not be connected to the grid in the medium term. Morocco has 40 000 villages with an average of 50 households each, totalling about two million rural households. A significant share of these are either located in douars (villages) that are very remote, or are thinly spread over a wide area.

Many pilot projects, using PV systems and hydroelectric microgenerators for electrification, have been developed with the participation of thousands of rural homes. More generally, Morocco has put in place, often through private initiatives, a wide variety of projects addressing technical aspects as well as organisational and financial issues (see Table 1).

Table 1: PV projects in Morocco

Projects	*International financing*	*Morocco financing*	*Application*
ERD-CE (EU)	Euro 10 m	Dh 30 m	Nord
ERD-KFW (Germany)	DM10 m	Dh 45 m	Tensift
PPER (France)	FF30 m	Dh 70 m	Azilal, Erra-chidia, Safi
Village Power (Spain)	Dh 8 m		Chefchaouen Taounate
PV Initiative (GEF-IFC)	US$5		Private sector assistance

Lessons from PV electrification activities

Experience from these projects provides some basic principles for intensified decentralised rural electrification. These include:

- Electrification projects should be initiated by the communities and should thus be demand driven.
- Financial investment must be shared between the project and the community beneficiaries, who should also take responsibility for operation costs. The National Electricity Company should only assist in acquisition of initial equipment.
- Only technologically proven technologies should be promoted. Integrated planning is necessary, taking into account extension of the grid.
- A mechanism for transition from off-grid to grid should be established.

These principles are in accordance with the recommendations of the Marrakech International Symposium, held in November 1995 under the framework of the United Nations Commission on Sustainable Development and dedicated to discussion of issues and perspectives concerning widespread decentralised rural electrification.

Key achievements

The key achievements under the decentralised rural electrification activities include the following:

- Large-scale implementations. SHSs are expected to reach around 10% of the rural inhabitants in the near future. The factors that have contributed to this success include experience gained through the pilot programmes, the global rural electrification planning programme, the choice of the service approach, research on financial and technical operation and mobilisation of local resources.
- Strengthening of the co-operation between private and public sector to promote technologies, develop standards and reduce costs.
- Mobilisation of important investments, with the help of GEF, European Union, UNDP, and bilateral cooperation (French, German, Spanish, Japanese, US).

- The establishment of employment opportunities through growth of ESCOs.
- Strengthening local technical expertise and resources.

PV experiences in southern Mali

IBRAHIM TOGOLA
Director, Mali Folkcenter

This summary is based on a Danida-funded solar rural electrification project in the Sikasso region of Mali, 290 km south of the capital, Bamako. The three-year project, which started in June 1999, is being implemented by Mali-Folkecenter and aims to curtail rural exodus. The project site includes three villages and targets provision of lighting in schools, lighting and refrigeration in health centres, lighting of public squares and pumping of drinking water. In addition, 20 villages schools will be provided with PV systems for lighting. The project was designed to deal with the specific shortcomings of other previous PV installations. The challenge is to create management and support structures which can effectively maintain installed hardware.

Mali is located in the centre of West Africa and has an area of 1 241 000 km^2. Of the 11 million inhabitants, 80% live in the southern third of the country, as the northern two thirds are desert. In Bamako, about 25% of households have access to electricity, but in rural areas the figure is less than 1%.

The Malian government has stated its priority for electrification of 500 villages over the next ten years, and that renewable energy should play a key role. Hence, after so many years of unsuccessful solar installations, there is a need for a demonstration of sustainable off-grid energy supply solutions.

Problems encountered so far

Mali was among the first few countries to be targeted for PV-fuelled development. Installations have been made by Mali Aqua Viva, Danida, the Regional Solar Programme, CMDT (the state cotton company), the National Directorate of Water, and numerous small NGOs and community associations. Some installations have been successful, but long-term sustainability has generally been poor. Long-term sustainability refers to the ability of an installation to continue providing electricity or fresh water services in the longer term.

Around 500 PV water-pumping systems have been installed in Mali (mostly by Mali Aqua Viva, Danida, and the Regional Solar Programme). About 60% these systems are not functioning efficiently. In some cases this is due to technical reasons (incorrect sizing of PV array, pump etc.), but more often failure is attributable to the organisational capacity. The fundamental problem with the water pumping systems has been the lack of appropriate management structures. Installations have been made through the National Directorate of Water, but without communicating the value of the installations or providing the maintenance training or facilitating development of income-generating activities to allow for payment for maintenance services. The installations were undertaken with little consultation and involvement of the target group. Often the management of the sale of water is not efficient. The funds collected are insufficient to purchase replacement equipment, and training in maintenance is not focused on the right areas or at the right people. As a result, communities fall back on previous water supplies such as private shallow wells.

