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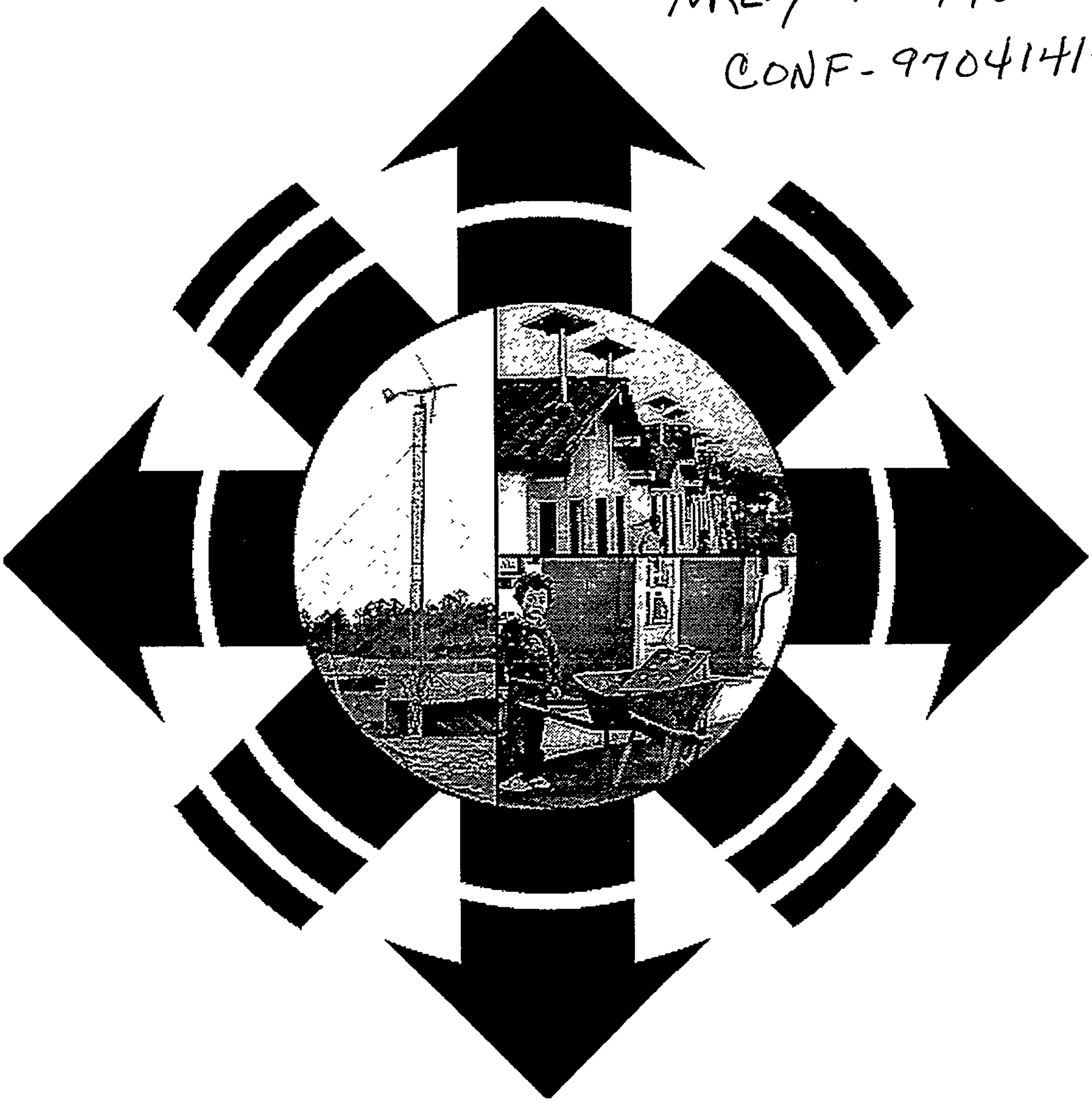

Proceedings of
Village Power '97

April 14-15, 1997
Arlington, Virginia

NREL's Village Power Program Synopsis

It is estimated that two billion people live without electricity and its services. In addition, there is a sizable number of rural villages that have limited electrical service, with either part-day operation by diesel gen-sets or partial electrification (local school or community center and several nearby houses). For many villages connected to the grid, power is often sporadically available and of poor quality. The U.S. National Renewable Energy Laboratory (NREL) in Golden, Colorado, has initiated a program to address these potential electricity opportunities in rural villages through the application of renewable energy (RE) technologies. The objective of this program is to develop and implement applications that demonstrate the technical performance, economic competitiveness, operational viability, and environmental benefits of renewable rural electric solutions, compared to the conventional options of line extension and isolated diesel mini-grids. These four attributes foster sustainability; therefore, the program is entitled Renewables for Sustainable Village Power (RSVP). The RSVP program is a multi-disciplinary, multi-technology, multi-application program composed of six key activities, including village application development, computer model development, systems analysis, pilot project development, technical assistance, and an Internet-based village power project database. The current program emphasizes wind, photovoltaics (PV), and their hybrids with diesel gen-sets. NREL's RSVP team is currently involved in rural electricity projects in thirteen countries, with U.S., foreign, and internationally based agencies and institutions. The integration of the technology developments, institutional experience, and the financial solutions for the implementation of renewables in the main line rural electrification processes in both the developing world and remote regions of the developed world is our goal.

For more information on RSVP, please visit our Web site

www.nrel.gov/business/international/rsvp

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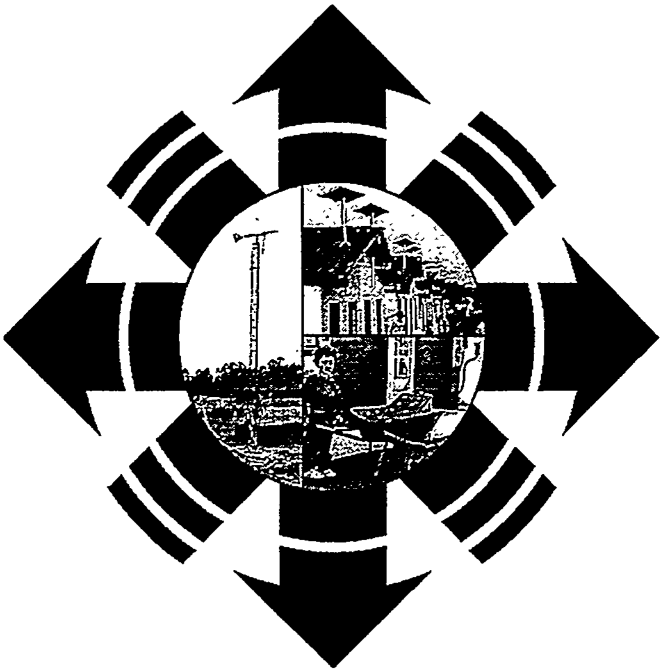

Village Power '97

April 14-15, 1997
The Ellipse Conference Center at Ballston
Arlington, Virginia

Organized by
National Renewable Energy Laboratory

Hosted by
National Rural Electric Cooperative Association

Sponsored by
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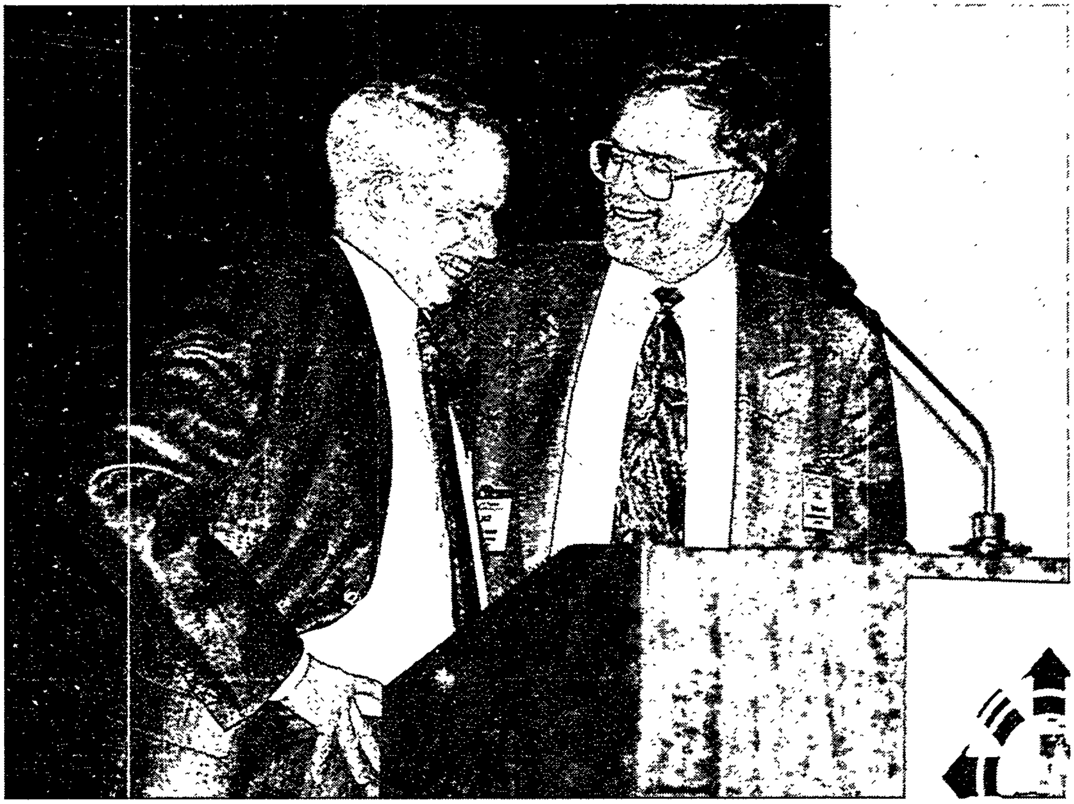
Village Power Road Warrior Award
Robert H. "Bud" Annan

Bud Annan has had a long and distinguished career with the U. S. Department of Energy and its predecessor, the Energy Research and Development Administration. He began his DOE/ERDA career in September 1975 after a fifteen-year association with the U.S. Navy. His responsibilities have included Staff Assistant to Vice Admiral H. G. Rickover, Director of the Division of Photovoltaic Technologies, Director of the Office of Solar Energy Conversion, and Special Assistant to the Secretary of Energy. He was recognized with the Secretary's Award with a Medal "for performance, leadership and management which has advanced the deployment of renewable technology in the business and policy interest of the U.S."

In each of his positions, Bud has worked to advance U.S. renewable energy technologies and business interests by maintaining a focus on sustainability that was closely tied to U.S. environmental policy. He was the first DOE solar technology manager to fully understand that for an industry to thrive, all elements of the industry must be in place. This is vitally important as renewable energy companies make the transition from R&D and demonstration to commercial sales and production.

Bud has also been instrumental in nurturing creative, collaborative partnerships with domestic and international organizations to leverage existing resources and to increase the investment in renewable energy worldwide. Following his attendance at the U.N. Conference on Environment and Development (the "Rio Summit") in 1992, he devoted his energies to focusing the technology's acceptance in the international arena. As a member of the Secretary's Missions, he established collaborative programs in Brazil, India, China, South Africa, Mexico, and Central America. Much of his efforts were in support of village electrification to bring the benefits of electricity to the world's masses. In 1984 he designed and set up the Committee on Renewable Energy Commerce and Trade (CORECT). He has cooperated with the World Bank, USAID, USTDA, OPIC, Eximbank, and others to put in place small renewable energy projects in emerging and developing nations leading to GEF loans and grants. He was also a prime mover in the creation and support of the FINESSE program in the Asia Technical Department at the World Bank.

Because of Bud's extraordinary vision and commitment, and his strong support of the NREL Village Power program and of related initiatives in the village power arena, he has been chosen for the first NREL *Village Power Road Warrior Award*. In between mountain bike trips and marathons, Bud continues to work in the international arena following his "retirement" from public service. We are honored to have him as a leader in the renewable energy and village power community.



Bud Annan (left) being awarded first *Village Power Road Warrior Award* by NREL Deputy Director, Bill Marshall (right).

Village Power "Road Warrior" Award

Renewables for Sustainable Village Power

Bud Annan

for his extraordinary vision, creativity, leadership, dedication, and determination in the promotion of renewable energy for international applications

April 14, 1997

Bill Marshall, Deputy Director
National Renewable Energy Laboratory

Date

Realities of Sustainable Development

Remarks by Robert Annan
Village Power Workshop
April 14-15, 1997

Most Sundays when I go to church there is plenty of room, making it easy to find a seat. But, Easter Sunday is different. Usually the priest has to plead for us to sit closer together in order to make room for the hordes of visitors. So, this past Easter Sunday, while in the process of squeezing together to make more room, I thought the world must be having the same problem: there is only so much space and with the population growing at 100 million each year, we must do what it takes to make room. This issue of exploding populations and its impact on our resources is just one of the many indicators that tells us we are living in a time of immense change.

Countries around the world are in the midst of a historic transition to an inclusive democracy and a vibrant, free market economy. Economic and social development in the growing economies are dependent on an adequate energy supply. Over the past twenty years, 1.3 billion people have gained access to electricity. Policy reforms leading to a stable macroeconomic environment, predictable and transparent standards for competitive investment, regulatory reforms, and transformed financial markets are driving this change. Urban wealthy households are the beneficiaries. American firms, assisted by government programs, are actively involved in these market opportunities, creating jobs here and in the host countries.

There are another 1.3 billion people that remain unserved and will continue to be unserved because they live in rural dispersed areas, and grid extension is too difficult and too expensive. Most of these citizens are economically poor by any standard. Their households are denied basic services of lighting and refrigeration. Inadequate energy supplies contribute to contaminated drinking water, spoiled vaccines, and backward communication and education capabilities. Without energy, there are declines in agricultural production, higher infant morality and low levels of worker productivity. If the democratic transition is to be successful, these citizens must be brought into the economic mainstream.

It starts with energy supply. New energy technology development, primarily in small scale renewables, is often the ideal solution. They are modular, reliable, use available in-country resources, and are cost competitive with grid extension, kerosene, and batteries. Finally, they have significant environmental advantages relative to fossil fuels.

The U.S. renewable energy industry, our national laboratories, universities, and the non-governmental sector have formed a partnership with the U.S. Department of Energy to create rural development opportunities using renewable energy.

The U.S. Department of Energy, using the authority of the 1992 Energy Policy Act, establishes long term bilateral agreements with Native American tribes and designated countries to promote sustainable rural energy policies. It follows-up this policy dialogue by tasking the National Renewable Energy Laboratory (NREL), Golden, Colorado, the nation's premier renewable energy research institution, together with Sandia National Laboratory, New Mexico, to work with American industry, non-governmental organizations, and universities to design and build projects. This partnership has helped to reduce risks of new energy technologies, validate their technical and economic value, and identify the best in-country institutional framework to develop finance, implement and maintain a rural energy infrastructure.

The National Rural Electric Cooperative Association exemplifies the non-governmental effort in building technical and policy capacity. Policy research introduces decisions makers in developing economies to a full range of sustainability issues, enhancing their understanding of the cross-sectoral linkages between energy, development and the environment, and providing them with specific tools to integrate these understandings into their decision making. By providing technical, analytical, and planning assistance to governments and major institutions, non-governmental organizations are helping shape government rural development policies.

The U.S. renewable energy industry leads the world in technology and sales. Seventy percent of its product is exported. Recently, the firms have teamed with U.S. utilities and independent power producers to expand their operations. These firms originate and close their own ventures and business arrangements. They champion their own technologies. They stand behind their products through warranties, maintenance, and inventory. They take equity risk, share in the project costs and take prudent market risks. However, unlike the entrenched energy industries, this new industry finds it hard to achieve economies of manufacturing and cost effectiveness because of perceived technical and project risks. Most of the firms are unknown internationally, making marketing energy for rural development time consuming and very expensive.

Following the 1992 United Nations Conference on Environment and Development, UNCED, the United States team launched an aggressive program of renewable energy based rural development projects. Currently, there are ongoing projects in the Navajo Nation, Brazil, India, China, Mexico, South Africa and Central and South America. These projects, costing a total of $25 million, or $5 million a year, have featured small hardware demonstrations – fully cost shared at a 50-50 level. Significant attention has been placed in building in-country infrastructure and introducing U.S. firms. With good project design, hands on project implementation coupled with policy assistance demonstrating technical, economic and institutional viability, the United States team has accelerated the acceptance of the technology and increased the sales of U.S. manufacturers. In many countries, national policies now include the promotion of renewables for rural development.

We have learned a great deal. We now know that to be successful, you must start with a good analysis of the problem and an assessment of all possible interventions. The resulting pilot projects test alternative models for institutional, technical and economic sustainability. We have learned that experience is cumulative and that each project, successful or not, adds to our data on best practices. It is important that we do not lose this corporate memory because it is the key to accelerating our sustainability objectives.

We are a laboratory without walls. But we need to be more organized in our information and the presentation of that information. This meeting has grown from just a few individuals sitting around a table telling stories of projects to almost 200 people, and we are still telling stories. We should change our objective and focus on the 2002 UNCED Conference. We should seek to be the UNCED success story. We must turn projects into viable programs. To do this, we should strive to double the participation at this workshop. We should plan for broader involvement by governments, non-governmental organizations, and multilateral and bilateral financing institutions. We should target private investment. This calls for a different kind of meeting. It needs to be structured around a template. We need fewer stories and more information on economics and institutional successes.

We should get started now. I recommend that NREL serve as a village and rural development secretariat and work with project sponsors around the world to gather information, fill in the gaps and formalize an agenda so that we all become informed and energized.

The pursuit of sustainable development requires a partnership between all sectors. The urgency of the environmental issue requires leadership. This workshop demonstrates that it has the critical elements of that leadership. The introduction of renewables will be a long-term process with larger numbers of economic applications developing rapidly. What is required is a sustained commitment. The investment is small and the payoff of a cleaner environment, jobs, and a more secure world, enormous.

National Renewable Energy Laboratory

Key Activities

- Pilot project development and support
- Resource assessment/mapping
- Options analysis prefeasibility
- Applications development
- Systems testing
- Bid specifications development and review
- Training
- Village power data base and internet discussion forum

SQP4-132605

National Renewable Energy Laboratory

International Activities by Country

	Applications			Current Activity			
Country	Remote	W/D	Grid	Resource Assessment	Pilot Program	Analysis	Training
Brazil	✔	✔		✔	✔	✔	✔
Chile	✔			✔	✔	✔	✔
Argentina	✔	✔		✔	✔	✔	✔
Mexico	✔	✔		✔	✔	✔	✔
Dominican Republic	✔			✔	✔		✔
China	✔	✔	✔	✔	✔	✔	✔
India	✔				✔		✔
Bangledesh	✔	✔			✔	✔	
Thailand	✔			✔			
Indonesia	✔	✔		✔	✔	✔	✔
Philippines	✔	✔		✔		✔	✔
Russia	✔	✔			✔	✔	✔
South Africa	✔						✔
Ghana	✔						✔

✔ Current activity

SQP4-1326013

Rural Energy And Development

by

Richard Stern

Industry and Energy Department

The Challenge

- Over 2 billion people are without access to electricity.
- Over 2 billion people rely on biomass fuels and often use them inefficiently in ways that are not sustainable.
- Modern energy (including renewables and modern use of biomass energy) is a necessary condition for rural development.
- Despite innovative rural delivery mechanisms, 3 billion people in developing countries will not have access by 2030.

Meeting the Challenge

- The Bank and many others have worked on these issues for many years.
- There have been mistakes, wrong paths, missed chances. But there have been successes too.
- Further progress currently depends on major new policy and institutional innovations at the country level

Rural Electricity: The Un-served Will Pay

Rural people will pay around 3-5 times more per kWh for off-grid supplies than do on-grid consumers.

- They want the light and power.
- They'll pay a lot for it - often enough to cover (much of) the supply cost.
- What they can't afford are the high first costs of connection and wiring, etc.

Broadening the Scope of Energy Operations

What the Board approved in 1992:

Bank
Commitment lending
Promotion of clean technologies

Countries
Sector reform

- Transparent regulation
- Commercialization/corporatization
- Private involvement
- Importation of services
- Market pricing
- Demand management

Added dimensions - a renewed commitment to

- Extend modern energy supplies to unserved populations
- Promote sustainable supply and use of biofuels
- Introduce new and renewable energy technologies

by

- Promoting commercial pricing and private involvement in distribution
- Providing incentives for extension of service
- Supporting agroforestry and biofuel programs
- Encouraging local initiative and open markets

Emerging Principles and Strategies

- Promote wide variety of energy choices.
- Reduce subsidies and distorting tariffs.
- Lower first costs of energy services.
- Provide innovative credit and financing.
- Encourage diversity of investors and investments.
- Emphasize local participation and institutional development.
- Governments address market failures, assure level playing field and provide technical assistance.

Role of Public Policy and Governments

- Breaking the state monopoly
- Ensuring a neutral import regime for electricity supply
- Developing and promoting low cost design standards
- Developing support systems for microgrids (TA, training and support services)
- Promote market based tariffs (i.e. no universal pricing)
- Develop highly targetted lifeline pricing
- Pilot new delivery mechanisms and support services

Biofuels: Paths to More Sustainable Use

Increase resources

- Transfer forest "control" to local people
  - *management, use rights, revenues*

Reduce Consumption

- Improve energy efficiency (stoves, charcoal making).
- Facilitate move to modern fuels. What most users really want.

Rural Electricity: Many Routes to Explore

- Public sector grid extension.
- Private Sector grid extension.
- Community mini-grids (diesel, renewables, hybrids; many patterns of ownership, management, financing).
- Single household systems (e.g., Solar PV)

Collaboration is Necessary

- **NGOs/Communities:** Develop local intiative and capability.
- **Governments:** Allow markets to work and provide TA, information, and support.
- **Investors and Industry:** Focus on innovative delivery solutions for affordable energy.
- **Financiers:** Provide innovative financing solutions for rural energy supply and demand.
- **World Bank and Donors**: Support innovative experiments, but focus on the need for policy and institutional reforms.

VILLAGE APPLICATIONS

R.238
V-755

PHOTOVOLTAIC GENERATING SYSTEMS IN RURAL SCHOOLS IN NEUQUEN PROVINCE, ARGENTINA

by

Thomas A. Lawand
Jon Campbell

Presented at

VILLAGE POWER '97
14,15 April 1997

Sponsored by

U.S. National Renewable Energy Laboratory
Golden, Colorado

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Faculty of Engineering
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Québec, Canada H9X 3V9

PHOTOVOLTAIC GENERATING SYSTEMS IN RURAL SCHOOLS IN NEUQUEN PROVINCE, ARGENTINA

PREFACE

The Dirección de Nuevas Fuentes de Energía of the Ente Provincial de Energía del Neuquén (DNFE/EPEN) has been given the responsibility of assisting the Consejo d'Educacion of the Province of Neuquen in providing electricity to rural schools located in remote regions of the Province. The Brace Research Institute (BRI), Faculty of Engineering, McGill University, has collaborated with EPEN since 1991 to help train their professional personnel with respect to the use of renewable energy systems in meeting the energy requirements of these rural schools.

Efforts were concentrated on photovoltaic (PV) electrical generating systems installed at small schools installed in remote regions of Neuquén Province, Argentina.

Project objectives included:

- training of EPEN personnel in the assessment, design and selection of appropriate renewable energy systems for the school energy needs;
- developing a systematic survey questionnaire for assessing the energy needs and resources at any particular school;
- developing strategies to help train students, teachers and caretakers regarding the technical details of the renewable energy systems;
- developing a usage and maintenance manual to help school staff understand the operations of the renewable energy systems so as to enable them to carry out the proper usage and maintenance procedures;
- establishing links with the Canadian renewable energy industry through the demonstration of some equipment at specific schools.

Amongst the outputs of this Report, are three documents which have been prepared to enhance the above activities. These are:

- A Basic Questionnaire for the Provision of Electricity in Rural Schools
- A Manual for the Use and Maintenance of a Photovoltaic Electrical Generating System
- A Manual to accompany an educational photovoltaics kit.

Brace Research Institute
V-755 (stats.doc)

April 1997

PHOTOVOLTAIC GENERATING SYSTEMS INSTALLED IN THE NEUQUEN SCHOOLS

During the period 1994-95, solar photovoltaic systems were installed at a number of schools in Neuquen Province, Argentina, by the Provincial electric utility, Ente Provincial de Energia del Neuquen. This was undertaken with funds provided by the Inter-American Development Bank. In all, there are 12 schools that have had photovoltaic generating systems installed.

These generating systems are designed to provide electricity for the basic needs at the schools: primarily for lighting, and to operate small electrical appliances such as communication radios, televisions, VCR's, AM/FM and short-wave radios. They do not provide enough energy to operate large consumption appliances such as washing machines, microwaves, refrigerators, power tools, etc.

The other basic energy needs at the school are the provision of energy for:

- cooking meals for the teachers and students;
- heating during the winter months (most of the schools are located at a relatively high altitude -- the average latitude of the Province is 39 deg South);
- hot water for the lavatories and the kitchen;
- fuel to operate the fossil fuel powered generator which serves as a backup to the renewable energy system.

The program of provision of P.V. systems was supplemented with training on simple systems for cooking food or drying fruit, etc. These techniques are primarily intended for demonstration at the schools thus serving an educational role with the hope that they will be transmitted in time to the families of the students where the need is manifested the most.

An example of the equipment of the P.V. system installed at the school at Colipilli Abajo, which is typical of the systems used in the program, is listed below:

PHOTOVOLTAIC GENERATING SYSTEMS IN RURAL SCHOOLS IN NEUQUEN PROVINCE, ARGENTINA

- 16: ground mounted, SOLARTEC, M40 photovoltaic panels with the following technical characteristics:

  - Nominal Power Output:: 42W
  - Current (typical load): 2.75A
  - Voltage (typical load) 15.3V
  - Short Circuit Current 3.15A
  - Open Circuit Voltage 19.8V
  - Angle of Inclination 55°

- 12: FADEPLAC, S10, medium to high discharge batteries with the following technical characteristics:

  - Battery Voltage 2V (batteries are connected in series)
  - Nominal Capacity (10 Hour Charging rate) 470 Ah
  - Useful Life (floating) 12 years
  - Useful Life (cyclical) 50% Depth of Discharge: 1200 cycles; 20% Depth of Discharge: 2500 cycles

Internal Resistance 0.4 mΩ

Note that the batteries are installed in an Styrofoam-insulated, steel box located outside the building.

The following is a brief description of the twelve PV systems installed in Neuquen Province ---the name of each school is listed in bold followed by the number of the school .

PHOTOVOLTAIC GENERATING SYSTEMS IN RURAL SCHOOLS IN NEUQUEN PROVINCE, ARGENTINA

- **Pichi Neuquén**, school number # 236
    - Rated Power of Panels (Watts): 420
    - Rated Capacity of Battery Bank (Amp-hours): 344
    - Nominal System Voltage (Volts):24
- **Butalon Norte**, #256
    - Rated Power of Panels (Watts): 672
    - Rated Capacity of Battery Bank (Amp-hours): 600
    - Nominal System Voltage (Volts): 24
- **Las Chacayes**, #207
    - Rated Power of Panels (Watts): 420
    - Rated Capacity of Battery Bank (Amp-hours):455
    - Nominal System Voltage (Volts): 24
- **Colipilli Abajo**, #302
    - Rated Power of Panels (Watts): 672
    - Rated Capacity of Battery Bank (Amp-hours): 65
    - Nominal System Voltage (Volts): 24
- **Trahuncura**, #6
    - Rated Power of Panels (Watts): 588
    - Rated Capacity of Battery Bank (Amp-hours): 400
    - Nominal System Voltage (Volts): 24
- **Paso de Los Indios**, #230
    - Rated Power of Panels (Watts): 672
    - Rated Capacity of Battery Bank (Amp-hours): 464
    - Nominal System Voltage (Volts): 24
- **Bardas Negras**, #215
    - Rated Power of Panels (Watts): 588
    - Rated Capacity of Battery Bank (Amp-hours): 400
    - Nominal System Voltage (Volts): 24

- **Laguna Miranda**, #218
    - Rated Power of Panels (Watts): 672
    - Rated Capacity of Battery Bank (Amp-hours): 368
    - Nominal System Voltage (Volts): 24
- **Currimil Quillen**, #85
    - Rated Power of Panels (Watts): 504
    - Rated Capacity of Battery Bank (Amp-hours): 304
    - Nominal System Voltage (Volts): 24
- **Costa del Malleo**, #139
    - Rated Power of Panels (Watts): 588
    - Rated Capacity of Battery Bank (Amp-hours): 448
    - Nominal System Voltage (Volts): 24
- **Nahuel Mapi**, #306
    - Rated Power of Panels (Watts): 408
    - Rated Capacity of Battery Bank (Amp-hours): 660
    - Nominal System Voltage (Volts): 12
- **Carrán Cura**, #84
    - Rated Power of Panels (Watts): 408
    - Rated Capacity of Battery Bank (Amp-hours): 770
    - Nominal System Voltage (Volts): 12

GENERAL CONDITIONS AT THE RURAL SCHOOLS IN THE PROVINCE OF NEUQUÉN

This section provides a general picture of the energy and operational situation at rural schools in the Province of Neuquén. The particular situation at each of the schools varies from one location to the next., however, they all have similarities.
The situations at each of the schools can be divided into two groups:

(1) the **technical systems** at the schools, (i.e. energy, water and sanitation systems)

(2) the **organizational routines** at the schools (i.e. delivery of supplies, maintenance, instruction of new teachers, etc.).

Technical Systems at the Schools

The energy, water, and sanitation systems that provide the necessary services of operation at the schools can be divided into various categories.

Electrical Generation Systems

Most of the 150 rural schools in the province of Neuquén have some level of electrification. Of the 113 schools for which information is available, 34 are grid connected, 57 have gas or diesel powered electrical generators, 13 have large photovoltaic generating systems, 1 has a wind powered electrical generator, and 8 have no electricity at all. In addition to the PV systems already mentioned, the large majority of rural schools have small photovoltaic electrical generating systems for powering radio communication equipment.

The schools that are grid connected generally do not have problems with their supply of electricity. Those systems are very reliable and also have the advantage of an established maintenance routine and other support mechanisms to keep them operational.

These problems with the gas and diesel powered generators were the primary motives which caused the Provincial Consejo d'Educacion and EPEN to explore other means of electrical generation for the schools, primarily the installation of photovoltaic systems. Of the 13 schools that have photovoltaic generating systems, only one of them has been in operation for a extended period of time. The school in La Matancilla has had a 1280 W (rated @ 1000 W/m^2 of Solar Radiation) photovoltaic system in operation since 1987. (This system was donated by the **Agencia Francesa para la Conservación de la Energía.)** That system has been operating effectively and reliably since its installation. The other systems have not been in use long enough to make statements about their effectiveness (only 3 years of continuous use). It is felt however, that the simple, robust P.V. systems, with no moving parts, will make them less troublesome, and the savings in fuel and personnel costs will justify the large initial investment, as long as they are properly used and maintained..

Cooking Systems

Every rural school in the province has some facilities for cooking. All the children in these schools receive a large midday meal, and in most schools, they receive either a light breakfast or late afternoon snack, depending on what time of the day they attend the school. Also, at nearly all of the rural schools, the teacher lives at the school, often with their family. Some sort of facilities must be available to accommodate them as well.

Nearly all of the rural schools have gas powered cookstoves to cook with. In addition, most of those same schools have wood cook stoves that are also used for making the students' meals. Large amounts of bread are baked at these schools and the wood stove is generally used for that purpose. However, occasionally the gas ovens are used as well, and some of the schools have adobe ovens outside that could also be used for baking bread.

Space Heating Systems

All of the rural schools in the province of Neuquén require space heating at certain times of the year. Even during the summer, night time temperatures at many schools often drop to 10°C and occasionally below freezing due to the altitude. During other times of the year, it is rare not to have snow and freezing temperatures, at least during the night.

The most common fuel used for space heating is wood. The wood cook stove provides significant amounts of heat. As well, there are usually smaller wood stoves distributed in other parts of the school that are used solely for heating. Gas heaters are occasionally used but this is expensive and subject to the problems of fuel delivery.

It is often the case that the space heating at the schools is inadequate. One factor that commonly contributes to this is the high ceilings in the older buildings. As a result, most of the useful heat is ineffective.

Water Supply, Distribution and Water Heating Systems

Every school has running water.. In some schools , there are gasoline powered pumps that draw water from a well or nearby stream. One school has a P.V. powered pump , and another has a windpowered pump.

The gravity fed water systems are generally the simplest and most trouble free because they do not have motorized pumps that require fuel or maintenance. However, the gravity systems are not always provided with a filter in the inlet of the water line and hence the pipe frequently becomes clogged with silt from the spring. All of the rural schools in the Province have a large storage tank, usually located on the roof of the school, and from these, water flows to the various inside locations such as the kitchen, bathrooms, showers, etc.

Most of the rural schools in the province have some sort of hot water heating system. These are generally gas or wood powered. The wood powered systems can be connected to the cook stove, or they can be a separate tank with its own fire box.

These hot water systems generally operate satisfactorily, without requiring significant amounts of maintenance. However, when maintenance is required, it often takes some time for repairs to be undertaken.

Communication Systems

Most of the rural schools in the province have battery powered, radio communication systems. The 12 VDC battery for the radio is charged by two photovoltaic panels. The panels are mounted, one above each other, on an antenna tower. These PV powered radio communication systems were installed several years ago by the Provincial Ministry of Communication and generally operate reliably, requiring little maintenance .

General Comments on the Technical Systems in the Rural Schools

As a general rule, the simpler the system is technically, the less effort it requires to keep it operational. For example, the photovoltaic powered radio communication systems, and the gravity fed water distribution systems generally are very reliable. These systems have no moving parts and they require no fuel to operate. In contrast, the use of complex systems such as diesel electric generators have significantly more problems and interruptions of service. Besides being disruptive to the operation of the school, these problems are also expensive and time consuming to correct.

It should also be noted that with all of the different systems described above, and all of the different fuel and maintenance requirements that are inherent in these systems, the amount of effort that is required to keep them operational is significant. This is where the organizational routines in the rural schools become important. The effectiveness of the technical equipment that is installed at a school is significantly dependent on the quality and thoroughness of the support mechanisms that aim to keep it operational.

ORGANIZATIONAL ROUTINES AT THE SCHOOLS

The following is a discussion of the organizational routines that generally exist, at least to some extent, in the rural schools of the province of Neuquén. These are the standard practices and activities by which the schools are operated. They include maintenance of equipment, provision of supplies - including fuel, instruction of new teachers in the particularities of their new situation, etc.

It should be noted that many of the routines in place in the schools appear to have been developed by the teachers rather than the Ministry of Education. In most cases, the teacher is responsible for all details related to the operation of the school. This is an enormous job for one person, and as a result it is not uncommon for the teacher to be generally unsatisfied, or unhappy with the conditions at the school. Teachers come largely from the urban sector of Argentina where all water, electricity, cooking and heating services are readily available. On arrival at the schools , they must undertake to manage and provide all these services , a task for which many are ill-prepared. This is in essence the crux of the problem and has to be recognized as such.

The implications that these routines may have on the new photovoltaic systems installed by EPEN are obvious. Hence , the human side of engineering must be taken into account at each stage of the Project.

Instruction of New Teachers

One of the very significant characteristics of the rural schools in the province of Neuquén is that the teachers at these schools change on a very regular basis - often every year. This has serious implications relating to the functioning of the systems installed at each school. When a teacher is placed in a new school by the Ministry of Education, there appears to be very little in the way of instruction as to how to manage the systems at that particular school. Every rural school in the province is different, in the systems that are employed, in the supplies that are required, in the climate in which it is located, in its distance to the nearest municipality, etc. This means that the routines at every school must also be distinct. It is therefore, necessary for a new teacher to learn these in order to continue the effective operation of the school. However, as there often appears to be little advice given by the Ministry of Education, and usually no interaction between the new and old teachers, it is apparent that the new teacher is generally responsible for their own familiarization with the school.

It is likely that the caretaker plays a significant role in this process of educating the teacher, since they do not change so often. The caretakers at the rural schools are local people and usually hold that position for many years. However, the caretakers are generally not instructed themselves in the use and operation of the equipment at the schools. It is likely that they know the best ways, and places, to purchase supplies and fuel, etc., but they may not understand the proper usage and maintenance procedures of a diesel electric generator for example, or of the new photovoltaic systems that have been installed.

This lack of formal instruction likely has significant, detrimental effects on the operation of the equipment at the school. It has for example, probably played a large role in the overall poor performance of the gas and diesel electric generators that have been installed in the province. In late 1996, a representative of the Consejo received some training at the Brace Research Institute in Canada and it is hoped that this and other methods described herein can contribute to an amelioration of the situation at the schools.

Provision of Supplies and Fuel

The only provision that is generally organized and supplied by the Ministry of Education is the wood that is burned at these rural schools. This is usually delivered in large trucks, once or twice per year, and is not something with which the teacher has to concern himself.

This provision of supplies for the schools is a constant process and by no means an easy one. Therefore, the more fuel that is consumed by the systems installed at a particular school, the more effort that is required on the part of the teacher to ensure that this supply does not run out. This is one large advantage of the photovoltaic generating systems over the gas and diesel powered electric generators.

Maintenance

The maintenance of the equipment at the rural schools is a major difficulty. The gas or diesel electric generators constitute a serious maintenance problem. Nearly all schools that have had gas or diesel electric generators installed have had significant troubles with this equipment at one time or another. Indeed many of these systems no longer operate at all.

It is not known for certain why the maintenance of these gas and diesel electric generators has proven to be so difficult. Certainly it is the nature of that type of equipment to require considerable maintenance - both in a preventative and a corrective nature. However, there are other points that indicate the problems may not lie only in the complicated technical nature of the equipment. The routine by which technical problems are addressed seems to be inadequate in some cases. Certainly there are many steps that must be carried out for repairs to be made: the proper authorities must be contacted; arrangements must be made to examine the faulty equipment and determine what the problem is; and then the necessary repairs must actually be carried out. This is the routine of corrective maintenance.

There is also a routine of preventative maintenance that can be carried out by the teacher or the caretaker. This involves the proper use and periodic inspection of the equipment. Complicated preventative maintenance by the teachers and porters is discouraged by EPEN however, at least in the case of the photovoltaic generating systems. It is felt that, since the teachers do not generally have sufficient training in making repairs to this equipment, it is best that they do not attempt beyond the most basic of operations, such as changing fuses and adding distilled water to the batteries. As well, there are concerns that teachers might injure themselves working with electrical connections and battery acid

It is not certain whether teachers have been discouraged from carrying out significant preventive maintenance of the other types of equipment as well. It appears fairly obvious however, that this preventative maintenance has not been carried out, whatever the reason may be. The result of this has been that small problems have often gone undetected and have been allowed to develop into larger ones. These larger problems have often lead to inoperative equipment, requiring that trained staff visit the schools to effect repairs, often traveling large distances.

There are several possibilities that exist as to the source of these problems. It could be that the teachers have not been instructed on how to properly use the equipment or that they have not been properly instructed on the necessary steps to take in the case of equipment malfunction. It is also possible that an adequate procedure has not been developed by which the proper authorities can effect the necessary repairs: poor communication between schools and the Ministry of Education, insufficient staff to carry out maintenance in rural schools, etc. There are many possible reasons for the difficulties experienced in maintaining the equipment at the rural schools in the province. More investigations would have to be undertaken to determine where exactly the problem lies. The important point is to be aware that problems do exist in this area of the schools' operation and avoid these same problems occurring with the photovoltaic systems.

Attitudes of the Teachers Towards the Equipment in their Schools

The attitudes that the teachers have towards the usage and maintenance of the equipment of these rural schools varies greatly from one person to the next. Some teachers appear to be happy about being there. They take an active and positive role in the operation of the school. Others seems to be unhappy about the difficult conditions that they are forced to live in and the huge amounts of responsibility that they are asked to deal with. The job of the teacher in these rural schools is not an easy one. Naturally, some people are better suited to it than others, and consequently are more happy with their own situations.

This difference in the disposition of the teachers, along with many other personal factors, must surely affect the attitude that each person has towards the proper usage and maintenance of the equipment in their school. Those that consider it more important for the systems at the school to run properly will likely be more concerned about treating the equipment correctly than those who do not consider it as important. That is simply a result of human nature that must be dealt with in the management of the systems of these rural schools.

Normal Tenure of the Teachers at the Rural Schools

As mentioned above, it is very common for the teachers at these rural schools to change frequently - often every year. This makes it much more difficult to ensure the proper functioning and maintenance of the equipment at these schools. For someone to take care of a system, like a diesel electric generator, they must be familiar with it. They must learn the "tricks" of how to operate it, and keep it running correctly. This process takes time, and if a person only spends eight months at a school (that is the length of a normal school year, including vacation time) then it will be difficult to properly familiarize themselves with complicated pieces of equipment.

Finally, it is very important that the teacher and the caretaker feel that they have a personal stake in the proper functioning of the PV system at the school. Without this, it will be very difficult ensure that they carry out the proper management of the equipment. This is one reason why it is so important to involve the caretaker in all activities. While the teacher may be somewhere else within a year, where they will not have to deal with a faulty PV system, the caretaker will still be working at the school and will have to live with any problems that may arise. That may give that person much more incentive to ensure that that system is properly taken care of.

STRATEGIES FOR ENSURING THE PROPER OPERATION OF EQUIPMENT IN THE RURAL SCHOOLS

Given the conditions in the rural schools of Neuquén, as generally described above, there are certain strategies that can help ensure that any electrical generating equipment that may be installed at a school, function properly and without excessive periods of inoperation.

UNDERTAKE A THOROUGH PRELIMINARY ANALYSIS OF EACH SCHOOL

Before any electrical generating system is installed at a rural school, a thorough analysis of the particular situation at that school must be carried out. Areas of investigation should include details concerning, among other things:

- the physical and geographical situation at the school,
- current uses of energy at the school
- energy requirements at the school,
- energy resources available at the school.

It is very important to keep the social aspects of each of these categories in mind as well. The feelings, habits, and customs, etc. of people will play heavily on the success or failure of any equipment which might be installed.

This preliminary step is crucial, and should be carried out in as much detail as possible. It is vital that any equipment installed at a school be the most appropriate means of satisfying that school's electrical needs. If it is not, problems are sure to arise and the equipment will likely prove ineffectual. A well designed questionnaire is a useful tool in carrying out this process. It provides a structured guide, that if well designed, will reduce the chance that some critical point be overlooked.

Questionnaires have been used in many areas of the world where it has been desired to install technical equipment to be used by initially untrained people. They can be designed to be filled out by local residents of a particular site, or by trained technical staff in conversation with local residents. Where possible, the later option is generally preferable. A person with sufficient technical knowledge is probably better able to gather the relevant information required. That is probably the case in the Neuquén schools, especially considering that teachers may not be completely familiar with the situations at the schools. It is however, very important that the teacher, porter, and other locals be involved in completing the questionnaire.

A questionnaire such as the one described above has been written for the Neuquén schools. It was designed to be used in Neuquén, but it would be possible to adapt it for use in other situations where the installation of electrical generating equipment was being considered.

PROVIDE DETAILED, INSTRUCTIVE LITERATURE TO ACCOMPANY INSTALLED EQUIPMENT

It is important that school staff understand the operation of an electrical generating system installed in their school. This helps to ensure that the equipment is properly used. A solid understanding of the operation of a system is also crucial in ensuring that a system is maintained. While in the Neuquén schools, the teachers are generally not capable of carrying out complicated repairs, they will be much better able to recognize abnormalities in the operation of the system if they understand the basics of how it functions. Noticing problems, and notifying the proper authorities before those problems become serious is an important aspect of keeping equipment operational.

In order to properly use an electrical generating system, monitor its operation, and carry out minimal maintenance, teachers and caretakers at these rural schools must understand how that system works. One practical method of instructing these people in the operation of the system is to supply them with a usage and maintenance manual. In the case of the Neuquén schools using P.V. systems, such a Manual has been prepared and distributed to all schools where these systems have been installed. It includes explanations detailing:

- the overall operation of the system,
- each of the components of the system,
- the daily use the system,
- the minimal preventative maintenance that is expected of the teachers and caretakers,
- how to spot possible problems before they become serious, and what actions to take in such cases.

Installing systems in schools is quite different from installing them in homes. The fact that teachers are often in the schools for relatively short periods of time and are not ultimately responsible for the equipment makes it difficult to ensure that the equipment will be properly cared for. In homes, where people do not move and are responsible for their own equipment, that task becomes easier. To train a person to operate and fully maintain a photovoltaic generating system requires a large amount of time. That time may be well spent if training is required only once. Training every new teacher however, in every school, about all of the details of the operation and maintenance of one of these systems would be an enormous task. As well, due to the transitory nature of the teachers, and due to the different attitudes of teachers towards the equipment at their schools, it could not be certain that every teacher would be willing to give the systems the proper care that they require. For these reasons, it is felt at EPEN that a better solution is to reduce to a minimum the amount of maintenance that is required of the teachers. This attitude is reflected in the Manual. The teachers are primarily responsible for the daily use of the equipment. Due to the simple nature of photovoltaic systems, this involves a minimum amount of effort on their behalf. The teachers are simply asked to recognize problems and report them, rather than effect the repairs themselves.

EMPLOY EDUCATIONAL AIDS AND DEMONSTRATION WORKSHOPS TO IMPROVE UNDERSTANDING OF THE SYSTEMS

There are other methods, besides the Usage and Maintenance Manual, that can be used to help explain the operation of an photovoltaic electrical generating system. One such method that has been employed in the Neuquén situation is an educational photovoltaics kit. A small Manual for the kits was written, explaining some basic solar energy and electrical principles. A pamphlet was included with the kits, but it was felt that there were points that could be expanded upon. As well, an AM/FM radio and a walkman were acquired as additional loads for the photovoltaic cells in the kits. It is hoped that this will make the kits more enjoyable for the school children, and help to better demonstrate some of the different applications for photovoltaics.

The idea behind these kits is that by playing with the small photovoltaic cells of the kits, children will gain a better understanding of the larger systems installed in their schools. They have been exposed to some of the basic ideas of solar energy and electricity. As well, in having to teach the children to properly use the kits, the teachers themselves also become more familiar with these ideas.

A second training method that is being used in Neuquén is to give demonstration workshops on various solar related technologies, including photovoltaics. EPEN has established a renewable energy technology demonstration centre at a boarding school in the capital city. This school is called the Albergue Nayahue. One of the main activities at this school is a program in which teachers and children from rural schools in the province come and spend a week at the school. During this week they are involved in many activities, but the primary aim of their stay is to gain some exposure to some of the aspects of city life, and to learn about various institutions such as the Legislature etc. As well, during this week, these children spend several hours at the renewable energy technology demonstration centre. Here they have explained to them such technologies as solar cookers and dryers, and photovoltaic systems for generating electricity and pumping water. Again, the idea of these demonstrations is to explain some basic ideas about solar energy, conservation, etc. to young people, and to gain exposure for renewable energy technologies.

Most of the children who attend the Albergue Nayahue do not have large photovoltaic generating systems at their schools, though many schools have the smaller PV radio communication systems. In this regard, this Centre is an effective manner of reaching a larger number of people. Besides these rural students, there are also many other groups that pass through the Albergue Nayahue and are given tours of the demonstration centre.

These are the two main educational strategies that are currently being employed in Neuquén. There are countless others, no doubt that could also be used to reinforce the understanding of the photovoltaics systems.

INVOLVE THE CARETAKER IN THE USE AND MAINTENANCE OF THE SYSTEMS

Due to the transitive nature of the teachers at the rural schools in the province, it is necessary to involve the caretakers in all aspects of the operation of the systems at a school. Caretakers seldom change at these schools and consequently, they are in a much better position to be familiar with the established systems and routines than are the teachers. Ensuring that the caretaker is well informed, and active in the proper use and maintenance of the photovoltaic system will help to create stability and continuity in its operation and reduce the amount of damage caused by inexperienced users.

As well, since the caretakers generally remain at schools for many years, are part of the communities in which the schools lie, and often have children of their own attending the schools, they may feel it more important to properly maintain and operate a system than does a teacher. This is another reason to ensure that the caretakers are involved in all aspects of instruction concerning the use of the equipment at a school. Note that some of the caretakers may not able to read. This makes it even more important to involve them in discussions between EPEN staff and the teachers as the Usage and Maintenance Manual may not be of help to them.

ESTABLISH A PROPER ROUTINE OF INSTRUCTION FOR NEW TEACHERS AT THE SCHOOLS

It is of the utmost importance that every time a new teacher arrives at a school with a photovoltaic electrical generating system, he/she be properly instructed in the use and maintenance of that system. This instruction should be given by someone from EPEN - though not necessarily someone from DNFE - who is familiar with the equipment and can explain exactly what the teacher is responsible for. One possible method of accomplishing this would be to establish a link between EPEN and the local Ministry of Education Office responsible for each of the schools with the PV systems. Through this link, EPEN can be made aware whenever there is a change of teachers. This will enable them to provide the necessary instruction.

This instruction should be given to the teacher in the presence of the caretaker who will presumably be familiar with the operation of the system and be able to offer valuable insights and advice. The instruction should be verbal, and should involve a hands-on explanation of each piece of equipment in the system and what its function is. It should also detail what steps should be taken in the day to day usage of the system and what steps should be taken with regard to the periodic maintenance and troubleshooting that the teacher and caretaker will be responsible for. Finally, the teacher should be given explicit instructions about who to contact in case of a system malfunction.

In addition to this verbal instruction, the teacher should be shown the manual that accompanies the PV system and have that explained to him/her. Other written and visual aids, such as the educational kit, could also be developed to help in this instruction process.

It is at this point that it can most easily be stressed to the teacher the importance of properly managing the PV system at the school. This may be the most effective time to ensure that the teacher takes some personal stake in that equipment.

INVOLVE THE NEAREST EPEN OFFICE IN THE MAINTENANCE OF THE SYSTEM

It is not realistic to expect the EPEN office in Neuquén City to be responsible for the maintenance of the all of the systems in the province. The distances are too large to make this feasible. Some schools, for example , are a long day's drive from Neuquén City. As well, if more systems are installed at a later point in time, it is likely that the job of maintaining all of them would be too large for the staff at EPEN, especially if they begin to investigate other novel areas of electrical generation. It is therefore important that the closest EPEN office to each of the schools with PV systems take an active role in the maintenance and instruction of teachers.

It is likely however, that the staff at each of these local EPEN offices will need to receive some instruction in the use and maintenance of the new systems, as photovoltaics are a relatively little known method of electrical generation in many areas. The simplest way to accomplish this would be to have someone from the local office spend a day at the school as the system was being installed. This would allow for that person to receive the same instruction that the teacher and caretaker do, and also to ask more technical questions that will enable them to carry out any maintenance that might arise. An in depth photovoltaics manual, more detailed than the one discussed above, should be given to these local EPEN offices to serve as an information resource. It is encouraging to note that EPEN and the Consejo are moving in this direction to decentralize maintenance on these P.V. Systems and to provide better training to the teachers and caretakers .

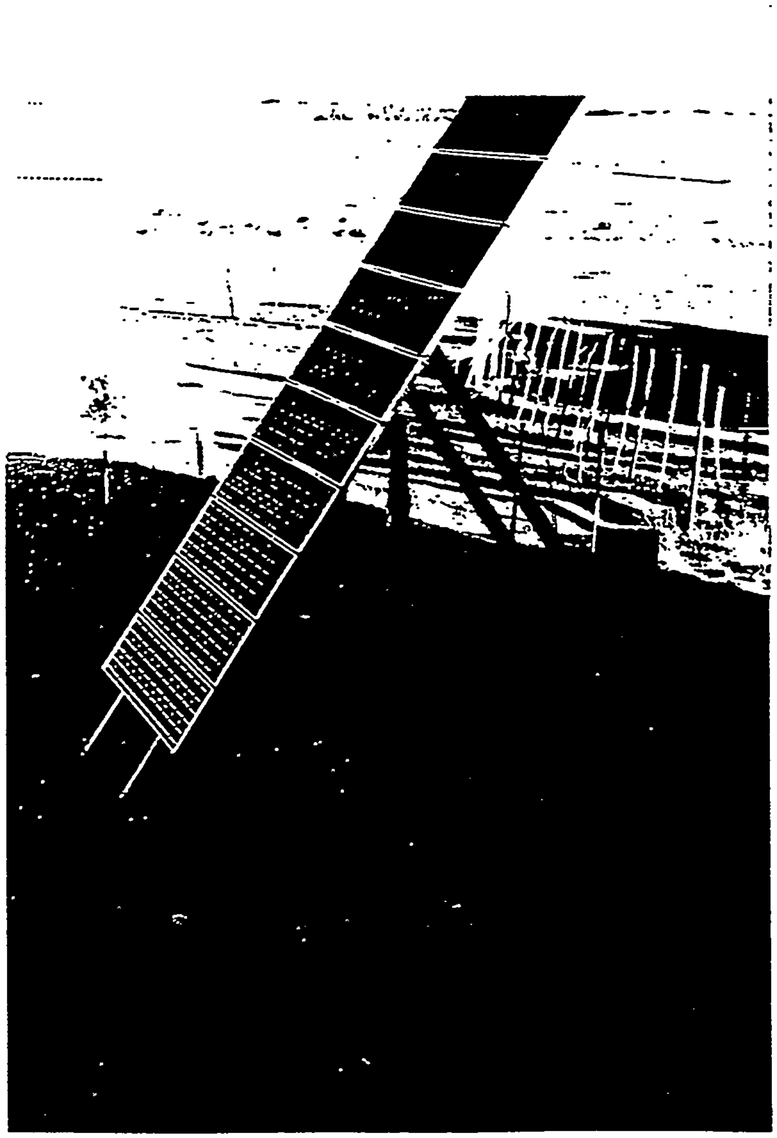
CONCLUSIONS

The following conclusions can be made concerning means for ensuring the proper operation of the photovoltaic generating systems. Note that many of these points could be applied to the other technical systems installed at the rural schools of the province.

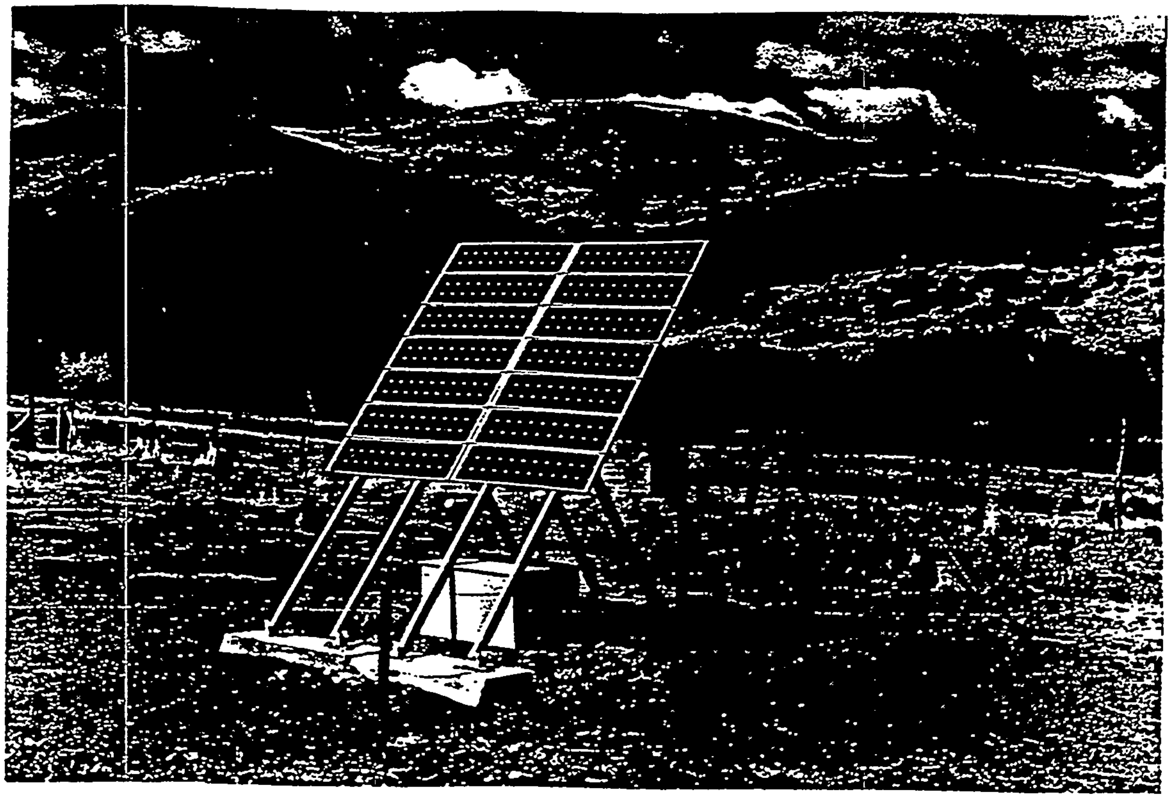
- Undertake a thorough preliminary analysis of a school before making an installation.
- Provide detailed, instructive literature to accompany installed equipment.
- Employ educational aids and demonstration workshops to improve understanding of the equipment.
- Involve the caretaker in all activities concerning the PV system.
- Establish a link between local Ministry of Education Offices and EPEN so that EPEN can be notified when a new teacher arrives at a school with a PV installation.
- Provide every new teacher with detailed verbal instruction concerning the proper use and maintenance of their PV system.
- Give every new teacher explicit instructions on what to do in case of a technical difficulty that they are unable to repair themselves.
- Involve the nearest EPEN office in the installation of the new systems so that they will be able to carry out future repairs and the local training of the new teachers at the school

This should also lead to an enhanced usage of renewable energy systems in the remote areas of the Province where it is most needed.

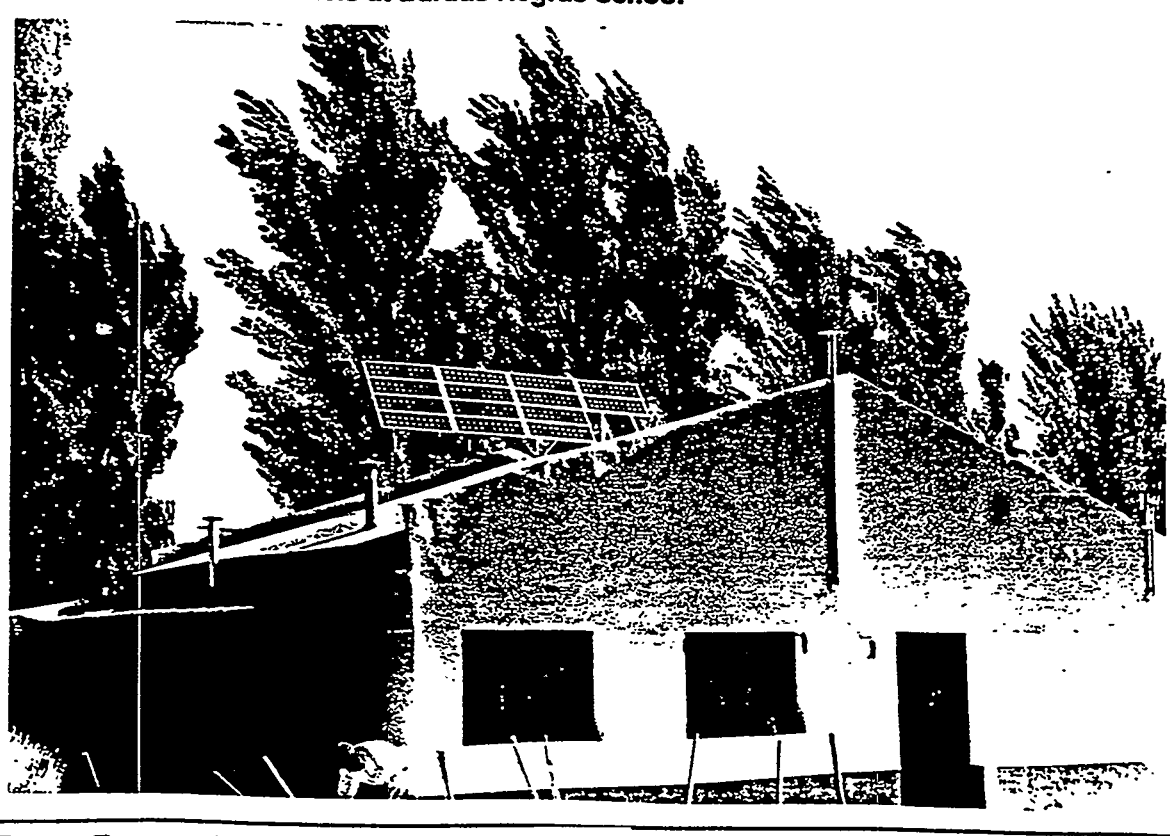
Panels, Battery Box, and Regulator Box at Laguna Miranda School



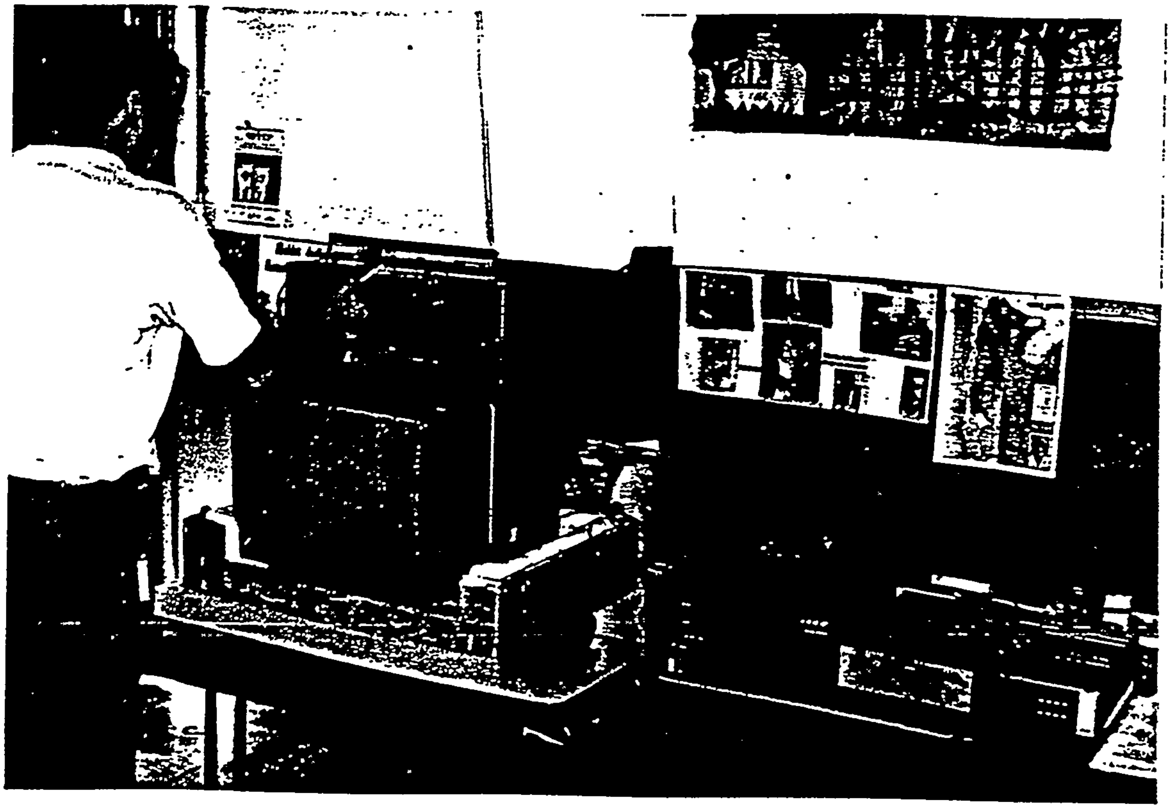
Panels, Battery Box and Regulator Box at Costa del Malleo School



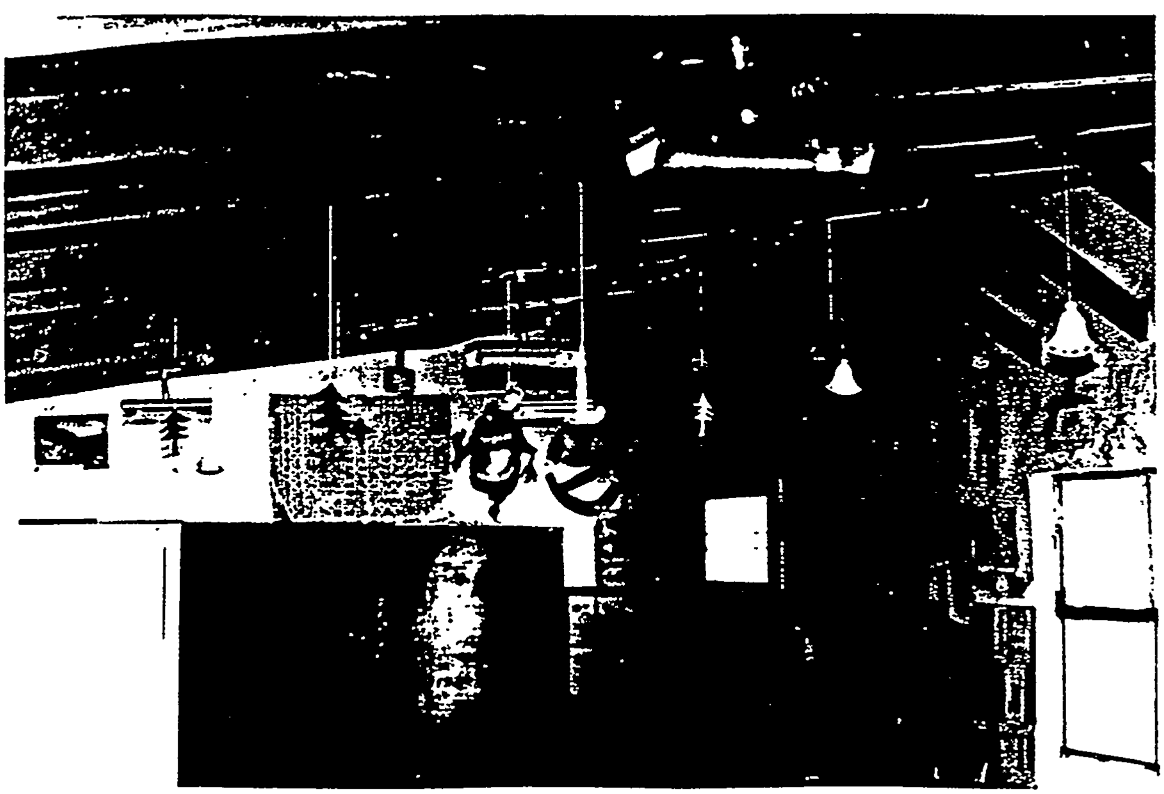
Wall-Mounted Panels at Bardas Negras School



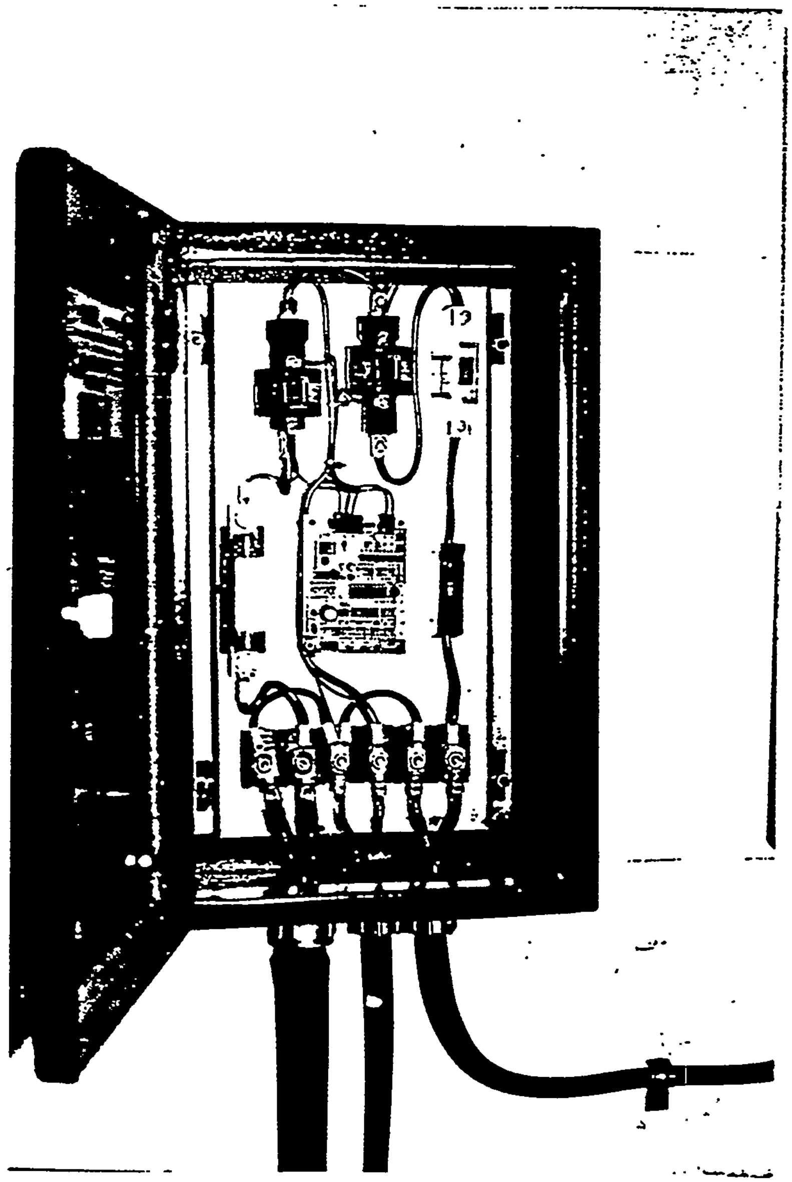
TV, VCR, and Cassette Player Being Tested with Inveter



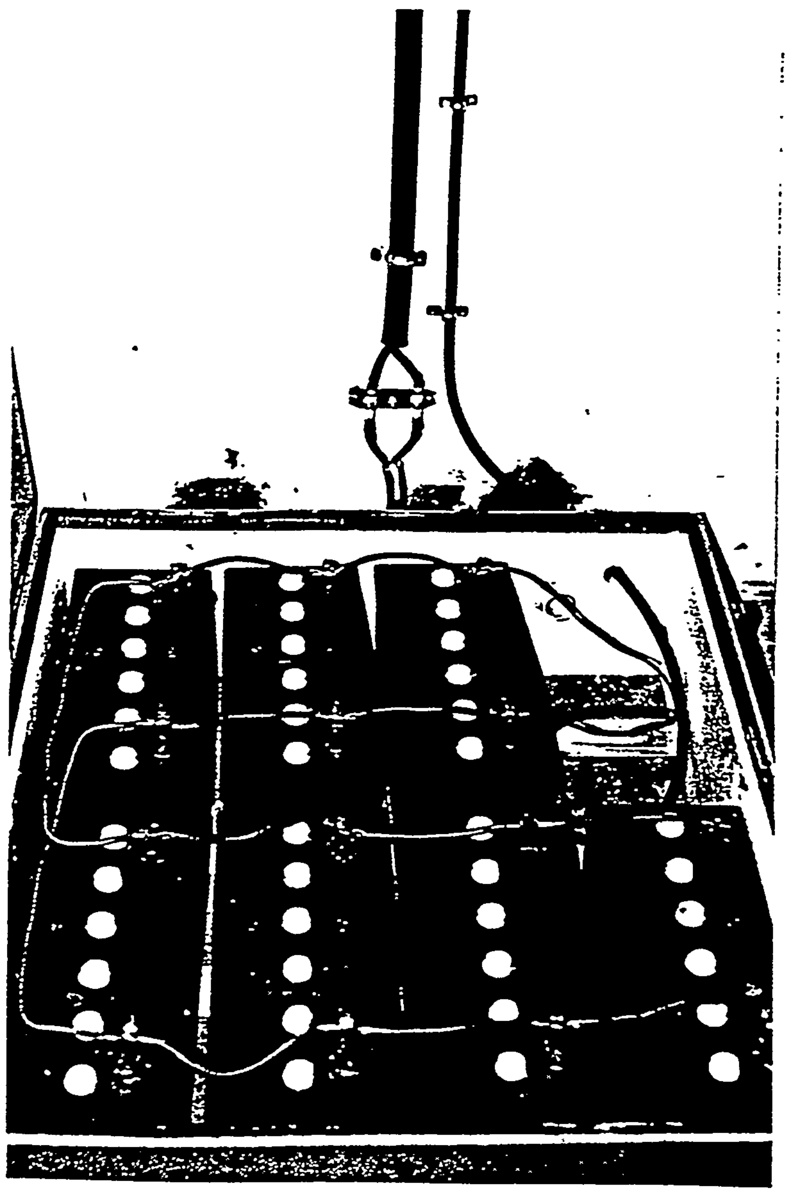
24 V, Direct Current Lights at Costa del Malleo School



Regulator Box Used at All of the Twelve Schools



Battery Bank at Carrán Cura School: 7, 12 V Cells in Parallel



PHOTOVOLTAIC GENERATING SYSTEMS IN RURAL SCHOOLS IN NEUQUEN PROVINCE, ARGENTINA

TRAINING CENTRE AT THE ALBERGE NAYAHUE, NEUQUEN, ARGENTINA

Photovoltaic Battery Charging Experience in the Philippines

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Abstract

With the turn of the century, people in remote areas still live without electricity. Conventional electrification will hardly reach the remaining 50% of the population of the Philippines in remote areas. With photovoltaic technology, the delivery of electricity to remote areas can be sustainable. Malalison island was chosen as a project site for electrification using photovoltaic technology. With the fragile balance of ecology and seasonal income in this island, the PV electrification proved to be a better option than conventional fossil based electrification. The Solar Battery Charging Station (SBCS) was used to suit the economic and geographical condition of the island. Results showed that the system can charge as many as three batteries in a day for an average fee of $ 0.54 per battery. Charging is measured by an ampere-hour counter to determine the exact amount of charge the battery received. The system was highly accepted by the local residents and the demand easily outgrown the system within four months. A technical, economic and social evaluation was done. A recovery period of seven years and five months is expected when competed with the conventional battery charging in the mainland. The technical, economic, institutional and social risks faced by the project were analyzed. Statistics showed that there is a potential of 920,000 households that can benefit from PV electrification in the Philippines. The data and experiences gained in this study are valuable in designing SBCS for remote unelectrified communities in the Philippines and other developing countries.

1.0 Introduction

1.1 PV technology had reached a fair level of reliability. While research on the technology side of PV is being advanced, the financial, social and institutional barriers of implementing the technology also needs further study.

1.2 The past programs done for the promotion of renewable energy (RE) was to find a suitable location for a specific technology. Another approach would be to find the RE technology suitable for a specific site. Programs using the first approach had been very selective in choosing sites. The latter approach took a while before projects were implemented but with a more sustainable operation due to longer periods of study.

1.3 There is always resistance to change specially in the introduction of new technology in remote and isolated areas. The approach using PV battery charging station is to complement the existing practice of charging automotive batteries in rural areas. This paper covers the experience gained in providing village power system using the battery charging approach.

2.0 Solar Battery Charging Station

A Solar Battery Charging Station (SBCS) centrally charges batteries in a day to be used for several days in each house hold. It is composed of an array of solar modules mounted on the frame with a charge regulator and indicator. Batteries are clipped to the BCS early in the morning and taken off at dusk or whenever the battery is full. The batteries are usually owned by the household and a fee is paid per charging

In a single channel BCS, two batteries can be connected while only one is being charged. When the first battery approaches full charge, current is automatically directed to the next battery. This way, energy is not wasted by the regulator.

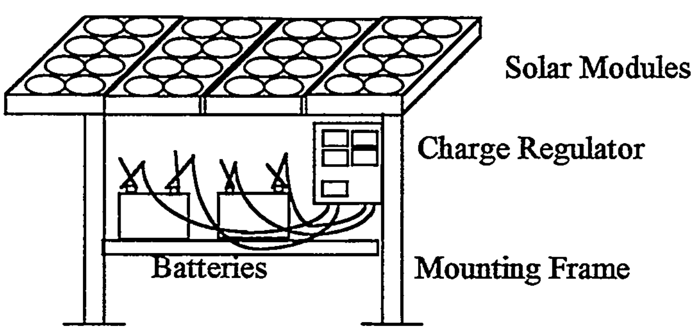

Figure 1. Solar Battery Charging Station

2.1 BCS Capacity

The capacity of a BCS depends on the number of battery that needs to be charged in a day. This depends on the climate, size of the battery and the depth of discharge of the battery. A typical capacity of a single channel BCS should be enough to charge a 100 AH battery in one day. In the Philippines with an average insolation of 5 kWh/m2/day, a 300 Wp PV array can fill this battery at 80% efficiency. BCSs are modular. Another channel can be easily added if the demand increases.

2.2 Metered Charging

The conventional BCS using grid electricity charges a flat rate for every battery charged based on its rated capacity. This pricing method had been used in the past but only favors the battery users. There were instances that a deeply discharged and slightly damaged battery will sit on the charging station for two to three days before it gets full charge. It occupies the BCS only for a fee of one battery instead of three. With this experience, the pricing scheme was revised.

The next approach is to base the fee on the number of days the battery was charged before it gets full. However, this does not favor the users during rainy days. They will pay the same amount for a lesser charge due to lower solar insolation.

To settle this argument on the cost of charging, a charging meter was included in the charge controller. This will display the equivalent fee that the battery user will pay for the amount of charge received by the battery. The meter can be calibrated to meet the changing cost of operating the BCS.

2.3 System Cost

The breakdown of the cost of a single channel 300 Wp BCS is shown in the table below. The PV modules takes 80% of the cost of the total system. Commercial cost of PV modules in the Philippines is US$ 7.18/Wp. This makes the BCS cost $ 2,692.30.

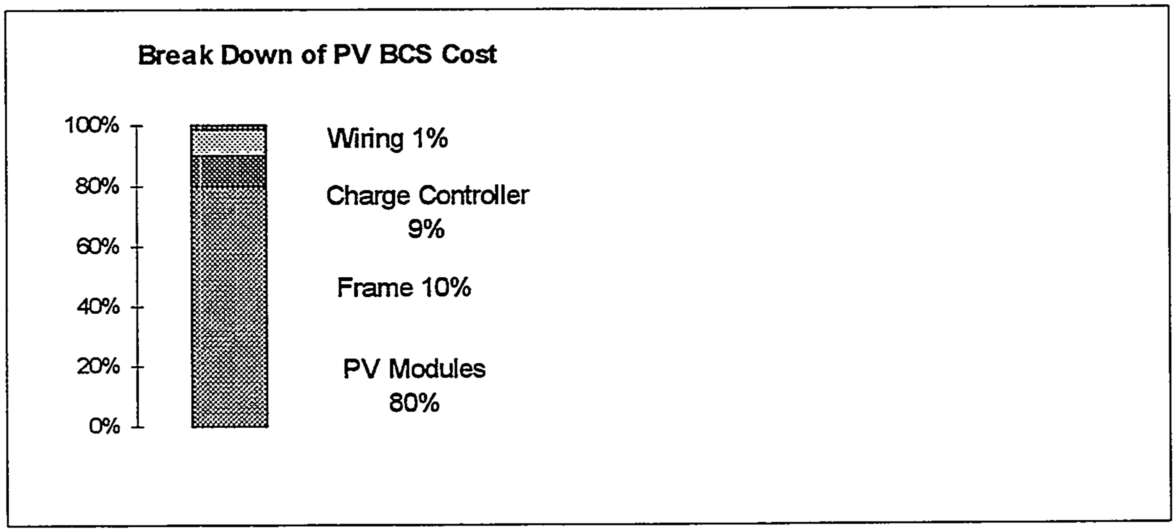

Figure 2

The system cost may vary with the source of the PV modules. Labor and transportation costs increase as the project site becomes very remote. For fully commercial projects, development fee will also add to the total project cost. With volume of installations, this developmental costs will be marginal.

2.4 Energy Cost

To make a simple procedure in costing energy delivered by the BCS, the system cost can be amortized for several years within the period allowed by the funding institution. However, the cost of charging should be competitive with the existing BCS facilities in the area. This topic will be discussed further with the Malalison experience.

3.0 Project Site: Malalison Island

In this study, a typical site is chosen to develop experience and establish data for rural electrification using a Solar Battery Charging Station.

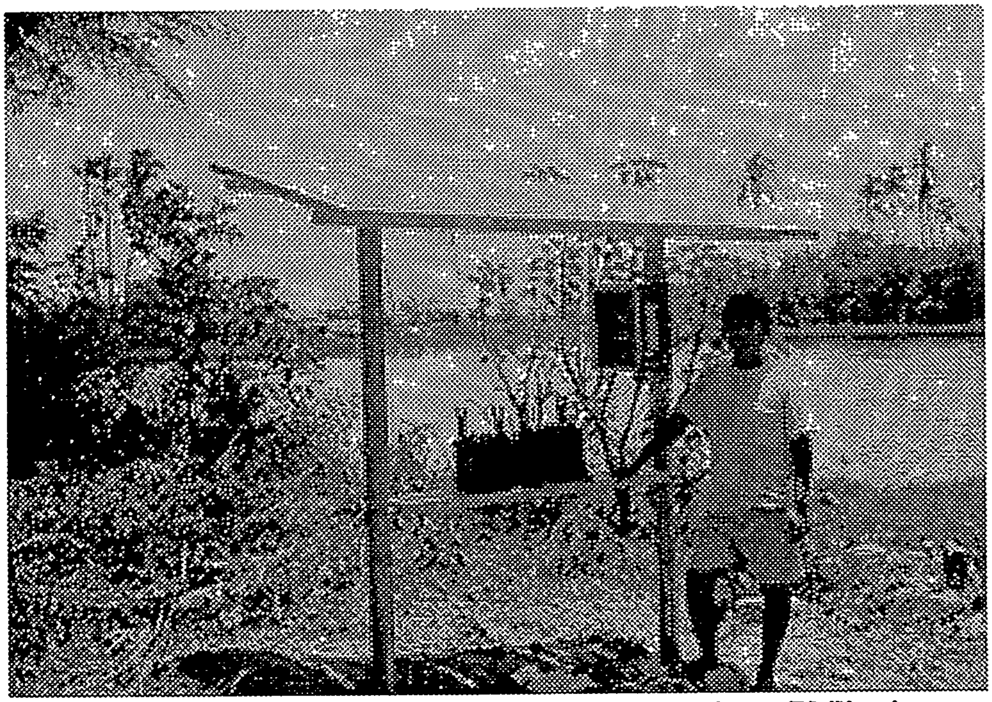

Figure 3. SBCS in Malalison Island, Culasi, Antique, Philippines

3.1 Rural Conditions

Malalison Island is located off the shore of Culasi, Antique. It can be reached by pump boats in 15 minutes from the shore of Culasi town proper. There are about 110 houses, a primary school and a Roman Catholic chapel in the island. Fishing is the main source of income. The Fishermen's Association of Malalison Island (FAMI) was organized to protect and manage the aquatic resources of the island and the surrounding coral reefs. The establishment of FAMI was assisted by the South East Asian Fisheries Development Center (SEAFDEC).

There is a SEAFDEC field station in the island where various studies are conducted. The presence of this station had made a major contribution in the education and livelihood of the local residents. Fishing is regulated by the association. It is further restricted by the big waves and strong winds during northwest and southeast monsoons.

3.2 Present Energy Situation

Due to the isolation of the island, the electric grid can not reach the island. The island belongs to the franchise area covered by Antique Electric Cooperative (ANTECO) who holds the mandate to provide electric service to the community. Any electrical connection from the main line to the island would not be viable because of high initial cost and very low expected revenue. With this condition, the energy sources are limited to the following:

1. Kerosene wick lamps, Pressure Lamps - these kerosene fed lighting fixtures are the basic lighting equipment in the island. Using this lighting fixture is difficult during windy seasons.

2. LPG Lamps - used only by the SEAFDEC station. The light's pressure requirement is only met by the LPG tank for less than one month of use. The LPG tank is then transferred to the LPG burner for cooking.

3. Drycell Batteries - groups of fishermen use underwater flashlights when diving at night. They consume as much as ten D size dry cell batteries per night for a cost of $ 0.29 each. When the batteries become weak, they are used in transistor radios and cassette players. Improper disposal of these batteries with mercury content pose as a potential health hazard.

4. Rechargable Automotive Batteries - charged in the mainland for one to two days and are used for household lighting with automotive bulbs and 12 volt fluorescent lights. Automotive lights are also used during fishing because it can withstand humidity and strong winds at sea. Automotive batteries are also used for karaoke, radio cassettes and VHF communication sets.

5. Diesel Generator / Battery Charger Set - The local SEAFDEC station has a diesel engine coupled to an alternator to charge automotive batteries they use for their VHF and SSB communication sets. The local battery users bring 2 liters of diesel fuel to charge their batteries for two hours. In less than a year of operation, the alternator was damaged. It was brought to the mainland for major repair.

6. Diesel Engines with battery charger - Without SEAFDEC's diesel charger, battery charging is done with the alternator of their service pump boat. This is done exclusively for SEAFDEC's use only.

3.3 Solar Battery Charging Station Installation

With funds provided by the Antique Integrated Development Foundation (ANIAD), an NGO based and operating in Antique; the SBCS was installed in Malalison island last August 30, 1996. The installation was done by Engr. Silverio Navarro, Jr. of Solar Electric Company with Engr. Jeriel Militar and Engr. Eilrem Fernandez of Central Philippine University - Affiliated Non-conventional Energy Center. The local residents also took part in the site selection and installation.

3.4 User Education

The residents were gathered for a meeting to discuss the operation of the charger. Battery care and safety were also thought to prolong the operating life of the batteries. Batteries have to be resold for recycling after its service life instead being disposed indiscriminately. The existing battery users already have knowledge on battery operation and care. There were no difficulties in educating the users.

4.0 Technical Analysis

4.1 Basic Assumptions

The estimated solar insolation in Malalison Island is 5.0 kWh/m^2-day. With the 300 Wp, the SBCS will have an average of 1.5 kWh output daily. This should be enough to charge a 100 AH battery at 80% efficiency. The rate of charge is not measured in watt hours or kilowatt hours because of the variation of battery voltage from 10 to 14 volts DC. nstead, the charging rate in amperes multiplied by the time in hours or amp-hours (AH) is used.

The calibration used was $ 1.38 per 100 AH or $ 0.0138 /AH. This was based on the assumption that the regular size of battery used is 17 plates with 100 AH capacity and discharged 100%. At 14 volts average, 100 AH is equal to 1.4 kWh. The SBCS should charge a battery in a day.

4.2 Actual System Performance Data

After four months of operation, data was gathered based in the receipts issued by the association. The technical data is tabulated below.

	September	October	November	December
No. of Battery Users	9	14	16	20
Growth Rate	-	56%	14%	25%
Revenue Collected US$	11.78	14.12	12.19	12.19
No. of Battery Charged	21	26	22	24
Average Payment per Charging	0.56	0.54	0.55	0.51
Calibration ($/AH)	0.0138	0.0138	0.0138	0.0138
Average AH/Charging	40.55	39.19	40.03	36.67

Table 1. Technical evaluation of the data gathered

The average daily energy generated by the SBCS based in the revenue and present calibration is only 0.416 kWh/day compared to the assumed 1.5 kWh/day. This is only 27.78% of the ideal condition. The losses are due to the decrease in the conversion efficiency of the solar modules due to increase in solar cell temperature, shading of nearby coconut trees, and charging efficiency of the regulator.

