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Lessons Learned–
NREL Village Power Program

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LESSONS LEARNED−NREL VILLAGE POWER PROGRAM

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BACKGROUND/INTRODUCTION

In 1993, a workshop was convened at the National Renewable Energy Laboratory (NREL) with 33 representatives from the private sector, government agencies, development organizations, non-government organizations, and research institutions to discuss the issues of applying renewable energy in a sustainable manner to international rural development. One of the summary recommendations was that NREL could assist in the renewable energy for rural electrification effort by developing and supplying six related activities: resource assessment, comparative analysis and modeling, performance monitoring and analysis, pilot project development, internet-based project data, communications, and training. In response to this recommendation, NREL launched its Village Power Program consisting of these activities that cut across NREL technologies and disciplines.

Currently NREL is active in 20 countries, with pilot projects in 12 of those countries. At this time the technologies include photovoltics, wind, biomass, and hybrids. The rural applications include home lighting and communications, water pumping, schools and health posts, battery charging stations, ecotourism, and village systems.

These pilot projects are central to the renewable energy village power development through the demonstration of three aspects critical to replication and implementation of the projects on a significant scale. The three aspects are technical functionality, economic competitiveness, and institutional sustainability. It is important to note that the pilot projects from which NREL s experience has been gained were funded and, in many cases, developed by other organizations and agencies. NREL s role has been one of technical assistance or project management or both.

The purpose of this paper is to describe the lessons NREL staff has gleaned from their participation in the various pilot projects. We hope that these lessons will help the Renewable Energy-Based Rural Electrification (RERE) community in implementing sustainable projects that lead to replication.

APPROACH

The approach we used to document the lessons was to poll the eight NREL Village Power team members who have been involved in the development, implementation, and evaluation of renewable-based pilot projects. Because each team member had been involved in a subset of projects that were specific to country, technology, application, and institution, the lessons represent different perspectives. The author made an attempt to look for common themes, while maintaining the variety of experiences. Needless to say, some of the richness was lost in trying to generalize the lessons. While there are a number of ways the lessons could be characterized, the following four categories were chosen: institutional aspects, pilot project characteristics, implementation processes, and technology developmental needs.

LESSONS LEARNED

INSTITUTIONAL ASPECTS:

It has long been held that technology is important, but institutional aspects are the critical elements to the success of rural energy pilot projects. It is, therefore, not surprising that there were more institutional issues noted than any other category. The institutional lessons include the following.

Partnering. Establishing a capable, credible in-country partner(s) is critical to project success. In-country partners know the law of the land, act as champions, and are the interfaces with local and regional authorities. Just as good partners facilitate project acceptance and support, poor partners can kill the project, poison the technology and undermine the development team/organizations. Lesson: Be careful in selecting your partner(s).

Maintenance. Nothing is maintenance-free. Therefore, a maintenance support infrastructure needs to be established and nurtured. It needn t be complex, but it does need to be functional and appropriate for the size, complexity and sophistication of the system, and matched to the local capabilities. It needs an up front training program and documentation; regular refreshers for new people; a spare parts inventory and supply information; and funds for preventive and problem maintenance personnel. Lesson: Don t skimp on the maintenance plan.

Tariff design. Developing-world rural tariffs are often heavily subsidized and send the wrong price signals. While we recognize the need for rural subsidies in some cases, the tariff design needs to reflect both the actual cost and quality of service. Multi-level or stepped tariff designs are particularly important when 24 hour, AC service with renewable hybrids is subsidized. Lesson: Design the tariff to the cost and quality of service.

Development Coordination. Most countries have significant rural development programs which including education, health, communications, economic development, agriculture, water, and electricity. The links among these programs and the supporting agencies are potentially substantial, but are currently not exploited. Lesson: Work at developing/leveraging linkages; think about an integrated village concept.

Delivery. There are a variety of institutions that provide rural electricity. It is important to consider the local (energy) infrastructure when determining the appropriate delivery mechanism. However, in many cases innovative modifications need to be made to incorporate renewables and their idiosyncracies. Lesson: Consider the options, including enlightening/enhancing the existing energy delivery approach.

Planning tools. Rural electrification planning methodologies and policies generally do not integrate and evaluate renewable energy solutions fairly. While pilot projects often do not need to be formally evaluated up front by the planning agencies, there needs to be a parallel effort to modify the evaluation methodology to fairly accommodate renewable energy solutions. Lesson: Adapt the rural energy planning methodology to accommodate renewables.

Economics. Because rural electrification generally consists of line extension or diesel mini-grids, the concept of life-cycle cost analysis, which fairly compares capital intensive and annual-expense intensive technologies, is uncommon. Lesson: The concept of annualized costing needs to be integrated in the training of the evaluation/planning officials.