Project activities

The Danida project seeks to address these problems by training and building the capacity of the Village Associations, Women's Associations and Youth Associations. These are organisations that already have some management and organisational ability, but this needs to be strengthened and reinforced to deal with solar equipment installed.

Maintenance Committees, comprising teams of eight men and women, have been established in each of the three villages. These people are undergoing training for the maintenance of systems and are gradually taking responsibility for their operation. Use of systems is logged to provide a database for analysis of performance. The performance of the maintenance committees is also being monitored.

The water pumping installations will generate income by sale of water, at a price everyone can afford, to provide income to the Women's Association, as agreed at a village assembly. This money will be used to cover maintenance costs and remuneration for people working in the jobs created by the project – including selling water, accountancy, and membership of Maintenance Committees. Effective accounting procedures and financial management will be put in place to ensure that funds are well managed, and that there is always sufficient funds to cover replacement of worn-out hardware.

Outputs

The project targets three core villages in Koumantou, southern Mali. The main outputs of the project will be:

- electrification of the school in each village to allow literacy training for rural women in the evenings;
- lighting for public squares for meetings and communication;
- lighting and refrigeration for the village health centres; and
- supplying drinking water using solar water pumping systems.

A solar training school will be established for training rural technicians in PV installation and maintenance. A further twenty PV installations in schools in the surrounding area will provide experience and hands-on practical skills, thus creating a decentralised human resource base for renewable energy services. These lighting installations will then allow adult literacy classes for women in the evenings in these villages.

The rural technicians trained in solar energy will have the possibility to set up a small business under the AREED programme (African Rural Energy Enterprise Development, a UNEP initiative supported by the UN Foundation), of which Mali-Folkecenter is the Malian representative. This programme provides support to small entrepreneurs who want to make a business based on renewable energy services. Entrepreneurs can receive help to develop a business plan and have access to a small loan for implementation of their business idea.

The results of the project will be disseminated via workshops and seminars at local and national levels. The opportunities for income-generation and the establishment of efficient management structures should provide a model for sustainable operation of future installations.

The Ghana Renewable Energy Services Project

CLEMENT G ABAVANA
Project Coordinator, RESPRO

Ghana has a population of about 18.5 million (census in 2000) and enjoys a national electrification level of 61%, which is relatively high compared to many West African countries. However, a significant share of the rural population remains unelectrified. Efforts, such as the one discussed here, are being made to improve this situation.

The Ghana Renewable Energy Services Project (RESPRO), started in February 1999, is being implemented by the Ministry of Mines and Energy through the Renewable Energy Services Project unit on the basis of what is known as 'National Execution'. The government of Ghana and the Global Environment Facility (GEF) fund RESPRO, and technical support is provided by the National Renewable Energy Laboratory of the US Department of Energy. The project phase is three years, after which the lessons learned will enable a public sector company to efficiently provide rural energy services. The project addresses the need to find sustainable energy paths for social and economic development that can use renewable energy based electricity and fuel supply technologies in place of fossil fuel-based electrification. The project is in line with the government's policy to make electricity widely available to all communities by 2020.

RESPRO is presently installing solar PV systems in thirteen communities in the East Mamprusi District, Northern Region. The success of this pilot effort is expected to encourage widespread adoption of such technologies by government in the rural electrification programme.

At a project tripartite meeting held in September 2000 in Tamale, the Project was given the permission to expand its operations into the adjoining districts. This is mainly to reduce overhead costs and spread the usage of PV systems.

RESPRO is building technical capability in the design, installation and maintenance of PV systems and equipment, and PV/wind hybrid power systems combining both private sector and public sector efforts. Its technical staff, made up of two engineers and six technicians, has received training in the design, installation and maintenance of PV systems at Kwame Nkrumah University of Science and Technology in Kumasi. RESPRO has drawn up a programme to train, in each district into which its operations will be extended, a total of ten electricians in DC/solar PV wiring and the basics in the design and maintenance of PV systems. The trained electricians will be certified to install and maintain PV systems under the supervision of RESPRO Technicians. Presently, an average of twenty solar home systems are installed monthly.

Project implementation

RESPRO is operating on a fee-for-service basis. The systems for homes, commercial or public facilities such as community water pumping and health clinics are installed and owned by RESPRO.