The average consumption of each battery charged is only 40 AH compared to the assumed 100 AH. According to the operator, there are batteries that require 2 days for charging.

There were days that three batteries are charged in a day. There were battery users that will charge their batteries only up to
p10.00 regardless of the state of charge of the battery after charging.

When the counter malfunctioned for two weeks, a flat rate of P 20.00 or $ 0.77 per battery was imposed. Battery users complained of the new rate because they were already used to the AH counter and the length of days they use their battery for a given fee. Any modification of the calibration will be noticed by the users.

Data was evaluated to determine the number of days they use their battery before recharging. Results showed that the length of use depends on the user and the availability of the SBCS. The shortest average was seven days and the longest was fifty six days.

Weekly charging of batteries are due to large consumption and small battery capacity. This is also due to decreased capacity of aged batteries. Around 25 % of the users consume their batteries for two weeks. The optimum number of battery users for size of BCS is 28.

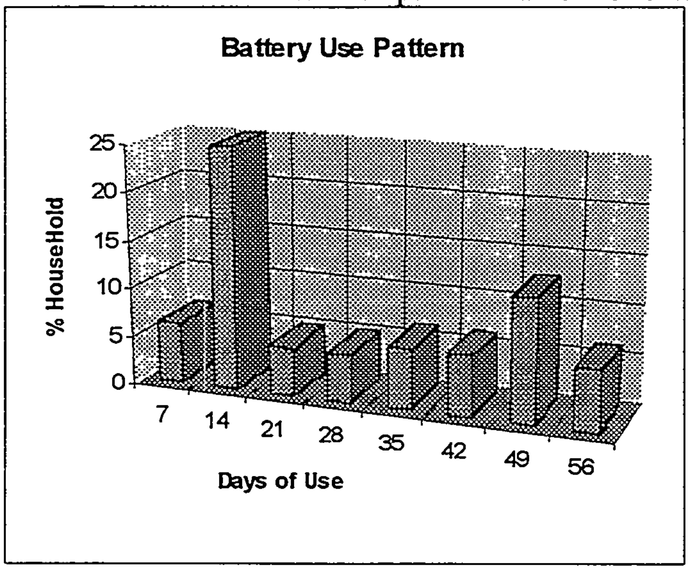

Figure 4

As the number of battery users goes beyond 28, the BCS will be congested. Users that charge their battery once a month will not be affected by this situation. Heavy users will have to wait in a longer queue as the number of battery users increase. Small batteries that are frequently charged, and also discharged; will soon lose capacity and have to be replaced earlier. On the other hand, large batteries that are used lightly with longer recharging time will last longer. However, heavy batteries are more costly and are difficult to transport, they are ideal for this type of use. Batteries with 100 AH or less capacity is the most popular.

As the number of users increase, the availability of the SBCS will be less. This will result to:

- lesser frequency of charging
- longer standby time of the battery before recharging
- charging their battery in the mainland with conventional electricity

5.0 Economic Analysis

5.1 Project Funding

The SBCS was funded by ANIAD for $ 2,692.30. Labor and technical supervision were shouldered by CPU-ANEC.

5.2 Cost of Energy

The charging fee was set at $ 0.0138/AH. An AH is equivalent to 14 watt hours at 14.0 volts DC. This rate is $ 0.96/kWh which is 5.3 times the rate charged by ANTECO of 0.18 $/kWh.

The present charging rate of conventional battery charging station is $ 0.96 per battery. Assuming that they only charge 40 AH, this will be $ 0.024/AH or an equivalent of 1.716 $/kWh. This is almost 10 times the rate of electric utilities. This is illustrated in Figure 5.

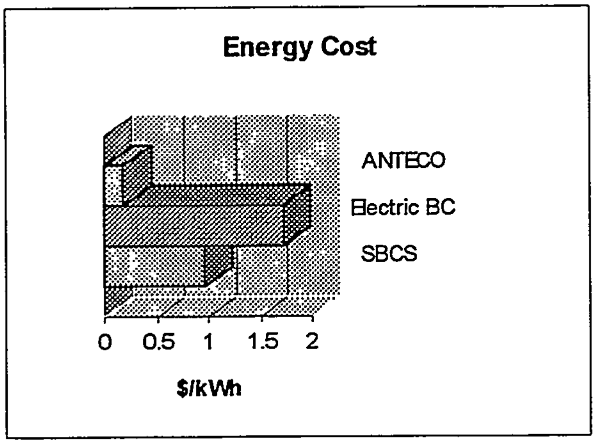

Figure 5

5.3 Revenue Generated

The revenues collected by the association is segregated among the officers. Figure 6 shows the sharing of the revenue.

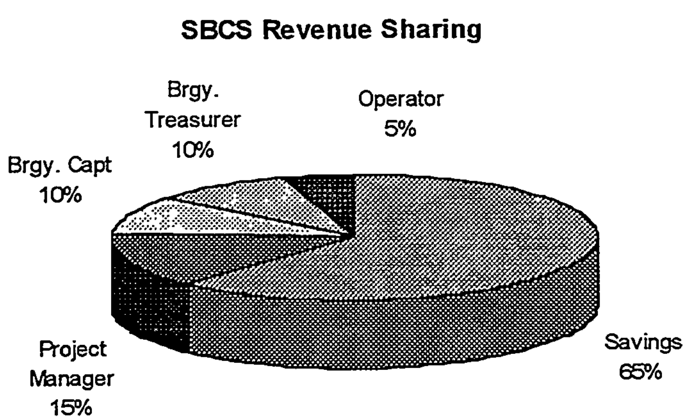

Figure 6

The current average monthly revenue generated is $ 12.19 with 23 batteries charged. This translates to $ 7.31 savings per month and the operator monthly income is $ 0.61.

Date Started	Name of User	September	October	November	December	Total
02-Sep	Aquilino Macuja	38.00				38.00
03-Sep	Salvador Calawod	20.50	56.00	52.00	26.00	154.50
03-Sep	Winnie Leciones	65.50	53.00	65.00	42.00	225.50
04-Sep	Aba Doroteo	29.50	31.00	5.00	20.00	85.50
04-Sep	Arthur Doroteo	37.00	11.00	10.00	48.00	106.00
06-Sep	Lopenido Catamura	22.00	11.00			33.00
10-Sep	Efraim Doroteo	12.00	21.00			33.00
16-Sep	Ricardo Catamura	38.00	19.00		20.00	77.00
21-Sep	Renato Macuja	44.00	72.00	41.00	19.00	176.00
06-Oct	Emil Doroteo		13.00	20.00	20.00	53.00
08-Oct	Nelfa Macuja		16.00	22.00		38.00
09-Oct	Ronnie Dayo		12.00	44.00	20.00	76.00
18-Oct	Rocela Catamura		14.00	29.00	32.00	75.00
24-Oct	Paterne Elio		38.00			38.00
01-Nov	Rolly Santiago			7.00	5.00	12.00
18-Nov	Fe Doroteo			22.00		22.00
08-Dec	Romeo Macuja				22.00	22.00
12-Dec	Ban Doroteo				33.00	33.00
24-Dec	Henry Doroteo				3.00	3.00
31-Dec	Pablo Doroteo				7.00	7.00
	Total Revenue	306.50	367.00	317.00	317.00	1307.50

* $ 1.00 = P 26.00 or P 1.00 = $ 0.038

Table 2

Table 1 contains the summary of the revenues collected during the first four months of operation. The names of the battery users are rank chronologically to show the number of new battery users added each month.

5.4 Cost Recovery

To analyze the cost recovery of the system, this will be covered in 18 years and 5 months by dividing $ 2,692.31 by $ 12.19/month. If competed with the cost of battery charging in the mainland, the calculations would be as follows:

Charging Fee per Battery in the mainland	$ 0.96*
Number of batteries charged per month	23 (average)
Total revenues saved with SBCS per month	$ 22.12
Inflation rate per year	10%
SBCS preset worth cost	$ 2,692.31
Salvage value	$ 0.00
The number of payment periods would be	7.3483 years
or	7 years and 5 months

* transportation hauling costs are excluded since these are highly variable.

6.0 Socio-Economic Benefits

6.1 Benefits to Battery Users

Battery users in the island were the first to benefit from the charging station. The advantages of the SBCS are summed as follows:

1. No transportation cost. Batteries used to be shipped by the pump boat and carried by the tricycle to the charging station in the mainland.

2. Less waiting time. Charging with the SBCS takes only a day while the conventional charger will take two days excluding transportation.

3. Quality charging. Batteries charged with the SBCS has a longer usage time than the conventionally charged batteries.

4. Safer battery handling. With the SBCS in the island, the distance the battery has to be hauled is less. The risk of battery damage due to mishandling is also reduced.

5. Conservation of funds. The charging fee to be spent in the mainland is circulated back to the community.

6. Reliable energy source. Even during rainy days, the SBCS was still able to charge batteries but of a slower rate. This proved to be more reliable than the diesel charger SEAFDEC has been using. The diesel charger was pulled out for repair in less than a year of operation.

7. Secured and versatile power source. Transportation to the mainland during windy days is difficult. Shipment of fuel is also a problem during this time. With the SBCS, the local residents are still supplied with electricity even during this type of weather.

8. Environment friendly. The SBCS does not produce noise, heat, smoke, fumes and other harmful wastes that pollutes the island.

6.2 Advantages of Using Automotive Battery

In contrast to other sources of energy used in the island, electric energy stored in the battery has advantages:

1. Superior lighting quality. The lights powered by batteries are:

   - brighter
   - cleaner
   - safer to use
   - can withstand humidity and strong winds
   - easy to turn on and off
   - can be mounted in any position

2. Rechargable batteries can eliminate the use of disposable batteries that are costly and pose as potential health hazard.

Even with an energy cost of 5 times the rate of conventional electricity, people in Malalison island still appreciate the availability of energy. Without any flat rate charges, the residents can have the flexibility of buying energy with the SBCS.

7.0 Risks Analysis

There are potential risks that will affect the success of the SBCS projects not only in Malalison Island but almost any remote project site.

7.1 Technical

The source of solar energy is the sun. Decrease of solar entry in a location due to excessive cloud cover during storms and rainy days particular to a location affect the output of the system. Dense vegetation and natural topographic condition of the site will also affect the conversion efficiency of the system.

The SBCS can only cater to a limited number of battery users. It is typical that the SBCS will be easily outgrown in a few months time. In Malalison, the 9 users grew to 20 in four months. The batteries will start to pile up and cause dissatisfaction among users. Expansion should be done to meet the increasing demand. Users with high demand will have to shift to solar home system with their own solar charger in their houses.

7.2 Institutional

The strength of the local organization determines the success of the implementation of a SBCS. Special treatment to some battery users will cause grievances among the users. Intervention of outside political influence will affect the operation of the project. Politicians usually donate a generator set to an unelectrified community without any consideration of its sustainability and the harm it would cause to the sensitive ecology of the community.

7.3 Economic

The SBCS operates with sunlight regardless of the cost of fluctuations on fossil based fuels. However, the cost of project operation is affected by inflation caused by fossil fuels. The revenues generated by the SBCS will soon devaluate due to inflation until it is not worth operating. Recalibration of the charge counter can be done to compensate for inflation.

With the increasing demand, expansion have to be done to accommodate the additional battery users. The cost recovery period of the first SBCS is too long to pay for the needed expansion.

SBCS are designed to increase the load demand of the community with availability of energy. Battery users with high load demand should shift to solar home system to decongest the SBCS. The initial cost of an individual system will be a thousand times the charging fee. The shift will be difficult unless a financing scheme is available for long term installment period.

7.4 Social

Peer pressure will encourage use the of batteries as a more convenient way of having light and operating appliances and also as a status symbol. This will result to the congestion of the SBCS.

8.0 Project Replicability

8.1 Common Rural Conditions

The present rural conditions that are common in the country sides are:

- Unelectrified
- Inaccessible in certain months of the year
- Low income level
- Seasonal income
- Absence of lending facilities
- Low level of technical skills

8.2 Necessary Conditions for Replication

To duplicate this electrification model, there are several aspects that need to be present in a site.

1. Good Solar Insolation - The Philippines receive and average solar radiation of 5 kWh/m^2-day. However, mountain villages receive less radiation due to fog and cloud formation. Entry of sunshine can also be restricted by vegetation and natural geological formations.

2. Financial Assistance - The initial investment for a PV system has to be financed. This can be done by LGU's and NGO's through the local organization. The Development Bank of the Philippines has a special financing package for renewable energy under Window III. Private banks are still reluctant in funding these type of projects because of the risks involved and long term financing requirements.

3. Technical Capability - PV systems are very easy to operate and maintain. Most remote villages have a level of skills to handle battery operation and care. Local technicians can be trained to do monitoring and repair.

4. Reliable Product and Supplier - There are at least seven PV suppliers in the country that deliver reliable products and services nationwide. Several suppliers have provincial branches that can render fast response to service calls or supply requirement.

5. Strong Community Organization - Most of the rural areas now have community organizers and working cooperatives that handle income generating projects. These were organized by NGO's and the local government. These organizations can be utilized to implement and operate PV projects.

6. Source of Income - To sustain the operation of the PV project, a minimal financial requirement is needed. Most of the income generated by PV projects will be returned to the community. For commercial projects, the regular household income required will be at least P 6,000.00 per month.[3]

8.3 The Potential Sites

The data in the regional office of NEA showed that within the franchise area of ANTECO, only 58.8% of the total barangays are electrified as of June 1996. Looking further, only 37.96 % of the total households are reached by electricity.

The demand assessment done by the Philippine-German Special Energy Program (PG-SEP) showed an estimated potential of 125,000 households nationwide. This was based on the evaluation of pilot PV projects. With an assessment based on the statistical data from the National Census and Statistics Office and a matrix of user profiles developed by PG-SEP, the number of potential households with sufficient economic standing is realistically assumed to be 920,000.[4]

9.0 Conclusion

PV electrification in Malalison Island using the solar battery charging station model is a viable method in providing sustainable energy for lighting and radio. This can serve the initial battery users and generate income for the barangay. However, the SBCS can only charge a limited number of batteries that an expansion is required after four months of operation. The increase in number of battery users shows acceptance and fast adaptation of the local resident to the system. The SBCS can compete with the conventional battery charging in the mainland. An outside subsidy is required to shoulder the high initial cost of the SBCS.

10.0 Recommendations

10.1 Recalibration of the SBCS

The present calibration of the charging station is set to 0.0138 $/AH. The cost of battery charging in the mainland is already 0.024 $/AH. Battery users would even pay more because of convenience and the quality of charging. Transportation cost is also eliminated using the SBCS.

10.2 SBCS addition/expansion

To cater to the increasing number of battery users, an additional charging facility is recommended. This could be another set of SBCS with two or more channels. A solar- wind hybrid charging system can also be installed.

10.3 Shift to SHS

Battery users with high demand should shift to solar home systems. Depending on the financial capacity of the users, a long term installment scheme can be implemented. The electric utility can be tapped for the initial investment needed. The National Electrification Administration has already included the PV electrification in providing basic electric services in areas not viable for regular grid electrification.

10.4 Wind Energy Option

During the January 21, 1997 visit a maximum 40 anemometer was installed 20 meters high just above the coconuts. This was coupled to a wind run counter to measure the traversed distance of the wind. The reading is logged with the time to measure the average wind velocity.

Short term measurements during the installation showed velocities from 8.3 m/s to 12.5 m/s blowing almost 24 hours a day. If a WIND SEEKER 503™ wind turbine is installed, it will generate at least 200 watts. For approximately 18 hours of charging, 3600 watt hours will be produced. This will be enough to charge 7 batteries in a day with 40 AH charge per battery.

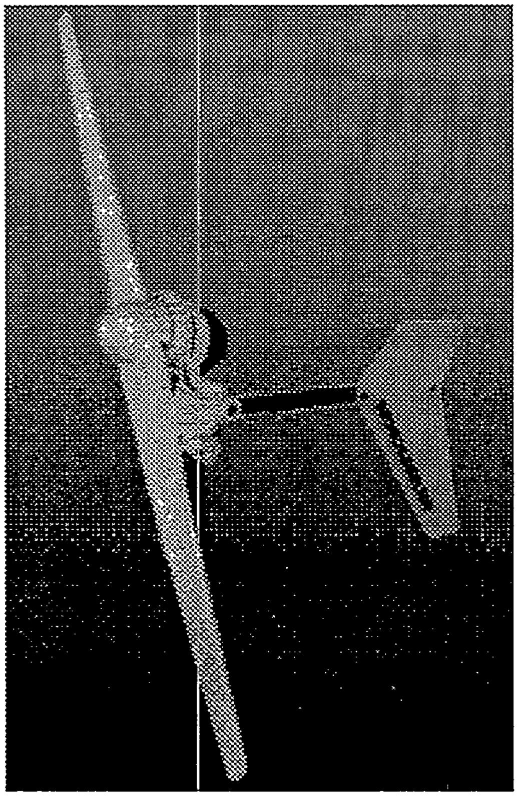

Figure 7. Wind Seeker 502

An estimated investment for a small wind turbine is $ 2,692.31. This can be recovered in less than 4 years using the present charging rate of 0.0138 $/AH. Even if the turbine has to operate only for 8 months in a year, the system will still be viable.

Revenues generated by the wind turbine can be used to subsidize the cost of the SBCS. With only eight months of operation, the SBCS will compensate for the demand of battery charging during months of low wind velocities.

If the energy produced by the wind turbine is more than the demand of the battery users, excess energy can be used for street lighting, refrigeration or other income generating loads.

Acknowledgments:

1. Fishermen's Association of Malalison Island (FAMI) for choosing to use the SBCS instead of diesel generator sets and for managing the operation of the project.

2. Antique Integrated Area Development Foundation (ANIAD) for organizing the fishermen in Malalison Island and financing the SBCS.

3. Central Philippine University - Affiliated Non-conventional Energy Center (CPU-ANEC) for conducting a non-conventional energy forum for the province of Antique and for assisting the project development of the SBCS in Malalison Island.

4. Solar Electric Company, Inc. for supplying the materials and the technical support of the SBCS.

5. National Electrification Administration (NEA) Region VI office for providing the data of the electrification status in the region.

6. Philippine-German Special Energy Program (PG-SEP) for providing the experience in rural photovoltaic electrification.

7. NRG, U. S. A. for providing the maximum 40 anemometer to asses the wind data in Malalison Island.

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RURAL HEALTH CLINICS INFRASTRUCTURE

PRESENTED BY
KEN OLSON
SOLAR ENERGY INTERNATIONAL

NREL Village Power '97
April 14, 1997

APPLICATIONS

- Vaccine Refrigeration
- Ice Pack Freezing
- Lighting
- Communications
- Medical Appliances
- Sterilization
- Water Purification
- Income Generation

World Health Organization

WHO Fact Sheet N132

- "...Health and energy are interdependent factors."
- "...Energy strategy for rural areas....critical in achieving lasting health improvements."
- "Solar Energy can play an important role in improving the health/energy infrastructure if integrated with a broader array of end uses."

INFRASTRUCTURE ROLES

- DECISION-MAKERS
- MANAGEMENT
- TECHNICIANS
- USERS
- COMMUNITY

INFRASTRUCTURE ROLES

- ***DECISION-MAKERS***
  - ***Policy***
  - ***Funding***
  - ***Evaluation***
- MANAGEMENT
- TECHNICIANS
- USERS
- COMMUNITY

INFRASTRUCTURE ROLES

- DECISION-MAKERS
- ***MANAGEMENT***
  - ***Supervision***
  - ***Procurement***
  - ***Logistics***
  - ***Quality Control***
- TECHNICIANS
- USERS
- COMMUNITY

INFRASTRUCTURE ROLES

- DECISION-MAKER
- MANAGEMENT
- ***TECHNICIAN***
  - ***Logistics***
  - ***Installation***
  - ***User Training***
  - ***Maintenance & Repair***
- USER
- COMMUNITY

INFRASTRUCTURE ROLES

- DECISION-MAKER
- MANAGEMENT
- TECHNICIAN
- ***USER***
  - ***Operation***
  - ***Daily Maintenance***
  - ***Record Keeping***
- COMMUNITY

INFRASTRUCTURE ROLES

- DECISION-MAKER
- MANAGEMENT
- TECHNICIAN
- USER
- ***COMMUNITY***
  - ***Operate Enterpeises***
  - ***Benefits***

ELEMENTS OF INFRASTRUCTURE

- POLICY GUIDELINES
- MANAGEMENT
- STANDARDS
- CERTIFICATION
- TRAINING
- INCOME GENERATION
- MAINTENANCE PROGRAM
- USER PARTICIPATION
- CREDIT

HEALTH CLINIC POWER SYSTEMS

- GENERALLY DONATED FUNDS
- LACK OF FUNDS FOR OPERATIONS & MAINTENANCE
- NOT SUFFICIENT IN NUMBER TO SUSTAIN A COMMERCIAL PRIVATE ENTERPRISE

CASE STUDY

DOMINICAN REPUBLIC

- 652 Rural Health Clinics
- $1,000,000 from EC for PV
- 164 Health Clinics with PV
  - Vaccine Refrigerators
  - 4 Lights
- $6,000 each installed
- Installed 1992-94

DOMINICAN REPUBLIC

PERFORMANCE

Of systems evaluated after one year:

- 25% Failed to Function
- 60% Required Repair
- 15% Functioned w/o problems

CASE STUDY

DOMINICAN REPUBLIC

- WHAT WENT WRONG?
  - Inefficient Loads
  - One-Size-Fits-All Design
  - Inappropriate siting of Systems
  - Inexperienced Installers
- WHAT WAS DONE?
  - Technician Training Program
  - Repair Program Detailed
  - Funds not allocated

Dominican Republic

RECOMMENDATIONS

- GUIDELINES FOR PROJECT MANAGEMENT
  - Funds for O & M
  - Placement, Procurement
- STANDARDS
  - Design, Installation, Service
- CERTIFICATION TRAINING
  - System Designers, Installers, Users
- MAINTENANCE PROGRAM

CASE STUDY

SOLAR ENERGY FOR HEALTH

AN INTEGRATED FOCUS

CHOCO, COLOMBIA

Summary of an evaluation by

Pan American Health Organization

Government of Holland

An Integrated Focus: GOALS

- Improve Rural Primary Health Care Using Solar Energy
- Achieve Sustainability with Community Participation
- Demonstrate Feasibility of PV Rural Electrification

An Integrated Focus: OBJECTIVES

- Establish Community Council
- Generate Funds Locally
  - for Operations & Maintenance
  - by Community-based Micro-Enterprises
- Training of Community
  - Solar Energy Systems
  - Micro-Enterprise

Micro-Enterprises for Income Generation

- VIDEO THEATERS
- BATTERY CHARGING STATIONS
- SALE OF LIGHTING SYSTEMS
  - PV Portable Lanterns
  - 2 Lamps, Battery, Control
  - 2 Lamps, Battery, Control, PV Panel

INCOME GENERATED FOR OPERATIONS & MAINTENANCE

April - Dec, 1995

- Orpua $496.
- Guineal $655.
- Docordo $420.
- Noanama $335.

Income in pesos, US dollar equivalents shown

Conclusions: General

- The project was well accepted by the Community and Health Institutions.

Conclusions: Health

- Solar Energy Improved Rural Health Services
  - Increased Vaccination Coverage
  - More Rapid Malaria Diagnosis
  - Effective Emergency Communication
  - Lighting for Night Visits
  - Lighting for Staff Residence
  - Improved Health Education
  - Fewer Home Accidents w/ lamps

Conclusions:
Community Participation

- The Community can generate funds to maintain PV Systems for Health Care.
- Community Councils always need assistance with:
  - Management Skills
  - Knowledge of the Market for PV
  - Direct Relation with Suppliers

Conclusions:
PV Electrification

- A Financial Credit Program needs to be Established to expand the Market for PV Systems.

Renewable Energy Water Supply
Mexico Program Summary

U.S. Agency for International Development
Sandia National Laboratories

Village Power Conference
Washington D.C.
April, 1997

Robert Foster
Southwest Technology Development Institute
New Mexico State University
Las Cruces, NM

Common Solar Energy Water Uses

- Water Pumping
- Water Disinfection
- Water Distillation
- Water Desalinization

Common Wind Energy Water Uses

- Water Pumping

Southwest Technology Development Institute
SWTDI

SNL/USAID Mexico Program: Water Pumping Systems Summary

- 72 PV Water Pumping Systems for farms, ranches, and communities installed in the States of Baja California Sur, Chiapas, Chihuahua, Sonora, Quintana Roo, Veracruz
- 1 Wind-Electric Water Pumping System installed in the State of Oaxaca
- 4 Solar Distillation Systems for potable water in the State of Chihuahua

Southwest Technology Development Institute

SWTDI

General Mexico Program Statistics

Description	Quantity
Number of Projects Beneficiaries	6,571
Number of Water Pumping Systems Installed	72
Total Number of Renewable Energy Projects	115
Total PV Water Pumping Peak Capacity	39.5kW
Total PV Projects Installed Capacity	57.3kW
Total Wind Projects Installed Capacity	13kW
Total CO_2 Emissions Offset**	5,330 Metric Tons

**Assumes 1.3 Kg of CO_2 displaced for every kW-hr of conventional electric generation. PV module lifetime is 30 years with 6 hours/day average operation. Wind turbine lifetime is 20 years with a 25% capacity factor.

Southwest Technology Development Institute

SWTDI

Guides to Successful Renewable Energy Water Pumping Projects

- Promote an integrated development program
- Install QUALITY systems that develop confidence
- Instill local project ownership
- Train local industry and project developers
- Develop a local maintenance infrastructure
- Provide users training and operations guide
- Develop clear lines of responsibilities for system upkeep

Southwest Technology Development Institute SWTDI

Importance of Training

- Create Awareness of Technology Options
- Establish Networks between Industry and Project Developers
- Diffuse Knowledge
- Develop Local Capabilities
- Improve Overall System Quality and Installation

Southwest Technology Development Institute SWTDI

SNL Mexico Renewable Energy Water Pumping Systems Training

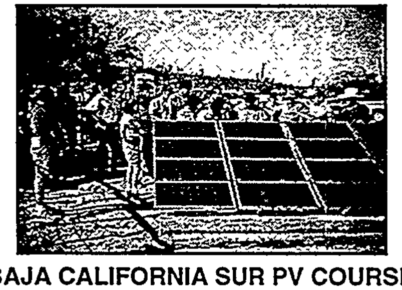
- BAJA CALIFORNIA SUR - 2 COURSES
- CHIAPAS - 1 COURSE
- CHIHUAHUA - 4 COURSES
- MEXICO CITY - 1 COURSE
- OAXACA - 1 COURSE
- SONORA - 1 COURSE
- QUINTANA ROO - 1 COURSE
- VERACRUZ - 1 COURSE

Presentations by more than 30 U.S. & Mexican Companies

Southwest Technology Development Institute SWTDI

Water Pumping Systems Training

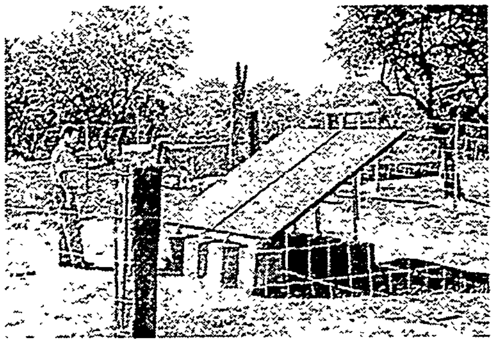
CHIHUAHUA PV COURSE



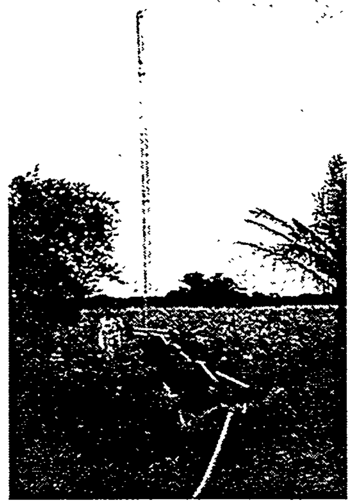
BAJA CALIFORNIA SUR PV COURSE

Training of Local Industry and State Development Engineers by SNL, SWTDI, and Industry.

Southwest Technology Development Institute SWTDI



SONORA PV COURSE



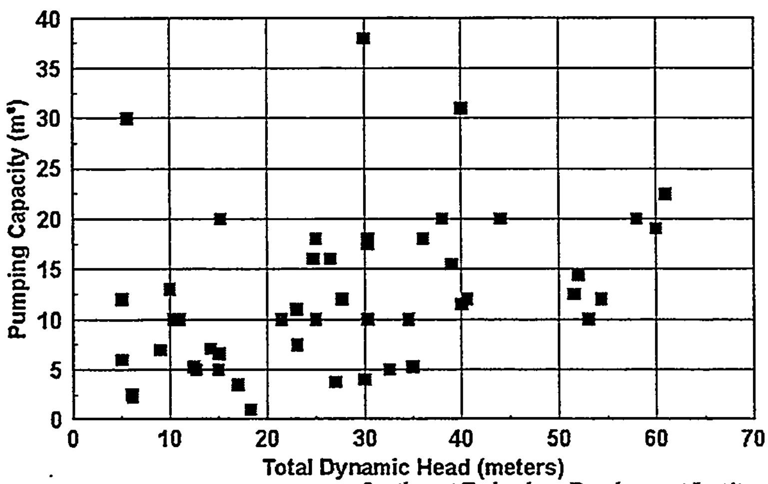
OAXACA WIND-ELECTRIC COURSE

Southwest Technology Development Institute

SWTDI

Mexico Water Pumping Systems

Total Dynamic Head versus Pumping Volume

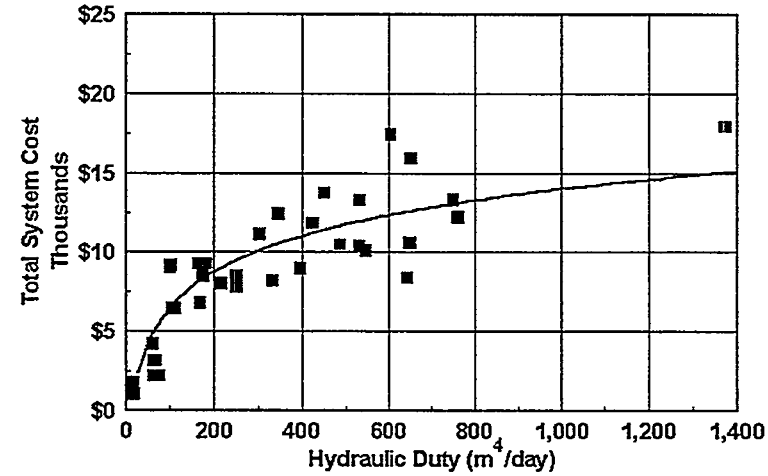


Southwest Technology Development Institute

SWTDI

Mexico Water Pumping Systems

Hydraulic Duty versus Total System Cost

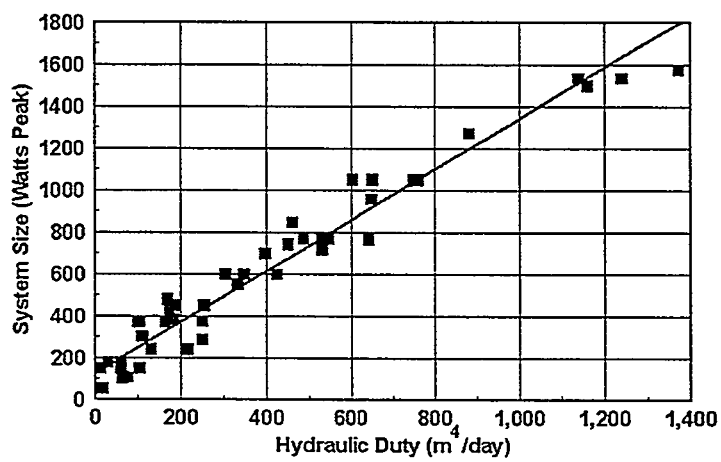


Southwest Technology Development Institute

SWTDI

Mexico Water Pumping Systems

Hydraulic Duty versus System Size

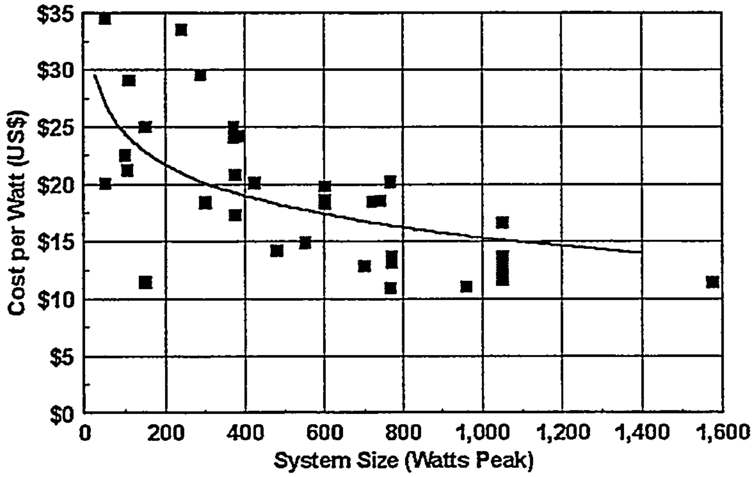


Southwest Technology Development Institute

SWTDI

Mexico Water Pumping Systems

System Size versus Cost per Watt

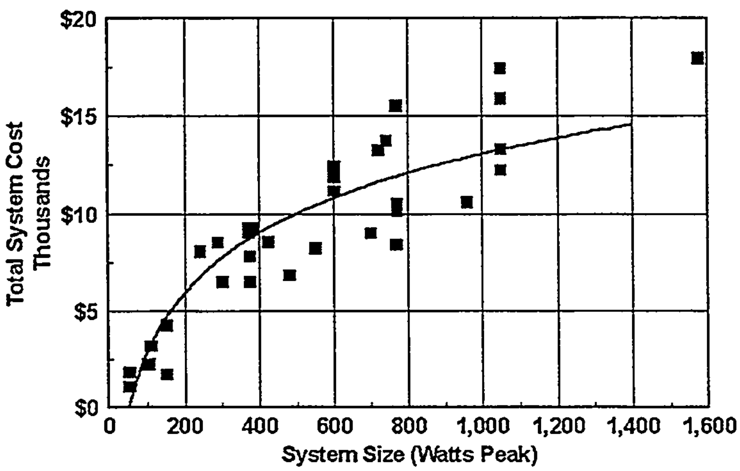


Southwest Technology Development Institute

SWTDI

Mexico Water Pumping Systems

System Size versus Total System Cost



Southwest Technology Development Institute

SWTDI

Community Power Corporation

Lighting: The Killer App of Village Power

Village Power '97

April 14-15, 1997

Arlington,VA

What Defines A Killer App?

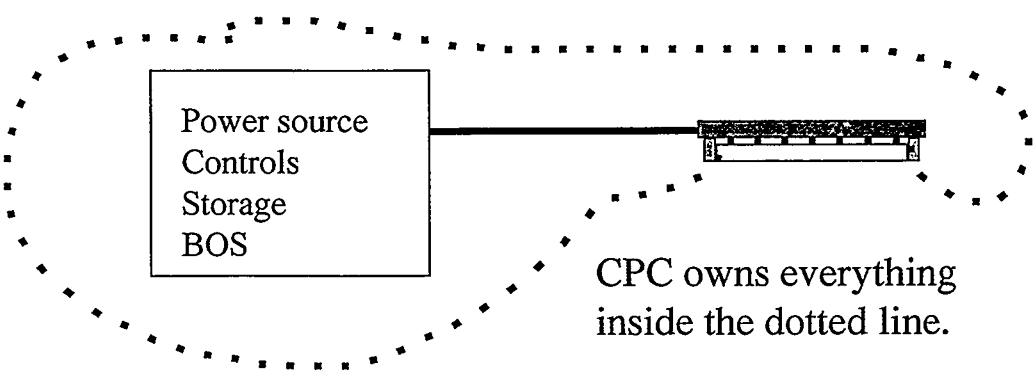
- User's perspective
  - Satisfies a fundamental need
  - Can't live without it, but always looking for something better!
  - Price less important than affordability, convenience and reliability
- Supplier's perspective
  - Enormous base of existing customers
  - Pulls through a lot of other products and services
  - Even small penetration can create big winners

CPC's Goal Is to Develop A Thorough Understanding of The Lighting Application

- Preliminary evaluation
  - quantify key parameters
  - compare to competing sources
  - long-term performance tests in the lab
- Field tests
  - install with customers
  - survey results
  - incorporate results in business

Community Power Corporation

RESCO Concept Makes Selection Of The Light A Critical Event



CPC owns everything inside the dotted line.

Customer owns the bulb!

Community Power Corporation

The Impact of Light Selection Can Make or Break A RESCO

- 10% reduction in energy consumption
  - 50% more hours of TV, or
  - smaller power system = 23% increase in NPV of business
- 10% increase in ballast failure rate
  - lot of unhappy customers, and
  - 2.5% reduction in NPV of business

Light Testing Procedure Designed to Improve CPC's Basic Understanding

- Define a "standard" measurement zone
  - Typical room layout
  - Luminaire location, orientation
  - Measurement locations
- Determine types of lights to test
- Measure and record LUX at each test point
- Subject one light to extensive follow-on testing
- Evaluate results - gain insights

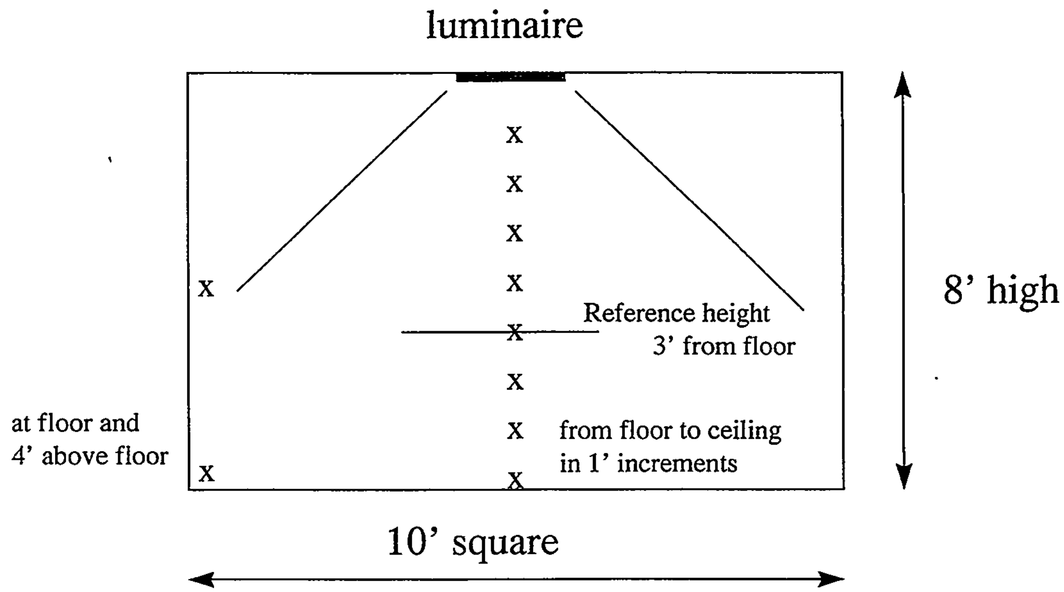
Types of Lights Tested

- Fluorescent lights
  - tube lamps (4, 6 and 8W DC)
    - with and without lens cover
    - metal Vs plastic reflectors
    - flat Vs curved reflectors
    - different lengths and diameters of tubes
    - domestic and imported
  - compact (5W AC)
- Incandescent (60W AC)
- Kerosene (wick lamp)

Community Power Corporation

Measurement Locations

(Elevation View)



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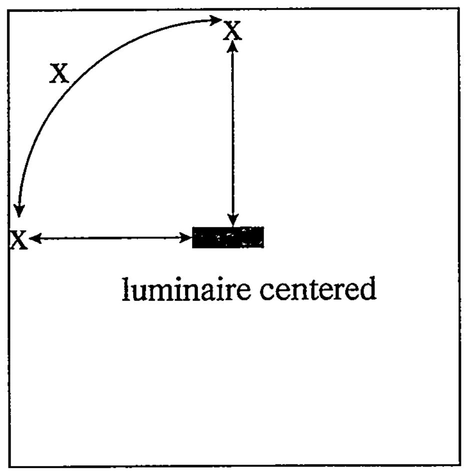
Measurement Locations
(Plan View)



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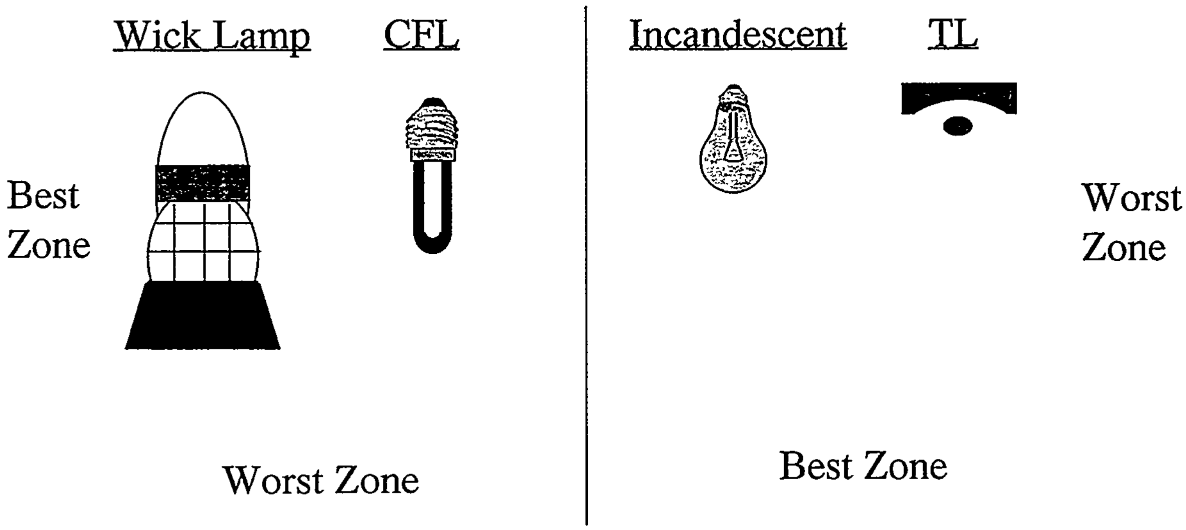
Definitions

- Lumen - a unit of luminous flux equal to the light emitted in a unit solid angle by a uniform point source of one candle
- LUX - a unit of illumination that is equal to one lumen per square meter

Luminaire Type/Design Determines Where Light Shines Best



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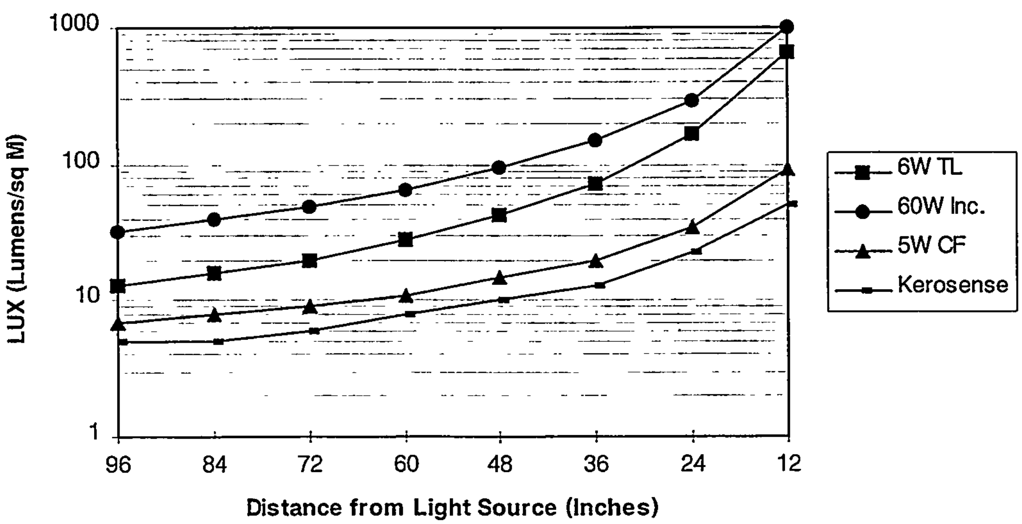
Four Light Types Were Compared



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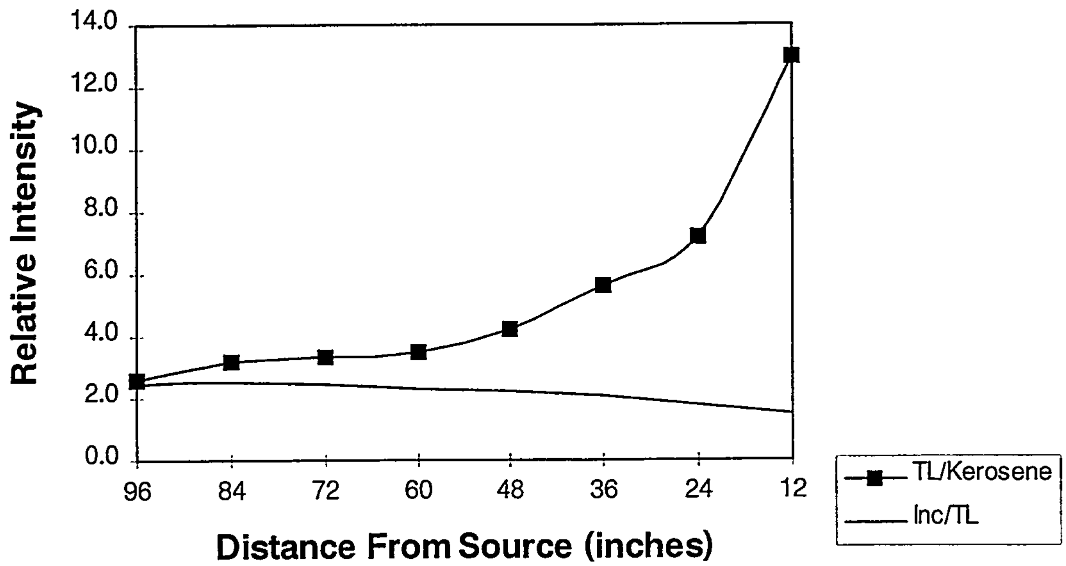
6W TL Performed Well Against Kerosene and Incandescent



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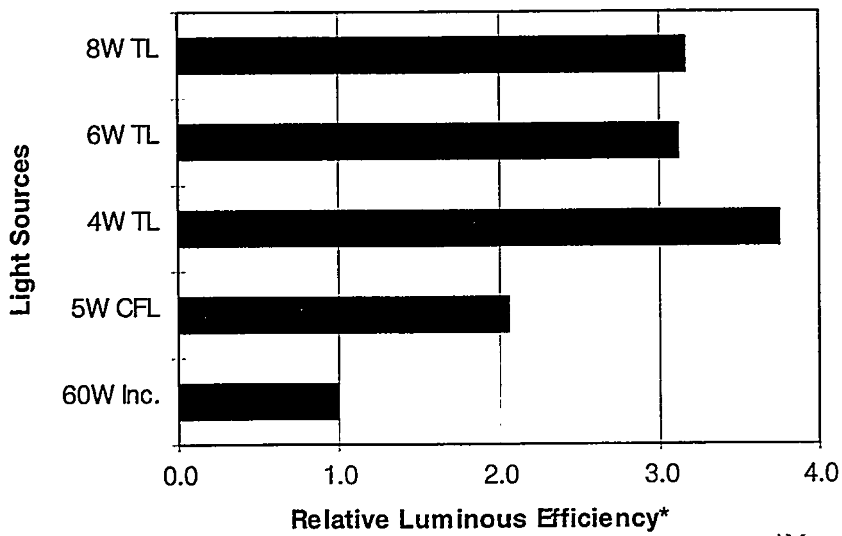
Fluorescents Were Significantly Higher In Luminous Efficiency



*Measurements 5' below light source

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Additional Tests Were Performed By CPC Based Upon the World Bank Specification

Lumen Output At Ambient Temperature
Minimum Striking Voltage
Maximum Continuous Operating Voltage
Minimum Operating Frequency
Electrical Wave form Of Inverter Output
Crest Factor
Reverse Polarity Protection
Protection Against Fluorescent Open Voltage
Bulb Replacement Easiness
Luminous Efficiency
Insect, Corrosion And Weather Protection
Technical Identification And Specification
Radio frequency noise
Heat and humidity Test
Salty Fog Test

Community Power Corporation

Conclusions

- For the most part, low wattage fluorescents perform well, but critical improvements are necessary
- Volume will be important in driving further improvement and cost reduction
- We've just scratched the surface of our understanding of this Killer App

Community Power Corporation

Village Microgrids: The Chile Project

E. Ian Baring-Gould
National Renewable Energy Laboratory

Project Definition

Objective:

Demonstrate the technical, economic and institutional viability of renewable energy for rural electrification.

Allow local partners to gain experience with hybrid/renewable technology, resource assessment, system siting and operation.

Hybrid Power Systems

Hybrid power system can be used to cover a wide range of needs. These include:

- **Dedicated use:** Water pumping/ice making.
- **House systems:** Power systems for individual buildings, dispersed generation.
- **Village Power Systems:** Providing power to a whole community from a central production point.

Village Power Systems

Village power systems can further be distinguished by size.

- Micro-grids
- Mini-grids
- Combines systems

All have the same feature that they are centrally located and used by the whole community.

VPS - Micro-grids

- Small village systems up to ~1200kWh/day load (50 kW peak load).
- Components of wind, PV, batteries and conventional generators.
- Usually single generator source.
- Use of batteries to cover light day time loads.

VPS - Mini-grids

- Large systems up to a few MW.
- Configured with multiple generators and turbines.
- Usually do not incorporate PV due to cost.
- Batteries used to smooth power fluctuations or in areas with very high fuel cost.
- Renewables can be used to reduce consumption of fuel.

VPS - Combined systems

- Combines a centralized hybrid system with home systems for more remote dwellings
  - Optimal stopping point of grid needs to be determined.
  - High and low voltage grid layout.
  - Maximizes coverage for given expenditures.

Advantages of Micro-grids

- AC power delivered
- Central power system, easy & controlled O&M
- Community based financing
- More consistent/reliable power
- Centralized distribution systems, the utility model
- Modular design allows flexibility and expansion as needed.
- Not dependent on single energy source.

Disadvantages of Micro-grids

- Metering required to reduce single consumption
- System capital costs
- Power distribution system that needs service

Chile Project Overview

- Resource assessment
- Rural electrification database
- Site selection
- Site clarification/data collection
- **Pilot system design/installation**
- Replication program
- Institutional Strengthening

Region IX Pilot Projects

- Regional resource assessment
- Siting trips
- Detailed data collection
- Basic system modeling and procurement review
- Technical assistance in system installation
- Data acquisition system design and installation
- System commissioning and testing
- Community training
- Long term system monitoring and technical assistance

Region IX Project Partners

- National Renewable Energy Laboratory (NREL) and the U.S. Department of Energy
- National Rural Electric Cooperative Association (NRECA)
- Chilean Comision Necional de Energia (CNE)
- American Wind Energy Association (AWEA)
- Frontel a local Chilean utility

Initial Investigation

Review of regional resource data to determine likely project areas

Field trips taken by NREL, AWEA, NRECA and Frontel staff to identify potential sites

- Discussions with Utility and local government
- Talk with local community leaders

Site selection

3 site selected

- Access to grid power
- Political motivations
- Good resource present

Detailed data gathered

- Resource data gathered using Scondwind Nomad dataloggers and fixed met towers
- Load estimate generated considering power usage and expected growth potential

•Pauacho

- Small hamlet on coastal ridge
- Regional school, heath post w/ professors quarters and 2 privet residences
- School only operated seasonally
- 4.0 kWh daily load with a 0.7 kW peak estimated.
- Average wind speed of 5.3 m/s with diurnal coastal sea breeze

•Isla Nahuel Huapi

- Island community of about 60 people in a coastal lake
- Mainly subsistence agriculture and fishing
- Health post and 11 homes
- 5.1 kWh daily load with a 0.7 kW peak estimated.
- Average wind speed of 5.1 m/s

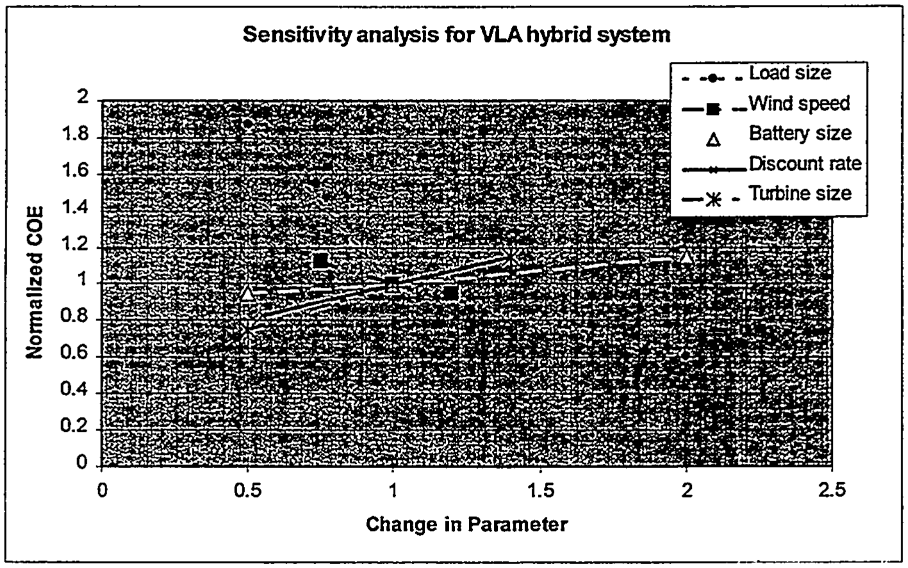
•Villa Las Araucarias

- Inland community on the coastal range
- Mainly supported by forest industry
- Health post, school and 17 homes
- Community very prosperous and growing
- 9.8 kWh daily load with a 1.2 kW peak estimated.
- Expected load increase and system expansion required
- Average wind speed of 4.8 m/s

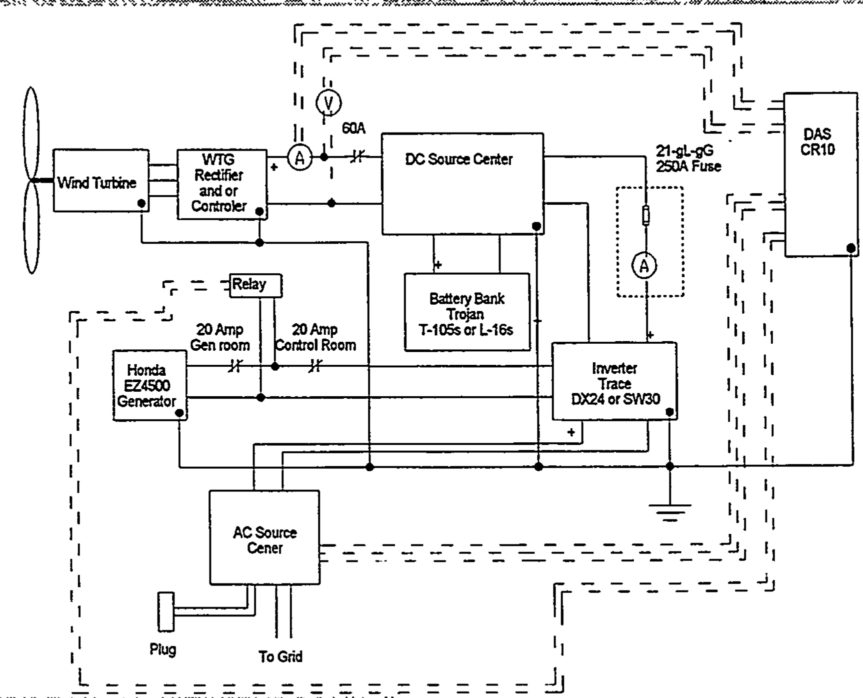
System Modeling

- Each of the proposed systems were extensively modeled at NREL and NRECA
- HOMER and Hybrid2 software models used in analysis
- Design constraints required 220V, 50 Hz power with a 97% load coverage
- Load growth was modeled into systems
- Local equipment was used when possible
- Parametric analysis was conducted on Wind speed, load, battery and turbine size and discount rate

System Modeling - Example



Basic System Design



System Procurement

- Bid specification determined from simulation modeling and RFP outlined
- Proposals reviewed and awarded
  - **Bergey Windpower: 2 systems**
  - **WorldPower Technology Company: 1 system**
- Systems purchased w/ replacement parts by NRECA and forwarded to Chile

System installation

Installation conducted over the Summer and Fall of 1996

Installation completed by

- NREL contractors
- NRECA
- Frontel engineers
- Frontel Contractors

Basic system design - Pauacho

Power System Components

- Bergey Windpower 1.5 kW wind turbine
- 14.4 kWh battery bank of Trojan T-105's
- Trace Engineering DX2424E inverter
- Honda EZ4500, 4.5 kW manual start gasoline generator
- 24 V DC bus with no DC loads
- 220 V, 50 Hz AC distribution on a 0.37 km grid

Basic system design - INH

Power System Components

- WorldPower Technologies Whisper3000 3.0 kW wind turbine
- 16.8 kWh battery bank of Trojan L-16's
- Trace Engineering SE3024E inverter
- Honda EM4500S 5.4 kW auto-start gasoline generator
- 24 V DC bus with no DC loads
- 220 V, 50 Hz AC distribution on a 1.61 km grid

Basic system design - VLA

Power System Components

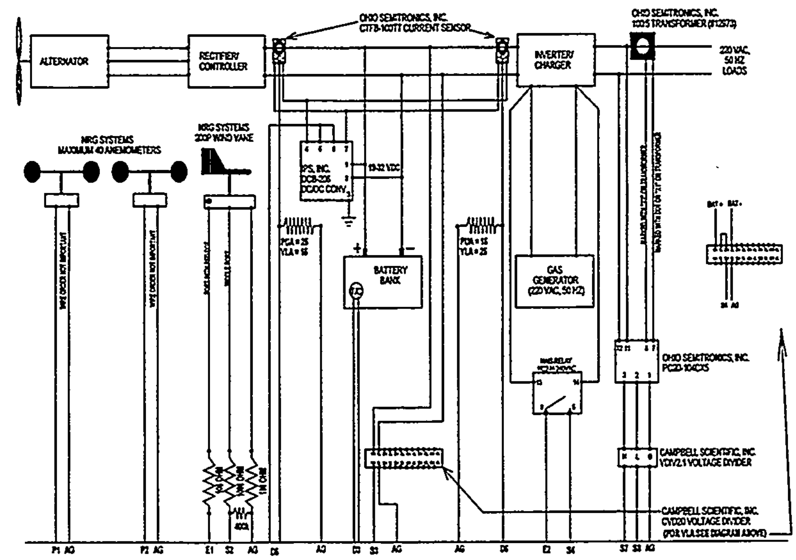
- WorldPower Technologies Whisper3000 3.0 kW wind turbine
- 33.6 kWh battery bank of Trojan L-16's
- Trace Engineering SE3024E inverter
- Honda EM4500S 5.4 kW auto-start gasoline generator
- 48 Volt DC bus with no DC loads
- 220 V, 50 Hz AC distribution on a 0.91 km grid

Data Acquisition System

System parameters

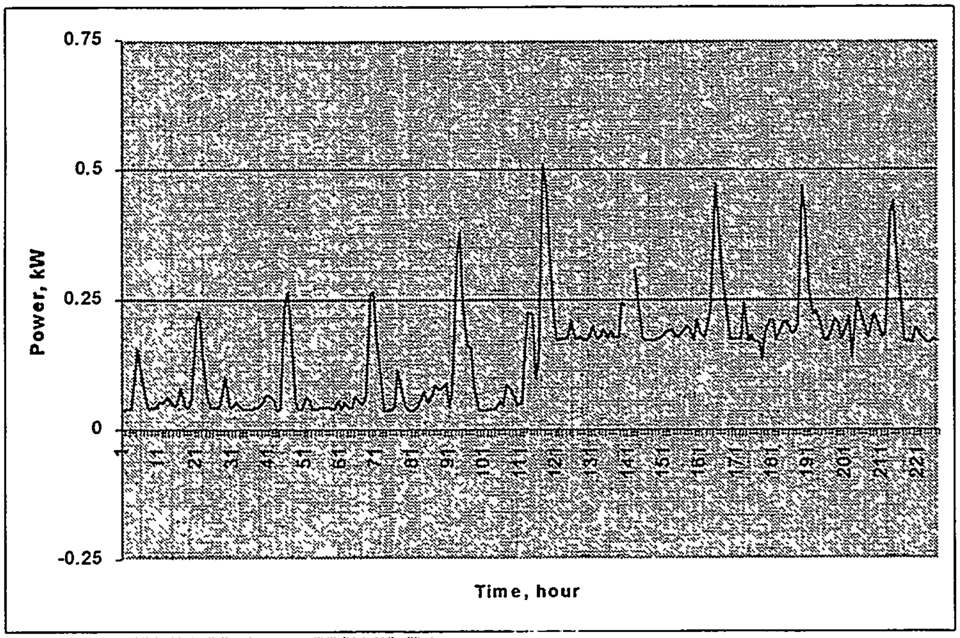
- 2 wind speeds and direction
- Grid Power (AC)
- Current from wind turbine and into Converter
- Battery bank temperature
- Diesel operational status
- Several temperatures

DAS for pilot projects



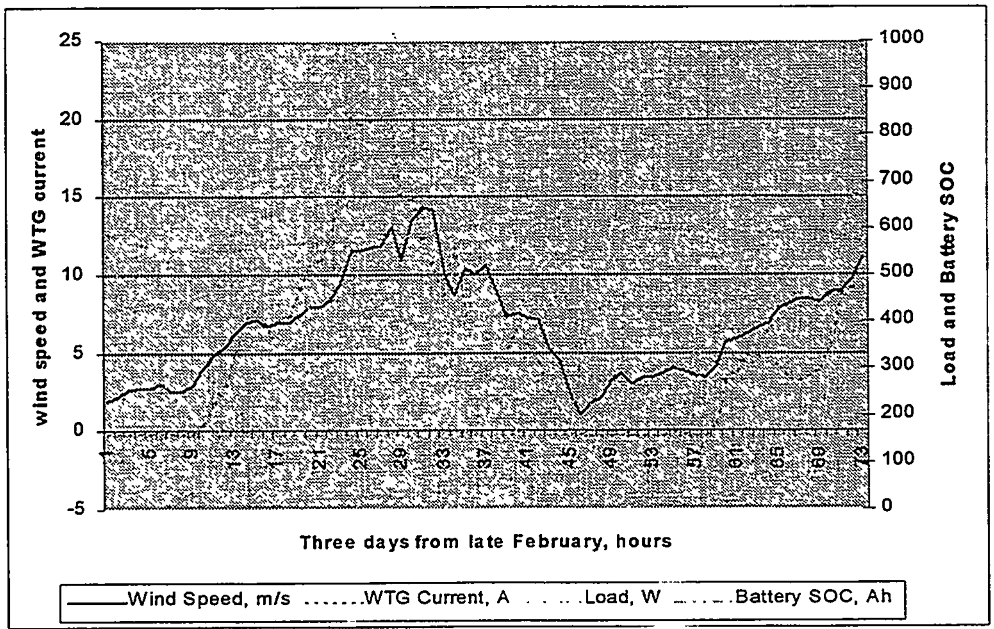
•System Results from VLA

Load data from mid March - Note load increase



System Results from Pauacho

Data taken by DA system for late February 1997



Village Education

Education class given

- A discussion was held at each village to discuss system operation, load management and electric safety.
- More education will follow

Community participation

- Several community member is responsible for system operation
- System checked daily and any problems reported to Frontel

System Status

Pauacho:

- System operating well, question about low battery voltage and watering

INH

- Problems with the WorldPower Technologies dump load has lead to temporary shutdown of the wind turbine

VLA

- No problems reported, load growth an issue

Rural Productivity Zones (RPZs) for Microenterprises

Richard D. Hansen
Global Transition Group

Village Power '97
Washington, D.C.
April 14, 1997

Global Transition Group

Global Transition Group

- Enersol Associates, Inc.
- SOLUZ, Inc.
- Global Transition Consulting, Inc.

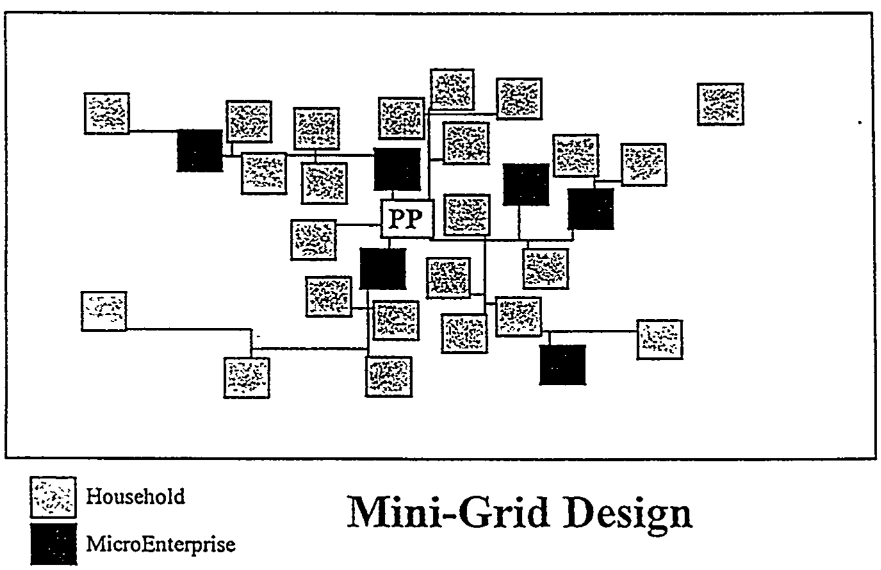
Global Transition Group

Rural Electrification Designs

- Grid Extension - central power source
- Mini-Grid - independent power unit
- Wireless energy services

Global Transition Group

Clustered Population



Mini-Grid Design

Enersol Associates, Inc.

Matching Energy Technology and Rural Need
(Dispersed Population)

ENERGY SECTOR/APPLICATION	ENERGY SOURCE					
	PV	Wind	Diesel Hybrid	Kerosene/ LPG	Biomass	Solar Water Heating
Household						
Lighting	◆	◆				
Radio/Cassette	◆	◆				
Television	◆	◆				
Fan	◆	◆				
Iron				◆		
Refrigerator	◆	◆		◆		
Cooking				◆	◆	
Water Heating					◆	◆
Community						
Potable Water Pumping	◆	◆				
Schools (audio-visual, computers, lighting)	◆	◆				
Health Centers:						
Lighting	◆	◆				
Refrigeration	◆	◆				
Hot Water						◆
Community Centers (lighting, PA/music system)	◆	◆				
Street Lighting	◆					
RPZ for MicroEnterprises						
Woodworking Shop			◆			
Laundry Service			◆			
Cafeteria/Ice-Making			◆			
Telephone/E-Mail Center			◆			
Battery Charging Station			◆			
Electronics Repair Shop			◆			
Beauty Salon			◆			◆
Seamstress/Tailor Shop			◆			
Agriculture						
Water Pumping for Livestock and Irrigation	◆	◆				

Household Needs

- Electricity - PV or small wind turbines
- Cooking - kerosene, LPG, or biomass

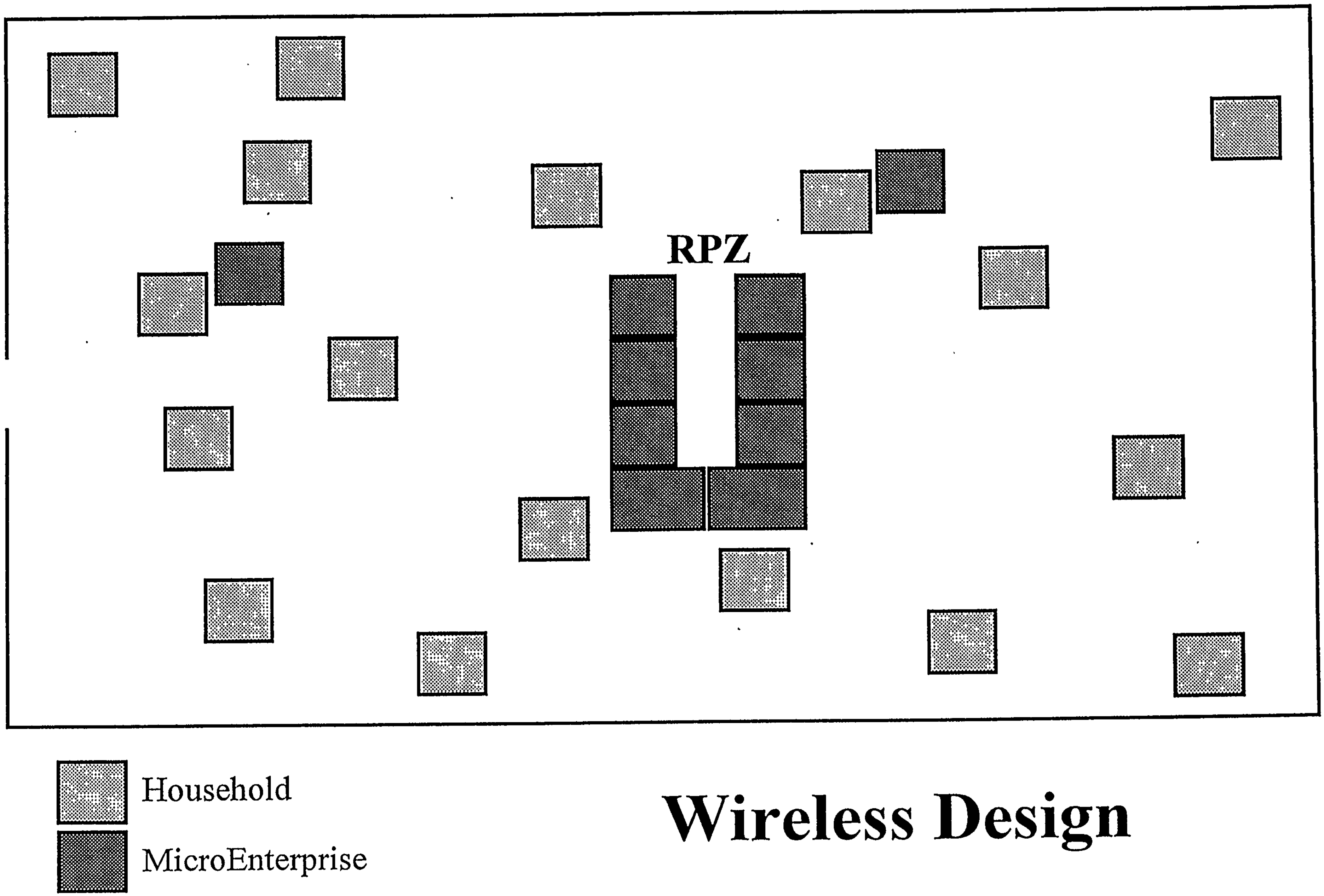
Global Transition Group

Community Needs

- Electricity for schools, clinics - PV or wind
- Water Pumping - PV or wind

Global Transition Group

Dispersed Population



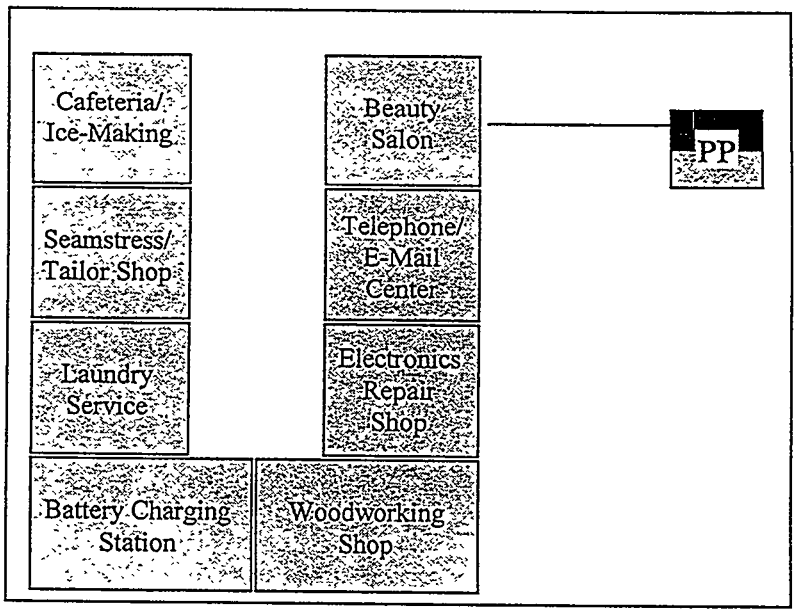
Wireless Design

Enersol Associates, Inc.

Rural Productivity Zones (RPZ) for MicroEnterprises

RPZ - a business incubator to foster income-producing opportunities for the rural poor.

Global Transition Group



RPZ for Micro-Enterprises

Enersol Associates, Inc.

RPZ - Essential Ingredients (Support Services)

- Electric Power
- Business Development Assistance
- Office Services
- Quality Work Space

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Enersol Associates, Inc.

RPZ - Electric Power

- High quality diesel/wind/PV hybrid
- Reliable electrical service (6-6 or 10)
- Maintenance contract w/ supplier
- Load management program

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Enersol Associates, Inc.

RPZ - Business Development Assistance

- Accounting
- Marketing
- Loans

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Enersol Associates, Inc.

RPZ - Office Services

- Photocopier/computer
- Telecommunications
- Receptionist

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Enersol Associates, Inc.

RPZ - Work Space

- Legal and Stable
- Secure
- Healthy

Global Transition Group

VILLAGE ELECTRIFICATION OPTIONS

Battery Charging Stations

NREL Village Power '97

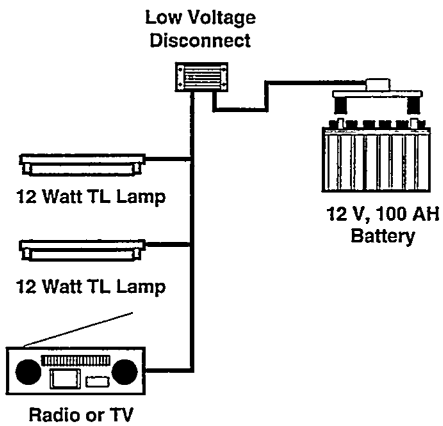
Michael Bergey
Bergey Windpower Co.

Battery Charging Stations (BCS)
Batch Delivery of Electricity

- Transport of Vehicle Batteries to Urban Areas for Charging is a Common Self-Electrification Approach in Rural Areas
- BCS Moves the Charging Capability Closer to the Customers and Usually Upgrades Components and Services
- Probably Powered by Renewables and Hybrids
- Captures Economies of Scale Available from Some Renewable Technologies
- *Has the Potential to Provide Lower Costs of Service, More Consistent Service, and Better Cost Recovery than Other Rural Electrification Approaches*

Level of Service

Comparable to Solar Home System

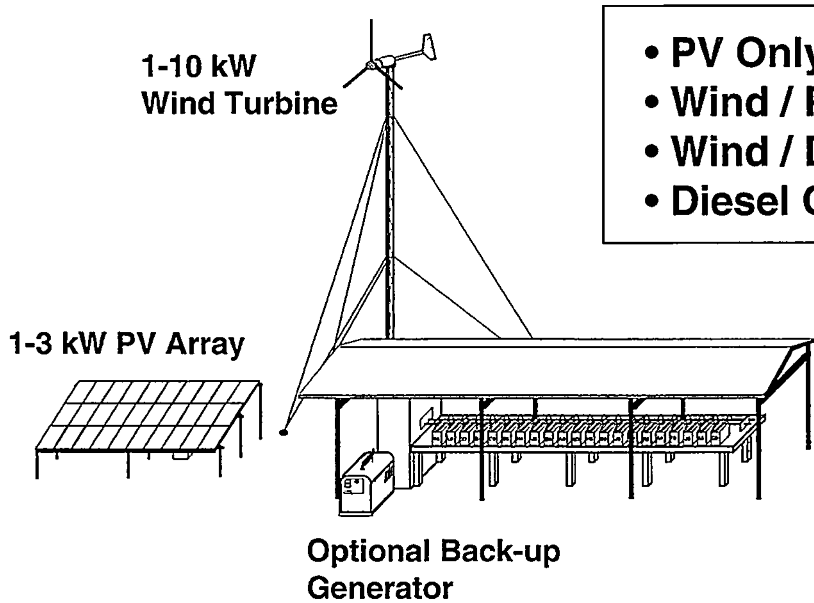


Typical Home System

- 12 VDC
- ~ 130 Wh per Day

Typical Configurations

Serving 200 - 1200 People



- PV Only
- Wind / PV
- Wind / Diesel
- Diesel Only

Thailands PV Battery Charging Stations

- Department of Public Works: Over 1,000 stations installed since 1988. ~ 1 kW each
- Department of Energy Development and Promotion: ~ 150 stations installed. ~ 3 kW each
- Stations are in Northern Thailand
- Users bring batteries in for charging and must use specific ~ 50 AH batteries
- Charging fee is between 50¢ and $1.00

Other Non-Grid BCS Projects

- Zimbabwe: Battery charging rigs retrofitted to diesel grinding mills, ODA project
- Philippines: PV powered stations, part of GTZ project
- Mauritania: Wind powered stations, part of Alize Electric GEF project
- Guatemala: Wind powered station(s), NRECA
- Indonesia: Wind powered station, part of Winrock GEF project
- Brazil: PV powered stations, private enterprise, Golden Photon

Bergey Windpower Activities

- Developing system with 10 kW BWC wind turbine and ~8 kW diesel, serving ~ 400 homes
- NREL providing technical assistance through the National Wind Technology Center
- Costs ~ 40-50¢ to charge 100 AH battery
- BWC is very interested in private sector electrification
- Full service concept: Station owns batteries and delivers weekly
- Hope to provide lower service level (70 Wh/day, self delivery) for less than $3 per month
- R&D focusing on the specific charging architecture

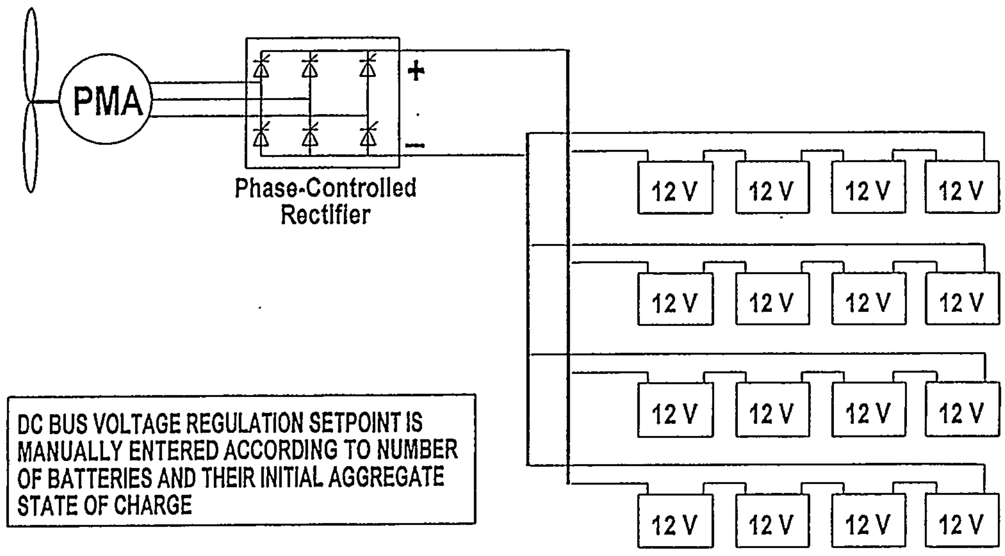
Battery Charging Architectures

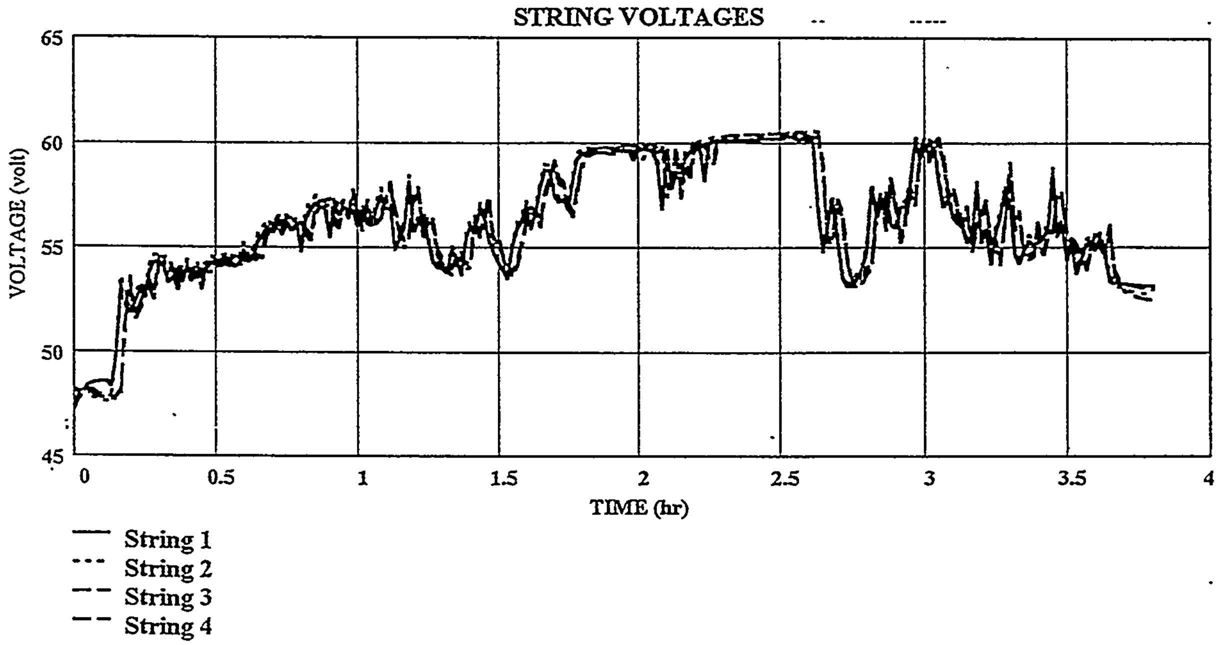
- Single DC Bus
- Dual or Multi-Bus
- DC-DC Converters
- Station Battery with Fast Chargers

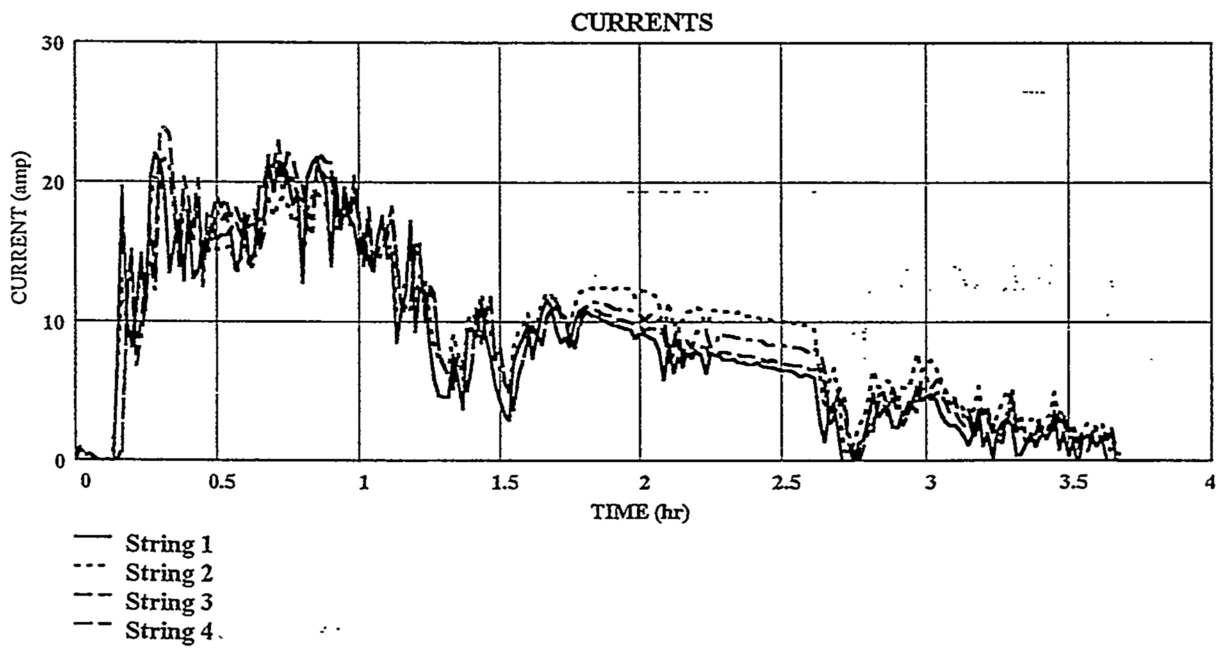
<u>Considerations</u>

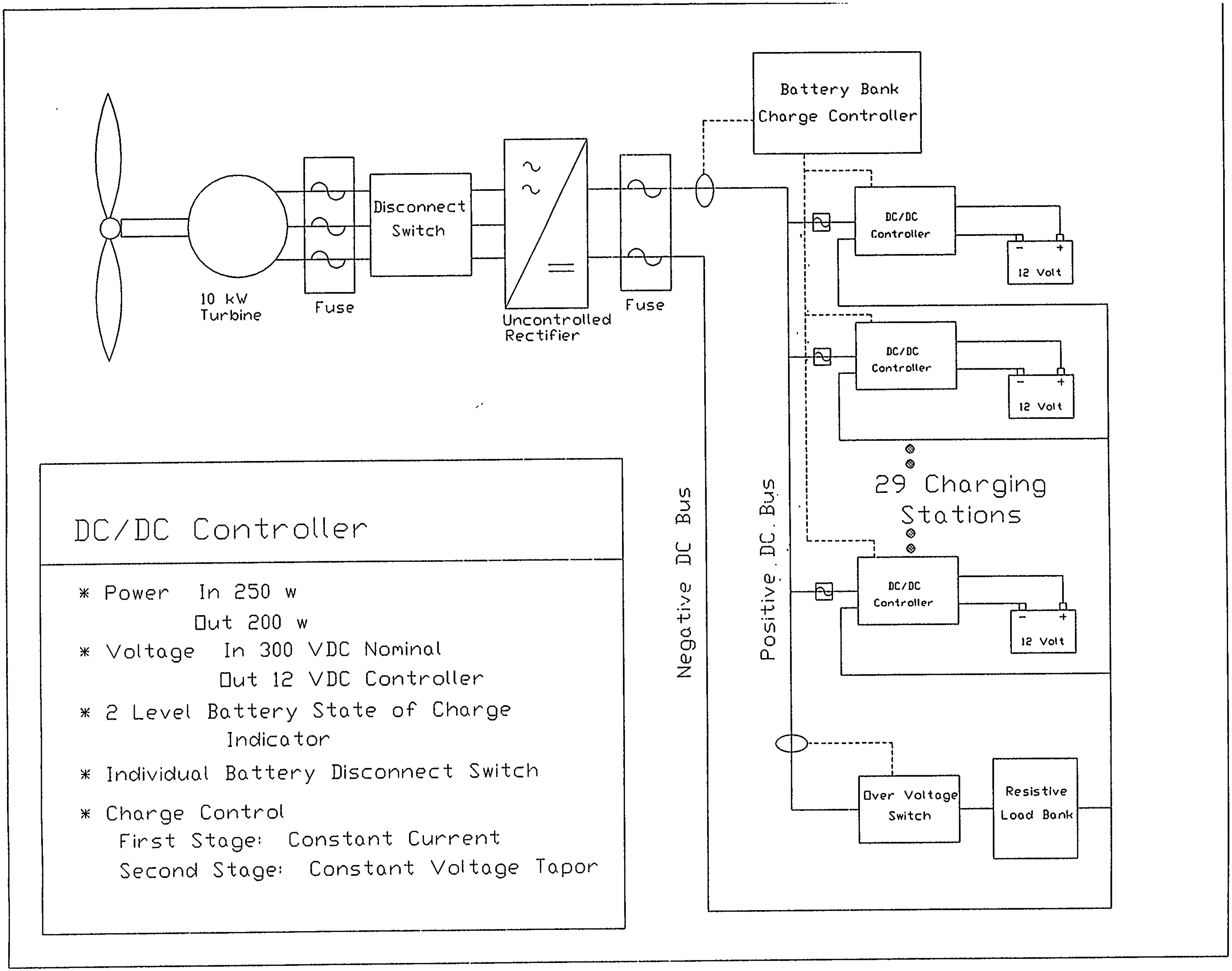
- Cost & Reliability
- Optimal use of available renewable energy
- Ability to provide full charge
- Operational aspects of charging mode (e.g.: batch mode)

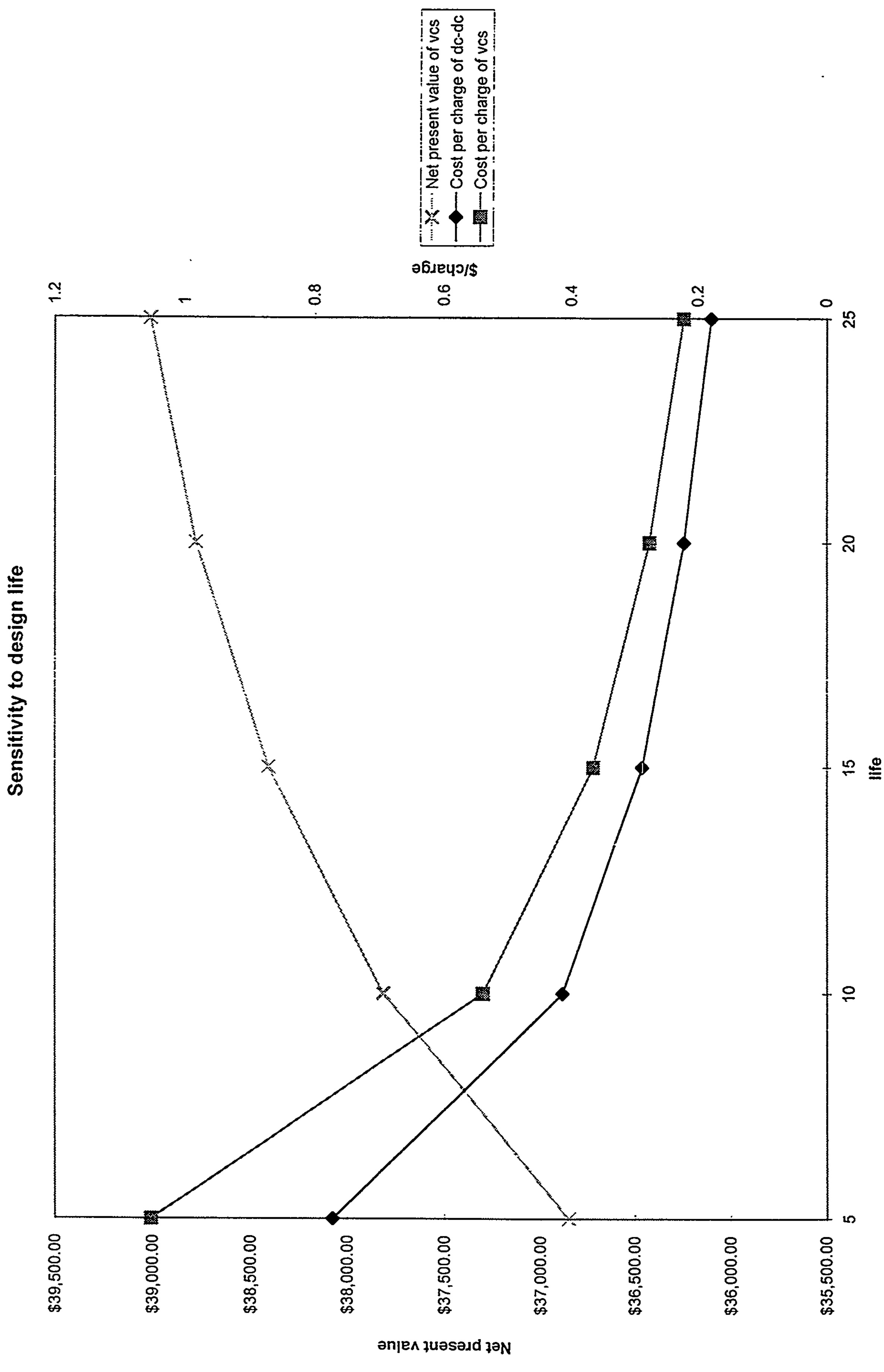
DC BUS VOLTAGE CONTROL




STRING VOLTAGES
VOLTAGE (volt)
65
60
55
50
45
0
0.5
1
1.5
2
2.5
3
3.5
4
TIME (hr)
String 1
String 2
String 3
String 4


CURRENTS
CURRENT (amp)
30
20
10
0
0
0.5
1
1.5
2
2.5
3
3.5
4
TIME (hr)
String 1
String 2
String 3
String 4


10 kW
Turbine
Fuse
Disconnect
Switch
Uncontrolled
Rectifier
Fuse
Battery Bank
Charge Controller
DC/DC
Controller
12 Volt
DC/DC
Controller
12 Volt
29 Charging
Stations
DC/DC
Controller
12 Volt
Negative DC Bus
Positive DC Bus
Over Voltage
Switch
Resistive
Load Bank
DC/DC Controller
* Power In 250 w
Out 200 w
* Voltage In 300 VDC Nominal
Out 12 VDC Controller
* 2 Level Battery State of Charge
Indicator
* Individual Battery Disconnect Switch
* Charge Control
First Stage: Constant Current
Second Stage: Constant Voltage Tapor



Sensitivity to design life
Net present value
$39,500.00
$39,000.00
$38,500.00
$38,000.00
$37,500.00
$37,000.00
$36,500.00
$36,000.00
$35,500.00
$/charge
1.2
1
0.8
0.6
0.4
0.2
0
5
10
15
20
25
life
Net present value of vcs
Cost per charge of dc-dc
Cost per charge of vcs

MINI-BIOMASS ELECTRIC GENERATION

Gary Elliot
International Applied Engineering, Inc.
Atlanta, Georgia

Objective

Awareness of the living standards achieved by others has resulted in a Russian population which is yearning for a higher standard of living. Such a situation demands access to affordable electricity in remote areas. Remote energy requirements creates the need to transport power or fossil fuels over long distances. Application of local renewable energy resources could eliminate the need for and costs of long distance power supply. Vast forest resources spread over most of Russia make biomass an ideal renewable energy candidate for many off-grid villages.

