renewable energy technology diffusion

Final Report, 2003

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Introduction

The e7 is a group of leading international electricity companies from the G7 nations, collectively dedicated to serving as a forum for global electricity issues and promoting sustainable energy development. The e_7 carries out its work in sustainable energy development through non-profit activities in human capacity building and capital projects throughout the developing world, working in partnership with governments, international agencies, and non-governmental organizations.

This report on Renewable Energy Technology Diffusion is the culmination of the e_7's theme year actvities for the 2002-2003 e_7 chairmanship term of American Electric Power (USA). With the goal of providing a roadmap to improve the diffusion of energy technologies for sustainable development, this assessment's major conclusions include guidelines for strategic actions to address project-level "microbarriers" and recommendations for sustained cooperation to address policy-level "macrobarriers."

Executive Summary

Context

1.1. At the 2002 World Summit on Sustainable Development, world leaders gathered and recognized the vital role of energy in sustainable deveopment. This consensus has stimulated global interest from governments, industry, and civil society in improving the diffusion of energy technologies to accelerate sustainable development.

1.2. Electricity is an especially important technological arena in energy technology, as electric power is a unique commodity that supports all three pillars of sustainable development – economic growth, social progress, and environmental improvement. Electricity powers economic development by enabling industry and commerce; stimulates social progress by catalyzing communications, healthcare, and education; and promotes environmental improvement by displacing less efficient means of energy conversion. however, electricity faces challenges in becoming accessible, reliable, and affordable for the people living in energy poverty, who today represent one-quarter of humanity.

1.3. These opportunities and obstacles must be addressed if electric power is to increase its contribution to sustainable development. Population growth and rising economic activity lead inexorably to accelerating electricity demand in the developing world. The extent to which sustainable electric power technologies are diffused to developing nations to meet these needs will strongly influence the future compatibility of energy, economy, and environment.

1.4. This report is the first of a proposed series of e_7 assessments that will address the question: What are the barriers to and opportunities for improving diffusion of electric power technologies to underserved areas for sustainable energy development? Technology areas that are planned to be assessed include renewable energy, conventional generation, energy delivery, and end-use. The authors, convened from a range of disciplines and backgrounds (Annex A), offer a unique perspective on this topic by drawing upon the experiences of the e_7, a non-profit group of the nine leading electricity companies from the G7 nations, collectively dedicated to promoting sustainable energy development.

1.5. This first volume of this proposed series addresses renewable energy, covering power generated from solar, wind, biomass, geothermal, and small hydro resources. While adhering to the “fuel neutral” position of e_7, the authors have prioritized renewable energy to be the first of the guidebooks because of these energy sources’ particular appropriateness for meeting the distributed demand of rural communities, a situation commonly encountered in underserved areas, especially in developing countries. Furthermore, the generally environmentally friendly nature of renewable energy has led to widespread support for a greater role for these resources in the global electric power sector. Acknowledging that renewable energy sources should be complemented by high-efficiency fossil fuel stations and advances in other conventional energy technologies to address global climate change, the authors also note the priority given to technology diffusion of environmentally friendly technologies under the United Nations Framework Convention on Climate Change (UNFCCC). The 2002 World Summit on Sustainable Development underscored the poverty alleviation benefits of energy by highlighting the merits of renewable energy and calling for parties to:

> *… take joint actions and improve efforts to work together at all levels to improve access to reliable and affordable energy services for sustainable development…bearing in mind that access to energy facilitates the eradication of poverty. This would include actions at all levels to…improve access to reliable, affordable economically viable, socially acceptable and environmentally sound energy services and resources…*
> *[WSSD Plan of Implementation, Point 9]*

1.6. The intended audiences for this report are numerous, since many parties hold interests in energy and development issues. It is the authors’ hope that energy companies, both multinational and local, will learn from and contribute to this body of knowledge. Cooperation from governments - both donors and recipients, as well as national and local - will be critical to accelerating the pace of technology diffusion for sustainable energy development. Finally, there are a number of other stakeholders - ranging from multilateral development institutions and international aid organizations to local community NGOs, businesses, and consumers - that can benefit from and build upon the work initiated by this assessment.