Prospective customers apply for systems just as they would for grid electricity supply. At present, two standards sizes of solar home systems are being installed: 50Wp (cost: US$630) and 100Wp (cost: US$950). A US$100 fee is charged for installation and the monthly rate is fixed at US$3 for the 50Wp and US$5 for the 100Wp system. In addition, customers with special requirements have systems sized to meet those requirements. A few community and public installations for water pumping, school lighting, and street lighting have so far been undertaken as a government contribution to community development.

With the expansion of project activities into other districts, the strategy for implementation will change to include the option to purchase systems. In addition, new customers who will want to remain on the fee-for-service will be required to engage the services of the certified electricians to wire their premises for them, as would be done if they were applying for conventional grid electricity supply from VRA-NED (or ECG), the two local electricity utility companies.

Project progress

Some of the assumptions and facts considered during the concept stage are no longer applicable or correct. These have therefore affected the progress of the project and made implementation rather slow and expensive. Some of these are discussed here.

The non-involvement of VRA-NED (or ECG), in the project has meant that the cost of hardware, which the government normally bears for rural electrification through grid-extension, is not extended to PV systems. The benefits that all grid customers get under the lifeline tariff are denied to customers of PV rural electrification – they are called upon to pay full cost recovery rates.

Affordability has become a big issue because of changing economic conditions. Even though ability to pay might not have been significantly eroded by the general economic situation, since prices of the farm produce and livestock also increased, the willingness to pay is low – partly because politicians seeking votes promised grid extension sooner rather than later.

There was an initial rush to register for the solar systems. This was followed by a very low rate of installation when it was realised that the systems were not being given away. However, with public education, interest has steadily built up and the following installations have been done so far: 283 solar home systems, 155 solar home systems (paid-up but not installed), five school systems, one water pumping system, and 22 street lights.

Future prospects

With about one year of the project period remaining, to demonstrate success (besides providing electricity to the pilot area and adjoining districts), RESPRO will have to:

- demonstrate the commercial viability of the provision of PV-based electricity services;
- influence government energy policy towards the development of a market for rural electricity services based on renewables, especially photovoltaics;

- develop and produce a private sector power contract framework for the provision of off-grid and rural electricity services with specific incentives to encourage private sector participation.

Lessons learned

- The establishment of a rural energy services company (ESCO) has inherently high overheads.
- In RESPRO, high operating costs are due to the small size of the project and its remoteness.
- A mix of strategies should be employed in implementation of PV programmes
- Suitable policy frameworks with appropriate financing mechanisms are necessary to encourage wider participation.

MME/Spanish-funded solar PV electrification in Ghana

WISDOM TOGOBO
Ministry of Mines and Energy

In 1990 the government of Ghana initiated a National Electrification Scheme (NES) with the aim to extend electricity by 2020 to all parts of the country with populations above 500.

Until 1989, only 478 communities out of an estimated national number of 4 221 had access to grid electricity. However, with the implementation of the NES programme, access to the grid has increased from 11% in 1989 to about 52% in 1999. All the 110 District capitals in the country have now been connected to the national grid. In addition, over 2000 rural communities have also been electrified through the Self-Help Electrification Programme and the NES.

This modest achievement was made possible at great cost to the nation. It cost between US$11 000 and US$15 000 per kilometre of grid extension, and it is becoming more expensive for government to extend grid power, particularly to isolated remote rural communities. In some of these locations, decentralised systems, such as solar PV, could be more financially feasible. However, before embarking on this on a national scale, it is important to establish through pilot demonstration the conditions necessary for integrating solar PV into the NES. In view of this, the government secured a US$5 million mixed credit facility from the Spanish government in 1998 for the implementation of an Off-Grid Solar PV Electrification Project.

The project

• Goals and objectives

The goal of the project is to demonstrate the viability of PV for rural electrification on a fee-for-service basis, with a view to identifying the issues that need to be addressed before a comprehensive policy on the role of PV in the NES is enacted. The specific objective was to provide 2 193 solar PV systems with a total capacity of 214.9kWp in ten remote rural communities and a 50kWp grid-connected solar system at the Ministry of Energy building.

• Services and system types

Services provided with PV in the communities include home lighting and power for TV and radio operation, vaccine refrigeration and lighting in the health centres, streetlights, solar battery charging and solar water pumping. The types of PV systems, their capacities and quantities are detailed in Table 1.

Table 1: System types, capacity and total installed

Solar system	*Unit capacity*	*Total quantity*	*Total capacity*
Home/household (A)	50Wp	760	38 000
Home/household (B)	100Wp	1163	116 300
Hospital	600Wp	14	8 400
Streetlight	150Wp	200	30 000
School/community	250Wp	48	12 000
Water pump (drinking)	6 000Wp	1	6 000
Water pump (irrigation)	1 200Wp	1	1 200
Battery charging centre	500Wp	6	3 000
Grid-connected solar system	50 000Wp	1	50 000
Total		2 194	264 900

• Management structure

The project is financed through a mixed credit facility made up of 50% concessional loan and 50% official export credit from the Spanish government to the government of Ghana. It is being executed and managed by the Ministry of Mines and Energy (MME).