The primary objective for this preliminary evaluation is to examine the economic feasibility of replacing distillate and gasoline fuels with local waste biomass as the primary fuel for village energy in outlying regions of Russia. Approximately 20 million people live in regions where Russia's Unified Electric System grid does not penetrate. Most of these people are connected to smaller independent power grids, but approximately 8 million Russians live in off-grid villages and small towns served by stand-alone generation systems using either diesel fuel or gasoline. The off-grid villages depend on expensive distillate fuels and gasoline for combustion in small boilers and engines. These fuels are used for both electricity generation and district heating. Typically, diesel generator systems with a capacity of up to 1 MW serve a collective farm, settlement and their rural enterprises (there are an estimated 10,000 such systems in Russia). Smaller gasoline-fueled generator systems with capacities in the range of 0.5 - 5 kW serve smaller farms or rural enterprises (there are about 60,000 such systems in Russia).

Historically, the state farming collectives and rural industries received energy practically free of charge. The former Soviet Union's artificial and centralized pricing system kept the price of fuels for energy generation and the gasoline to transport the fuels to remote places very low. Furthermore, the electric tariff the consumers paid was subsidized by the central government and had no relation to the actual cost of power production and delivery. Understandably, locally available renewable energies were not used significantly.

Today, newly privatized farms and rural enterprises must pay for sharply increased energy prices themselves. The much higher costs of energy severely threaten the rural economies. In addition, it is believed that close to half of the stand-alone diesel and gasoline systems are no longer operating. This is true mostly because of high fuel costs. Other factors contributing to the shutting down of present operating systems are inadequate maintenance and/or failure to replace components which have exceeded their operating life.

As the fossil fuel and new equipment prices in Russia have increased, the local governments or village utilities that are responsible for rate collection are faced with the difficult task of either passing the high costs to rate payers or subsidizing the power supplied. Consequently, implementing a strategy to replace expensive fossil fuels with lower priced alternatives has become critically important.

Since Russia is heavily forested, most of the off-grid areas have access to abundant wood and, in many cases, have an established timber industry. The wood wastes derived from wood utilization in the area are not currently used to maximum potential; i.e. energy production. Establishment of village power plants utilizing local waste biomass seems to be the proper strategy to provide low cost power to these remote areas. Even in the absence of a timber industry, collection and delivery of biomass just for the purpose of energy production may prove to be cost-effective.

Implementation of a biomass-fueled village energy program creates opportunities for transfer of US know-how, and a market for local and US based goods and services. This market is large enough - in the order of hundreds and perhaps even thousands of MWs - that it could attract participation from the US energy industry; provided it can be determined that social, political, financing, technical, and technology transfer sustainability obstacles can be overcome. A pilot project will help address these sustainability issues and set the foundation for replication of the project in other remote villages. The intent of this preliminary evaluation is to determine if a full feasibility analysis for the pilot project and replication stage would be worthwhile, to identify potential fatal flaws, and to propose a methodology for the ensuing feasibility study if it is warranted.

Background

The US Department of Energy (DOE) has agreed to provide technical assistance to its Russian counterpart, Ministry of Fuel and Energy (MFE) in the renewable energy area. DOE has designated the National Renewable Energy Laboratory (NREL) to provide this assistance. MFE has identified the Russian Northern Territories as a priority area demanding NREL's assistance. The program initially affects about 900 villages. Biomass and wind energy, and to lesser extent small hydroelectric energy, depending on resource availability, are expected to play the dominant role in the program. Geothermal energy may also have a role in the Russian far east. Arkhangelsk, Kariela, Novo Sibirsk, and Krasnoyarsk regions, all in Russian Northern Territories, have abundant forest resources and forest products industries.

The 900 villages included in the program span across 15 administrative regions, 6 autonomous republics, and 10 autonomous districts inhabited by indigenous minorities. The regional authorities in the Northern Territories proposed these villages to MFE according to the following criteria: a) Remote off-grid location, b) high cost of transporting fuel, c) old age of existing power generation equipment, and d) preliminary determination as to availability of alternative energy resources. Inclusion of indigenous minorities in the program was also heavily emphasized.

The village chosen for this study is Verkhni-Ozerski (Upper Lake) which is located 80 km to the north of Onega Port. A dirt logging trail owned by the saw-mill connects the village to Onega. While traveling on the trail one could see thickly covered virgin fur, pine, and birch forests with every now and then the thick forests opening up to show beautiful lakes and large marshlands. The village has a population of approximately six hundred living in 215 homes. The primary source of income is the saw-mill. The saw-mill leases forest from the Onega District Administration. The village has two police officers and a school. For village power distribution there exists a micro-grid. The source of electricity is a small power plant comprised of three 315 kW diesel engines - two operating and one back-up. A waste biomass-fueled district heating facility comprised of four old boilers (three operating and one back-up) provides hot water to the village buildings.

Analysis and Conclusions

The Attachments A through J provide a complete analysis and financial overview of the opportunity for replacing diesel fueled electric generation with waste biomass fueled capacity. Replacement of the existing wood fired district heating system is also included in the analysis. These preliminary calculations indicate good economic driving forces supporting a waste biomass fueled cogeneration facility. A more detailed study is warranted to finalize the approach for initiating a pilot project as an example for other village based mini-biomass electric generation projects to follow.

APPENDIX A

COST of DIESEL FUEL
for
RUSSIAN WASTE BIOMASS ENERGY PILOT PROJECT

FUEL COSTS

The most significant cost savings benefits derived from the used of waste biomass fuel electric generation is the reduction in #2 fuel oil costs. The biomass plant requires some costs of operation. However, the additional costs required to produce energy from biomass are more than offset by the reduction in non-fuel operating costs of the diesel generation equipment as set forth in Appendix G. Therefore, the #2 (diesel) fuel oil cost savings are a net cost savings and represent increased profitability for the forest products company which owns and operates the village power plant.

Based on annual average operating data and fuel purchase records, the #2 fuel oil cost savings resulting from the proposed waste biomass power plant can be determined as follows:

1. The average 5 month (May - September) 1995 daily diesel fuel consumption was 0.900 tonnes (t_m).
2. The average 7 month (October - April) 1995 / 1996 daily diesel fuel consumption was 2.330 tonnes (t_m).
3. The average daily (5 - 10 days) winter peak diesel fuel consumption was 3.000 tonnes (t_m).
4. The average net kilowatt-hour (kWh) requires 0.318 kg of diesel fuel.
5. The present cost of a tonne (t_m) diesel fuel delivered to the village power plant is 1,754,000 Russian rubles (R).
6. The present exchange rate is 5,500 Russian rubles per US dollar (5,500 R/$1.00).

From the above, the delivered cost of diesel fuel at the village can be shown as:

(1,754 kR/t_m) / (5.5 kR/$1.00) = $318.90/$t_m$ or $318.90/$t_m$ / 2,205 lb/t_m = $0.1446/lb
or $0.446/$lb_{oil}$ (7.206 lb_{oil}/gal) = $1.042/gal

The 1995 / 1996 diesel fuel costs can be calculated as follows:

<u>May - October 1995</u>
5 months (30 days/month) 0.900 t_m/day ($318.90/$t_m$) = $ 43,052
<u>November - April 1995/1996</u>
7 months (30 days/month) 2.330 t_m/day ($318.90/$t_m$) = $156,038
<u>Winter Peak load 5-10 days</u>
7.5 days (3.000 t_m/day) $318.90/$t_m$ = <u>$ 7,175</u>

Total Annual Diesel Fuel Oil Cost = $206,265

APPENDIX B

COST of BIOMASS FUEL
for
RUSSIAN WASTE BIOMASS ENERGY PILOT PROJECT

FUEL COSTS

Assumptions:

1. Raw biomass processing costs including all labor and equipment for forest cutting and collection, loading and unloading and the labor for sizing are not a cost factor since it will be provided by the present infrastructure.

2. Transportation costs for waste biomass to be processed is only the marginal cost of the added fuel used to transport the waste biomass along with merchantable logs which is estimated to average $0.50/wet tonne.

3. Profit is not a factor since energy generation is a cost of operations.

4. 50% average fuel moisture content.

5. Waste softwood and hardwood mixed higher heating value is 8,400 Btu/dry lb (19,500 kJ/dry kg).

Total fuel costs per the above assumptions will then be no more than $0.50/wet tonne as received at the pilot project plant site.

- The calculated gross and net heat rates for electric generation is 53,800 Btu/kWh, gross (23,100 kJ/kWh, gross) and 64,100 Btu/kWh, net (27,600 kJ/kWh, net).

- The average annual operating biomass fueled electrical consumption can be calculated as:

Average for 5 months (30 d/month) 2,830 kWh/day	=	424,500 kWh
+ Average for 7 months (30 d/month) 7,338 kWh/day	=	1,540,980 kWh
Total Annual Biomass Electric Consumption	=	**1,965,480 kWh**

- The as received higher heating value per the above assumptions is calculated to be:
8,400 Btu/dry lb (0.5 dry lb/lb as received) = 4,200 Btu/lb as received

- The cost per tonne as received can then be calculated to be:
  ($0.50/tonne) / [4.2kBtu/lb(2.2 klb/tonne)] = **$0.0541/MBtu**

- The fuel cost per kWh can then be calculated as follows:
  $0.0541/MBtu(0.0641MBtu/kWh) = **$0.00347/kWh**

The annual cost of waste biomass fuel required for electric generation can then be calculated as follows:

1,965,480 kWh/yr(0.0641MBtu/kWh)$0.0541/MBtu = **$6,816/yr**

APPENDIX C

COST of OPERATION & MAINTENANCE
for
PRESENT AND FUTURE RUSSIAN DIESEL FUELED OPERATIONS

PRESENT AND FUTURE OPERATION & MAINTENANCE (O&M) COSTS:

ITEM	DESCRIPTION	PRES. ANNUAL COST ($)	FUTURE ANNUAL COST ($)
1. Oil Changes	Cooling and lubrication oil every 2,000 op. hrs.	7,110	948
2. Min.Upper Unit	Heads and assoc. equip. every 6,000 op. hrs.	9,480	1,264
3. Maj.Upper Unit	Ejectors and outside machining every 18,000 hrs.	11,850	1,580
4. Full Overhaul	Major upper and lower repair every 42,000 hrs.	13,543	1,806
O&M	**Totals**	**41,983**	**5,598**

The costs are based on 14,220 present and 1,896 future (with waste biomass fueled pilot plant) average operating hours over a 12 year period. The above annual cost estimates assume that all other charges remain constant and that costs not required in any one year are accumulated in a reserve account.

The O&M costs were determined for each item as follows:

1. Oil Changes (oc) - Cost of cooling and lubrication oils, filters, etc. at $1,000/oc required every 2,000 operating hours calculated as follows:

   Present - (14,220 hr/yr / 2,000 hr/oc) $1,000/oc = $7,110/yr
   Future - (1,896 hr/yr / 2,000 hr/oc) $1,000/oc = $948/yr

2. Min. Upper Unit (mu)- Cost of routine maintenance of upper diesel including replacing broken springs, worn rockers and other moving parts, rebuilding ejectors, lapping valve seats, etc. at an average of $4,000/mu required every 6,000 operating hours calculated as follows:

   Present - (14,220 hr/yr / 6,000 hr/mu) $4,000/mu = $9,480/yr
   Future - (1,896 hr/yr / 6,000 hr/mu) $4,000/mu = $1,264/yr

3. Maj. Upper Unit (mau) - Cost of major overhaul of upper diesel including sending heads out for reconditioning at an average of $15,000/mau required every 18,000 operating hours calculated as follows:

   Present - (14,220 hr/yr / 18,000 hr/mau) $15,000/mau = $11,850/yr

Future - (1,896 hr/yr / 18,000 hr/mau) $15,000/mau = $1,580/yr

4. Full Overhaul (fo) - Cost of major overhaul of upper and lower diesel including sending heads and crankshaft out for reconditioning at an average of $40,000/fo required every 42,000 operating hours calculated as follows:

   Present - (14,220 hr/yr / 42,000 hr/fo) $40,000/fo = $13,543/yr
   Future - (1,896 hr/yr / 18,000 hr/fo) $15,000/fo = $1,806/yr

APPENDIX D

COST of OPERATION & MAINTENANCE
for
RUSSIAN WASTE BIOMASS ENERGY PILOT PROJECT

ANNUAL OPERATION AND MAINTENANCE (O&M) COSTS:

ITEM	DESCRIPTION	ANNUAL COST ($)
1. Auxiliary Fuel	Peaking loads, scheduled & unscheduled outages	N/A
2. Real Estate Tax	For land and plant facilities	N/C
3. Maintenance	Includes material and outside labor	9,400
4. Spare Parts	Restocking and local Spare Parts Only	7,300
5. Consumables	Includes water treatment chemicals, lubrication oils, etc.	3,500
6. Ash Removal	Continues local land application	N/C
7. Administrative	Includes all plant overhead and office supplies	N/C
8. Miscellaneous	Outside engineering and maintenance	11,700
9. Cap. Improvement	Reserve account accumulated for future use	N/C
O&M	**Total**	**31,900**

Note: N/A means "not applicable" and N/C means "no change".

The above annual cost estimates assumes one scheduled outage totaling 2 weeks, and numerous unscheduled outages totaling 240 additional hours of down time. Estimates do not include annual biomass fuel costs or any other external costs which are calculated separately.

The O&M costs were determined for each item as follows:

1. Auxiliary Fuel - The existing diesel generator installation will provide back up, peaking and outage load capacity and does not add to the operating cost calculations. However, use of the existing diesel generation equipment will impact the cost by reducing the savings resulting from installation of the waste biomass fueled facility as set forth in Appendix C.

2. Real Estate Tax - The present tax assessments, if any, for land and real property are not expected to be affected.

3. Maintenance - Assumes turbine retrofit and partial re-tubing every 5 years, refractory every year, etc.

4. Spare Parts - Assumes replacement of all spares used for US sourced equipment including all conveying and auxiliary systems from US suppliers.

5. Consumables - Includes oil, grease, water treatment chemicals, hydraulic fluids, etc. from local supply sources.

6. Ash Removal - Local gardens already use ash from district heating for soil conditioning and fertilizing.

7. The present village administration is not expected to alter present practices and personnel requirements.

8. Assumes that outside professional services will be contracted every other year. This cost will be reduced as local labor learns the techniques and practices.

9. Capital Improvement - Funds to allow for improvements to plant and operations, such as personnel training and equipment upgrades should not be changed from present practices.

APPENDIX E

LABOR COST ESTIMATES
for
RUSSIAN WASTE BIOMASS ENERGY PILOT PROJECT

ANNUAL LABOR COSTS:

The present labor pool in the village operates, maintains and repairs the existing wood fired district heating and diesel electric generating systems including the high and low voltage electric systems. Since the waste biomass fired electric generating system replaces 90% of the diesel generation and 50% of the district heating, it is expected that the waste biomass plant will not add any additional labor requirements or annual labor costs to the present energy operations. In fact, since the proposed waste biomass energy generating plant is more automated than the present energy systems, there may be less direct labor required.

It is likely that the skilled and semi-skilled labor force present in the village will be capable of doing most of the repairs and maintenance allocated to outside labor in the operating cost estimates provided in Appendix D. Since this work will be provided as part of the day to day work activities already covered by the cost basis of present operations, the total costs to operate and maintain the waste biomass energy system will be reduced accordingly.

APPENDIX F

HARD COST ESTIMATES
for
RUSSIAN WASTE BIOMASS ENERGY PILOT PROJECT

ENGINEERING, PROCUREMENT, AND CONSTRUCTION (EPC) COSTS

This table shows the full cost structure as if a firm were hired to engineer, procure and construct the waste biomass energy pilot plant on a "turn key" basis. Cost savings can be realized by utilizing existing and local labor and equipment and by buying only those special or proprietary items from foreign sources. Savings can also be realized if multi-unit procurements are possible so that certain common engineering and design elements can be spread over multiple applications. Volume discounts can also be negotiated with multiple orders.

ITEM	DESCRIPTION	COST ($M)
1.	Boiler Equipment Module (Including pollution control, fans, pumps, etc.)	108
2.	Turbine/Generator Equipment Module	71
3.	Water Treatment Module	15
4.	Plant Facilities Systems (Including buildings and structural members)	123
5.	Electrical, Controls & Instrumentation (Including transformers & MCC's)	43
6.	Material Handling and Processing Systems	108
7.	Construction and installation (Including concrete)	198
8.	Engineering and Design	223
9.	Construction Supervision, Start-up and Training and Expenses	113
10.	Shipping, Import Duties, Taxes and Fees	58
11.	**Sub-total EPC Costs**	**1,060**
12.	Contingency of 10%	106
13.	**Total EPC ("HARD") COSTS**	**1,166**

The assumptions made for the above Hard Cost determination are as follows:

1. The construction will be performed with Russian skilled labor.
2. The boiler and turbine/generation modules will be shipped from the US.
3. Land will be donated.
4. Site preparation is not included.

5. Roads and other access requirements are not included.
6. Biomass Fuel and Environmental Impact Assessment costs are not included.
7. Feasibility studies and technical transfer costs are not included.

TABLE OF EPC, MODULAR , MULTI-UNIT, AND AVOIDED COSTS

This table shows the full cost structure of EPC "hard" costs verses hard costs resulting form estimates of modular purchases of equipment with a maximum of local content, verses the same components purchased on a one of ten multi-unit purchase. Also included is the hard cost estimate if local owners utilize there existing infrastructure to the maximum extent possible to avoid higher external costs.

	A - EPC			B - Local/Modular			C - Local/Multi-Unit		
ITEM	EPC COST ($M)	AVOID. COST ($M)	FINAN. COST ($M)	MOD. COST ($M)	AVOID. COST ($M)	FINAN. COST ($M)	M.-U. COST ($M)	AVOID. COST ($M)	FINAN. COST ($M)
1.	108	0	108	97	0	97	92	0	92
2.	71	0	71	64	0	64	61	0	61
3.	15	0	15	15	0	15	14	0	14
4.	123	123	0	123	123	0	117	117	0
5.	43	0	43	43	0	43	41	0	41
6.	108	31	77	103	26	77	98	25	73
7.	198	198	0	198	198	0	168	168	0
8.	223	37	186	190	74	116	162	63	99
9.	113	0	113	38	11	27	32	10	22
10.	58	7	51	0	0	0	0	0	0
11.	**1,060**	**396**	**664**	**871**	**432**	**439**	**785**	**383**	**402**
12.	106	40	66	87	43	44	78	38	40
13.	**1,166**	**436**	**730**	**958**	**475**	**483**	**864**	**422**	**442**

Note: The item numbers correspond to the descriptions provided in the initial EPC table.

The changes in assumptions made for the above Hard Cost determinations are as follows:

A - EPC: No changes in the base assumptions. The avoided costs are based on using local construction and existing infrastructure and equipment. For example the pilot project village administration owns chipping equipment which could be used in lieu of US sourced purchased equipment. The site village personnel have the ability to do all construction labor and materials and supplies for the required building structures.

B - Local/Modular: Assumes that all components are manufactured locally and that some of the engineering and all the construction supervision is handled locally.

C - Local/Multi-Unit: Assumes multi-unit purchase discounts for all components and engineering.

APPENDIX G

FINANCING & FEASIBILITY STUDY COST ESTIMATES for RUSSIAN WASTE BIOMASS ENERGY PILOT PROJECT

FINANCING COSTS

The nature of the biomass to energy project is such that they will be subject to typical bank financing fees and loan closing charges which are estimated to be **7.50% of the loan amount**. The average fee cost would be lowered if the projects were completed under a muli-unit loan program to be installed at ten sites including the pilot project.

FEASIBILITY STUDY COSTS

The estimated costs required prior to the development of the Pilot Project which have not been in the Soft Cost determination are estimated as follows:

	COST ($M)
1. Pre-feasibility Assessment (rough budget pricing) not covered by NREL funding.	33
2. Feasibility Study (firm pricing) and negotiated technical transfer agreements for US based technology for a minimum of 10 sites.	285
3. Environmental Impact Assessment (pilot and 9 additional sites)	70
4. Waste Biomass Assessment (pilot and 9 additional sites)	50
Sub-Total Feasibility Study Costs	**438**
5. Contingency of 10%	44
TOTAL FEASIBILITY STUDY COSTS	**482**

APPENDIX H

PRESENT VALUE CALCULATIONS
for
RUSSIAN WASTE BIOMASS ENERGY PILOT PROJECT

A. FUTURE DIESEL PURCHASE COSTS

Assumptions:

1. If the biomass equipment is **not** installed, then the existing diesel/generator equipment will need to be replaced according to the following schedule:
   a) The first unit will be replaced in the summer of 1999.
   b) The second unit will be replaced in the summer of 2001 if its life is extended by the preferential use of the new equipment.
   c) The third unit will be replaced in the summer of 2003 if its life is extended by the preferential use of the newest equipment.
2. The salvage value of each of the existing diesel/generator units is $10,000.
3. The cost of each replacement installation (in 1997 dollars) is estimated to be $400/kW: 315 kW ($400/kW) = $126,000.
4. The present value is calculated using a discount rate of 8%/yr.

<u>Present Value Calculations:</u>

The installation of a waste biomass energy plant in the summer of 1999 eliminates the need to replace two of the three diesel/generator units. One unit will need to be replaced to provide the necessary emergency and peaking capacity. The savings resulting from avoiding the purchase of each of the two diesel/ generator units is simply calculated as follows: $126,000 - $10,000 = $116,000

The present value of the two diesel generation sets which do not need to be replaced can be calculated as follows:

1. Since the first diesel/generator unit will not need replacement in 1999, the value discounted to 1997 can be calculated as **99,451.**
2. Since the second unit will not need replacement in 2001, the value discounted to 1997 can be calculated as **85,263.**
3. The total discounted value of avoiding the purchase of the two units is **$184,714.**

Life Extension Calculations:

The third diesel/generator unit must be replaced. However, since the biomass plant will be on line in 1999 and will provide a large majority of the electric load, the remaining two diesel/ generator units will operate fewer hours. Using the same hours of life as they would otherwise be expected to operate, the biomass project will extend the operation of the unit to be replaced in 2001 by three years and the unit to be replaced in 2003 by an additional six years. The overall nine year life extension will add value which is calculated as follows:

If the unit were replaced in 2003 its present value would be:	$73,100
With life extension of 9 years to 2012 the present value would be:	$36,568
The difference is the net present value derived from the biomass plant =	**$36,532**

The total net present value of savings in the purchase of diesel/generation equipment derived from the installation of the waste biomass to energy pilot plant is: **$221,246.**

B. FUTURE BOILER PURCHASE COSTS

Assumptions:

1. If the biomass plant is **not** installed, then the existing district heating boiler equipment will need to be replaced according to the following schedule:
   a) The first unit will be replaced in the summer of 1997.
   b) The second unit will be replaced in the summer of 1999.
   c) The third unit will be replaced in the summer of 2003.
   d) The fourth unit will be replaced in the summer of 2003.
2. The salvage value of each of the existing boiler units is zero.
3. The cost of each replacement installation (in 1997 dollars) is estimated to be $80,000.
4. The present value is calculated using a discount rate of 8%/yr.

Present Value Calculations:

The installation of a waste biomass energy plant in the summer of 1999 eliminates the need to replace one of the four boiler units. The other three units will need to be replaced to provide the necessary district heating and hot water capacity.

The present value of the boiler unit which does not need to be replaced can be calculated as follows:

The value of the unit which will not be replaced in 1999 discounted to 1997 is **$68,587.**

Life Extension Calculations:

The other three boiler units must be replaced. However, since the biomass plant will be on line in 1999 and will provide a portion of the district heating and hot water load, the remaining boiler units will operate fewer hours. Using the same hours of life as they would otherwise be expected to operate, the biomass project will extend the operation of the two boiler units to be replaced after 1999 as calculated below:

Present Case Boiler Operations:	
Summer - 1 unit (5 months) 30 days/month (24 hr/day) =	3,600 hr
1 unit (5 months) 30 days/month (6 hr/day) =	900 hr
Winter - 3 units (7 months) 30 days/month (24 hr/day) =	15,120 hr
1 unit (7 months) 30 days/month (6 hr/day) =	1,260 hr
Winter Peak - 4 units (7.5 days) 24 hr/day =	720 hr
Total annual operating hours =	21,600 hr

The annual operating hours/boiler would be: 21,600 hr / 4 boilers = 5,400 hr/boiler

Biomass/Electric Case Boiler Operations:	
Summer - 1 unit (14 days) 24 hr/day =	336 hr
1 unit (14 days) 6 hr/day =	84 hr
Winter - 2 units (7 months) 30 days/month (24 hr/day) =	10,080 hr
1 unit (7 months) 30 days/month (6 hr/day) =	1,260 hr
Winter Peak - 3 units (7.5 days) 24 hr/day =	540 hr
Sub-total annual operating hours =	12,300 hr
Additional unscheduled biomass boiler outages	120 hr
Total annual operating hours =	12,420 hr

The annual operating hours/boiler would be: 12,420 hr / 3 boilers = 4,140 hr/boiler.

The reduction in the annual operating hr/boiler is: (5,400 - 4140) = 1,260 hr/boiler.
Extending the life of three boilers by 1,260 hr/yr for 4 yr = 15,120 hr of additional life.
The two boilers to be replaced in 2003 would receive approximately 2 years of additional life each.

The present value of replacing two boilers in 2003 is:	$100,828
The present value of replacing the boilers in 2005 is:	$ 87,784
The net increase in the present value is:	**$ 13,044**

The total net present value of savings in the purchase of the boiler equipment derived from the installation of the waste biomass to energy pilot plant is: **$81,631.**

The total net present value of savings in the purchase of both the diesel/generation and boiler equipment derived from the installation of the waste biomass to energy pilot plant is: **$221,246 + $81,631 = $302,877.**

APPENDIX I

CRITERIA and GREENHOUSE GAS EMISSION OFFSETS for RUSSIAN WASTE BIOMASS ENERGY PILOT PROJECT

A. WASTE BIOMASS FUEL

Carbon dioxide emissions are considered to be neutral since the waste biomass used will decompose and produce equal or greater greenhouse gas impacts. Using a similar output of 315 kW at 7500 hr/yr as was used for the diesel case below, the emissions of criteria pollutants from the waste biomass fueled pilot plant are as follows:

Component	Predicted (lb/MBtu)	Annual Emissions (lb/yr)	(kg/yr)
NO_x	0.02	3,039	1,378
So_x (high)	0.003	454	206
Particulate	0.30	45,431	20,607
Hydrocarbons	0.007	1,060	481

The Greenhouse gas emissions are as follows:

	(lb/MBtu)	(ton/yr)	(tonne/yr)
CO_2	N/A	N/A	N/A

B. DIESEL FUEL

The emissions from the existing diesel generators are presently unknown. The actual emissions data will be collected during the in country data gathering trip during the feasibility study. The data shown below is the predicted and/or guaranteed emissions from similarly sized diesel generators presently being marketed in the United States. The emissions of criteria pollutants from a diesel utilizing a low sulfur #2 diesel fuel at maximum load for 7,500 hours per year is as follows:

Component	Predicted (lb/MBtu)	Annual Emissions (lb/yr)	(kg/yr)	Difference (+/- %)
NO_x	1.24	53,620	24,370	+ 1,769
So_x (low)	0.13	5,621	2,555	+ 1,240
Particulate	0.042	1,816	825	- 96
Hydrocarbons	0.068	3,718	1,690	+351

The Greenhouse gas emissions are as follows:

	(lb/MBtu)	(ton/yr)	(tonne/yr)	(tonne/yr)
CO_2	147.68	3,912	3,549	3,549

APPENDIX J

RETURN ON INVESTMENT AND INTERNAL RATE OF RETURN CALCULATIONS for RUSSIAN WASTE BIOMASS ENERGY PILOT PROJECT

A. RETURN ON INVESTMENT CALCULATIONS

From Appendix E, it can be seen that the cost of the waste biomass pilot plant is estimated to be $1,166,000. The local owners of the pilot plant are capable of buying down the cost of the plant by $436,000 or 37.4% by investing locally available materials and labor. The balance of $730,000 must be borrowed.

Savings derived from the estimated initial investment of $436,000, as determined in Appendix I, are approximately $303,000. The resulting return on investment is calculated as follows:

$303,000 / $436,000 = 0.6950 or **69.50% ROI.**

B. INTERNAL RATE OF RETURN CALCULATIONS:

Using a loan period of 12 years, quarterly payment periods, 7.5% loan and bank fees and an interest rate of 10% per year, the annual debt service for the borrowed amount of ($730,000 + $54,750 = $784, 750) is calculated to be ___________($102,620?).

The net annual savings derived from the biomass plant operations can be determined as follows:

1.	From Appendix A, the annual diesel fuel cost savings are:	$206,265
	From Appendix B, the annual additional cost of biomass fuel are:	$ 6,816
	The net annual fuel savings are:	**$199,499**
2.	From Appendix C, the annual biomass plant operating cost are:	$31,900
	From Appendix G, the future annual diesel plant operating cost are:	$ 5,598
	The total future operating cost are:	$37,498
	From Appendix G, the present annual diesel plant operating cost are:	$41,983
	The net annual operating cost savings are:	**$ 4,485**

3. From Appendix D, the labor costs for either biomass or diesel operations are the same and no net annual labor costs savings are allocated.

4. Total net annual savings are: $199,499 + $4,485 = $203,984 ~ **$204,000.**

The pre tax internal return on investment is then: $204,000 - $203,000? = **$101,000.**

The return on the borrowed funds is: $101,000 / $784,750 =0.1282 or **<u>12.82%</u>**

Village Power Options

Presentation to:

Village Power '97
Arlington, Va.
April 14, 1997

Peter Lilienthal, Ph.D.
National Renewable Energy Laboratory
Golden, Co. U.S.A

Rationale for Model Development

- Limited Field Data
- Diverse Applications
- Cost and performance comparisons
- Generate insights into cost structures

3 NREL Models

- **Hybrid2 - publicly available, detailed engineering simulation model to analyze the performance of specific configurations**
- **The Hybrid Optimization Model for Electric Renewables (HOMER) - economic screening model for sensitivity analysis**
- **The Village Power Model (VIPOR) - network optimization model for comparing mini-grids to individual systems**

Village Power '97
Arlington, Va.
April 14, 1997

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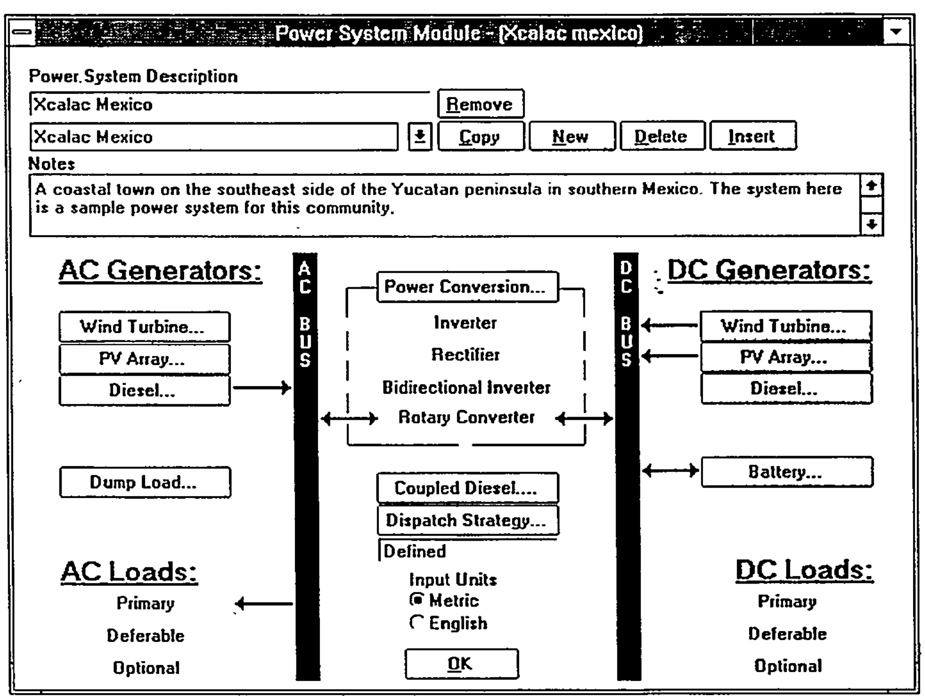
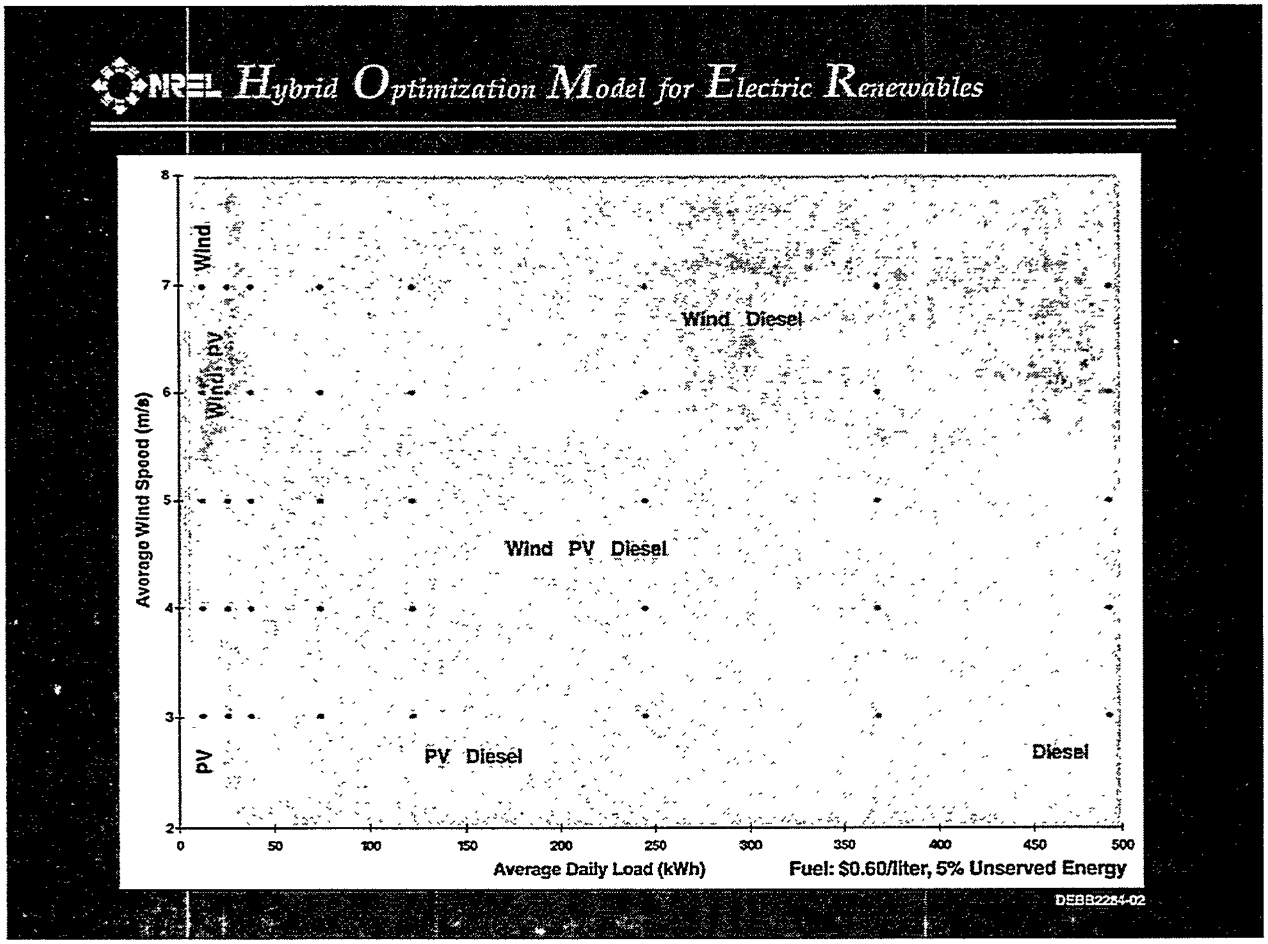
Peter Lilienthal

NREL



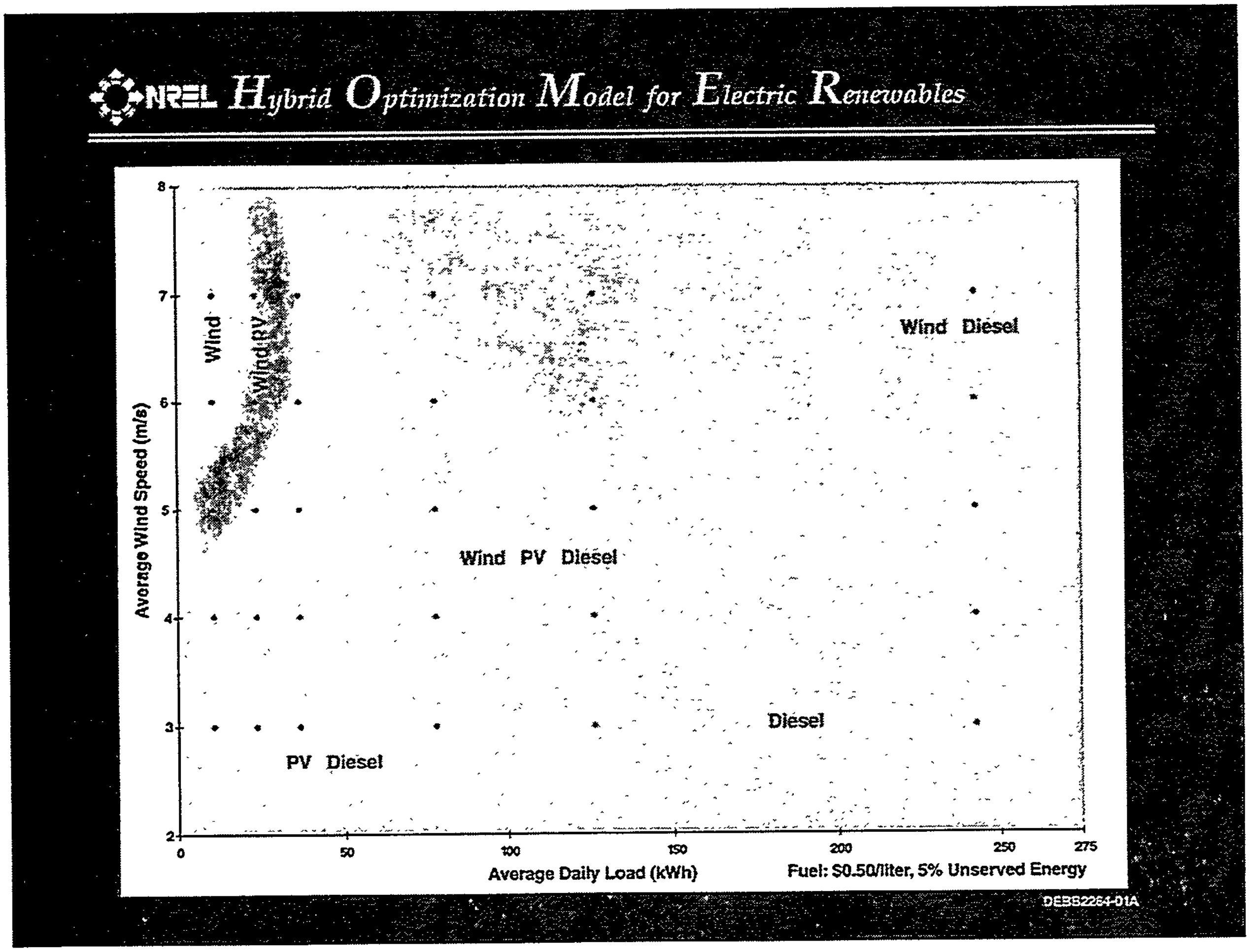
HOMER

- **Prefeasibility analysis when data is sketchy**
- **Quickly generate a preliminary design**
- **Sensitivity of design to: resource profiles, equipment and fuel cost, load shapes**



Assessing the least cost mix of supply technologies is a difficult analytical problem that depends on the quality of the various resources, the local costs of equipment, labor and fuel, and the site-specific descriptions of the daily and seasonal variations in the loads, as well as the options for simple load management. The Hybrid Optimization Model for Electric Renewables (HOMER) is a screening model that is useful for prefeasibility and sensitivity analysis. This graph is an example of HOMER's outputs for a specific set of assumptions. The results can change dramatically with different assumptions.

Sensitivity analyses were performed on the size of the load and the average annual windspeed. For very low loads in a good wind resource one small wind turbine will produce more energy than required. In lesser wind resources or as the load increases a combination of wind and PV is preferred. Although in this example PV-diesel is the optimal choice in poor wind resources for the smallest loads that were modeled (12 kWh/day), a pure PV system would be preferred for smaller loads or higher fuel prices or if more than 5% unserved energy would be acceptable. In the larger sizes, both wind turbines and diesel gen-sets have economies of scale that make PV less competitive. The vertical line representing 125 kWh/day demonstrates a seemingly counter-intuitive insight from the model. At moderate windspeeds PV is cost-effective, even though it was not cost-effective at low windspeeds. This is because the cost of the balance of systems required to utilize PV (batteries and inverter) is being shared by the wind turbines.



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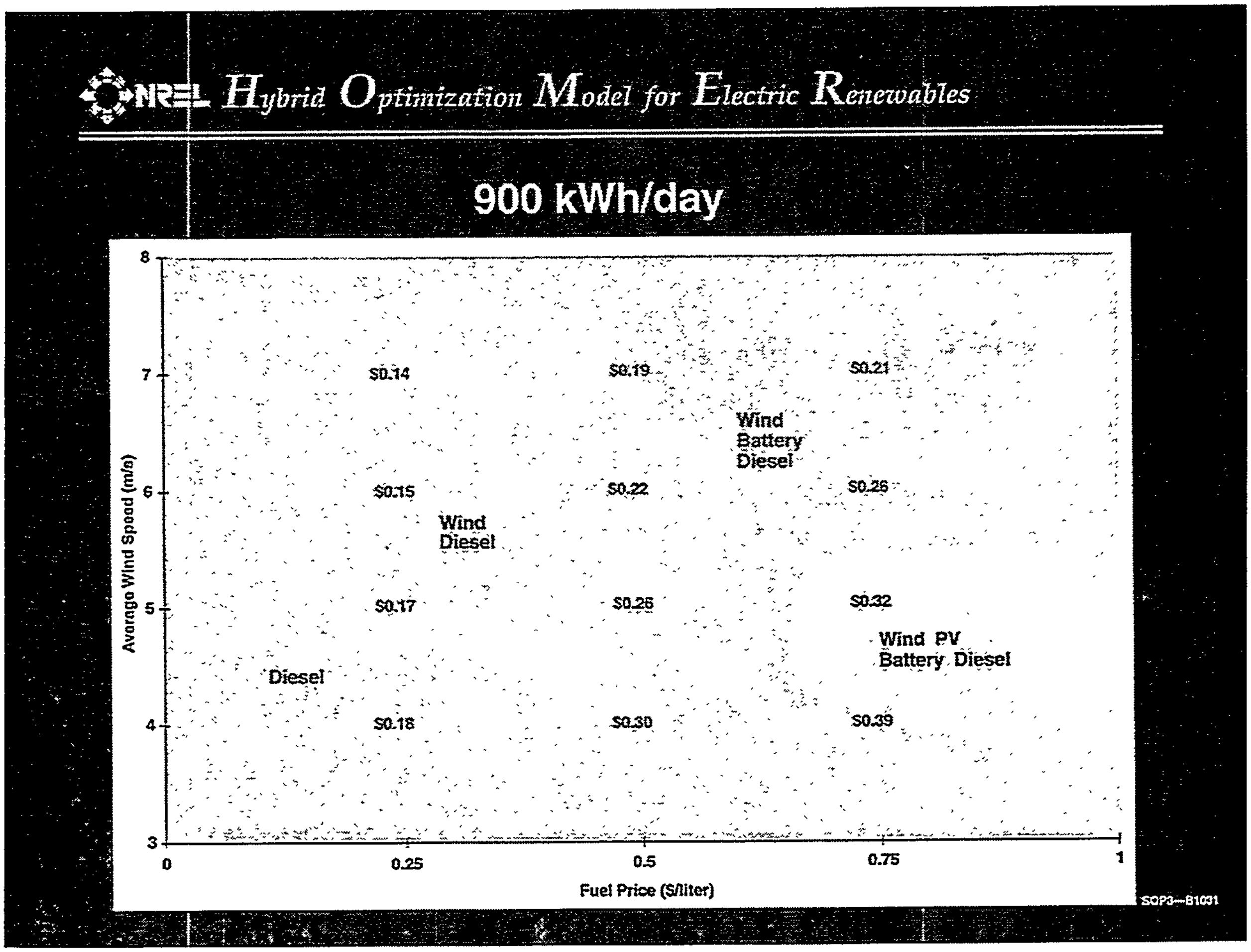
Sensitivity analyses were performed on the size of the load and the average annual windspeed. This graph clearly shows a minimum load below which diesel is not cost effective and a maximum load above which PV is only cost effective in conjunction with wind. It also shows that 4 meters per second is a minimum annual average windspeed for the cost-effective utilization of wind turbines. For very low loads in a good wind resource one small wind turbine will produce more energy than required. In lesser wind resources or as the load increases a combination of wind and PV is preferred. In the largest sizes there is a seemingly counter-intuitive insight from the model. At moderate windspeeds PV is cost-effective, even though it was not cost-effective at low windspeeds. This is because the cost of the balance of systems required to utilize PV (batteries and inverter) is being shared by the wind turbines.



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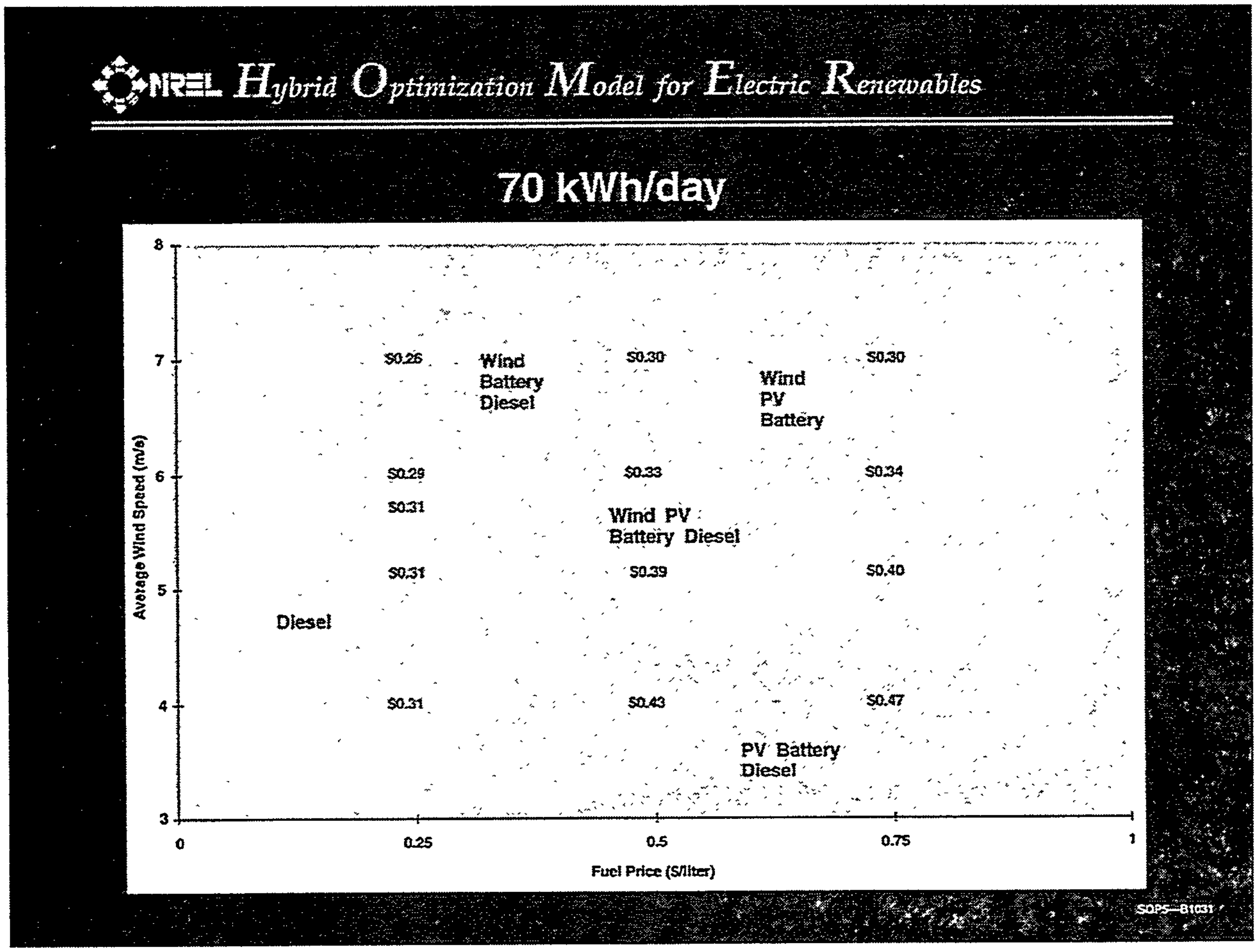
Sensitivity analyses were performed on the fuel price and the average annual windspeed for villages of 70 and 900 kWh per day. In the smaller village photovoltaics are competitive if the fuel price is at least $0.50 per liter, while in the larger villages the fuel price must be $0.75 per liter and PV's role is merely to supplement the wind in moderate wind regimes. At lower fuel prices wind can be competitive, but only in very good wind regimes of at least 5-6 meters per second. In the small size range diesels are less cost effective, so at high fuel prices and decent wind regimes the justification for a diesel is redundancy for reliability rather than minimizing cost. In the larger size range diesels are more competitive and batteries are less competitive. The role of batteries is very sensitive to load shape, but there are many applications in this size range where only a very small battery bank or none at all is the optimal design.



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ViPOR

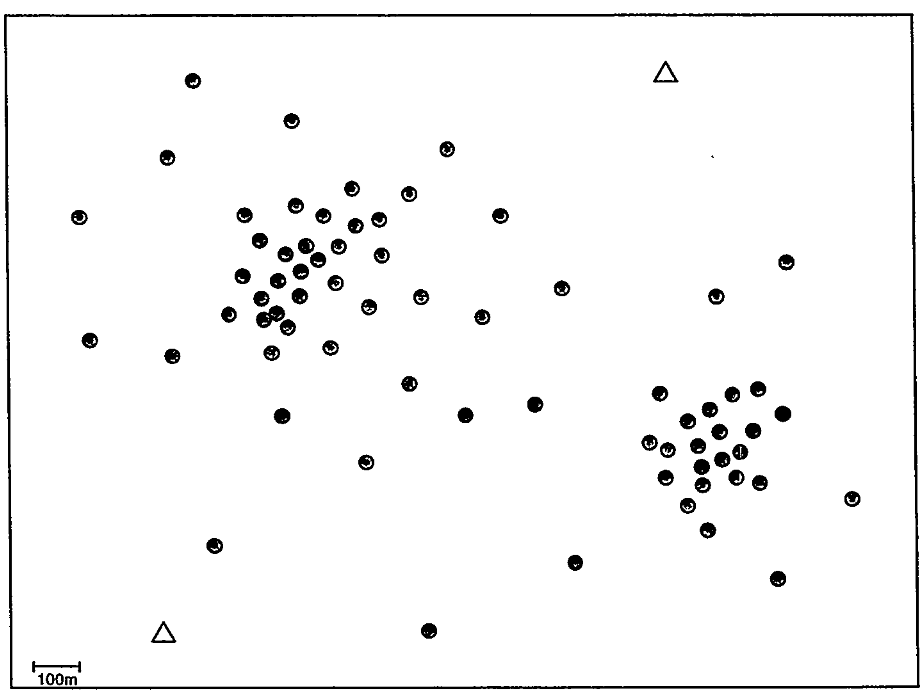
ViPOR is an optimization model than can be used in conjunction with HOMER to find the lowest-cost method of electrifying a remote village.

For a specific village, ViPOR can:

- Optimize the mix of centralized and individual generation
- Determine the optimum number and placement of transformers
- Design a near-optimal low voltage distribution grid
- Select the lowest-cost site from among several potential sites for the centralized power system

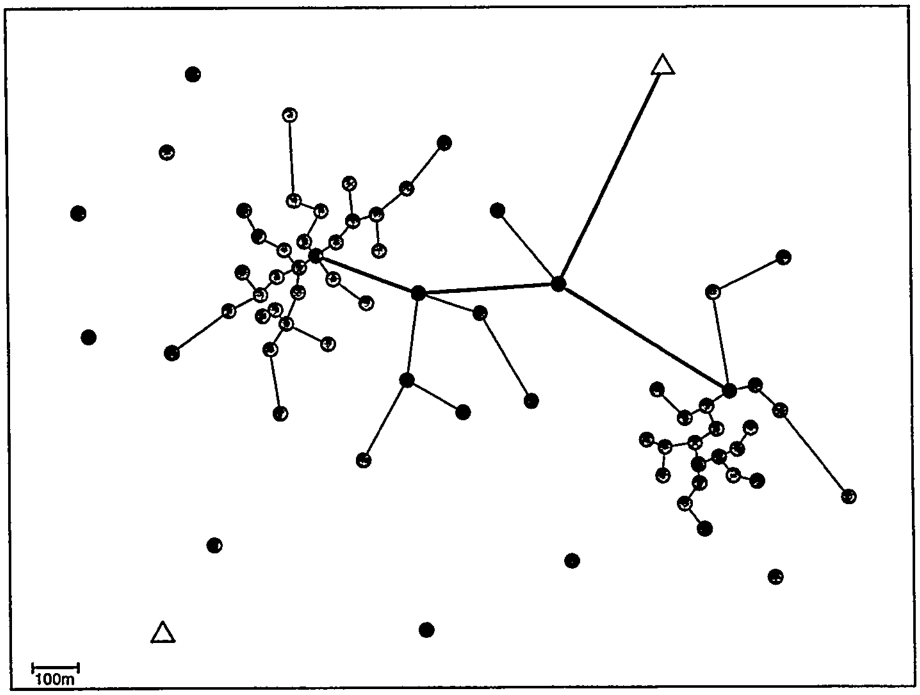
ViPOR

Sample village layout:



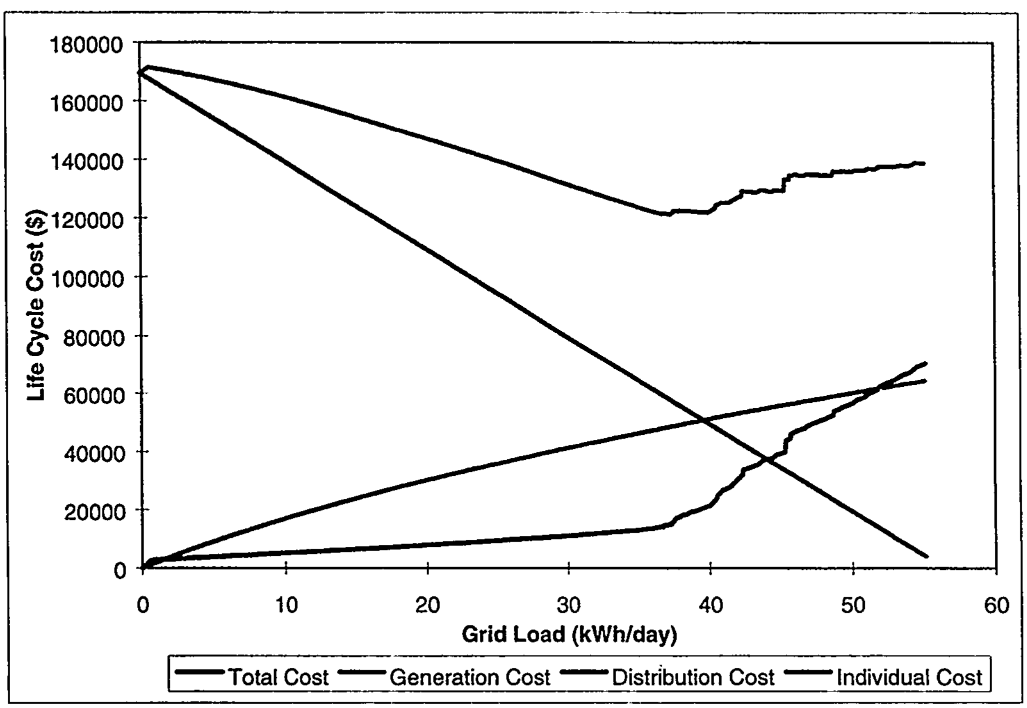
ViPOR

Lowest cost configuration:



ViPOR

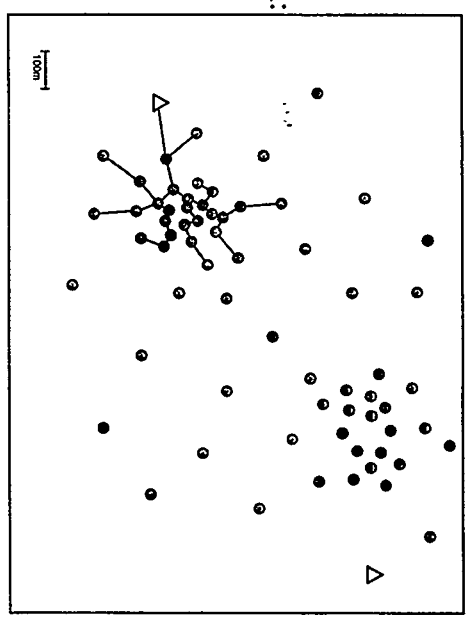
Graph of cost versus grid load:



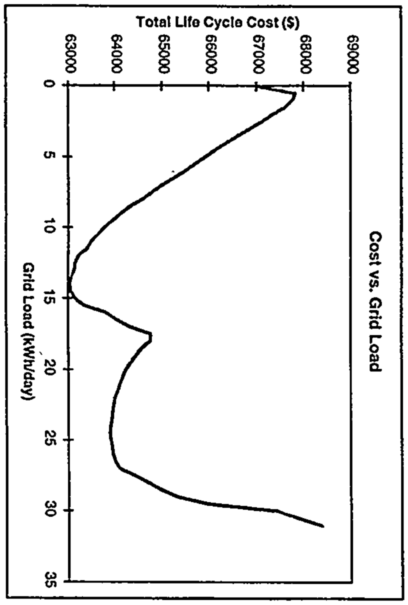
ViPOR

Effect of minigrid source location

Lowest cost configuration:

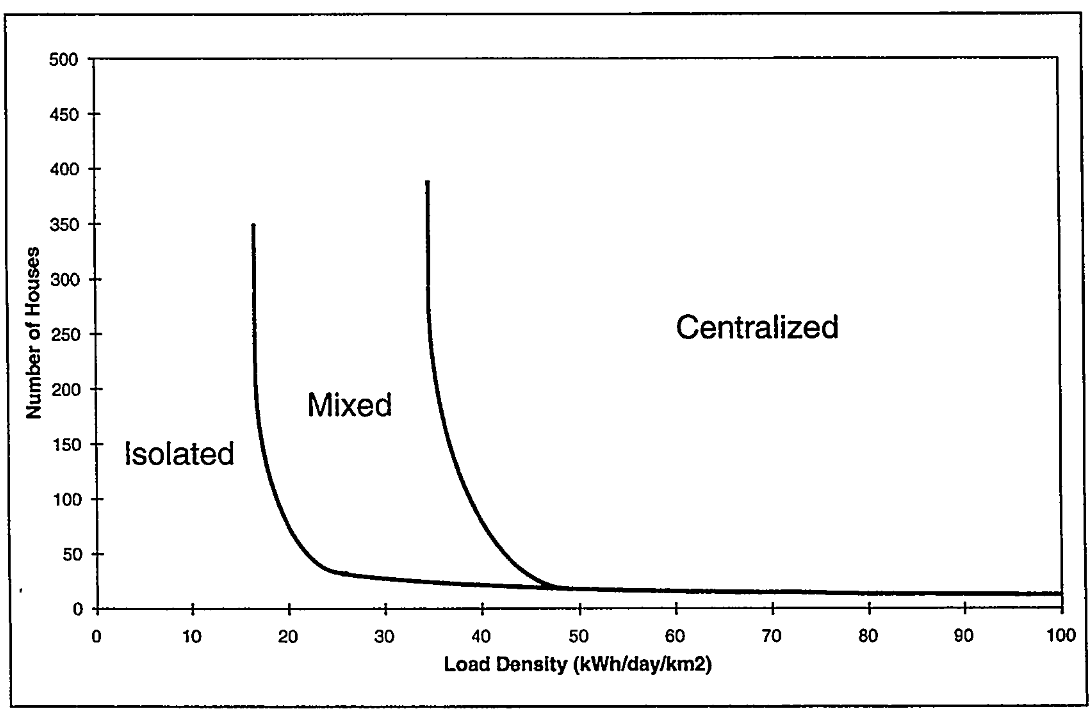


Cost vs. grid load graph:



ViPOR

ViPOR results for uniform density villages: (average wind speed = 4 m/s)



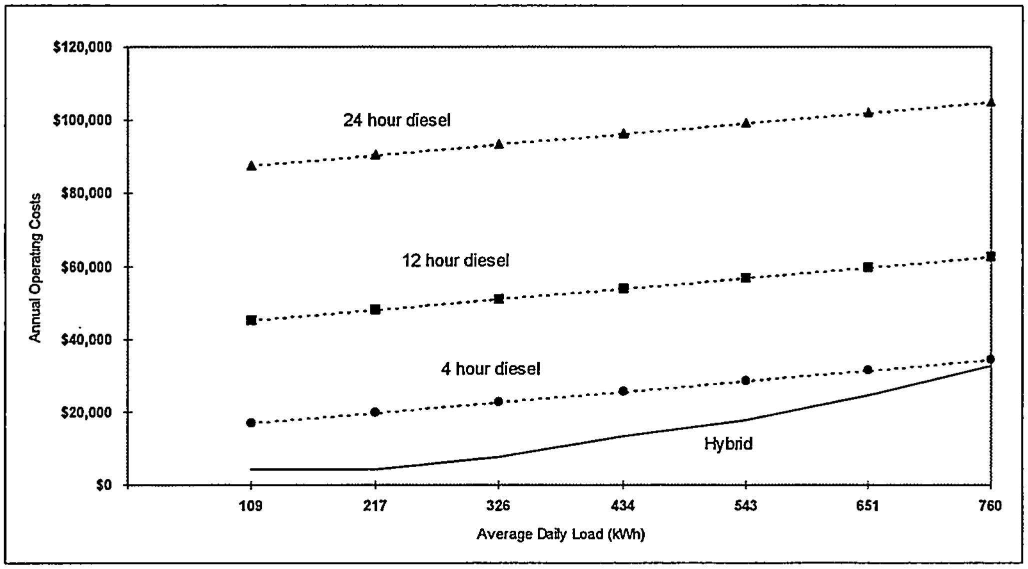
Comparing Hybrids to Diesel Mini-grids

- 24 hour vs. part-time power
- The role of energy efficiency
- Metering and tariffs

Village Power '97
Arlington, Va.
April 14, 1997

Village Power Options
Peter Lilienthal

NREL



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NREL

Diesel Operating costs

- **Primarily depends on operating hours**
  Operating labor can be very costly
  Maintenance schedule based run-hours

- **Substantial no-load fuel consumption**
  ***Marginal* fuel efficiency ~ 4 kWh / liter**
  At $0.30 / liter the marginal cost is $.075/kWh
  Although the average cost is 10-20 times higher

Simple analysis of compact fluorescents

- **1 CFL costs $20 and saves 75 - 18 = 57 watts.**

1000/57=18 CFLs <=> 1 kW of renewable capacity
Assuming similar capacity factors

$360 for CFLs saves $5000-$15,000 in capital costs
More savings in new bulbs and operating costs

- **By contrast, with diesels there is no capital cost savings, each CFL saves only $7.80 per year.**

Metering and Tariffs

- Some part-time diesel systems have no meters
  Some don't even have light switches

- Even with efficient appliances, users need incentive to turn off lights

- Lifeline or 2-part progressive tariffs very appropriate for hybrid systems

COUNTRY ACTIVITIES - ASIA

Sino-American Cooperation for Rural Electrification in China

William L. Wallace and Y. Simon Tsuo, Roger Taylor
National Renewable Energy Laboratory

Village Power '97

April 14-15, 1997
Washington, D.C.

NREL

LS-CD-b242601

Solar Home System Market in Western China

Province	Current Installed Systems	Unelectrified Households (1994)	Five Year Market Potential
Qinghai	10,000	107,000	50,000
Tibet	5,000	120,000	10,000
Inner Mongolia	7,000	536,000	100,000
Xinjiang	7,000	560,000	150,000
Gansu	3,000	832,000	200,000
Total	32,000	2,155,000	510,000

Source: World Bank Report No. 15592-CHA, China Renewable Energy for Electric Power

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Gansu Solar Home System Project

Participants

Overall Project Management:
- Ministry of Agriculture in Beijing
- NREL in U.S.

Project Implementation:
- SELF in Washington D.C.
- GSELF in Lanzhou

Cost Sharing in China:

Gansu Poverty Alleviation Office	54%
Gansu Planning Commission	18%
Gansu Economic and Trade Commission	18%
Gansu Solar Electric Light Fund	10%

Rural Energy Offices (Market Assistance)

LS-CD-b242601

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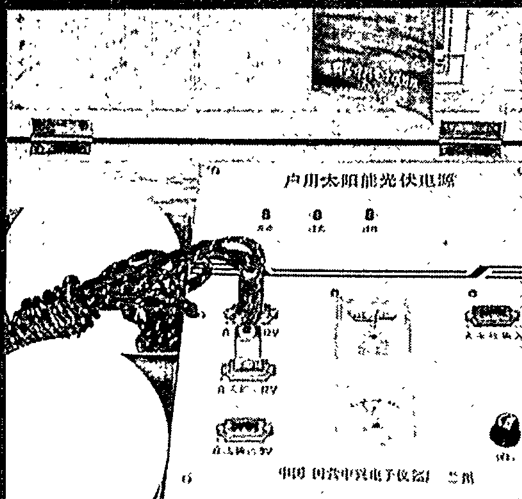
Gansu Solar Home System Project

Project Scope



Sustainable Market Development

PV Household System Project:
$220K each side

Applications:
- Small Lighting Systems - 20 Watts
- Small School Systems - 50/100 Watts
- Water Pumping and Telecommunications

600 Households Minimum Over 18 Months

LS-CD-b242601

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Gansu Solar Home System Project

Suppliers

Chinese Companies:
- Gansu Photovoltaic Company
- Zhong Xing PV Company
- Gansu Zi Neng Automation Engineering Company
- SEC Industrial Battery Company (U.S./China JV)

U.S. Companies:
- Solarex (PV Modules)
- USSC/ECD (Lighting Kits)

Local Gansu Companies
- Install and Service Systems
- Provide System Warrantees
- Train Users

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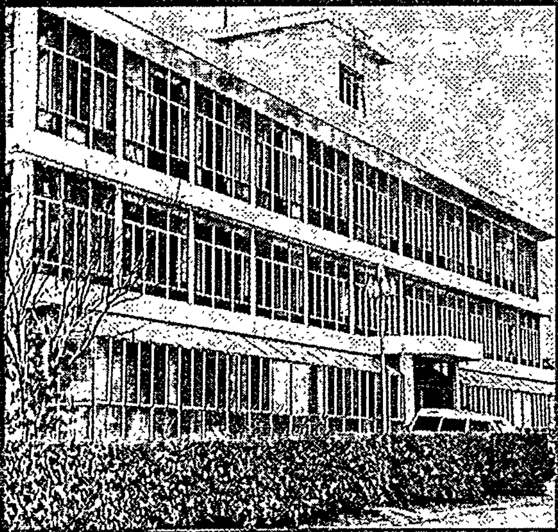
Gansu Solar Home System Project

Activities



Component Testing

Training
- Village Technician/Rural Energy Office Personnel
- Advanced Engineering Training
- Train the Trainers Session

Financing
- Use of Revolving Accounts for Leverage
- Use of Installment Credit

Monitoring
- Data Collection and Analysis
- Project Assessment

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Gansu Solar Home System Project

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Energy Protocol Partners in China

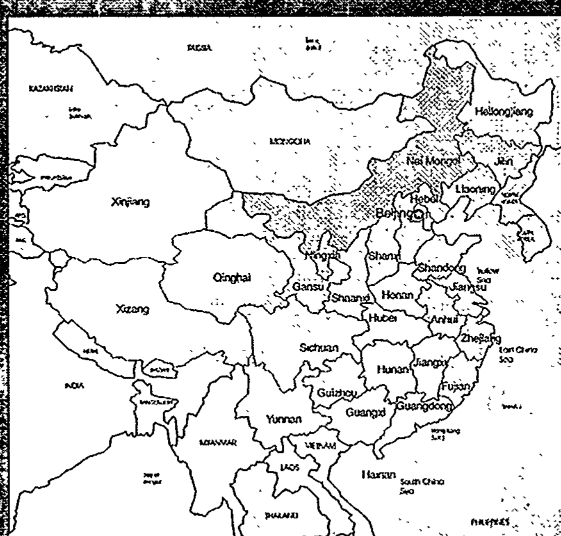
State Science and Technology Commision and DOE
Protocol Coordinators

- State Planning Commission
  Energy Efficiency
- State Economic and Trade Commission
  Business Development
- Ministry of Agriculture
  Rural Energy Development
- Ministry of Electric Power
  Grid Power Development

LS-CD-b242801

Inner Mongolia Hybrid System Project

Opportunities



- Leader in Renewable Energy
  - Aggressive Policy Initiatives
  - Excellent Wind/Solar Resources
  - 1,100 Villages/198 Townships Unelectrifi
  - 400,000 Remote Households Unelectrifi
  - Highest Rural Per Capita Income
- Status
  - 110,000 Small Wind Turbines Installed
  - Over 9 Village Hybrid Power Systems
  - 23% of China's Large Wind Farm Capac
  - Extensive Infrastructure for Rural Energy

LS-CD-b242801

Inner Mongolia Hybrid System Project

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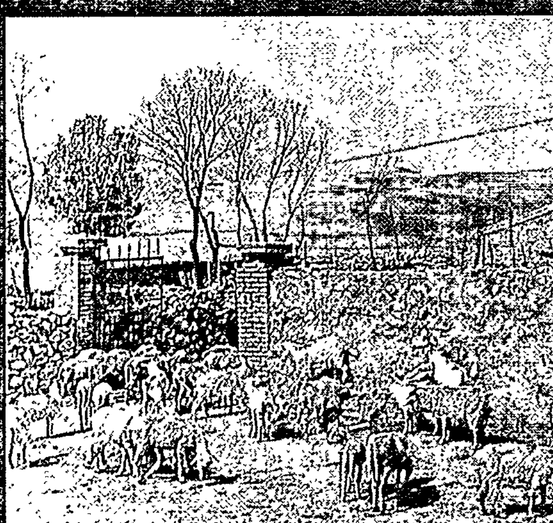
Inner Mongolia Hybrid System Project

Participants



Beijing
- State Science and Technology Commission
- Chinese Academy of Science

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- IM New Energy Office
- IM Electric Power Bureau
- University of IM and Polytechnic Inst.