Conclusions and Recommendations

1.7. The e7 Technology Diffusion Working Group has concluded that:

- It is necessary to distinguish “microbarriers” from “macrobarriers”. The former exist at the project level, specific to different technologies and geographies, while the latter can be identified at the policy level, often spanning technological categories and geographical boundaries.
- Microbarriers to the diffusion of renewable energy technologies arise from cultural, environmental, financial, human capacity, legal, political, institutional, and technological factors. These microbarriers can be identified and addressed directly through *focused, committed actions* from individual stakeholders. A broad menu of recommendations to address microbarriers is outlined in the report.
- Macrobarriers to renewable energy technology diffusion are rooted in financial, legal, political, institutional, and technical issues. Addressing these macrobarriers requires *broad, coordinated initiatives* from various sustainable development stakeholders. These include:

Finance

- Cooperation with governments to provide transparent and consistent policy treatment of competing energy supply alternatives.
- Research to improve our understanding of the relationship between, and the externalities resulting from, electricity and development, including patterns of consumption, fuel displacement, and economic benefits associated with electrification.
- Cooperation with financial institutions to develop financing approaches suited to the scale and characteristics of renewable energy technologies.

Political/Institutional Issues

- Recognition that while broad promotion of renewable energy is valuable, a diversity of models for public-private cooperation is appropriate.
- Development of appropriate and effective non-governmental associations, academic centers, and industry groups for renewable energy in developing countries with high renewable energy potential.

Technical Concerns

- Cooperation between governments, research centers, and private firms to develop appropriate renewable energy technologies for the challenging operating conditions that are often encountered in under served regions of the world.
- “South-South” cooperation between developing countries on renewable energy technology diffusion.

2. Background

Terminology

2.1. In promoting “sustainable energy development” and “technology diffusion”, it is necessary to make clear the meaning of these terms. The e7 usage of “sustainable energy development” refers to the use of energy, especially electricity, in a manner that promotes and balances economic growth, social progress, and environmental protection. The e_7 recognizes the sovereign rights of nations to utilize their domestic fuel resources, and e_7 promotes energy diversity to reduce risks and volatility in a sector unique in its inability to economically store large amounts of its product. Although this report focuses on renewable energy, the authors approach the overall topic of technology diffusion with neutrality in regard to fuels for power generation, ultimately seeking to illuminate means of improving diffusion across the full spectrum of electric power technologies.

2.2. Multiple terms, such as “technology transfer” and “technology dissemination” have been used to discuss the movement of technologies from one part of the world to another. While these different terms generally refer to the same topic, there are subtle nuances that reveal underlying divergences in the meaning of these words. This report utilizes the term “technology diffusion” for reasons that merit explanation.

2.3. This report differs from other analyses in that it adopts the term “diffusion” instead of “transfer” or “dissemination.” The two latter terms are often understood to connote a “supply-push” model of the flow of technologies, where there is some organized flow of technologies across national borders, coordinated by stakeholders in accordance with official objectives or managed by centralized organizations. In contrast, this report uses the term “diffusion” to describe a “demand-pull” conceptualization of how technologies should flow. In this model, public policies do not dictate the movement of technologies directly. Rather, stakeholders cooperate to encourage free market forces, in the context of a “level playing field” of public policies, to pull technologies from the places where they are created to the places where their application would be of highest value.

2.4. It is important to clarify the use of “technology” in this report. Common usage of this word often is limited to the tangible equipment that people associate with industrial or commercial activities. For electric power this describes “hardware” such as turbines, transformers, power lines, etc. While hardware is undoubtedly an important factor in the electricity sector, this report espouses a broader definition of “technology” that includes not only physical equipment but also embraces knowledge. Human capacity, in the form of “software” such as management practices, social structures, and institutional arrangements, constitutes another critical dimension of the technologies that make electricity possible. In adopting this broader definition of "technology", this report is consistent with the IPCC report *Methodological and Technological Issues in Technology Transfer*, which understands technology to describe "know-how, experience, and equipment." (IPCC, 2000)

2.5. This report addresses the diffusion of "renewable energy technologies," in which category the authors include:

2.5.1. ***Biomass:*** Biomass can be used for stand-alone electricity generation or combined electricity and thermal energy (cogen) applications. Applicable projects can range from small projects for local community use in the 1 to 100 kilowatt (kW) range, to larger local/industrial projects of up to 100 megawatts (MW). Typically they involve:

- *Combustion*: Biomass combustion technology varies from the very simple, very small grate type boiler with small turbine to larger, more efficient fluid bed type units. The nature of the technology is often based on the scale, but also the fuel feedstock involved. Projects can frequently involve several feedstocks or blends of feedstocks, including:
  - Agricultural waste - wood, palm tree crops, rice husks, etc. Industrial biomass - vegetable oil industry residues, sugar industry bagasse, molasses (ethanol); etc.
  - Forest industry - wood industry sawdust, natural forest trimmings

- *Conversion:* Biomass conversion - gasification or liquefaction – can be used in a gas engine –diesel, gas, gas turbine - or boiler/steam turbine. Units have been built and operated from the small kW size up to about 25 MW size.

2.5.2. ***Geothermal:*** Electricity from geothermal sources uses the energy in active underground geothermal fields either directly or by converting a working fluid into vapor to drive a turbine. Several different working fluids may be used to match up with geothermal conditions. The key variables in project development are the extent and physical characteristics of a geothermal field. These factors determine the sustainability of geothermal projects. Typically, these facilities are in the 10 to 100 MW size but can reach as large as several hundred MW in capacity.

2.5.3. ***Small hydro:*** This report considers only run-of-river facilities or the use of existing smaller reservoirs and dams, typically for flood and local water management control. Small hydro facilities often are affected by fluctuations in water resource availability. Hydroelectricity in the context of this report does not include projects requiring extensive dams and creation of artificial reservoirs.

2.5.4. ***Solar Photovoltaics:*** Solar photovoltaics (PV) uses light-sensitive materials in photovoltaic cells to create small voltage differences which, when combined into panels and arrays, can produce electricity anywhere from the 10 watt range to the multi-MW range. The technology includes mounting and power conversion and can also involve storage for periods of low solar intensity.

2.5.5. ***Wind Power:*** Wind power involves harnessing wind energy through standing wind turbines to generate electricity. Generation capacities for wind power stations range from less than one kW to almost two MW per turbine, often with many turbines arrayed together in a single location. The technology may also include power conversion and storage for non-windy times.

2.5.6. ***Others:*** Many other sources of energy for electricity production do exist and are used in some places – solar thermal, landfill gas, solid waste, ocean thermal, sea-wave, tidal power. Although these technologies were not specifically addressed in the case studies of this assessment, the authors believe that the findings and recommendations of this report likely remain applicable for systems utilizing these renewable energy resources.

Channels of Diffusion

2.6. The flow of technologies occurs through a number of different channels, each with its own unique characteristics. Understanding these pathways is a necessary first step to assessing technology diffusion. *Official development assistance* (ODA), in which resources are transferred from wealthier nations to less-developed countries through governmental means, is perhaps the most recognizable means of moving technology across national boundaries. In recent years, there has been a downward trend in ODA levels, but this pathway remains the major source of development financing and technology diffusion for countries and sectors where private capital flows remain low.

2.7. *Private development funding* represents a small but growing avenue of development supported by public-interest efforts. These initiatives are commonly led by non-profit organizations possessing expertise in a specific field such as healthcare, agriculture, energy, or education. The expert nature of the organizations supporting private development funding enables technology diffusion through this channel.

2.8. *Foreign direct investment* (FDI), led by market-driven multinational firms, has become the chief means of diffusing financial and technology resources to developing nations. FDI is unevenly distributed, reflecting disparities between countries' abilities to attract capital. The sheer volume of capital and knowledge associated with FDI, combined with the hands-on management of these investments, make FDI the leading channel for technology diffusion today.

2.9. Other vehicles for technology diffusion include collaborative *research and development* of energy technologies, as well as *educational and professional exchanges*. These channels are important in that they can be decisive means of diffusing key technologies, but the relatively small scale of such pathways limit the extent to which they can be improved to facilitate sustainable energy development.

2.10. This report will examine barriers to technology diffusion that affect official development assistance, private development funding, and foreign direct investment. This assessment seeks to guide stakeholders in overcoming these barriers so that technology diffusion mechanisms can become more effective drivers for sustainable energy development.