The project began in July 1998. The first two years were for installation work plus a guarantee period of one year provided by the contractor. Isofoton SA of Spain, with Wilkins Engineering as their local counterpart, is supplying hardware and installing systems. The MME will undertake the monitoring of the project for a period of five years to establish conditions necessary for the integration of PV into the NES.

The project targets ten remote rural communities from six districts. Selection of beneficiary communities was made in close collaboration with the district council, taking into consideration the national electrification plan for the community, its remoteness from the grid and the ability of the people to pay for the services.

The project is implemented on a fee-for-service basis. Solar home systems are rented out to consumers at a subsidised fee of US$2 per month (representing 20% of the economic rate of US$10.02). This, however, is twice what their counterparts pay for grid electricity. To ensure effective management of the systems at the local level, the MME, in close co-operation with the local and district council, established solar service committees in each of the ten communities. These committees undertake the basic maintenance of the systems and also collect the tariff on behalf of the MME. A team from the MME undertakes quarterly visit to the communities to monitor the impact on the use of the systems.

- **Current status and impacts**

Installation of the 2 194 solar systems is nearly complete. The water pumping and battery charging systems are yet to commence. The 50kWp centralised grid-connected solar system located at the MME is about 93% complete. It is hoped that all outstanding jobs with regards to the installation of the systems will be completed by May 2001.

PV for electrification has meant a great economic and social improvement for entrepreneurial beneficiaries, including bars, retail stores and music shops, who have reported increases of between 30% and 150% in income after installing the systems. Consequently, monthly payment of the tariff by these entrepreneurs has been encouraging. However, for users who do not use the systems for any income-generating activity, payment is often irregular.

The impacts on the school and hospital systems appear to be good. Schoolchildren can be found studying at night with better lighting quality. With regard to the hospital, medical staff can now undertake emergency work at night. Medical treatment requiring vaccination which hitherto meant referral to larger health centres (with vaccine refrigerators), can now be administered locally.

Key notes

- It may be more cost effective to electrify remote rural areas via solar PV than to extend the grid.
- Most end-users (particularly in communities with populations over 4 000), however, are not satisfied with the restricted services of PV, as it cannot be used for domestic electrical appliances such as fridges, fans, and colour TV. Furthermore, the system cannot be used to power any small-scale rural processing industry that could create employment. The dissatisfaction expressed by the communities has forced the government to consider extending grid power to five of the ten solar-electrified communities.
- By-passing of charge regulators by technicians is very common when the system shuts down due to overuse and low battery voltage, particularly during the rainy season. This has resulted in battery damage.
- The fee-for-service concept may be a viable approach to electrifying most rural settlements with PV, but some form of government subsidy is still necessary.
- Payment of tariffs is seasonal, particularly for households not generating income from the system. Collection of moneys involves moving from house to house and, considering the dispersed nature of houses in rural communities, this is labour-intensive and expensive.

Dissemination of family photovoltaic systems in rural Senegal

SÉCOU SARR
Enda-TM, Energy Programme

Senegal has a population of about ten million, the majority of whom reside in the rural areas. The national level of electrification is approximately 25%, while the rural electrification level is 7%. The government aims to increase electrification levels to facilitate economic development.

In 1998, a project on the dissemination of PV systems in the rural areas of Senegal came to a conclusion after a period of eleven years of research work. The project was implemented within the framework of the Senegalese-German Cooperation, and it was supervised by the Ministry of Industry, Mines and Energy in collaboration with the following stakeholders:

- GTZ and the national technical structures, Senelec, Hydraulics Directorate, the Delegation for Scientific and Technical Research, who were responsible for the project coordination;
- Enda-TM,[1] a NGO which had a dual role: firstly, to define and follow-up on the application of strategies for disseminating the systems in the rural zones; secondly, to monitor the project's socio-economic impacts.

1 The organisation Enda-TM was assigned, through a collaborative agreement with the project, to set and apply innovative strategies for FPS distribution. It participated in selecting the intermediary relay associations and was at the root of the creation of the Federation of Solar System Distributor Associations (La Fédération des associations distributrices de systèmes solaires).

- community-based organisations for the handling of equipment installation and after-sales service; and
- private operators who were given the task of supplying the equipment to the village organisations.