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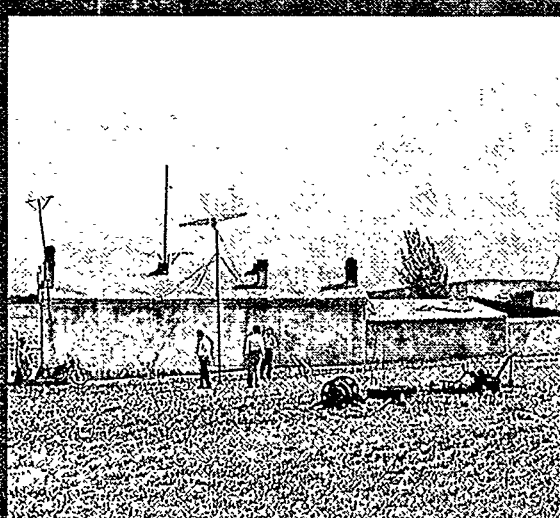
Inner Mongolia Hybrid System Project

Hybrid System Analysis and Development



Rural Electrification Options Study
- PV, Wind, and PV/Wind Systems
- Diesel Generators, Gas Gen-Sets
- 41 Household Systems (22 W to 1 kW
- 3 Village Power Systems (5 - 10 kW)
- Technical and Economic Analysis

Near Term IM Plans for Rural Electrificati
- 80,000 Households Over Next 5 Years
- 47 Village/Township Centers by End 1997
- Use of Wind/PV and Wind/Diesel Hybrids

LS-CD-b242601

Inner Mongolia Hybrid System Project

Hybrid System Analysis and Development

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Summary

U.S. DOE actively engaged with China for photovoltaics and rural electrification

Several projects in place to assist sustainable market development

Potential for leveraging opportunities

Engaged in business development activities

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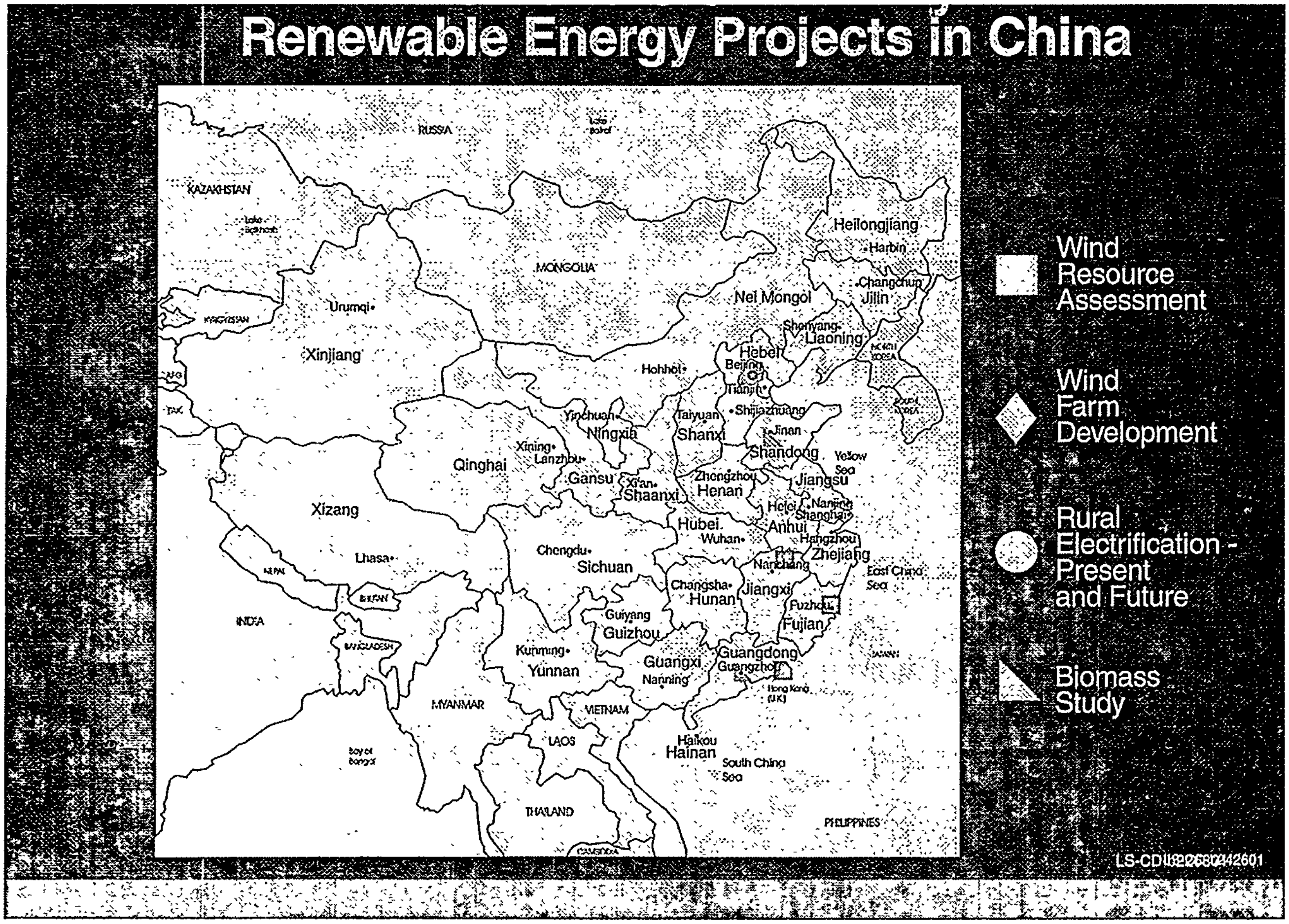
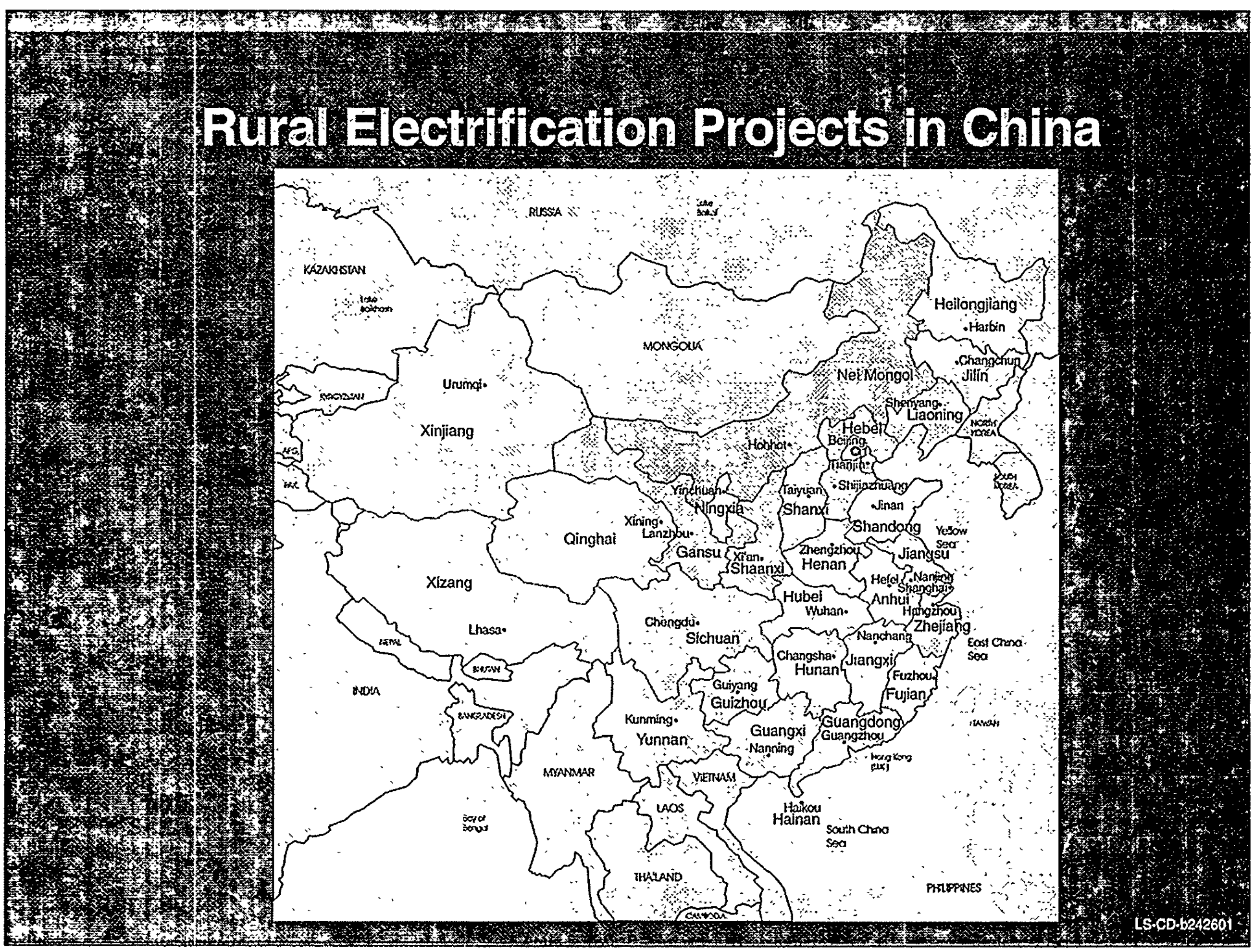

Renewable Energy Projects in China
Wind Resource Assessment
Wind Farm Development
Rural Electrification - Present and Future
Biomass Study
RUSSIA
KAZAKHSTAN
MONGOLIA
Heilongjiang
Harbin
Changchun
Jilin
Nei Mongol
Urumqi
Xinjiang
Shenyang
Liaoning
Hebei
Beijing
Tianjin
Hohhot
Shijiazhuang
Yinchuan
Taiyuan
Ningxia
Shanxi
Jinan
Shandong
Yellow Sea
Xining
Lanzhou
Qinghai
Gansu
Xi'an
Shaanxi
Zhengzhou
Henan
Jiangsu
Xizang
Hefei
Nanjing
Shanghai
Hubei
Anhui
Wuhan
Hangzhou
Zhejiang
Lhasa
Chengdu
Sichuan
Nanchang
East China Sea
Changsha
Jiangxi
Hunan
Fuzhou
Fujian
INDIA
Guiyang
Guizhou
Kunming
Yunnan
Guangxi
Nanning
Guangdong
Guangzhou
Hong Kong (UK)
MYANMAR
VIETNAM
LAOS
Haikou
Hainan
South China Sea
THAILAND
PHILIPPINES
Bay of Bengal


Rural Electrification Projects in China
RUSSIA
KAZAKHSTAN
MONGOLIA
Heilongjiang
Harbin
Changchun
Jilin
Nei Mongol
Urumqi
Xinjiang
Shenyang
Liaoning
Hebei
Beijing
Hohhot
Tianjin
Shijiazhuang
Yinchuan
Taiyuan
Ningxia
Shanxi
Jinan
Shandong
Yellow Sea
Xining
Lanzhou
Qinghai
Gansu
Xi'an
Shaanxi
Zhengzhou
Henan
Jiangsu
Xizang
Hefei
Nanjing
Shanghai
Hubei
Anhui
Wuhan
Hangzhou
Zhejiang
Lhasa
Chengdu
Sichuan
Nanchang
East China Sea
Changsha
Jiangxi
Hunan
Fuzhou
Fujian
INDIA
Guiyang
Guizhou
Kunming
Yunnan
Guangxi
Nanning
Guangdong
Guangzhou
Hong Kong (UK)
MYANMAR
VIETNAM
LAOS
Haikou
Hainan
South China Sea
THAILAND
PHILIPPINES
Bay of Bengal
LS-CD-b242601

Potential Remote Markets for Rural Electrification

LS-CD-b242601

Table 1. Levelized Cost of Energy Values for Rural Electrification Options in IMAR for Remote Households

System	Output Range kWh/year	Levalized COE $/kWh
Wind	200-640	0.24-0.36
PV/wind	400-900	0.30-0.45
PV	45-230	070-0.85
Gas Gen-set	480-730	11.0-1.20

LS-CD-b242601

Solar-energy an America India (SAI) Partnership: The Ramakrishna Mission PV Project

Harin S. Ullal and Jack L. Stone

National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, CO 80401 USA

VILLAGE POWER '97
Arlington, VA 22203
April 14-15, 1997

Acknowledgments

In the United States:

Dr. Chris Sherring, Sherring Energy Associates
Mr. Jim Welch, Remote Power International
Ms. Christy Holz, Applied Power Corporation
Mr. Jerome Hicks, NREL

In India:

Dr. E. V. R. Sastry, MNES
Swami Asaktananda, Ramakrishna Mission Ashrama
Dr. Amiyo Basu, Exide Industries Ltd.
Mr. S. P. Gon Chowdhury, WBREDA

Background

- Cooperative program established in 1993 by the Minister of the Indian Ministry of Non-Conventional Energy Sources (MNES) and the Secretary of the U.S. Department of Energy (USDOE)

- Three projects were identified, 50-50 cost shared, $1.5M from each country; budget reductions necessitated reducing to one project, $250K for each country

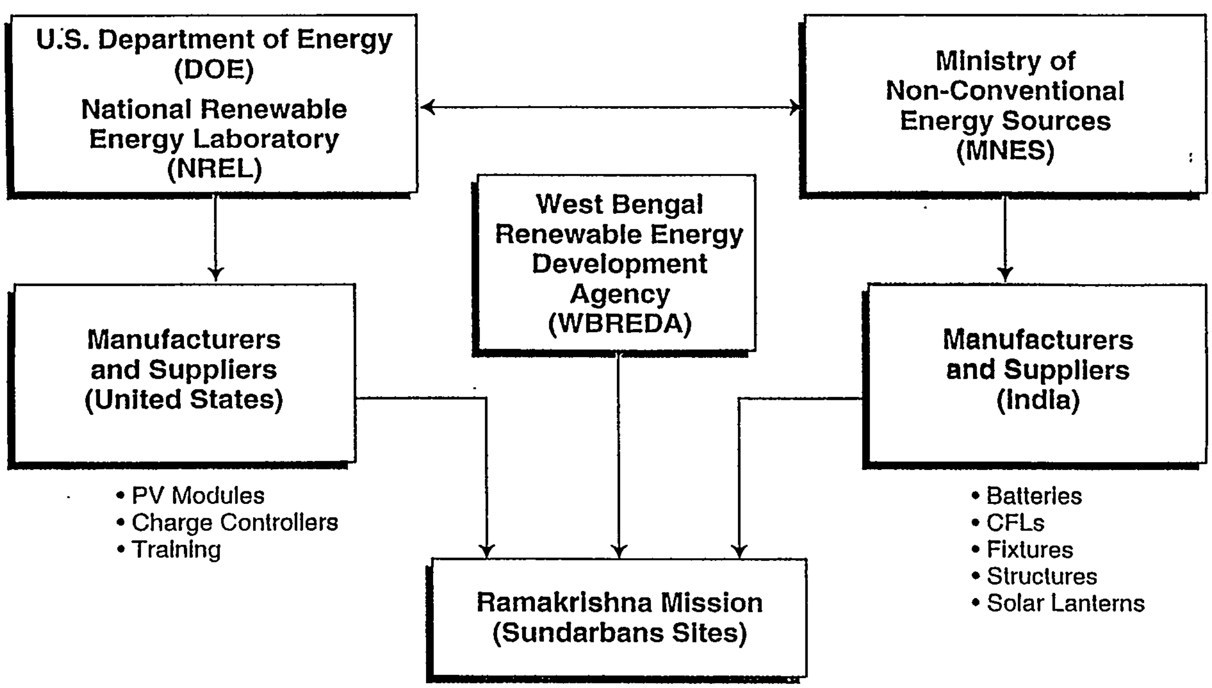
- Selected sustainable rural economic development initiative with Ramakrishna Mission in West Bengal, India as the nongovernment organization (NGO)

- Public solicitation resulted in selection of Applied Power Corporation, Lacey, WA for the systems integration and Remote Power International, Ft. Collins, CO for the training

Objectives

- Establish the economic viability of PV in the Sundarbans region of West Bengal
- Have the project self-sustaining with minimal subsidies to the beneficiaries
- Establish the infrastructure for financing, training, installation and maintenance with the NGO taking the lead
- Work with the NGO to expand utilization of PV in the region
- Perform a before and after social, economic, and environmental impact study with the Tata Energy Research Institute (TERI)

Sustainable Rural Economic Development Ramakrishna Mission Initiative



Project Responsibilities

- The United States furnishes:
  - PV modules, charge controllers
  - Water pump
  - Training
- India furnishes:
  - Batteries, compact fluorescent lamps, fixtures
  - Mounting structures, wiring , all balance-of-systems components
  - Solar lanterns
  - Custom duties
- The Ramakrishna Mission furnishes:
  - Personnel for installation and maintenance
  - Revenue collection from systems beneficiaries

Project Responsibilities (cont'd)

- The West Bengal Renewable Energy Development Agency furnishes:
  - Technical backup to the project
  - PV powered vaccine refrigerator
- Exide Industries Ltd. (under contract to MNES) furnishes:
  - Equipment delivery from customs and to sites
  - Assistance in installation

Project Financing

- Beneficiaries of the PV systems are asked invest their own money according to their ability to pay
- Typical domestic home lighting systems in India cost approximately Rs. 14,000 (1$ ≈ Rs. 35); Rs. 6,000 is available as a government subsidy
- The amount to be borne by the user, Rs. 8,000, requires a down payment of Rs. 3,500 at the time of installation with Rs. 4,500 treated as a low interest loan repaid in monthly installments of Rs. 40 over ten years, realizing Rs. 4,800 (Rs. 4,500 against the loan, Rs. 300 as interest)
- In addition Rs. 20 per month will be charged as a maintenance fund for which beneficiaries receive free service at their doorsteps
- Any surplus will go into a revolving credit fund to purchase additional systems

Applications to be Fielded

Village Name	Domestic	Street Lights	Battery Charger	Water Pump	Vaccine Refrigerator
Gosaba	Training Center-10 with 1, 50-W PV panel, 70A-hr bat.,plus 5 at battery charger	3 with 11-watt CFL's, 100 A-hr battery	1-for 10, 100 A-hr batteries, 4 kW PV 20 solar lanterns	1 Grundfos , SP5A-7, 800 W. PV	
Katakhali	100 homes Youth club-2				
Pakhirala	Weaving center-8, 11-W CFL's	3 with 11-watt CFL's			
Satyanaryanpur	Health Clinic 8-11W CFL's		1 (same as Gosaba)		1(furnished by WBREDA)
Kumirmari	100 homes				
Satjelia	100 homes				
Various Jetties		9			

Lessons Learned

- Project delayed by one year
  - U.S. vendor delayed shipment dates, e.g. charge controllers
  - Indian group wanted shipment in one consignment which couldn't be met because of the delays in the charge controllers
  - Freight delivery by boat delayed from three weeks to three months
  - Custom clearance delayed due to over crowding, changes in custom rates, and local employee strike at the docks
  - Coordination of various groups in the U.S. and India a major challenge, e.g. training, installations
- Project expected to be completed by April 1997
- The importance of a reliable NGO partner was very obvious - the RKM turned out to be the BEST part of the project
- RKM is planning to expand the project with potential funding from IREDA (WB/GEF)

http://www.nrel.gov/research/pv/indian.html

INTERNATIONAL NEWS

NREL COMPLETES RAMAKRISHNA MISSION PROJECT IN INDIA

Thirty kilowatts of PV home systems, street lights, battery chargers, vaccine refrigeration, water pumps, and training have been completed at the Ramakrishna Mission Ashrama, in West Bengal,India. The joint NREL/ MNES (India's Ministry of Non-Conventional Energy Sources) PV project had its impetus in the visit by DOE's Secretary Hazel O'Leary to India in 1994. The memorandum on understanding (MOU) between NREL the Indian Renewable Energy Development Agency (IREDA) called for a 50/50 cost shared project to include a village power project, a PV hybrid project, and a low cost housing project using PV. The cost of the one million dollar project was to be shared. DOE budget reductions in FY '95 caused the scope to be reduced to a single village power project at a total level of $500K, with DOE and MNES each paying $250,000. At the suggestion of IREDA, the Ramakrishna Mission (RKM) was chosen as the implementing NGO in India. The RKM is a humanitarian organization known for is work in urban redevelopment including education and training, agricultural and medical. Out of the 160 RKM sites the Mission Ashrama, Narendrapur was chosen for the PV project. The mission is in the non-electrified Sundarbans region of West Bengal, where the Ganges River meets the Bay of Bengal.

NREL furnished the PV modules from Solarex, charge controllers from Morningstar, systems integration and training. MNES furnished batteries, fluorescent lights, mounting structures, and balance of systems components, and the custom duties. U.S. companies Applied Power Corporation and Remote Power International were selected to furnish the system components and the training. Exide systems Limited in Calcutta, India installed the systems. In order that the program be self-sustaining, the participants paid the full cost of he PV system. A down-payment and a payments on a low interest loan covered the remaining costs. One of the more exciting results is the establishment of the "**ADITYA--THE SOLAR SHOP**" PV stores owned by the Mission. Six of the planned 50 **ADITYA** shops are now operational (see photo below). The solar shops sell, install, and maintain PV systems, as well as displaying and selling other fuel saving and non-conventional energy using items such as: improved chullahs, biogas ovens and lamps, highly efficient electric lamps, etc. They also act as an agent for the government, World Bank and other financial assistance for customers to receive PV Systems. NREL continues to work with MNES to develop testing protocols and standards which will allow the U.S. industry to compete for the huge Indian market. NREL is working with the RKM to identify a private sector partner in the U.S. to joint venture with an Indian partner to expand the project beyond the limited scale deployment in the initial NREL-MNES phase. For details on this important project contact Jack Stone or Harin Ullal at NREL, 1617 Cole Blvd, Golden CO 80401-3393. Phone 303 275 3000.

Renewable Energy and Rural Development Activities Experience in Bangladesh.

- Dipal Chandra Barua
Managing Director
Grameen Shakti

Abstract

The per capita per year fuel consumption in Bangladesh is only 56 kg oil equivalent. The supply of electricity by Bangladesh power development board (BPDB) and Dhaka electricity supply authority (DESA) is mainly confined to cities and towns. Rural Electrification Board (REB) distributes electricity the rural people through cooperatives. The rural cooperatives cover only 10% of the total population. Only about 15% of the total population is directly connected to the electricity. In order to meet the increasing energy demand for development of agriculture and industry and for the generation of better employment opportunities, it will be necessary to harness all the available alternative sources of energy immediately.

1.0 Introduction

Bangladesh lies in south Asia. It is bounded by India on West, the north and north-east and Myanmar on the south-east and Bay of Bengal on the south.

1.1 The general outlook of Bangladesh is given below :

Area of the country	:	148,393 sq. km.
Forest area	:	14% of the total land area.
Population data (1995)	:	
Population	:	119.7 million
Number of households	:	19,397,992
Population growth rate	:	1.84%
Rural population	:	85442,788
Number of rural households	:	15,608,654
Total number of village	:	85,650 (68000 bigger size)
Rural population growth rate	:	1.46%
Urban population growth rate	:	4.97%
Population density	:	800 inhabitants per sq.km.

1.2 Economic data :

GNP	:	541,410 million taka (1991-93)
GNP distribution by sector	:	
Agriculture	:	34%
Service	:	27%

Transport. & communication	:	12%
Manufacturing	:	12%
Trade	:	10%
Construction	:	5%

1.3 Primary energy :

Domestic resources :

Oil Potential	:	300 bb/day
Natural gas	:	10 to 20 trillion cuft reserve
Coal	:	Reserve 1000 million tons, not being exploited for economic reasons.
Hydropower	:	300 Mw (potential) 230 Mw installed.

Imports :

Oil	:	1.25 million tons (1990)
Coal	:	455,555 tons (1990)

Consumption :

Oil	:	1.25 million tons (1990)
Natural gas	:	84 billion cuft
Coal	:	459,259 tons

Besides commercial energy sources, fuel wood and agricultural residue are widely used in rural areas for thermal energy needs (cooking, domestic heating, heat source in some industries). It is estimated that this consumption constitutes more than 70% Of the total energy consumption of the country.

1.4 Electricity :

Production :

Source	Nbr of stations	Installed capacity (Mw)
Oil	7	279
Gas	13	1988
Hydropower	1	230
Total	21	2497

1.5 Energy Prices :

Gasoline	:	14.67 Taka/liter (US$0.33/liter)
Kerosene	:	16 Taka/liter (US$ 0.38/liter)
Electricity	:	3.7 Taka/Kwh (US$0.09/Kwh)(Commercial) 1.7 Taka/Kwh(domestic)

1.6 Rural Electrification :

Total of villages connected to the grid	:	18000 (21%)
Total number of households connected	:	1400000 (9%)

1.7 Energy sources and costs in areas not connected to the grid :

Energy Sources of Lighting :

Sources	Utilization hrs/day	Consumption average/month	Cost Taka/month
Kerosene lanterns + Kuppies	4 to 5	5 liters	80
Candle	occasionally	6	25
Flash lights	occasionally	pair of 1.5 v batt.	24

Lighting Equipment Cost :

Equipment	Cost (in Taka)
Kerosene Lanterns	120
Kerosene Kuppies	30
Flash lights	200

In some areas, private diesel set generators supply electricity to commercial shops at a price 5 Taka/light for 4 hours.

2.0 Solar Energy

The long term average sunshine data indicates that the period of bright (i.e. more than 200 watts/sq.m intensity) sunshine hours in the coastal region of Bangladesh varies from 3 to 11 hours daily. The global radiation varies from 3.8 kwh/sq.m/day to 6.4 kwh/sq.m/day. These data indicate that there are good prospects for solar thermal and photovoltaic application in Bangladesh. In 1989, the first solar photovoltaic projects were opened at Sandwip island in Bangladesh. The program, consists of two projects : one is a natural calamity management project for a cyclone shelter center at Sharikait Union and other is a medicine preservation. It was found that during and after a disaster (cyclone) over some islands and coastal belts of Bangladesh in 1991, the photovoltaic generation of Sandwip island was the only source of energy to provide a communication link between the people of that island the main land when all other communications were totally disrupted.

With good to excellent solar resource available throughout the country and throughout the year, there is a good potential for vp due in unelectrified rural homes on unelectrified villages, if affordable products meeting consumer needs can be supplied and supported.

VP systems will be also ideal for the 2,500 cyclone shelters which not only provide shelter for about 1,000 persons each during an emergency, but also serve as community center, school and health center one year-round basis. Each could require about 1 to 2 Kwp of provide power for lighting, warring beacons, refrigerators, water purification, radio communications, telecommunication, TV, etc.

2.1 Solar Energy Related Organizations/Companies in Bangladesh.

Government sector:

Bangladesh Atomic Energy Commission (BAEC)
Rural Electrification Board (REB)
Dhaka University Renewable Energy Development Centre
Bangladesh Council of Scientific and Industrial Research (BCSIR)

Private Sector :

Grameen Shakti
Rahimafrooz (Bangladesh) Ltd.
Siemens (Bangladesh) Ltd.
Energy Systems

2.1.1 **Bangladesh Atomic Energy Commission (BAEC)** launched a number of PV pilot projects to assess their technical feasibility and social acceptance and to determine the potential for local manufacture of balance of system components. These applications included pumping, lanterns and power for cyclone shelter, hospitals, mosques and a village. System sizes ranged from a few watts to 2.3 Kwp. The results of the pilot projects were-mixed with technical problems occurring with the lanterns and a pump, and cyclone damage at several other sites.

2.1.2 **The REB** with assistance from the French Government is launching a major PV pilot project to provide electricity services to about 1300 on an island on the Meghna river in Narsingdi district. Total size of the project is about 62 Kwp. The REB has assigned responsibility to the Narsingdi Palli Biddyut Samity (NPBS) to execute the project and be responsible for day to day operations. The equipment, sourced from France and the European Community, has been delivered and REB/NPBS are in the process of identifying consumers and beginning installation.

2.1.3 **Dhaka university & BCSIR** were also taken few solar projects due to R & D but information is not available.

2.1.4 Cyclone Shelter PV electrification in conjunction with **LGED.**

2.1.5 **Grameen Shakti**

- **GS Renewable Energy Development Project: Phase I, 1996-97**

Decentralized solar power is a low cost energy source that is environment friendly and its supply is unlimited. Bangladesh has plenty of sunshine that can be used to generate cost effective solar electricity for rural households. Initial investigations suggest a number of factors pointing to bright prospect for testing solar photovoltaic energy in the rural areas.

First, it is clear that improved technological efficiency and economies of scale would make solar energy cheaper in near to medium term future. Second, additional and assured lights from solar panels may extend the workday of users, women in particular thereby making it an investment in income generation for poverty alleviation. Finally, solar energy source would certainly help better quality education for the user's children. Thus our proposed pilot solar energy project has the possibility to induce demand generation on the one hand and acting as a tool for improving the quality of life via additional employment and income generation. Grameen Bank is a bank owned by the poor people and is dedicated to the welfare of the poorest of the poor in rural Bangladesh. GS has installed 21 units solar home systems (SHS) at Bhaluka, Dhobaura, in Mymensingh district, and 35 units (SHS) at Narandia,Ghatail in Tangail district, with the collaboration of Rahimafrooz Limited and Siemens Bangladesh respectively. The Solar Household Systems are functioning well.

- **Solar Home Systems (SHS) at Bhaluka, Dhobaura, Mymensingh.**

a. 30 Wp Module (poly-crystalline), Two 6 Watts Fluorescent Tube Lights, 55 amp-hr deep cycle battery for Taka 14,000.00

b. 40 Wp Module (poly-crystalline), three 8 Watts Fluorescent Tube Lights, one black and white T.V point, 100 amp-hr deep cycle battery for Taka 20,000.00

c. 60 Wp Module (poly crystalline), Two 8 Watts and two 6 Watts Fluorescent Tube lights, one black and white T.V point, 100 amp-hr deep cycle battery for Taka 23,000.00

- **Solar Home Systems (SHS) in Narandia, Ghatail, Tangail.**

a. 17 Wp Module (single crystalline), two 7 Watts Compact Fluorescent Lamps (CFL), 50 amp-hr car battery for Taka 13,000.00

b. 34 Wp Module (single crystalline), three 7 Watts Compact Fluorescent Lamps (CFL), one black and white T.V point, 100 amp-hr car battery for Taka 18,000.00

c. 48 Wp Module (single crystalline), Four 7 Watts Compact Fluorescent Lamps (CFL), one black and white T.V point, 100 amp-hr car battery for Taka 22,000.00)

GS is in the process to procure 300 solar pv units from Siemens (Bangladesh), Rahimafrooz Bangladesh Ltd. and Webel SL-Energy Systems Ltd. India to initiate its pilot project to test and understand the market. Moreover, this pilot project will study the adaptibility and acceptability of the technology. The project will be further scaled upto 400 units. GS intends to develop local service company with the privilege of using Grameen Bank's rural infrastructure. However, GS will extend its service to GB members as well as non-members. With financing from GB, GS will set up micro-enterprises to offer sales and service centers with capacity of manufacturing spares and components. In this respect an energy service company may be formulated and structured using network of GB.

In regard to the payment plan , the Grameen member has to pay 25-40% down payment of the total cost and rest of the money will be collected with the interest rate of 8% within 2 years. In case of non-Grameen members the payment plan includes 50-75% down payment and rest of the money will be collected from 6 months to 1 year period with service charge of 8%.

- **Phase II: Expansion Upto 5000 Units of Solar Household Systems Period: 1997-98.**

  During this phase Grameen Shakti will expand the operation from 400 to 5000 households in different parts of the country to get the real experience of peoples acceptance, finance, marketing and technology of SHS.

- **Phase III. 1999-2000/Near Commercial :**

  In this 3rd Phase Grameen Shakti will target to market 100,000 SHS's.

- **Phase IV. 2001-/Fully Commercial**

  During this phase IV Grameen Shakti will become 100% commercial operation.

- **Marketing Strategies of Grameen Shakti :**

  400,000 houses already constructed through GB loans. So, they are potential customer for solar home system and they may get loan from GB to buy the system. Non members will also buy with cash or part payment system. GB members can also sale SHS to non-members through loan from Grameen Bank. Grameen Shakti has already reduced tax and duties of renewable energy parts from the government. So, GS trying to market SHS at affordable price to rural people.

2.1.6 **Siemens Bangladesh Ltd. & Rahimafrooz (Bangladesh) Ltd** Supply PV modules and related components.

3.0 Wind Energy

Good quality wind data for one year is now available for patenga, chittagong, potential wind farm site, where in 1995 wind speeds ranged from 4.2 to 8.1 m/s and averaged 6.5 m/s at 20m (see the figure). Winds are strongest from March to October, but exceed 5 m/s at 20m for over 6000 hours per year (cut-in speed of large wind turbines is about 4 m/s) Preliminary estimate of net output from a 500 kW wind turbine with a 40m hub height is 1200 Mwh/ year at Patting.

3.1 BAEC & REB

The BAEC with the assistance of REB has installed anemometer at different sites. The sites are patenga, Cox's Bazar, Companygoanj, Sandwip, Hatia, Kutubdia and Khepupara. These anemometers were procured with grant assistance from Germany. GTZ is working with BAEC

Monthly Average Wind Speeds,
Patenga (near Chittagong), 1995
(estimated for 30 M height from data at 20 M)

Jan.	5.1 m/s
Feb.	5.8 m/s
Mar.	7.2 m/s
Apr.	7.9 m/s
May.	8.2 m/s
Jun.	8.5 m/s
Jul.	8.9 m/s
Aug.	8.3 m/s
Sep.	7.3 m/s
Oct.	6.6 m/s
Nov.	4.5 m/s
Dec.	4.1 m/s

3.2 Grameem Shakti

GS has installed two small wind turbines at Chokoria, in Cox's Bazar. These wind turbines are: one 300 Watt Southwest Air Module, USA; and one 1 kW unit from LMW, the Netherlands. Both the turbines start generating electricity since December 15, 96. The 1 kW LMW wind turbine has an option for grid connection. The experimental wind turbine will allow GS to gather practical data on the basis of which the load factor will be evaluated for future plans. In the meantime GS has procured two anemometer from USA.

3.3 Wind/Solar Hybrid Energy System

The monthly average values of wind speed and sun-shine hours of the coastal and islands of Bangladesh, indicate that the wind sun-shine date complement each other very well.

In other words the best sunshine hours occur during the periods of the worst wind speed hours and vice-versa. There is a good prospect for wind solar hybrid energy system with diesel/storage back up in such coastal islands.

4.0 Bio mass :

In Bangladesh the following three types of Bio-gas plant are used :

(i) Floating dome type
(ii) Fixed dome type
(iii) Bag type

4.1 Bangladesh Agriculture University And Bangladesh University Of Engineering & Technology.

The first bio gas plant in Bangladesh Was installed at Bangladesh Agriculture University (BAU) in 1972. Since then considerable research on low cost efficient bio gas plants has been undertaken at BAU, Bangladesh University of Engineering and Technology (BUET) Bangladesh Council of Scientific and Industrial Research and Integrated Rural Development Programme. A scheme to install 'within one year' 5000 bio gas plants. One in every union had been launched by the Environment Pollution Control Division (EPCD) of the Bangladesh Government. These were pilot plants, to be provided by the Government free of cost at an expenditure of about US$ 160 per plant. Each plant requires the dropping of 3-4 head of cattle per day. It has a capacity of 100 cft of bio gas per day and is suitable for a family of 6 persons.

4.2 LGED

LGED first installed their bio gas plant in Kurigram in August 1992. LGED also installed a bio gas plant in Muslim Mission at Faridpur in August 1992. This plant produces gas for cooking and waste material coming out from digester used as fertilizer. LGED has also successfully installed bio gas plant in Ganaktuly of Dhaka city using human waste as raw materials. 4 nos. of such plants are installed in 1993 in the slum area of Dhaka.

4.3 Jute and Sugar Mills

The potential for using sugar and jute bagasse for grid power supply should be also investigated as Bangladesh is a major jute and sugar producer. Bangladesh has 18 sugar mills and 38 jute mills. The sugar mills already meet their steam and power requirements by burning bagasse. Their milling season is from October to Febuary. Each mill has a bagasse fired steam boiler at 25 kg/cm-- and has turbo generator rated at 2.5 Mw. Jute mills use bagasse for steam production only. Jute mill power is supplied either from diesel generators or the grid.

4.4 Grameen Shakti

The concept of integrated farming system utilizing bio-digesters is quite relevant to Bangladesh agriculture as it ensures increased production on a more sustainable basis and benefits the poor. The method is both environment friendly and economically profitable for it reuses bio-materials on a continual basis at relatively low cost with prospects of higher yields. This process takes into consideration the natural demand of the soil to increase its productive capacity.

A bio-digester can produce bio-gas, fertilizer and fish feed. Each unit meets about 20 kg of animal waste per day (the waste produced by two healthy cows) and can provide enough bio-gas for a family to four to cook 2 meals a day. Effluent from the digesters, which is 60% oxidized, is readily usable as quality fertilizer. However, a better alternative involves mineralizing the effluent in a shallow basin, where it becomes a further 30 to 40% oxidized, and then discharging it into fish ponds to encourage the immediate and prolific growth of plankton. This process of mineralizing or converting the organic component of animal waste represents a major improvement on the widespread practice of putting raw cowdung into ponds as fish feed. This is because the organic component of raw cowdung consumes the water's dissolved oxygen, and hence pollutes the fish ponds. Whereas, by completing the oxidization process outside the fish ponds' first inside the bio-digester and then in the shallow basin, the bio-digester effluent does not pollute the water at all. Initial findings at the Joysagor Fish Farm that have shown ponds using bio-digester effluent producing fish fingerlings twice the size of those produced in ponds using raw cowdung, are indicative of the new method's superiority. The entire process, in addition to being quite inexpensive involves a simple technology and is quite easy to perform.

Approximately, polyethylene (PE) bio-digesters made from thin shēet material and these were susceptible to tear and torn under the rural conditions of Bangladesh. This problem leads to frequent replacement and repair of the digesters. This type of digester would costs around US$20-30.

The experience from this PE bio-digesters leads to some valuable knowledge that can be utilized for undertaking any future initiative in this area. One important issue is that the input source to be an integral part of the project, and as such, critical to the project's success. To make the bio-digester project economically feasible and acceptable to the poor, it is of utmost necessity to provide them with cattle, that is, the source of the input, together with the bio-digester itself.

Hence, whereas initially the project was thought of entirely in terms of bio-digester, it must now be viewed as having two components, the bio-digester and the cattle. Initially the lessee should have two cattles on their own and two other cattles will be provided on lease basis. The proposed bio-digester is made of concrete and brick with the amount of cow dung that can be supplied from four cattles. Recently we have constructed eleven brick-concrete digester in our Joysagar Fish Farm, Grameen Krishi Foundation and Comilla zone which are already under operation. The immediate results are encouraging. GS has installed 11 brick bio-digester & has plan to construct another 25 brick-concrete bio-digester. The lessee will be able to use the digester to produce bio-gas as fuel, digester effluent for fisheries and milk for dairy products. Thus, lessee will have income generating **mini-bio-dairy-project** to repay the loan and also earn some profit.

Conclusion :

In conclusion, rural renewable energy development in Bangladesh is underway, taking advantage of the entrepreneurial initiative of Bangladesh's rural population specially the microcredit credit experiences of Grameen Bank.

References :

* *Evaluation of Renewable Energy Potentials and Projects in Bangladesh by UNESCO, November 1996.*

* *Status of the Renewable Energy in Bangladesh Compiled by Power Cell, Ministry of Energy & Mineral Resources, Bangladesh. November, 1996.*

DOE/NREL Supported Wind Energy Activities in Indonesia

Steve Drouilhet

1. **USAID/Winrock Wind for Island and Non-governmental Development (WIND) Project**

2. **CPC/PLN Case Studies of Village Hybrid Power Systems**

3. **World Bank/PLN Preliminary Market Assessment for Wind-Diesel Systems**

USAID/Winrock Wind for Island and Non-governmental Development (WIND) Project

Objectives

Train local NGOs in the siting, installation, operation, and maintenance of small wind turbines.

Install up to 20 wind systems to provide electric power for productive end uses.

Create micro-enterprises that will generate enough revenue to sustain the wind energy systems.

NREL's Role

- wind resource mapping
- technical assistance
  - siting
  - system definition
  - proposal review
  - performance monitoring and evaluation

USAID/Winrock Wind for Island and Non-governmental Development (WIND) Project

Project Status

- Detailed wind maps of Timor and Sumba have been produced
- 20 wind datalogging systems have been installed
- 10 wind systems have been installed on the islands of Timor and Sumba

  wind turbines range from 1.5 kW to 10 kW rated output; applications include:

  - water pumping for irrigation and household supply
  - peanut processing
  - lighting for community kiosks
  - AC power for a blacksmith shop
  - freezers for fish storage and popsicle production
  - battery charging

CPC/PLN Case Studies of Village Hybrid Power Systems

Project Participants

- Community Power Corporation
- Idaho Power Corp.
- PLN (Indonesian National Electric Utility)
- National Renewable Energy Laboratory

Objective

Evaluate the economic viability of various hybrid power options for several different village power situations.

Case 1: Small village diesel system (40 kW) with good wind and solar resources. Upgrading from 12 hour to 24 hour service. Various wind/PV/battery/diesel configurations.

Case 2: Larger village minigrid (500 kW) with good wind resource. Various wind-diesel configurations.

Case 3: Small village system with poor renewable energy resource. Diesel/battery/controls configurations.

CPC/PLN Case Studies of Village Hybrid Power Systems

NREL's Role

- Host CPC and PLN at NREL for training in hybrid system modeling using Hybrid2

- Technical assistance in interpretation of modeling results

World Bank/PLN Preliminary Market Assessment for Wind-Diesel Systems

Objective

Estimate the size of the total potential market for wind-diesel hybrid power systems in Indonesia.

The study will examine both wind retrofits to existing diesel mini-grids and new wind-diesel plants in currently unelectrified villages.

Project Structure

NREL is performing the analysis under contract to the World Bank using data provided by PLN.

World Bank/PLN Preliminary Market Assessment for Wind-Diesel Systems

Approach

1. Analyze database of all existing and planned diesel generating stations and classify them according to:

    - existing diesel capacity
    - load size
    - population density
    - terrain and elevation
    - exposure to prevailing winds
    - proximity to medium voltage distribution lines

2. Based on the database analysis, determine the percentage of existing and planned village power stations that are good candidates for wind-diesel.

3. Estimate the capital cost and economic return of a representative set of system configurations.

Philippines:

Small-Scale Renewable Energy Update

Village Power '97

April 14-15, 1997

Philippines

- Population: 70 million
  - 2800 inhab. islands (7100 total)
- GNP/Capita: $950
- Renewable Use: 39%
  - Hydro, geothermal, biomass
  - 47% target by 2005
- Resources:
  - Solar: 161.7 W/m2 avg.
  - Biomass: 150 MW potential
  - Micro-hydro: 28 MW (436 sites ID'd)
  - Mini-hydro: 1157 MW (1117 sites ID'd)
  - Wind: 4.5-10 m/s
  - Mini-geothermal: undefined, although resource broadly distributed

Philippines

- 4 million unelectrified households, millions more underelectrified
- Electric distribution grids on 27 of 2800 inhabited islands
- Electric system being privatized
- NPC 79% of capacity
- Remainder is private utilities, cooperatives, industry
- Small Power Utilities Group (SPUG) being spun off from NPC to carry out "missionary" rural electrification (dependent on restructuring)

Philippines

- SPUG will be responsible for remote grid electrification
- Putting in dozens of diesels from 50 kW-several MW
- Renewables expected to be an important part of the SPUG program--carrying out wind, solar and hydro resource assessment & pilots
- Plans to utilize wind, solar, biomass, micro-mini hydro to date
- Willing to buy turnkey systems or kWh from private generators

Philippines

- Prices vary, but published rates range from 8 cents/kWh for wind, 16 cents/kWh for PV--open to negotiation
- Questions about allowability of diesels in these systems--NPC says yes, PDOE says no
- Current effort underway to incorporate renewables under restructured system, including guarantees, loan funds and incentives (grid and non-grid)

Philippines

- Many government programs to encourage renewables with low-cost loans, capital subsidies, etc.
- Bureaucratic nature of programs (sometimes more perception than reality) mean they have generated little activity
- Private sector generally going their own way--Solar Electric Co. prime example
  - innovative financing through NGOs, incorporating barter, bundling
  - battery charging, refrigeration coming

Philippines

- Many installations of SHS, pilots by PDOE of productive uses, telecom, poultry incubators, water pumping, lighthouses
- 1500 solar hot water systems, primarily in metro Manila; industrial applications untapped
- NPC plans to buy 1 MW of PV (grid)
- Many mechanical wind water pumping systems installed; NPC pilot of wind electric village system in northern Philippines

Philippines

- Wind mapping project underway (NREL/Winrock/Phil. Gov't.)
- AUSAID supporting $39 million (grant and loan) project for PV community infrastructure in southern Philippines
- Proposed Dutch program for 15,000 SHS
- German/EU/Japanese aid programs long established with RE projects

Philippines

- Many biomass opportunities
  - 10,000 rice mills, 250-1000 kW systems
  - Coconut-fired, 1-5 MW systems
  - 1000s of Pig farms: 250-500 kW (captive)
  - Industrial cogen, 39 mills, 5-20 MW systems

Philippines

- Winrock Program
  - REPSO/PEI
    - US/AID capital investment funds deobligated
    - work with DFIs on evaluation and recs for end-user financing mechanisms
    - work with DFIs on design of pre-investment funding window
    - work with DFIs on flexible financing and guarantee facility to encourage private sector investment in grid, mini-grid and off-grid renewables

Village Power in Thailand

NREL Village Power '97

Michael Bergey
Bergey Windpower Co.

Overview

- 61 million people
- 513,000 square kilometers
- EGAT generates, MEA and PEA distribute
- 99% electrified
- ~ 1,000 villages (out of 60,000) without grid connection (protected areas, islands, border areas, etc.)
- ~ PEA operates ~60 autonomous diesel systems (down from 500 a decade ago)
- PEA has current project to electrify37 islands: 18 with subsea cables and 19 with diesels or hybrids
- PEA design practice with diesels creates high costs and high level of service

Renewables

- Center for Applications of Solar Energy Projects
  - 12 kW PV integrated into micro-hydro / diesel mini-grid
  - 12 kW PV integrated into diesel mini-grid
- PV Battery Charging Stations Program
  - DPW: > 1,000 at 1 kW
  - DEDP: ~ 150 at 3 kW
- PV Water Pumping Programs
  - DPW: > 500 sites since 1990
- EGAT Demo's '/ Installations:
  - 70 kW PV at 62 sites
  - 42 kW wind at 1 site

CASE / PEA Project

- Khun Pae, Northern Thailand, retrofit to existing system of 40 kW micro-hydro & 55 kW diesel
  - 12 kW PV, 110 kWh battey, 40 kW inverter, remote monitoring
- Ko Kut Island, SE Thailand, retrofit to existing diesel generator
  - 12 kW PV, 110 kWh battey, 40 kW inverter, remote monitoring
- Ban Den Mai and Ban Mea Ka, Central Thailand, connect idled PV systems to grid
  - 50 kW inverters, small battery banks, remote monitoring
- Funding from PEA and AusAID

Energy Conservation Fund

- Established in 1992
- Some core funding, but primarily funded through taxes on petroleum
- Current revenue ~ $340 million
- Conservation budget is $771 million for 1995-1999
  - Compulsory, Voluntary, & Complementary Programs
- $228 million earmarked for renewables and industrial sector energy efficiency
- Funding implemented through the National Energy Policy Office

COUNTRY ACTIVITIES - LATIN AMERICA

NREL Technical Assistance to Argentina

Presentation to:

Village Power '97
Arlington, Va.
April 15, 1997

Peter Lilienthal, Ph.D.
National Renewable Energy Laboratory
Golden, Co. U.S.A

NREL Technical Assistance to Argentina

Tariff Analysis for Rural Concessions Program

Wind-diesel retrofits in Patagonia

Small hybrid system designs for rural schools

Wind resource assessment

Tariff Analysis for Concessions Program

4 Classes of service
- Individual systems, primarily PV
- Diesel with 5 hour / day of service
- Hybrid renewables with 24 hour service
- Micro-hydro, typically with excess capacity

Assure a reasonable rate of return to concessionaire

Wind-diesel retrofits in Patagonia

Very high wind speeds ~ 10-12 meters/second

Several dozen isolated mini-grids

Prefeasibility analysis for Tres Lagos
 < 4 year payback

Village Power '97
Arlington, Va.
April 15, 1997

NREL Technical Assistance to Argentina
Peter Lilienthal

Bolivia Renewable Energy Development

VILLAGE POWER - 97

Pete Smith
NRECA - BOLIVIA
73762.1355 @ compuserve.com

2

VILLAGE POWER - 97

- 1996 - Changes in Bolivian policies
- 1996 - National Rural Electrification Plan
- 1996 - USAID rejects renewables
- 1996 - NRECA changes development direction

3

VILLAGE POWER - 97

- 1996 - Changes in Bolivian policies
- Privatization of generation and distribution sectors
- Role of State Governments (Prefecturas)
- Popular participation

4

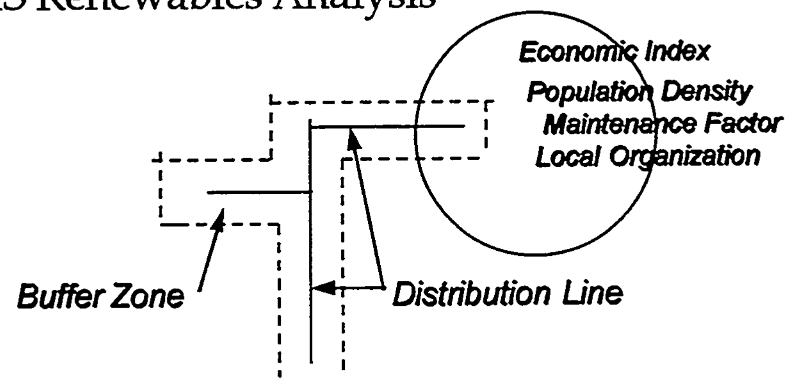
VILLAGE POWER - 97

- 1996 - National Rural Electrification Plan
- GIS Based
- SHS investments - $48 million in very near term
- Criteria - off grid, economic index, population density, maintenance risk, local organizational structure

5

VILLAGE POWER - 97

- GIS Renewables Analysis



6

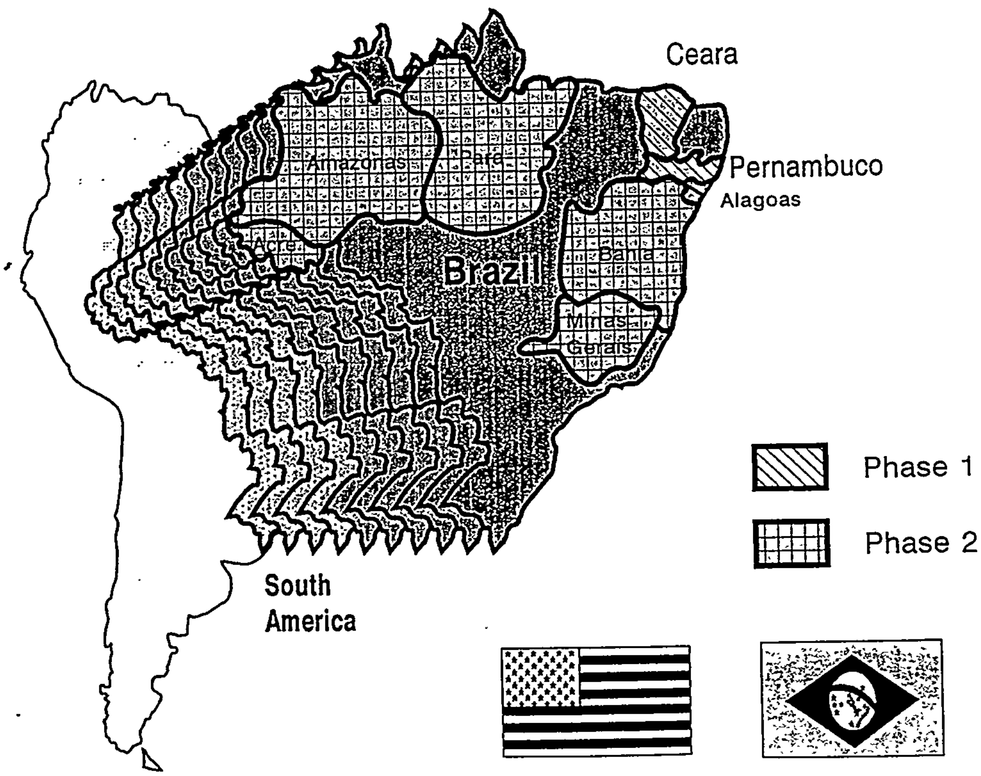
VILLAGE POWER - 97

- 1996 - USAID rejects renewables
- USAID Strategic Objectives - Economic development, Environment, Health
- World Bank Funding
- UNDP Funding
- Spanish/Dutch/GTZ/etc. funding

VILLAGE POWER - 97

- 1996 - NRECA changes development direction
- CRE Project
- Prefectura Projects
- Geothermal Projects
- Private sector - non profit?

U.S./Brazilian Rural Electrification Pilot Project



U.S./Brazil Joint Pilot Project Objectives

- Establish technical, institutional, and economic confidence in using renewable energy (PV and wind) to meet the needs of the citizens of rural Brazil.

- Establish on-going institutional, individual and business relationships necessary to implement sustainable programs and commitments.

- Lay the groundwork for larger scale rural electrification through use of distributed renewable technologies.

-- Approach --
U.S./Brazilian Rural Electrification Pilot Project
DOE
NREL

Eletrobras → **CEPEL**

U.S. Suppliers

Statement of Work
- System design assistance
- Supplý specific project components to Brazil
  - FOB Vessel, freight pre-paid, Insured
  - Specific shipping instructions will be provided during contract negotiations
- Systems for NREL Testing

Mutual Agreement
- Title Transfer
- Shipping Details
- Warranty Provisions

↓ **CEPEL**

CEPEL

Statement of Work
- Project Management Support
  - Facilitate communications
  - Clear Brazilian Customs & Fees
  - Visual inspection, file claims (if any)
  - Oversee in-country shipment to specific states if different than port-of-entry
- Quality assurance of installation
- O&M support
- Performance evaluation
- Reporting

Mutual Agreements
- Procure all BOS & Install Systems
- Perform O&M and Provide Data
- Collect and Provide Performance Data
- Provide Reporting Information

↓ **State Utilities**

-- Status --
U.S./Brazil Joint Pilot Project

Phase 1

- U.S. supplied components:
  - ≈1300 PV modules (65kW)
  - ≈1300, 100Ah batteries
  - ≈900 charge controllers

- Ceará -- 14 villages
  - 420, 50W home lighting systems
  - 14 schools: lights, refrigeration, TV
  - 2 medical centers: lights, refrigeration
  - 52 street lights

- Pernambuco
  - 350, 100W home lighting systems

-- Status --
U.S. Brazil Joint Pilot Project
Phase 2

- Extends pilot project into additional states
  - Acre
  - Alaǵoas
  - Amazonas
  - Bahia
  - Minas Gerais
  - Para

- Expands the variety of PV stand-alone applications in Acre, Alagoas, Bahia, Minas Gerais

- Includes 2 village-level hybrid (PV, wind, battery, diesel) power systems in Amazonas and Acre

-- Status --
U.S. Brazil Joint Pilot Project
Phase 2 Stand-Alone Systems

Acre
- 3 small health clinics and 3 small schools
- 6 large health clinics and 6 large schools
- 9 small water pumps and 2 large water pumps

Alagoas
- 5 local radio-telephone systems
- 1 village including lighting, and refrigeration, for a health clinic, a school and a community center, along with 30 homes
- 3 small and 3 large water pumping systems

-- Status --
U.S. Brazil Joint Pilot Project
Phase 2 Stand-Alone Systems

Bahia
- 85 dc home lighting systems
- 17 surface and down-well water pumping systems
- 10 ac home electrification systems

Minas Gerais
- 15 ac electrification systems for health clinics, community centers and homes
- 15 dc home lighting systems
- 5 wind water pumping systems
- 2 wind electric generation systems with inverter for home cluster

Stand-alone product supplied by Photocomm (with United Solar modules), Solarex, Siemens, and Bergey. Batteries, installation, BOS and operation by state utilities.

-- Status --
U.S. Brazil Joint Pilot Project
Phase 2 Hybrid Systems

Amazonas
- 50 kW hybrid power system
- 50 kW PV (Solarex)
- option for 20kW of wind (Bergey pending resource confirmation)
- 50 kW controller (AES, Austrailia)
- Batteries, installation, BOS and operation by CEAM

Para
- 50kW hybrid power system
- 40kW of wind (Bergey-option for 20 more kW)
- 10kW of PV (Siemens)
- 50kW controller (Northern Power)
- Batteries, installation, BOS and operation by CELPA

-- Status --
U.S. Brazil Joint Pilot Project
Phase 2 Hybrid Systems

Product Summary

Stand Alone Systems
- 51.5kW of PV
- 195 charge controllers
- 25 inverters
- 32 pumps
- 5 wind turbines & pumps
- 2 wind electric & inverters

Total price about $400K

Hybrid Systems
- 60kW of PV
- 40kW of wind (40kW options)
- 50kW electronic hybrid controller
- 50kW rotating hybrid controller

Total price about $700K

-- Future --
U.S. Brazil Joint Pilot Project

- Support and monitor (ground and VITASAT) O&M experiences for at least 3 years

- Continue efforts on institutional and business development
  - Support efforts directed at PAPP loan program
  - Support REC developments through NRECA
  - Support other parallel programs as they develop

- Support in-country training, education and information exchange

- Increase focus on financial analysis and assist in developing dialogue and plans for major World Bank financed project expansion

- Use Brazilian successes to expand renewable opportunities in LAC region and elsewhere

"Brazilian Model"

Establish sustainable institutional (laboratory-to-laboratory) relationship that can trancend involvement of specific individuals (NREL-CEPEL)

Establish a (cost-shared) project focus that moves hardware, builds active working relationships, and insures in-country "buy-in"

Maintain a focus on in-country infrastructure (human resource and knowledge base) development

Maintain a focus on the "long term" goal of major in-country financed procurements and support performance documentation and analysis need to achieve this goal

Maintain a recognition of the time-frames required for success, 3-6 years.

Be patient

PRODEEM

Program for Energy Development of

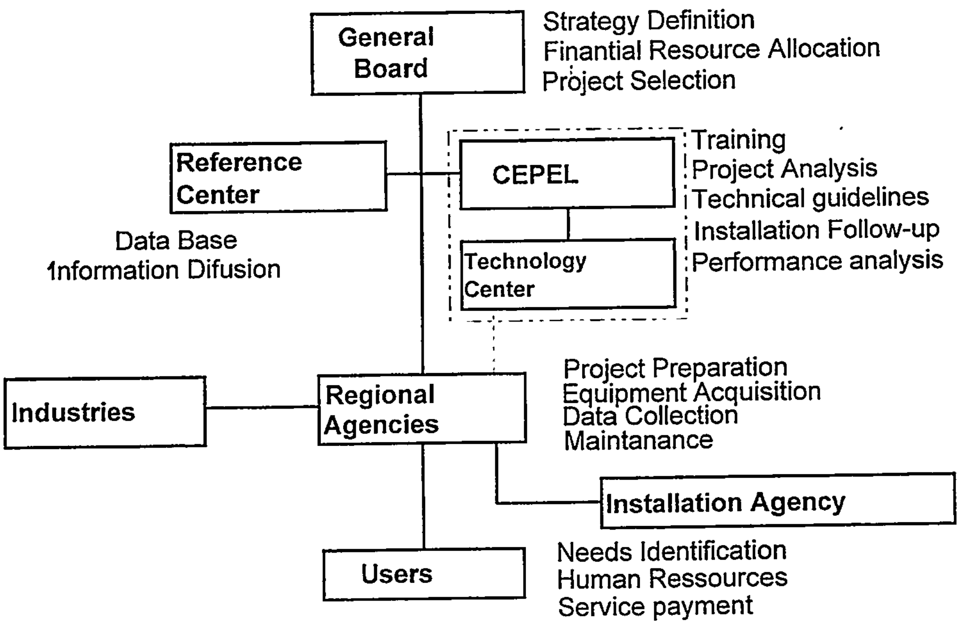
States and Municipalities

Programa de Desenvolvimento Energético

de Estados e Municípios

Nov. 96

PRODEEM's General Structure



Basic Tasks for the involved institutions in PRODEEM

Phase 1 Projects' Remarks:

- **Sizing Evaluation**
  - **Some undersized**
  - **Some oversized**
- **Technical Approach of the Projects**
  - **Use of conventional appliances**
  - **Lamps and ballasts without specifications**
- **Costs Quite Above Expected: 2 to 4 times**

Typical Applications

- Public Lighting (137 PV systems)
- Water pumping (55 systems: 54 PV & 1 wind)
- Energy Systems (192 systems: 190 PV e 2 wind)
  - Schools

    Health Clinics
    Community Centers
    Telephone Stations
    Water Desalination
    Ice Making
    Others

Total 384 systems

Overview - Phase 1 Systems

State	Villages	Systems
Amapá	9	24
Amazonas	1	3
Bahia	15	31
Ceará	3	22
Maranhão	1	4
Mato Grosso	1	2
Mato Grosso do Sul	9	38
Minas Gerais	13	39
Paraíba	1	4
Piaui	6	18
Rio Grande do Norte	18	27
Rondônia	1	9
Roraima	2	3
Tocantins	1	5

Features of Phase 1

Item	PRODEEM Phase 1
Funding resource	MME: emphasis on definition new costs level
Project Definition	MME/CEPEL/Regional Agents
Other institutions integration	Comunidade Solidária/other Ministries
Selection & equipment acquisition	CEPEL
Total systems' power	187 kW (165.5 kW PV & 21.5 kW wind)
Energy Efficiency	Concern with the loads used like: lamps, refrigerators, etc.
Home appliances	Conventional: all AC power
Projects' Geographical distribution	14 States including all 5 Regions
Systems' installation	Private Sector (Contracted) e Government
Performance Evaluation	Data Collection by the Universities
Data Processing	CEPEL & Universities

PRODEEM MME/DNDE - ELETROBRÁS/CEPEL Slide 5

Features of Phase 1 (cont.)

Item	PRODEEM Phase 1
Special Applications	Desalination & ice making: using wind energy
Maintenance	Decentralized: trained local agents & communities representative
Charge for the energy	Methodology definition to cover the costs with O&M
Training Levels	Several levels: Regional Agents, installation team, users, maintenance crews, universities & schools
Basic Objectives	Establishment of a network for future programs, technology and methodologies R&D
Installation's configurations	Same basic configuration for each type of installation: health clinic, school, community center, lighting, etc.

PRODEEM MME/DNDE - ELETROBRÁS/CEPEL Slide 6

Standardization of the Systems

The same basic system configuration allows:

- Standard installation
- Easy identification of problems
- Prompt maintenance
- Facilitate CEPEL's support
- Involved personal training

Standardization of the Equipments

Use of Inverters dc/ac (12Vdc-127Vac)

- Conventional appliances - Schools, Health Clinics and Community Centers

  TV's, Refrigerators, etc.

Use of Adequate Lighting Fixtures (12Vdc)

- Fluorescent compact lamps with high efficiency and long life cycle (>8000 h.)
- Easy replacement
- Easy to find in regular market

International Bidding

- 25 companies acquired the RFP document
- 9 (nine) companies for the competition
- Begin of work: February 1996
- 'RFP document: 23rd of March 1996
- Proposals delivery: 10th of May 1996
- End of technical analysis: 23rd of May 1996
- Opening of commercial proposals: 29th of May 1996
- Results published on the Official Gazette on the 3rd of June 1996

Bidding General Classification

RANK	1º	2º	3º	4º	5º	6º
GROUP I	SIEMENS US$75.666,95	PHOTOCOMM US$94.614,00	SOLAREX US$141.107,00	FUJIMAQ R$272.139,10	—	—
GROUP II	PHOTOCOMM US$479.788,00	SOLAREX US$514.358,00	SIEMENS US$581.814,81	BP SOLAR R$708.523,02	ANIT (X1000) Li$1.124.085,00	FUJIMAQ R$1.021.447,90
GROUP III	BERGEY US$36.219,00	—	—	—	—	—
GROUP IV	BP SOLAR R$34.788.97	PHOTOCOMM US$47.082,00	—	—	—	—
GROUP V	BP SOLAR R$48.363,64	PHOTOCOMM US$68.000,00	FUJIMAQ R$85.400,00	SIEMENS US$116.200,00	REBRATA R$171.350,00	—
GROUP VI	BERGEY US$74.475,00	—	—	—	—	—
GROUP VII	PHOTOCOMM US$490.833,00	SOLAREX US$531.644,66	BP SOLAR US$585.605,19	FUJIMAQ R$904.021,40	COELE US$1.991.680,6	—

Currency exchange rate on 29th of May 1996:
US$1.00 = R$1.0006
Li$1.00 = R$0.000645

Costs Comparison with other Countries

Country (year)	SHS Sizes (Wp)	SHS Prices (US$)	Wp Prices (US$/Wp)
Kenya (1993)	53	1378	26
Indonesia (1994)	53 100	510 715	9.62 7.15
Sri-Lanka (1993)	53	1500	28.30
China (1994)	20	280	14
Philippines (1994)	53	900	16.98
Brazil (1994) (*) PRODEEM (**)	50 100	700 1100	14.00 11.00 6.80
Mexico (1994)	50	700	14.00
Dominican Rep.(1993)	48	700	14.58
USA	90	1500	16.67

(*) Cooperation Agreement Program between: CEPEL/ELETROBRÁS - NREL/DOE

(**) Including: Modules, Charge Controller, Batteries, Inverters, Pumps, etc
The installation costs are not included.

Phase 2 Projects (carried out by CEPEL)

State	Municipality	Village
Alagoas	1	2
Amapá	5	5
Bahia	6	14
Ceará	3	6
Goiás	10	15
Maranhão	5	12
Mato Grosso	5	8
Pará	5	23
Paraná	1	1
Piauí	18	34
Rondônia	10	16
Santa Catarina	1	1
São Paulo	2	2

Chile Rural Electrification Cooperation

USDOE/CNE: signatories

NREL/NRECA: implementers

Project Leader: Larry Flowers, NREL

April, 1997 Chile Rural Electrification Cooperation 1

Project Activities

- initial focus on Regions IX and X
- regional wind resource mapping
- pilot project development
- training
- comparative assessment methodology development

April, 1997 Chile Rural Electrification Cooperation 2

Current Status/Plans

- three pilot projects installed in Region IX
  - owned and operated by regional private utility
  - 1.5, 3, and 10 kW wind hybrid systems
  - based on school/health post and some homes
  - micro grid and meters
- three pilots are in design stage for Region X

April, 1997 Chile Rural Electrification Cooperation 3

Current Status/Plans Cont.

- island in Region VIII being evaluated
- Chiloe Island area of Region X next focus location
- use of GIS-based approach combined with analytical optimization models will be evaluated

April, 1997 Chile Rural Electrification Cooperation 4

Current Status/Plans Cont.

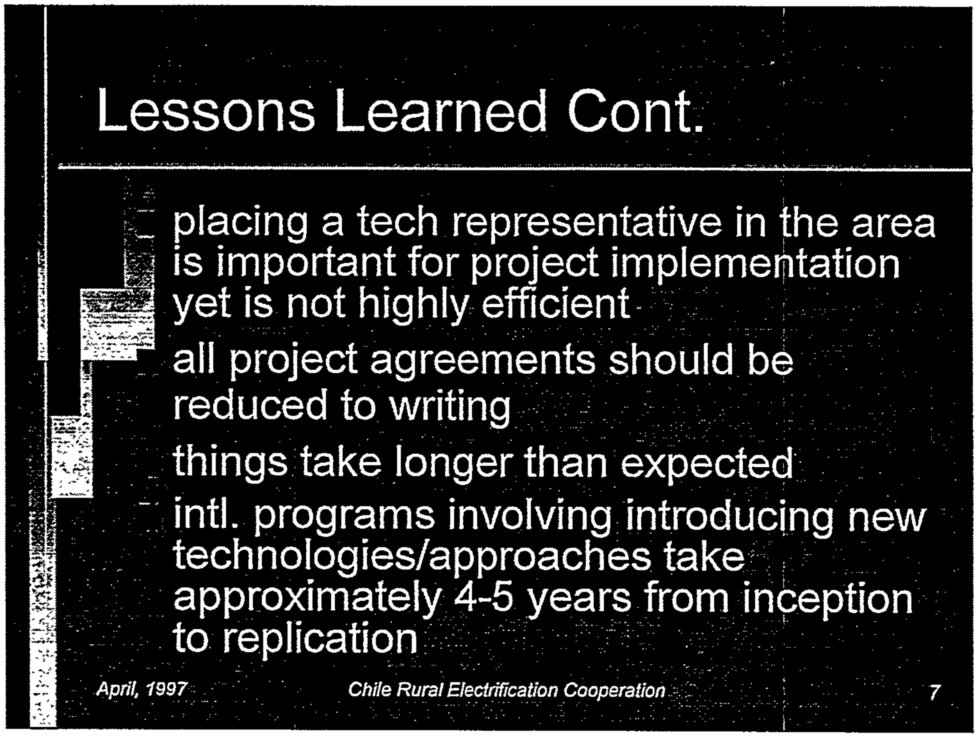
- wind mapping of Regions VIII, IX, and X will be completed
- training of planners, implementers, and operators will continue

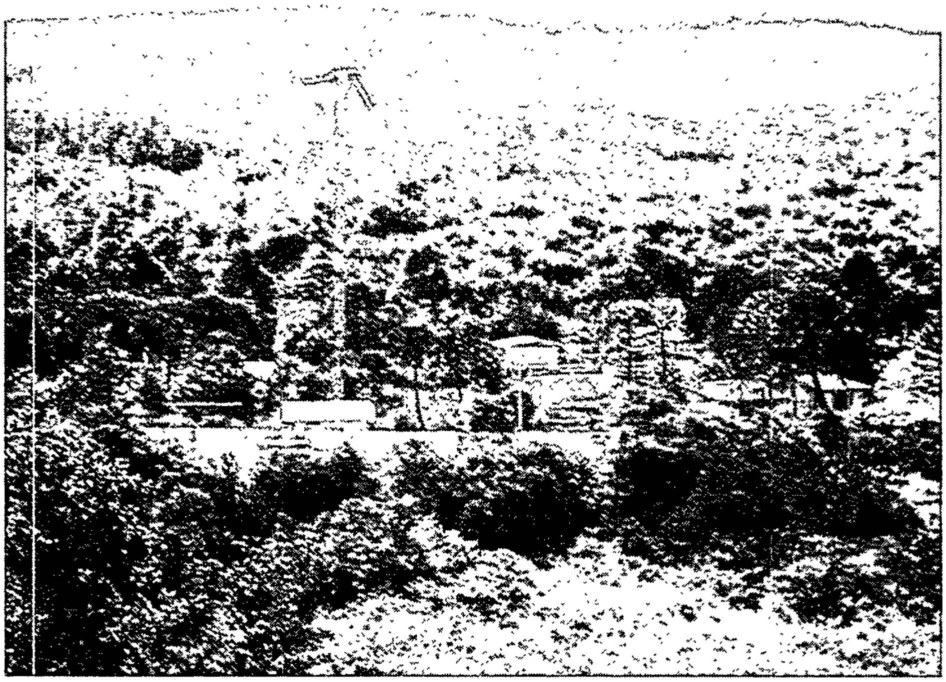
April, 1997 *Chile Rural Electrification Cooperation* *5*

Lessons Learned

- pilot projects are excellent learning experiences for all parties
- wind mapping is very helpful in eliminating areas of low resource from consideration
- working with utilities is time-consuming and getting priority attention is difficult

April, 1997 *Chile Rural Electrification Cooperation* *6*


Lessons Learned Cont.
placing a tech representative in the area is important for project implementation yet is not highly efficient
all project agreements should be reduced to writing
things take longer than expected
intl. programs involving introducing new technologies/approaches take approximately 4-5 years from inception to replication
April, 1997
Chile Rural Electrification Cooperation
7



WINROCK INTERNATIONAL

Renewable Energy Projects in the Dominican Republic

Bruno Viani
Winrock International

Village Power 97
April 15, 1997

Winrock International

EESR PROJECT IN THE DOMINICAN REPUBLIC

- Total USAID funds: US$ 2,850,540 (includes US$ 720,000 for a Loan Fund)
- Total program amount: US$ 4,145,723
- Partners: EEAF; GTConsulting; IDAC; NRECA; PRONATURA (DR); SWTDI
- October 1996 - September 1998

Winrock International

Objective:

To demonstrate the commercial viability of renewable energy generation projects, primarily small-scale wind and hydropower.

Winrock International

Strategy:

- Establishment of a Loan Fund
- Technical assistance to potential investors for project development
- Technical training to local professionals and firms
- Outreach activities
- Environmental regulatory component

Winrock International

Main activities undertaken:

- National Renewable Energy Seminar (March 1997)
- Small wind & hydropower workshop (March 1997)
- Preliminary studies completed for three micro-hydropower projects with total installed capacity of 262 kWe

Main activities undertaken (cont'd):

- Preliminary studies completed for two small wind projects for water pumping with a total estimated investment of US$ 35,000
- Wind resource data gathering in collaboration with NREL
- Consultants: Loan Fund establishment, Government Regulations on small-scale power generation and distribution

Project targets by September 1998

- 275 kWe of small hydro and windpower installed or under construction
- Not less than ten small firms active in the installation of small wind and hydropower systems

Winrock International

Project targets by September 1998 (cont'd)

- Total investment of US$ 1,300,000 on small hydro and wind projects developed directly with the assistance of the Winrock EESR team
- 4,000 people directly benefiting from energy generated by small wind and hydro systems

Winrock International

Renewable Energy for Productive Uses in Mexico

Program Sponsored by
US Agency for International Development
US Department of Energy

Charles Hanley
Sandia National Laboratories
ph. (505) 844-4435
fax (505) 844-7786
email: cjhanle@sandia.gov

Village Power Conference
April 15, 1997

15 April/1

Sandia National Laboratories

Program Supports DOE and USAID Goals

To increase the sustainable use of renewable energy technologies, thereby:

- expanding markets for U.S. and Mexican industries
- combatting global climate change, especially greenhouse gas emissions

15 April/2

Sandia National Laboratories

Program is Implemented by a Diverse Team

- Sandia and NREL provide technical direction
- Contractors:
  - Southwest Technology Development Institute
  - Winrock International
  - Enersol Associates
  - Ecoturismo y Nuevas Tecnologías
- U.S. industry organizations are active participants
  - US/ECRE, AWEA, SEIA, IIE, REETI
- Many Mexican partner organizations
  - federal, state, local government agencies
  - financial institutions
  - industry members and associations

15 April/3

Sandia National Laboratories

Emphasis on Infrastructure and Replicability

- Partnering with Mexican implementation organizations
  - rural development and conservation
  - established and funded programs
- Focus on off-grid productive-uses
  - economic and/or social benefits
  - provide built-in payback mechanisms
- Developing institutional capabilities to use renewables
  - pilot-project implementation
  - training and field technical assistance

15 April/4

Sandia National Laboratories

Technical Assistance Takes Several Forms

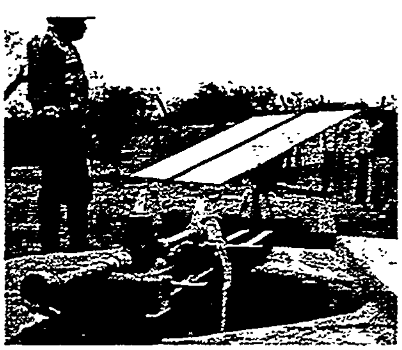
Anemometer Installation in Quintana Roo

- Resource Assessment
- Training
- Technical, Economic Analysis
- Financing Mechanisms
- Industry Interactions
- Project Monitoring, Evaluation
- Environmental Assessments

15 April/5

Sandia National Laboratories

Most Activities Occurring at State Levels



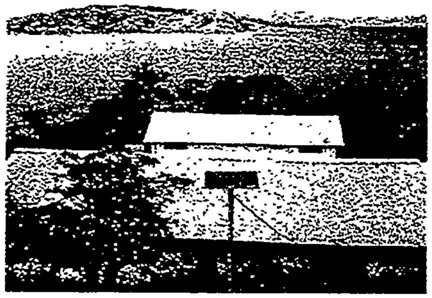
PV Water Pumper in Sonora

- Primary focus is water pumping for livestock
- Main partner is FIRCO, an agricultural development organization
- Well-developed programs in 4 Mexican states
- Over 50 installed projects

15 April/6

Sandia National Laboratories

Protected Areas Management



PV Power for a Training Center in El Ocote Reserve, Chiapas

- Partnerships with:
  Conservation International,
  World Wildlife Fund,
  The Nature Conservancy
- Projects for reserve management and buffer communities
- Over 20 projects installed to date

15 April/7

Sandia National Laboratories

Replication of Successes with FIRCO

Wind Water Pumper in Oaxaca

- $1.8 billion agricultural development program
- FIRCO has requested Sandia renewables technical support in at least 4 more states
- Several hundred project proposals under review
- Sandia, FIRCO working together to determine potential national market, impacts

15 April/8

Sandia National Laboratories

Other Present and Future Activities

- Village power
  - U.S./Mexican utility partnership in San Juanico, Baja Ca. Sur
- Wind power for Baja fisheries
  - Sandia developing up to three projects for $750M industry
- Increased cooperation with electricity commission (CFE)
  - potential for Joint Implementation projects
- Application of established models in new areas
  - ecotourism, potable community water

15 April/9

Sandia National Laboratories

Results Indicate Sustainable, Growing Markets

- Renewables are a line item in $1.8 billion rural development program
- Self-sustaining model financing program
  - $500k line of credit specifically for renewables (in Chihuahua)
- Strengthened links between U.S. and Mexican suppliers
- Huge testbed for technical assessment of fielded water pumping (and other) systems

15 April/10

Sandia National Laboratories

Communications are Key

- Latest newsletter in final preparation stages
  - feel free to give me business cards, or
  - email requests to clhickm@sandia.gov
- Home page on World Wide Web
  - "usaidlap.nmsu.edu/usaidlap"
  - email subscriber list for updates
- Call me anytime.

15 April/11

Sandia National Laboratories

COUNTRY PROJECTS - OTHER

DOE/NREL Supported Wind Energy Activities in Alaska

Steve Drouilhet

1. STEP Wind Energy Deployment Project (Kotzebue)

2. Large Village Medium-Penetration Wind-Diesel System (Kotzebue)

3. High-Penetration Wind-Diesel Pilot Project (Wales)

Sustainable Technology Energy Partnerships (STEP) Wind Energy Deployment Project (Kotzebue, Alaska)

Objectives:

Install 6 AOC 15/50 wind turbines and connect to the existing village diesel grid (approx. 1 MW average load). (~8% penetration)

Develop solutions to the problems of arctic wind energy installations (transport, foundations, erection, operation, and maintenance)

Establish a wind turbine test site in Kotzebue

Establish Kotzebue Electric Association as a training and deployment center for wind-diesel hybrid technology in rural Alaska.

NREL's Role

Financial assistance

Provide technical support in wind turbine performance monitoring.

Large Village Medium-Penetration Wind-Diesel System (Kotzebue, Alaska)

Background:

1997 $2M Congressional appropriation specifically for a wind energy project in Kotzebue.

Objectives:

Install a 1-2 MW mini-windfarm, supplementing the AOC turbines installed under the STEP project. (~30% total penetration).

Investigate impact of medium penetration wind energy on power quality and system stability.

NREL's Role:

Assist KEA in technical specification development, proposal review, and project management.

Assist KEA in the assessment of the technical and economic performance of the project.

The Alaska High-Penetration Wind-Diesel Village Power Pilot Project (Wales, Alaska)

Project Objectives:

Install a high-penetration (80-100%) wind-diesel system in a remote Alaskan village. System will include about 180 kW installed wind capacity to meet an average village load of about 60 kW.

Provide a model for high penetration wind retrofits to village diesel power systems

Build capability in Alaska to operate, maintain, and replicate wind-diesel technology

Resolve some outstanding technical issues in the implementation of high-penetration wind-diesel systems:

effective use of excess wind energy

reliable diesel-off operation

role of energy storage

The Alaska High-Penetration Wind-Diesel Village Power Pilot Project (Wales, Alaska)

Principal Funding Sources

U.S. EPA - Environmental Technology Initiative

U.S. Department of Energy

Alaska Department of Community and Regional Affairs - Division of Energy

Alaska Science and Technology Foundation

NREL's Role:

Test the wind-diesel system controller.

Technical assistance in resource assessment, turbine siting, and integration with existing village power system.

NREL

National Renewable Energy Laboratory
http://www.nrel.gov

USDOE/Russian Ministry of Fuel and Energy Joint Collaboration for Renewable Energy Resources, Cont'd (Ken Touryan, NREL)

1. Establish Intersolarcenter as a sister organization to NREL for joint R&D activities. Provide training to staff

2. Install demonstration systems in parks and selected locations around Moscow (Fili Park and Istra, outside Moscow)

3. Install pilot projects:
   A. Wind-diesel hybrid systems in 21 sites in the Russian Northern Territories
   B. 500 kW biomass power plant in Arkhangelsk Region.

4. Assist in the start-up operation of a 2MW/yr Triple Junction a-Si manufacturing facility in Moscow using U.S. technology (ECD)

5. Explore possibilities of financing large-scale wind-hybrid and biomass power systems for the Northern Territories (900 sites)

NREL

National Renewable Energy Laboratory
http://www.nrel.gov

Renewable Energy 1997 Workplan

Implementation of the program of Energy Supply to the regions of the Russian Far East, Siberia, and the Far North using small and non-traditional energy sources.

Renewable Energy 1997 Workplan

- Continuation of work with Intersolarcenter/Federalcenter
  - √ Developing a system of heating individual residential buildings using wind energy and heat storage devices
  - √ A study of new environmentally clean technologies in production of solar cells, modules & batteries
  - √ Biomass power using wood waste
  - √ Development of small-capacity hybrid systems for energy supply to off-grid communities using American (Bergey Wind Power) 10 kW wind installation & Russian 8-10-16 kW diesel motors.

NREL
National Renewable Energy Laboratory
http://www.nrel.gov

Renewable Energy 1997 Workplan, Cont'd

- Based on CIP grant for purchase and installation of wind turbine systems in the Northern Territories, NREL to assist Federalcenter(FCSNE) in monitoring, evaluating and summarizing results from demonstration systems

- FCSNE and NREL use experience gained from demonstration projects to develop a pre-feasibility study for securing a World Bank loan to implement the Federal Program of Electrification for the Northern Territories

Renewable Energy 1997 Workplan, Cont'd

- Complete the pre-feasibility study started in FY 1996 by NREL (for installation of a 500kW biomass electric power system in Arkhangelsk Region)

- Explore possibility of financing this project, along with several other renewable energy pilot projects in the Northern Territories (EX-IM/World Bank have expressed interest in these projects).

Renewable Energy-Based Electricity for Rural Social and Economic Development in Ghana

Jerome Weingart, consultant

United Nations Development Programme / Global Environment Facility

Regional Bureau for Africa

Presentation for Village Power '97

Ghana in Brief

- In West Africa, 239,000 sq. km. (slightly smaller than Oregon)
- 18 million people, 3%/year growth rate
- Infant mortality rate - about one in twenty
- 60% of population is literate (m 70% f 50%)
- per capita income = $400
- **60% of the population lacks electricity** (including ca. 4,000 villages of > 500 people)

The Electric Power Sector

- Two electric utilities
  - Electricity Company of Ghana (privatized in February 1997)
  - Volta River Authority (with distribution by Northern Electricity Department) *Privatization of NED soon, possibly in 1997*
- Generating capacity
  - ca. 1,200 MWe, primarily hydropower; generation growth by thermal power and imports
  - 400 MWe thermal coming on line (300 MWe, gas/oil-fired combined cycle in 1987/88)

Project Goals

- Establishment of a pilot renewable energy-based rural energy services enterprise to serve communities in the Mamprusi East District, focused on
  - Economically productive activities
  - Community services
  - Household non-thermal energy
- Establishment of the technical, economic, financial, institutional, and socio-cultural requirements for sustainability
- **Demonstration of bankability and financial sustainability, as pre-investment prelude to commercial diffusion**
- Establishment of technical, financial, and service performance standards for private sector rural energy service companies

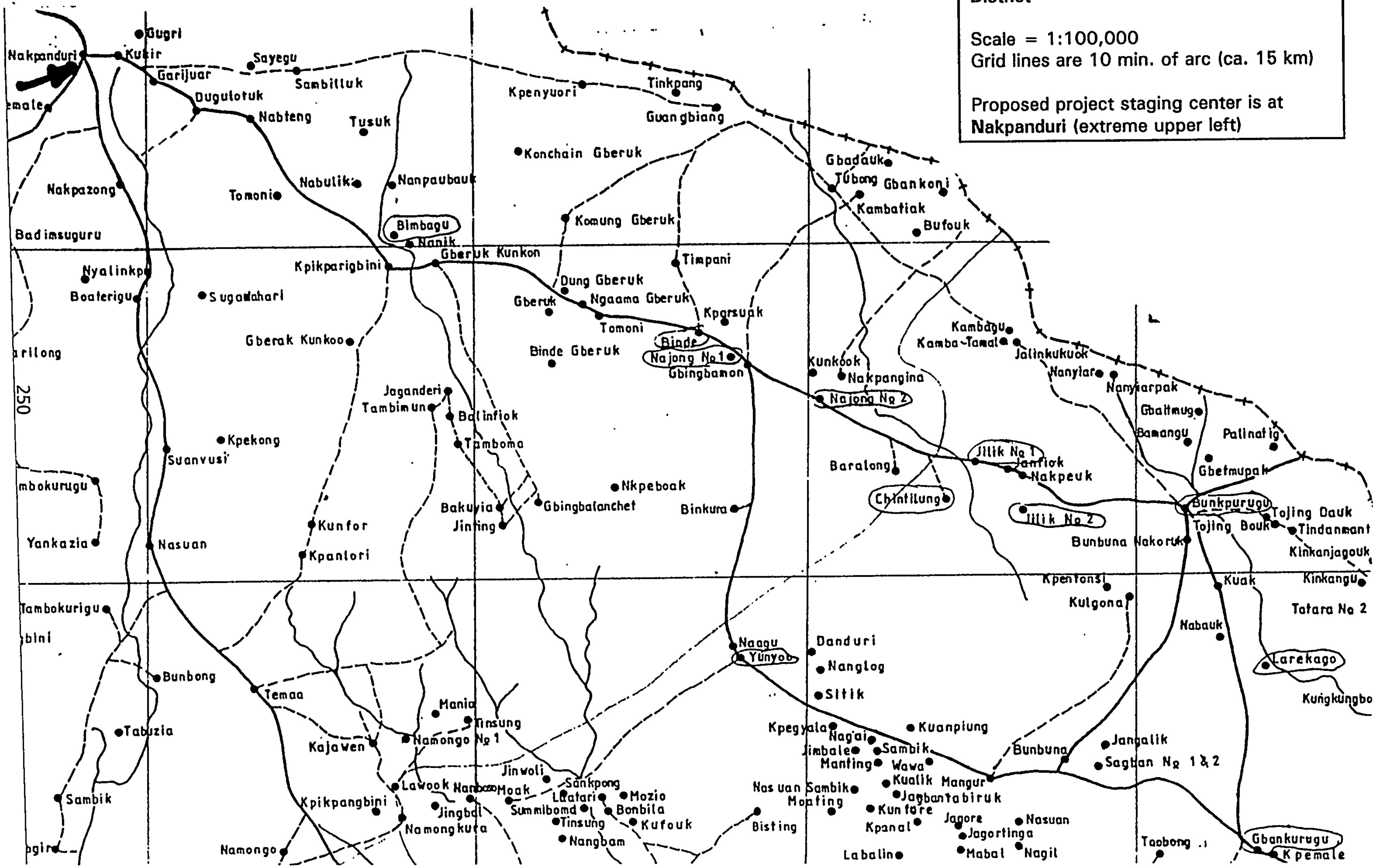
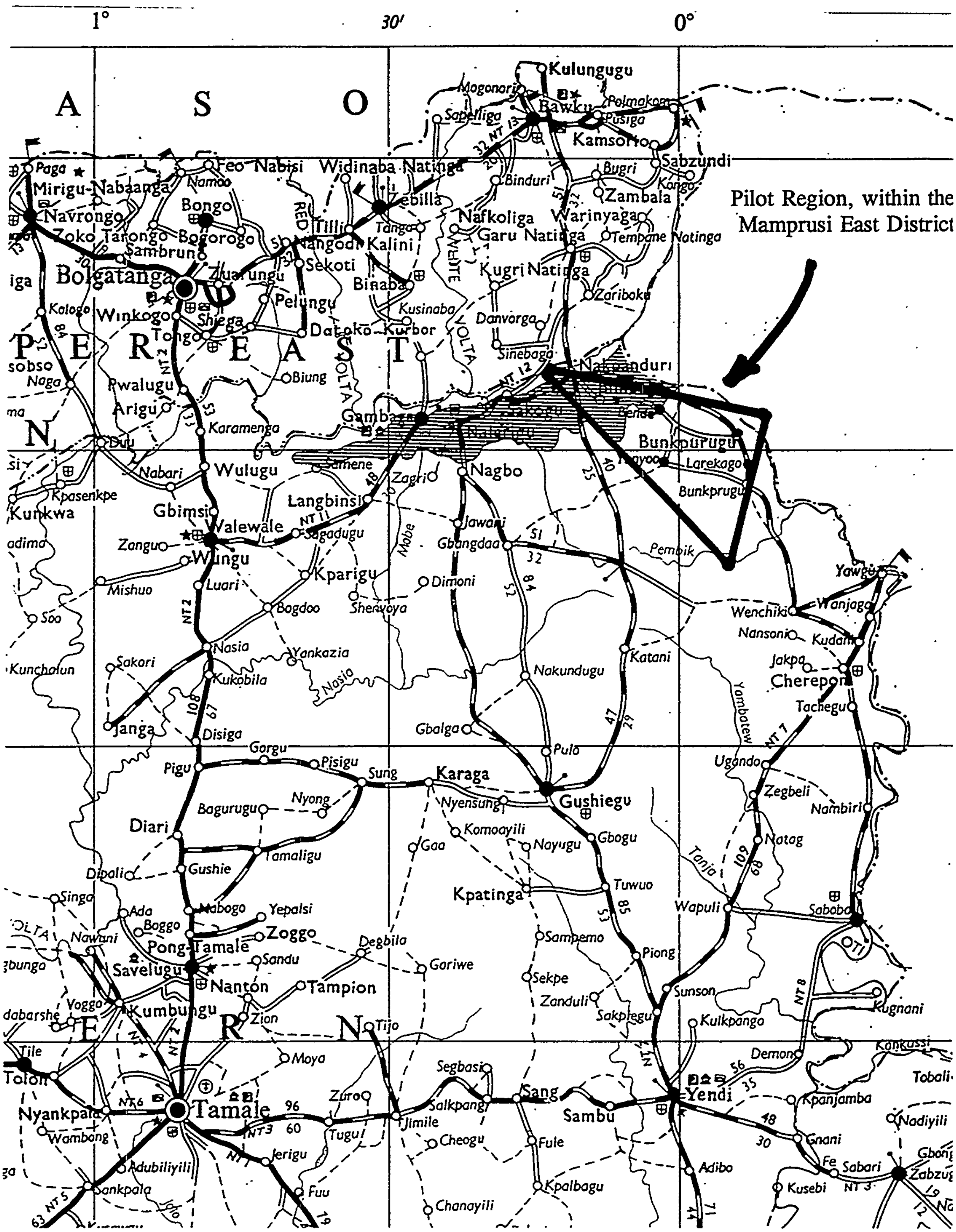


Figure 1: Pilot Region in Mamprusi East District

Scale = 1:100,000
Grid lines are 10 min. of arc (ca. 15 km)

Proposed project staging center is at **Nakpanduri (extreme upper left)**

Figure 2
UNDP/GEF Project Pilot Region
(within the Mamprusi East District)



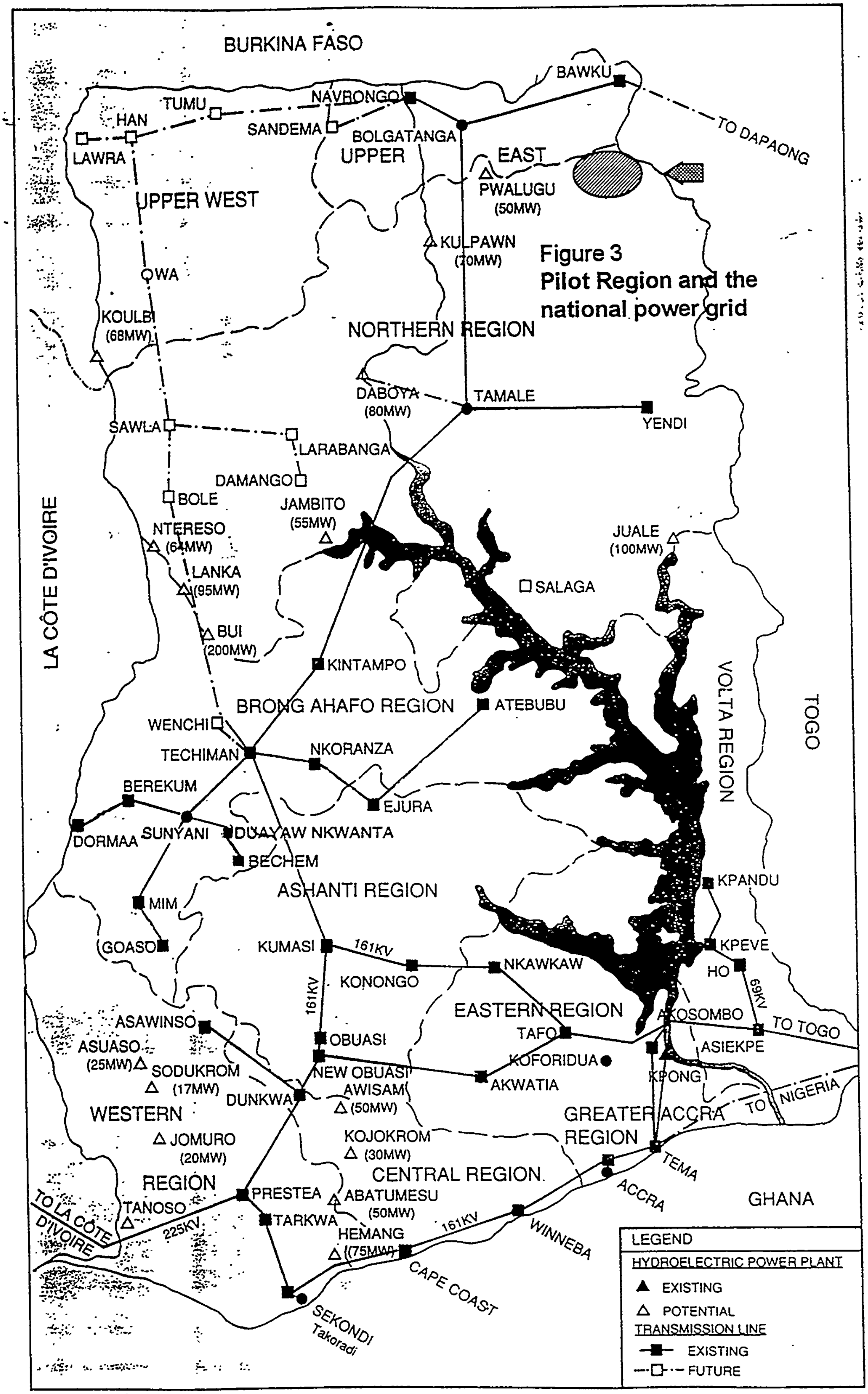


Figure 3
Pilot Region and the national power grid

Project Budget and Implementation

- Initial Budget (3-year)
  - $2.5 million GEF grant funds
  - $0.5 million Government of Ghana
  - ca. $100K USDOE/NREL parallel financing for technical support *USDOE/MOME Memo of Understanding*
- Implementation
  - Ministry of Mines and Energy (executing agency)
  - Volta River Authority / Northern Electricity Department (VRA/NED): Implementating agency
  - Universities, NGOs, health clinics, ...
  - ✱NREL: international technical collaboration

Why Do It?