Dimensions of Diffusion

2.11. Technology diffusion is a complex process presenting diverse dimensions for analysis. In categorizing the major aspects of technology diffusion, this report identifies the following dimensions of the diffusion process:

Legal and Political	Human
Financial	Cultural
Technical	Environmental

2.12. *Legal and political* barriers largely define the policy environment in which technology diffusion occurs. Effective host country governance and reliable rule of law are essential elements in improving the success rate of technology diffusion projects. Institutional structures determine the procedures through which stakeholders interact and reach decisions on energy-related projects. For example, energy project proposals handled by Ministries of Environment or Sustainable Development are likely to be managed quite differently from one overseen by Ministries of Energy or Industry. The political climate influences the priorities that host governments use in encouraging or discouraging projects. Rural development policies affect electrification initiatives in remote locations, which is important for bringing power to those living in energy poverty. The significance of political relationships between stakeholders cannot be underestimated.

2.13. *Financial* dimensions of technology diffusion rank among the most commonly encountered constraints in energy projects. Availability of capital resources, including both up-front costs borne by project partners and the long-term revenue stream derived from consumers, remains a challenge facing energy proposals. Financial mechanisms to stimulate markets into making available the necessary capital often are in short supply in developing countries, where they are most needed.

2.14. From a *technical* perspective, many host countries lack the education and training to provide the expertise required to ensure long-term viability of modern energy projects. Local economies often are unable to offer the ancillary technical resources and capabilities necessary to support sustainable electrification efforts. Many small-scale power systems have not been optimized for developing country markets, leading to technical limitations to the success of diffusing these technologies.

2.15. *Human* barriers also characterize the conditions for energy technology transfer on a level that is difficult to quantify but is vital to understand. Variations in management practices at relevant institutions and organizations can affect the dissemination of knowledge. Sensitive factors, such as the delicate balance of age, gender, ethnicity, and religion can exert significant influences on the process of technology transfer.

2.16. *Cultural* aspects of technology diffusion strongly affect the approach to and the viability of projects. The ability of energy project participants to secure local acceptance and build social trust determines the extent to which the disruption to existing patterns of life resulting from energy technology diffusion is tolerated by communities that receive them.

2.17. *Environmental* considerations exist at many levels when it comes to energy technology diffusion. At the household and local levels, potential benefits must be weighed against potential adverse effects. At the regional and global levels, environmental improvements in air quality and progress in addressing global climate change, both of which can be achieved through the diffusion of sustainable energy technologies, must be factored into the long-term analyses of energy projects.

Mandate

2.18. The e7 decided upon Technology Diffusion for Sustainable Energy Development as its theme for the 2002-2003 chairmanship term of its U.S. member, American Electric Power. This activity mandated an assessment of the barriers to and opportunities for improving the diffusion of sustainable energy technologies to underserved areas.

2.19. An e7 Technology Diffusion Working Group was assembled, which included experts from the e7 member companies and represented a range of professional disciplines and backgrounds (Annex A). This diversity of viewpoints served to broaden the array of inputs that informed this assessment. The Working Group was chaired by the representative from American Electric Power, the 2002-2003 chair company of e7.

Methodology

2.20. The Working Group developed a portfolio of case studies examining different examples of diffusion of renewable energy technologies. These cases covered renewable energy projects undertaken in developing regions of the world by e7, as well as projects implemented by other organizations. These examples offered a useful cross-section of efforts to diffuse renewable energy technologies. Coupled with the experience and research of Working Group members, these case studies served as the basis from which the findings and recommendations were drawn. The studies are summarized in Table 1 and are presented in fuller detail in Annex E.

Table 1: Case Studies

	Project Name	Location	Size	Technology	Author
1	**Micro-solar distance learning**	Bolivia	2.5 kW	Photovoltaic	AEP
	A charitable effort implemented by a partnership between an e_7 member company and local NGO to provide electricity to a rural village to power internet via satellite communications and to enable school lighting; the case shows challenges facing projects in remote locations.				
2	**Solar home systems**	Indonesia	5 kW	Photovoltaic	Kansai
	A hybrid charitable/self-supporting project led by e_7, local government, and local NGO to provide residential power to remote villages; the case describes the importance of cooperative governance and management				
3	**Micro-hydro project**	Indonesia	145 kW	Small hydro	TEPCO
	A self-sustainable e_7 project aimed at providing residential power to remote communities; the case described the role of local training and cultural acceptance in determining the project's viability.				
4	**Malavalli biomass power plant**	India	4 MW	Biomass	RWE
	A private enterprise to develop commercial power; the case shows the challenges presented by technical issues and policy frameworks.				
5	**Olkaria geothermal system**	Kenya	45 MW	Geothermal	Enel, SP
	A multi-phase, multilateral bank-supported development project aimed at creating commercial sales to electricity grid; the case demonstrates the challenges of securing financial support and the need to ensure institutional compatibility.				
6	**Mokai geothermal system**	New Zealand	55 MW	Geothermal	Enel
	A tribal trust-led effort to develop geothermal fields; the case highlights the role of local leadership in minimizing environmental impacts.				
7	**Koudia Al Baïda wind farm**	Morocco	50 MW	Wind	EDF
	A commercial joint venture between an e_7 member company and other investors to produce power sales to grid; the case underscores the importance of regulatory systems and legal concerns.				