The project team selected a standard equipment for the family photovoltaic system (FPS) which consisted of a 50Wp panel, a 50AH battery, a regulator with four bulbs and a socket for radio and TV. Today this system costs US$642. On the other hand, connection costs to grid is about US$26 and consumption costs are US$0.13 per kWh.

The main achievements of the project included: installation of more than 2300 FPSs in five of Senegal's ten regions; the development of local and decentralised maintenance support; the establishment of an FPS distribution and supply and after-sales service system; the creation of small rural enterprises offering energy services; labelling as a quality control measure; and a sound understanding of the local socio-economic dimension and the emerging solar market structure.

Out of the 13 000 villages in Senegal, 540 were involved in the project – a geographic coverage rate of about 4%. A campaign to promote FPS was launched, using brochures, activities at rotating weekly village markets, and radio broadcasts.

In terms of impact, in addition to the qualitative aspects such as improved comfort for households having replaced their storm (kerosene or oil) lamps with FPS and access to information through radio and television, the distribution project created 50 jobs in the rural areas. Each of the dozen or so associations belonging to FOPEN have been offering energy services. An equipment quality control system[2] has been established.

Background

The project's objective was to contribute to improving the electricity supply to rural populations through the use of FPSs. Two complementary and mutually reinforcing approaches were defined to provide a framework to adapt to market changes and to better optimise the

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2 The quality control laboratory is located in CERER, the Centre for Research and Study on Renewable Energies (CERER)

product-market articulation: a project-based approach and a market-oriented approach.

Agents were chosen from the community-based organisations and trained information dissemination and awareness-raising on solar systems. The constant search for a compromise between the price of technology and the household's ability to pay explains why a system of credit[3] was applied in the beginning to stimulate demand.

The project-based approach facilitated the target populations to familiarise themselves with the product. More than 1300 FPSs were distributed in 1994. This approach opened up the market and, finally, it proved that the distribution network created by the associations had sufficiently developed to maintain itself through a dynamic of distribution by private operators.

The project-based approach was shifted to a market-oriented approach in 1994. This entailed withdrawal of the marketing project and an increase in product price. The drastic change in FPS prices caused the market to shrink. FPS demand, which initially reflected a diverse socio-economic profile of buyers, became very selective, consisting solely of high-income households. A brainstorming session was organised to identify ways and means to reduce the product's price, and it was recommended that the associations' supply scheme be reorganised. The associations regrouped into a formal structure called the 'Fédération des organisations pour la promotion des énergies renouvelables' (FOPEN), designed to serve as an advisory, informative and coordinating council for their actions. Since the traditional banks were resistant to investment in the sector, other operational mechanisms were tested:

- Mechanism 1: A credible intermediary agency acts as guarantee for any loans obtained by an association from a financing institution. Such an agreement was struck between the project and Alliance de Crédit et d'Epargne pour la Production (ACEP). Through this mechanism, ACEP pays the FPS supplier on the association's behalf.
- Mechanism 2: Salaried workers organise and reach a joint agreement with their employers to take out loans to acquire equipment.

[3] The initial credit system was indirectly subsidised by the project, which availed the associations of a bundle of equipment to serve as working capital.

The firm pays the association (which supplies the equipment). The loan is then paid in instalments from the employee's salary. This considerably reduces the risk of non-payment.

Present status

Although the project has ended, FOPEN is pursuing the maintenance activities and continues to install new units. Investigations indicate that most of the FPSs are still functioning. Lack of funds to replace dead batteries was the main reason for systems ceasing operation. This induced Enda-TM, in partnership with SGI (Solar Group International), and with the financial support of the Swiss DDC, to design a decentralised electrification programme based on the sale of energy services through an Assembly and Service Centre.

Lessons

Dissemination of FPSs was successful because the product was properly matched with the market. The other reason for its success was that it persistently sought to involve local operators in the production of components (batteries, accumulators) and village groups in marketing.

The distribution of FPSs through community-based organisations (local technicians network) is a key link for the development of a 'neighbourhood' after-sales service that is effective and less costly. However, the cost of the systems remains a key barrier to their widespread adoption.

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Photovoltaic water pumping in Zimbabwe

WASHINGTON NYABEZE

About 69% of Zimbabwe's estimated 11.8 million people live in rural areas, 64-80% of them women. Only about 5% of rural households have access to electricity, and woodfuel supplies about 26% of Zimbabwe's total energy demand.