- Government commitment to provide electricity services to all by year 2020 *(rural people vote!)*
- Reliable electricity services, *in concert with investments in economically productive activities and primary community services*, are essential for sustainable human development
- Much of the off-grid population can be served at lower total costs by decentralized low-carbon technologies than by grid extension

Why Use UNDP/GEF Funds?

- Low greenhouse gas (GHG) emission energy technologies are essential for environmentally friendly global development
- UNDP's focus on sustainable human development
- UNDP/GEF grant funds make possible *high-risk high-potential payoff pathfinding projects*, lowering the risks for subsequent investments in widespread diffusion

Why Now?

- Structural reform and economic modernization in Ghana, including privatization of the electric power sector
- Active interest by international development finance community
- Government commitment
- The people want electricity, and are *willing and able to pay for a range of services that renewable energy and low-GHG technologies can provide.*

For further information, contact:

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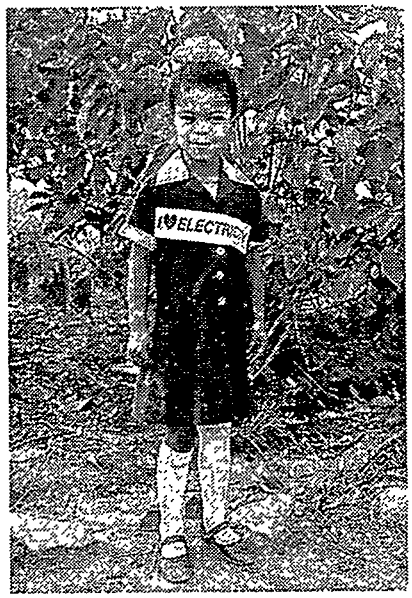
Rural Development

Update: VP '97



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NREL
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fax: 202-651-7501
darent@nrel.gov

Rural Development

- ***Renewable Energy Activities***
  - **Renewable Energy for South Africa (REFSA)**
  - **Hybrid Collaborative R&D**
  - **Electricity Sector Restructuring.**
  - **Provincial Level Initiation of Renewable Energy Applications**
  - **Renewable Energy for African Development (REFAD)**
  - **Suncorp Photovoltaic Manufacturing Company**

Rural Development

- **Partnerships for Sustainable Development:**
  - Department of Minerals and Energy
  - REFSA
  - Energy for Development Research Centre
  - Independent Development Trust
  - Dev. Bank of Southern Africa
  - Council for Scientific and Industrial Research
  - Eskom
  - Energy & Development Group
  - Universities of Port Elizabeth, Pretoria
  - Penninsula Technikon, Cape Technikon
  - Minerals and Energy Policy Centre
  - National Electricity Regulator
  - Foundation for Research and Development
  - International Finance Corp.
  - Industry: Africa Solar, Siemens, AEG, Suncorp, Franklin,
  - Matshoba & Assoc (PR), Jacana (Soul City), Renaissance
  - NRECA, REFAD, SNL, Inst. for Sust. Power, NEOS

Rural Development

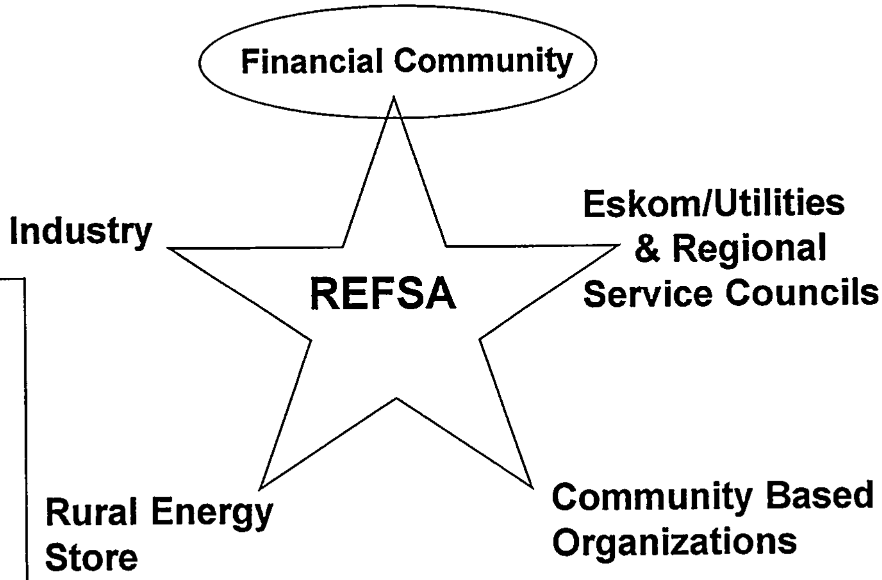
- **Renewable Energy for South Africa (REFSA)**

National Electrification Forum(1993)

SAFIRE
(South African Financing and Implementation Agency for Renewable Energy)

- Serve remote rural populations => 2.5 million households by 2012
- Align with other rural electrification and development programs

Rural Development



- Government's Implementation Agency
- Plan and Contract Projects
- Mobilize Funding
- Facilitate Consumer and contractor education
- Manage revolving credit facility

Rural Development

REFSA

- **Key Successes thru July 1996**
  - Corporation Formed, late 1995
  - CEO Appointed, April 1996
  - Business Plan Drafted in collaboration with NRECA
  - Board Members Identified
  - Initial Funding secured
  - Financial institution linkages established and industry proposals received
- **Key Successes since July 1996**
  - Board of Directors actively engaged.
  - Board met with Minister Maduna:
    - National Electrification Policy to include appropriate technology. Grid/non-grid subsidy leveling to be explored.
    - Board of directors to be expanded.
    - Pilots to continue accelerating.
  - Mobile Demonstration Unit redesigned
  - New positions advertised
  - NRECA and NREL Technical Assistance continued.
  - New delivery channel identified and under exploration (municiple utilities, Regional Service Councils)

Rural Development

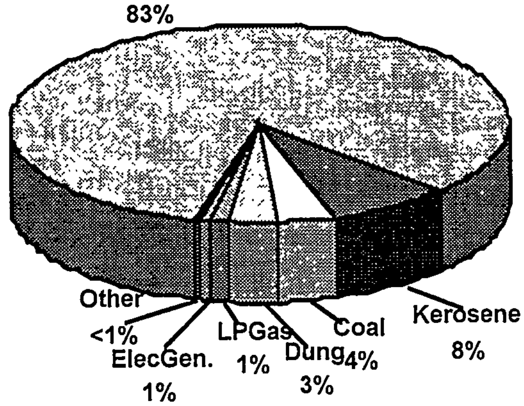
- **Status:**
  - Organizational:
    - » Section 21 Corporation reorganization
    - » Subsidy/integrated electrification policy recommendations, 1500R/system
    - » Commercial director, project manager and community liaison officer
    - » Overall funding/3 yrs: DOE: $400k, AID: $1.1m, South Africa: $3m, USIS: $80k, DANCED:proposed $1m
    - » MOU with U.S. National Laboratories for Technical Assistance.
    - » USDOE/NREL tech. assist for design of business systems and roll out.
    - » Linkage with LPGas association, Ellerins (furniture), SA Breweries, COKE distribution
  - Market Foundation:
    - » Training and Sales Promotion Mobile Unit built.
    - » Marketing Stategy Plan
    - » Support training and certification standards
  - Expand Pilot Efforts.

Rural Development

- **Other off-grid electrification efforts:**
  - Hybrid village power technology transfer
    - » 3 month visit of Principle Investigator to NREL
    - » 1st South African national R&D workshop
      - web page and coordinated efforts
    - » "RAPS" manual for hybrids in process
    - » Testing Center at Eskom under consideration
    - » 1997 technical exchanges under consideration

Rural Development

Net rural energy consumption in South Africa (1993)



„ Source: R P Viljoen: Rural Wood and Woodfuel Survey: National Comparative Report - The Biomass Initiative, Department of Mineral and Energy Affairs, Pretoria, 1994.

Rural Development

- Renewable Energy Products & Services + Employment Opportunities = Suncorp
  - Majority Owned & Operated PV Module Manufacturer
  - Uses US built & donated equipment
  - Structured by Renaissance/Monitor
- Q1-1997 status: AEG Restructuring
  - » Seeking investment partner
  - » Manufacturing contracts available
  - » Expanding to offer energy systems & services through franchising to reach rural communities and create jobs

Rural Development

- Provincial Level Initiation of Renewable Energy Applications
  - Northern Cape inquired on applicability of RE technology for servicing low population density regions.
    - » Feasibility Study and Demonstration Projects
      - DME
      - Northern Cape Government
      - Council on Scientific and Industrial Research (CSIR)
      - Eskom
      - U.S. National Laboratories
    - » Study completed
    - » GEF proposal under consideration
  - PV-water pumping:
    - » Collaboratively facilitated awareness campaign with DWAF
    - » DME funded evaluation study completed
    - » National workshop, possible DOE technical advisory role and workshop presentation with provinces and Regional Service Councils

Rural Development

- Renewable Energy for African Development (REFAD)
  - Train the Trainers: Renewable Energy Capacity Building Program
  - Collaborative Effort among government, industry and educational institutions in the South Africa and the U.S.
    - » Aligned with eight institutions, including Peninsula Tech, Vista University, Northern Province Tech, and Fort Hare University
  - Organized by REFAD and Texas Southern University, historically black U.S. school
  - Annual 3-5 week training sessions: Texas Southern University (1994), Peninsula Technikon (1995, 1996)
  - 1996 curriculum included business skills
  - Over 85 faculty members from majority schools of Southern Africa trained

Rural Development

- Technical Assistance and Energy Education
  - Regulatory and ESI Restructuring.
  - Assist national coordination of PV programs
    - » solar village pilot program
    - » SADC Finesse
    - » Coordination of School, clinic and solar home PV electrification
  - "PSN" services for SHS and PV water pumping efforts
  - CD-ROM and "School Energy Dr" programs for educational support.
  - web page
- Upcoming Events:
  - US/ECRE Trade Mission: August 1997
  - Regional Workshop on PV Training Standards, Fall 1997

Solar Electricity for Africa

The Case of Kenya

Robert J. van der Plas
Energy Planner
Industry and Energy Department
The World Bank

Two Recent WB Activities

Looking at Alternatives for Rural Electrification

* Micro-Lights
  * About 500 lanterns (some 8 different models, in Kenya Niger, Cameroon)
* Survey among households using solar electricity
  * 410 households, 8 districts, Kenya

Micro Lights

Overview of Activities

* Open tender among solar companies
  * Place different lamps in rural stores
  * Purchase at costs (factory gate price + 20% margin)
  * 6 months unconditional warrantee
* Carry out surveys to identify consumer preferences
  * 1 at purchase - expected benefits
  * 2 after six months - realized benefits
  * 3 when returning unwanted equipment
  * 4 among retailers

Micro Lights

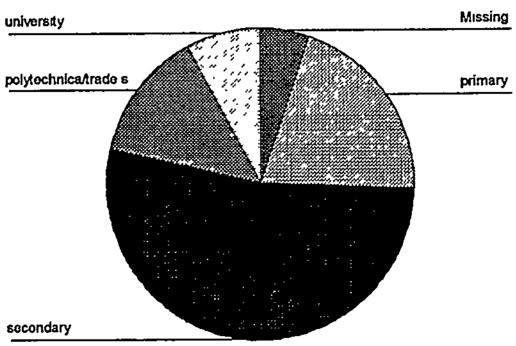
Results

* Consumers have distinct preferences
* Consumers willing to spend cash
* Equipment is technically not good enough
  * Need for low-voltage disconnect or timer
  * Need for quality lamps
* Yet, people are satisfied, but quickly want more
  * Tremendous improvement in quality of life
  * Payback time about 1 year
  * Satisfied at the beginning, want soon more

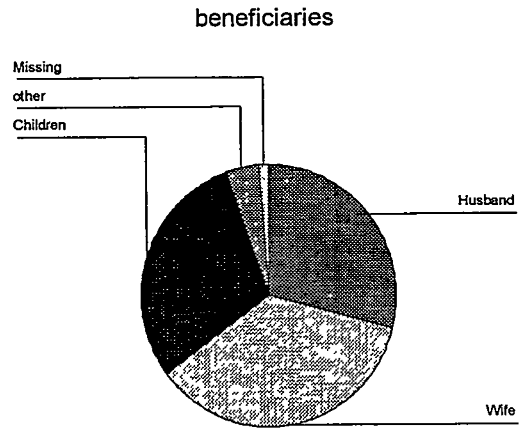
410 Household Survey

of 50,000 - 70,000 systems = 0.7%

Education Level



Beneficiaries



Random Survey Among 410 Users

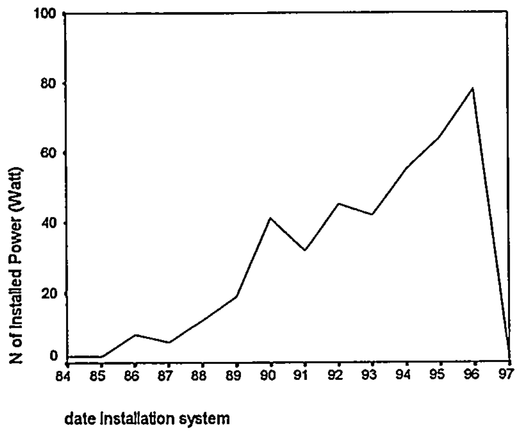
Satisfaction Level

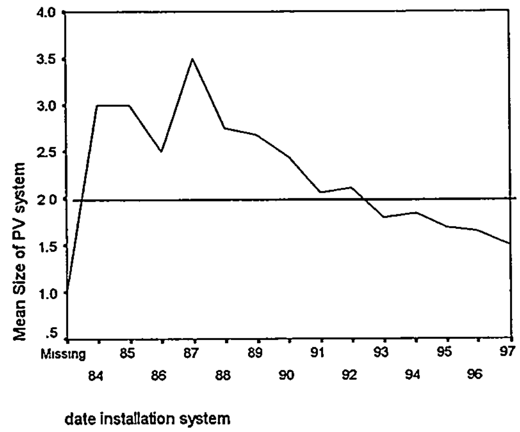
		Satisfied with system			Recommend to a friend		
		yes	no	not sure	yes	no	not sure
Size of PV syste	1-15 W	49%	46%	4%	95%	3%	3%
	16 - 25	56%	40%	4%	96%		4%
	26 - 45	80%	18%	2%	93%	3%	4%
	46 - 200 W	67%	30%	2%	93%		7%
Total		60%	37%	3%	94%	2%	4%
		244	150	14	386	8	15

State of Operation

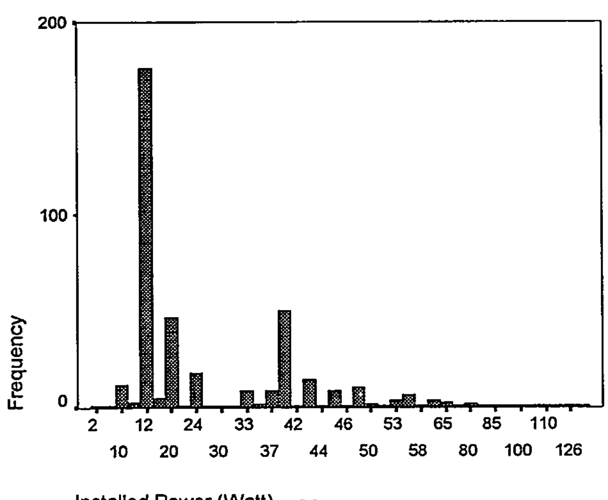
		problems with system				
		functions well	too limited power	battery is finished	applicances/lights perform poorly	other
Size of PV system	1-15 W	104	31	34	16	8
	16 - 25 W	42	10	10	6	4
	26 - 45 W	53	7	23	8	7
	46 - 200 W	30	4	9	3	
Total		56%	13%	19%	8%	5%
	Count	229	52	76	33	19

Installed Systems & Mean Size





Number & Size of Installed Systems



47% 1-15W
18% 16 - 25
24% 26 - 45
11% >46W

Appliances

* 4.2 incandescent lamps
* 4.9 fluorescent lamps
* 89% has a TV set
* 70% has a radio/cassette player

* if asked what will be your next appliance: more lights

Long-Terms Views

* 64% wants to connect to the electricity grid
* 23% wants to expand PV system
* 11% is satisfied
* 2% wants to buy a generator

* if connecting to grid impossible
    * 70% will expand their PV system
    * 30% will keep as is

Lessons Learnt

* households think small
* .... and in increments rather than packages
  * this fits their expenditure pattern
  * PV systems are modular
  * Implications for donor financed programs

* solar electricity is as real an option for obtaining electricity as possible
* .... and households in Kenya have understood this.
  * now it is up to the Government (policy conditions)
  * and Donors (listen to people)

Page 9 NREL Village Power Workshop April 14 - 15, 1997

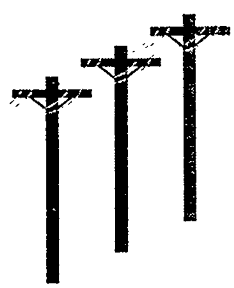
INSTITUTIONAL APPROACHES/ISSUES

Institutional Issues in Village Power

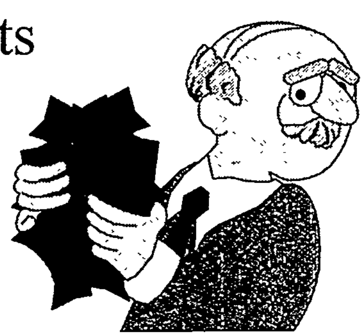
Ron Orozco, P.E.

Energía Total, Ltd.

Observations of Village Power



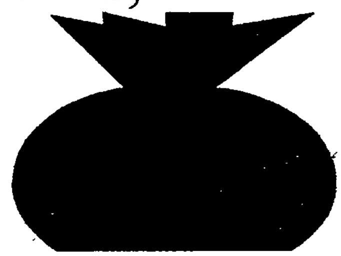
- Electricity is not the goal
- Technology is not the problem
- Site selection is more than resource assessment
- Demonstration Vs. pilot projects
- Engineers can not do it all



Energía Total, Ltd.

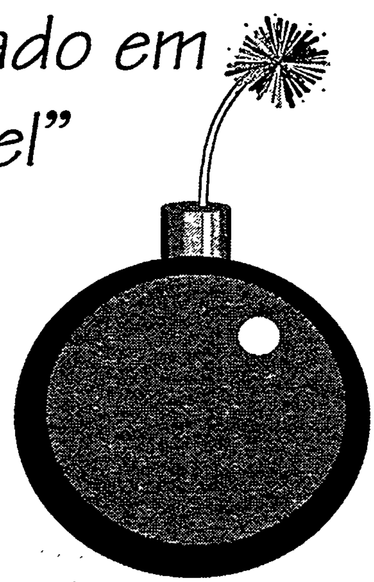
Lessons from Traditional Rural Electrification Experience

- Competing for funds with health, education and road projects
- High cost must be offset by high economic impact
- Must clearly quantify/justify economic costs and benefits (Munasinghe, 1987; Barnes, 1988)



Energía Total Ltd.

"Como conseguir o Maior Retorno para cada Real Aplicado em Energia Renovável"



Energía Total Ltd.

Uso Productivo de la Electricidad

Cualquier uso de la electricidad que mejore la situación financiera del usuario final o que provee un estímulo para el desarrollo económico

Eneraía Total. Ltd.

There is no Single Institutional Answer!

Some institutional models tried in renewable-based <u>hybrid village power</u>

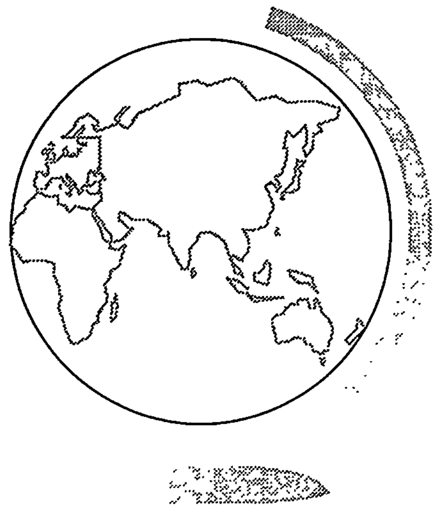
- None - Xcalak
- State utility - Joanes & Campinas, Brazil
- Private sector- Essene Way Resort, Belize
- Casa Blanca Resort, Mexico
- Other

Eneraía Total. Ltd.

What can we do to make village power work?

- Let's assure presence of political will at all levels before we get too far.
- Let's coordinate with other development activities
- Let's understand local conditions.
- Let's select our partners (and sites) well
- Let's do true <u>pilot</u> projects!
- Let's show how renewables can really work!

Energía Total. Ltd.



April 1997

E&Co Briefing

Solar Development Corporation

Core Energy Strategy

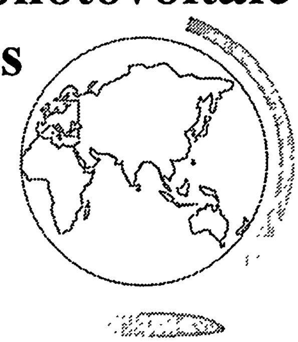
- **Promote the transition to a New Energy Paradigm---**
- **Environmentally sound**
- **Economically viable**
- **Equitably available**
- **---Through the support of energy enterprises in developing countries**

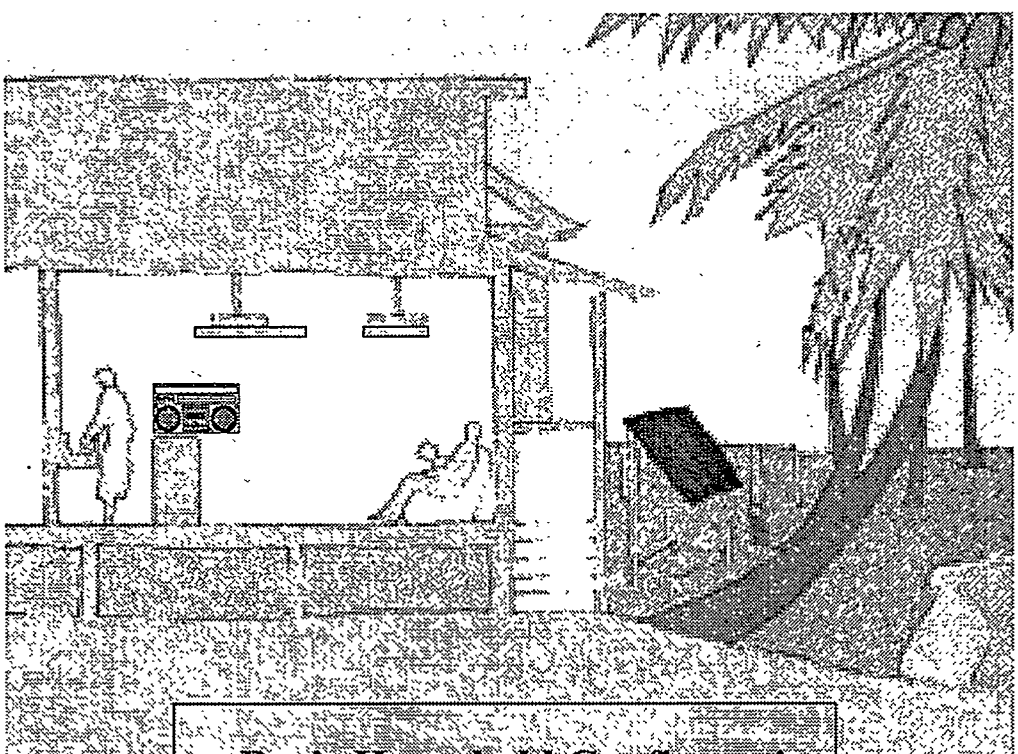
Problem

- Providing affordable, environmentally sound energy services
- To rural communities
- In developing countries

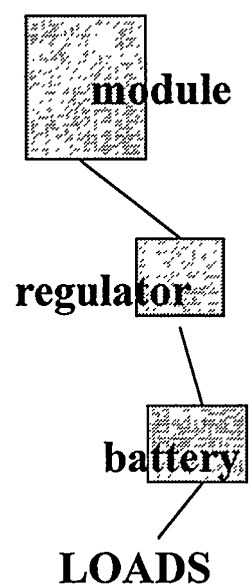
Objective

- Dramatically increase the availability of energy services using photovoltaic systems





Basic Household Configuration

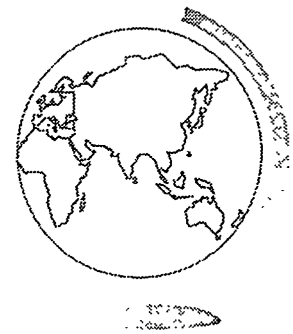


PV Economics

50 watt unit = 2 -3 lights and power point = $500

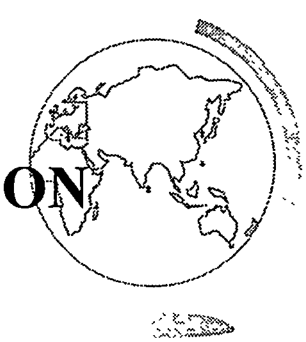
Finance over three years with 30% down payment at 12% interest = $11.62 per month

Lease-purchase over five years at 12% with no down payment =$11.12 per month

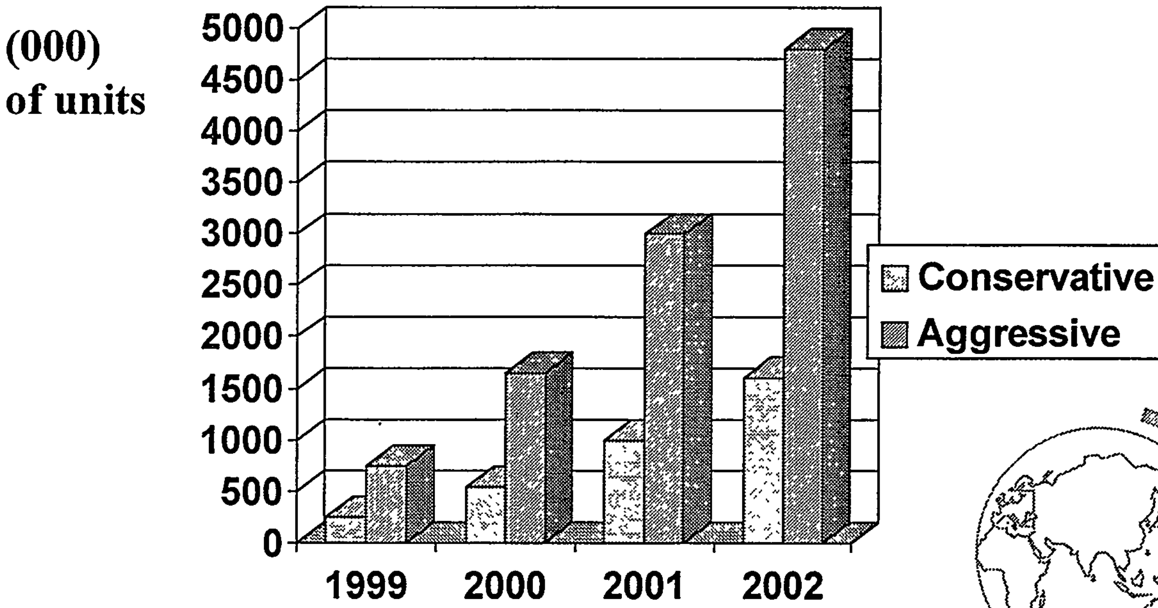


Proposed Strategy

- Join forces with multilateral development institutions, US private foundations, the PV industry and others
- Create channels of distribution
  - financing
  - product and service
- Through an independent **SOLAR DEVELOPMENT CORPORATION**



PV Scale Increase Objectives by 2002: 1.6 million to 4.8 million units per year



present = +/- 200,000 units per year

How the Solar Development Corporation Will Function

- **Business Development**
- Identify in-country financial intermediaries
- Support in-country distribution companies
- Pair up product companies with finance

- **Finance**
- Via in-country financial intermediaries
- Through product distribution companies and directly
- To local entrepreneurs and end-users

Best Markets for PV per 1996 PV Industry Survey

ASIA: India, China, Indonesia Philippines, Sri Lanka, Thailand

AFRICA: Kenya, Morocco, South Africa Zimbabwe, Tunisia, Egypt

LATIN AMERICA: Brazil, Argentina, Bolivia Mexico, Dominican Republic, Honduras

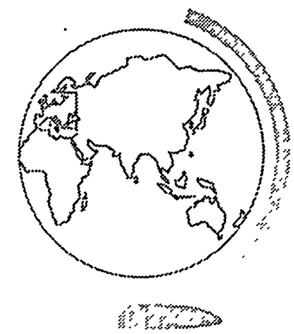
After Start-up the Solar Development Corporation will be Financially Self Supporting

- 5 year target of 3.5 million units, cumulative +
- $ 953 million in financing (cumulative)
- $421 million in year 5
- and growing

- Business development operations = $3 million per year
- = 0.07% of direct financing
- and shrinking

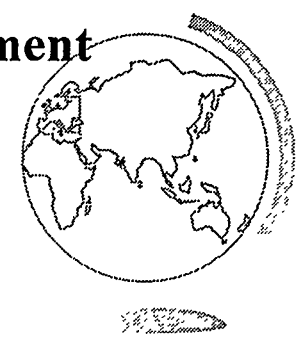
Next Steps

- World Bank Group sign on...Dec 1996-DONE
- U.S. Foundation sign-on-DONE
- Rockefeller Foundation funding for business plan development...Dec 1996-DONE
- World Bank Group funding for business plan development...Feb 1997-DONE
- Transition team established...DONE



More Next Steps...

- RFP to complete "business case" and prepare Information Memo to solicit independent management...Expected Mid-April
- Investment-business plan document to potential investors and management teams...October, 1997
- Debt, equity, Program Related Investment fund-raising...Expected 4th Q 1997



First Three Year-Pro Forma Case #1

Capital *GRANTS* (IBRD, GEF, IFC) $10 million

PRIs , debt oriented $10 million

Bilaterals, debt oriented $20 million

Equity, private sector and foundations $10 million

Pro Forma #1, continued

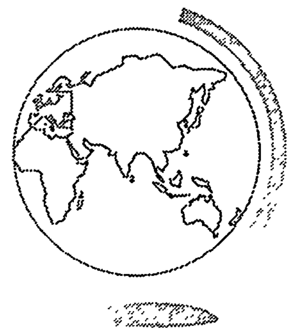
PRI type debt at 8% annual
Bilateral debt at 10% annual
Energy enterprise equity investing at 17% IRR*, 4-6 years
Financial intermediary lending at 10%-12% annual*
Repayments over 1, 2 and 3 years
Operating cost of $3 million annual
net of country and forex risk

Return on equity = 12 to 13%

Full scale Pro Forma at $200 million/year-breakeven analysis…Year 2000, conservative case

$170 million to FIs…600,000 to 700,000 units*.
$30 million to energy enterprise investments.
Capital cost of 12%.
Lending and investment returns at 14%.
30-40 transactions per year.
Operating cost of $4 million.

**assumes 50% financing by SDC and $500 unit cost*

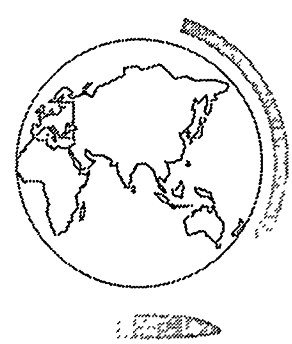


Needs

Equity expressions of interest
---subject to business-investment plan

PRI expressions of interest
---subject to business-investment plan

Industry involvement



Grameen Bank's Experience with Energy Related Microenterprise Development

Presented by

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Presented to

Annual Conference on the Applications of Renewable Energy to Village Electrification held in Washington D.C. organized by National Renewable Energy Laboratory,USA on April 14-15,1997

Grameen Bank's Experience with Energy Related Microenterprise Development

- **Dipal Chandra Barua**
Managing Director
Grameen Shakti

1.0 Background:

Increased population and growth of industry have resulted in greater demand for energy worldwide. Most of this energy is derived from fossil fuel (coal, gas, oil and nuclear) will soon be depleted. In this context the need for developing renewable sources of energy was taken on a greater sense of importance and urgency. Over the years significant technological advances have been made in the area of renewable energies especially in the field of solar photovoltaics (PV), wind energy and bio-gas technology. In addition, for remote rural areas where there exits no infrastructure for conventional energy supply, these forms of decentralized alternative energy system will be far more adaptable and well suited.

The shortage of electrical power in Bangladesh is revealed in a mere 15% of the total need being met by the power generation authorities. The chances of reaching conventional power to the 85% of the unserved people may not likely to be happened in near future. In this context it would be of great benefit for rural people to adopt the rènewable energy to bridge the gap of energy needs of the 85% people with clean, safe and environment friendly energy without depleting our precious natural gas reserves resources. Renewable energy can also bring considerable improvement in rural life through income generation and thus alleviating poverty. In addition, it can bring multiple positive results in terms of women's welfare, children's education, fertility reduction and curbing the urban migration.

2.0 Grameen Shakti (GS):

Grameen Shakti (Energy) is an addition to the family of companies of **Grameen Bank,** to promote and supply renewable energy sources to rural households. **GS,** a not-for-profit company, expects not only to supply renewable energy services, but also to create employment and income generation opportunities in rural Bangladesh. **GS** will focus on supply, marketing, sales, testing and development of renewable energy systems of solar pv, biogas, wind turbines and windpumps.

Grameen Shakti aims to:

- popularize and deliver renewable energy to the unelectrified rural-households.

- market solar, bio-gas and wind energy on commercial basis, focusing on rural areas, particularly clientele of Grameen Bank.

- provide services that alleviate poverty and protect our environment through applied research and development of renewable energy based technologies.

- undertake a project to progressively manufacture and market efficient and affordable household based photovoltaic systems.

- implement projects to generate electricity from wind in the coastal belts and offshore islands; operate mini and micro hydro plants in the hilly areas.

- develop and implement special credit, savings and investment programmes for generation, storage and utilization of renewable energy for benefit of the rural people.

- test the new and appropriate technologies to provide more cost effective energy services at affordable price to the unserved and underserved.

- provide capital, technology and management services to energy enterprises, including individuals, communities, businesses, non-government organizations (NGOS), private voluntary organizations (PVOS) which promote, produce and finance enterprises based on renewable energy sources.

3.0 The Role of Grameen Bank

3.1 Origin of Grameen Bank :

The rural landless people who are desperately in need of credit generally remain outside of the orbit of the banking system. Dr. Muhammad Yunus, Professor of Economics, Chittagong University, launched an action research programme in 1976. With this experience Grameen became an independent Bank in October, 1983 by a special ordinance. The Chief executive and founder of Grameen Bank is Prof. Muhammad Yunus. The Board of Directors, which is the highest policy making body, Consists of 13 members of whom 9 are elected from among the borrowers (Shareholders) & 3 from the Government. Managing Director is the ex-officio. Various activities of the bank are organized & implemented by four tiers of administrative set-up, viz branch office, area office, zonal office and head office.

3.2 Present Status of GB :

Grameen Bank has completed its 20 years of operation with 2.1 million poorest families in Bangladesh of whom 1.93 million are women. The percentage of women's participation in this programme is 94%. Now we have 14 Zones, 115 Area offices, 1079 Branches covering 36654 villages which is more than half of the total villages in Bangladesh.

The cumulative amount of disbursement of different types of loans (General, Collective, Seasonal & Others) is US$ 1724.97 million. Average monthly disbursed is US$ 33 million. Grameen Bank's housing programme has been prevailing as a great source of hope for a new life to the Grameen Bank members who had no shelter or lost their houses during the devastating floods of 1987 & 1988 and the cyclone of 1991. The cumulative amount of housing loans disbursed is US$ 132.97 million. The cumulative amount of savings in group fund is US$ 127.15 million. Grameen Bank's recovery position in general & housing loans remain excellent as before. It continued to be 98 percent.

The Bank ended the last 20 years with reinforced confidence in the ability of the poor people and the Bank staff to shoulder any responsibility benefiting the poor.

4.0 Leasing :

The prospective members of GB with couple of years experience and loan cycle are selected by the centres for leasing (higher purchase) i.e for bigger investment specially in technology sector.

4.1 Terms of Leasing of Items :

i) The members of the centre are to possess the quality of high sense of decipline, satisfactory performance and faithful to the Bank discipline will be qualified for loan for the second time.

ii) The concerned member or any other member of his family must have the knowledge of operation and maintenance of the leasing items.

iii) Loan Proposal is taken up by the unanimous regulation of all the members. Ordinarily Zonal Manager has the authority to approve the lease up to Tk. 2,00,000/-. For any amount above Tk.2,00,000/- requires the permission of the head office.

iv) Leasing material or items are purchased through the spot quotation in presense of Lessee or his representative and Bank representative.

v) The propriety of leasing items will remain with the bank until loan is paid up.

4.2 The Items which are Leased out :

i) The leased out items create a source of income for the family of the lessee. Out of this income, he (lessee) should be able to pay off the installment after meeting the requirement of the family. But ordinarily machinary items are given priority as leasing materials.

ii) Till now the following items have been leased out:

a) Power Tiller
b) Shallow Tube-well
c) Rice mill
d) Boat run by shallow engine
e) Power pump
f) Power loom
g) Embroidry
h) Sugar crushing machine
I) Baby taxi
j) Tampoo (sort of vehicle)
k) Auto rickshaw
l) Electric motor
m) Generator
n) Gas cylinder
o) Mike and recording
p) Freez
q) Buffalo cart
r) Cattle cart
s) Poultry farm
t) Dairy farm
u) Nursery
v) Fisheries
w) Hybrid cow
x) Milky buffalo

The items leasing are ordinarily transferable

4.3 The Terms and Conditions of Payment for Leasing Items:

i) Maximum period of paying back the cost of lease items is 3 years. But for most of the items, payment has to be made in 2 years.

ii) At the rate of equal weekly installment or a minimum of Tk.100 as installment are to be paid off in off season and in peak season bigger amount should be paid off as installment in order to pay off the cost of lease items within lease period.

iii) For the period of lease an average of 20% as revenue should be realized along with the weekly installment.

iv) The revenue should be determined on the cost of the leasing items and other charges. The amount of installment includes the revenue.

vi) 2677 leasing items have been distributed upto Feb'97 the cost of which comes to Tk. 888.56 lakh, out of which Tk. 473.14 has been realised. 551 persons have earned proprietory of the leasing items after making payment of the full amount of the leasing items.

Out of 2677 leasing items 2055 energy related. Major 30 items are mentioned below :

Items of Leasing (Energy Related) Upto Feb, '97

[Amount in Million Taka]

Slno	Name of Item	Number	Taka	US $
01.	Battery Charger	1	0.02	404.76
02.	Biscuit Making Machine	5	0.13	3047.62
03.	Computer	1	0.08	1904.76
04.	Cotton Finishing Machine	1	0.06	1428.57
05.	Embroidery Machine	5	0.10	2309.52
06.	Gas Cylinder for Welding	2	0.05	1285.71
07.	Generator	8	0.39	9261.90
08.	Lathe Machine	7	0.62	14785.71
09.	Moulding Machine	1	0.10	2285.71
10.	Photostat Machine	6	0.07	17476.19
11.	Pipe Roller Machine	1	0.04	857.14
12.	Power Loom	113	4.54	108095.24
13.	Power Pump	42	1.05	24904.76
14.	Power Tiller	375	23.14	550952.38
15.	Rice Mill	53	1.84	43738.10
16.	Saw Mill	3	0.24	5785.71
17.	Shallow Engine Boat	37	1.94	46261.90
18.	Shallow Tube-well	1364	3.98	94809.52
19.	Shoe Making Machine	1	0.02	476.19
20.	Shuttle Factory	2	0.07	1714.29
21.	Sugarcane Crushing Machine	7	0.11	2619.05
22.	Volcanizing Machine	1	0.04	857.14
23.	Washing Machine	1	0.07	1571.43
24.	Welding Machine	10	0.23	5404.76
25.	Work Shop	1	0.07	1666.67
26.	Ice Making Machine	2	0.05	1285.71
27.	Button Making Machine	1	0.01	285.71
28.	Bread Factory	1	0.02	428.57
29.	Electric Motor	2	0.05	1190.48
30.	Ball Point Pen Making	1	0.05	1190.48
	Total :	*2055*	*59.91*	*1426333.33*

5.0 GS Renewable Energy Development Project: Phase I, 1996-97

Decentralized solar power is a low cost energy source that is environment friendly and its supply is unlimited. Bangladesh has plenty of sunshine that can be used to generate cost effective solar electricity for rural households. Initial investigations suggest a number of factors pointing to bright prospect for testing solar photovoltaic energy in the rural areas. First, it is clear that improved technological efficiency and economies of scale would make solar energy cheaper in near to medium term future. Second, additional and assured lights from solar panels may extend the workday of users, women in particular thereby making it an investment in income generation for poverty alleviation. Finally, solar energy source would certainly help better quality education for the user's children. Thus our proposed pilot solar energy project has the possibility to induce demand generation on the one hand and acting as a tool for improving the quality of life via additional employment and income generation. **Grameen Bank** is a bank owned by the poor people and is dedicated to the welfare of the poorest of the poor in rural Bangladesh. GS has installed 21 units solar home systems (SHS) at Bhaluka, Dhobaura, in Mymensingh district, and 35 units (SHS) at Narandia,Ghatail in Tangail district, with the collaboration of Rahimafrooz Limited and Siemens Bangladesh respectively. The Solar Household Systems are functioning well.

5.1 Solar Home Systems (SHS) at Bhaluka, Dhobaura, Mymensingh.

a. 30 Wp Module (poly-crystalline), Two 6 Watts Fluorescent Tube Lights, 55 amp-hr deep cycle battery for Taka 14,000.00

b. 40 Wp Module (poly-crystalline), three 8 Watts Fluorescent Tube Lights, one black and white T.V point, 100 amp-hr deep cycle battery for Taka 20,000.00

c. 60 Wp Module (poly crystalline), Two 8 Watts and two 6 Watts Fluorescent Tube lights, one black and white T.V point, 100 amp-hr deep cycle battery for Taka 23,000.00

5.2 Solar Home Systems (SHS) in Narandia, Ghatail, Tangail.

a. 17 Wp Module (single crystalline), two 7 Watts Compact Fluorescent Lamps (CFL), 50 amp-hr car battery for Taka 13,000.00

b. 34 Wp Module (single crystalline), three 7 Watts Compact Fluorescent Lamps (CFL), one black and white T.V point, 100 amp-hr car battery for Taka 18,000.00

c. 48 Wp Module (single crystalline), Four 7 Watts Compact Fluorescent Lamps (CFL), one black and white T.V point, 100 amp-hr car battery for Taka 22,000.00)

GS is in the process to procure 300 solar pv units from **Siemens (Bangladesh) Rahimafrooz Bangladesh Ltd.** and **Webel SL-Energy Systems Ltd. India** to initiate it pilot project to test and understand the market. Moreover, this pilot project will study th adaptibility and acceptability of the technology. The project will be further scaled upto 40(units. GS intends to develop local service company with the privilege of using Grameei Bank's rural infrastructure. However, GS will extend its service to GB members as well a non-members. With financing from GB, GS will set up micro-enterprises to offer sales an(service centers with capacity of manufacturing spares and components. In this respect a energy service company may be formulated and structured using network of GB.

In regard to the payment plan , the Grameen member has to pay 25-40% down payment o: the total cost and rest of the money will be collected with the interest rate of 8% within 2 years. In case of non-Grameen members the payment plan includes 50-75% down paymen and rest of the money will be collected from 6 months to 1 year period with service charge of 8%.

6.0 Phase II: Expansion Upto 5000 Units of Solar Household Systems Period: 1997-98.

During this phase Grameen Shakti will expand the operation from 400 to 5000 households in different parts of the country to get the real experience of peoples acceptance, finance, marketing and technology of SHS.

7.0 Phase III. 1999-2000/Near Commercial :

In this 3rd Phase **Grameen Shakti** will target to market 100,000 SHS's.

8.0 Phase IV. 2001-/Fully Commercial

During this phase IV Grameen Shakti will become 100% commercial operation.

9.0 Marketing Strategies of Grameen Shakti :

400,000 houses already constructed through **GB** loans. So, they are potential customer for solar home system and they may get loan from **GB** to buy the system. Non members will also buy with cash or part payment system. **GB** members can also sale **SHS** to non-members through loan from Grameen Bank.**Grameen Shakti** has already reduced tax and duties of renewable energy parts from the government. So, **GS** trying to market **SHS** at affordable price to rural people.

10.0 Wind Energy Resource Assessment:

Wind power is abundantly available resource that is probably the cheapest source of energy in the world. In spite of wind power's being used for groundwater pumping and electricity generation throughout the world, including neighbouring countries in the

Indian subcontinent, Bangladesh is, strangely, yet to realize its potential. Especially since, both irrigation and electrification are highly underdeveloped sectors and development of either is effectively restricted by the limited supply of currently used energy sources. In spite of two decades of considerable irrigation expansion, nearly 5 million hectors of potentially suitable lands, lying mainly in the north and west of the country, remains to be irrigated. Groundwater irrigation in Bangladesh is exclusively carried out by pumping technology, and electricity and diesel power are the mainstays of pumping energy. However, electricity is not available in large parts of the country, especially in the northern region, and even when it is, it is highly unreliable both in timing and voltage. Diesel, imported from abroad is an expensive alternative.

The wind power project proposed by **Grameen Shakti** is a study-cum-demonstration project on wind energy that addresses the potential for both ground water pumping and electricity generation, while keeping in mind the project's inherently experimental role. As such, the project is designed in two phases. Phase one has two components. The first component involves site selection, site preparation, installation, trial operation and performance evaluation of two wind pumps. The wind pumps will be of different types, selected with respect to wind speed-flow capacity ratio, suction depth, tower height, etc. This will enable **Grameen Shakti** to test wind-powered groundwater irrigation potentials of geo-physically and climatically different regions of the country. The second component of phase one is actually the preliminary step for phase two. Phase two of the project is the generation of wind-powered electricity, and it involves the installation and operation of a 250 kW capacity wind turbine. However, since this entails considerable financial investment in an area that has so far remained untested, a comprehensive and accurate study of wind speed in Bangladesh is a prerequisite for project viability. Thus, the second component of phase one involves the installation and operation of weather monitoring equipment, data collection and evaluation. The objective of the proposed study is to develop a plan for Chakaria wind farm. The generated power may be utilized in two ways: 1) to feed it to the REB grid lines and 2) to meet some of the requirements of the Chakaria shrimp farm. Locally built 2 kW wind turbine is being installed and tested at Chakaria to gather practical data along with the data collected using two anemometers for a period of one year. Preliminary observation and measurement of wind speed data from January to to-date using Baufort scale reveals that wind speed at a height of 10 m in this farm is adequate to generate electricity for sufficient number of hours per day to make it economically viable.

Recently GS has installed two small wind turbines at Chokoria, in Cox's Bazar. These wind turbines are: one 300 Watt Southwest Air Module, USA; and one 1 kW unit from LMW, the Netherlands. Both the turbines start generating electricity since December 15, 96.The 1 kW LMW wind turbine has an option for grid connection. The generated electricity from the turbines is more than what we have expected during the month of December. Normally November and December are the months for lowest wind speed in Bangladesh.The experimental wind turbine will allow **GS** to gather practical data on the basis of which the load factor will be evaluated for future plans. In the meantime GS has procured two anemometer from USA.

11.0 Integrated Bio-digester Project:

The concept of integrated farming system utilizing bio-digesters is quite relevant to Bangladesh agriculture as it ensures increased production on a more sustainable basis and benefits the poor. The method is both environment friendly and economically profitable for it reuses bio-materials on a continual basis at relatively low cost with prospects of higher yields. This process takes into consideration the natural demand of the soil to increase its productive capacity.

A bio-digester can produce bio-gas, fertilizer and fish feed. Each unit meets about 20 kg of animal waste per day (the waste produced by two healthy cows) and can provide enough bio-gas for a family to four to cook 2 meals a day. Effluent from the digesters, which is 60% oxidized, is readily usable as quality fertilizer. However, a better alternative involves mineralizing the effluent in a shallow basin, where it becomes a further 30 to 40% oxidized, and then discharging it into fish ponds to encourage the immediate and prolific growth of plankton. This process of mineralizing or converting the organic component of animal waste represents a major improvement on the widespread practice of putting raw cowdung into ponds as fish feed. This is because the organic component of raw cowdung consumes the water's dissolved oxygen, and hence pollutes the fish ponds. Whereas, by completing the oxidization process outside the fish ponds' first inside the bio-digester and then in the shallow basin, the bio-digester effluent does not pollute the water at all. Initial findings at the Joysagor Fish Farm that have shown ponds using bio-digester effluent producing fish fingerlings twice the size of those produced in ponds using raw cowdung, are indicative of the new method's superiority. The entire process, in addition to being quite inexpensive involves a simple technology and is quite easy to perform.

Approximately, polyethylene (PE) bio-digesters made from thin sheet material and these were susceptible to tear and torn under the rural conditions of Bangladesh. This problem leads to frequent replacement and repair of the digesters. This type of digester would costs around US$20-30.

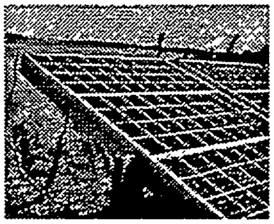
The experience from this PE bio-digesters leads to some valuable knowledge that can be utilized for undertaking any future initiative in this area. One important issue is that the input source to be an integral part of the project, and as such, critical to the project's success. To make the bio-digester project economically feasible and acceptable to the poor, it is of utmost necessity to provide them with cattle, that is, the source of the input, together with the bio-digester itself.

Hence, whereas initially the project was thought of entirely in terms of bio-digester, it must now be viewed as having two components, the bio-digester and the cattle. Initially the lessee should have two cattles on their own and two other cattles will be provided on lease basis. The proposed bio-digester is made of concrete and brick with the amount of cow dung that can be supplied from four cattles. Recently we have constructed eleven brick-concrete digester in our Joysagar Fish Farm, Grameen Krishi Foundation and

Comilla zone which are already under operation. The immediate results are encouraging. GS has plan to construct another 33 brick-concrete bio-digester. The lessee will be able to use the digester to produce bio-gas as fuel, digester effluent for fisheries and milk for dairy products. Thus, lessee will have income generating **mini-bio-dairy-project** to repay the loan and also earn some profit.

12.0 Conclusion :

Grameen Bank acts as catalyst to Grameen Shakti's activities in rural Bangladesh as Grameen Bank has strong network through out the country. The infrastructure of Grameen Bank may be useful for promoting renewable energy in rural Bangladesh. The commercial viability can be foreseen that Grameen Shakti can bring down the cost of renewable energy to make it affordable to rural people. So it can also bring considerable improvement in rural life and the quality of life.



COMMERCIAL DISSEMINATION APPROACHES FOR SOLAR HOME SYSTEMS

Ernesto Terrado
Principal Energy Planner
The World Bank

Village Power 97 Arlington, VA April 14-15

Solar Home Systems

Commercial Dissemination Approaches

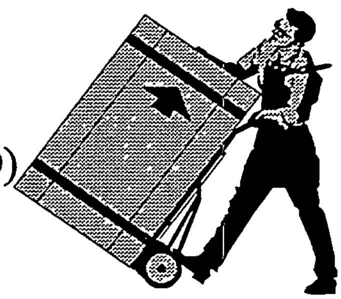
- **Open Market**
  - e.g. Kenya, Indonesia
- **Exclusive Market**
  - e.g. Argentina
- **Mix**

Solar Home Systems

Commercial Dissemination Approaches

Options possible under each approach:

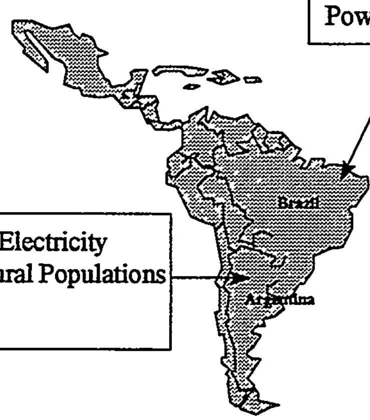
- Cash Sales
- Financed Sales
- Leasing
- Service Provision (ESCO)



Where Exclusive Market Approach is being applied or proposed...

Brazil: Northeast Social/Commercial Power Project

Coverage:
over 100,000 homes in 3 states



Argentina: Program for Electricity Supply for Dispersed Rural Populations (PAEPRA)

Coverage:
315,000 homes
6000 schools, etc
in 15 provinces

ARGENTINA PROGRAM GOALS

- ☐ Provide access to basic electricity services
- ☐ Economically sustainable supply
- ☐ Maintenance assured over life of equipment
- ☐ Private company to provide services
- ☐ Sufficient returns on investment, cover O & M and expansion costs

...understood that government subsidy will be required

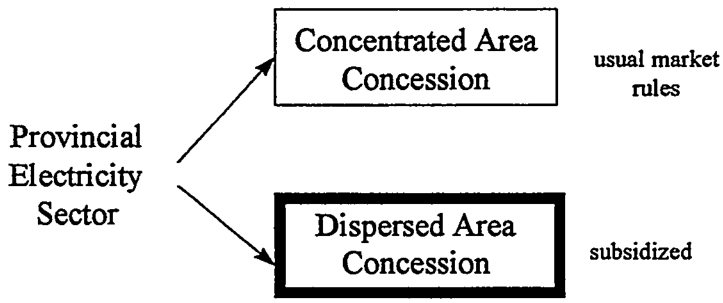
Argentina

Program for Electricity Supply for Dispersed Rural Populations (PAEPRA)

Estimated Cost, US $million (5 years)	
•Private User Fees	$142
•Provincial Subsidy Funds	75
•Federal Govt Funds	97
Total	$314

Government wants to borrow about $100 million from World Bank for total program but is going ahead with several provinces....

Privatization of Provincial Power Sector



•Separate bids

• *For dispersed area concession, winner is company asking for* ***least subsidy***

Dispersed Area Concession Contract

- Area monopoly: rights to provide services to homes and public service centers
- several levels of services
- Use PV, wind, micro-hydro, diesel, hybrids--as desired
- 3 x 15 years operation periods; rebid after each period, with last operator given priority
- Users pay connection plus tariff set by government; Subsidies provided per user
- Partial financing for initial investment

Status

- Two provinces already bidded out; same winners for concentrated and dispersed concessions in each
- Salta: Fenosa/BP Solar
  Jujuy: Cartelon-CEC (Chile)
- Ongoing studies on tariff schedules, willingness to pay, environmental impacts
- Preparation of bid documents for other provinces

Issues in Argentina Case

- Each municipality can decide on level and type of subsidy to homes and public centers
- Concessionaire can pick any technologies
- Subsidies provided continuously, not up front
- Right to renegotiate contract after two years

Hard to estimate profitability of concession !

Brazil Proposed Bank Project: Northeast Social/Commercial Power Project

Status: Identification Stage

Initially 3 States:

- Bahia
- Minas Gerais
- Ceara

What to do with electricity supply to dispersed areas as state utilities are privatized...

Principles

- Attract new players: investors, financial intermediaries, local operators, etc
- Price energy to improve access
- Provide financing to lower first cost and meet willingness to pay
- Reduce cost of extending coverage
- Ensure sustainability

Special Characteristics of Northeast...

- Network presence: relatively few well-defined non-grid areas
- Few dealers/systems integrators at local level
- Strong government programs for community applications
- Banking system flexible on financing terms

Initial Thoughts on Commercial Delivery Mechanism

- Divide each state into 2 or more "permission areas"
- Each PA to have critical mass of homes for SHS, plus public service projects to sweeten pot
- Award PA to bidder asking for lowest subsidy
- Privatized utility can bid
- "Permissionaire" has rights to all subsidized users
- Open line of credit for productive uses, but proponents not limited to permissionaire

Issues for Brazil

- How to estimate profitability to permissionaire
- How to handle pre-electrification areas
- Optimal delivery mechanism: service, lease or sell ?
- High cost of SHS in Brazil
- Criticisms on monopolistic structure

WHICH IS BETTER ?

Open Market Approach fosters competition, resulting in more choices, better services, lower prices to consumers

Exclusive Market Approach has economy of scale--lower administrative and transaction costs per consumer, reduced unit costs thru standardization and high-volume purchase

...WHICH IS BETTER ?

Open Market Approach will attract small dealers with high unit costs; uncertain market size; hard to administer many small operators

Exclusive Market Approach is monopolistic; bidding rules tend to be complex; hard to design fair contract for operation

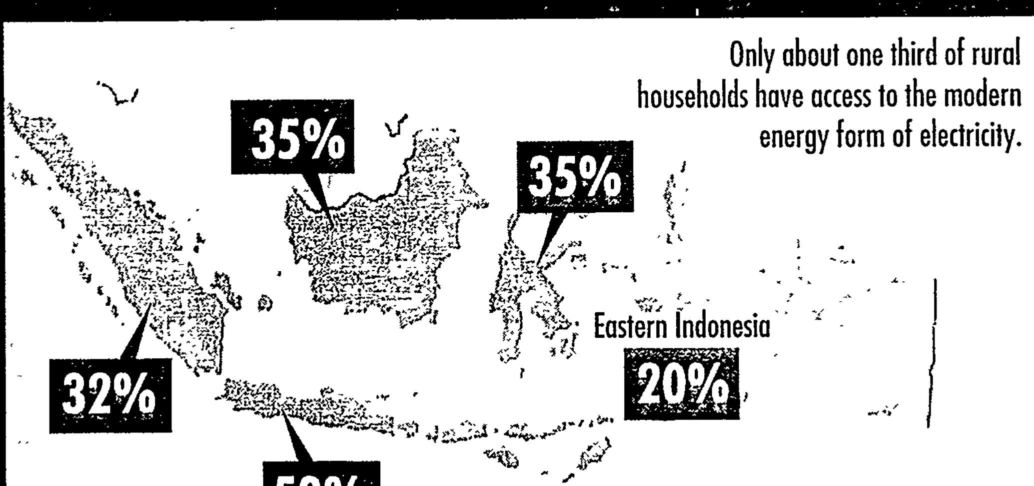
What do you think ?

INDONESIA SOLAR HOME SYSTEMS PROJECT FOR RURAL ELECTRIFICATION

Arun P. Sanghvi
Indonesia Policy and Operations Division, World Bank
Village Power '97, Washington, DC, April 1997

Sanghvi, EA3IP

. . . But the Unfinished Task Ahead is Formidable

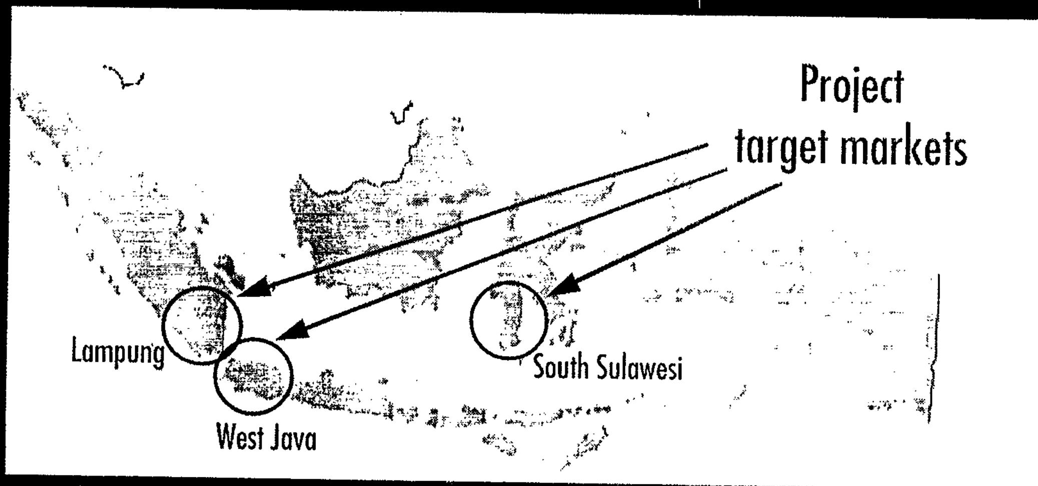


Over 20 million rural households (about 100 million people) remain "in the dark" and are forced to make due with vastly inferior and typically more expensive and polluting energy sources than electricity.

At the current pace of electrification, it would take about 30 years before the benefits derived from electricity service can be experienced by most households — setting aside the daunting financial challenge.

Sanghvi, EA3IP

Project Scope

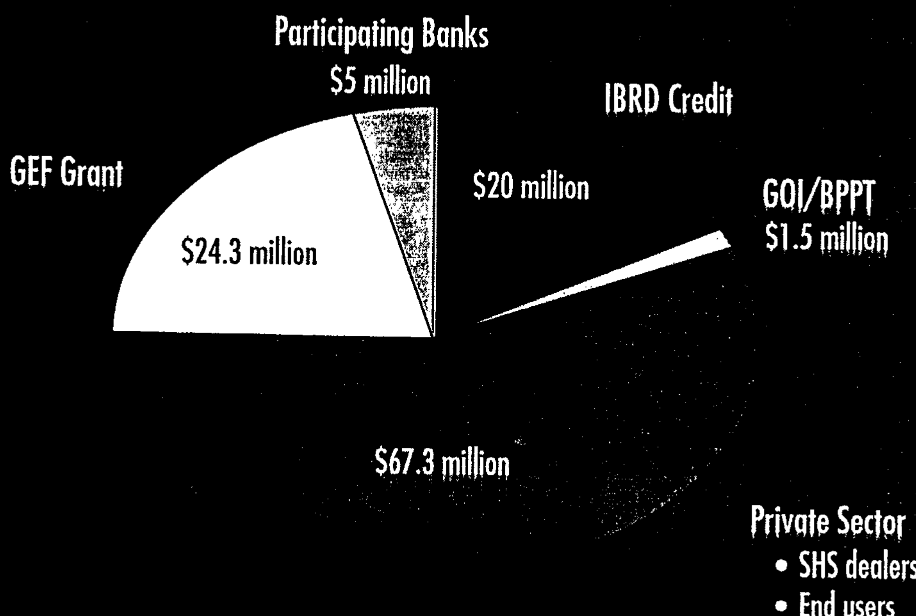


- Sale and installation of about 200,000 (10 MWp) SHS units in households and commercial establishments in three regional markets
- Capacity building

Sanghvi, EA3IP

Project Financing Plan

TOTAL: US $118 million



Sanghvi, EA3IP

Barriers to Market Development:

High retail price

Low profits

Low volume

Limited geographical coverage

Primarily a cash-sales market

Limited consumer awareness

- High first cost
- Lack of term credit availability to rural households

The key barriers need to be addressed simultaneously, taking into account:

- Affordability of the target market segment of rural households
- Terms and conditions under which commercial banks would extend term credit

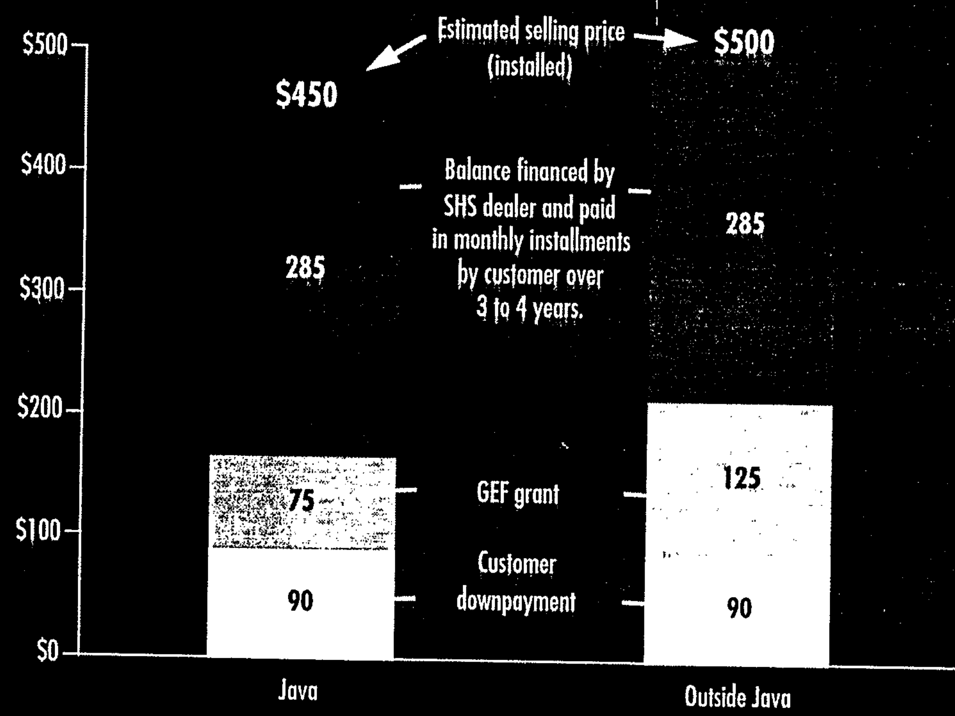
Sanghvi, EA3IE

Project Design Directly Addresses Three Key Barriers to Accelerated Market Development

- GEF grant lowers the high first-cost barrier to an affordable level.
- IBRD credit facilitates the availability of term credit at market rates from commercial banks to SHS dealers, making it possible for the dealers to offer installment payment plans to purchasers of SHS.
- Technical assistance — grant financed — will help raise consumer awareness, facilitate consumer protection through market monitoring, and provide limited support to dealers.

Sanghvi, EA3IE

Typical Financing of a Unit



Sanghvi, EA3IP

Key Issues in Project Design

1. Specifying the objective (s)

2. "Market structure"
   - Targetted vs. universal service/utility approach
   - Establish scale economies
   - Promoting competition

Sanghvi, EA3IP

Key Issues in Project Design contd

3. Financing
- Dealer financing vs. direct household credit
- Structuring the grant element — first-cost buy down vs. interest rate buy down
- Structuring affordable down payment and monthly payments

Sanghvi, EA3IP

Distribution of Monthly Expenditures on Energy by Rural Households without Electricity

$/Month	Lampung	South Sulawesi	West Java
Under 3.33	34%	28%	62%
3.33 to 6.67	40%	49%	23%
Over 6.67	26%	23%	15%
Total	100%	100%	100%

Rural households' willingness to pay for energy sources that help meet the highly valued end uses of lighting, security, entertainment and information is high for a large segment of households.

Sanghvi, EA3IE

Key Issues in Project Design cont'd

4. Assuring service quality and consumer protection
   - Information campaigns
   - Product standardization
   - Certification
   - Warranties and after-sales service
   - Monitoring
   - "Good dealer conduct code"

5. Aligning the risk-reward structure

Sanghvi, EA3IP

Risk Mitigation

1. Market Demand Risk
   - Sales of 200,000 systems are not achieved (even though dealers are willing and able to make sales)
     - lack of awareness or confidence about technology
     - concerns that PLN service will become available soon
     - lack of affordability

Mitigation — Facilitating Sales
- Information campaigns prior to commencement of sales, sponsored by PSG
- Open to new entrants
- Extend market areas if necessary

Sanghvi, EA3IP

Risk Mitigation (cont'd.)

2. Dealer Failure Risk

- Dealers unable to make sales of 200,000 systems or only 2-3 dealers able to establish themselves (even though there is demand)
  - weak management skills
  - poor installment collection mechanism
  - unable to grow business

Mitigation — Facilitating Dealer Success

- Selecting "good dealers"
- Pipeline filling — with strong preparation assistance prior to project start
- PBs to use their normal appraisal criteria
- "Start small-finish big" strategy
- Dealers encouraged to seek stronger partners

Sanghvi, EA3IP

Risk Mitigation (cont'd.)

3. Consumer Dissatisfaction Risk

- Customers who buy SHS systems are not satisfied and stop paying
  - failure of system/components
  - poor after-sales service
  - system does not meet customers' energy needs

Mitigation — Enhancing Customer Satisfaction

- Equipment installed must meet project's technical specifications and certified by world-class laboratories
- Dealers required to offer comprehensive consumer protection package including return policy, warranties, and after-sales service
- PSG to maintain two-way links with customers

Sanghvi, EA3IP

Post-Project Sustainability

- System cost reductions in real terms are expected
  - Economies of scale in sales-and-service chains
  - PV panels
  - Economies of scale in assembly of balance-of-system components
  - No need to incur high initial costs of establishing sales-and-service chains
- Increases in consumer affordability
- Lowering/elimination of other key barriers

Sanghvi, FA3IP

Longer-Term Market Development

SHS Market Segments: Affordability Profile and Delivery Modalities

Quartile	Delivery modalities	Downpayment ($)	Monthly Payment ($)	No. payments (years)
Top	SHS dealers	75-100	7-12	3-4
Second	SHS dealers Leasing; ESCOs	50-75	5-10	5-10
Third	ESCOs Concessions	20	3-5	Perpetual
Fourth	Fill other needs first		1-2	Perpetual

Sanghvi, FA3IE

Major Challenges: Forging an Entirely New Type of Working Partnership Between Key Stakeholders

1. Government
   - From procurer, financier and distributor of technology to enabler of quality service: setting standards, facilitating product testing and certification, training, raising consumer awareness, levelling the playing field for renewables (first cost barrier, credit)

2. Solar Industry
   - From supplier and installer of hardware to Government agencies on a cash basis to direct household sales on an installment plan basis

Sanghvi, EA3IP

Major Challenges (cont'd)

3. Raising the comfort level of commercial banks unfamiliar with solar technology and not accustomed to making even working capital loans to small enterprises serving rural market

4. Making a few good dealers "bankable"

Sanghvi, EA3IP

Major Challenges (cont'd)

Hopefully, the Indonesia SHS project will pave the way for a cost-effective and replicable model in many other country contexts and offer a viable approach for making electricity ***quickly*** accessible and affordable to a significant number of the nearly 2 billion people today without electricity.

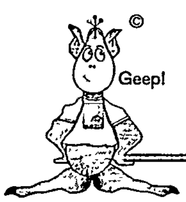
Sanghvi, EA3IP

Private Sector Village Enterprise A New Approach to Sustainable Financing

Charles F. Gay
April 15, 1997

Village Power '97

SQP7-B208901



Green Electrons Eliminating Poverty

Introduction to the GEEP - Solar Sewing Machine Conversion Kit:

- The Geep - Solar Sewing Machine Conversion Kit is one of the introductory products in the new commercial Rural Electric Series program.
- These kits are oriented towards income generation and increasing productivity in villages of developing countries.
- The kit has a pedal sewing machine that has been retrofitted to solar power.

SQP7-B208902

Marketing Program Plan

Establishing an infrastructure between the company, the village tailors, the shirt manufactures (Arvind Mills), and "Green" consumers.

The steps towards achieving this follow:

Step 1: Introducing the Sewing Machine Conversion kit to the village tailors in India. Estimated cost of the kit is Rs. 25,000 - 30,000 with a of deposit Rs. 5000.

SQP7-B208903

Green Electrons Eliminating Poverty

Marketing Program Plan

Step 2: Establish a contract for 1,000 shirts/annum for 2 years for each tailor. The total contract value will be Rs. 20,000 - 40,000 per annum depending on the type of product being produced.

Step 3: Educating tailors about the benefits of the electric sewing machine. This includes increased productivity from 9 shirts to 18 shirts a day. Explain the manufacturer's contract to make 9 additional shirts per day and how the associated benefits are valued.

SQP7-B208904

Marketing Program Plan

Step 4: A local financial institution is approached to arrange for loans to buy the solar powered retrofit at standard interest rates (~18%/annum).

Step 5: Creating a brand name to market the stiched "GEEP"garments using the Solar Sewing Machine.

Step 6: Obtain assistance for direct marketing from the "Green" Movement in developed countries.
Eg: "GEEP" shirts are included in "Green" Movement mailers.

Benefits to Village Tailors

- Primary: Additional work hours with guaranteed income
  Increased quality
  Work in village
- Secondary: More income for the village.
  Additional downstream village work (e.g. transportation)
  Additional quality will increase customer base

Green Energy Eliminating Poverty

Benefits to the Shirt Manufacturers

- Wealth Creation
- Increased productivity
- New captive markets using GEEP character marketing program
- Green image

SQP7-B208907

Green Energy Eliminating Poverty

Benefits for Consumer

- Reduces poverty
- Environmental Statement/Lifestyle
- Goodwill
- High quality shirts

SQP7-B208908

A shirt made with environmentally friendly energy will have a logo to identify that it has been made on a Solar Sewing Machine.
This money for logo use has been proposed to be employed as follows:

40% - Micro credit lending - cash pool
20% - Infrastructure development for sewing
20% - Administration market and infrastructure development in developed countries.
20% - Administration, market and infrastructure development in developing countries.

SQP7-B208909

Green Energy Eliminating Poverty

Sample Financial Detail

Equipment Costs:	Rs. 25,000
Down Payment:	Rs. 5,000
Loan Amount:	Rs. 20,000
Payment Period:	Rs. 24 months
Interest Rate:	18% per Annum
Contract Period:	2 years
	1000 shirts per year
Income:	Rs. 20 per shirt (labor contract)

SQP7-B208910

Financing Renewable Energy for Village Power Application

Grace Santibanez-Yeneza
Managing Director
Preferred Energy, Inc.
Philippines

Village Power '97
April 15, 1997

Financing Renewable Energy for Village Power Application

GOAL

"To provide rural communities access to reliable energy services at reasonable prices"

Financing Renewable Energy for Village Power Application

Why village-based renewable energy systems?

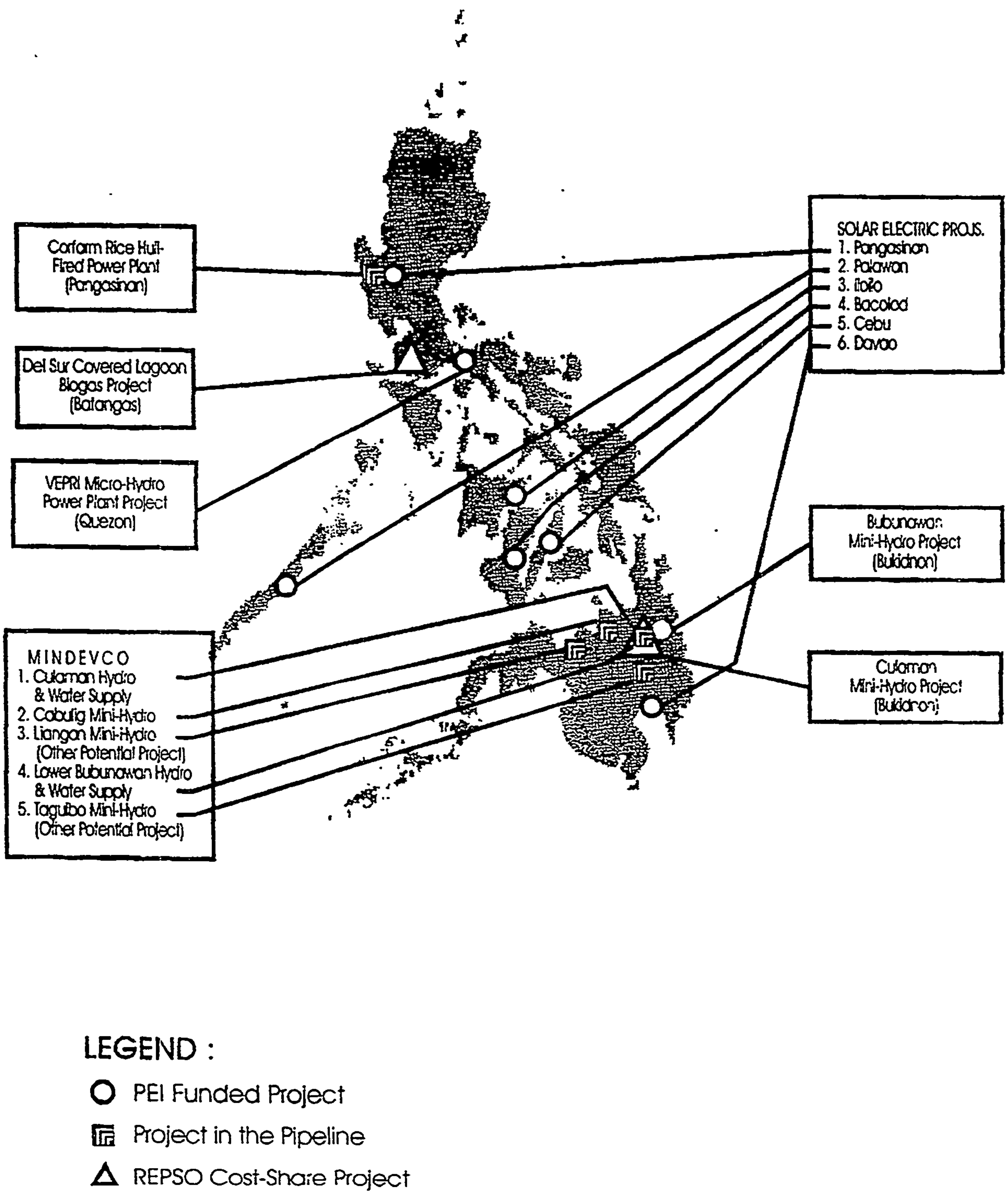
- Dispersed rural population
- High cost of line extension
- Low load density and low income patterns
- Renewable energy resources readily available in rural areas
- Environmentally-friendly, sensible, and politically sound

Financing Renewable Energy for Village Power Application

Village-based renewable energy systems in the Philippines setting

- About half of rural population unserved
- 30 rural electric cooperatives are using the solar option
- Other applicable technologies
  - micro/mini hydro
  - small-scale biomass
  - wind/diesel hybrids
  - mini geothermal

PEI-Winrock Project Initiatives



Financing Renewable Energy for Village Power Application

Constraints to renewable energy development

- High front-end costs
- Inadequate information
- Underdeveloped technical and market infrastructure
- Lack of capability to structure power projects
- Limited access to financing
- Biased policy environment

Financing Renewable Energy for Village Power Application

Some suggested mechanisms / structures:

- Local distribution utilities / electric cooperatives
- Community power cooperatives
- Private energy service companies

Financing Renewable Energy for Village Power Application

Basic considerations in structuring new financing mechanisms:

- Rural energy needs
- Income/repayment capabilities
- Energy options/available resources
- Acceptable financing schemes
- Technical and market support systems

Financing Renewable Energy for Village Power Application

Village Power Fund

- Direct investment fund for community energy systems
- Overseen by Trustees/Board from donor groups
- Managed by professional fund manager

Financing Renewable Energy for Village Power Application

Other financing support needed

- Guarantee Fund
- End-user Micro Credit

Financing Renewable Energy for Village Power Application

FINANCING RENEWABLE ENERGY SYSTEMS FOR VILLAGE POWER APPLICATION *

1. INTRODUCTION

When one talks of rural development, no doubt, the issue of rural energy is not far behind. As a significant component of any development strategy, rural energy is seen as the engine for growth that can bring about economic upliftment in the countryside. Many approaches to rural energy development have been tried. These approaches differ from country to country. But regardless of structure and approach, the goal remain essentially the same: to provide rural communities access to reliable energy services at affordable prices.

2. THE RENEWABLE ENERGY OPTION

In recent years, as global concern for the environment increased, many governments have turned to renewable energy as a more environment friendly alternative to rural electrification. Technological advances in renewable energy application has helped to encourage this use. System reliability has improved, development costs have, to some extent been brought down and varied application approaches have been tried and tested in many areas.

Indeed, there is huge potential for the development of renewable energy in the rural areas of most developing countries. At the rural level, renewable energy resources are almost always abundantly available: woodwaste, agricultural residues, animal waste, small-scale hydro, wind, solar and even sometimes geothermal resources. Since smaller scale systems are usually expected in these areas, renewable energy technologies can very well serve as decentralized energy systems for rural application. And not only for rural applications, new expansion planning paradigms have likewise led to the emergence of decentralized energy systems not only as supply options but also as corrective measures for maintaining end of line voltage levels. On the other hand, where renewable energy resource can provide significant blocks of power, they can be relied upon to provide indigenous power to the grids.

3. RENEWABLE ENERGY APPLICATIONS IN THE PHILIPPINES

The geographic feature of the Philippines, an archipelago of over 7,000 islands, makes it a perfect setting for the application of renewable energy in village power production. Its population of about 65 million is spread over 3,000 of these islands. While the big islands are already enjoying grid power services, most of the smaller islands and remote villages have remained in the dark due to inaccessibility and high cost of grid power extension. Thus today, about half of the rural population still do not have access to electric power.

Characteristically, the rural areas are sparsely populated. Many communities are settled far beyond the reach of the grid. Some mountain communities and remote fishing villages are accessible only during summer months. Power demand in these areas is low. Income patterns are similarly low and fluctuating, depending mainly on seasonal agriculture and small-scale fisheries. Hence,

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** A paper presented by Grace Santibañez-Yeneza, Managing Director, Preferred Energy, Inc., Philippines during the Village Power '97, 14-15 April 1997 at The Ellipse Conference Center at Ballston, National Rural Electric Cooperative Association, Arlington Virginia* borrowing capacities of these communities are equally low. With such features and considering the high capital cost of line extension currently estimated at about PHP 223,000 or $ 8,576 per kilometer of line, the prospects for grid extension to these areas therefore appear grim, unless otherwise supported by huge government subsidies.

It is in this context therefore that renewable energy has increasingly become the solution for remote area electrification. The application of solar power is gaining momentum in many areas of the country and is now accepted as an alternative, if not the only solution to providing households in remote villages a taste of electric power. Today, some 20 rural electric cooperatives which serve the power distribution requirements of the rural sector have implemented solar PV projects. Another 10 electric cooperatives have applied for solar PV loans from the National Electrification Administration (NEA) and 6 more have started installations of demonstration projects in their areas. Aside from electric cooperatives, several non-governmental organizations (NGOs) have also undertaken community-based PV electrification projects. Most of these projects involve the dissemination of solar homes systems (SHS) to rural households. Other uses for solar power include: battery charging stations, solar water pumping systems, PV-powered telecommunication systems and PV to support health facilities in remote communities.

Aside from solar power, micro-hydropower, small-scale biomass, wind/diesel hybrid systems are considered to have high application potential. In the case of biomass energy, the rice milling sector is seen as a major source of agricultural waste for power production. This sector alone produces over 2 million metric tons of rice husks annually. A study by the PNOC Energy Research and Development Center entitled "Preliminary Feasibility Study of Rice Hull Communal Power Plants in the Philippines" revealed that in five provinces, 18 potential sites are capable of supporting communal generation at 70-80% level of confidence.

On the other hand, power generation from biogas have not been maximized so far. In most cases, biogas projects are undertaken more as waste management measures rather than for power generations purposes. There are, however, a number of possibilities for self-generation by the hog and cattle raising sectors, given the proper information and incentives. One hog-raising farm, the Maya Farms has successfully operated independent from the power grid for many years supported only by its biogas generation project.

Micro-hydro and wind technology are similarly seen as potential sources for village power application. A number of micro-hydro projects have been developed to power small communities as well as for micro-economic application, such as powering small grain milling operations. On the other hand, hopes are high that the Philippines will, in the near future, produce power from wind farms. Winrock International (Wi) through its Renewable Energy Project Support Office (REPSO) Phils. and the National Renewable Energy Laboratory (NREL) are currently undertaking a National Wind Mapping Study that will help to identify the locations where these strategic areas for wind energy development are.

The challenge in the geothermal sector is the utilization of lower enthalpy resources. A number of wells that have been drilled but have not been utilized by large-scale geothermal producers are also considered as potential sites for non-power but economic application such as agricultural crop drying.

4. PEI INTIATIVES

The Preferred Energy Incorporated (PEI), is a non-stock, non profit corporation established primarily for the purpose of promoting private sector investments in renewable energy. Currently, it manages two projects for Winrock International, namely Renewable Energy Project Support Office (REPSO) Philippines and Renewable Energy Financing and Technical Assistance (REFTA), a project funded out of a cooperative agreement between Wi and the United States Agency for International Development (USAID). In line with these two projects, PEI provides cost-share pre-investment financing, technical and financial advisory services as well as equity investment or loan support for renewable energy projects undertaken by the private sector. Within the span of two years, PEI has managed to support the following renewable energy projects.

PROJECTS SUPPORTED	DESCRIPTION	SUPPORT PROVIDED
Bubunawan Corporation HydroPower Project	7-MW Minihydro Project for connection to the power grid of Cagayan Electric Power and Light Company	Equity investment of $304, 548
Solar Electric Company PV Dissemination Project	Dissemination of Solar PV in 6 provincial branches	Loan of $ 118,541
Viila Escudero Microhydro Power Project	98-kw micro-hydro project for self generation of power for the Villa Escudero Plantation and Resort	Loan of $ 279,043
Del Sur Farm Biogas Project	Feasibility Study for biogas generation using the covered lagoon technology at the Del Sur Farm in Batangas City	Cost-share pre-investment financing of $35,000
Culaman HydroPower Project	Feasibility Study for the 10-MW Culaman River Minihydro Project	Cost-share pre-investment financing of $35,000

In promoting the commercialization of renewable energy, PEI's approach is to demonstrate the viability of renewables by developing model projects that will showcase such viability. Hence the above projects were evaluated based on their capability to stand as commercial businesses. Loans given to projects were also given using commercial financial terms.

Aside from the above projects, two other projects are ready for possible financing. These include the establishment of the Mindanao Development Company (Mindevco), a company which shall undertake the development of small hydro projects in the Mindanao area to serve the growing requirements of the Mindanao grid. A number of hydro sites have been identified in earlier studies but each of the project site requires additional work to bring them to investment ready state. A development company, such as Mindevco, that would undertake the additional task of preparing the pre-investment studies for these projects is therefore necessary to facilitate the implementation of projects. PEI has already completed an investment study for the establishment of Mindevco and believes that it is worth pursuing. The project requires a PEI limited equity participation in the company. Aside from power generation, some hydro projects identified for development by Mindevco have good potential for water supply services as well. PEI is also giving advisory assistance to the Corfarm Grains Inc., a company engaged in rice milling for the development of a power plant project using ricehull for power production. Once developed, this project is considered a good project model for small-scale biomass that can easily be replicated in other parts of the country. PEI is expected to provide equity investment to this project.

5. CONSTRAINTS TO RENEWABLE ENERGY DEVELOPMENT

Despite the obvious need and potential of renewables for rural energy application, the progress in the development of these systems has been rather slow. This is largely due to the following factors:

- high front-end capital costs associated with the systems (in many instances, users are burdened with the payment of these systems upfront)
- inadequate information on the technologies and their cost effective application (negated further by effects of unsuccessful demonstration projects)
- underdeveloped technical and market infrastructure to provide access to products and services
- lack of capability to structure power projects (most potential project sponsors are not in the business of power production, e.g. rice millers in the case of biomass)
- limited access financing
- biased policy environment that tends to favor conventional energy forms

The high front-end capital costs of renewable energy systems contribute to the perception that renewables are expensive and high risk businesses. Since most project sponsors are not in the business of power production, they would normally prefer to keep their investment funds within the confines of their regular business and limit their exposure to these projects to the minimum. Convincing them to invest is difficult to do, specially if coupled with inadequate information about the technologies that would work. Moreover, while end-users are not usually burdened with the financing, ownership and maintenance of conventional power, renewable technologies, such as solar PV require that the users absorb all the risks as owner, operator and maintainer of the system.

The remote location, dispersed population, low demand and equally low affordability levels of rural areas increases project development and administrative costs for delivery of services to clients. This stems from the relative difficulty in client selection, delivery and installation of systems, monitoring and maintenance as well as collection of repayments.