2.21. The findings of this assessment were shared with experts in the development community and delegates from industrialized and developing nations at side events that were organized at the 11th meeting of the United Nations Commission on Sustainable Development, which met in New York City from April 28 to May 9, 2003. A panel of outside reviewers was formed as a result of these events, (see acknowledgements) and the final report was reviewed by this panel before final approval by the e_7 Chairmen in October 2003.

3. Results

Findings

3.1. Examination of the case studies described in Table 1 of this report revealed a number of findings that provided insight into the important differences between the various types of barriers encountered in the diffusion of renewable energy technologies. The case studies also illuminated specific barriers and introduced recommended solutions to address them. These findings are presented in this section.

Micro and Macro barriers

3.2. The Working Group found evidence documenting the existence of two major types of barriers to the successful diffusion of energy technologies: a) those that stakeholders can influence directly and b) those that require coordinated action from multiple parties to overcome. These two kinds of barriers will be referred to as "microbarriers" and "macro-barriers", respectively, in this report. This distinction is important in that it provides stakeholders with a means of distinguishing those barriers for which direct action is appropriate from those that demand partnership to address.

3.3. Microbarriers to the diffusion of renewable energy technologies arise from cultural, environmental, financial, human capacity, legal, political, institutional, and technological factors. These microbarriers can be identified and addressed directly by individual stakeholders. Microbarriers are significant because they can introduce obstacles or complications, some predicable and others unforeseeable. These factors can negatively impact individual renewable energy technology diffusion projects, even though possible remedies are available and preventative measures could have been taken by project participants.

3.4. Macrobarriers are policy-level impediments to technology diffusion that affect a range of renewable energy technologies across geographies and communities. These barriers require coordinated action from a diverse array of stakeholders and should form the basis for sustained partnership initiatives.

Microbarriers

3.5. Microbarriers describe obstacles to diffusion encountered at the project level. Such barriers were found in each of the projects examined in the case studies. The distinguishing characteristic of microbarriers is that they can be resolved by the participants in any specific project. These microbarriers are generally unique to each situation and require focused, localized solutions rather than broader, international coordination. Addressing microbarriers demands flexibility, openness, and creativity, especially with regard to human and institutional issues.

3.6. The failure to anticipate and address such project-level barriers in otherwise well-planned enterprises can lead to setbacks, which can result in major delays or even abandonment. This section will review some illustrative examples of how microbarriers affected the case study projects examined in this analysis. A summary of microbarriers to and recommendations for renewable energy technology diffusion can be found in Annex B of this report.

3.6.1. Legal and Political: The projects examined in this assessment range in size from multiple megawatts to only a few kilowatts and thus attract varying levels of political attention. However, the consistent theme this assessment finds is that extensive involvement of local stakeholders in renewable energy projects is necessary to motivate changes in public policies and institutional rules to create a more welcoming environment for such projects.

- *Example:* Early efforts in the Morocco wind farm project from the project developers to cultivate support from local authorities and businesses helped to establish a "welcoming infrastructure" of policies that proved invaluable as a stabilizing anchor during the necessary but challenging negotiations to select an arbitration mechanism.

- *Inadequate recognition of contributions to rural energy development:* Too often, policies fail to internalize the myriad positive externalities – improvements in healthcare, education, communications, employment, etc. – that result from bringing electricity to underserved areas. Community leaders, local residents and project developers should seek to explicitly identify such benefits and new growth opportunities to bring additional resources to bear on renewable energy technology diffusion projects.