As in most developing countries, the majority of people in rural areas of Zimbabwe do not have access to safe and adequate supplies of domestic water. In addition the country is susceptible to frequent and prolonged droughts. The last national population census (1992) established the existence of about 30 000 primary water supply points serving 4.9 million out of the estimated 6.4 million people in rural areas. Thus about 33% of the population was 'unserved'. Typical water consumption in these constrained situations is below ten litres per person per day. People, mainly women and children, carry water on their heads or use wheelbarrows.

A 1994/95 report on health facilities in the country established that 300 out of the 1000 rural health centres and clinics did not have piped water. The majority of schools in rural areas use hand pumps. Typical daily water demands for rural institutions are between six and $20m^3$/day, with considerable variations due to demands by surrounding homesteads and gardening activities at the institutions.

The National Master Plan for Rural Water Supply and Sanitation (NWMP) aims at providing clean drinking water and adequate sanitation for the entire rural population by 2005. In 1994 it was estimated that up to that year about 50 000 new water points are needed.

Background

Water pumping in rural areas in Zimbabwe is dominated by hand pumps, grid-electricity and diesel-powered pumps, with the latter being the most common. It is estimated that the Department of Water develops an average of 50 boreholes per year and most of these are equipped with diesel-powered pumps. Photovoltaic water pumping (PVP) systems are technically suitable for about 80% of these sites.

PVP systems were introduced in the country in 1982. Funding for these PVP schemes came from a variety of sources, which included international non-governmental organisations and private donors. These schemes were not based on economic or financial viability, a practice that was followed in later PVP installations. The typical cost of a 1 500Wp system, the most popular size, was approximately US$15 000 in the 1980s.

A larger programme was implemented by the Department of Energy, with assistance from the German government through the German Technical Co-operation (GTZ) programme, from 1992 to 1995. The aims of the programme were to test and demonstrate the technical maturity of PVP technology, and assess its viability and social acceptance. This paper looks at this experience in terms of the institutional arrangements, benefits and key lessons.

Key players and their roles

The District Development Fund and the Department of Water Resources under the Ministry of Water Development and Rural Resources play a major role in installing rural water supply systems. The Ministry of Health and non-governmental organisations are also involved.

In the DOE/GTZ PVP programme, equipment was sourced from an international manufacturer who sub-contracted a local installer. The manufacturer provided a ten-year warranty on modules, and the local installer provided backup service. The Department of Water Development gathered all the site data and carried out tests to inform system design. It also executed the civil works and provided support for day-to-day maintenance of each scheme and liaison with the consumers.

The water users paid a tariff for the water service based on a flat fee for the first ten cubic metres and an additional amount for each extra cubic metre thereafter. Water committees were established for communal water points. Each water committee was responsible for communicating with users, resolving conflicts and ensuring that tariffs were paid on time. PVP users generally paid 50 to 70 times more than those using communal hand pumps, but the same amount as those using diesel.

GTZ and DOE funded the programme. All equipment supplied under it was exempted from import duty, surcharge and customs charge – altogether amounting to about 45% of total cost.

Project benefits

The 16 PVPs installed under the DOE/GTZ PVP programme were strategically located to supply rural households as well as rural institutions within their immediate vicinity. Four of the selected sites replaced diesel-fuelled pumping systems with PVP systems. It is estimated that the PVPs service about 20 000 people. A post-installation survey on one pumping station indicated a reduction of 26% in the number of households fetching water from the river. Other benefits included a reduction in walking distance, which was most evident for those with private connections. For those using communal standpipes the change in distance was less pronounced because some users resorted to shallow wells and rivers in the rainy season to reduce their water bill.

Water use increased for consumers with private connections, but for those using communal standpipes daily household use remained below ten litres per person per day. This was attributed to inability to meet the cost of increased consumption. Teachers and nurses reported higher satisfaction with their working conditions due to reduced walking distance to fetch water. The Department of Water Resources incurred much lower running costs on PVPs compared to the diesel engines they had replaced.

Key lessons

The DOE/GTZ and other PVP projects in Zimbabwe have shown that PVP systems are susceptible to vandalism. This is mainly because of the demand for PV panels for private applications such as lighting and entertainment. The project avoided this problem by fencing the pumping station and turning the pump caretakers into 24-hour guards. However, it was shown that the best guarantee for protection of the system was for users to have social responsibility for their water supply system. The programme also illustrated the need to have on-site skilled personnel for operation and maintenance.

The project showed that PVP systems should be handed over to communities only after adequate institutional arrangements and training in operation and maintenance. Local water user groups are an essential feature to sustain PVPs.