Quality of service. Electric lighting provides better light than that from kerosene; 24 hour electrical service is preferred to 4-6 hour service; reliable, available electricity is more valued than an unreliable supply. These differences in quality of service should be reflected in comparing alternative solutions. Lesson: Stress the value of quality of service.

Subsidies. While the debate rages on regarding the need for subsidies for rural electricity, it is generally agreed that flat subsidies distort economic comparison of rural solutions and send the wrong signals to the users. Lesson: Tariff designs need thought and experimentation.

Language. Many expectations have not been met because of misunderstanding resulting from language differences, rather than nonperformance. Lesson: Take care in communicating agreements and expectations; better yet, learn the language of your partner.

PILOT PROJECT CHARACTERISTICS:

These lessons pertain to the pilot projects themselves.

Performance. First and foremost, the project must perform well technically. To this end, extra care and expense should be devoted to the design, construction, commissioning, robustness, and reliability of the pilot system. Lesson: Technical rigor is a sound investment.

Replication mind set. The pilot project needs to be designed technically and conceptually, with the commercial replication path in mind. Pilot projects that cannot be replicated in the region commercially serve only as technology demonstrations with little value to the existing electrification program. Lesson: Ask the question, if the pilot project is successful, what s the likelihood that the commercial solution will follow?

One-of-a-kind. Single projects in remote locations are nonsustainable. While it is tempting from a budgetary perspective to do single projects, they are operation and maintenance (O&M) killers. Multiple systems in a region are required to develop the necessary support infrastructure. Lesson: Do not attempt single regional projects, unless there is assurance of a follow-up, replication program in the region.

Proven technology. Pilot projects need to deploy proven components, systems, and control strategies. Innovative or non-proven components need rigorous testing before being deployed in a pilot project. Lesson: Better to fail in the lab than in the field; avoid the rush to demonstrate improved, untested technology in the field.

Loads. Estimation of electric loads for newly electrified villages is difficult, often resulting in over-design, wasted energy, and poor economics. Integrating deferrable and discretionary loads helps system economics, but is difficult in practice. Lesson: More experience in load growth, load management, and tariff impacts is needed to improve economic designs.

Diesel retrofits. It is often more economical (from a life-cycle cost perspective) to install a new, appropriately sized diesel than to incorporate the existing, oversized, poorly maintained one. Lesson: Local authorities and RE equipment suppliers resist scrapping the existing diesel because the new diesel reduces the capital available for the non-conventional equipment.

Performance monitoring. Pilot projects, unlike commercial projects, are explicitly intended, based on their performance, to lead to larger scale replication. To this end, they need to be instrumented to confirm energy and operational performance. They also need to be evaluated for institutional response and effectiveness. The results of these evaluations need to be communicated to both the local and international development communities so that technical and nontechnical lessons can be adapted in the replication process. Lesson: Monitor, evaluate, and communicate the results.

Buy-down. Because pilots generally introduce new technical solutions to regional authorities, it is often necessary to cost-share the initial project. However, it is important to require significant cost-sharing by the implementing/operating organization in order to capture management attention. Lesson: Be prepared to cost-share; avoid donating entire system.

Multiple projects. As described in the institutional lessons, it is better to fund multiple, smaller projects than one large project with the same funding. Lesson: Single projects are not sustainable.

IMPLEMENTATION PROCESS

These lessons relate to implementation of renewable energy technology into the rural electrification process.

Political will. The most important factor for successful implementation is a supportive, positive attitude by the rural electrification officials. The existence of a champion for renewables for rural services who is in a position of authority keeps up the momentum during the extended process of resource assessment, site selection, project design implementation, evaluation and replication. Lesson: Focus pilot projects in an area where there is local support/interest.

Duration. The time from initial interest in renewables to commercial replication takes 4-6 years, in a positive climate. The pilot phase usually takes 2-3 years from site selection through initial evaluation. Lesson: Be prepared to commit to providing technical assistance for the duration of the process.

Commercial replication. The transition from the pilot phase to commercial replication can be difficult. The transition is greatly aided by a well-funded pilot phase that includes multiple, regional projects; local capacity building; and substantial technical assistance. Lesson: Avoid skimping on the pilot phase effort if commercial replication is the goal (and if it is not, question the need for a pilot program).

Solution basis. Renewable energy solutions to rural electrification should be resource and need driven, rather than based on a specific technology/application. The available renewable resources, the village electrical demand interests, villagers willingness and ability to pay for electrical service, and the economics of alternatives should determine the appropriate solutions. Lesson: Be objective and neutral in evaluating and presenting options; let the locals participate, and select, the appropriate solutions.