- *Example:* The development of the biomass feedstock collection and delivery system in the Mallavalli case illustrates the downstream and upstream economic benefits that could be provided by the power plant, resulting in a large economic multiplier to the community. It is important that such externalities be integrated into the financial modeling through public policies affecting projects like this.

3.6.2. Financial: Barriers posed by financial considerations exist at both the micro and macro levels. Renewable energy technologies face special financial obstacles due to their generally small scale, distributed application, and significant capital costs. Of special importance are the cash flow profile of the project and the available income of potential customers. Incompatibilities between historical approaches to financing electricity projects and the characteristics of modern renewable energy projects require innovative solutions for the diffusion of these technologies. While macro-level cooperation is needed to address the financial concerns that affect the spectrum of renewable energy technologies in all regions, actions at the project level can address specific localized challenges.

- *Finance Mechanisms:* One theme that became apparent in a number of the case studies was the challenge of identifying appropriate finance mechanisms for projects involving renewable energy technology diffusion.

- *Example:* In the Kenyan Olkaria geothermal system example, the funds necessary to drill and connect new wells to supplement declining production from the first three projects were unavailable. The original plans were to produce these funds from the savings arising from reduced oil imports. However, this approach proved not to be possible and the necessary funds eventually had to be diverted from another World Bank project.

- *Incomplete Information:* Investment demands information; however, the limited penetration of renewable energy systems into the electricity sector and lack of technical data on certain technologies can stymie the flow of financial resources to renewable energy technology diffusion efforts.

- *Example:* The Malavalli biomass power plant faced difficulties due to the lack of established performance data on the firing of low-density crop residues in combination with other bio-mass fuels and the operation of biomass fuel supply systems. This, in turn, resulted in questions about the financial viability of the project, due to irresolvable variables arising from uncertainties in technical performance.

3.6.3. Technical: In the context of the other challenges facing projects and the core engineering competencies of many project proponents, technical issues often are the simplest challenges with which developers have to deal in renewable energy technology diffusion projects. Sometimes, however, a poor appreciation of the existing situation or an insufficiently robust concept development program can lead to a number of technical, reliability and cost issues.

- *Technical challenges:* Technical difficulties are encountered in all energy projects. The keys are to avoid major problems and to be able to respond adequately and swiftly to those that do arise. In projects involving renewable energy technology diffusion to remote underserved areas, technical risks and the appropriate complexity of solutions merit special consideration.

- *Example:* The Indonesia micro-hydro project used a significant number of Indonesian products – a positive feature that enhanced integration with the community and improved local acceptance, while also reducing costs, raising availability of parts, and benefiting the host country's industrial sector. It was noted, however, that some parts, in one case a household circuit breaker, were deficient and that additional spares had to be ordered to compensate for the rate of defects. While this negatively impacted this portion of the financial arrangements, the overall benefits of local purchasing were deemed to out-weigh the costs.

- *Management challenges*: Project management skills and the expertise to overcome challenges are key to a project's success. A technology may fit and the finances may work, but poor management can more than undo the benefits created by the first two factors. A lack of experienced and trained managers and support staff makes this a challenge in developing countries, particularly for more complex renewable energy projects.

- *Example:* The Indonesian solar home systems project demonstrated the value of effective project management skills and systems. The developer worked with a local NGO, which monitors a local distribution/management entity and also hires and trains aintenance/operators. The successful operation of the local management is evidenced by the facts that the systems have operated as planned and that most users have fulfilled payment obligations.

3.6.4. Human: Human factors rank among the most influential to the success of renewable energy technology diffusion projects. In the end, all projects rely on people to make them succeed, and so it is critical for project proponents to recognize the importance of human barriers to renewable energy technology diffusion.

- *Lack of trained personnel:* The lack of human resources trained to operate, maintain, and repair renewable energy technologies poses serious constraints to many projects. Training facilities generally are rare and inaccessible in underserved areas, and the services of qualified instructors are often even more difficult to secure.

- *Example:* The Bolivian micro-solar distance-learning and Indonesian solar home system cases offer insight into how local NGOs can play a valuable role in providing and maintaining training resources to local communities on the maintenance and operation of renewable energy systems.