A comparison of cost per amount of water pumped per day over a given head (daily hydraulic energy equivalent) showed that for systems requiring less than $2000m^4$ per day PVPs were cheaper than diesel, and diesel systems were much cheaper for requirements exceeding $4000m^4$/day. Competition with grid electricity depended on distance to grid and the need for a transformer. For distances of five, ten and 15 kilometres, and suitable line voltage, PVPs would be cheaper for requirements of up to $1300m^4$/day, $2000m^4$/day, and $3000m^4$/day respectively. However, if a transformer is required and the grid is nearby, PVPs only compete favourably where demand is less than $500m^4$/day.

Interestingly, during the implementation of the DOE/GTZ PVP programme, the Ministry of Health and Child Welfare had a major programme to improve water supply to rural clinics using diesel-powered pumps. An arrangement was later made through a collaborative programme to 'top-up' the investment on diesel units for some of the clinics and install PVPs instead. Following this experience, proposals have been made for a top-up scheme, which basically provides the difference between the costs of a diesel-powered system and a PVP system. However, the DOE/GTZ programme experience has not identified where the additional funding would come from in the absence of a donor and the inability of users to pay.

The programme reduced the imported component for each pumping station from an initial 78% to about 64%. PV modules constituted about 40% of installed system costs. Further reduction of the imported component was still possible through use of locally assembled modules.

A major problem experienced by the programme was that poorer users failed to meet the water tariff. Even the richer users were inconsistent in their payments. This was compounded by the fact that the PVPs were not tied to any income-generating activities, and payments came from an already over-stretched budget. Even for essential services such as clean water, the ability to pay is generally low in rural areas. This programme showed that water consumption is constrained by the ability to pay. Institutional users generally fared well in terms of payment, suggesting that PVPs may be more suited for this user group.

The walking distance to fetch water, at least for part of the year, has decreased. However, it is difficult to point to any meaningful gains on poverty alleviation, as the PVPs did not improve the income position of the users. It is impossible to put up any substantiated claims on the impact on health, although this could be due to lack of monitoring data from local health institutions. The observation that in the rainy season communal standpipe users revert to unprotected sources indicates that PVPs provide the poor with partial protection from health hazards. At a community-wide level the benefits are not visible, as a large proportion of the population remains unserved. In addition, the lack of monitoring data from local health institutions makes it difficult to benchmark improvements in health. Perhaps the greatest benefit which PVPs have brought, is higher assurance of service during droughts (subject to good operation and maintenance). Although no data is available to substantiate it, this improved security translates to survival for humans and livestock and may justify use of PVPs in remote rural areas.

The installed systems were handed over to the Department of Water Resources, which continues to run them at user tariffs far below those required to sustain the systems. They are, however, justified on a social basis.

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New institutional approaches to rural electrification

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Rural electrification remains a political priority in almost all developing countries. In recent decades many countries have achieved remarkable success in extending the grid to rural areas – South Africa is perhaps the most recent example: over two million new connections have been made in the past five years (1994-2000). These countries have employed the techniques used, by and large, by most industrialised countries during their electrification phase – large utilities, often state-owned, investing in network expansion and spreading the costs across the entire customer base.

For many countries, particularly in Africa, this does not represent a realistic solution. Existing utilities have extremely limited resources, and the scale of costs involved is simply not bearable by existing customers. Governments are preoccupied with developing policies to set the existing industry on a sounder footing, often involving privatisation and market reform in doing so. Electrification is often just not part of the picture.

Partly in response to this, there is considerable interest in alternative approaches to rural electrification – approaches that do not rely on centralised utilities leveraging debt and cross-subsidies from an urban and industrial customer base. These approaches are characterised, and partly driven by, progress made in new technologies. Isolated grids and stand-alone power supply systems such as solar PV systems have been around for many years, but cost reductions are helping to make them more attractive. However, the most important feature of these new approaches, and the feature which makes them a radical departure from previous approaches, is the institutional arrangements employed.

Institutional arrangements

Governments recognise that traditional utilities are not able to pursue rural electrification, and hence are seeking to attract other and more diverse types of organisations into the field. Examples range from international solar panel manufacturers to the local store operating a diesel generator and selling power to neighbours. At the heart of this trend is the set of regulations and incentives designed to attract new participants into rural electricity supply.

Governments are recognising that there are considerable barriers to private sector participation in rural electricity supply. These include the need to establish economies of scale, raise credit in an unfamiliar business area, build customer service systems designed to service small and dispersed populations and, of course, the limited ability of many rural customers to pay for new energy services. In response, actors are seeking to develop arrangements that lower these barriers, mitigate risk, and ultimately transform the market into a commercially self-sustaining one. While practices vary from country to country, two key elements are licences – the award of market rights or privileges – and subsidies, often constructed as a form of market privilege.