Moreover, with the high market and financial risks associated with renewables, access to commercial capital market is difficult to come by. The lack of knowledge among the financing sector about the peculiarities of the various renewable energy technologies likewise add to the perception of high risk.

Additionally, the policy framework is still biased toward conventional energy forms. Conventional energy is subsidized and has easy access to cheap government credit and/or government guarantees. Moreover, when assessing its energy technology option, the choice of technology by the government is usually taken from the supply perspective. Thus, the major criteria considered is the technology's contribution to total energy mix (or its barrel of oil equivalent) rather than its capability of providing people access to energy services. For lack of a level playing field for all types of energy systems, renewable energy is still generally perceived a poor and expensive alternative.

6. DEVELOPING NEW MECHANISMS TO FINANCING RURAL RENEWABLE ENERGY SYSTEMS

In the Philippines, as in most developing countries, rural electrification is undertaken largely by the government. The National Electrification Administration (NEA) is charged with the mandate of providing "total rural electrification on an area coverage basis" through the operation of 119 rural electric cooperatives. NEA basically provides government subsidies and loans to electric cooperatives for distribution system construction and operation. Despite these government initiatives however, about half of the rural population still remain unserved by the grid. As more remote areas are targeted for electrification, the distribution of power has become increasingly more expensive.

New and innovative mechanisms for delivery of financing to the rural sector are therefore necessary. Some possible structures for the channeling of financing are:

- **Local Distribution Utilities/Rural Electric Cooperatives.** The franchise for electrification of a rural community may belong to either a private local distribution utility or an electric cooperative. These organizations can be encouraged to undertake decentralized renewable energy projects to serve the communities distant from their grids wherein said organization will own, operate and maintain the system and correspondingly charge the user appropriate fees for the services delivered. In this case, the local distribution utility or electric cooperative will take on the responsibility to borrow funds for the project and is also responsible for repayment of such loan. By way of an example, in the Philippines some 30 cooperatives are already undertaking or about to undertake renewable energy projects, particularly using solar technology. Started in the early 1990's through a GTZ-assisted project, these cooperatives are implementing the Rural PV Electrification (RPE) Project which was conceived as a scheme for the distribution of solar home systems to rural communities beyond the reach of the cooperatives' distribution lines. The NEA extends a loan to these cooperatives who are then responsible for implementing the project. The solar project in this case is seen as a pre-grid electrification option for the communities. Since the cooperatives own the PV panels, the household are not burdened with the ownership of the system. Such system may be transferred to other areas once the grid reaches the area.

- **Community Power Cooperatives (CPC).** Communities that have no access to energy may desire to take it upon themselves to operate a renewable energy system to service their communities. These communities can organize themselves into CPCs that would likewise own, operate and maintain the systems as well collect the fees for the services it offers. This, however, would require organizing, training and support from a responsible organization such as possibly an established NGO with substantial community organizing expertise. The advantage of this type of structure is that the members of the communities are involved and will have the opportunity for self-determination in as far as the level, quality and rate of growth of the energy services they receive. In areas where some form of cooperative already exists, such local cooperative may be utilized to undertake the function of energy service provider to the community. This type of structure has been tested by the Development Bank of the Philippines, whereby financing for solar power dissemination was made available through an existing cooperative with a track record in lending operations. The disadvantage of using an existing local cooperative however, is that these organizations were not essentially organized for power services delivery. Therefore to a certain extent, they will have technical deficiency in managing power generation and distribution activities.

- **Private Energy Service Companies (PESCo).** In communities where private entrepreneurship exists, a person or a group of persons may want to organize a PESCo which may be given the rights to own, operate and distribute power using decentralized renewable energy technologies. The PESCo could then serve as the primary sponsor and borrower of funds for the renewable energy project. To the extent that the project may be large enough to extend services beyond the immediate community, the PESCo may even consider venturing into power generation business which exports power to the local grid.

But no matter the type of structure selected, these innovative mechanisms must be developed to finance and implement renewable energy systems that can meet the needs of the rural population for reliable energy services at reasonable costs. The structuring of these mechanisms must therefore take into consideration a) the rural energy needs of the community, b) income and repayment capabilities of the population, c) renewable energy options applicable in the area and their associated costs, d) financing schemes that are acceptable/workable, and e) technical and market support systems available, in order to succeed.

7. VILLAGE POWER FUND

To increase availability of credit to the countryside beyond just the regular financial channels, PEI has been conceptualizing, together with some interested donors, the possibility of creating a Village Power Fund. This fund will essentially provide direct, flexible investment funds for the development and construction of energy systems for rural communities. The operation of the funds will involve accredited NGOs, People's Organizations (POs), and Local Government Units (LGUs) whose main function will be to originate deals, i.e., propose a recipient community, help in formulation of the community's energization plan, propose credit collection and management scheme and provide guarantees in terms of the community's organizational ability to handle credit. These organizations likewise will commit to seeing the project through to the retirement of the community debt.

The fund will be managed by a professional fund manager who will be mandated to create a profitable and balanced debt portfolio based on a sustainable deal flow. A Board of Trustees selected from among the donor groups will oversee the operation of the fund.

8. OTHER FINANCING SUPPORT NEEDED

In addition to a village power fund, the following financing support will enhance the potential for success of a village power initiative:

- **Guaranty Fund** - a flexible guaranty fund is needed to provide guarantees to loans by proponents of power projects and/or their power purchase agreements with local power distributors. This is necessary to enhance the bankability of projects and allow these projects to access financing from regular financing institutions.

- **End-User Micro Credit Facility** - This facility will operate to provide end-users the opportunity to purchase the systems through affordable financing schemes that would fit their limited budgets. This will help to enhance the affordability levels at the community level by giving flexible financing and lightening the burden of having to pay for the systems up-front costs. PEI and Wi are in the process of studying workable options for this type of financing. Such options may include, PV leasing schemes, micro-enterprise financing that would include energy systems, etc.

9. CONCLUSION

No doubt, renewable energy has a critical role in bringing energy as well as eventual economic upliftment to the rural communities. The big challenge is finding the necessary funds as well as developing viable financing mechanisms to deliver the needed capital to implement renewable energy systems in these areas.

Village Power Conference

User-Owned Utility Models for Rural Electrification

Dan Waddle
NRECA International, Ltd.
April, 1998

NRECA - BOLIVIA

Electric Cooperative Model in the United States

- Electric cooperatives are owned and governed by their member-owners.
- The self-interest of the users is always foremost in governance for obvious reasons.
- The history of the REC model in the U.S. has been phenominal; less than 1/10 of one percent loan default.
- Keeping rates low, securing reliable energy, and customer satisfaction are of highest value to cooperative boards.

NRECA - BOLIVIA

Emergence of Competition and the Changes vis-a-vis REC's

- Rural markets are becoming increasingly attractive to IOU's.
- REC's are faced with the need to modernize, reduce costs, and to become more efficient.
- Economics of scale seldom favor REC's, so they must think of how to sell what they are.
- Provide many ancilliary services, appeal to customer satisfaction, and the ability to ALWAYS focus on member self interest.

NRECA - BOLIVIA

How Does this Apply to "Village Power"?

- The challenges are really the same for conventional and non-conventional utilities.
- Efficiency, economics of scale, cost control, and use of adequate technology will always be issues.
- The ability of local communities to govern themselves may also be an issue in many cases.
- Success of U.S. model was due to a partnership between the communities and the government.
- The key is the need to start with a sustainable financial model => cost recovery.

NRECA - BOLIVIA

Myths about REC's both in the U.S. and Abroad

- REC's must be subsidized to survive.
- REC's are inherently poorly managed.
- REC's are small electric utilities managed as "mom and pop" organizations.
- REC's receive huge fiscal advantages that IOU's do not.
- The cooperative model is a thing of the past that has run its course.

NRECA - BOLIVIA

Is the Cooperative Model Relevant to Village Power Applications?

- Cooperatives, like many rural businesses, have a mixed history in developing countries.
- Political framework, level of government intervention, and oversight are all critical to sustainability.
- Laws that affect the cooperatives access to capital are critical.
- The ability to broker a partnership between the government and the community is crucial.

NRECA - BOLIVIA

How Does one Decide Whether to Establish an REC or not?

- Measuring the community's commitment is key, both to manage themselves and to pay what is required.
- The intentions of the community are very important.
- Role and willingness of local government to support the project (financially, legally, politically).
- One must recognize that a cooperative is a dynamic politically influenced institution. Understand local politics.
- Level of support for cooperatives in the respecti[ve] country, and history of success or failure.

NRECA - BOLIVIA

What is NRECA's Perspective?

- Cooperatives have some very compeling advantages, but aren't always feasible.
- Cooperative or user-owned utilities can work very well for the communities.
- The communities must be coached through not only the formation of the institution, but they must understand the way in which the REC's must operate.
- Very useful to have an oversight mechanism, as well as a technical assistance function at some level.

NRECA - BOLIVIA

How can Success be Assured?

- By-laws and sound commercial practices must be adopted and followed vigilantly.
- Financial accountability and transparency must be established.
- SOW's for technical and administrative positions must be defined when the cooperative is being formed.
- The cooperative must be well-capitalized.
- Energy prices must be rational and competitive.
- Government support is all important, at least at the beginning.

NRECA - BOLIVIA

Economics of Scale

- There is a lower limit under which a cooperative will not function financially.
- The business plan should take into account all economic factors.
- Saving money on management or technology will be counter-productive.
- Social benefits are always important but must be set aside when performing the economic analysis.

NRECA - BOLIVIA

How much emphasis is REALLY being placed on institutional sustainability?

- Programs demand projects and have little or no funding for institutional strengthening activities.
- Donor programs provide little or no funding for TA efforts.
- Lots of talk about sustainble models, but the money doesn't show real interest.
- Bottom line: private sector is unlikely to get involved, government institutions haven't gotten involved, and very little funds are currently available to address institutional sustainability issues.

NRECA - BOLIVIA

A Role for NGOs in International Renewable Energy Project Development

Todd R. Bartholf

Village Power '97
April 14-15, 1997
Arlington, VA

Common Definition of an NGO

An international term for non-government organizations, often used in connection with non-profit, community-based and/or voluntary business activities.

Possible Structural Configurations

- Philanthropic development organization
- Technical/management/financial assistance organization
- Community-based utility
- Many others

Advantages to Working with NGOS

- Familiar with end-use requirements
- Typically technology neutral
- Training is usually a focus of technology involvement
- Specialize in maintaining low cost, local field presence
- Many maintain existing trust relationships with desired customer base
- Good ones able to adapt to perform numerous roles
- Often capable of attracting additional support for future activities
- Short term creativity often translates to long term innovativeness

Disadvantages to Working with NGOs

- Many lack adequate technical/ financial training for effective project management
- Most do not specialize in high-tech hardware installation
- Larger ones have very diverse agendas
- Smaller ones have cash flow concerns

Success Stories

- Enersol in the Dominican Republic, Honduras
- SELF in Africa, Viet Nam
- NRECA in Guatemala, Bolivia
- Winrock in Indonesia, India
- ITDG in Peru, Sri Lanka
- Grameen Bank in Bangladesh
- RBF and E & Co. globally

Expanding on These Successes

- Maintain focus on commercially viable technology
- Share lessons of affordability with industry
- Share models for development with other NGOs
- Expand training programs to incorporate 'next generation' capability
- Use project experience to help prepare markets for commercial involvement
- Consider for-profit spin-offs from successful ventures

The Future of NGOs in Renewable Energy

- Continue role in seeding new activity in rural markets
- Maintain lead in preparing institutional framework for future market activity
- Increase role in managing international development activities
- Work directly with for-profit technical/ finance organizations
- Fundamental role in RE Consortium

The U.S. Renewable Energy Consortium

A *true* collaboration between government agencies, NGOs and international finance institutions to efficiently channel interests in the form of funds and assistance to international project development in partnership with industry.

Benefits of True Collaboration

- Actual growth of the industry instead of growth of the Washington support network (bandwagon)
- Harnessing of inherent competitive edge of U.S. technologies instead of perfecting the state of international confusion
- Clear priorities set by consortium members instead of pursuing isolated agendas of separate funding sources

INSTITUTIONAL PERSPECTIVES

PRESENTATION TO VILLAGE POWER WORKSHOP
BY ROSS PUMFREY, OFFICE OF ENERGY, USAID

4/15/97

Good afternoon. I sincerely believe that you are all involved in what is truly a revolution in delivering energy services to rural areas. USAID is excited about the implications for rural economic and social development.

Several of the programs related to village power to which USAID has contributed funding have been described to you over the past day and a half. So there is no reason for me to review any of those programs in detail. It is my experience that in workshops of this kind there are often many people in the audience who do know understand what USAID is or how it works. So I believe that the best thing I can do with the majority of the time allotted me is to explain our agency:

What is USAID?

Where does the money go and who makes the decisions?

Where does USAID fund energy programs, and especially renewable energy?

Who are our "partners"?

What is our approach to renewable energy?

What, in summary, has USAID funded that is relevant to village power?

First, USAID is the foreign aid agency of the U.S. Government.

Approximately seventy-five countries receive regular assistance. In nearly all of those countries, usaid has a permanent office called a mission.

The fiscal year 97 budget for the agency is approximately $5.8 billion. About half of the total budget goes to Israel, Egypt, and the countries of the former Soviet Union. These budgeting decisions are geopolitical -- they are made by congress and the president, not by usaid. The rest of the money goes to the other sixty-five or so countries.

Congress also earmarks total budgets for a few sectors or subjects. Family planning is probably the biggest example.

With those decisions as given, most of the money and most of the decision-making on specific programs in usaid is at the mission level, in the field. A partial exception to that is the Bureau for Europe, which exercises significant control from Washington with regard to what programs are funded in the countries of the former Soviet Union.

The office in which I work, in the Global Bureau of USAID, is supposed to engage in (1) generic activities useful globally, (2) support to the field missions in response to requests from them, and (3) innovative programs that if they are country-specific require the approval of the usaid mission in that country.

Turning to the missions again: with the money available to each mission, that mission chooses a small number of sectors or subjects in which to fund programs -- they choose from education, health, family planning, judicial reform, forestry, agriculture, energy, and several others.

The largest energy budgets in usaid are in the Egypt mission and in the Europe Bureau, and they currently are focusing on large-scale energy projects and are not paying attention to renewable energy.

Where else is USAID involved in energy, and where specifically in renewable energy? Outside of Egypt and the former Soviet Union, ninety-five percent of USAID's energy programs are in India, Indonesia, the Philippines, the Dominican Republic, Mexico, Central America, Brazil, and South Africa. In each of those countries, there are also renewable energy programs specifically.

Who are USAID's partners in renewable energy activities? We work most closely with US/ECRE, Winrock and the Renewable Energy Project Support Offices (REPSOs), the Environmental Enterprises Assistance Fund (EEAF), IFREE, DOE, the MDBs, local entrepreneurs, and local governments where appropriate. Through US/ECRE, Winrock, and EEAF, our assistance gets relayed to additional groups.

The goal of our renewable energy programs is simple: We are interested in accelerating the market penetration of commercial technologies. We do not engage in technology R&D. Developing countries have energy needs <u>now</u>, and commercial technologies are available now. The approaches are through work on policy, information dissemination, project identification, brokering business relationships, pre-investment studies, and coordination with financing institutions, including the formation of innovative credit mechanisms.

With regard to programs pertinent to village power, I will briefly hit the high spots, so you will have an overview of the breadth and depth of our interest:

The USAID mission in Jakarta has been funding the pilot program in wind-powered battery stations in Indonesia. Winrock is the manager, and Mike Bergey is significantly involved. That

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same USAID mission recently funded a training course for solar entrepreneurs, to help kick-start the implementation of an important World Bank loan approved at the beginning of the year.

The USAID mission in New Delhi, through Winrock, has provided funds for SELCO, the company that Neville Williams of SELF helped establish in India.

The USAID mission in the Dominican Republic has provided funding for Enersol's work in that country, as well as funding to a consortium comprising Winrock, NRECA, and New Mexico State and working on micro-hydro and wind for village electrification.

The USAID office in Brasilia has provided funding for the work of Bill Howley and Mary Grady in that country. They have been providing guidance to U.S. companies investigating opportunities in that country and have been assisting the World Bank in developing a loan that will focus on village power.

The USAID mission in Guatemala has provided funding for Fundación Solar, which as many of you know has been the leader in that country in getting solar home systems into rural areas.

The USAID missions in Guatemala and Bolivia provided funding in the past for NRECA and its pioneering work in those countries.

The USAID mission in Mexico has provided money through Sandia for small-scale use of renewable energy technologies.

Our Office of Energy in Washington, where I work, has complemented many of those efforts with our budget. One in particular that I should mention is our support for the Environmental Enterprises Assistance Fund, core support that has enabled EEAF to raise investment capital and perform due diligence on promising programs. On two occasions EEAF has made useful loans to the Soluz and an affiliate, including a loan that helped launch the world's first leasing program for solar home systems.

I should mention that EEAF in 1996 joined forces with the Multilateral Investment Fund (MIF, a sister organization to the Inter-American Development Bank) in establishing a $10 million environmental business investment fund for Central America. Those of you with good business ideas in that region should consider EEAF as a potential source of capital.

Similarly, EEAF will be one of the fund managers for the new global Renewable Energy and Energy Efficiency Fund being established later this year by the IFC.

In addition, our office has provided funding for Renewable Energy for African Development (REFAD) and its efforts in Namibia and South Africa to set up credit mechanisms in support of rural energy.

It is important to note that in several of the above cases, USAID support was complementary to support from the U.S. Department of Energy. I think this synergism has been extremely important. Bud Annan and Scott Sklar deserve credit for helping make many of these collaborative things happen.

USAID has taken note of the interest taken by subsidiaries of U.S. utilities in the past couple of years in bringing their expertise and resources to bear on meeting the challenge of rural energy needs in developing countries. We believe that the entry into the market of these players could be one of the most important catalysts for making the rural energy revolution happen. In addition to expertise and resources, these companies bring a long-term service perspective to the situation. It is energy services, not simply hardware, that individuals, communities, and businesses in the rural areas of developing countries need. Energy is an input to social and economic development, and it is critical to have an appreciation for how and why energy services are needed over time, and how they may evolve over time.

In conclusion, I would like to note that our office is currently and quite deliberately considering the subject of rural energy and what we should be doing more of, or less of, or differently, in order to maximize the beneficial impact of our relatively small amount of funds. I invite any of you who have ideas or suggestions regarding the types of relatively low-budget interventions by USAID that might be helpful to contact me at my e-mail address: rpumfrey@usaid.gov.

Thank you, and keep up the good work.

CLIMATE CHANGE OPPORTUNITIES

Ron Benioff

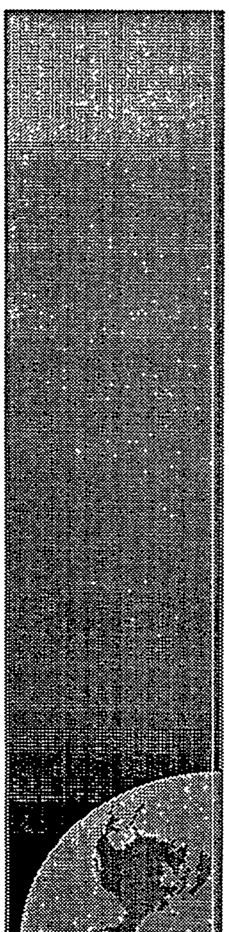
National Renewable Energy Laboratory

FRAMEWORK CONVENTION ON CLIMATE CHANGE

- Developed & Transition Countries Must Implement Measures with Goal to Stabilize Emissions at 1990 Levels by 2000
- Developing Countries Must Conduct Emission Inventories & Communicate Steps
- Developed Countries Must Support Technology Transfer and Financing

CLIMATE CHANGE STIMULATING VP MARKET

- Joint Implementation / Emission Trading
- Developing Country Action Plans
- Technology Transfer Programs
- Financing (GEF)



Reducing Greenhouse Gas Emissions through International Partnerships

U.S. Initiative on Joint Implementation

Supporting the Principles and Objectives of the Framework Convention on Climate Change

Goals of USIJI

- Encourage the development and implementation of voluntary, cost-effective projects between U.S. and non-U.S. partners aimed at reducing or sequestering greenhouse gas emissions

- Contribute to the formulation and implementation of the UNFCCC AIJ pilot phase

USIJI Project Summary

USIJI Engages Private Sector & Helps Develop High-Quality Projects

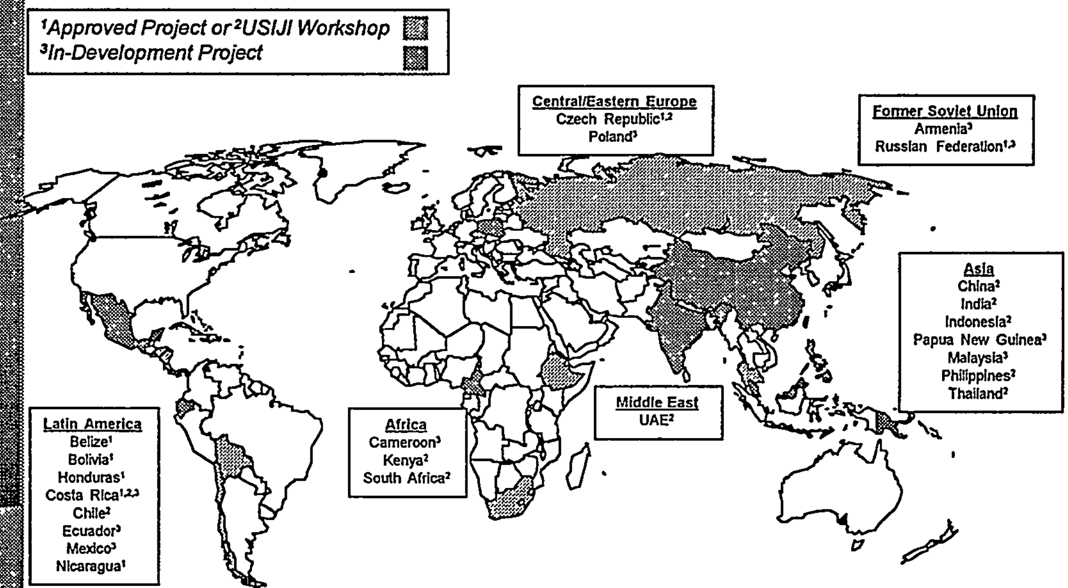
- More than 70 proposals from 30 countries

- Twenty-four projects approved

- Diversity of technologies and practices

- Broad geographic distribution

Location of USIJI Activities



USIJI Project Criteria

- **To be approved as a USIJI project, a proposal must demonstrate that it:**
  - Has acceptance of the host country government
  - Will reduce or sequester net greenhouse gas emissions
  - Was developed or realized because of USIJI
  - Provides data and methodological information sufficient to measure emissions with and without the project
  - Provides for tracking and verifying the emissions reduced or sequestered by the project
  - Identifies associated environmental and developmental benefits
  - Provides assurance that benefits gained will not be lost over time

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BENEFITS OF PARTICIPATION IN USIJI

- Cost-Effective reductions of greenhouse gases and other environmental and economic benefits
- Leadership in shaping the future of activities implemented jointly under FCCC
- Technical assistance in estimating GHG reductions, M&V, and securing financing
- Public recognition

HONDURAS SOLAR RURAL ELECTRICATION PROJECT

- Enersol Associates is teamed with counterparts in Honduras to install solar-based lights in 240,000 homes
- Will displace 1,200,000 metric tons of CO2
- USIJI providing public recognition and facilitating access to financing

STATES EXPERIMENTING WITH CO2 OFFSETS, E.G.

- Oregon recently required CO2 offsets for new 500 MW power plant
- Utility provided $500,000 to SELF to finance installation of 182,000 PV household systems in India, Sri Lanka, and China
- Oregon now considering offset legislation

RE MEASURES IN CLIMATE CHANGE ACTION PLANS

- Countries are Preparing Climate Action Plans and National Communications
- For Many Countries Off-Grid RE Applications are a Climate Priority
  - e.g. China, Indonesia , Mexico, Micronesia, Russia, Tanzania, Venezuela, etc.
- U.S. Country Studies Program & NREL are Assisting these Countries with their Plans

TECHNOLOGY TRANSFER

- Climate Technology Initiatve is Supporting Energy Networks and Related Activities
- Technology Agreements Could Become Framework for New VP Initiatives
- Developing Countries Starting to Identify Technology Needs (e.g. China's List of 15 Technologies)

CLIMATE OFFICIALS NEED YOUR HELP

- Identify Joint Implementation Projects
- Propose VP Measures for Action Plans
- Structure Technology Transfer Initiatives
- Design Financing Programs

FOR FURTHER
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Rural Energy
ODA's Perspective

David Woolnough

ODA Energy Adviser, UK

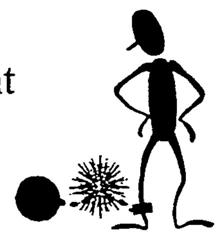
Overseas Development Administration

'To improve the quality of life of people in poorer countries by contributing to sustainable development and reducing poverty and suffering'

So where does energy fit in?

ODA's View of Rural Energy

- A means to an end, not an end in itself
- Emphasis firmly on the service provided
- Provision of basic needs
- Its role in rural development



Providing Basic Services

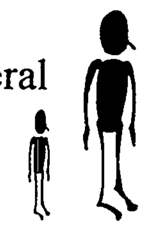
Households:	cooking, warmth, lighting, radio...
Health Centres:	vaccine refrigeration, lighting...
Schools:	lighting, fans, TV, radio...
Communities:	water pumping, street lighting...
Small Enterprises:	lighting, milling, small appliances...
Agriculture:	irrigation, crop processing, tilling...

ODA's Role

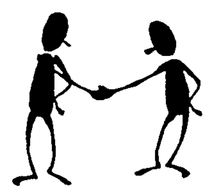
Research & Development

Supporting NGOs

Multilateral Aid



Bilateral Aid



Research & Development

- IG controller for micro-hydro
- Wind pump development
- Wind pump networks in Asia
- Commercialisation of injera stoves
- Affordable household connections
- Participative planning
- Adoption barriers

Supporting NGOs

- Small scale, close to the ground
- Takes time to be sustainable
- Joint Funding Scheme
- Eg:

  efficient stoves

  PV for schools

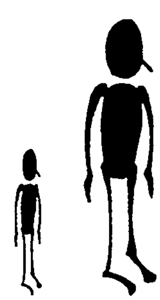
  village micro-hydro

Influencing Multilateral Aid

- Increasing proportion of ODA funds
- European Commission:

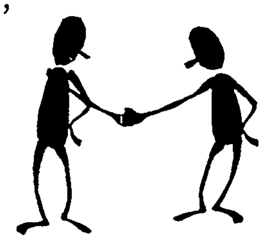
  DGVIII (ACP) energy expert group

  DGI (Asia) energy strategy
- World Bank & ESMAP



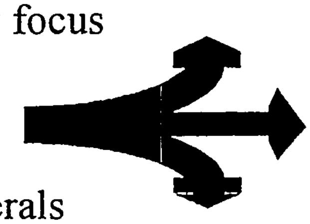
Bilateral Aid

- Not a typical bilateral project
  - small scale and decentralised
  - country priority sectors
- Donors *'want to do something'*
- A few project examples...
- Link to other programmes



Where do we go from here?

- Bilateral - rural energy guide
  - future rural energy projects
  - increased poverty focus
- Continue NGO support
- Target R&D programme
- Increase links with multilaterals



ODA's View - Conclusions

Emphasis on service provided

Must be economically sustainable

Better suited to R&D and NGOs than major bilateral or multilateral projects, BUT...

Increasing emphasis on Rural Energy

US/ECRE and Renewable Energy Market Development: An Institutional Perspective

US EXPORT COUNCIL FOR RENEWABLE ENERGY

Presented by:
Judith M. Siegel
at the
NREL Village Power '97 Workshop
April 15, 1997

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U.S. Export Council for Renewable Energy Overview

US EXPORT COUNCIL FOR RENEWABLE ENERGY

When:
- Founded in 1982

Who:
- Consortium of U.S. RE Trade Associations Representing 1,600+ Companies
- Non Profit Organization - Industry Counterpart of CORECT

What:
- Accelerate the diffusion of sustainable RE/EE services worldwide, and enhance U.S. industry's position in this expanded marketplace

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US EXPORT COUNCIL FOR RENEWABLE ENERGY

United States Export Council for Renewable Energy

American Wind Energy Association
Geothermal Energy Association
National Association of Energy Service Companies
National Bioenergy Industries Association
National Hydropower Association
Solar Energy Industries Association

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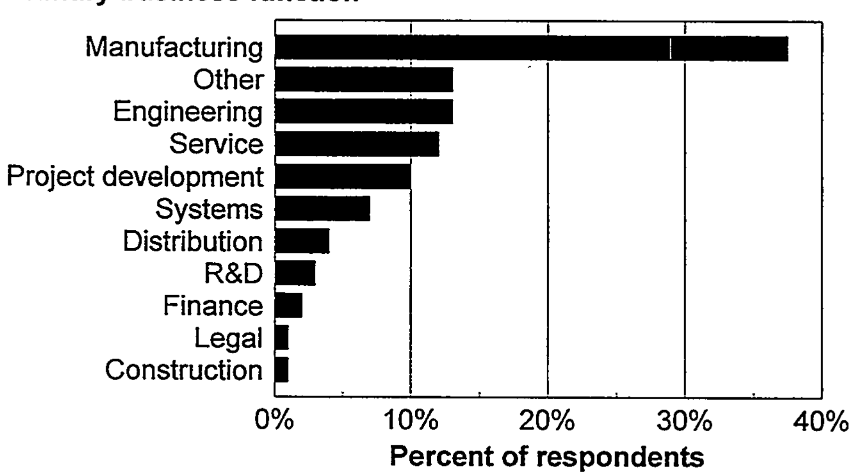
US EXPORT COUNCIL FOR RENEWABLE ENERGY

Manufacturers Comprise the Largest Segment of the Renewable Energy Industry

Primary business function



Source: US/ECRE survey of renewable energy industry, 1995

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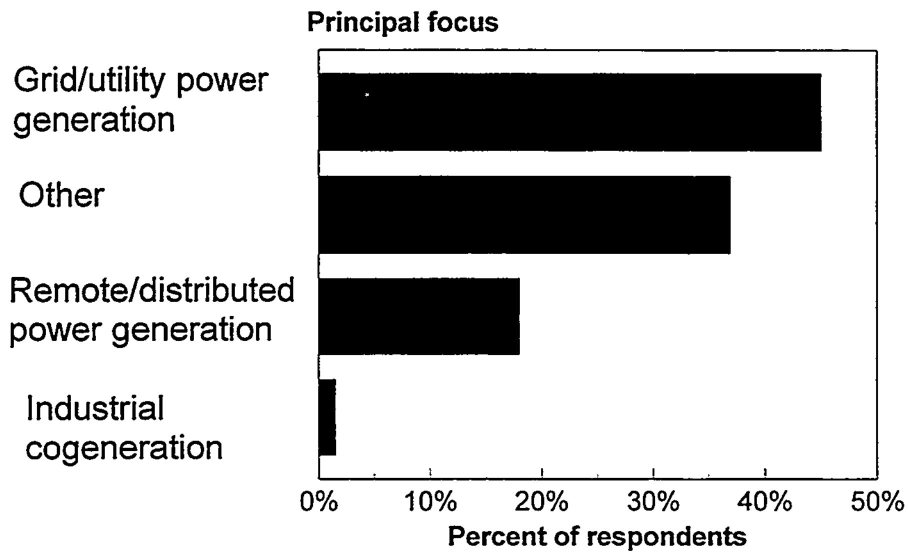
US EXPORT COUNCIL FOR RENEWABLE ENERGY

Markets



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US EXPORT COUNCIL FOR RENEWABLE ENERGY

On-grid Applications

	Bio-energy	Geo-thermal	Hydro	PV	Solar Thermal	Wind
Bulk power	O	O	O	O	O	O
Grid support	O	O	O	O	O	O
Demand-side management	O	O	O	O	O	O
Distributed generation	O	O	O	O	O	O
Heat, cogeneration	O	O			O	

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US EXPORT COUNCIL FOR RENEWABLE ENERGY

Off-grid Applications

	Bio-energy	Geo-thermal	Hydro	PV	Solar Thermal	Wind
Power for village, industrial facility, tourism	O	O	O	O	O	O
...house, school, clinic, business			O	O	O	O
Pumping, water treatment	O		O	O	O	O
Unattended loads (e.g. telecom)		O	O	O	O	O
Space heating, water heating	O	O	O	O	O	O
Process heat, cogeneration	O	O			O	
Motor fuel	O					

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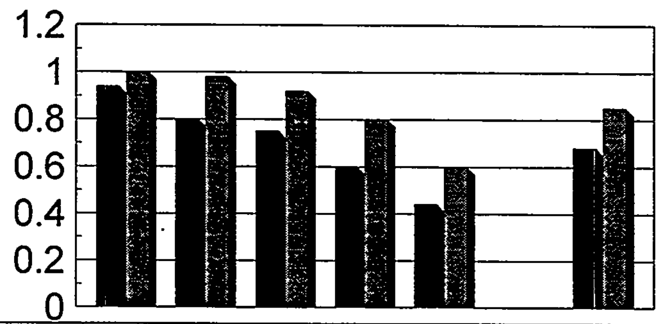
US EXPORT COUNCIL FOR RENEWABLE ENERGY

Projected Growth in Exports

70% of companies had exported recently, and 85% plan to export in next 5 years



	Geothermal	Solar	Wind	Bioenergy	Hydropower		Overall
Past 5 years	0.94	0.80	0.75	0.60	0.44		0.68
Next 5 years	1.00	0.98	0.92	0.80	0.60		0.85

Source: US/ECRE survey of renewable energy industry, 1995

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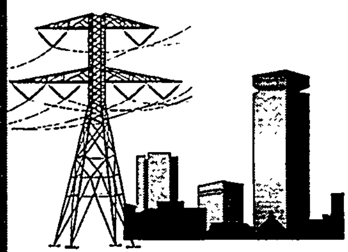
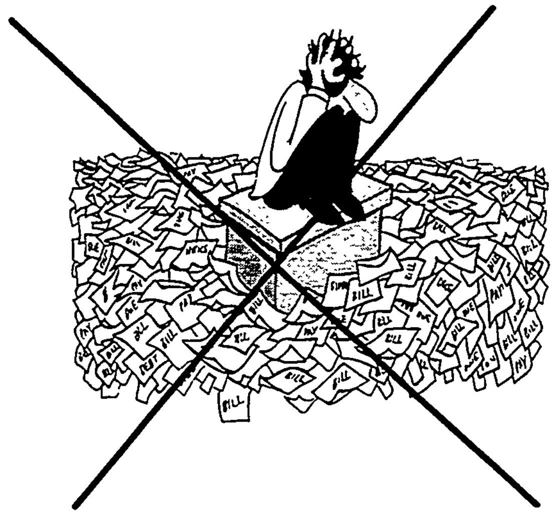
US EXPORT COUNCIL FOR RENEWABLE ENERGY

Projects, Not Papers





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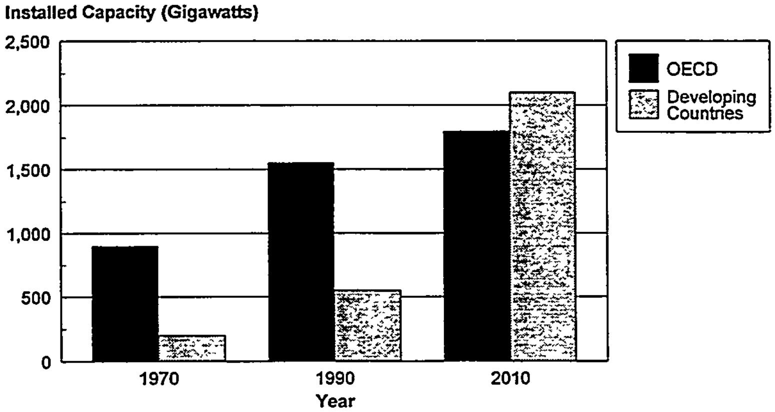
Projected Energy Growth Worldwide

Installed Capacity Trends



Source: World Bank

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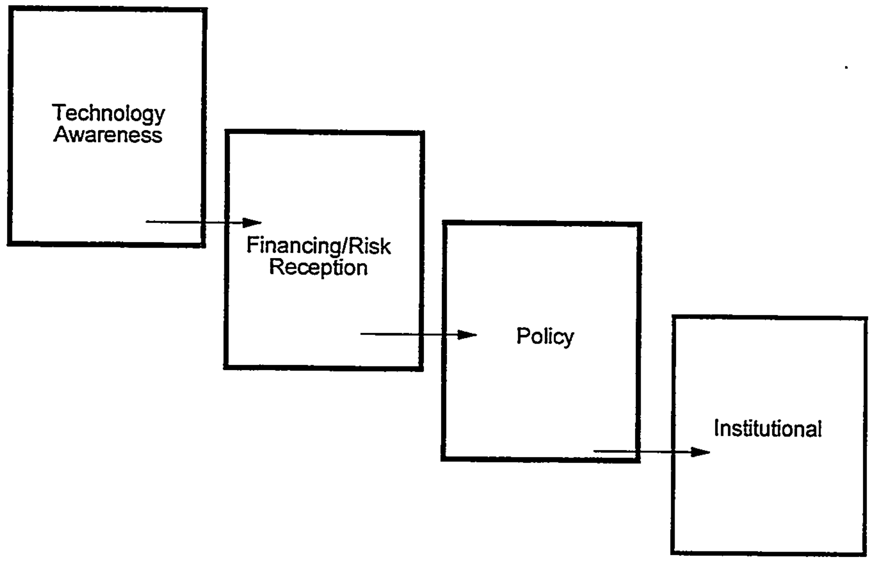
Barriers to Alternative Energy Technologies



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US EXPORT COUNCIL FOR RENEWABLE ENERGY

The Industry Team Supports The Path to Development

Strategic Alliances
- Federal (CORECT, Federal Agencies
- Regional Initiatives (APEC, HES, MDBs)
- Bilateral (Trade Groups, Governments)
- Sectoral (End-User Groups)

End-User Outreach
- Participate/Sponsor Conferences/Workshops
- Technology/Applications Data
- CREST/Internet Information Dissemination

Industry Market Development
- REXPORT Trade leads
- Trade/Reverse Missions
- Country Market Data
- In-Country Networks/Offices
- Small Business Travel Fund

Policy/Project Development
- Resource Law Assessment
- Policy Development, Analysis & Suppor
- Industry Policy Papert

Financing Facilitation
- U.S. Government
- MDB's
- Commercial Banks

Tracking/FollowUp
- Assist Trade Assoc. and Industry
- Publicize Successes
- Regional Replication/Expansion

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U S EXPORT COUNCIL FOR RENEWABLE ENERGY

CORECT Member Agencies

Environmental Protection Agency
Export-Import Bank of the United States
United States Trade Representative
Overseas Private Investment Corporation
U.S. Agency for International Development
U.S. Department of Commerce
U.S. Department of Defense
U.S. Department of Energy
U.S. Department of State
U.S. Department of the Interior
U.S. Information Agency
U.S. Small Business Administration
U.S. Department of the Treasury
U.S. Trade and Development Agency
U.S. Export Council for Renewable Energy

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U S EXPORT COUNCIL FOR RENEWABLE ENERGY

MDB Support

Activity / Organization	Project Preparation	MDB Staffing Training	US ED Briefings	RE Strategic Planning	On-Site Staff Support
WORLD BANK	✔ (On-Going)	✔ (On-Going)	✔ (On-Going)	✔ (On-Going)	✔ (On-Going)
INTER AMERICAN DEVELOPMENT BANK		✓ (Possible)	✔ (On-Going)	✔ (On-Going)	✓ (Possible)
AFRICA DEVELOPMENT BANK		✔ (On-Going)	✔ (On-Going)		
ASIAN DEVELOPMENT BANK		✔ (On-Going)	✔ (On-Going)		✓ (Possible)

✓ Possible

✔ On-Going

- WB/ASTAE Cross-Cutting $1 B RE/EE Portfolio
- IFC RE/EE $200M Fund In Process
- WB Solar Initiative (16 Non-Asian Countries); pursuing $300M+ portfolio
- IDB Sustainable Market Unit in Place
- ADB exploring increased RE participation

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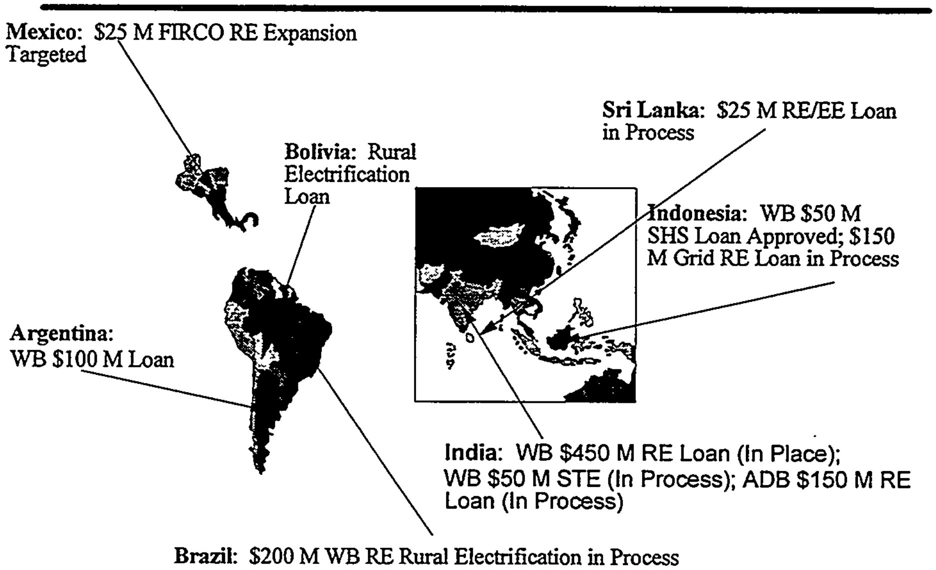
US EXPORT COUNCIL FOR RENEWABLE ENERGY

MDB Activities



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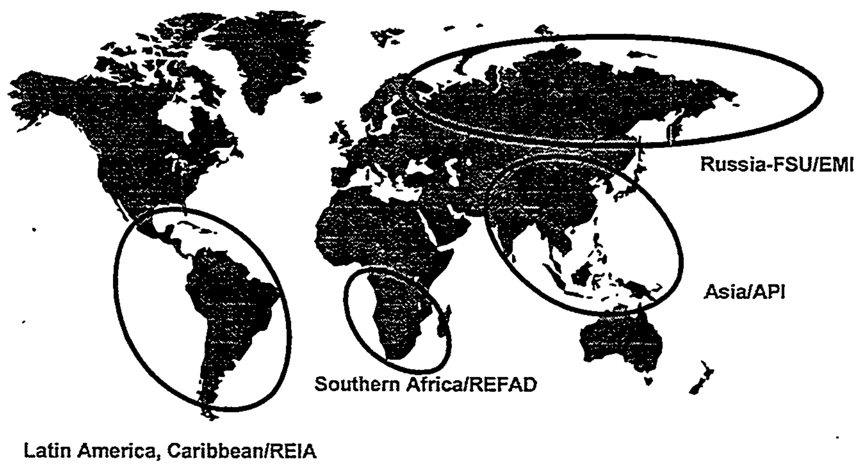
Current U.S. Government/Industry Focus Regions



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US/ECRE REGIONAL MODEL

PHASE III
FOLLOW - UP
IMPLEMENTATION

- REIA

PHASE I
MARKET
CONDITIONING

- REFAD
- Russia/FSU

PHASE II
REGIONAL
CONFERENCE/
EXHIBITION

-API

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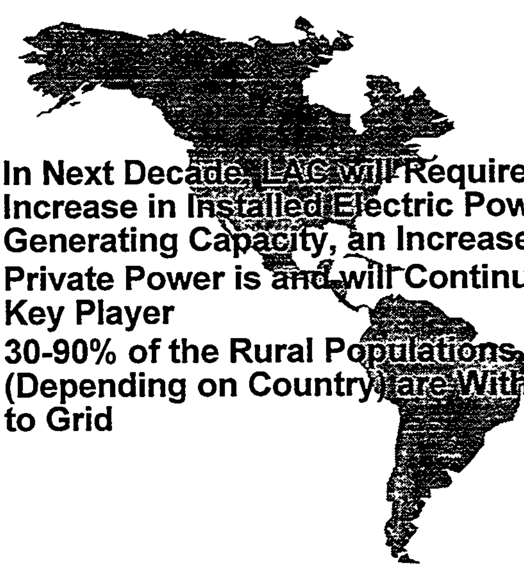
US EXPORT COUNCIL FOR RENEWABLE ENERGY

LAC Energy Market



- In Next Decade, LAC will Require a 50% Increase in Installed Electric Power Generating Capacity, an Increase of 90 GW
- Private Power is and will Continue to be a Key Player
- 30-90% of the Rural Populations in LAC (Depending on Country) are Without Access to Grid

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US EXPORT COUNCIL FOR RENEWABLE ENERGY

LATIN AMERICA AND THE CARIBBEAN: THE REIA INITIATIVE

Activities To Date:

- **Over 20 Training Events**
- **Over 10 Trade Events**
- **Landmark Regional REIA'94 Conference**
- **Policy Support in 8 Countries**
- **Financial Engineering**
- **Summit of the Americas Coordination**

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US EXPORT COUNCIL FOR RENEWABLE ENERGY

REIA: WHAT IS IT LEVERAGING?

- REIA Declaration Signed by 20 Energy Ministers
- REIA Working Group Established

- Project Portfolio of 200 Projects ($2.5B)

- World Bank RE loans in process (> $300M)
- IFC REEF Fund ($100M to Leverage $500M)
- IDB Sustainable Markets Program
- Commercial Bank RE Lending

- Tariff Reductions
- Resource Policy Development
- Policy/Regulatory Reforms

- LAC Market Reports
- LAC Financing Report

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US EXPORT COUNCIL FOR RENEWABLE ENERGY

Asia Energy Market

- Fastest Growing Region in the World
- Over Next Decade, 460 GW of New Electric Generating Capacity Anticipated ($460B)
- Significant Portion of Population in Rural Areas Without Grid Access

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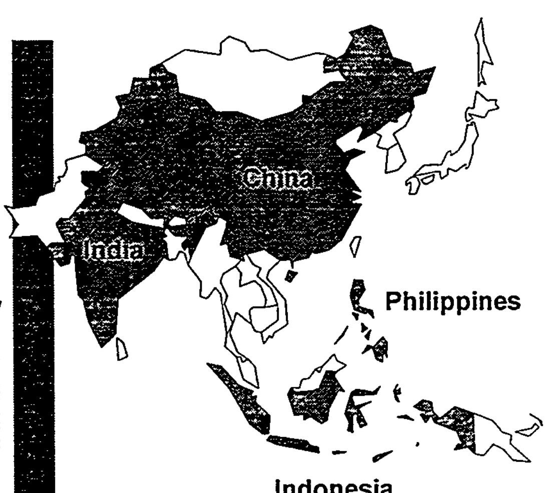
US EXPORT COUNCIL FOR RENEWABLE ENERGY

Asia-Pacific Initiative (API)



- 10 Trade Events
- 5 Financing Seminars
- MOU's with Trade Groups/Governments
- MDB Innovative Financing
- Policy Support

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US EXPORT COUNCIL FOR RENEWABLE ENERGY

API: WHAT IS IT LEVERAGING?

- Project portfolio of over 40 projects (> $1B)
- Eximbank Indonesia fund in development
- World Bank RE/EE loans in place/process (> $1B)
- PPA's in place/process
- Policy/regulatory reforms underway in 4 countries
- Links into regional organizations (APEC, ASEAN)
- 5 MOU's with industry/government
- High Value End-Use Studies
- Environmental/Utility Brochures

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US EXPORT COUNCIL FOR RENEWABLE ENERGY

Southern Africa Energy Overview

- Commitment to rural electrification
- Over 12 million unelectrified homes (50-75% in most countries)
- 10,000+ clinics, schools and larger loads

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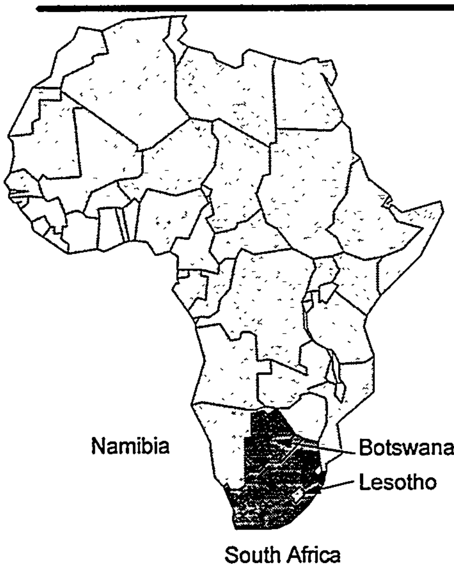
US EXPORT COUNCIL FOR RENEWABLE ENERGY

Southern Africa: Renewable Energy for African Development (REFAD)



Activities:
- Large-Scale Revolving Funds
- Industry Linkages
- Capacity Building

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US EXPORT COUNCIL FOR RENEWABLE ENERGY

REFAD: WHAT IS IT LEVERAGING?

	Namibia	South Africa
Number of Systems in Year 1 (PV-Houses)	150	2,000
Participant	Ministry of Mines and Energy	Renewable Energy Education for South Africa
Contribution	USAID-$32K Namibia-$76K	USAID-$900K South Africa-$2.2M
Project Start Date	December 1995	Spring 1997
Leveraging	Commitment to 1,000 Homes in Phase II	Seeking to Electrify 2M Homes

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US EXPORT COUNCIL FOR RENEWABLE ENERGY

Russia, Former Soviet Union: The Emerging Markets Initiative

Country Focus:
- Armenia
- Bulgaria
- Georgia
- Russia
- Ukraine

Activities:
- Trade Missio
- Financing Facilitation
- End-Use Sector Expansion
- Chernobyl Alternative

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US EXPORT COUNCIL FOR RENEWABLE ENERGY

EMI: WHAT IS IT LEVERAGING?

- Senior-level support for renewables in Russia/Georgia

- Over 40 project opportunities identified

- RE pilot program underway in Russia
- World Bank loan for Russia in process

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US EXPORT COUNCIL FOR RENEWABLE ENERGY

KEY UPCOMING EVENTS

- Russia/Ukraine/Georgia Trade Mission, April 21-May 2, 1997
- REIA'97 Conference and Exhibition, Rio de Janeiro, Brazil, July 8-11, 1997
- API Conference and Exhibition, Jakarta, Indonesia, October 14-16, 1997
- South Africa/Zimbabwe Trade Mission, August 3-9, 1997

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Mega-Cities

"Almost half of the world's population lives in cities, but by 2025, nearly two-thirds will be urban." Source: The Washington Post

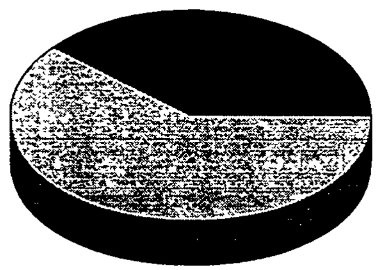
US EXPORT COUNCIL FOR RENEWABLE ENERGY

A Next Frontier for the Power Industry

Fraction of the World's Population

With and Without Electricity (In billions of people)

COUNTRY	NON-GRID ACCESS
Brazil	20% of population (36M)
Central America	55% of population (regional avg.)
China	Up to 50% of population (600M)
India	72,000 villages
Indonesia	36,000 villages
Mexico	Up to 140,000 villages
Peru	53% of households
Philippines	60% of population



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US EXPORT COUNCIL FOR RENEWABLE ENERGY

The Developing Country Opportunity

- Rapid LDC Energy Growth
- Reduced RE Technology / Systems Costs
- Reduced Trade Barriers
- Increased Credit/Financing Access
- Increased Role of Privatization
- Emerging RE Interest
- Growing Environmental Awareness
- Push for Sustainable Development

bd96.pre

NRECA's Electrification Model

- Historically, grid extension exclusively.
- Promotion of productive uses of electricity.
- Support of rural development programs.
- Construction standards, operational guidelines for distribution and sub-transmission systems.
- Distributed power systems.

NRECA - BOLIVIA

How do Renewables fit in?

- They didn't until just recently, other than micro hydro.
- We realized that most of our future clients could not be reached by the grid.
- We recognized that renewables were part of the solution, and had to be integrated.
- We tried to get smart on the technologies, but continue to focus on what we do best.

NRECA - BOLIVIA

Utility Management Assistance

- Have always worked with state utilities, private utilities, and cooperatives.
- The intention has been to provide both project management and management consultanting services.
- Training programs, management efficiency programs, cost of service studies, and sector reform assistance.
- Privatization has ALWAYS been a princi[ple]

NRECA - BOLIVIA

NRECA's Role in Village Power

- We have the expertise to make village systems work.
- We don't have all the technological expertise needed, and like to work with NREL, Sandia, and other technologically oriented partners.
- We specialize in forming, training, and supporting user-owned electric service companies.
- We are dedicated to using renewables in [the] future.

NRECA - BOLIVIA

Perspectives on Renewable Energy and Village Power

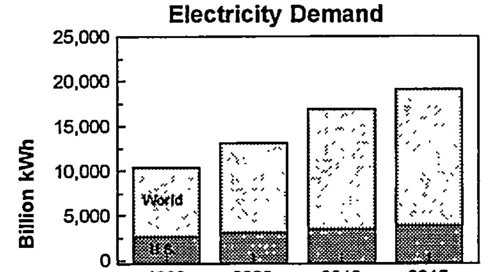
April 15, 1997

Dr. Allan R. Hoffman
Acting Deputy Assistant Secretary
Office of Utility Technologies

World Energy Situation

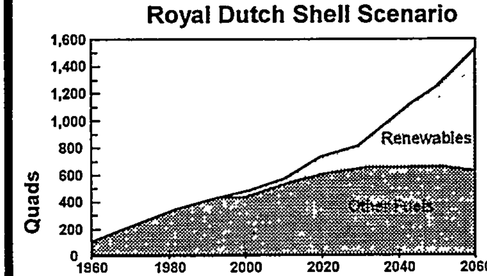
- **U.S. and World Electricity Demand**
  - Demand for electricity increasing rapidly while shortages become more frequent and more acute (China, India, Latin America)
- **Increasing Business Interest**
  - Over the next 30 – 40 years, developing countries alone will require 5 million MW of new generating capacity, corresponding to a market of $5–10 trillion.
- **Environmental Concerns**
  - Increasing climatological awareness heightens concern for environmentally-benign fuel choices
- **New Technologies**
  - New technology options are emerging (e.g., renewable energy, hydrogen, efficient gas turbines, etc.)
  - Only renewables are inherently suitable for situations with no supporting infrastructure

Electricity Demand



Source: EIA, International Energy Outlook, 1996, May 1996

Royal Dutch Shell Scenario



Renewables' Attributes Make Them Important Options for the Future

- Proven effectiveness and reliability
- Promotes self-sufficiency and local control over indigenous energy resources
- Expands human productivity
- Builds on local economic base, whatever the existing level
- Suitable for rural, off-grid, low-tech locations
- Fuel cost issues are minimal
- Environmentally responsible

Renewables Build Local Economies

- Two examples
  - Fairfield Energy Ventures - Maine
    Biomass gasifier power plant developer generates $1.7 million in wages and 140 jobs, $938,000 taxes paid, and $94 million added to local economy
  - Spirit Lake County School District - Iowa
    DOE grant and local funds establish wind turbine that generates surplus electricity, paying for turbine in 5 years, and then serving as a source of revenue

Overall Objectives of International Renewable Energy Activities

- Disseminate information on technologies and applications
- Increase renewable energy and efficiency technology marketshare
- Reduce greenhouse gas emissions
- Establish sustainable energy supplies and markets

Supporting International Activities

- Committee on Renewable Energy Commerce and Trade (CORECT)
- U.S. Initiative on Joint Implementation (USIJI)
- DOE/IEA Collaboration
- Greenhouse Gas Technology Information Exchange (GREENTIE)
- DOE/GEF (Global Environment Facility) Cooperation
- Support for World Bank's Asia Alternative Energy unit (ASTAE)
- Participation in Asia-Pacific Economic Cooperation (APEC) to promote energy efficiency and conservation

Support For U.S. Village Power Applications

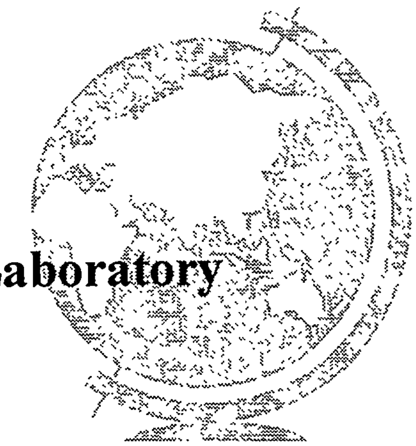
- Alaskan Village Power Wind Projects
  - $2 million for Kotzebue wind farm, 1 MW of added power
  - High penetration Project: 150 kW in village near Seward Peninsula
  - Sustainable Technology Energy Partnership (STEP) 150 kW wind turbine installation at Kotzebue
- Native American Projects

Support for International Village Power Applications

- Wind/PV Hybrid Systems - DOE/USAID collaboration
  - $4.8M for water pumping, lighting, village power and off-grid industrial uses
  - Xcalac (Mexico) ice making project
- South Africa
  - NREL contract with Spire Corp to support SA PV assembly plant,
  - 500 kW capacity, 1.5 MW with three shifts
- India
  - Ramakrishna Mission - PV demonstration
- Brazil
  - PV Electrification - Bahia, Ceara and Minas Gerais states

Experiences in Mainstreaming Alternative Energy

Anil Cabraal
Asia Alternative Energy Unit (ASTAE)
The World Bank
4/15/97



Village Power '97
National Renewable Energy Laboratory

Renewables and a Sustainable Energy Future

"There is clearly a limit to fossil fuel. [Fossil fuel] resources and supplies are likely to peak around 2030 before declining slowly. Far more important will be the contribution of alternative, renewable energy supplies."

Chris Fay
Chairman and CEO
Shell U.K. Ltd.

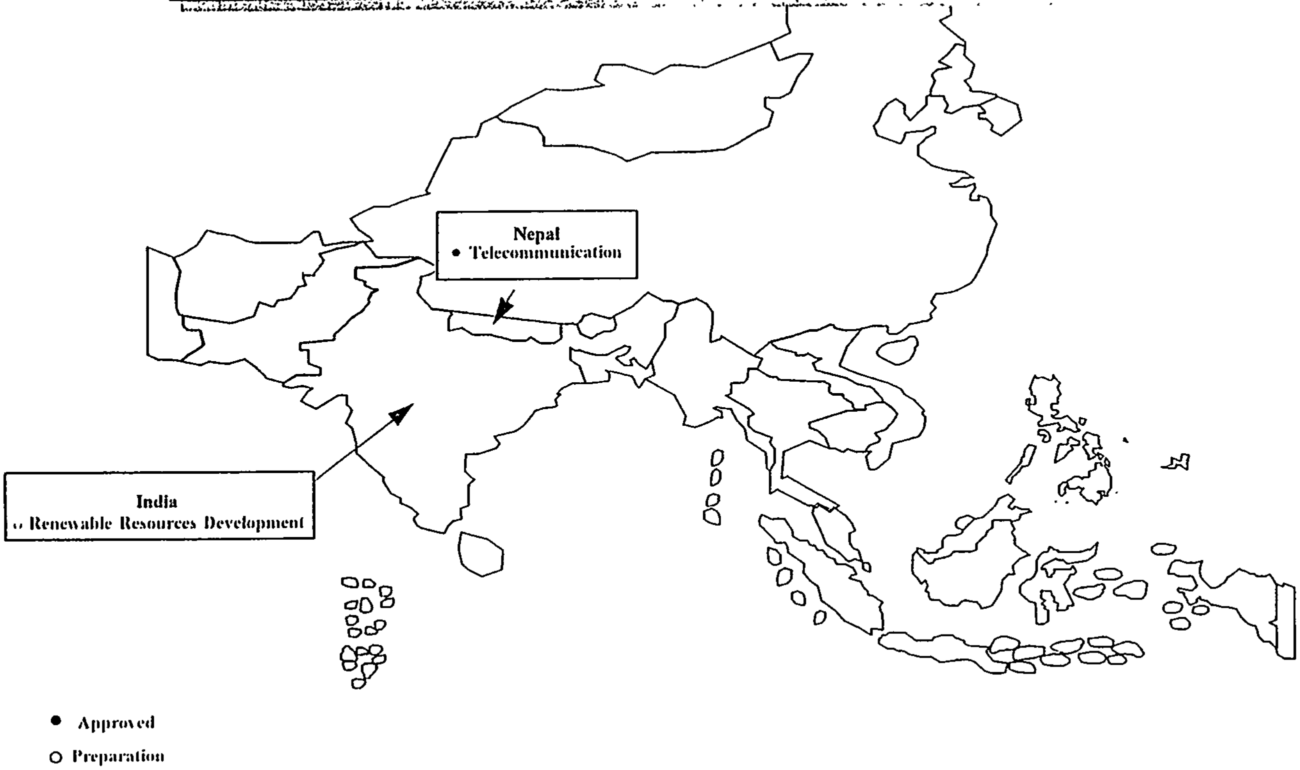
Overview

- Energy Background in Asia
- Asia Renewable Energy Portfolio - 1991
- From FINESSE to ASTAE
- Asia Alternative Energy Unit
- ASTAE Renewable Energy Goal and Strategy
- Asia Renewable Energy Project Portfolio

Energy Background in Asia

- Energy growth rate as high as 18% per annum
- Power generation capacity doubled every decade in the 1960's, 1970's and 1980's.
- Power sector investments: $600 billion/year
- Power sector energy supply mainly from fossil fuel and large hydro
- Asia will exceed OECD in CO_2 emissions by 2015
- Asia will exceed European SO_2 emission by 2000

Asia Renewable Energy Portfolio - 1991



ASTAE

From FINESSE to ASTAE

- FINESSE Program initiated in 1988 - World Bank, U.S. Department of Energy, Netherlands DGIS, UNDP
- Workshop in 1991 - Identified alternative energy opportunities in Malaysia, Indonesia, Thailand and the Philippines
- Set the stage for Bank, its borrowers and donors to mainstream alternative energy investments in Bank-assisted projects
- ASTAE established in January 1992

Asia Alternative Energy Unit (ASTAE)

- Pilot Program - Asia Technical Department
- Funded principally by the FINESSE donors
- Supported also by other donors on project/task-specific basis
- Small core staff of renewable energy and DSM specialists with support from consultants

ASTAE Renewable Energy Goal and Strategy

GOAL: MAINSTREAM RENEWABLE ENERGY IN WORLD BANK OPERATIONS

STRATEGY: WORK WITH COUNTRY MANAGERS AND TASK MANAGERS TO:

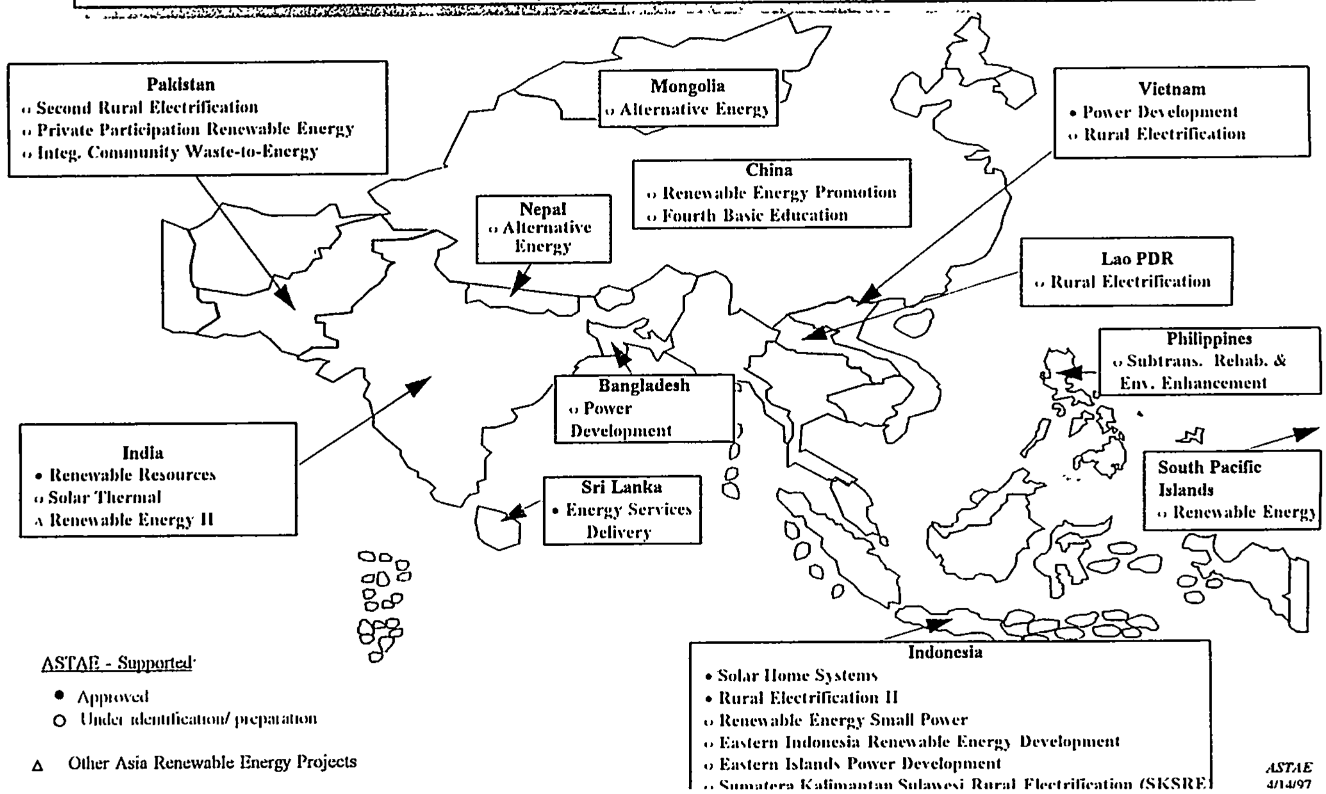
a) Include renewable energy in Country Assistance Strategies and Sectoral Development Plans

b) Provide assistance to renewable energy initiatives

c) Expand initiatives to new countries, sectors and technologies

Projects with Renewable Energy Components in Asia

- 21 Projects
- $700 million loan/credit/grant portfolio 1993-2000
- 500+ MW Capacity



Sustainable Markets for Sustainable Energy

Presented to
VILLAGE POWER '97
April 14 - 15, 1997
Arlington, VA
by

Jaime Millán and Connie Smyser
Inter-American Development Bank

IDB Bank Group

- Inter-American Development Bank
  - Regional Departments
  - Private Sector Department
- Inter-American Investment Corporation
- Multilateral Investment Fund

The IDB and Sustainable Energy

- Nearly 50 loans and grants for $600 million to non conventional renewable energy (NCRE)
- Ten loans and grants to efficiency for $17 million
- Renewable Energy: 96% of the capacity of generation financed by the Bank, if the large hydro is included
- Only 100 MW in NCRE, 40 MW wind power and 60 MW small hydro

Financing is the Solution, but what was the question?

- If only IADB could open its coffers...
- How critical is credit in overcoming barriers to sustainable energy?
- Building a sustainable market for energy efficiency and renewable energy

Our Challenges

- Can we create a sustainable market for sustainable energy?
- Where and how to intervine?
- To be humble enough to learn and to experiment.
- To find proper roles for government, private sector, NGOs, trading allies, credit, regulators.
- To develop programs adequate to the conditions of each country.
- To develop strategic partnerships

Partnership among Countries, Donors and the Bank: a Win-Win-Win.

- Countries must provide commitment.
- Donors must provide soft money
- Bank working with donors and countries develop sustainable programs that will feed projects to be financed by the Bank
- Developers can joint, but remember it must be win-win-win-win.

SMSE Vision and Objectives

- Vision: Mainstreaming sustainable energy via new and innovative delivery mechanisms appropriate to restructured and competitive energy markets
- Objective: Develop and test a strategy for the IDB to act as catalyst for establishing sustainable markets for sustainable energy

SMSE Strategy

- Provide assistance to 3-4 countries to identify, develop and implement promising sustainable energy projects that demonstrate the SMSE concept
- Work with project participants to develop a viable delivery mechanism, e.g., by:
  - Constructing action plans
  - Establishing the market feasibility of innovative pilot projects (including the selection of adequate delivery mechanisms and identifying and removing barriers)
  - Obtaining financing for the most promising pilot projects

SMSE Strategy (continued)

- Areas Targeted for Assistance
  - Energy Efficiency
  - Urban Transport Systems
  - Renewable (Clean) Energy
  - Infrastructure
- World Class Consultants in the Fields of:
  - Business Feasibility Assessment and Planning
  - Financial Packaging and Risk Mitigation
  - Energy and Transportation Markets
  - Institutional Trade, Regulatory & Tax Policies
  - Renewable Energy and Energy Efficient Technologies and Policies

Sponsors and Funding: Stage I

- IDB: $940K of which $250 in Mex Pesos
- European Commission: $267K
- US DOE: $250
- US AID: $120

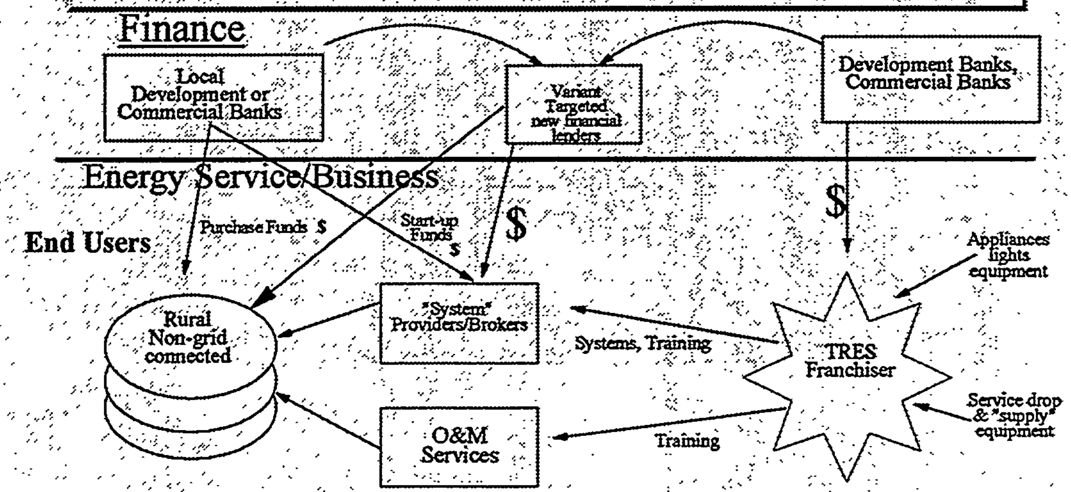
Timeline

- May/June, 1997: visits to candidates/develop SMSE ideas
- End of June: report to Board on selections
- July: make agreements and do contractual work; assemble teams, in country and external assistance, to develop SMSE action plans
- April-June, 1998: meetings with donors on Stage II requirements
- July-December: develop action plans

Innovative Delivery Mechanisms Could Improve Market Conditions by:

- Reducing Transaction Costs
- Stimulating Market Demand
- Improving Access to Markets
- Developing Enabling Policy Environment
- Overcoming known Market Barriers
- Promoting Competition among Service providers
- Helping to Allocate and Mitigate Risks
- Bringing Natural Partners Together

Market Niche
Total Rural Energy Services (TRES)



Total Rural Energy Services in Brazil

- Community systems focus
  - Social services - health, water supply, sanitation, education
- Clean, local resources
  - Renewables - hydro, biomass, wind, PV, as available
  - Diesel upgrades and hybrids
- Scale - up from 500 to 150,000 communities
- Transition from Treasury - financed to market - driven development

Questions for each DM

- What is the market at which delivery mechanism aimed? (e.g., rural, urban specific end use)
- Is the "natural" market regional or country specific fully competitive or partially competitive?
- How large is this market? How large is one such business in this market?
- Who would invest in this business and what returns would be needed?

Questions for Each DM (continued)

- Who/what are the competitors or alternatives in this market?
- What kind of entity (public, private) would be involved in implementing the DM?
- What is the likely timeframe for implementing this DM?
- What are the strengths and weaknesses of using this DM in this market? How to maximize first and minimize second?
- What financial tools are needed (e.g., leasing, guarantees, loans), and are they available to this DM?

THE UNITED NATIONS DEVELOPMENT PROGRAMME INITIATIVE FOR SUSTAINABLE ENERGY[1]

Dr. Suresh Hurry
Energy and Atmosphere Programme
Sustainable Energy and Environment Division (SEED)
United Nations Development Programme

SUMMARY

Energy is central to current concerns about sustainable human development, affecting economic and social development; economic growth, the local, national, regional, and global environment; the global climate; a host of social concerns, including poverty, population, health, and gender-related issues, the balance of payments, and the prospects for peace. Energy is *not* an end in itself, but rather the *means* to achieve the goals of sustainable human development.

The energy systems of most developing countries are in serious crisis involving insufficient levels of energy services, environmental degradation, inequity, poor technical and financial performance, and capital scarcity. Approximately 2.5 billion people in the developing countries have little access to commercial energy supplies. Yet the global demand for energy continues to grow: total primary energy is projected to grow from 378 exajoules (EJ) per year in 1990 to 571 EJ in 2020, and 832 EJ in 2050, with the developing-country share increasing from 34 percent in 1990 to 49 percent in 2020, and 60 percent in 2050. If this increase occurs using conventional approaches and energy sources, already serious local (e.g., indoor and urban air pollution), regional (eg., acidification and land degradation), and global (e.g., climate change) environmental problems will be critically aggravated. There is likely to be inadequate capital available for the needed investments in conventional energy sources (US$ 100 - 200 billion per year in developing countries), making the lack of available energy a barrier to development.

Similarly, development assistance is in crisis as well. The amount of available assistance is shrinking, even as a number of non-traditional country claimants are emerging. in 1994, net total official development assistance finance amounted to US$ 67.4 billion compared with US$ 74 billion in 1986 (based on 1993 constant dollars). Moreover, the conventional approach to development assistance, based on significant use of expatriates, is becoming increasingly more expensive. A new, more cost-effective approach to development assistance is needed.

Government spending on energy must also be re-assessed. Government subsidies for conventional energy technologies are approximately US$ 300 billion per year worldwide. In 1992,

[1] This is an excerpt from the *UNDP Initiative for Sustainable Energy*, published June 1996 by the Energy and Atmosphere Programme within the Sustainable Energy and Environment Division of UNDP.

subsidies in *developing countries* amounted to approximately $50 billion, more than official development assistance from all sources taking debt repayment into account.

Current approaches to energy are thus not sustainable and will, in fact, make energy a barrier to socio-economic development. What is needed now is a new approach in which energy becomes an instrument for sustainable development. The two major components of a sustainable energy strategy are 1) more efficient energy use, especially at the point of end-use, and 2) increased use of renewable sources of energy. Technologies now exist and/or are in advanced stages of development to support such a new path for energy development.

The UNDP Initiative for Sustainable Energy (UNISE) is designed to harness opportunities in these areas to build upon UNDP's existing energy activities to help move the world toward a more sustainable energy strategy by helping programme countries.

The activities to promote sustainable energy strategies include:

- mobilizing support for indigenous capacity building, so that countries can identify and make use of new approaches and technological opportunities as well as train entrepreneurs and implement new financing/credit modes;

- encouraging countries to create a supportive legal, institutional, and regulatory climate for sustainable energy development, including an investment climate that will attract private capital;

- contributing to a leapfrogging strategy through innovative demonstration projects and through promoting the rapid development and dissemination of key technologies for sustainable energy development;

- supporting the formulation and implementation of national energy action programmes linking measures related to energy to goals in areas (poverty, jobs, environment, women) affected by energy system developments;

UNDP already provides substantial technical assistance in the field of energy. In the last two decades, UNDP has committed more that $400 million to more than 900 projects in Africa, the Asia/Pacific region, Latin America, the Arab States, and Eastern Europe. Many lessons have been learned from this experience. UNISE draws on these lessons and orients UNDP's energy funding toward energy activities that contribute to long-term sustainable development by taking advantage of the opportunities provided by new technologies and approaches. Energy can become an instrument for meeting all of UNDP's primary objectives - poverty elimination, employment creation (with increasing labour productivity), the advancement of women, and environmental regeneration.

The UNISE builds on UNDP's proven strengths, its experience in supporting indigenous capacity building, its considerable convening power, its respectability and credibility, and its decentralized structure. These characteristics make UNDP an effective agent for sustainable energy strategies. However, UNDP cannot fund the needed activities alone. Rather, it must collaborate with governments, the private sector, other UN agencies, and non-governmental organizations.

Through UNISE, UNDP can play a catalytic role among donors and host countries. It can make energy a priority within its own funding, leverage additional funding from other sources, and provide crucial pre-investment assistance in channelling appropriate proposals to other sources.

A Unique Opportunity

The current situation offers UNDP a unique opportunity to undertake actions that can effectively help alter the energy path on which much of the world is headed. The actual or near availability of new energy technologies offers the prospect of low-cost, localised solutions to national energy concerns. At the same time, system-level changes in UNDP's funding and programming -- the so-called "successor arrangement" -- make a whole new approach to energy possible. This new approach -- incorporated in the UNDP Initiative for Sustainable Energy -- makes energy an instrument for achieving UNDP's central goal of promoting sustainable human development.

Postscript by Jerome Weingart

At *Village Power 97* copies of the executive summary of the 1996 UNDP report *Energy After Rio - Prospects and Challenges* were made available by Dr. Hurry to all participants. Additional copies of the executive summary and of the full 176-page report are available from UNDP. This is an outstanding and authoritative report, with major contributions by twenty-two international experts in the areas of energy, environment, and development. It is highly recommended to the international village power community. The conveners of VP97 are grateful to Dr. Hurry and to UNDP for these materials.

For further information about the UNISE and related matters, including copies of relevant documents, please contact:

Energy and Atmosphere Programme
Sustainable Energy and Environment Division (SEED)
United Nations Development Programme
212-906-5148 (fax)
212-906-5030 (phone)

The International Finance Corporation and Financing of Sustainable Energy

The International Finance Corporation (IFC), a member of the World Bank Group, is the largest multilateral source of loan and equity financing for private sector projects in the developing world. IFC participates in an investment only when it can make a special contribution that complements the role of market operators. Since its founding 40 years ago, IFC has provided more than $18.8 billion in financing for 1,706 companies in developing countries. Its share capital is provided by its 170 member countries, which collectively determine its policies and activities. Strong shareholder support and a substantial paid-in capital base have allowed IFC to raise funds for its lending activities through its triple-A rated bond issues in international financial markets.

IFC created an Infrastructure Department in 1992 in response to the growing demand for its services in this area. During fiscal 1996 IFC approved 33 projects for new investments of $715 million of which 27% were in the power sector. In recognition of the continuing demand growth for private power investments an expanded Power Department has been formed to handle IFC's investments in electric power generation projects using renewable resources such as: run-of-the-river hydro, geothermal, biomass cogeneration, wind energy, and solar (photovoltaic, solar thermal, etc.), as well as conventional thermal generation projects, transmission and distribution projects, and energy efficiency investments.

IFC has recently financed hydro projects in Belize (25 MW), Chile (450 MW and 80 MW), Costa Rica (11 MW), and Guatemala (11 MW), as well as a biomass cogeneration plant in Guatemala (70 MW). Geothermal plants have been funded in Guatemala (30 MW) or are under review in Indonesia, Nicaragua, and Vietnam. Wind power projects are under review in Argentina, Chile, China, Costa Rica, Egypt, Guatemala, Honduras, Mexico, Morocco, Ukraine, and Uruguay. Biomass or PV projects have been considered in Belize, Brazil, Colombia, Costa Rica, India, Jamaica, Malaysia and the Philippines. IFC has also invested in PV manufacturing in China and is considering an investment in Mongolia. IFC has funded a number of supply side efficiency investments with private electric distribution companies or invested in energy efficiency equipment manufacture in Argentina, India, and Poland. IFC is also considering its first direct investments with energy service companies (ESCOs) and has recently concluded a corporate investment strategy for energy efficiency.

IFC has made the environment one of its most urgent priorities and is actively involved, through the World Bank, in the development of strategies for mobilization of private capital and technologies through the Global Environment Facility (GEF). As part of these efforts, and in relation to its power investments, the Environmental Projects Unit in IFC's Technical and Environment Department is actively seeking to expand the Corporation's involvement in renewable energy and energy efficiency investments. Among the operations underway are: a $150-210 million Renewable Energy and Energy Efficiency Fund (REEF), being developed in partnership with the Power Department, which has a $20-30 million GEF co-financing arrangement; the $30 million GEF-funded Photovoltaic Market Transformation Initiative (PVMTI) which will be implemented in India, Kenya and Morocco; the $5 million Poland Efficient Lighting Project (PELP); a $5 million Hungary Energy Efficiency Co-financing Program;

and a $20 million Small and Medium-Scale Enterprise (SME) Program that can support smaller scale ventures in sustainable energy through financial intermediaries (FIs). IFC is also participating with the Bank and a number of U.S. foundations in efforts to mobilize up to $50 million in capital for a proposed Solar Development Corporation which could make business advisory, training and market development services available to solar entrepreneurs as well as financing.

IFC/GEF RENEWABLE ENERGY AND ENERGY EFFICIENCY FUND

Overview

The International Finance Corporation (IFC) is contemplating the establishment of a Renewable Energy and Energy Efficiency Fund (REEF) as the first global fund dedicated to investing in these sectors in developing countries. The fund is expected to pursue the following types of private sector-sponsored investments:

- grid-connected power projects using wind, biomass, small hydro, geothermal, solar and other RE resources, as well as "inside-the-fence" RE power projects supplying a host industrial or commercial concern;
- projects and companies supplying solar home systems, small central stations and other "distributed" RE applications in off-grid communities;
- energy service companies (ESCOs) and end users themselves undertaking EE investments in such areas as industry, buildings, public lighting, and district heating; and
- in select cases, local manufacturers of RE/EE equipment and local financial intermediaries (FIs) focusing on the RE/EE sectors.

A recent IFC feasibility study, funded by the governments of France, Germany, the Netherlands, Norway and the United States, confirmed that a large pipeline of on-grid RE projects has emerged, and that there is also growing activity in the off-grid RE and EE sectors in many countries. Since they offer direct alternatives to the combustion of fossil fuels, the major source of greenhouse gas (GHG) emissions, the commercial expansion of these sectors is critical to advancing global climate change mitigation objectives, and considerable public sector support is available. At the same time, RE and EE projects face many challenges, given their generally small size, market unfamiliarity and other constraints.

Proposed Structure and Objectives

The Fund will focus primarily on RE/EE projects or project portfolios of US$5 to US$50 million, which account for the bulk of the investment opportunity in the target sectors. The Fund will also seek to invest an indicative 20-30% of its resources in even smaller projects on a selective basis and with special support from the Global Environment Facility (GEF).

It is expected that the Fund will be comprised of two investment vehicles, operating side-by-side and managed by a single management team: (a) a closed-end equity fund with a term of up to 10 years, capitalized with $75-100 million in equity commitments; and (b) a parallel debt facility of similar size, to be used to extend senior and mezzanine loans to investee companies. IFC is presently in advanced discussions concerning the management of the Fund with a consortium of firms with extensive fund management and commercial lending experience.

The proposed Fund structure seeks to address the primary financing needs of high quality projects in these sectors, while providing a competitive rate of return to its investors. On-grid RE projects are typically being financed with a higher percentage of equity capital than conventional power projects, giving rise to numerous investment opportunities for a specialized fund. However, long-term senior debt is the scarcest resource, as it is for most private infrastructure projects in non-OECD countries. The Fund's ability to provide some of this debt directly would help attract other lenders, strengthen its ability to secure equity investment opportunities, and maximize equity returns at the project level.

Debt is expected to play an even more important role in many EE and off-grid RE investments. While some sponsors intend to develop large balance sheets (e.g., through ownership of assets installed for clients) or are the end users themselves, many are energy service companies and/or equipment vendors. They must be adequately capitalized to meet working capital needs, giving rise to venture capital opportunities, but their principal need is for highly leveraged medium or long-term debt or lease financing for their clients, a requirement best addressed with debt funding.

GEF Support

At its April 1996 meeting, the GEF Council approved in principle the allocation of up to $30 million in GEF funds to support the Fund's activities. This support is intended to help broaden the Fund's scope of investment, enabling it to consider opportunities that are not receiving focused attention from international investment funds, such as smaller or more complex, leading-edge projects with proportionately higher transaction costs.

Some of the GEF funding will be provided directly to the Fund's management team to offset its additional costs in making and managing such investments, while the bulk of the funding will be channeled directly into projects in which the Fund also invests. The GEF co-financing will be provided in both grant and non-grant forms (loans, guarantees and equity instruments). The GEF funds will be administered by a joint IFC-World Bank Committee.

The Fund will also measure, monitor and report on the GHG reduction impact of the GEF-supported projects in its portfolio, both to contribute to the knowledge base on the climate change benefits of RE/EE projects, and to position the fund for participation in a potential future market for carbon offset credits.

Market Overview

The feasibility study confirmed that rapid growth in energy demand in many non-OECD countries, the opening up of energy sectors, price reforms, budget tightening and other factors are creating significant opportunities for competitive RE and EE projects and businesses. The study developed an indicative pipeline of approximately 100 investment opportunities totaling over $2 billion.

The largest and most advanced market segment consists of **grid-connected RE projects** seeking to sell power to electric utilities or large end users under long-term power purchase agreements. The fastest growth has been in India and Central America, but projects are being pursued by a variety of qualified sponsors in many other markets, and overall investment potential is estimated at $3-5 billion over the next 5 years.

Most on-grid RE projects are in the 5-30 MW range, with costs typically in the range of $1-2 million per MW. Their advantages include: (i) their use of local energy resource, offering a more decentralized approach to capacity development; (ii) their modularity and small scale that allow for more rapid development and replication; and (iii) their cost-competitiveness on a life-cycle basis (higher capital costs but lower operating costs than fossil fuel plants) and ability to generate strong operating cash flows with suitable long-term financing.

Off-grid RE businesses target the potential mass market of households, enterprises and communities in regions unlikely to be served by the grid in the foreseeable future. The two major sub-sectors are (a) small power plants, generally in the 50 kW to 5 MW range, with project sponsors typically seeking to develop a series of such projects with varying degrees of local private or community ownership; and (b) commercial deployment of solar home systems, typically costing several hundreds or thousands of dollars each. Most of the sales have been on a cash basis to higher-income clients in leading markets such as India, Indonesia, Kenya, Mexico and Brazil, but there is growing evidence that lower-income consumers are also willing and able to pay when suitable after-sale service and medium-term financing are in place.

EE investment opportunities are being pursued both directly by end users and by multinational and local investment equipment suppliers and ESCOs. The market study conservatively estimates the five-year investment potential at $2 billion, against a technical potential typically measured in the hundreds of billions of dollars. Central Europe and India are leading EE markets today, but considerable sector development work is taking place in most developing regions.