3.6.5. Cultural: National, regional, and local culture can significantly impact a a project from its conception through implementation, as well as during operation. Cultural barriers can involve differences between the expectations of project developers and local communities regarding social norms, consumer preferences, and local customs.

- *Institutional integration with local communities:* Local institutions are critical to the way of life in all communities. Local customs and governing body structures can be considerably different from those in developed countries. In developing a project, these differences can impede projects if they are not identified and respected.

- *Local acceptance and social trust:* Suspicions about the intentions of project proponents should be expected in any effort where an external developer is dealing with a different culture. Trust and acceptance are difficult to build and easily damaged, but for any project to succeed in a sustainable manner, the confidence of the communities served must be earned.

- *Example:*The Indonesian Solar Home System project demonstrates the importance of cultural factors at work. The main project proponent, e_7, secured the cooperation of a local non-governmental organization (NGO), which in turn established an operating company under the leadership of a key villager. The NGO was instrumental in ensuring that the project ran smoothly during construction, and it cooperated with the local operating company to facilitate ongoing operation, maintenance, and management. In contrast to other villages with similar facilities and comparable projects with lower electricity rates, this particular effort is working well, paying for its ongoing operational costs, and, most importantly, satisfying its customers.

3.6.6. Environmental: Environmental considerations exist at many levels when it comes to renewable energy technology diffusion. At the household and local levels, potential benefits such as expanded education, improved human health, and reductions in physical labor arise from renewable electrification. These must be weighed against the costs of addressing possible impacts such as new sources of localized pollution (i.e., from biomass), impacts on wildlife (i.e., from wind power), and safety concerns (i.e., from electrification). At the regional and global levels, environmental improvements in air quality and progress in addressing global climate, both of which can be achieved through the diffusion of sustainable energy technologies, must be factored into the long-term analysis of energy projects.

- *Example:* In the Mokai geothermal system case study, the high priority given by the project proponents, the Tuaropaki Trust, to environmental considerations may have constrained the rate at which the resources were tapped. However, this approach ultimately seems to have resulted in a gradual development of the geothermal resource that enabled sustain able, long-term production while minimizing environmental impacts.

Macrobarriers

3.7. Looking across the spectrum of barriers encountered in the case studies analyzed in this assessment, issues in financial, political/institutional, and technical areas appeared with frequency, meriting their designation as macrobarriers. In cases that encountered such issues, no immediate solutions presented themselves, indicating a need for a common approach from a variety of stakeholders. Some of the macrobarriers described here reflect microbarriers also encountered at the project level in some instances, while others introduce concepts that are applicable only at the policy level.

3.7.1. Financial: A common theme spanning all of the case studies was the challenge of attaining financial viability, whether this meant generating revenue sufficient only to cover operating and maintenance expenses or to realize enough of a profit to attract investment capital.

- *Challenging project economics*: This issue challenged most of the case studies examined by the authors, rooted in such problems as the cost profile of renewable energy technologies, as was the case in the Bolivian micro-solar distance-learning case, and the exposure of imported equipment costs to currency exchange rate variations, as demonstrated in the Indonesia solar home system case.

- *Lack of access to capital*: For each project studied in this assessment, the authors suspect that there are many other proposals that failed to materialize due to lack of access to capital. The challenges overcome by the projects examined in this study suggest some of the reasons that lack of access to capital constrains renewable energy technology diffusion. There has been a general trend away from multinational electricity company investments in developing regions, and the high risks associated with projects using relatively unproven technologies in undeveloped markets is evidenced in several of this assessment's case studies.

3.7.2. Legal/Political

- *Sovereignty issues*: The e7 long has recognized the primacy of respecting sovereignty. Yet this principle may require flexibility and innovation to support the diffusion of renewable energy technologies, as was the case in the Morocco wind farm case, where the national electricity authority refused the arbitration mechanism proposed by the project developers. The Bolivian micro-solar distance-learning case reinforces this notion, where concerns were raised that the local government might look upon the project as an instrument of opposition similar to a radio network it recently had shut down. It is important that project participants respect the sovereign rights of nations.

- *Government policies*: The relatively small scale and recent emergence of the renewable energy sector has resulted in a situation in which many governments have not yet developed public policies supportive of the technologies and approaches advocated by the projects studied in this assessment. Examples can be found in the Bolivian micro-solar distance learning case, where import tariffs designed to tax consumer electronics were nearly applied to electronic equipment associated with the solar photovoltaic systems used in this project. The Indonesian micro-hydro case also illustrates these ideas, where the complexity of the value-added tax exemption process made it impractical for the project to secure this benefit.