Administration. In order to sustain a newly implemented rural electricity system, an administrative system needs to be developed and sustained. Many rural villages have formed cooperatives for fishing, agriculture, and other economic development activities. The specific electricity administrative solution will be regional or village dependent or both. While a number of models have been successful, care is needed in matching the administrative system to the village social dynamics. Lesson: Administrative system/procedures need to match local circumstances.

OPERATIONAL ISSUES

Successful operation of the pilot projects requires attention to administrative and system operational details that are new to unelectrified communities; these lessons are not new (or unique to renewables) to those who have been electrifying rural communities (e.g., National Rural Electric Cooperative Association).

> Meters. Village mini-grids require electric meters that are the basis for revenue collections. A number of prepayment meters, both kWh and fixed fee-based, have been developed for rural applications. Lesson: Not metering leads to uncontrolled demand growth and electricity use inequities.
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> Energy efficiency. Energy efficient end-use applications/appliances are critical to economically sized renewable energy systems. Investment analysis has shown that investments in energy efficiency have much more economic value than adding generation capacity to meet the demand of inefficient appliances. Lesson: Require demand side efficiency and load management.
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> Maintenance. Because nothing is maintenance free, a maintenance system needs to be established; the system needs to include clearly defined responsibilities, procedures, and capabilities. Because the technology is new to the community, and often to the operator, extensive training and nurturing is required in the pilot phase. Lesson: Don t underestimate the efforts required to develop and support a maintenance program.

TECHNOLOGY AND DEVELOPMENTAL NEEDS

While it is essential to deploy only commercial technology in pilot projects, it is fair to say that there are opportunities for technological improvement in components, systems, ancillary equipment, and supporting processes.

> Hybrid systems. While wind, PV, and micro-hydro have been commercial technologies for a number of years, their hybridization with fossil fuel gensets for rural applications are an emerging (not developing) technology. RE-fossil hybrids have their roots in telecommunications applications in remote sites; however, the extremely high-value electricity for telecommunication applications has resulted in expensive, extreme reliability designs that are inappropriate for rural electricity service. Furthermore, the village hybrid market is infinitesimal at this stage, and thus, the design, manufacturing, integration, implementation, and distribution segments of the industry are very sparse and immature. This results in high prices, costly implementation and support, and evolving designs. Hybrid systems are a potentially significant solution to rural AC electricity needs. Lesson: Typical of emerging technologies/markets, design and industry structure will continue to evolve, the speed of which will be determined by growth in demand and technology development funding.
>
> Controls. Electronic controls and converters are the least robust component in the reliability/robustness chain. While there have been significant improvements in the quality and functionality of these components over the last five years, they remain the chief cause of system problems. Complicating the issue is the lack of maintenance support capacity for these components in rural areas. Lesson: Robustness and modular electronics need to be the focus of controls development; additionally, spare parts and electronic service capacity need to be part of the pilot program.

Lightning/corrosion. Many developing countries rural applications are exposed to severe corrosion and electrical storm conditions. While much is known about lightning and corrosion protection of electrical components, in many cases conventional solutions for high value, electrical systems are not cost effective or appropriate for rural systems. Lesson: Cost-effective application engineering is required for corrosive and electrical storm sensitive environments.

Meters. As noted previously, prepayment meters will greatly increase the sustainability of mini-grid systems. While several prepayment meter designs are commercial, they need to be less expensive in order to receive serious international attention. Lesson: Low-cost prepayment meters need development.

Resource data. Wind resource data for rural areas are either nonexistent or of marginal quality, yet are important for comparing wind-based systems to other options. Wind mapping, using various existing meteorological and geographic databases and customized computer models have enhanced the ability to evaluate wind as an option. Existing solar databases are sufficient for estimating PV as an option. There is an increasing use of GIS-based census and demographic data in the developing world for grid extension planning. Lesson: There is an opportunity to combine resource mapping and GIS-based rural planning models for determining the opportunity and the best locations for renewable village electrification.

Integrators/packaged systems. Because the market for rural renewables is just emerging, the role of system integration is underdeveloped. There are a number of component and system suppliers, but the function of system integration (comparing and packaging alternative architectures and solutions) is very limited, especially as an in-country capability. Lesson: While integrated, packaged systems have certain commercial and functional benefits, they (and their supply) are premature; therefore, the market will need to develop further to attract/enhance the role of systems integrators.

SUMMARY

Renewable energy solutions for village power applications can be economical, functional, and sustainable. Pilot projects are an appropriate step in the development of a commercially viable market for renewable rural solutions. Moreover, there are a significant number of rural electrification projects underway which employ various technologies, delivery mechanics, and financing arrangements. These projects, if properly evaluated, communicated, and their lessons incorporated in future projects and programs, can lead the way to a future that includes a robust opportunity for cost-effective, renewable-based village power systems.