Many EE projects offer paybacks in the range of one to five years, often using simple and well-proven technologies, such as meters and controls, efficient industrial motors, furnaces boilers, lighting and appliances. However, EE financing is a specialized and relatively complex area. Since EE projects generate returns through energy cost savings as opposed to incremental revenues, ESCOs often seek to overcome client reticence by providing or arranging up to 100% "performance-based" debt or lease financing, to be repaid from properly documented energy savings. In addition, while large EE projects can be found in the industrial and power supply sectors, much of the opportunity lies in the development and financing of smaller projects (e.g., $100,000 to $3 million) on a portfolio basis.

GEF SMALL GRANTS PROGRAMME

OVERVIEW

Purpose

To enhance the role and contribution of households and communities to conserving global biodiversity, mitigating global climate change, and protecting international waters.

- Catalytic role
- Opportunistic
- Piloting innovative approaches

Objectives

(1) To enhance the capacity of selected households and communities to address local environmental and livelihood needs in the GEF areas of concern;

(2) To expand the impacts of community-level interventions supported by the programme through replication, scaling-up and policy advocacy; and

(3) To set GEF/SGP country programmes on a path toward long-term institutional sustainability.

GEF SMALL GRANTS PROGRAMME

STRATEGIC FRAMEWORK

**GEF OPERATIONAL STRATEGY/
OPERATIONAL PROGRAMMES**

↕

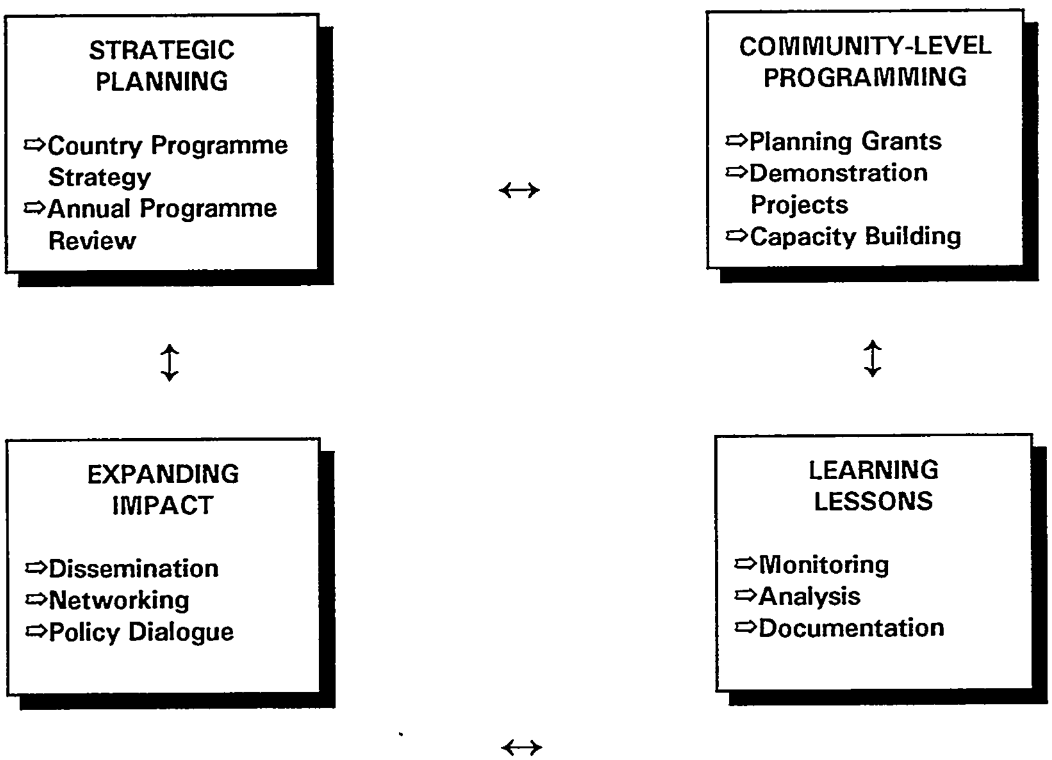
GEF/SGP GLOBAL STRATEGY

↕

COUNTRY PROGRAMME STRATEGY

GEF SMALL GRANTS PROGRAMME

PROGRAMME METHODOLOGY



GEF SMALL GRANTS PROGRAMME

IMPLEMENTATION

- ❑ Pilot Phase completed; currently in 2-year cycle of longer-term operational phase (thru June '98)
- ❑ Grants of up to US$50,000 (micro-credit?)
- ❑ Decentralized

    National Coordinator based at UNDP Country Office or "host" NGO

    National Steering Committee

- ❑ Currently operating in 33 countries and extending the programme to 12 new countries

GEF SMALL GRANTS PROGRAMME

IMPLEMENTATION

AFRICA		
Botswana	Ghana	Mauritius
Burkina Faso	Kenya	Senegal
Cameroon	Mali	Zimbabwe
Cote d'Ivoire		
ARAB STATES		
Egypt	Tunisia	Jordan
ASIA AND PACIFIC		
India	Pakistan	Sri Lanka
Indonesia	Papua New Guinea	Thailand
Nepal	Philippines	
EUROPE		
Poland	Turkey	
LATIN AMERICA AND THE CARIBBEAN		
Barbados	Chile	Ecuador
Belize	Costa Rica	Mexico
Bolivia	Dominican Republic	Trinidad and Tobago
Brazil		
NEW COUNTRIES		
Albania	Kazakstan	Peru
Bhutan	Laos	Tanzania
Cambodia	Malaysia	Uganda
Guatemala	Morocco	Vietnam

GEF SMALL GRANTS PROGRAMME

CLIMATE CHANGE STRATEGY

Objective

- ❑ To build local capacity to support low-carbon energy development in order to meet the energy and sustainable livelihood needs of rural households and communities.

Focus

- ❑ Supporting community-level initiatives which address key local barriers to the adoption, sustainable use and diffusion of renewable energy technologies.
- ❑ Programme activities will target primarily rural, unelectrified households and communities without ready access to the central power grid in the foreseeable future.
- ❑ Forging partnerships (NGOs, local governments, RESCOs, private sector, etc.)

GEF SMALL GRANTS PROGRAMME

CLIMATE CHANGE STRATEGY

Core Activity Areas

- ❑ Supporting community-level energy assessments and planning.

- ❑ Building local institutional capacity for supporting and promoting energy efficiency and renewable energy services.

  - Awareness
  - Access to information
  - Innovative financing
  - Innovative institutional arrangements

- ❑ Demonstrating and promoting household and community-level applications of energy efficienct and renewable energy technologies.

  - Biomass fuels
  - Mini-hydro
  - Small-scale wind
  - Solar PV

- ❑ Monitoring, analysis, and documentation of experience.

  - Project monitoring
  - Case study analysis
  - Video

- ❑ Promoting an enabling environment for low-carbon renewable energy applications (networking, policy dialogue).

  - Networking
  - Policy dialogue/advocacy

Winrock International

THE INTERNATIONAL REPSO NETWORK

Winrock International, with sponsorship from the Center for Environment of the U.S. Agency for International Development (USAID) and the U.S. Export Council for Renewable Energy (US/ECRE), is building a global network of non-governmental organizations to help catalyze the use of renewable energy technologies for rural energy supply in developing countries. Known as the Renewable Energy Project Support Offices (REPSOs)[1], these -in-country facilities are managed by local institutions in coordination with Winrock. REPSOs provide an array of technical and financial support services to help developers identify and evaluate opportunities for renewable energy projects.

The REPSO

The REPSO is an effective vehicle for matching the global interests of the renewable energy industry with the specific needs of the numerous rural populations, most living without electricity services, in the developing world. Winrock establishes a REPSO by collaborating with a local institution that is well positioned in the energy community, to gather vital information and to identify project opportunities. The REPSO functions as a window for local project developers to commercially-proven technologies and services, and as a window for U.S. industry to local opportunities and expertise.

The Network

Collectively the REPSOs form an international network that will act as a medium for the critical exchange of ideas and information, helping to promote an alliance between the growing community of renewable energy uses and their suppliers in a common pursuit of harnessing proven technologies for sustainable energy development.

Brazil: Launched in Spring 1996, the Brazil REPSO has focused on providing preinvestment support to renewable energy projects and in channeling World Bank lending to renewable energy projects and programs. The Brazil REPSO - located in Salvador, Bahia - focuses on the north-eastern region, where cyclical drought and migration are coupled with natural renewable energy resource such as plentiful sunlight and wind. The REPSO works in concert with local NGOs, ABEER - the renewable energy trade association for Brazil, state utilities, the Brazilian Ministry of Mines and Energy, the Ministry of Science and Technology, CEPEL, ELECTROBRAS, and other entities.

[1] In Indonesia this office is referred to as the Renewable Energy Network Indonesia, or RENI.

Central America: In 1993 the *Fundacion Solar* was established as a non-profit organization in Guatemala to implement the REPSO program in Central America. The following year the REPSO/Fundacion Solar conducted its first round of renewable energy project identification and assistance for preinvestment studies - identifying a total of 103 MWe in capacity. Each of these projects was evaluated based on its environmental, technical, and financial merits, and preinvestment assistance was offered to projects totaling 32.7 MWe incapacity. The REPSO is active both in larger projects that have a potential for grid connection and in village-level electrification and illumination projects. The REPSO/Fundacion Solar is staffed by twenty experts in engineering,participatory development, law, architecture, and other fields that are dedicated to Central American development through the medium of renewable energy and rural electrification.

India: The REPSO in New Delhi, India aims to support the commercialization of renewable energy technologies through building local capacity and by the transfer of commercially-ready technologies. The staff of the REPSO has worked both within the Indian Government and in the private sector on renewable energy projects and initiatives. They are currently managing the three-year Renewable Energy Commercialization (RECOMM) project funded by USAID/India. This program is designed to build successful models in the private sector that demonstrate commercial applications of renewable energy, while improving access to financing and capital, and facilitating renewable energy partnerships. The project includes a sugar cane cogeneration program, rural PV commercialization, an emerging technologies program and a financial advisory services program.

Indonesia: Located in a country with a diverse potential in renewable energy and the world's fourth largest population, the Indonesia REPSO is knows as the Renewable Energy Network Indonesia (RENI). RENI is managed by the Indonesian NGO Yayasan Bina Ushaha Lingkungan (YBUL). YBUL's strength lies in its established track record of financial analysis and sourcing and assistance for commercially successful renewable energy and environmental projects. The staff of YBUL draws from backgrounds in private sector banking, renewable energy research, energy development, and environmental and biodiversity project management.

Philippines: In the Philippines Winrock has helped to launch Preferred Energy, Inc. (PEI), a non-profit organization whose objective is to stimulate private sector investments in renewable energy projects in the Philippines. PEI aims to reduce technical, financial,and institutional risks associated with small-scale renewable energy development by providing both financing and technical advisory services to private individuals and organizations interested in setting up renewable energy businesses. PEI manages a capita investment fund that can be used for debt or equity financing. To stimulate investments and private sector interest in renewable energy, PEI carries out activities geared toward creating a pipeline of renewable energy projects.

For further information on REPSO initiatives in Brazil, Central America, Indonesia, India, or the Philippines, contact:

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Appendix A

Agenda

VILLAGE POWER '97

April 14-15, 1997

The Ellipse Conference Center at Ballston
National Rural Electric Cooperative Association
National Renewable Energy Laboratory4301 Wilson Blvd.
Arlington, VA 22203

AGENDA

Monday, April 14

09:00 - 10:00 Registration (coffee/tea/beverages will be available)

10:00 - 10:15 **Welcome and Introduction** (Larry Flowers - NREL)

10:15 - 12:30 **Village Applications - I (Larry Flowers, chair)**
- Schools (Tom Lawand - Brace Research Institute)
- Health Clinics (Reinhold Viljoen - Independent Development Trust/South Africa)
- Clean Water Supply (Robert Foster - SouthWest Technology Institute)
- Battery Charging Stations (Silver Navarro - Solar ElectricCo, Philippines)

12:30 - 13:30 **Buffet Lunch**

13:30 - 14:30 **Village Applications - II (Larry Flowers, chair)**
- Lighting (Art Lilley - Community Power Corporation)
- Village Microgrids - the Chilean Project
- Renewable Energy-Powered Microenterprise Zones (Richard Hansen - ENERSOL)

14:30 - 17:00 **Village Electrification Options (Roger Taylor, chair)**
- PV Lighting (Neville Williams - SELF/SELCO)
- Battery Charging Stations (Mike Bergey - Bergey WindPower)
- Diesel/Hybrid Minigrids (Bruce Levy)
- Biomass Hybrid Systems (Gary Elliot)
- Village Diesel Power Station Retrofits (Peter Lilienthal)
- Village Options Modelling (Peter Lilienthal)

Tuesday, April 15

08:00 - 08:30 Registration, coffee/tea/beverages

08:30 - 09:30 **Country Activities - Asia (Griff Thompson, chair)**
- China (Roger Taylor)
- India (NREL)
- Indonesia (Steve Drouilhet)

- Philippines (Larry Flowers)
- Thailand (Mike Bergey)

09:30 - 10:30 **Country Activities - Latin America (Mark Lambrides, chair)**
- Argentina (Peter Lilienthal)
- Bolivia (Pete Smith)
- Brazil (Roger Taylor)
- Chile (Larry Flowers)
- Dominican Republic (Bruno Viani - Winrock International)
- Mexico (Charles Hanley - Sandia National Laboratories)

10:30 - 12:30 **Institutional Approaches (Doug Arent, chair)**
- World Bank - Solar Development Corporation (Christine Eibs Singer - E&Co)
- Grameeen Bank - Dipal Barua
- Models for Off-grid Energy Services Delivery (Ernie Terrado - World Bank)
- World Bank (Arun Sanghvi) Indonesia PV Project
- Private Utility Enterprises
- Private Sector Off-grid Initiatives (Grace Yeneza - PEI Philippines)
- Cooperatives (Dan Waddle - NRECA)
- NGOs - Todd Bartholf

12:30 - 14:00 Catered Lunch (Richard Stern - World bank: luncheon speaker)

14:00 - 15:00 **Country Activities - Other (US/ECRE - chair)**
- Alaska (Steve Drouilhet)
- Russia (Ken Touryan)
- Ghana (Jerome Weingart - UNDP/GEF)
- South Africa (Doug Arent)
- Vietnam (Solar Electric Light Fund)
- Bangladesh (Grameen Bank)

15:00 - 16:00 **Institutional Perspectives (Allan Hoffman, chair)**
- USAID
- U.S. Department of Energy (Allan Hoffman)
- Climate Action Perspectives (Ron Benioff)
- British ODA (David Woolnough)
- Industry - U.S. Export Council for Renewable Energy
- NRECA (Dan Waddle)

16:00 - 17:30 **Institutional Perspectives (Jerome Weingart, chair)**
- InterAmerican Development Bank (Jaime Millan/Connie Smyser)
- UNDP/SEED (Suresh Hurry)
- UNDP/GEF NGO Small Grants Programme
- NGOs (Winrock International)
- Industry - Bruce Levy

* * *

17:30 - 20:00

Reception (buffet, cash bar) and

NREL VILLAGE POWER ACTIVITIES POSTER SESSION

* * *

Appendix B

Project Briefs - NREL Village Power

Renewables For Sustainable Village Power (RSVP) Web Site

by Julie Cardinal 3/97

Background

The Renewables For Sustainable Village Power (RSVP) web site provides information to assist in the implementation of renewable energy solutions for rural electrification programs in developing countries. The RSVP web site has several components including a project database, a library database, a discussion forum, introduction to analytic models, a roundtable of contacts, information on issues in village power, and links to Internet resources that offer a wide array of information to users.

- The RSVP Database provides information on more than 160 international village power projects from over 30 countries. Projects are indexed by technology (wind, photovoltaic, biomass and microhydro) and village applications. Each project entry contains information on the economic, financial, institutional, and technical aspects; host country, project partici pants, and lessons learned during the project are also included.
- The libraries database includes those of the National Rural Electric Cooperative Association (NRECA) and the NREL Hybrid Library as well as links to libraries on the Internet.
- A discussion forum provides a platform for sharing experiences and opinions related to village power topics through e-mail. Topics include announcements of new village power services, requests for information, requests for proposals, Internet resources, opportunities, networking, updates on NREL's Village Power program, new technologies, social and cultural issues in village power, economics and financing of village power, and working with cooperatives. Past discussions can be viewed on the site's archives link.

Scope

The RSVP web site covers a wide range of interests to provide useful and up-to-date information to a wide variety of village power stakeholders. It also helps to identify and establish working relationships to further village power projects around the world. It is available to all village power stakeholders, private and public. Certain components such as the project index and discussion forum are only available upon access request (see contact).

Results

- An average of 250 users access RSVP's home page monthly.
- One hundred and thirty people participate in the discussion forum throughout the year.
- An average of 30 specific requests are completed every month.
- RSVP has 60 international working relationships that help to keep the database current and productively useful to its users.

Planned Events (1997)

The primary goal is to expand and operate the database. It is currently being converted into a Microsoft Access database that will give users better access through the WWW. We plan to have the entire database converted into Access by July 1, 1997. A particular, but not exclusive near-term emphasis is to expand the Asian section of the project database in anticipation of the Asia Pacific Initiation.

NREL Contact

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PROJECT BRIEF

Argentina: Concession for Rural Electrification Services

by Peter Lilienthal 3/97

Background

Argentina is in the process of privatizing its electric power sector on a province-by-province basis. This is proceeding on two tracks: grid connected service and off-grid service. The Secretaria de Energia, in collaboration with provincial authorities, has identified the maximum reasonable extension of the grid for the near future. All areas outside of that region will be eligible for regulated non-grid connected service. The concession to provide this service as a regulated monopoly will be allocated through a competitive auction. Many of the details will differ in each province, but a consistent part of the program will be a maximum tariff that the private company can charge. Two auctions occurred in 1996 and a third is occurring this year that will serve as a pilot program for a nationwide program funded by the World Bank.

Scope

The National Renewable Energy Laboratory (NREL) has provided technical assistance to the concessions program in the design of the subsidy and tariff structure and in estimating the costs of the program. The subsidy and tariff structure must provide the concessionaire with a revenue stream sufficient to maintain a sustainable operation, while providing the end-users with appropriate incentives for efficient use of the electricity. These two features are often absent in rural electrification programs and result in substantial burdens to the government and constrain the expansion of rural electrification services. NREL, with assistance from NRECA-Bolivia, reviewed the Secretaria de Energia's estimates of the expected costs of a business supplying solar home systems and made recommendations both about the estimated costs and the methodology for calculating the sustainability of the enterprise as a function of its scale of operation. NREL also provided information on the costs and applicability of hybrid powered collective mini-grid systems. Additional technical assistance was provided in the design of systems for the electrification of rural schools.

Results to Date

A methodology was developed that identified the cost of service and the required tariff and subsidy as a function of the number of customers for different business plan scenarios. This methodology can be easily adapted to different regions where the business costs and infrastructure requirements may be different. The methodology has been applied to the two provinces (Salta and Jujuy) for which concessions have already been granted and will be applied to additional provinces as the concessions program proceeds. Wind resource mapping has also been performed for the concession's third province, La Rioja.

Planned Activities (1997)

NREL will continue to assist in the development and application of the tariff methodology for additional provinces. A possible additional activity is the generalization of the methodology for more widespread use wherever renewable energy is being considered for rural electrification. Additional wind resource maps will be created for provinces in the concession program.

NREL Contact

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PROJECT BRIEF

NREL Wind Technical Assistance to Mexico Renewable Energy Program

by David Corbus 3/97

Background and Scope

The Mexico Renewable Energy Program facilitates the use of renewable energy, primarily PV and wind, in rural, off-grid, productive-use applications. This program is co-sponsored by DOE and USAID and managed by Sandia National Laboratories, with NREL providing technical assistance for wind projects. The project approach emphasizes sustainability and the development of in-country institutional capacity.

Program goals are to expand markets for U.S. industry by increasing the appropriate and sustainable use of renewable energy technologies and to increase the use of renewable energy technologies as a mechanism for combating global climate change, especially greenhouse gas emissions.

The program team is working with established Mexican organizations and within established and funded programs to incorporate the use of renewable energy technologies where they are the best technical and economic solution. The team provides training and technical assistance and uses the implementation of pilot projects as a tool to institutionalize the use of renewable energy technologies.

More than 50 PV projects and several wind projects have been installed to date, including a 10 kW wind-diesel system for an ecotourism resort. Significant near-term replication of these projects is under way with the Fideicomiso de Riesgo Compartido (FIRCO—a federal shared-risk trust fund under Mexico's agriculture department), the major program partner. FIRCO is working to implement one of Mexico's largest agricultural development programs, and Sandia and NREL are providing technical assistance as FIRCO begins to install hundreds of renewable projects (mostly water pumping projects).

The Mexico Program is divided into specific program areas and cross-cutting activities. These areas include working with FIRCO at both the state and national levels, along with state-agency activities in several states, including Chihuahua, Sonora, Baja California Sur, Quintana Roo, Oaxaca, Veracruz, and others. In addition, cooperative projects are underway with Conservation International, The Nature Conservancy, World Wildlife Fund, and their local Mexican partner organizations to incorporate the use of renewable energy into ongoing protected-areas management activities in Mexico. Cross-cutting activities include solar and wind resource assessment, training, technical and economic analysis, financing mechanisms, industry interactions, project monitoring and evaluation, and environmental assessments.

Approach emphasizes sustainability and infrastructure

- Work with established Mexican organizations
- Work within established and funded programs
- Provide training in technologies, applications, project implementation
- Provide technical assistance and cost-shared funding for pilot projects

Emphasis is on productive uses

- Provide economic and/or social benefits
- High degree of sustainability and replicability because they provide a mechanism for paying for renewable energy systems

- Can compete with subsidized renewable energy programs in Mexico
- Examples: water pumping for livestock or crop irrigation, lighting for commercial or business activities, ecotourism

NREL Activities

Purpose of Work. Assist in site identification and provide technical assistance to wind projects.

Oaxaca Workshop and 1.5 kW Turbine Installation. Participation in Mexico/AID Renewable Energy Workshop held in Oaxaca in August of 1996. In addition to presenting material on wind water pumping and hybrid system design, NREL trained others in the installation of the 1.5 kW wind water pumping system.

10 kW Costa de Cocos Wind-diesel Installation. This work consisted of prefeasibility and economic analysis, preliminary design, preparation of bid specification, evaluation of bids, coordination between vendor and owner on project implementation, participation in project implementation, and follow up evaluation of project including analysis of monitoring data.

San Juanico Analysis. Working closely with Arizona Public Service (APS), NREL has done extensive economic and performance modeling of a proposed hybrid system for the village of San Juanico. Work has included the following: tariff structure definition; ability to pay assessment; loads analysis; site visits and dialogue with villagers; preliminary design trade-off studies based on CFE and APS cost requirements; extensive meetings with APS and CFE and related parties; time series modeling of system performance with estimated hourly loads and hourly anemometer data from the site, as well as related work.

Wind and Solar Resource Assessment Activities. The NREL resource assessment team has analyzed both wind and solar data for Mexico. The wind resource assessment team is in the process of producing a catalog of Mexico wind data from various sources. In addition, they are producing wind resource maps for several regional areas. Two of the important activities during the past year were the acquisition of digital terrain data for all of Mexico, and analysis of ocean wind speeds near the Gulf, Caribbean, and Pacific coasts as derived from satellite data.

Other technical analyses. NREL has conducted other technical analyses including assessments of a wind/PV/diesel hybrid system in Quintana Roo for the fishing lodge of Casa Blanca, analysis of several wind water pumping sites in Quintana Roo, and analysis of potential "Protected Areas Management" projects in the states of Quintana Roo and the Yucatan.

Work Plan for FY 1997

1. San Juanico Hybrid System. Continued technical analysis for the San Juanico Hybrid power project. This will include technical assistance in the design of the system, as well as design of a monitoring system for the project. NREL will also provide technical assistance in the areas of equipment selection (e.g., inverter size and type), energy efficiency implementation, battery selection and maintenance, and other related topics.

2. Replication of FIRCO Water Pumping Activities. NREL will continue to provide support for FIRCO replication of water pumping projects as they pertain to wind. The goal is to replicate wind water pumping systems in an area with a good, homogenous wind resource such as Oaxaca. Complete installation of wind water pumpers in Quintana Roo. This will include review of wind resource assessment data and calculation of water output for potential sites.

3. Wind Resource Assessment. This will include the design of a template for a catalog of all wind monitoring activities under the program. A general summary discussion of the wind resource in Mexico, with an regional emphasis, will also be provided. Detailed wind resource maps of at least two regions of Mexico, the Yucatan Peninsula and Baja California Sur, will also be completed.

4. Other Projects. NREL will continue to provide technical assistance for wind projects. This will include technical assessments, prefeasibility analysis, site visits for projects that pass initial screenings by other team members in the field, and related work. Near-term potential wind projects include a hybrid system at the Casa Blanca fishing lodge and a small wind/PV system at the Isla Contoy nature reserve.

Program Funding

Program is cost-shared by DOE and USAID:

FY94-97: $4.9 M total from USAID (includes funds for NREL); ~ $3.5 M total from DOE

For project management information contact Charlie Hanley, Sandia National Laboratories, 505-844- 4435. For information on specific wind projects contact Larry Flowers (303) 384-6901.

RSVP Renewables for Sustainable Village Power
PROJECT BRIEF

Xcalak, Mexico, Hybrid Power System

by David Corbus 3/97

Background

A coastal fishing village located at the southern tip of the Yucatan peninsula in Eastern Mexico, Xcalac has about 60 homes and about 300 residents. Xcalac had never been connected to the national utility grid because its remoteness and small size made grid extension uneconomic. But Xcalac had been electrified in the past. In fact, it had been electrified at least five times. The first four were with diesel-electric generators and the latest with a hybrid wind and solar system.

In 1992, after nearly a decade without power from the last diesel, Xcalac received a 71 kW renewable energy based power system consisting of six wind turbines and a photovoltaic array. Other components in the system included a 400 kWh battery bank and a 40 kW inverter. The system was designed around a 220 V direct current (DC) electrical bus. The system was installed by Condumex S.A., a Mexico city firm that has been the pre-eminent supplier of solar energy equipment in Mexico for many years. The new system was funded by the State of Quintana Roo and the federal PRONASOL rural development program.

Electricity generated by the wind and solar equipment is first used to satisfy, through the DC-AC inverter, the immediate electrical load. If there is excess electricity produced it is stored in the battery bank. The energy stored in the batteries is then available to help satisfy the load during times of low wind and solar output.

The Xcalac wind and solar system was energized in August 1992. The system produces about 120–250 kWh of AC power per day, depending on the wind resource. The system performance has been slightly better than predicted, primarily because the wind resource has been higher than originally assumed; however, the load has grown substantially from the original estimate, hence the system often cannot meet the entire load. Detailed performance of the Xcalac is monitored by the Southwest Technology Development Institute and NREL.

There have been several technical problems over the last five years. One wind turbine alternator had to be replaced after a wiring defect caused it to short circuit, and the PV array has been out of operation twice due to regulator and wiring failures. There has been prolonged system downtime due to problems with the inverter. However, it should be noted that the majority of the technical problems were not severe and could of been fixed in a timely manner had there been an appropriate institutional structure in place for system maintenance. A significant problem has been salt corrosion on the wind turbine towers, especially the guy wires. Last summer the guy wires were replaced; however, significant corrosion on other parts of the turbine has occurred and hence some other turbine parts have also been replaced.

Xcalac has taught us some important institutional lessons, principally things to avoid. The system was installed before a local electrification committee (patronate) was formed and, therefore, the ownership and responsibility for the system is largely indeterminate. The Quintana Roo Governor who championed the project was voted out of office in 1993; the utility company was never involved with the project; and the locals have lacked the cohesion to organize themselves. Compounding the problem was the fact that the users were not originally charged for the electricity, which, naturally, caused consumption to balloon. There has been difficulty in getting the users to pay once a method for charging them was implemented.

Status

NREL became involved with the system in 1994 with an analysis of the system performance data and has been providing technical assistance to the project since then on an ad-hoc basis. To date, nothing has changed institutionally with the Xcalak system, hence the system is in danger of falling into disrepair. Technical challenges, although significant, are not the primary problem, but lack of any organization and planning is a major impediment. The number one problem is that there is still no owner of the system: The American Wind Energy Association (AWEA) and NREL have commissioned a study into institutional alternatives available for solving the existing crisis, but no significant action on those alternatives has taken place to date.

Planned Activities (1997)

This could include involve- ment by NREL to continue to mitigate the existing institutional problems plaguing the system, as well as possible technical assistance regarding system maintenance (there are several wind turbines in need of maintenance). The system will continued to be monitored by SWTDI/NREL and the data analyzed. One very important data point from a monitoring point of view is the battery life of the system, which is currently at 5 years.

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RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

Battery Charging Stations

by David Corbus 3/97

Project Background

It is a common practice in some areas of the developing world for rural habitants to acquire electrical service by charging 12 volt, 50-100 AH batteries from diesel grids. To date there have been a few examples of renewables-based battery charging stations. For example, GTZ installed a photovoltaic battery charging station in the Philippines, and NREL is deploying a mobile photovoltaics powered battery charging station in India.

In these systems, transportation of the batteries to and from the household is either the responsibility of the end user or is a service provided by the station. The batteries can be owned by the end user or leased from the station owner. The batteries are charged either on a set schedule or as the batteries need a recharge. While these and other logistical issues provide a challenge to the implementation of battery charging stations, battery charging stations have the major advantage that they can bring electric service to a very low income population.

In addition to studying the institutional arrangements for battery charging stations, NREL has conducted research, both design and testing, on the architecture and controls for battery charging stations.

Status

NREL has studied different alternatives for battery charging stations. As part of the deployment of a PV-powered battery charging station in India, NREL has tested a PV powered battery charging station (identical to the one in India) provided by Applied Power Corporation. Initial testing has been completed and results can be obtained by contacting Byron Stafford of NREL (see contacts).

Significant research has also been conducted on wind battery charging stations. Because of the variable voltage DC bus typical of small wind turbines, the design of a wind powered battery charging station can be more complex, yet there is a greater economy of scale for a wind powered battery charging station as compared to a PV station.

Testing at NREL on wind powered battery charging stations has focused on a low cost method for charging 12-volt deep cycle batteries from a small wind turbine with three alternatives being evaluated: 1) four batteries with a common state-of-charge in series with many strings in parallel and voltage control for the entire DC bus, 2) individual charging control for each 12-volt battery using a DC to DC converter/charger for each battery, and 3) an AC mini-grid system comprised of batteries and an inverter whereby the battery charging load is only one of many various village loads on the system. This last system may use a "quick charger" to charge the batteries in about a half hour. (Batteries under test are 85 amp-hour.) In addition to presenting data of actual test results with a 10 kW turbine, modeled data are also available and show a good correlation to the test data.

Issues with wind-powered battery charging stations.

An online internet discussion was held by NREL with researchers and renewable experts worldwide. Key issues presented dealt with operational, technical, financial, environmental, and safety issues of battery charging stations.

Partial Summary of Responses.

Operations. The batteries can either be owned by the station and leased to the user, or owned individually by the user. An end-user lease system has the following benefits:

- standardization of the batteries
- cost leverage from bulk purchase and transport single point failure responsibility
- weekly maintenance at station .

An individual ownership system has one, very key, benefit: The individual is responsible for their own battery maintenance

Transportation.

- If the end user transports the batteries, they may mishandle the battery, shortening life. Also battery acid spills may result from improper handling.
- An alternative is to have a transportation service that may be a donkey cart or a truck etc. While this option is more expensive, it may pay off economically due to better battery handling, battery throughput control and a larger service territory.

Environment and Safety.

Recycling is a vital component of all battery programs. A station may be able to facilitate recycling as it is a single facility to collect batteries and deal in bulk with battery recyclers. Safe packaging of batteries has started in South Africa and Brazil, replication will be necessary for new battery charging schemes.

Financing Issues.

- A centralized business can provide credit history and probably get a loan more easily than several hundred individual PV users; cost recovery is with a single point of contact.
- High up-front costs are the limiting factor for home systems in some communities. In these cases battery charging stations hold a critical advantage with low or no capital expenditure for the end user.

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RSVP **Renewables for Sustainable Village Power**

PROJECT BRIEF

Murmansk, Russia Village Wind-Diesel Retrofit

by Dennis Barley 3/97

Background

In the Murmansk region of northwestern Russia (including the Kola peninsula), a number of villages, frontier outposts, meteorological stations, and lighthouses are supplied with electrical power from one of two sources:

1. An existing grid serves a portion of the peninsula. In some cases, the reliability of this service is deemed unacceptable, and local independent power stations are desired.

2. Small, local diesel power plants serve the remaining locations. Diesel fuel prices on the peninsula range from about $0.47/liter to $1.38/liter, and the demand for electricity often exceeds the supply of fuel available.

The wind resource is regarded as very goodC estimates of the annual average wind speed range from 7 to 9.5 m/s in the northwest and from 4 to 6.8 m/s in the southeast, and lower inland. Most of the peninsula lies north of the Arctic Circle, so icy conditions are a concern.

Scope

USAID has provided for the purchase of 40 wind turbines (10 at 1.5 kW and 30 at 10 kW rated), as well as batteries, solid-state power converters, etc. for retrofitting hybrid systems to existing diesel plants. This amounts to a nominal total of 315 kW of wind generating capacity. Candidate project sites will be selected on the basis of (1) the infrastructure necessary to maintain the systems, (2) the wind resource at the site, (3) the fuel price and availability at the site, and (4) a variety of applications to serve as pilot projects. System designs, equipment, and training in installation and maintenance will be provided to local technicians by the U.S. team.

Status

Based on a preliminary assessment of loads, wind speeds, and fuel prices, analysis at National Renewable Energy Laboratory (NREL) indicates that optimally cost-effective hybrid retrofits for roughly 6 villages and 10 smaller projects could be fashioned from the set of equipment provided. Selection of projects and more detailed designs are pending the gathering of more specific information regarding institutional factors, loads, and detailed local wind speed data.

Planned Activities (1997)

1. Information gathering
2. Analysis, system design
3. Installation and training
4. Monitoring of installations

Results to Date

The following graph (see back page) illustrates a study of the least-cost sizing of the wind turbine array for a sample small village, based on preliminary data and analysis, with fuel price and wind speed as parameters.

Team/Partners

Intersolarcenter of Russia

Darup Associates

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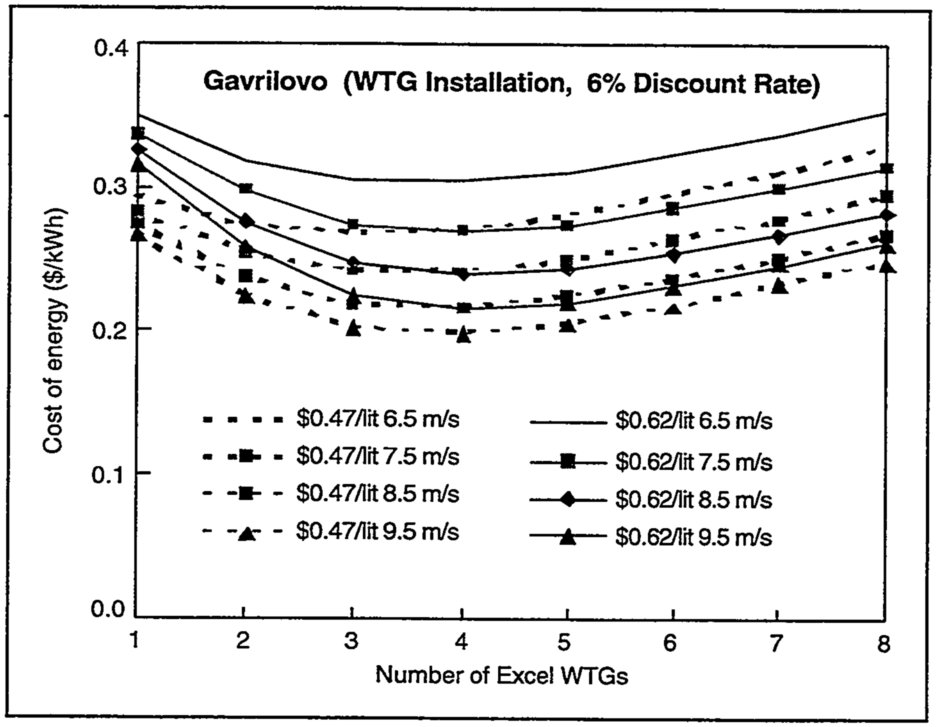

Gavrilovo (WTG Installation, 6% Discount Rate)
Cost of energy ($/kWh)
0.4
0.3
0.2
0.1
0.0
$0.47/lit 6.5 m/s
$0.47/lit 7.5 m/s
$0.47/lit 8.5 m/s
$0.47/lit 9.5 m/s
$0.62/lit 6.5 m/s
$0.62/lit 7.5 m/s
$0.62/lit 8.5 m/s
$0.62/lit 9.5 m/s
1
2
3
4
5
6
7
8
Number of Excel WTGs

RSVP Project: Household Wind/PV Hybrid Systems for Inner Mongolia, China

by Dennis Barley 3/97

Background

In 1995, the Chinese Academy of Sciences and the U.S. Department of Energy (DOE) embarked upon a plan to implement renewable energy systems in electrifying remote areas of China. The first part of the project involved a policy and case study analysis of existing household and village power systems that was completed in early 1996. The second part consisted of pilot projects for the Autonomous Region of Inner Mongolia. The Inner Mongolian government, the Chinese Academy of Sciences, the University of Delaware's Center for Energy and Environmental Policy (CEEP), and the National Renewable Energy Laboratory (NREL) have joined forces to design and implement these demonstration projects.

Scope

Phase I will involve the dissemination of 150 small wind/photovoltaic (PV) systems for household use. These will be distributed in two counties that are rich in wind and solar resources: Suniteyou (Xisu) and Dongwu Zhumuqin. Both counties will be equipped with resource monitoring stations, and 20 of the households will be monitored and analyzed for technical performance. The project will be cost-shared between DOE and the Chinese State Science and Technology Commission (SSTC). The systems, which will cost about $3,000 each, will be paid for in full by the villagers or through a revolving loan fund administered by the Inner Mongolian government. Systems composed of U.S. equipment, Chinese equipment, and combinations of the two will be featured in the pilot project.

Status

Analyses have been conducted at CEEP and at NREL to identify the most cost-effective designs in each of the two counties. This analysis includes identifying load profiles, assessing the wind and solar resources, collecting prices and performance specifications for components of both U.S. and Chinese manufacturing, running sophisticated computer models, and evaluating various designs on the basis of cost of energy (the system cost per kWh of energy delivered to the load) and percentage of unmet load. Because the seasonal profiles of wind speed and solar radiation are somewhat complementary, combinations of wind and PV are indicated as the most cost-effective designs. Further analysis is underway to determine cost-effective designs for village power systems in Inner Mongolia.

Planned Activities (1997)

Negotiations are underway for specification and implementation of the pilot projects.

Results to Date

In the following graph (see back page), a number of possible designs are compared on the basis of unmet load and cost of energy (COE).

Team/Partners

NREL/DOE
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Chinese Academy of Sciences
University of Delaware's CEEP

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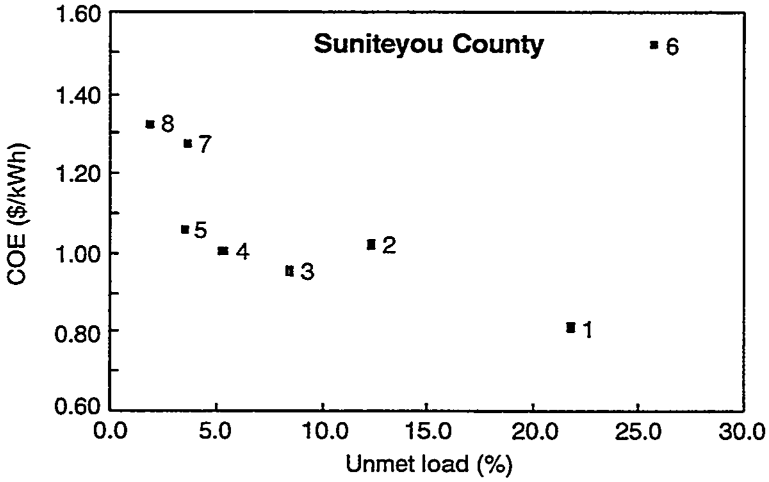

Case	Wind	PV	Batt
1	2 x fd200	0 w	2.1 kWh
2	2 x fd200	0 w	4.2 kWh
3	2 x fd200	50 w	4.2 kWh
4	2 x fd200	100 w	4.2 kWh
5	2 x fd200	150 w	4.2 kWh
6	1 x Wh60	100 w	4.2 kWh
7	1 x Wh60	150 w	4.2 kWh
8	1 x Wh60	200 w	4.2 kWh

Renewable Energy For South Africa

by Doug Arent 3/97

Overview

Approximately 20% of South Africa's rural population is not expected to be reached by the electrical utility grid within at least the next 20 years. The government has elected to shoulder the costs of electrifying the 2000 clinics and 16,800 schools serving this population through photovoltaics (PV), but cannot provide the funds to electrify what is now estimated to be 2.5 million homes and 100,000 small businesses with systems for lighting, television/radio, and light productive uses. REFSA, or Renewable Energy for South Africa, has been established to facilitate this rural domestic/business electrification task.

REFSA's approach to providing rural electricity off-grid and on a sustainable basis will be developed and prototyped through a pilot program in which 2500 PV systems will be installed in rural South Africa. The United States is playing a major role in this pilot. Approximately $1 million of pilot cost is being contributed by USAID. The National Rural Electric Cooperative Association (NRECA) is bringing their 6 decades of relevant experience to the pilot using Department of Energy (DOE) support. Technical and financial consultation is being provided by the DOE national laboratories.

Basic foundations for REFSA continue to be constructed. Numerous meetings of the REFSA board of directors have been held to clarify operational principles and draft a memorandum for parliamentary consideration regarding restructuring of the electricity goals of South Africa to include specific reference to the appropriate utilization of PV and other self-standing electricity generating means. REFSA has also begun to seek additional personnel, to expand board of directors, and to reincorporate as a non-profit entity, offering additional freedoms to accept and dispense concessional funding. Renewable Energy for African Development (REFAD) has sponsored part time assistant for business alliance creation and institutional outreach.

Under DOE sponsorship, NRECA worked closely with RSA principals to coordinate the drafting of a detailed business plan for the first years of REFSA's operation, including the critical 2500 installation pilot projects. Four basic models for the pilot were defined. Two of these, the so-called ESKOM Model and the Community-Based Model, will draw heavily on the infrastructure already created by ESKOM (rural schools) and the Independent Development Trust, IDT, (rural clinics), respectively, and are expected to provide the bulk of the early installations. Two others, the Industry-Led and Solar Store Models, are largely untried, but have motivated industry to submit numerous unsolicited proposals for pilot operations. DOE has also provided support for the development of a Mobile Demonstration Unit (National Renewable Energy Laboratory [NREL]), to be used for consumer education and training. Negotiations for the first pilot projects began in the third quarter of 1996, with first installations planned for early 1997. Initial programmatic design assistance for the Community-Based Model, led by the Independent Development Trust, has been completed with assistance from NRECA, and support from DOE, the IDT, and the Binational Commission through the USIS fund.

REFSA has coordinated educational materials for the general public with the creators of the sitcom Soul City. The expected outreach of television viewership and listeners is more than 12 million, in addition to 750,000 nationally distributed pamphlets. Concurrently, a master marketing strategic plan for REFSA is under development, standard loan portfolios, competitive market-based methodologies for dispersement of concession and in-country sourced subsidy funding. National coordination of training standards, supported by DOE/NREL, the US-South Africa Binational Commission, REFSA, Eskom, the Independent Development Trust and the Development Bank of Southern Africa, will be addressed by the Institute for Sustainable Power in a regional workshop planned for fourth quarter of 1997.

An additional implementation channel that leverages existing resources of the electricity distribution industry in South Africa forms the basis of a proposal developed under U.S. support by the NEOS Corporation, the creator of DOE-sponsored, U.S.-based Photovoltaic Services Network. Villages in the province of Mpumalanga are targeted for initial installations. Products offering quality control and standardization are expected to be addressed through the development of a solar home system product catalog, codeveloped with U.S. technical assistance, while training of installation and operations, and maintenance personnel will be addressed through U.S.-RSA cosponsored national workshops. The "product catalog" is based on the successful Photovoltaics Services Network model currently in use in the United States.

Key to achieving the REFSA goal is expected to be an initial large (~ 50%) loan guarantee likely financed through utility cross subsidization. Also key is anticipated ESKOM support for PV electrification, which is possibly an economically superior alternative to line extension in meeting a significant portion of its 300,000 annual connection quota through the end of the decade.

It is expected that REFSA's lifetime will last 20 years, and the total value of installed hardware will be in the $1 billion range.

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RSVP **Renewables for Sustainable Village Power**

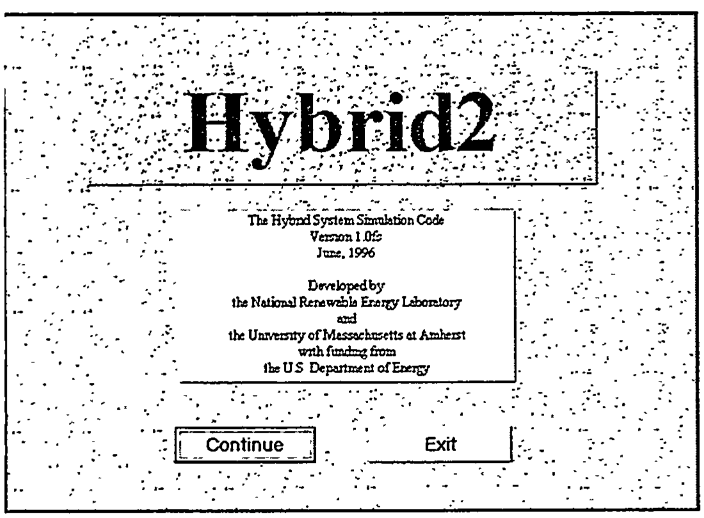
PROJECT BRIEF

Hybrid2, Hybrid Power System Simulation Software

by Ian Baring-Gould 3/97

Background

With the increasing need for electrical generation in the developing world, the market potential for renewable based hybrid power systems is emerging. In order to address this emerging market, an analysis tool was required by industry, researchers, and development institutions to accurately model the performance and economics of alternative hybrid designs. This analysis tool would require enough versatility to model the many system locations, widely varying hardware configurations, and differing control options for potential hybrid power systems. In response to this need, the *Hybrid2* software was developed. *Hybrid2* is a time-series/probabilistic model that uses time-series resource and load information, combined with statistical analysis, and manufacturers' data for hybrid system equipment to accurately predict the performance and cost of hybrid power systems. *Hybrid2* allows for the direct comparison of many different renewable and non-renewable power system designs. This is completed in a user-friendly format where off-the-shelf equipment is combined into potential power systems.



Scope

To elucidate the performance of a variety of wind/diesel and hybrid power system configurations, the University of Massachusetts and the National Renewable Energy Laboratory (NREL) developed the *Hybrid2* software. The *Hybrid2* code can model many combinations of wind turbines, photovoltaic arrays, diesel generators, power converters, and battery storage, both in AC, DC, or two-bus systems. *Hybrid2* also allows for more than 100 different dispatch configurations with multiple diesel generators, renewable sources, and battery storage. The model has been designed with an easy to use graphical interface, an in-depth library to facilitate system design, and a detailed glossary of frequently used terms to assist users who are not familiar with hybrid power system terminology. The code also includes a comprehensive economics package.

Status

The code was released in June at the 1996 American Wind Energy Association, WindPower Conference in Denver, Colorado. The software has undergone numerous updates over the past 9 months and is available to the general public for a $100.00 reproduction charge. The University of Massachusetts is providing support for users of the software and has set up a homepage where more information can be located. The software is used extensively at NREL and approximately 100 copies have been distributed worldwide.

Planned Activities (1997)

The *Hybrid2* software will be undergoing continuous upgrades over the next year with the planned release of updated versions in June and December of this year. Upgrades being considered are the addition of a synchronous condenser, simplified system dispatching, a user-defined control offset and a simple prefilter for wind and solar resource data.

Team Participants

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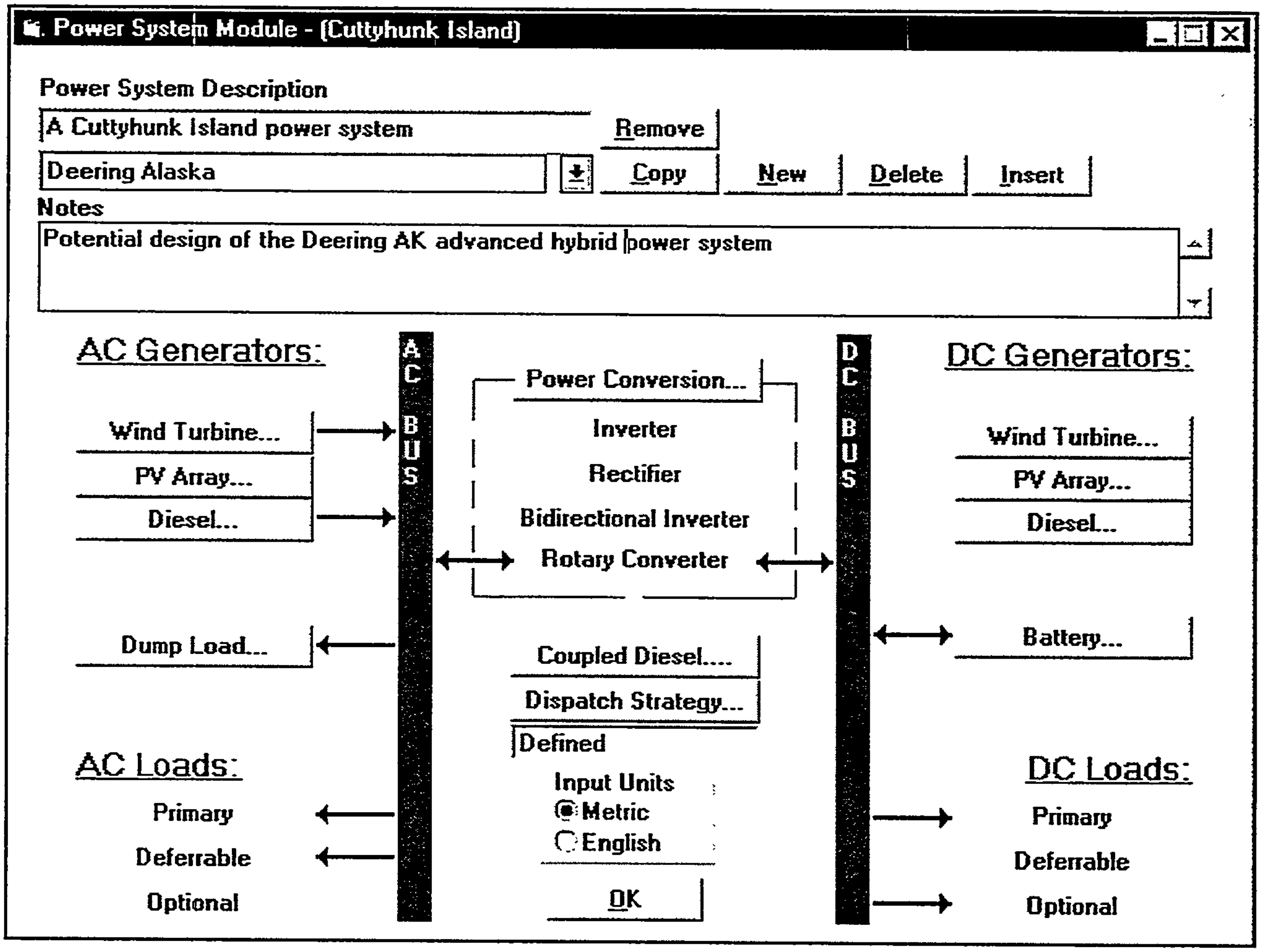

RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

Wind-Electric Icemaking System Development

by Steve Drouilhet 3/97

?roject Objective

J.S. small wind turbine suppliers and various nternational development agencies have xpressed a need for a reliable and cost-effective, vind-powered icemaking system. The primary lemand is for ice in remote fishing villages in leveloping countries that do not have access to grid power. Having ice with which to refrigerate heir catch, fishermen in these villages would xtend the market for their fish, reduce spoilage, ind increase the quality of the delivered product.

3ecause it promised to be simpler and more cost effective than a system employing batteries and in inverter (to supply conventional AC power), he National Renewable Energy Laboratory (NREL) lecided to investigate the approach of having a ommercial icemaker directly connected to the electrical output of a small variable-speed wind urbine generator. In this configuration, the elecric power supplied to the icemaker would vary n voltage and frequency as the wind speed varied. Because ice is itself a storage medium, there vould be no other energy storage in the system. Ice would only be produced when there was sufficient wind power available.

Progress Summary

In the first phase of the project, we demonstrated variable frequency operation of a standard commercial icemaker connected to a Bergey wind turbine. While the particular icemaker (a Scotsman) used produced ice over a range of electrical frequency and voltage, a number of operational problems were encountered, particularly difficulty in starting the compressor motor with the relatively weak (compared to a standard utility grid) wind turbine generator. By developing a computer model of the electromechanical system, looking at both steady state and dynamic operation of the system, we acquired a thorough understanding of the system characteristics, including the start-up problem. We then conducted bench-scale tests to validate the model and to demonstrate the predicted effectiveness of series capacitors in increasing the starting capability of the compressor motor.

In the second phase of the project, we tested a Northstar icemaker, powered by a 10-kW wind turbine alternator, driven by a dynamometer. The Northstar icemaker was chosen because it appeared to have the robustness necessary to provide reliable service in a remote fishing village environment. It also can make ice from seawater (unlike the Scotsman), which eliminates the need for a fresh water supply. We monitored icemaker start-ups at various combinations of alternator frequencies and capacitor size. We also conducted steady-state measurements over the entire range of operating frequencies to determine the power vs. frequency and ice production rate vs. frequency characteristics of the system. These curves, combined with the known rotor-power curve, enabled us to determine an ice production rate vs. wind-speed curve for the system.

Unfortunately, the Northstar icemaker testing revealed its own set of operational problems associated with variable-speed operation. These included mechanical resonances, control malfunc- tions, poor spray jet performance, and attenuated ice production rate at the higher operating frequencies. Taken together, the resolution of these problems would call for a major redesign of the icemaker, which called into question our original premise that it would be possible to configure a direct wind-electric icemaking system using a standard commercial icemaker. At present, this appears not to be the case. Consequently, the icemaking project has been put on hold while we determine if a more complex system, involving batteries and an inverter to provide a more stable AC power supply, can be implemented cost-effectively.

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RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

NREL's Hybrid Power Test Bed

by Jim Green 3/97

Background

In a remote Alaskan village, wind turbines and back-up diesel generators can hypothetically provide electricity for lighting, heating, and hot water on a short winter day. This is one of many hybrid power systems researchers can simulate at the National Renew-able Energy Laboratory's (NREL's) Hybrid Power Test Bed (HPTB) at the National Wind Technology Center (NWTC).

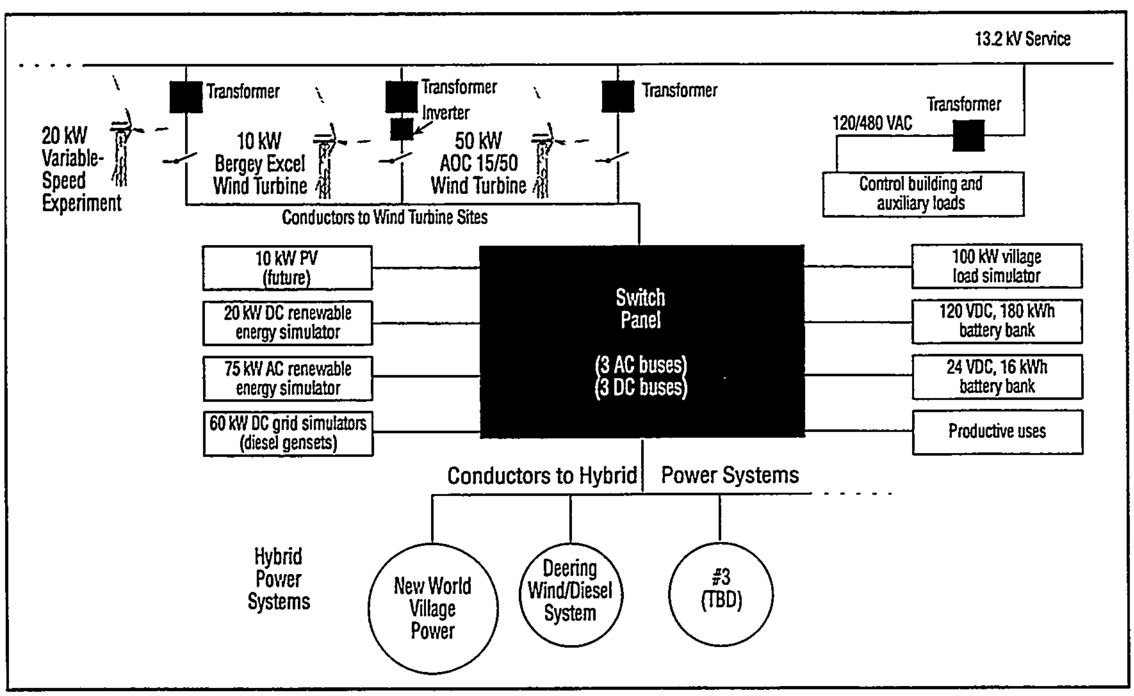
Hybrid power systems combine multiple power sources such as wind turbines, photovoltaic (PV) arrays, diesel generators, and battery storage systems. They typically are used in remote areas, away from major electric grids.

Scope

The HPTB is designed to assist the U.S. wind industry in developing and testing hybrid power generation systems. Using simulated village loads, researchers can evaluate the interaction of these power sources under realistic conditions at the test bed. Design engineers are able to work through actual problems the system might encounter in the field.

The test bed allows engineers to evaluate system performance, cost-effectiveness, and reliability using real or simulated solar and wind energy resources. Simulated energy resources allow designers to repeat experiments as they improve system designs. This feature is important for developing new components, advanced hybrid systems, and dispatch and control systems.

U.S. wind companies can use the HPTB to train customers from other countries. By providing technical assistance to potential users, the NWTC encourages the growth of international markets for the U.S. wind industry.



Test Bed Capabilities

Engineers can evaluate the moment-by-moment dynam ics of hybrid power system operation, gather data on long-term performance, or demonstrate innovative design concepts with the HPTB. High-speed data acquisition equipment monitors power quality, harmonic distortion, and electrical transients. A village load simulator (a load bank with resistive and inductive elements) can create power factors down to 0.5, allowing test engineers to evaluate system operation under severe conditions that may be encountered in real power systems. Engineers can also investigate the power system's dynamic response to sudden load changes and to conditions of phase imbalance or loss of phase.

Engineers can evaluate the long-term performance of a hybrid power system, including its energy delivery (in kilowatt-hours), and diesel fuel consumption. They can monitor wind speed, insolation, and the performance of battery energy storage. They can characterize system performance under a range of operating conditions, evaluate alarms, emergency shut-down procedures, and other critical functions.

The research test bed provides a good environment for developing, testing, and evaluating new concepts with less technical and financial risk than proving them in the field at a remote location. New power conversion devices, emerging energy storage technologies, prototype control systems, and innovative system architectures are examples of concepts that could be evaluated using the HPTB.

Test Bed Features

The Hybrid Power Test Bed contains a number of unique features, including the ability to test up to three hybrid power systems simultaneously, use either real or simulated renewable energy sources, simulate a local electric grid, test with real or simulated village loads, and test wind turbine systems producing direct or alternating current (DC or AC).

A custom-designed switch panel with 3 AC and 3 DC buses gives the test bed the flexibility to connect or disconnect various system components to meet the objectives of a specific testing program. The switch panel can connect selected components, with combined capacities of up to 100 kW onto common power buses. Engineers can rapidly change testing configurations by opening and closing a few switches.

Simulated renewable energy sources allow engineers to conduct repeatable testing. A large induction generator functions as a 75-kW AC source simulator. The DC source simulator is a solid-state device that provides up to 20 kW of reproducible DC power.

Two 60-kW diesel generator sets are available for use in hybrid systems under test. They may also serve as grid simulators, allowing researchers to test a hybrid power system's ability to synchronize its power output and connect with an existing small grid.

Renewable energy technologies at the facility include 3 wind turbines, rated from 10 to 50 kW. A photovoltaic array between 10 and 20 kW is planned. The NWTC's good solar and wind resources allow a full range of power system testing under normal operating conditions.

The test bed incorporates a 100-kW village load simulator. The computer-controlled simulator mimics typical electric loads for a small village. The test bed also has the flexibility to incorporate real village loads such as power tools, lighting systems, water pumps, or an ice-maker into its tests.

The HPTB includes a personal-computer-based control and data acquisition system with a graphical interface in LabVIEW©.

Hybrid Power Test Bed Equipment

Component	Rating
AOC 15/50 wind turbine	50 kW
Bergey Excel wind turbine	10 kW
Variable-speed wind turbine	20 kW
PV array (to be added)	N/A
DC renewable energy simulator	20 kW
AC renewable energy simulator	75 kW
Diesel gen-set grid simulator	60 kW
Two village load simulators	100 kW
DC battery banks	24 and 120 volts

Current Status

The goal is to be operational in summer 1997, with the first series of tests to be testing the control system for a high penetration wind/hybrid project in Alaska, completion of a New World Village Power 50-kW power system characterization, and evaluation of an Advanced Energy Systems inverter. We anticipate the HPTB will be a very valuable and heavily used test capability for the next several years.

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RSVP Renewables for Sustainable Village Power

PROJECT BRIEF

Desalination for Villages

by Karen Thomas 3/97

Background

As the world's population grows, so will its demand for potable water. Communities in arid coastal regions or regions with brackish groundwater, especially island communities, are already experiencing shortages of potable water, and such shortages will grow more acute as populations increase. Many of these communities are small and remote, such as islands in the Caribbean and Mediterranean, small communities in arid Australia, remote coastal areas of South America, and remote communities in the Middle East. In many communities demand management and conservation can meet the water needs. However, in a large number of cases, desalination is the most appropriate solution.

Because of the high energy demands of desalination, it is desirable to find methods of using renewable energy for desalination, and to encourage communities to use these methods rather than non-renewable based methods. In addition, desalination is an ideal application for a hybrid power system, because it can be operated as a deferable load to improve the load management of the hybrid system.

Scope

Because of the growing need for desalination and the importance of using renewable energy for desalination, the Village Power group conducted an survey of desalination methods. This survey examined the various ways in which renewable energy has been used for desalination, including photovoltaic-powered electrodialysis units, small scale solar thermal-powered multiple effect distillation systems, and direct-drive, wind-powered reverse osmosis systems. The systems were compared on the basis of capital cost, life-cycle cost, energy consumption, pretreatment requirements, and operational complexity.

The research also sought to identify the possible ways in which renewable energy could be used for desalination, in order to determine areas of further research. Because few companies or communities will invest in an untested use of renewable energy, ideas for key pilot projects to demonstrate the feasibility of renewable energy-powered desalination were analyzed.

Results

The overview was completed in September 1996. It is currently in the process of being published for publication as an technical report. Several areas where further research is needed were identified (see Table 1 on back page). There are many combinations of renewable energy source-desalination technology couplings which have not ever been tested, but which seem quite viable in concept. These couplings are represented by the empty spaces on the chart. Prototype and pilot scale testing are needed to determine the viability of such systems and to determine how they compare with other combinations. For example, while PV-battery electrodialysis and reverse osmosis systems have been operated successfully, a wind-battery electrodialysis or reverse osmosis system has not been tested. A mechanical wind pump-reverse osmosis system using pressurized water storage has been tested in Australia, but a similar electri-cal wind pump system has not been tested, even though several researchers have concluded that electrical wind pumps are superior to mechanical in high wind regimes. And while recent improvements have indicated that vapor compression can be the least expensive and lowest energy consuming form of sea water desalination, no testing of a renewable energy-powered vapor compression system has been completed to date.

Testing of the most promising combinations is being planned. A vapor compression system manufactured by Superstill has been purchased and will be tested during summer of 1997 using a PV/propane hybrid system supplied by Sunwize as well as a wind/PV/battery hybrid, a wind/battery hybrid, and wind-direct drive. Discussions with the Bureau of Reclamation have centered on the possibility of collaboration on a renewable energy-powered desalination unit suitable for use in a Native American reservation. The Bureau currently is requesting proposals from manufacturers to produce a PV-powered electrodialysis system it designed for a reservation in New Mexico. In addition, the Solar Thermal division of NREL has initiated an investigation into small scale solar thermal-powered multiple effect distillation systems.

Planned Activities (1997)

The NREL Technical Report, Overview of Village-Scale Renewable Energy-Powered Desalination, will be published in 1997.

The superstill vapor compression desalination unit will be tested at the NWTC's Hybrid Test Facility. The testing would include a PV/propane hybrid supplied by Sunwize as well as a wind/PV/battery hybrid, a wind/battery hybrid, and potentially wind-direct drive, and would be a joint wind-PV effort.

Dialogue with the Bureau of Reclamation toward a collaborative pilot project will be continued.

Dialogue will continue with members of CASE/Australia who have developed a commercial prototype of a PV-reverse osmosis system, with the goal of cooperation between Australian researchers and NREL.

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Table 1. Development status of renewable energy-powered desalination

(Italic text indicates research areas of greatest interest for near-term commercialization. Blank cells represent renewable energy-desalination combinations which have not been tested. n/a means that the particular technology cannot be powered with this form of energy.)

Renewable Energy Source	Desalination Technology				
	Multiple Effect Distillation	Multistage Flash Distillation	Vapor Compression	Reverse Osmosis	Electrodialysis
Solar thermal	pilot plants (Spain, 1988; U.A.E., 1984) *Rugged ME*	pilot plants (Kuwait, 1984; Mexico, 1978)	n/a	n/a	n/a
Solar thermal-electric or mechanical		pilot plant thermal plus Stirling engine (Texas, 1987)		pilot plant mechanical direct drive (France, 1978)	
PV-battery inverter	n/a	n/a		commercial	pilot plant (Japan, 1988)
PV, no inverter	n/a	n/a		commercial direct drive (Australia, 1996)	commercial prototype battery/all-DC (New Mexico, 1995) *PV-direct drive*
Wind-battery	n/a	n/a	pilot plant (Spain, in progress) *Wind-battery-inverter*	pilot plants (France, 1990; Spain, in progress) *Wind-battery-inverter*	pilot plant (Spain, in progress) *Wind-battery*
Wind-diesel			*Wind-diesel-load management*	pilot plants in progress (Spain, Greece) *Wind-diesel-load management*	
Wind-mechanical	n/a	n/a		pressurized water storage pilot plant (Australia, 1990)	n/a
Wind-electric direct drive	n/a	n/a		cut in/cut out control pilot plants (Germany, 1979; France, 1987) *Pressurized water storage*	

RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

The Hybrid Optimization Model for Electric Renewables (HOMER)

by Peter Lilienthal 3/97

Background

Hybrid power systems can be powered by any combination of wind, photovoltaics, diesel, and batteries. This level of flexibility has obvious advantages for customizing a system for particular sites resources, costs, and load requirements. The flexibility, however, makes the design process more difficult. Existing models were either very simple spreadsheet models that did not consider the variability in the loads and resources or detailed simulation models, such as *Hybrid2*, that can give precise performance projections for specific systems, but are unwieldy to use for comparing among a large number of different configurations.

Scope

The National Renewable Energy Laboratory (NREL) has developed HOMER, an optimization model that takes into consideration hourly and seasonal variations in the loads and resources, simple performance characterizations of each component, equipment costs, reliability requirements, and other site specific information. HOMER identifies the optimal configuration as well as its sensitivity to user specified ranges of input parameters. It is intended for prefeasibility analysis, when the area of interest spans a broad range of inputs, either because the input data is uncertain or because the analysis covers a large area with differing conditions. In addition to the configuration, HOMER outputs include hourly energy flows through each component, the impact of several simple load management strategies, and economic information such as the cost of energy and net present costs of the system.

Results to Date

HOMER has been used in several NREL analyses for Indonesia, China, Russia, Argentina, Chile, Mexico, South Africa, and for market analysis for domestic renewable suppliers. It has been used both for market assessment and screening to initialize detailed site-specific *Hybrid2* analyses.

During 1996, an Excel spreadsheet-based user interface has been developed and the software has been converted from the UNIX to the Windows platform. This substantially simplifies the process of making runs and describing HOMER's capabilities. Major new capabilities include multiyear runs with load growth, a maximum annual fuel use constraint, economies of scale in diesel capital costs, improvements to the diesel fuel curve and dispatch such that the no-load fuel consumption of the diesel is included when the diesel is manually dispatched.

Planned Activities (1997)

HOMER will continue to be used for system screening and market assessment. Further enhancements to the diesel fuel curve and dispatch capability are planned. These enhancements should allow the no-load fuel consumption to be always considered. They will also allow the use of a dispatch strategy that corresponds to actual operation, rather than optimal dispatch. HOMER will also be integrated with a mini-grid optimization model to help planners compare mini-grids to individual systems for a particular village. A non-operative version of HOMER's interface will be put on the World-Wide Web along with sample results. If program priorities allow, a fully functional version could be put on the Internet and made available to select users.

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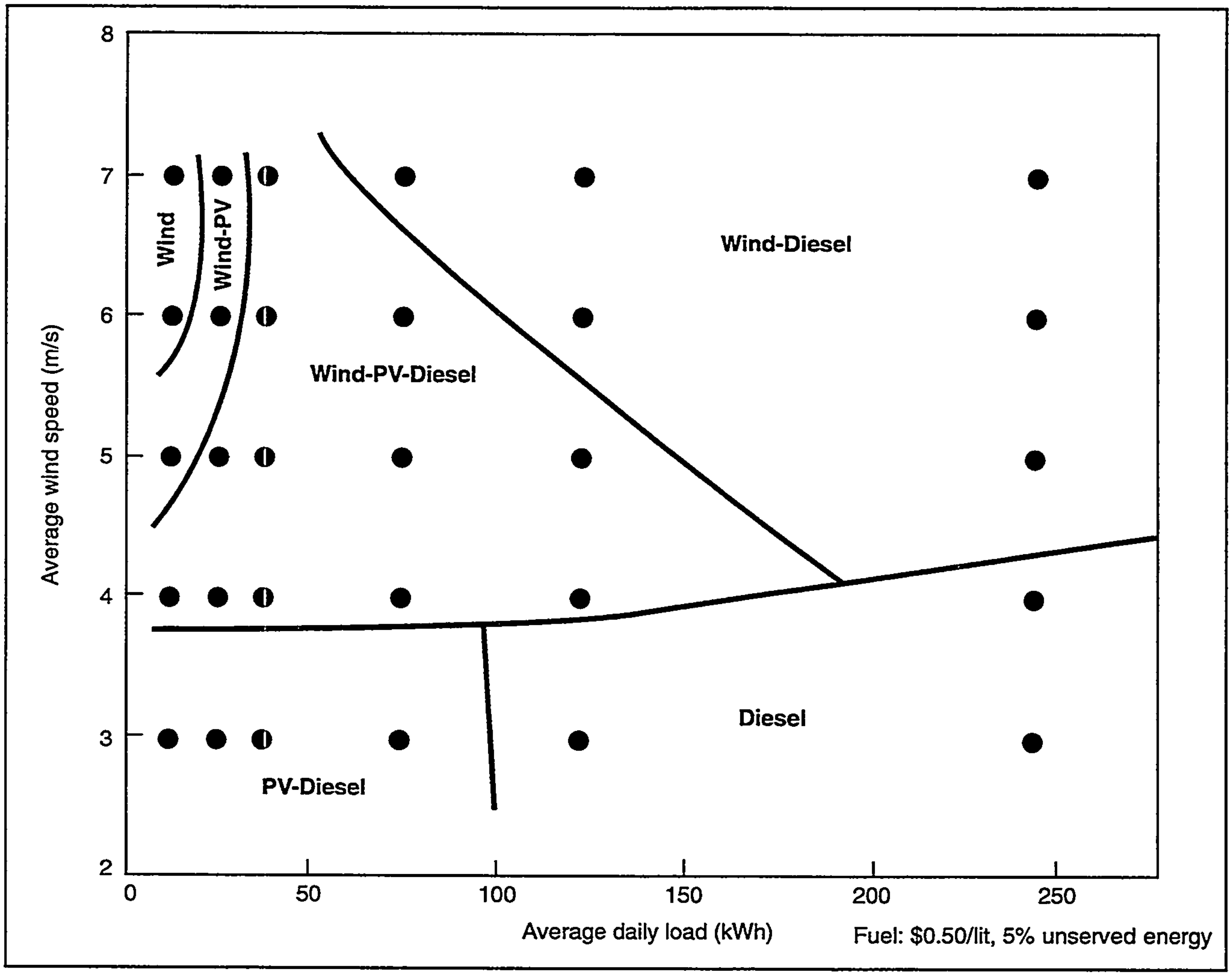


Figure 1. HOMER. Assessing the least cost mix of supply technologies is a difficult analytical problem that depends on the quality of the various resources, the local costs of equipment, labor and fuel, and the site-specific descriptions of the daily and seasonal variations in the loads, as well as the options for simple load management. The Hybrid Optimization Model for Electric Renewables (HOMER) is a screening model that is useful for prefeasibility and sensitivity analysis. This graph is an example of HOMER's outputs for a specific set of assumptions. The results can change dramatically with different assumptions.

Sensitivity analyses were performed on the size of the load and the average annual wind-speed. For very low loads in a good wind resource one small wind turbine will produce more energy than required. In lesser wind resources or as the load increases a combination of wind and PV is preferred. Although in this example PV-diesel is the optimal choice in poor wind resources for the smallest loads that were modeled (12 kWh/day), a pure PV system would be preferred for smaller loads or higher fuel prices or if more than 5% unserved energy would be acceptable. In the larger sizes, both wind turbines and diesel gen-sets have economies of scale that make PV less competitive. The vertical line representing 125 kWh/day demonstrates a seemingly counter-intuitive insight from the model. At moderate windspeeds PV is cost-effective, even though it was not cost-effective at low wind-speeds. This is because the cost of the balance of systems required to utilize PV (batteries and inverter) is being shared by the wind turbines.

RSVP **Renewables for Sustainable Village Power**

PROJECT BRIEF

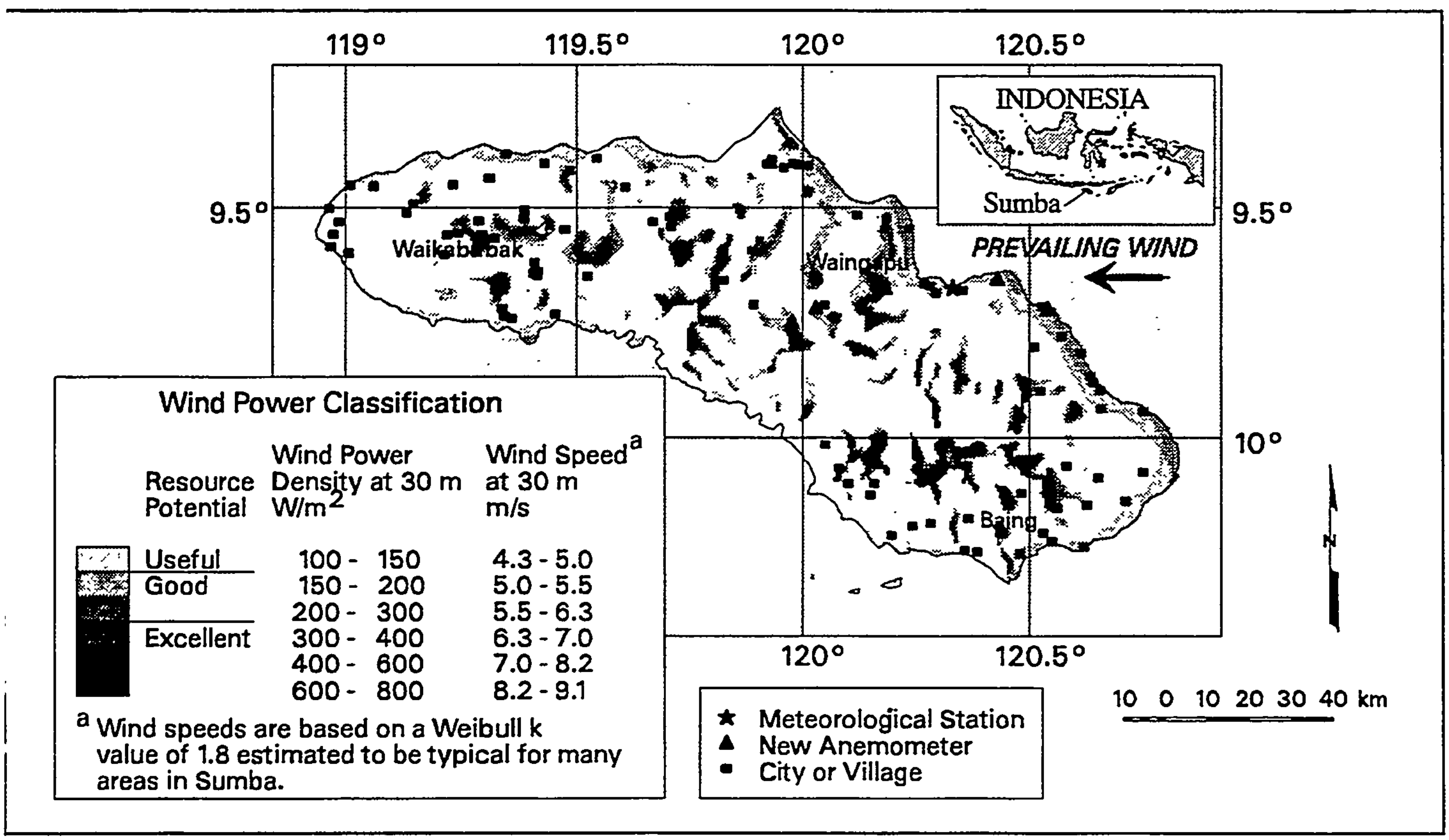
Wind Resource Mapping

by Dennis Elliott and Marc Schwartz 3/97

Background

One of the chief goals of wind resource assessment activity at the National Renewable Energy Laboratory (NREL) is to help accelerate the deployment of wind energy projects by producing the most useful and sophisticated wind maps possible.

In late 1995, work began on developing an automated wind mapping technique using Geographic Information Systems (GIS) software. Previously employed wind mapping techniques were limited by laborious and subjective analysis methods. The distribution of the wind resource for a particular region is often very complex and had to be physically drawn for topographic features such as ridge crests, elevated plateaus, and coastal areas. This process was time consuming, subjective, and prone to inconsistencies in the analysis. NREL's computer mapping technique substantially reduces the subjective analysis and greatly improves the accuracy of the maps. The technique enables the analysis of the distribution of the resource to be treated consistently throughout the region of interest. Utilizing advanced computer mapping techniques reduces the time needed to produce a wind resource map for complex terrain.



Approach

A key component of the wind mapping activity at NREL is the development of updated comprehensive global data bases that are used as inputs for the computerized mapping technique. NREL uses a variety of meteorological and geographical data sets in support of wind mapping projects. The principal meteorological data used in resource assessment projects are surface meteorological data, upper-air (weather balloon) data, and marine wind data from ships and satellites. In some regions, these data are supplemented by surface data from new surfacemeasurement programs. The major type of geographical data used are shaded maps of elevation and digital elevation data.

NREL's computer mapping system uses an analytical approach and is designed to portray the distribution of the wind resource over a large area. These maps can be used to identify and target areas for possible project sites and further wind measurement programs.

Results

Wind resource maps using this new computerized technique have been produced for an island in southeast China and for islands in southeastern Indonesia. An example for an Indonesian island is the wind map for Sumba. This island is fairly large with varied terrain with not much available wind data in the surrounding region. Nevertheless, using advanced analysis techniques of the meteorological and topographical data that were available, a wind map was generated that delineates the most favorable wind resource areas on that island.

Planned Activities

Wind mapping activities are either underway or will be in the near future for regions around the world including areas in Chile, Mexico, Argentina, China, Indonesia, and the Philippines. Some of these countries present complex wind flow regimes and topography. Additional computer modules that account for extremely complex terrain and topography will be developed and added to the computer mapping system.

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RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER
PROJECT BRIEF

Village Pilot Projects in Chile

by Rick Holz

Scope

In October 1994, the U.S. Department of Energy (DOE) and the National Energy Commission of Chile (CNE) signed the Technical Cooperation Agreement for the implementation of renewable energy rural electrification projects, to be developed within the framework of the Chilean "Rural Electrification Program" or PER. The goal of the PER is to have 100% electrification throughout the country by the year 2005. This goal is to be met through a process of project funding from the national level (FNDR or Fondo Nacional de Desarrollo Regional), project selection by the regional authorities (SERPLAC), and implementation by private enterprises.

According to the PER, stand-alone alternatives based on renewable energy sources and village-wide mini-grids are to be an important part of the solution. Furthermore, in 1994 the Inter-American Development Bank (IDB) announced that the FNDR funds, which previously had been only available to finance grid extension projects, were to be opened to renewable energy sources. While photovoltaic (PV) systems are to be the focus for Regions I though IV in the north of Chile, hydro and wind-hybrid systems were to be the focus in Regions VI through X.

In December 1995, the SERPLAC of Region IX and a private electricity distribution company, SAESA/ Frontel, signed an agreement to implement hybrid wind-energy projects in Region IX for purposes of demonstration. The original agreement stated that the projects would be funded as follows: FNDR subsidy ($71,605), U.S. contribution ($100,000), beneficiaries ($5,852), and Frontel ($13,580). These funds were to be exhausted on at least two sites (Puaucho and Villa Las Araucarias) and possibly others in Region IX.

Activity Summary and Status (1996)

Work on the pilot projects began in January 1996. The two sites specified in the SERPLAC/ Frontel agreement, Puaucho and Villa Las Araucarias, were inspected by a National Renewable Energy Laboratory (NREL)/National Rural Electric Cooperative Association (NRECA) team and judged to be viable sites for wind-energy systems. Puaucho, on a hill overlooking the Pacific Ocean, is a small site with three residences, a school, and a health post. A 1.5-kW system was selected for Puaucho.

Villa Las Araucarias (VLA) is a larger village located in the highlands bordering the Pacific coast. While there is a good wind resource at VLA, there were also some demographic and political unknowns. There is a resettlement project in progress, and it is unknown how much the population will grow from the original 13 households that existed in January. At the present time, the number of residences has grown to 20. A 10-kW system was selected for this site that can accommodate some population growth (see photograph on back page).

A third project site was selected, Isla Nahuel Huapi (INH). This tiny island in Lago Budi, near the Pacific coast, has 11 residences and a new health post. A 3-kW system was selected for this site.

From January until May, the project activities included (1) loads surveys (NREL/ NRECA/ Frontel), (2) monitoring of wind resources at the project sites (NREL/NRECA/ Frontel), (3) design of the power systems (NREL/NRECA), (4) design of mini-grids (Frontel), (5) design of data acquisition systems (NREL), and (6) procurement of the systems' hardware (NRECA).

Construction of the power systems and mini-grids took about 3 months longer than expected. By the end of September, the turbine towers, power conversion systems, mini-grids, and data acquisition systems were installed at all three-sites. The final hurdle was getting the interior loads installed in theresidences. The SERPLAC/ Frontel agreement on the pilot projects states that Frontel must install the interior equipment and collect the tariffs themselves. The municipal governments of Puaucho and INH decided to pay the tariffs. Municipal workers installed the interior loads at those two sites. In January 1997, the municipality agreed to pay for the interior equipment and Frontel agreed to install the equipment and make the connections to the power system.

A team from NREL and NRECA commissioned all three systems in January 1997. The team performed all necessary preoperation check-outs, system start-ups, and initial monitoring. Also at that time, the NREL/NRECA team trained Frontel personnel on the systems' operations and maintenance procedures. One representative from each village was also trained to perform basic system diagnostics and maintenance. To date, these systems continue to operate satisfactorily. The only power outage was due to a limb falling across a distribution line during a storm.

Planned Activities (1997)

Activities in 1997 will fall into three categories: (1) performance monitoring, (2) fine-tuning of system operation and maintenance procedures, and (3) training. All three sites are equipped with devices for monitoring the wind resource, the energy flows, the state of charge of the batteries, and the on/off status of the generator. These data will be used to determine the quality of service, system efficiency, and cost of operation. Based on the data and feedback from Frontel and the systems' users, the system operations parameters and maintenance procedures will be fine-tuned. The training activities that are planned will deal with replication of the pilot projects. The management of Frontel and other viable Chilean counterparts will be invited to attend workshops on the pilot systems.

Results to Date

All three pilot systems are operational and performing satisfactorily. After three months of operation, the village loads are still very small. Consequently, there has been very little use of the backup gas generators. We do not have enough information at the present time to determine if and when the village loads will grow to their anticipated levels.

Team/Partners

The U.S. team consists of NRECA (South America), the American Wind Energy Association (AWEA), and NREL.

Sponsoring Agencies

These projects are jointly funded by the USDOE and the Government Chile (Comision Nacional Energia). The Chilean FNDR funds are supported by the Inter-American Development Bank.

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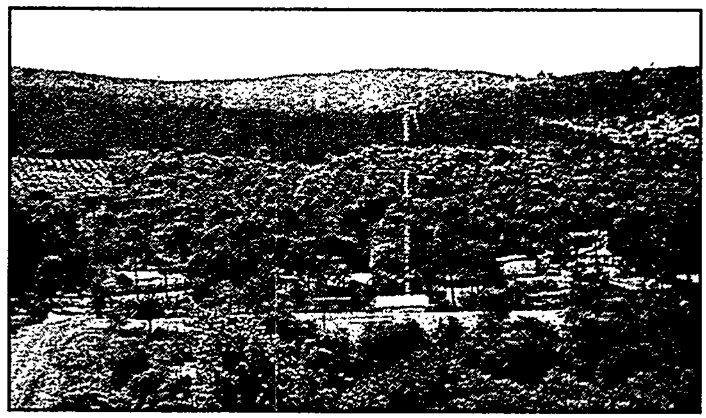

RSVP **Renewables for Sustainable Village Power**

PROJECT BRIEF

Hybrid Village Power Systems in Amazonia

by Roger Taylor 3/97

Amazon Region: Electric Energy Aspects

The Amazon region in Brazil is sparsely populated, with 17 million people living in 5 million km^2. This translates to less than 12% of the country's population in 58% of the total area. Electricity generation, where it exists, is based mainly on isolated diesel systems ranging from a few kilowatts in small villages, to tens of megawatts in some capital cities. Only 9% of Brazil's electric energy is consumed in Amazonia, but consumption has been increasing at a rate of about 18% per year for the last 20 years, while the national rate increased at only 8.2%. Over 30% of the population does not have access to electric energy.

More than 300 mini-grid systems are operated by local utilities, and thousands more are privately owned. Table 1 gives the distribution of system capacity for the 300 systems operated by utilities. Normally, the small systems operate for only 6 to 12 hours per day.