• Licences and concessions

Firstly, by awarding market privileges, governments hope to attract investors. These privileges may be exclusive rights to supply customers in a certain geographical area, or exclusive rights to a resource, such as hydropower.

It is important to note that many rural electrification technologies do not necessarily exhibit the economies of scale that constitute the rationale for regulation of conventional grid networks. The rationale for awarding these market access rights is mainly directed at reducing the risk barriers faced by investors.

In addition to lowering risks (and so financing costs), such market rights also allow investors to focus on their particular area, thereby capturing the economies of scale that do exist in customer service industries. Naturally, if customers' interests are best served, in the long term, by competition, then these market privileges may well only be justified as an interim measure.

- **Subsidies**

A second form of market privilege is the exclusive right to receive subsidies, again often restricted to a particular geographical area. Subsidies typically provide a multiple function. Firstly, they reduce the costs to end-users, and so represent a financial transfer to rural households. However, few governments are able or willing to sustain such transfers in the long run, particularly in the face of other social demands such as health and education.

Secondly, they act to 'level the playing field' between grid and off-grid supplies. Where grid supply is cross-subsidised across the entire customer base, which to some degree it inevitably is, customers may be unwilling to participate in alternative schemes. Providing subsidies to off-grid can go some way to reducing these distortions in the market. In a few countries, electrification via PV technologies has been receiving more support in form of subsidies. However, once again, most governments are unwilling and unable to sustain such subsidisation programmes.

Lastly, and perhaps most importantly, subsidies are used to lower start-up costs in an emerging industry. These subsidies are typically targeted at bringing down the capital costs of installations. By bringing down the costs to the first group of customers, subsidies allow a more rapid build-up of the customer base, thereby allowing the supplier to achieve the economies and 'critical mass' necessary to sustain operations. In this sense, subsidies are envisaged to be temporary and are often designed to decline over a space of three to five years.

It is not obvious that a company should receive exclusive rights to subsidies. If customers' interests are best served by competition, then surely the subsidy should be linked to the customer or installation rather than the supplier? Under this arrangement, customers would face competing suppliers, all of whom are offering services with the same level of subsidy built into them. However, the intention is to use subsidies to attract an investor into an area, and support them in bringing down the start-up costs through rapidly building up a customer base. In this sense, subsidies become another form of market privilege; that is, by receiving an exclusive right to receive subsidies (in a particular area), the investor is effectively being awarded a market monopoly. Once again, this right is expected to be a temporary one, either by reducing and ultimately eliminating subsidies or by removing the exclusive element to the subsidy award.

Conclusion

It is perhaps too early to judge whether these new institutional approaches will succeed where conventional arrangements prove inadequate. However, they mark a significant departure from traditional policies and are being considered or adopted in a range of countries. It is perhaps possible that their weakness will lie in precisely the same area that they innovate – in the limited capability of public and regulatory institutions to implement and sustain the policies assigned to them.

In the cases presented in the previous chapters, the absence of a regulatory framework is marked. The sustainability of these initiatives is likely to be influenced by implementation of such a framework.

The way forward

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The case studies reported in this booklet deliver a common message: in several African countries, the design and implementation of PV projects is occurring in regulatory and institutional environments undergoing change. The general trend is from state-directed planning and implementation towards de- and re-regulated private investment. Reforms in the energy sectors of case study countries have led to the inclusion of new players, expectations and mechanisms capable of influencing the structure and direction of PV initiatives, and their contribution to sustainable development goals.

Though varying in depth, scope and speed, the 'invisible hand' of the market is displacing traditional approaches to promotion of solar PV options. Although the state has been at the forefront in virtually all cases under review, the private sector is playing an increasing role. The growing importance being attached to private investment is exemplified in attempts to promote ESCOs and other private operators in several case study countries. While the state has been compelled to withdraw from direct involvement in the planning and implementation of PV projects, the case studies also suggest that government responsibility for developing appropriate policy instruments supportive of sustainable PV usage has improved.

The goal of the authors is to direct the attention of influential actors to the role of PV in poverty alleviation, and to strengthen local capacity for accelerating responsible electrification for sustainable development. The current document foreshadows a more comprehensive two-part publication. The first part will provide detailed analyses of the cases presented in this booklet. The second part will contain guidelines for identifying and evaluating potential PV applications in meeting poverty alleviation objectives and sustainable development in Africa.

An initial draft of the published work is expected to be available January 2002. A final version, directed principally at policy makers, planners, project developers and implementers, will be published in March 2002. In the interim, the authors welcome and encourage comments and critiques from all interested readers.

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