Table 1. Distribution of Utility Diesel Systems, by Size

System Size (kW)	% of Total # of Systems
0–100	10
100–500	37
500–1000	23
>1000	30
Total	**100**

The cost of remote electricity is high and depends strongly on system size. In villages with diesel systems smaller than 100 kW, the cost can be greater than $ 0.50/kWh. These high costs are due largely to operation and maintenance and low capacity factor, and secondarily, to high fuel costs. The small systems are normally very unreliable. As a result of the present situation, small remote villages experience both high electricity cost and very low-quality energy service, if any. High electric costs are not borne by villagers, however, due to fixed electric tariff rates mandated by the government. Hence, such service, when provided, must be subsidized.

Description of the Hybrid Systems

Details of the two systems and their locations appear below. The designs of the systems are significantly different. The Campinas system will meet the entire load requirement with photovoltaic (PV)-generated electricity, and the Joanes system will operate in a Apeak shave@ mode, transferring the peak demand of the village to Aoff peak@ periods at the diesel generation plant. In this way, it will use the maximum energy available from renewable sources. In Joanes, renewable generation is expected to reach 115 MWh/year, or some 45% of the total present demand. A concurrent program for energy conservation in the village is expected to boost the fraction of the load met by renewable energy to over 60%.

Joanes

The first system, a 50-kW PV-wind-battery hybrid, is being installed in the village of Joanes, located at the municipality of Salvaterra, on Marajó Island, state of Pará. The system design and control and the power-processor hardware were supplied by New World Village Power Company of Vermont. This system will operate either isolated or interconnected to the local grid. While in the interconnected mode, it will either deliver excess energy to or charge the battery bank from the grid.

One year of solar radiation (global horizontal, direct normal, and diffuse), ambient temperature, and wind (speed and direction) data at the site is available. During this period (May 1994 to April 1995), the average wind speed was 6.58 m/s, and the daily average global-horizontal radiation was 5.30 kWh/m2. There is a good match of resource availability to the demand during a typical day. Figure 1 shows the average normalized daily profile of load, wind, and solar energy for Joanes.

The ratio of diffuse to global radiation ranged from 0.26 in July 1994, to 0.63 in February 1995, whereas the clearness index ranged from 0.40 in April 1995 to 0.60 in September 1994. The average temperature was approximately 27°C.

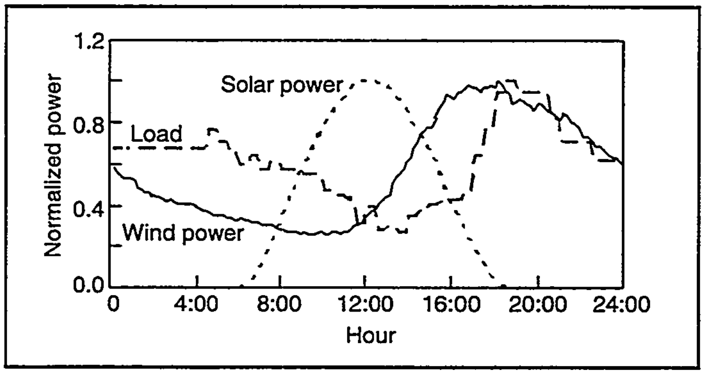

Figure 1. Daily load and generation profiles, village of Joanes—annual daily average (1994/1995).

System Design, Configuration, and Grid Connection

This system is based on a rotary converter (shaft-coupled DC motor and synchronous alternator), rather than an electronic inverter, for power conversion. It comprises four 10-kW wind machines supplied by Bergey Windpower and 10 kW of PV modules from Siemens Solar Industries. A system schematic showing the connection to the Salvaterra grid is given in Figure 2.

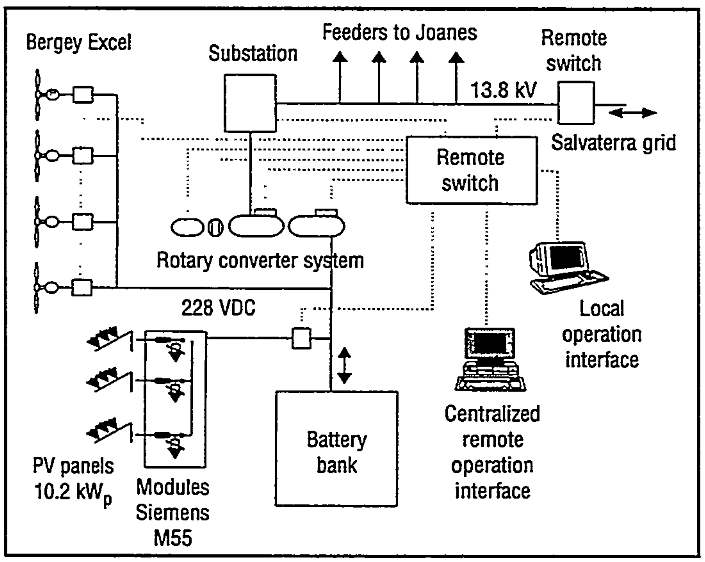

Figure 2. Simplified schematic drawing of Joanes hybrid system.

Joanes is connected to the Salvaterra power plant, one of 41 utility owned and operated diesel systems presently installed in Par·. The plant has a nominal capacity of 1.2 MVA. Joanes receives its electricity from this system, through a 17-km line operated at 13.8 kV. The village has 170 consumers, plus public lights.

Campinas

The second hybrid power system, a 50-kW PV-diesel-battery hybrid, is being installed in the village of Campinas, about 100 km upstream from Manaus, in the state of Amazonas, between the Solimoes and Negro rivers. System controls and power processor for the Campinas plant were supplied by Advanced Energy Systems Ltd. (AES), as a subcontractor to Bergey Windpower Corporation. A 50-kW PV array was supplied by Solarex Corporation. Two existing diesel units, currently supplying the village load, are being modified to interface with this hardware.

System Design and Configuration

A system schematic is given in Figure 3. PV panels are fixed. Control, data acquisition, fault detection, and diagnostics are primarily provided by the AES inverter's internal capabilities. A local operator interface is connected to the inverter via a serial link.

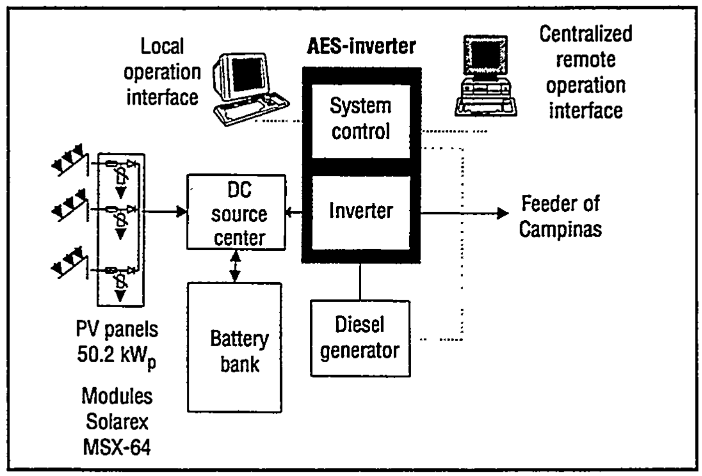

Figure 3. Simplified schematic of Campinas hybrid system.

Conclusions

The hybrid systems described here represent two significantly different approaches to the problem of remote power supply using renewable energy. Deployment of both systems is expected to provide the Brazilian utilities with installation and operating experience in hybrid power. Monitoring the performance of these systems will contribute significantly to the body of knowledge in hybrid power systems, influencing the design, implementation, and operating strategy of future projects.

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PROJECT BRIEF

Renewable Energy Electricity for Rural Social and Economic Development In Ghana

by Roger Taylor 3/97

Country Background

The Republic of Ghana is located between 4 deg. and 12 deg. north latitude, bordering the North Atlantic Ocean, between Côte d'Ivoire to the west and Togo to the east. The climate is tropical and extremely sunny; warm and comparatively dry along the southeast coast; hot and humid in the southwest; and hot and dry in the north. The country has about 18 million people with an average per capita income of approximately $400. In 1990 it was estimated that 70% of men and 51% of women age 15 and over could read and write.

Energy and Electric Power Sectors

Ghana's electric power system is operated by two parastatal utilities: the Volta River Authority (VRA) and the Electricity Corporation of Ghana (ECG). The VRA is responsible for power generation and transmission at 161 kilowatt-ampers (KVA) and 225 KVA. The ECG is responsible for power distribution in the south. In the north, the Northern Electricity Department (NED), a subdivision of VRA, handles distribution. VRA and ECG report to the Ministry of Mines and Energy.

The government of Ghana is committed to extension of electricity services to every community of 500 people or more by the year 2020. The *National Electrification Scheme (NES)* is planned to proceed in six 5-year phases over the period 1990B2020. The electrification of the several thousand unelectrified villages in the country has been assumed to be via grid extension, with community participation under the *Self-Help Electrification Program (SHEP)*. This will be a challenging and financially difficult task, due to (1) the low density of potential consumers of rural areas, (2) the low income levels in rural communities, and (3) the significant distances required for medium-voltage lines, the costs of medium-voltage and low-voltage lines, transformers, and service drops. Also, most of the equipment is imported, and over 90% of the cost of the equipment is in foreign exchange. And, because SHEP requires that communities be within 20 km of a medium-voltage line, many communities may not receive electricity services for several decades.

A national study has identified 4,221 village communities with a population above 500 inhabitants. As of 1991, when the study was submitted, only 478 of these communities had been electrified, all of them via grid extension. By December 1995 the number of electrified small communities had grown to 904.

Even if NES is completed as planned, many remote communities will still lack electricity. The use of free-standing photovoltaic (PV) systems can provide valuable electricity services to these smaller communities as well as to the larger communities that would otherwise be electrified via grid extension. *If the present rate of population growth (3%/year) continues, by the year 2020 the population of Ghana will have doubled; this presents an enormous added challenge to rural electrification.*

Project Objectives

The goal of the project is to facilitate the development of a national capacity, combining both private-sector and public-sector efforts, to use primarily renewable energy-based technologies, especially PV and PV/diesel hybrid power systems, to provide sustainable rural electric power services. These technologies would be used for both individual applications and centralized electrification of off-grid communities not technically or economically suitable for electrification via grid extension.

In this approach, the parastatal utility company VRA/NED will own and operate the power systems, and provide electricity services to the target villages, on a fee-for-service basis. Rural communities will not be expected to own, operate, or maintain the systems, although they will be expected to take good care of the equipment, and prevent it from being abused or damaged. They will also be expected to invest some "sweat equity" in the systems through contribution of labor and some capital for installation of power poles and assistance in the installation of PV units. Because the government of Ghana is presently subsidizing electricity prices, especially in rural towns, the government will cofinance the delivery of electricity services, while requiring a fee for service from the communities. There is some precedent (MOME-sponsored PV battery charging project in northwestern Ghana) in having rural communities pay for electricity services at a level comparable to current household payments (ca. $5 to $15/month equivalent) for candles, kerosene, dry cell batteries, auto batteries, and battery charging services. The pricing of electricity services will be determined in the detailed project design, but the government appears committed to moving toward cost recovery for electricity services as part of economic restructuring. This has become even more imperative with the recent passage of utility restructuring legislation.

A supporting objective of this project is to assess the technical and economic performance of these renewable energy options on a pilot scale that *fully reflects the environment in which they would be used on a much larger scale in subsequent investment projects.* The project is intended to remove barriers to the introduction and widespread diffusion of renewable energy-based technologies for off-grid electricity supply in rural Ghana.

Project Description

Twelve villages in the Mamprusi East District of Northern Ghana and the village of Tenzug in Northern Ghana have been selected by the government of Ghana for project participation. Microgrids powered by PV/diesel-hybrid systems for low voltage power supply will be established in three villages in the country under this project, and free-standing PV units will be used in nine others in a pilot region identified by the government. Market, and community, energy surveys, and resource assessments will be conducted to identify potential renewable electricity resources, suppliers, and users; technical standards will be established; local operators and NGOs will be trained; a local operation and maintenance center will be established to serve the pilot region; and standard contracts for private-|sector based electricity service companies will be designed. The parastatal Volta River Authority/Northern Electricity Department will play the central implementation role in spurring the widespread use of these technologies.

Community energy surveys will be conducted to assess likely energy consumption patterns, community willingness, and ability to pay for electricity. A community energy and socio-economic survey was initiated by the MOME in collaboration with VRA/NED and the National Renewable Energy Laboratory (NREL) for the target region.

Information will be developed for costs, training requirements, and operational problems and solutions encountered with the use of free-standing PV systems for hybrid power systems installed in the United States, Brazil, Mexico, the Philippines, Dominican Republic, Zimbabwe, Indonesia, Malaysia, Australia, and elsewhere.

Practical technical standards for equipment and installation practices will be established for such systems for Ghana. Preliminary standards will be established for the hybrid systems, including rigorous standards for hybrid system components. Equipment specifications will be developed by the VRA/NED and MOME in collaboration with NREL and with technical experts from the private sector with extensive experience with free-standing PV systems and with PV/diesel hybrid power systems products and applications.

Commercial equipment and appliances will be selected according to their simplicity, robustness, potential for local supply and eventual local production, and price. Particular attention will be paid to ease maintenance in Ghana. Negotiations with suppliers will be held to consider their conditions for participating in joint ventures and technology transfer operations.

PV Systems for Household Applications: Household PV systems will be installed in all 12 of the pilot communities, because those communities suitable for village minigrids will still have many households that are too far from the minigrid to justify direct hookup. The lighting options will include high-efficiency compact fluorescent units.

Many levels of energy service will be offered, providing different levels of service, to respond to the different levels of income and willingness and ability to pay for electricity. Services will be offered that range from portable solar lanterns through fixed solar home systems on the residential side, to community services such as water pumping, to systems for productive use applications such as refrigeration, sewing, carpentry, and grain grinding.

Several villages will be assessed for possible implementation of local minigrids powered by PV/diesel hybrid power units. These villages will also have some distributed PV systems for residential compounds and community functions that are located too far from the minigrid for hookup. Both technical and economic criteria will be used to determine the most suitable power generation system and distribution system designs, performance, and costs.

Establishment of a Regional Operations and Maintenance Center

Providing highly reliable electricity services on a sustainable basis in rural areas requires a local operation and maintenance capability. An operations and maintenance center will be established near the pilot communities. A monitoring system for the hybrid power systems will permit diagnostics and early warning of potential problems. Quick-response maintenance and repair capabilities will be necessary to respond to technical problems with the hybrid power systems. The center will also support the PV solar home systems.

The operations and maintenance center will be established and staffed by trained VRA/NED technicians. A government-owned former guest house is located in the town of Nakpanduri about 30 km northwest of the center of the pilot region in the Mamprusi East District, and is less than 10 km from the nearest of the pilot communities (Bimbagu). With renovation and equipment it will provide the facilities to support project implementation and post-project sustainability.

Project Status

The Project Document (action plan) is now being prepared for in-country discussion and consensus building. Once the Project Document has been approved by the government of Ghana and the UNDP/GEF, project implementation can begin, hopefully in late 1997.

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Joint U.S./Brazilian Renewable Energy Rural Electrification Project

by Roger Taylor 3/97

Introduction

In Brazil, it is estimated that about 20 million people do not have access to electric energy. A good fraction of this population lives in the relatively arid northeast part of Brazil. While the electric grid reaches all larger towns and is being systematically extended to rural properties and villages, these rural electric customers consume only very modest amounts of electricity, typically 10 to 30 kWh per month. The cost of even short distance grid extensions is often greater than $1,000, and, thus, investments in grid extensions for these populations are economically inefficient.

Small stand-alone PV systems can provide the basic low-energy consumption services desired by the rural peoples (lighting, TV, radio) for $500 or less, making this option a very promising alternative to grid extension.

A different situation exists in the north of Brazil. This is the region of the Amazon Basin. Many places are accessible only by boat, and 310 villages in this region have diesel electric generators, which often provide electric service for only 6 hours each day due to the very high cost of diesel fuel deliveries to these villages. Renewable energy hybrid (PV, wind, battery, diesel) power systems are of great interest to the state utilities and to Eletrobras (the main federal utility) as a method of enhancing electric services in the Amazon Basin while reducing diesel fuel consumption, and the associated cost of fuel deliveries. Today, electricity in these 310 villages is being subsidized by the rest of the Brazilian population at approximately $250 million per year. The demonstration of viable hybrid power system operation in these remote regions could open up a significant near-term market for renewable hybrid power systems.

Program Scope

The U.S. Department of Energy (DOE), through the National Renewable Energy Laboratory (NREL), is undertaking a two-phase cooperative joint technology research and demonstration effort with the Centro de Pesquisas de Energia Elétrica (CEPEL) in the Federal Republic of Brazil. The objectives of the Joint U.S./Brazilian program are:

(1) to establish technical, institutional, and economic confidence in using renewable energy, PV, and wind systems to meet the needs of the citizens of rural Brazil,

(2) to establish on-going institutional, individual, and business relationships (U.S./Brazilian partnerships) necessary to implement sustainable programs and commitments that benefit both Brazil and the United States, and

(3) to lay the groundwork for large-scale rural electrification through the use of renewable energy systems.

Phase 1

Phase 1 of this technology research and demonstration assessment program consisted of (a) providing PV electric lighting systems to about 350 homes in the Sertao de Sao Francisco region in the Brazilian state of Pernambuco; and (b) providing PV electric lighting systems to about 400 homes and 14 schools in the outback of the state of Ceará. Key system components (PV panels, batteries, and charge controllers) were provided by NREL to CEPEL under the terms of a contract for subsequent use by the state utilities in Ceará

(COELCE) and Pernambuco (CELPE). COELCE and CELPE were responsible for procuring the balance-of-system components not provided by NREL/CEPEL, and for performing the systems integration, installation, maintenance, and evaluation for a 3-year period following installation. All system installations were completed in early 1994.

In Phase 1, a total of 65 kW of PV modules, 1300 (100 Ah) batteries, and 900 charge controllers were provided. The electric utilities in Ceará and Pernam-buco provided all other equipment (structures, wiring, switches, DC breakers, housings, conduit, fluorescent lights and ballasts) and installation. Training courses for the installers were provided through a cooperative effort among CEPEL, the equipment vendor (Siemens Solar Industries [SSI]), and PV experts at the Federal University of Pernambuco.

Phase 2

The Phase 2 project expansion extends the pilot proj- ect into six additional Brazilian states (Acre, Alagoas, Amazonas, Bahia, Minas Gerais, and Para). Phase 2 also extends the demonstration of PV applications to a wider variety of stand-alone end uses as well as hybrid village power, and introduces the use of wind-electric power generation for selected sites and applications.

The hardware subcontracts awarded under Phase 2 have been executed in a manner substantially similar to the implementation of Phase 1, and were completed in October 1994. The subcontracts awarded under the project expansion have three primary tasks: system design integration assistance, supply of specific U.S. manufactured components to Brazil, and system installation supervision and operator training. The NREL agreement with CEPEL has also been extended to cover supervision of Phase 2 equipment installation and a 3-year operations and maintenance (O&M) period following installation.

Phase 2 stand-alone systems are being supplied to the Brazilian states of Acre, Alagoas, Bahia, and Minas Gerais. U.S. vendors providing this equipment include SSI, Solarex, Photocomm (using USSC modules), and Bergey Windpower. A total of 51.5 kW of PV modules, 195 charge controllers, 25 inverters, 32 water pumps, 5 wind-electric systems with water pumps, and 2 wind-electric systems with inverters will be shipped by the vendors in early 1995.

In addition to the stand-alone projects, two hybrid power systems are being installed in the Amazon basin. A 50-kW PV-wind-battery hybrid system will be installed in the village of Joanes, on the island of Marajo, near Belem, Pará. The system control and power processor is being supplied by New World Village Power, 4B10 kW wind machines will be supplied by Bergey Windpower, and 10 kW of PV modules are being supplied by SSI. A battery bank of approximately 500 kWh (exact dimensioning still to be determined) will be supplied by the local electric utility, CELPA.

The second hybrid system site is located at the village of Campinas, approximately 100 km upstream from Manaus between the Solimões and Rio Negro rivers at approximately 3.3E south latitude. Accessible only by boat, electricity in Campinas is supplied to 65 users through a local electric grid that is energized for 6 hours per day, from 6:00 pm to midnight, by one of two on-site 48-kW diesel generators. Diesel fuel is supplied to the power plant every 2 months and stored in a local tank.

A 50-kW PV-battery hybrid system will be installed in Campinas, with the option for 20 kW of wind generation if the resource proves sufficient. The system control and power processor is being supplied by Advanced Energy Systems Ltd., as a subtier contractor to Bergey Windpower. The 50 kW of PV modules are being supplied by Solarex Corporation. As with Joanes, a battery bank of approximately 500 kWh (exact dimensioning still to be determined) will be supplied by the local electric utility, CEAM.

Conclusion

The Brazilian utilities and federal government continue to show a strong interest in developing and deploying solar electric systems as an alternative to grid extensions. As evidence of the growing interest in renewable energy in Brazil, CEPEL has organized a PV working group among the utilities and other interested stakeholders. The Grupo Trabalho de Fotovoltaica has established a number of working committees to address the broad array of data, standards, and development concerns regarding PV commercialization in Brazil. The PRODEEM program was recently begun by the Brazilian federal government with the assistance of CEPEL to install solar systems in rural schools and health clinics.

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RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

A High-Penetration, Wind-Diesel Hybrid Power System Pilot Project in Northwest Alaska

by Steve Drouilhet 3/97

Background

The state of Alaska has approximately 250 rural villages that have no link to the central power grids serving the main urban areas. While a few of these villages have no central electric generating facility, the vast majority are served by diesel-driven generators and local village electric distribution systems. Despite Alaska's crude oil resource, diesel fuel must be imported by the rural villages. Because of the extreme remoteness of most of the rural villages and the lack of roads, fuel is delivered by barge to the rural communities. The great distances and difficult transport conditions result in a diesel fuel cost (delivered) ranging from $0.80 to $3.00 per gallon. The high fuel cost and high O&M cost of diesel generating stations result in electric generation costs that range from $0.15 to $1.00/kWh.

To ease the energy cost burden on rural inhabitants, the state Department of Community and Regional Affairs (DCRA) administers the Power Cost Equalization Program (PCE), which provides a subsidy to rural electric customers as high as 41¢/kWh and totals nearly$20 million. Because of declining Alaskan pipeline oil revenues, the fund from which the PCE subsidy payments were derived is expected to be depleted in approximately 6 years. To stave off a rural energy crisis, the state of Alaska is urgently seeking to develop alternatives and supplements to diesel for both electric generation and heating requirements.

In addition to the economic problems associated with diesel use, there are significant environmental problems as well. Since many of the ports along the coast and along the interior rivers are accessible only a few months per year, large quantities of fuel must be stored on-site in bulk fuel tanks. Many of the rural village tank farms have deteriorated with age and are leaking, contaminating surrounding soil. Environmental Protection Agency regulations threaten many village tank farms with closure. The DCRA estimates that it would cost $200 million to upgrade existing diesel tank farms to today's standards, not including the cost of environmental remediation. Beside fuel storage and transport problems, diesel operation introduces substantial noise and air pollution into the village environment. Use of renewable energy to reduce fuel consumption will also reduce fuel transport and storage requirements and their associated environmental hazards.

The rural power situation in Alaska is similar to that of many developing countries around the world, where rural electricity is provided, if at all, by small isolated diesel power plants. Alaska can be seen as a domestic proving ground for U.S. industry in providing rural power solutions using renewable energy to remote communities worldwide.

Project Objectives

This project will design, build, install, and test a high penetration wind-diesel system in Wales, Alaska, a small village on the northwest coast of Alaska with approximately 160 inhabitants, mostly Inupiat Eskimo. The new components of the system (wind turbines, power conditioning, energy storage, control system) will be integrated with the existing diesel power generation system, which has an installed capacity of approximately 400 kW. The project will also demonstrate the effective use of community heating loads to absorb excess wind energy and maintain grid stability.

We expect the hybrid system to consume 40-50% less fuel than the current diesel plant, with additional heating fuel savings coming from the application of excess wind energy to village heating. The Wales project will be a prototype to validate the technical feasibility and economic viability of high penetration wind-diesel hybrid electric generation systems for widespread applicability to rural villages, both in Alaska and internationally.

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Wind for Island and Non-governmental Development (WIND)

by Steve Drouilhet 3/97

Purpose

The purpose of the WIND project is to strengthen local capability to adapt wind-based energy technologies to numerous applications as an accepted means of supplying the energy necessary for local productive uses, leading to social advancement and increased self-sufficiency in indigenous economies.

The project seeks to mobilize sustained local interest and ability through demonstration and participation. This objective will be achieved through careful selection of at least 10 system applications at locations in the eastern islands of Indonesia for which energy delivery systems will be designed, installed and operated, all with the active participation of the local communities and non-governmental organizations.

One of the priorities of the WIND project is to stimulate interest in wind energy technology as an environmentally-safe, commercially-viable investment for local and regional economies to the extent that the practical application of these technologies leads to entrepreneurial opportunities and an increased market for related products and services provided through a system of local tariffs. This feature will enable possible project replication while providing a mechanism for ongoing system operations and maintenance, a vital ingredient for long-term project success.

Key Activities

Winrock International has contracted with the National Renewable Energy Laboratory (NREL) to provide technical assistance to the WIND project in the following areas:

- wind resource assessment
- technical training in wind energy technology and applications
- system design review
- system performance modeling and economic analysis
- system monitoring and evaluation.

Status

Twenty wind data-logging systems have been installed at various sites in the eastern islands of Indonesia and are currently collecting data to support the NREL/Winrock wind mapping effort. Ten Bergey wind systems have been installed on the islands of Timor and Sumba to provide energy for various community or entrepreneurial enterprises. The applications include water pumping for irrigation and household supply, peanut processing, lighting for community kiosks, a blacksmith shop, freezers for fish storage and popsicle production, and battery charging.

Plans (1997)

Continue wind resource assessment and mapping.

Continue site identification and project design activities.

Develop cost-effective system performance monitoring protocols, and install monitoring equipment on a representative set of systems.

Assist Winrock with system startup and commissioning.

Location: Nusa Tenggara Timur (NTT), Indonesia

Project Manager: Winrock International

Sponsor: USAID

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RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

The Ramakrishna Mission PV Project—A Cooperation Between India and the United States

by Jack L. Stone and Harin S. Ullal 3/97

Summary

The Sustainable Rural Economic Development Ramakrishna Mission PV Initiative was conceived as a small-scale demonstration project that would show the economic viability of photovoltaic (PV) systems in the Sundarbans region of West Bengal. The viability was to be predicated on the systems being economical without substantial subsidy, and eventually without any subsidy at all. The operation and maintenance of the systems were to be the responsibility of the chosen NGO, the Ramakrishna Mission. Mission personnel were to identify beneficiaries of the PV systems, define a financing arrangement that would be acceptable and sustainable to the villagers of the region, and serve as a banker to collect revenues from the end users. The potential for expanding the project beyond the limited demonstration was also a prime consideration. With U.S. systems used for the installations, our industry would also have the advantage of satisfying any future PV system purchases. The cooperative nature of the project would also be expected to lead to improved relationships between our two countries and lead to further trade expansion. The project was also designed so as not to distort market forces, (i.e., true costs). Further, without excessive subsidies, and with end-user money required for participation, the systems were expected to have the best of care. And most importantly, the benefits of electricity would be made available to those who in the past had little or no access. Improvements in educational opportunities, health care, productivity, and entrepreneurship would be standards for success of the project. Finally, the project should be self-sustaining. An infrastructure should remain that would support further applications including financing, education, training, repair, and maintenance. Successful PV deployment under these most difficult circumstances would pave the way to acceptance of the technologies as a way to fulfill the tremendous need for energy in the developing world.

Applications

The following applications and involved villages were initially identified and agreed to. In the village of Gosaba (with 1000 families), the training center will be provided 10 lights for 4 hours of operation each night, two 30-watt wall sockets, a battery-charging station for ten 100 amp-hour batteries and 20 solar lanterns, and 3 stand-alone street lights with 11-watt compact fluorescent (CFL) lamps. The possibility of mounting the charger station on one of the Mission's boats will be investigated. This would allow the service to be transported throughout the island communities. The village of Katakhali, with 100 families, will be provided 100 domestic lighting units with one 11-watt CFL and one 30-watt socket per home. The youth club will have two 11-watt CFLs and one 30-watt wall socket. The village of Pakhirala will have its weaving center provided with three 11-watt CFLs, a community street light and eight 11-watt CFLs with two 30-watt wall sockets. These additions to the weaving center will extend the productivity hours by about four per night. The health clinic in Satyanaryanpur will receive a vaccine refrigerator and eight 11-watt CFLs with two 30-watt electrical sockets. A second battery-charging station for ten 100 amp-hour car batteries will be placed at the Chota Mollakhali youth center. The village of Kumirmari will have 100 home lighting systems installed. The village of Satjelia will be furnished 100 domestic home lighting systems with a 9-watt CFL and a 30-watt electrical socket.

The 2 week training program will be available for 16 participants who have been chosen by the Mission for their background in basic electrical applications (including radio and television repair). The Mission has a very good reputation for providing high-quality training in a variety of areas. Remote Power International prepared a detailed training manual that will be left for the Mission to continue training sessions after the National Renewable Energy Laboratory (NREL)-funded trainers leave the area. The last week of training will be used to do hands-on installations in the island communities. Applied Power Corporation, the prime contractor for the project, has prepared detailed schematics and installation procedures for all systems provided.

Project Responsibilities

The agreement calls for 50-50 cost sharing: the United States provides the PV modules, charge controllers, a water pump, and the training; India provides the batteries, compact fluorescent lamps, lamp fixtures, a vaccine refrigerator, mounting structures, all balance of systems components, and solar lanterns, and pays all custom duties for the imported system components. The Ramakrishna Mission is responsible to identify the recipients of the various systems and participants in the NREL- furnished training sessions, provide follow-up training, maintenance and replacement, and serve as the collector of revenues from the end users. NREL will also work with the Mission to identify potential private sector partners with whom proposals will be submitted to IREDA to move the project beyond the limited size possible from this initiative.

Project Financing

In India, the domestic unit of two lights plus one wall socket along with the necessary PV panel, battery, and accessories cost approximately Rs. 14,000 ($1 ≈ Rs. 35). Out of this amount Rs. 6,000 is available as a government subsidy. Hence, the amount to be borne by the user is Rs. 8,000 per unit. The end user will be asked to provide a down payment of Rs. 3,500 at the time of installation. The rest of the amount (Rs. 4,500) will be treated as a low-interest loan to be repaid in monthly installments of Rs. 40 per month over 10 years. In this way Rs. 40 x 12 months x 10 years or Rs. 4,800 will be realized Rs. 4,500 against the loan and Rs. 300 as interest. In addition, an amount of Rs. 20 per month will be charged for each unit as maintenance charges for which the users will receive free service at their doorsteps. However, the costs for spares will be at the owner's expense. Thus the users will pay a total of Rs. 60 per month for 10 years. They may also opt to pay Rs. 100 per month (80+20) for 5 years. For a few beneficiaries of special category who are not in a position to make the Rs. 3,500 down payment, provision will be made to pay Rs. 500 only during installation and the rest of the amount will be treated as a loan to be repaid in 5 to 10 years. After the loan is liquidated, ownership will be transferred to the users. The amount recovered from the end users in the form of the down payments and loan interest will form the Revolving Fund Capital for the project, which in turn will be used to replicate the program to other villages and other beneficiaries of the same village.

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RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

Sizing of Stand-Alone Power Systems for Rural Health Facilities

by Tony Jimenez 3/97

Overview

t is estimated that two billion people currently ive in areas that lack electricity. Many of these ıreas will not be connected to the grid in the :oreseeable future due to high grid extension :osts. Areas beyond the grid are serviced by a variety of stand-alone systems. These stand-ılone systems can consist of combinations of photovoltaic (PV) panels, wind turbines and generators running on diesel, or gasoline or propane. Stand-alone systems range in size from solar lighting systems providing 100–200 watt-hours per day to diesel mini grids with peak capacities of over a megawatt.

In a remote community the first facility to be electrified is often the local health clinic. Traditionally this was done using fossil-fuel generators. More recently, PV panels have been installed in some clinics to provide electricity. Wind turbine generators (WTGs) have received less consideration for providing electricity to clinics. This thesis examines the least cost options for providing stand alone power to a clinic under a variety of climactic and economic conditions. In this study three load profiles are developed for typical rural clinics of different sizes. A stand-alone power system is designed for each load for three different climactic regimes, including South Africa, Indonesia, and Brazil. Parametric analysis is done around these optimal systems to study the effects of wind speed, fuel price, capital costs, and type of wind on a hybrid system.

Typical Applications Requiring Clinic Electrification

Lighting

Electric lights are used in practically all electrified clinics. Electric lighting is vastly superior to candles and kerosene lamps. Often when a clinic is electrified, lights are included in the initial installation package. Due to the need to conserve electricity, most off-grid clinics use compact fluorescent lights that typically draw from 5 to 20 watts each. Even in clinics that use daylighting, electric lights make emergency night care much easier.

Communication

Communications equipment ranks with lighting as the most important equipment when a clinic is electrified. Radio and satellite enable the clinic staff to consult with specialists as needed and to arrange for the speedy evacuation of a seriously ill/injured patient.

Refrigeration

In the last 15 years great progress has been made in the development of vaccine refrigerators. These are small, highly efficient, usually DC, refrigerators that can be powered by a modest sized solar array. Typical models draw 80–120 watts and will run for around 10 hours per day. Some super efficient models use even less energy. Even though they are expensive, these refrigerators are increasing in wide spread use. These refrigerators are so important that the World Health Organization has set standards for them. Like lighting, a vaccine refrigerator is often included in the installation package when a clinic is initially electrified.

Other equipment that can be used in clinics include small water pumps, ceiling fans, small sterilizing stoves, vaporizers, computers, centrifuges, and TV/VCRs. The latter are used not only for entertainment, but to show instructional and public health videos. Larger facilities such as district hospitals may have additional laboratory equipment.

Typical Services Offered at Clinics

Inoculations

Treatments:

Respiratory infections	Venereal diseases
Diarrheal diseases	Skin disease
Eye disease	Malaria
Parasitical diseases	

Pre-natal/post-natal care and child birth

Trauma:

Burns	Simple fractures
Wounds	Burns

Dental

Referral to hospitals

Public health education
Family planning

Electrical Appliance Data

Item	Power (Watts)	Duty Cycle (hours/day)	Energy Use (kWh/day)
Lights	5–20	Varies	Varies
Radio (2 way)	75	1	0.075
Refrigerator	60–120		0.3–0.7
Stove	200–500	1	0.2–0.5
Vaporizer	35–70	1	0.035–0.070
Computer			
Ceiling fan	5–20	Varies	Varies
Centrifuge			

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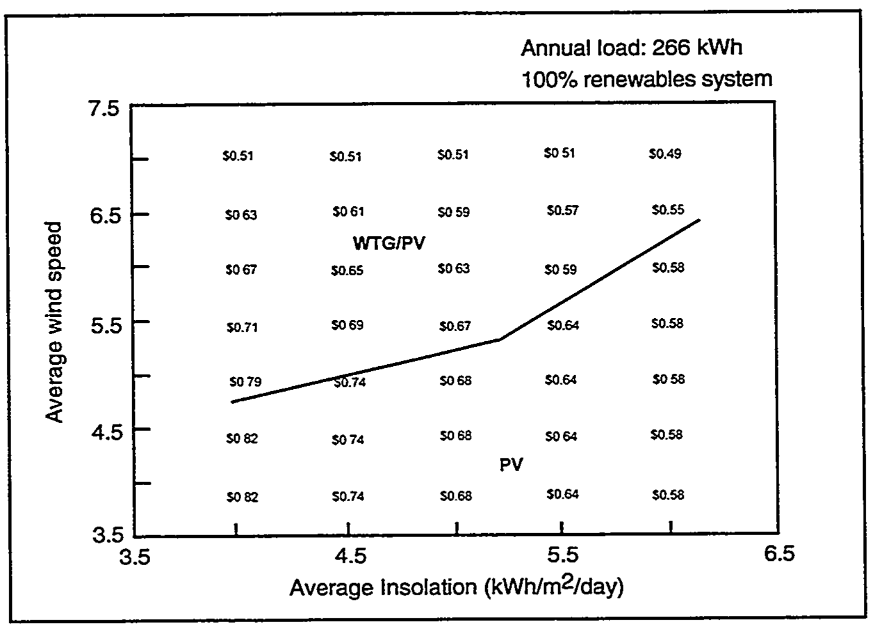


Figure 1. Health post cost of energy, $/kWh

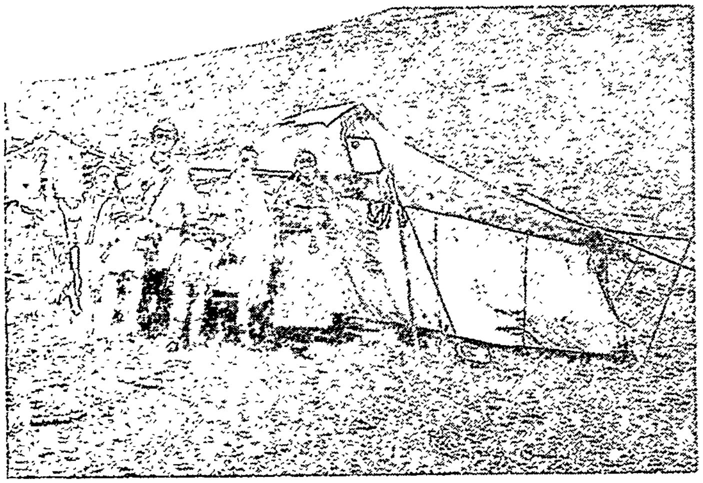
Appendix C

Project Briefs - The Solar Electric Light Fund

Solar Electric Light Fund

Photovoltaic Rural Electrification

Power to the People



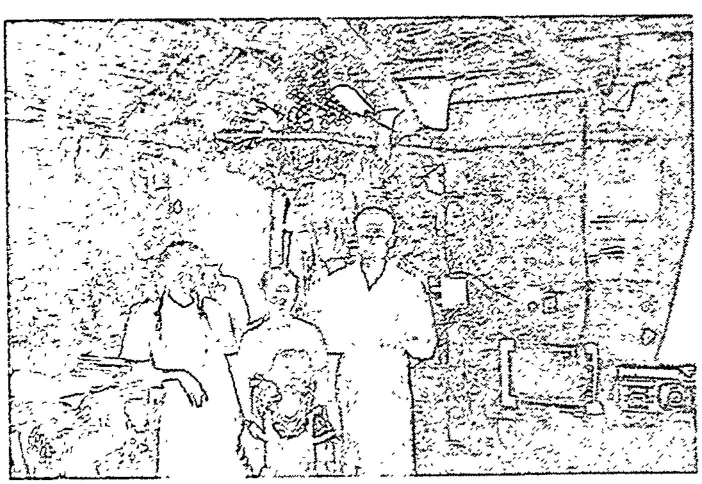
Tibetan herders in Western China enjoy the benefits of electricity produced by a small PV panel.

Our Mission: Solar Electricity for the Developing World

The Solar Electric Light Fund, (or SELF, for energy SELF-sufficiency and SELF reliance) was founded as a non-profit charitable organization in 1990 to address the issue of how 70 percent of the people in the third world are going to get electricity without doing additional damage to the planet.

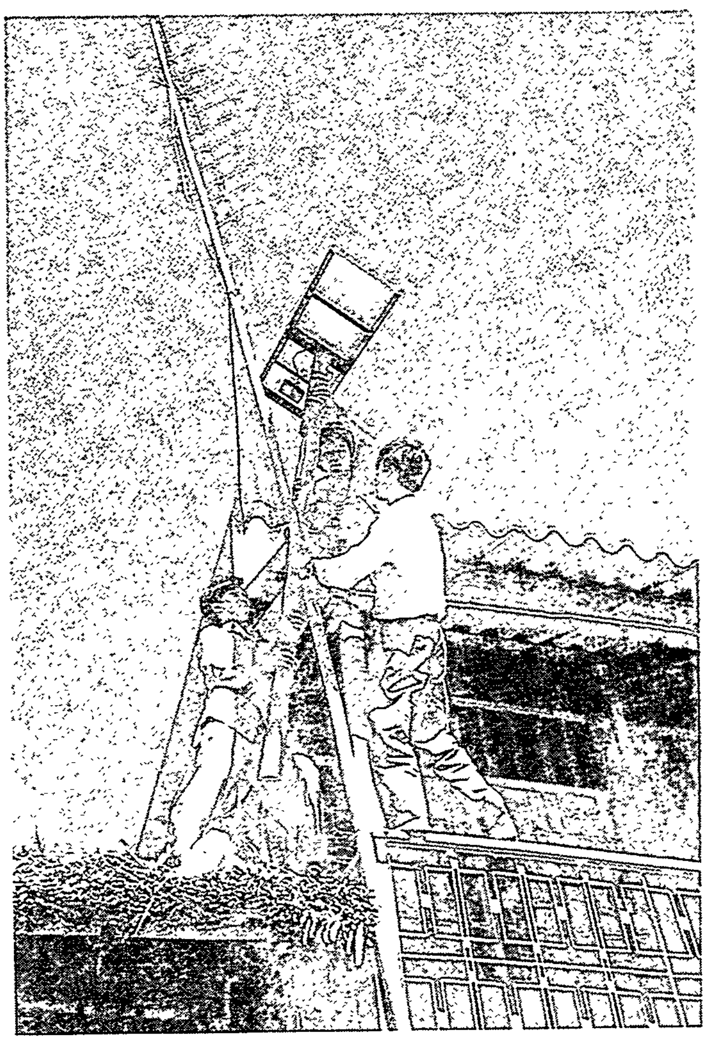
Two billion people attempting to emerge from centuries of darkness into an electrically lighted future will be one of the critical issues of the 21st century. Developing countries will produce the largest increase in greenhouse gas emissions. But for millions of people, there is a non-polluting way to get electricity-- from the sun!

Generating solar electricity at the individual household level is the only known sustainable and already proven means of meeting the electric power needs of the widely dispersed rural population of the developing world.



A solar home system in Sri Lanka powers lights, television, radio.

Hundreds of millions of families in the developing world still don't have electricity. They use kerosene and dry cell batteries for lighting and radios. Instead of waiting for the grid tomorrow, which may never come, we are hooking them up to the sun today! Rural families already pay ten dollars a month for kerosene and batteries. Small photovoltaic (PV) systems can bring light and electricity to a home for as little as $500. While families can't pay this up front, they can afford a solar home system over several years through SELF-financed credit programs.



Installing a solar module in Viet Nam

Acting as a catalyst, SELF provides technical and financial assistance for solar energy in the developing world. SELF operates solar rural electrification programs and enterprises in India, China, Viet Nam, Indonesia, South Africa, Brazil, Uganda, Nepal, Sri Lanka, Tanzania and the Solomon Islands.

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Solar Electric Light Fund
Photovoltaic Rural Electrification

NEWS RELEASE

SELF and Vietnam Women's Union Host Vietnam's First National Workshop on Solar Rural Electrification

April 22, 1997, Washington, DC: On April 4 The Solar Electric Light Fund (SELF), a Washington, DC-based non-profit organization that develops solar electrification projects in developing countries, sponsored a one-day workshop in Hanoi in association with the 11-million-member Vietnam Women's Union (VWU).

The VWU together with SELF's support has electrified 240 households and 5 community centers with solar photovoltaics (PV) during the past two years in a project aimed at bringing energy SELF-sufficiency to rural families without access to the electrical grid. Families make a 20% downpayment, then pay off their solar home systems (SHS) over 4 years, replenishing a revolving credit fund operated by the VWU allowing more families to purchase SHS. The project to date has received support from the Rockefeller Brothers Fund and the U.S. Dept. of Energy.

The first *"National Workshop on Solar Electrification In Support of Women in Remote Areas"* attracted 75 participants from The World Bank, the United Nations Development Program, the Danish, Swedish and Italian governments, the Ministry of Planning and Investment, the Institute for Energy, Electricity of Vietnam, the Vietnam Bank for Agriculture, The Rockefeller Bros. Fund, and the Solar Electric Light Company, along with regional officials of the VWU who have managed the pilot solar program in three provinces. SELF also flew SHS users from the Mekong Delta to the conference; it was their first time on an airplane and the first time they visited their country's capital, Hanoi.

The VWU and SELF together are proposing a one-million SHS program over the next ten years that would bring household power and light to some of the 7 million families (about 50 million people) who have no prospect of getting a conventional electrical hookup in their lifetimes. Vietnamese energy planners have made it clear that much of rural Vietnam, where the majority of the population live, will be bypassed by new power projects that will serve industry and the cities. The country's first national rural electrification master plan being prepared by World Bank consultants (who attended the conference) will integrate renewables, including solar PV, into the overall rural power delivery system.

The first-of-its-kind conference in Vietnam was sponsored by the Wallace Global Fund of Washington, DC.

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SRI LANKA
SOLANKA ASSOCIATES

In 1991, The Solar Electric Light Fund helped to launch SoLanka Associates, a development-focused, service-oriented, non-profit organization devoted to the development and promotion of solar photovoltaics in Sri Lanka. SoLanka was founded by Priyantha Wijesooriya, who holds a Master of Science degree in solar engineering from the University of Massachusetts at Massachusetts. Returning to his native Sri Lanka, Mr. Wijesooriya organized a program to bring solar home systems (SHS) to rural villages. Seventy percent of rural Sri Lanka remains unelectrified.

In 1992, SELF and SoLanka assisted the people of Morapatawa village in Sri Lanka's Northwestern Province to organize the country's first "solar co-op". The village of 111 families lies approximately 100 miles north of Columbo, and five miles from the nearest power line, in a dense low jungle near the sea. Solanka and the villagers established the "SoLanka Sun Society of Morapatawa Village" to manage a revolving-credit fund, capitalized by SELF. The revolving fund is used to finance solar home systems for its members. To obtain a system, Morapatawa Sun-Society members pay a small down payment and 96 monthly installments on a declining scale as the annual interest is paid. Payments go into the locally-managed fund which other families are able to access for solar loans as the fund grows. Each SHS, costing around $400, provides enough electricity to power several fluorescent lights, and a television or radio. After five years, the initial 48 families have paid enough into the revolving credit fund so that an additional 25 families have been able to borrow money to purchase SHS.

Following the success of Morapatawa, SoLanka expanded the solar electrification program to other villages. Twenty miles away, at Maha Thorawa Village, Rotary International provided money to capitalize a loan scheme that provided solar power to another one hundred families. Ultimately, SoLanka's solar seed projects, by increasing downpayments and interest rates as demand warrants, will demonstrate that continued outside dependence is unnecessary in implementing sustainable grass-roots level solar development programs.

In 1995-96, SoLanka Associates and the Solar Electric Light Fund began developing a business plan for a commercial rural solar energy service company. Solanka's Wijesooriya formed the Renewable Energy Service Company Asia, Ltd. (RESCO-Asia) in 1997. RESCO will access credit financing provided by the World Bank's Energy Services Delivery Loan ($24 Million). SELF initially campaigned for multilateral development assistance for solar electrification in Sri Lanka, and assisted the World Bank in the initial stages of preparing its recent loan for this purpose. The near-term solar home systems in Sri Lanka is estimated to be 450,000 rural households.

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SRI LANKA

SARVODAYA SHRAMADANA MOVEMENT

In 1991, SELF organized a two-year solar "introduction and development" project in association with Sri Lanka's largest NGO and self-help organization, the Sarvodaya Shramadana Movement. Representing 6000 villages--most of them without electricity--Sarvodaya, based on Buddhist principles, was founded 34 years ago by Dr. A.T. Ariyaratne, an internationally-renowned rural development visionary and activist. Today, Sarvodaya has 3 million members.

SELF and Sarvodaya, with financial support from the W. Alton Jones Foundation, trained 16 solar technicians in early 1992, drawing on skilled youth employed by Sarvodaya Rural Technical Services (SRTS), which handled the project in partnership with SELF. By August, 1992 the project had introduced solar electricity to 100 rural villages. SELF provided "technology inoculation", and SRTS conducted a two week training course in which 10 "showcase" systems were originally installed. SRTS then independently installed 90 more systems, purchased wholesale from the Colombo based *Solar Power & Light*, in various Sarvodaya community centers, primary schools, and Buddhist temples to provide lighting for after-dark classes, meetings, and study.

Thanks to the excellent training by SP&L's engineers and technicians, provided by SELF, Sarvodaya's technical people quickly adapted to their new calling. Six months later they were expert solar technicians, each two-man team having installed 12 to 14 systems.

The majority of the 100 "solar introduction" 36-Wp 6-light systems were installed at village Buddhist temples, and are looked after by the local Buddhist "priest" (monks). In the villages of Sri Lanka, the priests are local leaders, advisors, healers, and educators, and are generally a progressive force. The temples, which often serve as schools and community centers for evening education, were chosen to showcase solar lighting.

SELF then organized and capitalized a pilot revolving grass-roots credit scheme managed by Sarvodaya's Rural Enterprise Program which administers the central solar fund. One hundred and fifty systems were initially installed; more are being installed as payments replenish the revolving fund. Payment terms are 5 years at 10%, with a 10% deposit. Sarvodaya's village credit cooperatives operate the program locally, collecting monthly payments from beneficiaries. The Sarvodaya "Solar Seed" program, introducing solar to 100 villages, created a large demand for solar electricity, and dozens of families eagerly signed up for loans in each village.

Dr. Ariyaratne has called for a "Million Home" solar program to be funded by the World Bank, other donors, and the Sri Lankan government. A US$24 Million Energy Services Delivery Loan from the World bank, which contains a subsidy from the Global Environment Facility and which SELF initially helped prepare, was approved in 1997. A substantial portion of the loan is targeted for solar PV rural electrification, to be implemented through organizations like Sarvodaya, which has undertaken a pilot stage for the World Bank to electrify 2,200 homes with SHS.

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SOLOMON ISLANDS

The Solar Electric Light Fund (SELF) established the first solar-electric village in the Solomon Islands in early 1997. The 50-house Sukiki Village Power Project was undertaken in partnership with the Guadalcanal Rural Electrification Agency (GREA), a non-governmental organization based in Honiara which was established as the local partner for the project. The project was sponsored by the Council of State Governments, and the US Asia Environmental Partnership, with additional support from the Maryland Department of Business and Economic Development, and the Maryland Energy Administration

The Solomon Islands is the third largest archipelago in the South Pacific, located to the east of Papua New Guinea. The islands are sparsely populated, with 400,000 people living on three hundred islands. Aside from the capital city of Honiara, which receives its electricity from a diesel-powered grid, very few of the towns have access to electricity. Ninety percent of Solomon Islanders live in rural areas, and still rely on kerosene as a source of home lighting.

SELF undertook the electrification of Sukiki, a small village located on the southeast coast of Guadalcanal. A photovoltaic training course led by Johnny Weiss of Solar Energy International (SEI), of Carbondale, CO, was carried out to teach the fundamentals of PV design prior to installation of the solar home systems. Village technicians as well as other students from the College of Higher Education, the Ministry of Energy, Mines, and Minerals, and the Solomons Islands Electricity Authority (SIEA) were trained in PV design, installation, and maintenance in order to provide on-going technical support to the systems.

Each solar home system consists of a 50Wp Solarex module, a Morningstar charge controller, a battery, and three compact fluorescent lights. The SHS provide enough electricity for several hours of lighting as well as radio. Installment credit for the purchase of SHS was made available through a revolving credit fund managed by GREA. Participants pay a $50 downpayment, followed by monthly installments of US$15.00 over four years. Money repaid to the credit fund will be used to provide financing for additional families.

The project in Sukiki presented numerous challenges. Transportation to Sukiki was only possible by outboard canoe, and required skillful navigation through coral reefs. All wiring and mounting equipment for the project had to be imported to Honiara, and transported by boat to Sukiki. Once all the equipment arrived, the SHS were easily installed under the supervision of SELF Technical Manager Marlene Brown.

Thanks to the project, fifty families in Sukiki now enjoy the benefits of electric lighting. Household incomes will rise as productive activities extend into the evening hours. Children will have more time to read and study. No longer will the people of Sukiki have to breath in smoky kerosene fumes on a daily basis, nor will they be vulnerable to injuries or deaths caused by kerosene-related accidents. At a ceremony commemorating the project, the Premier of Guadalcanal Province declared Sukiki to be the first solar-electric village in the Solomon Islands, and expressed hope that it could be replicated in many other villages throughout the Solomons.

GREA has subsequently received many requests for SHS from other villages in the Solomons. Publicity generated by the project, including a radio program broadcast for five consecutive days after the opening ceremony, helped to garner support for the expansion of solar rural electrification. Based on its experience in Sukiki, GREA hopes to develop a larger-scale SHS program in the Solomon Islands.

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INDONESIA

SELF launched a 100-Household Solar Home System project in the West Java region of Indonesia in 1996 under the auspices of a "State Environmental Initiative" grant program sponsored by the Council of State Governments and US-Asia Environmental Partnership.

The archipelago of Indonesia comprises over 13,000 islands. At present, only 20,960 of the more than 60,000 rural villages are connected to a public electricity grid, leaving 25 of 36 million rural Indonesian households to rely on kerosene, dry cell batteries, and candles for lighting. The Government of Indonesia, through its national utility company, PLN, aims to connect another 11,600 villages through grid extension, but at the current pace, it will take at least another forty years to achieve this goal. Even under this ambitious grid extension program, over half of all Indonesian villages would remain unelectrified. In order to accelerate rural electrification, the government has begun to support solar rural electrification, and has recommended a "Fifty Mega-Watt Peak (50MWp) Photovoltaic Rural Electrification Project", to install one million SHS over the course of the next ten years. Working towards such a goal, SELF helped to further demonstrate and showcase a successful local grassroots model.

SELF's Indonesia project is being managed by PT Sudimara Energi Surya, a private solar energy service company in Indonesia with extensive experience in the sales and marketing of solar home systems. All hardware for the project has been supplied by Maryland firms, including Solarex Corporation, Morningstar Corporation, and Atlantic Solar Products, Inc. Sudimara has contributed hardware costs to the project in the form of BOS components (battery, lights, wiring, mounting structure, etc.) and additional soft costs in the way of installation, local management, technician training, monitoring, and publicity.

The SELF/Sudimara project was carried out in Cibeber, a subdistrict in West Java comprised of eight unelectrified villages which encompass part of the Halimun Game Reserve. Recipients of these 100 solar home systems were required to make an initial downpayment of $100.00, followed by monthly installments of roughly $10.00 over a three and half year period, representing an interest rate of approximately 30% for financing that is made available to the end-user. All payments are collected by Sudimara and used to finance additional solar home systems for the Cibeber communities.

Sudimara is the only company in Indonesia selling SHS on credit. At present, Sudimara sells 300 systems (mostly 50Wp) every month through a network of 50 Solar Service Centers located in three provinces -- West Java, Central Java, and Lampung in south Sumatra. As the leading SHS company in Indonesia, Sudimara is poised to become the largest participant in a recently-approved World Bank and GEF-sponsored loan package to finance solar home systems in Indonesia. SELF and Sudimara will be collaborating on putting these funds to work to electrify rural Indonesian homes with solar PV.

Prior to the SELF project, Sudimara had not utilized American-made solar hardware. At the same time, SELF was able to cross-pollinate project development experience between its projects in other countries and Sudimara's Indonesian operation, to the benefit of both parties, thereby furthering the international knowledge of "best practices" in the commercialization of SHS.

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UGANDA

SELF has completed its Uganda Pilot Solar Electrification Project in partnership with Habitat for Humanity, International. One hundred rural Ugandan homeowners now have the benefit of solar electricity in their new Habitat-built homes, thanks to solar home systems financed and installed by the Solar Electric Light Fund (SELF) of Washington, DC. Funds for the project were provided by a grant from the U.S. Department of Energy, Office of Solar Energy Conversion.

SELF installed solar electric systems on the roofs of one hundred rural homes, that were built by Habitat for Humanity, Uganda. The homes were built in various locations throughout Uganda, well beyond the reach of the electric grid. SHS recipients were qualified mortgage holders and could afford, with loan financing, to enhance their new homes with the installation of solar home systems (SHS), which use small solar panel to convert sunlight into electricity. During the day, electricity charges an electric storage battery, which is used to power several compact fluorescent lights, as well as a television or radio. SHS for the project cost approximately $400 installed and were supplied by Solar Energy for Africa (SEFA), a Ugandan-owned solar company using products made in the U.S. Families were offered 3 to 5 year loans for the purchase of the systems, with monthly payments equivalent to the cost of kerosene, candles and dry-cell batteries

SELF trained Habitat's Uganda personnel in solar pilot project management, and provided technical training for a core of local Habitat technicians to install and maintain the SHS. Training and field supervision were provided by SELF's Nairobi-based Associates, Energy Alternatives Africa. Solar Energy for Africa (SEFA), a Kampala-based solar energy firm was contracted to undertake the training, homeowner education, PV system installation, and service.

Habitat's Uganda office, which operates a home-building credit program, was utilized to collect monthly installment payments from the users. The money is capitalizing a revolving credit fund to be used for the purchase of additional solar systems. In order to avoid conflicts between loan repayments for their homes and their SHS, homeowners were required to have fully paid for their Habitat home to qualify for a SHS loan. As a result, *many families paid off of their Habitat for Humanity mortgages early in order to acquire electricity from an SHS.*

"News of the opportunity for solar electrification of Habitat for Humanity houses in Uganda was received with jubilation," said Sefatiya Mboneraho of Habitat Uganda. "The solar systems have raised eyebrows among people in our communities, from Rwenzori to Masindi, sensitizing them on what solar energy can do to avail them of electricity in rural areas of Uganda, hitherto a dream!"

The Government of Uganda is currently investigating how it can launch a national solar electric lighting program for its millions of rural people forced to rely on kerosene, candles and dry-cell batteries for light and communication. SELF, Habitat for Humanity International–based in Americus, Georgia– and the U.S. Dept. of Energy expect this pilot solar program will light the way for Uganda to put solar to work for its people.

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SOUTH AFRICA

SELF manages a small but highly-visible PV pilot project in the Zulu community of Maphaphethe in the Valley of a Thousand Hills in KwaZulu/Natal, South Africa. With a grant from the U.S. Department of Energy, and a contract with the South African Ministry of Energy in Pretoria, SELF brought the first solar home systems (SHS) to this rural Zulu community in early 1996. Working with the KwaZulu Finance Corporation of Durban, SELF provides guarantees for an experimental solar loan program so families can purchase their SHS on installment credit. The development bank collects directly from the users, who pay at the nearest branch or have their bank accounts debited monthly.

The 12,000-member community, headed by a young progressive Nkosi (chief), provides an attractive future market for a sizable program of domestic solar electrification in a region that South African utilities do not expect to reach for 5 to 10 years (if ever). Solar home systems specified by SELF cost approximately $600 and contain a 53 Wp solar module, charge regulator, 4 compact-fluorescent lighting fixtures, wiring, 98 Amp-hour deep-cycle battery, switches and mounting hardware. Loan terms are set at current development bank loan rates, with a 10% downpayment and 3 years to pay the balance. So far there have been no defaults, and the user pays the full cost of the systems without subsidy.

SELF initially provided a 200Wp community solar lighting system for the local courthouse to demonstrate the viability of this non-grid electric technology.

SHS installation and maintenance is provided by local technicians trained by SELF South Africa's project manager. Most of the technicians and project "motivators," who sign up families for the program, are young Zulu women. A Women's Solar Cooperative for Maphaphethe is being organized so the women can take over the project administration themselves.

SELF South Africa is acting as the not-for-profit middleman between the distributor and the end user. It is intended that eventually the women's Solar Co-op itself will become the "dealer," purchasing future systems (on both cash and credit basis) directly from PV distributors. In this way, solar home systems become more affordable; credit is provided to those who need it, and a community owns its own domestic solar power generation. The Cooperative, as its own solar dealer, would be like a municipality that buys bulk power from a utility. Communities could then purchase "electricity" directly from solar component manufacturers and their South African distributors.

SELF believes the program can be replicated widely throughout South Africa if the model proves successful. Currently, 3.7 million families in South Africa have yet to receive electric service from the grid; for at least half of them, solar PV can provide the most immediate and least-cost solution. The government of S.A. has been watching SELF's pilot project closely and is currently exploring the best means of widespread dissemination of SHS.

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VIETNAM

SELF launched a first-of-its-kind household solar PV project in Vietnam in association with the Vietnam Women's Union (VWU) in February, 1994. The VWU is a nationwide social service organization with eleven million members. The first two stages of the officially named "Solar Project in Support of Rural Women" have been completed. The program has directly benefited over 1,500 people through the installation of solar home systems (SHS) installations, and indirectly benefited hundreds more through solar systems in village community centers and village markets. Preparations are being made for a larger-scale program of solar rural electrification.

During the first stage of the project, 115 SHS were installed in rural communities in the provinces of Tien Giang and Tra Vinh in the Mekong Delta. Another 15 were installed in Hoa Binh Province near Hanoi with the assistance of the Institute of Energy, the government agency responsible for renewable energy research and development. In the second stage completed in February 1997, SELF and the VWU installed another 110 SHS in the Tra Vinh communes of Long Hoa and Hoa Minh. For the projects, 22Wp United Solar Systems "Uni-Kits" and 35 Wp Siemens modules were used, all with US made charge controllers and batteries. Vietnamese-made light fixtures, inverters, and mounting hardware were also employed. Solarlab, a PV technology group based in Ho Chi Minh City, was contracted by SELF to provide technical assistance directly to the Women's Union, and to oversee the after-sales maintenance program.

SELF also installed larger PV systems to provide electricity to community centers and village markets. Four 225Wp PV systems from Siemens Solar and one 490Wp community center system from ASE Americas were installed in village community centers. The systems were cost-shared with the local communities, who were responsible for providing AC television sets and VCRs for communal video viewing. In addition, two village markets were illuminated through the installation of two U.S.-made 100Wp solar street lights.

SELF's Technical Manager, Marlene Brown, along with Solarlab, trained a total of 25 local technicians on behalf of the Women's Union. In addition, the VWU trained 20 "motivators" to sign up families and collect their down-payments. Customers pay 10% down and make four years of monthly payments to the VWU revolving credit fund. As the solar fund grows, additional SHS are purchased through SELF.

Two hundred and forty rural families can now enjoy solar light in their houses. Many of the families have purchased black-and-white TV's and can now access educational and entertainment programming. Before SELF and the VWU joined forces to disseminate SHS, only solar battery charging stations and remote telecommunications facilities had made use of PV technology. The first two phases of the project have been funded by SELF, the Rockefeller Brothers Fund, Sandia National Laboratories' Photovoltaic Design Assistance Center, and The Wallace Global Fund of Washington, D.C.

SELF is actively working with the VWU to launch an economically sustainable, national household solar electrification program. The program would serve the 70 percent of Vietnam's population without electricity. The VWU's solar project has been approved by Electricity of Vietnam to serve rural people. In April 1997, SELF and the VWU sponsored a national seminar on solar electrification in Hanoi, attended by government policy makers and planners, practitioners and PV users, and representatives of the World Bank, UNDP and other donors.

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INDIA

SELCO Photovoltaic Electrification, Pvt., Ltd. (SELCO) was founded by the Solar Electric Light Fund (SELF). With initial funding from the Rockefeller Brothers Fund, SELCO was established in 1995 to market, install, and service Solar Home Systems (SHS) in south India. Doing business as The Solar Electric Light Company, SELCO has achieved international recognition as the first company to concentrate on marketing and servicing SHS in the rural Indian market. Under the direction of Managing Director H. Harish Hande, SELCO had installed over 500 SHS by early 1997.

SELCO has focused on providing reliable electric service to its customers, rather than simply selling a product. The Company uses TATA-BP solar modules and deep-cycle batteries purchased on the Indian market, while manufacturing its own lights and charge controllers. Currently, its primary products are 22 and 35 watt SHS, and it will be introducing a 50 Wp system to customers shortly. These systems provide sufficient electricity to power two to six compact fluorescent lights for several hours, as well as a radio, black-and-white television, or small fan. SELCO also performs high quality installations on each of its sales. Each SELCO SHS is installed with PVC conduit, switches, and additional outlets for lights or small appliances. After-sales service of SELCO SHS is also an essential part of the SELCO approach. Through its network of solar service centers (SSCs) and service technicians, SELCO provides after-sales service for one year on all SHS sold. Periodic maintenance checks on installed systems are made throughout the year to ensure the functioning of equipment, and provide further user instruction. Throughout rural Karnataka and Andhra Pradesh, the SELCO name has come to stand for quality, and interested customers have begun to ask for a "SELCO", rather than a SHS.

SELCO has been successful by coupling quality products and after-sales service with customer financing. SELCO has worked with several rural banking groups to set up financing programs for interested customers. Qualified homeowners can borrow money at Government subsidized rates for the purchase of a SHS, paying 25% down and repaying the remainder to the bank through monthly payments over 3 years. SELCO has set up financing programs through several rural banking institutions, including Syndicate Bank, the fifth-largest in India, with over 1,500 branches in South India. SELCO is the only company currently sanctioned to supply and service SHS for Syndicate bank borrowers. SELCO is also financing SHS through low-cost World Bank funds available through the PV Lending Program of the Indian Renewable Energy Development Agency (IREDA). Through the IREDA funds, SELCO has been able to provide SHS financing to members of several farmer societies and cooperatives in South and Central Karnataka. SELCO is the first organization to use World Bank funds to provide SHS financing for rural customers.

There is an enormous demand for rural electricity in south India, with more than ten million families in India's four southern states still unconnected to the electricity grid. In addition, there is a growing demand for SHS from grid-connected households which experience significant power outages. Daily power outages of 6-10 hours are common in urban areas, with rural areas suffer blackouts as much as 20 hours per day. As a result, backup electricity generators, such as diesel generators and battery backup systems have become popular consumer items. SELCO is beginning to market SHS as electrical backup systems to grid-connected homes and businesses. Through quality equipment, service, and financing, SELCO hopes to provide the solar electricity options to a larger segment of the south Indian population.

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CHINA

In the summer of 1993 SELF installed 100 Solar Home Systems in Majiacha, a remote mountain community of farmers in Gansu Province, thus launching the first-ever solar electric village in China. Following the success of this pilot project, which was supported by the Rockefeller Foundation, SELF then helped form a non-profit affiliate in China, the Gansu Solar Electric Light Fund (G-SELF), to manage PV rural electrification projects in Western China. With financial support from SELF and the Gansu provincial government, G-SELF has been responsible for implementing a 1000-House PV Project in Gansu. G-SELF provides 20Wp solar home systems (SHS) to farmers on credit and manages a central revolving fund. More than 300 families have been electrified so far under this program. The Gansu PV Company (see below) installs systems ordered by G-SELF, and provides after-sales maintenance service.

Last year, SELF was awarded a contract by the National Renewable Energy Laboratory (NREL), Golden, Colorado, to supply 500 solar electric home lighting systems to farmers and herdsmen in Gansu. This NREL-supported project builds on the PV rural electrification program initiated by SELF in 1993. It is being carried out as part of a protocol agreement signed in 1995 between the U.S. Department of Energy and the Chinese State Science and Technology Commission to cooperate on a range of renewable energy endeavors. Once completed, the Chinese Ministry of Agriculture will use the SELF/NREL project as a template for the expansion of PV-based rural electrification to other provinces in China. SELF's Director of International Programs, Robert Freling, who is fluent in Mandarin, has managed SELF's operations in China since 1995, including the NREL project, which will be completed in mid-1997.

In 1995, with financial support from the Rockefeller Foundation, SELF acquired a 49% equity interest in Gansu PV Company (GPV), a photovoltaic systems integrator and distribution company based in Lanzhou, Gansu. Managed by Professor Wang Anhua, known as the "father of PV in western China", GPV assembles and markets solar home systems to farmers and herdsmen in Gansu and neighboring provinces. Since its formation, GPV has sold more than 1000 PV systems, mostly for cash, to Tibetan herdsmen living in the southern region of Gansu. At present, GPV is negotiating SHS supply contracts with various government agencies which would increase annual sales by 2000 units. SELF's interest in GPV has since been transferred to its for-profit affiliate, the Solar Electric Light Company (SELCO).

In addition, Professor Wang has been requested by a large electronics company in Xian, which has financial backing from the Shaanxi provincial government, to find an overseas joint-venture partner to establish in China a large solar cell and module manufacturing facility. GPV, and by extension both SELF and SELCO would have an equity position in the new joint venture PV manufacturing facility in China.

The World Bank has recently completed a detailed study of renewable energy options in China, which featured a 5-year loan program to finance a 500,000 SHS project as a key element in building China's PV industry. SELF is uniquely positioned through its relationship with GPV and the soon-to-be-established PV manufacturing facility to take full advantage of the opportunities that exist in China for solar rural electrification.

Appendix D

Solar Development Corporation

Concept Paper

Solar Development Corporation
Concept Paper

Background:

A new approach to assist with the financing of photovoltaics (PV) for rural energy use was suggested in a letter to Mr. James D. Wolfensohn, President of the World Bank Group, from Mr. Peter C. Goldmark Jr., President of The Rockefeller Foundation, in March 1996. World Bank Group (IBRD and IFC) staff and representatives of a number of U.S.-based charitable Foundations were assigned to work on the basis set out in the initiating memorandum. A consensus was reached on the need to develop a means of bringing about an order of magnitude increase in the use of PV for rural households. An innovative investment vehicle is now proposed which has the potential to realize important social and economic development objectives while also providing environmental benefits.

Governments across the developing world have made rural electrification a high priority over the last two decades. Yet despite the rapid expansion of the power sector (including through private investment), current evidence suggests that there are 2 billion people living in rural areas without access to modern electricity, many of whom are able and willing to pay the full costs for the services it provides. Given the constraints of high capital costs and maintenance, there is little chance of achieving universal rural electrification through conventional grid services.

Off-grid PV systems can generate sufficient electricity to provide households with lighting and power for small appliances. PV modules can be combined to meet larger energy requirements for other household services or for productive uses in activities such as agricultural processing or cottage industries. Formidable barriers, in particular weak physical distribution systems, lack of credit and the high initial cost of PV systems, help to keep this technically feasible technology beyond the reach of most middle and upper income rural families. Recent experience in a number of countries suggests that PV financing can be a profitable business, generating adequate returns and low default rates if financings are appropriately structured and properly implemented.

The Concept

It is proposed to form a standalone company, the Solar Development Corporation (SDC), to be a business development and financing entity for PV operations with the potential to be commercially sustainable. SDC will have a fully integrated policy advocacy link to the World Bank. SDC will define target countries where the potential exists for significant early market expansion. In those countries it will provide:

- Market and business development services that will accelerate the growth of private firms and deepen the penetration of Solar Home Systems (SHS) and other rural PV applications in the market; and

- Access to pre-commercial and parallel financing for private firms to: (i) expand their capability in PV distribution businesses; and (ii) strengthen their ability to provide credit to end users. SDC itself will not engage in direct financing of the final consumer. It is intended that as far as possible SDC's finance will be provided in parallel with financing from Financial Intermediaries (FIs[1]).

The target initial capitalization of SDC is US$50 million, of which US$15 million is intended for the market and business development functions and US$35 million for the finance window.

The Market and Indicative Deal Flow

Worldwide PV shipments totaled 72 MW_p in 1995 which represented 18% growth over 1994 shipments. Total global manufacturing capacity in 1995 was 106 MW_p (capacity utilization of 68%). There are 55 major PV manufacturers with 15 companies representing 70% of shipments and the largest four companies responsible for 50% of shipments (and operating at 100% capacity utilization). There are indications that major manufacturers plan to double production over the next three to five years (historic trends suggest that this should reduce module prices by at least 20%) but prudence suggests that these capacity additions may not all take place. Most manufacturers are selling below break-even prices to maintain market share.

It is estimated that 35-40% of shipments are to emerging market countries. This implies a current market for 24-27 MW_p in these countries at present. An estimate of regional demand by emerging economies for 1995 PV shipments suggests that Asia accounts for 10-13 MW_p (India, the largest market, for 7.5 MW_p); Africa/Middle East for 8 MW_p; and Latin America for 5.6 MW_p. A 24-27 MW_p demand expressed in 50 W_p modules is 480,000 to 540,000 units. At an installed cost of US$10 W_p (of which roughly 50% is for the PV module and 50% is for "balance of system" (BoS) such as lights, fixtures, batteries, charge controllers and inverters) this level of demand represents an end use market of US$240-270 million (or US$108-121 million for PV modules alone at a cost of US$4.50 Mw_p).

PV shipments can serve a variety of market applications. In 1995 30 MW_p were estimated to be used globally for consumer and household electrification applications. In the Indian market it was estimated that in 1995 domestic lighting accounted for 23%, pumping 16%, and TVS or lanterns 8% (other uses were for street lighting 30%, central power 10% and other 13%). It is conservatively estimated that 15-25% of emerging market PV sales go for SHSs (50 W_p is the average manufacturer module shipment unit as well as an average SHS size which can power several lights and appliances for several hours in most locations with an average installed cost of US$500-700 or US$0.25-0.30/kWh). This represents a minimum US$36-67 million annual market today (other estimates range as high as US$100-150 million). Depending upon the country, SHSs are believed to be either the fastest or second fastest growing segment of emerging market PV sales with annual growth rates estimated to range from 8-20%.

Unelectrified residents account for 300-400 million households in developing countries and PV systems may represent the least cost option or are otherwise desirable for many of them. Worldwide, over 500,000 SHSs of various capacities are now installed and over 80,000 systems are

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[1]All Abbreviations appear in the Glossary

being added annually, mainly in developing countries. Current estimates are that 10% or 30 million households can afford PV SHSs today and that this number could be expanded rapidly with appropriate consumer credit arrangements or other delivery mechanisms such as PV private utility fee for service schemes and central PV battery charging station approaches.

The basic consumer economics of SHS emerges from their being substitute goods which replace candles, kerosene, and both dry cell and automotive type batteries. Market analyses indicate that rural people now pay between about US$3-17 per month for such energy services. A small SHS (15-50 W_p) costing between US$100-500 can replace about one-half to two thirds of previous monthly energy expenditure. To be economically attractive, therefore, SHS need to offer similar service levels at similar costs or better service at similar costs. PV energy supply options may be affordable for an estimated 25-50% of rural populations when consumers are offered appropriate credit or PV electricity delivery arrangements. Such systems can typically be financed to customers in moderate to high income rural households under end user financing terms with substantial down payments (15-30%), with the balance payable over three to five years in monthly installments of US$5-16.

The most promising PV markets include: China, India, Indonesia and Vietnam in Asia; Kenya, Morocco and South Africa in Africa/Middle East; and Brazil, Argentina, Bolivia, Mexico, Dominican Republic, and Honduras in Latin America. A recent IFC feasibility study identified 10 companies from 9 countries seeking a total of US$191 million in debt/equity financing to manufacture/assemble, distribute or finance PV systems using a variety of approaches. Excluding a US$100 million investment, the average financing request ranged from US$1.6 to US$25 million with an average of US$15 million. The 7 PV distribution companies were each targeting US$12 to US$25 million in sales over the next 2 to 5 years which they felt represented less than 10% of the estimated serviceable demand in their respective marketing territories. Projected IRRs ranged from 8-30%. A more recent evaluation of the Foundations' "pipeline" of PV financing proposals shows a total of 20 projects in 14 countries totaling more than US$200 million in financing requests. A growing number of local FIs are considering or beginning to offer PV financing programs.

A consistent observation from the PV industry has been that the lack of appropriate delivery infrastructure is hindering the expansion of the market. In particular, market education, training and standards need to be developed. Manufacturers have generally been reluctant to invest in distribution systems, because the returns are insufficient. At least in part, the low returns are because investing in the delivery infrastructure benefits competitors as much as the firm making the investment, be it in promotion, training or even establishing distribution systems. Moreover, some investors, including PV companies, see high risks in entering a new business in remote markets where they have little experience.

Without intervention, growth would largely be achieved by increasing cash sales market which does not require sophisticated distribution or financing infrastructure. Initial experience with small scale programs has shown that it is possible to achieve higher growth rates by reaching people beyond the cash sales market, and to do so profitably. At a larger scale, this requires the entry of FIs but because lending for PV requires specialist skills, many potential players are discouraged from entering the market. These barriers to entry are best overcome by helping the private sector enter the market but not attempting to substitute for it.

SDC Operations

SDC's role will be to assist the development and financing of a commercial market for entrepreneurs, companies, FIs, and other private entities involved in the distribution, sale, lease-hire, or financing of PV systems for electricity generation. Set out below are SDC's two core functions: (i) market and business development; and (ii) financing.

Market and Business Development Services
The market and business development function will:

- Identify and nurture: (i) individual entrepreneurs and businesses in the preparation of business plans and financing proposals. It is expected that business proposals will primarily concern PV distribution and system maintenance for local PV outlets and end-users, and (ii) there will also be an effort to educate and encourage FIs to be more responsive to financing this sector;

- Undertake PV marketing and promotion in the SDC's countries of operation including specific market development support and focused generic advertising;

- Identify those countries where government policies act as disincentives to the development of a private PV market. There will be an established link to the relevant parts of the Bank which will use its regular energy sector policy dialogue to remove policy and institutional constraints from the developing PV market;

- Create a "Code of Conduct" among the donor community to support market-driven PV interventions; and

- Provide training and support services for PV firms throughout the distribution chain, including technical training for installation and maintenance of systems, and quality control and standards. This training will also be available to the staff of interested FIs.

Financing Window
SDC will provide financing to PV businesses for equity investments, working capital and, indirectly, for end user credit. This finance is seen as pre-commercial and parallel to commercial financing. Financing will not be on a grant basis but will be tailored as close to commercial terms as is feasible. It is intended that wherever possible, this finance will be provided in collaboration with commercial FIs, but not necessarily on the same terms. Individual firms are expected to apply for total capital or financing needs that are generally between US$25,000 and US$5 million involving establishment of new ventures or expansion of existing companies. At the smaller end of this range, SDC may provide all of the funds, while at the upper end of this range it would be expected to be a co-financier, albeit expected to take longer terms or somewhat greater risks

(through first loss provisions or other mechanisms). Initiatives requiring larger investments can be referred to outside financiers with the assistance of SDC.

Geographic Scope of Operations
SDC will initially establish operations in three regions and be based in countries where there is strong evidence that potential operations will meet with success. Initial considerations, based on currently available market information, are that these should be in:

Southeast Asia, possibly based in Singapore or Bangkok which are centrally located, to serve markets in China, India, Indonesia and Vietnam;

Africa, possibly based either in Nairobi or Abidjan, to serve northern and sub-Saharan Africa (and the Middle East); and

Latin America, possibly based in either São Paulo or San José, to serve Argentina, Bolivia, Brazil, the Dominican Republic, Honduras, Mexico, Peru (and the Caribbean).

The headquarters operation will also be established in one of the regions, with the purpose of providing coordination services and ensuring that information exchange and lessons learned are exchanged between regional offices. Final locations will be determined by SDC Board and management in due course.

Period of Operation
As a standalone operation SDC will be required to demonstrate its capacity to operate on a self supporting basis over time. It is however recognized that during an initial three year period there will be a requirement for non-recoverable funding to support the setup and development aspects of SDC. It is intended that the financing window will support itself but it is assumed that some part of the capital may need to be written off.

Sponsorship, Management and Bank Group and Foundation Roles

Sponsorship
The sponsors of SDC are the World Bank Group (IBRD and IFC) and a number of US based private charitable Foundations which have been working jointly to address PV's commercialization potential.

Management
Management of SDC would be by appropriately qualified, international caliber personnel. Options for selecting the management team include direct recruitment, joint venture arrangements, selection of an external management team or by putting it out for bid to an outside contractor. The World Bank Group and Foundations will appoint a transition team to continue with further project development, to the point at which it can devolve SDC's management to the selected specialist organization or management team. These tasks will include undertaking: (i) detailed market

identification through a feasibility study/draft business plan; (ii) setting up SDC; (iii) mobilizing capital; and (iv) procuring management services for SDC.

The requirement for SDC's management team will be to: (i) implement the formation of SDC and launch the first phase of the business; (ii) develop the detailed work plans; (iii) take responsibility for staffing operations at the head office and the regional offices; (iv) manage the process to identify and qualify applicants for SDC's investments; and (v) when sufficient experience has been established, to identify the conditions and mechanism for scaling up SDC's financing operations including presentation to its Board of a strategy for effecting a scale up (including its spin-off as appropriate) and recapitalization.

World Bank Group Role

The World Bank Group's recent activities in PV and rural electrification will be an important element in ensuring a realistic approach to and structuring of the developmental side of SDC's business. It is anticipated that the World Bank will be an active partner in this endeavor, especially in SDC's technical assistance operations, through, for example, staff secondments. SDC will be an important part of the Bank Group's overall strategy to further develop PV markets in developing countries through private sector channels.

IBRD has indicated that it will seek up to US$10 million in funding over two years from the Special Grants Program (or its successor) to help finance SDC's operational costs. IFC has indicated that from its own resources it will contribute US$2-3 million for the developmental functions of SDC with the expectation that this would represent between 10-15% of the development funding component. IBRD or IFC may also apply for a justified level of financing from the Global Environment Facility (GEF). Support from IBRD is also needed for policy dialogue in countries where SDC plans to operate which will be achieved through the business development services link.

Foundation Role

The Foundation community has played an active role in providing early seed capital to many of the innovative private sector PV development approaches that form the basis for the proposed concept. They will, in addition to assisting with the funding of SDC, work with it in the business development activity. Collectively the Foundations may be prepared to contribute $5-10 million to SDC's capitalization and to secure an additional US$5-10 million from other private sector sources.

Other Bank Group and Foundation PV Projects

Under its loan activities the IBRD is currently implementing or preparing approximately US$95 million in SHS financing programs (with GEF assistance) in India (US$42 million), Sri Lanka

(US$9 million), and Indonesia (US$44 million). IBRD PV loan operations in early stages of project preparation include potential SHS programs in China, Bolivia, Brazil and Argentina.
It is expected that a limited number of off-grid PV projects will be funded during the life of IFC's proposed US$100-200 million Renewable Energy and Energy Efficiency Fund (REEF) which has US$20-30 million in GEF co-financing. IFC is also preparing a wholly GEF-funded US$30 million Photovoltaic Market Transformation Initiative (PVMTI) project to support PV private financing in India, Kenya, and Morocco. PVMTI is a complementary activity to SDC that may provide important lessons in its establishment.

Established and planned PV financing programs are not expected fully to cover either the total market potential for PV in key developing country markets or their developmental requirements over the next five to ten years. While single-country operations are helpful, they will not bring about the scale-change in the activity that is required to extend the reach of PV to all potential users: this will only happen if fully commercial financing is prepared to enter the market. The first phase of SDC's operation will lead to experience which will be globally applicable and facilitate systematic expansion and commercialization throughout selected regions, rather than on a country by country basis. In some cases, SDC could work in parallel with existing Bank programs, for example by providing an opportunity to expand efforts to other parts of a country or other segments of the market. In other cases, SDC may stimulate Bank activity, for example in the policy area, and complement a lending operation. SDC also offers the Foundations an opportunity to scale up their projects in both size and scope.

Financing Requirements
SDC's initial capitalization is expected to occur in two parts: (i) contributions to defray SDC's expected operating costs for the business development activity from which no return can be expected in the foreseeable future (though possibly recovered once SDC's activities reach a substantial scale), for which US$15 million is required; and (ii) financing of the initial window which will be raised and placed with quasi-commercial return objectives and for which a target capitalization is US$35 million.

The provision of finance through SDC's financing window is to demonstrate the commercial viability of PV business investments. It is therefore important that financing activities be designed to recover their costs and ultimately to achieve quasi-commercial rates of return. It may be possible for SDC's business development functions to generate some fee income (experience suggests that this will be 10% or less of costs). SDC's funds will be raised and structured in a manner consistent with these expectations.

Issues and Risks

SDC's objective is to develop the market for private sector PV companies. Therefore the main measure of the SDC's success will be its ability to promote, establish and finance a sufficient number of viable indigenous PV private enterprise investments. In terms of the overall goal of the activity, the most significant measure of success is the number of SHSs or other PV systems that have reached rural people who would otherwise not have got them. As with all development activities, there is no guarantee of sustainability although there are strong indicators that a market exists that can be demonstrated and further developed through SDC.

Detailed work is still required to develop: (i) criteria for selecting regional office locations and identifying initial target countries for the operation of SDC; and (ii) pro forma analyses of sample investments that SDC may finance. This is seen as part of the pre-implementation phase and will require more detailed market analysis and preparation of a draft business plan for SDC. During the first three years, continuous evaluation of the performance of SDC by the sponsors would seek to decide whether it has sufficiently demonstrated the fundamental viability of the businesses it will support. The purpose of the evaluation would be to ensure a market driven evolution of SDC.

Some financial contributors will probably wish to influence the scope of SDC's operations in geographic, market or business terms. Over-tight restrictions on the discretion of SDC's Board and management to invest as they consider appropriate would not be consistent with a market driven approach. Funding contributions will be solicited on the basis that they are to be made available for use by SDC without undue restrictions.

The risk profile for the operation is similar during the initial three years and subsequently. The main risks are:

i) Fund raising - from the perspective of the Bank Group, the amount, timing and proportion of funding available from the SGP is not yet certain. GEF has not yet been formally approached with a proposal which may be considered inappropriate. Externally there is risk that it will not be possible to raise sufficient contributions from donor and private sector participants. All these factors may result in having to scale back or abandon the operation;

ii) Recruitment - inability to recruit or delay in recruitment of a suitable management team;

iii) Market risk - it is always possible to overestimate market potential. A related risk is the ability of market players to deliver the kind of products and end user credit schemes that the market wants;

iv) Financial risk - the operation will create a limited number of small loans to borrowers with little or no credit history or collateral so a repayment risk exists;

v) Foreign exchange risk -the operation will incur much of its costs in hard currency while making loans in local currency; and

vi) Reputation risk - the Bank Group and the Foundations risk being associated with SDC in the event that its performance does not meet reasonable expectations or if the market environment for commercial PV financing fails to materialize.

Other risks include: those associated with poor management of the venture; inadequate understanding of local PV markets; high transaction costs that cannot be reduced through scale economies associated with new financial intermediation approaches; and market barriers in target countries that cannot be easily overcome.

Each of these risks can be mitigated or managed to some degree. Creation of SDC provides a rational point of entry to this immature but promising market. SDC's structuring with support for its pre-commercial activities avoids a mismatch between its initial mission, funding, and market expectations. Sufficient flexibility will need to be provided, to allow SDC to be extended and enlarged as necessary and as justified by its performance and the market.

Glossary

BoS	Balance of System. The shorthand term given for a PV system (of any kind, including an SHS) which is not the PV module itself.
FI	Financial Intermediary: banks or other credit institutions in developing countries.
kWh	Kilowatt hour. A measure of the amount of energy delivered, specifically, the amount of energy delivered if one thousand Watts were drawn for one hour.
Module	A PV module (or panel): PV cells, the actual units which produce electricity are fragile and produce small amounts of power. They are grouped together with others, for protection and to increase the power availability into sealed panels or modules.
MW_p	MegaWatt peak: one million times one W_p.
Panel	See Module.
PV	Photovoltaic(s): the name given to the effect by which the energy in light is transformed into electricity.
SDC	Solar Development Corporation: the proposed development and financing entity for PV operations
SGP	The IBRD's Special Grants Program
SHS	Solar Home System: a PV system which is able to provide power for a single household. Normally consists of a PV module, battery, controller, wiring, light fittings and outlets. Typically sized in the range 10-50W_p.
W_p	One Watt peak: a measure of the capacity to produce energy. The rating of a panel is given in terms of the number of Watts it would produce under standard conditions. The higher the W_p rating, the more power the panel produces.

Appendix E

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