- *Relationship dynamics*: In the cases that form the basis for this assessment, it was observed that competing priorities and conflicting agendas often led to complicated relationship dynamics between stakeholders. One example shows up in the Kenyan Olkaria geothermal case, where changing paradigms in the state government, the operating company, and the World Bank led to an evolution toward privatization as the means through which the geothermal resource was developed. Another example appears in the Indonesian micro-hydro case, where competition between upstream and downstream users of the water resource affected the performance of the project in unforeseen ways. There, increased agricultural consumption of upstream water resources negatively impacted the downstream power generation project.

3.7.3. Technical: The challenging operating conditions found in many of the locales in which the case study projects were located proved to act as a macrobarrier across diverse geographies to the diffusion of renewable energy technologies. Issues resulting from these conditions included the logistical challenges in moving bulky photovoltaic and telecommunications equipment in Bolivia to lack of "tropicalized" technologies to make them better suited for the tropical environment.

4. Microbarrier Recommendations

4.1. The wide variety of microbarriers identified in case studies examined by this assessment offer insight into the kinds of obstacles project stakeholders may encounter in diffusing renewable energy technologies to underserved areas. The solutions implemented by the organizations in the case studies similarly provide guidance into how project participants in prospective ventures might seek to manage these potential challenges. Because microbarriers by definition exist at the project level, the focused, committed actions that are recommended here to address microbarriers should be considered as a menu of options. Further information on these can be found through the case studies in Annex E.

4.2 Cultural

4.2.1. *Institutional integration with local community*: Local and regional institutions are critical to making a project successful. Local customs and governing body structures must be known and respected. Within the local and regional customs, however, sufficient governing mechanisms must be established to avoid subsequent conflict.

Recommended actions include:

- Do one's cultural homework through field studies.
- Initiate information-sharing with stakeholders as early as possible to secure local buy-in.
- Establish transparency in procedures and decision-making.
- Enlist the co-operation of locally-respected NGO as intermediary.
- Identify a credible local representative as a point of contact for local community.

4.2.2. *Securing local acceptance, building social trust*: Local trust and social acceptance are required in any project, but significantly more so in the case where an external developer is dealing with a different culture in a developing country. Wherever possible, local buy-in into decision-making should be sought. Recommended actions toward this end include:

- Establish early and broad personal dialogue, with the goal of garnering support from local residents and political leaders.
- Understand, respect, and, wherever possible, defer to local culture.

4.3 Environmental

Integrate environmental considerations: Environmental considerations balance global, national, regional and local issues. Recommended actions include:

- Comply with local, national, and regional standards. Understand relevant requirements and how they are applied. Seek to improve effectiveness of environmental laws, particularly through international standards.
- Apply Environmental Impact Assessment (EIA) practices consistent with the nature of the project. The scope of such assessments will depend on the nature of the project and local issues. While such measures may not be legally required, conducting EIAs benefits many other dimensions of diffusion.
- Pursue sustainability. Stakeholders should be engaged in a conversation that addresses the economic, social, and environmental impacts of projects, in an effort to strike a balance that reflects the values of the public, private, and civil society interests involved.

4.4 Financial

4.4.1. *Finance mechanisms:* Global finance of renewable energy technology diffusion ranks among the leading barriers to projects being undertaken, much less succeeding. Recommended actions at the micro level include:

- Mobilize often-underestimated local financial support, where practicable.
- Reflect in project business plans the realities of local factors that affect revenue collection, such as seasonal income or lack of domestic savings.
- Be absolutely clear about the financial objectives of the project. Is it just about operational cost recovery (a capital good-will project)? Is it to have a sustainable future (recovering funds for re-investment for repair and expansion)? Or is it to be a low-or high-capital recovery project?
- Ultimately, by what measure is the project expected to be financially sustainable? Identify alternative and supplemental finance sources (Clean Development Mechanism, foundations, etc.).
- Promote ancillary income generating activities as part of the project investments.

4.4.2. *Incomplete Information:* Incomplete information can be disastrous for any project, and this holds true for renewable energy technology diffusion projects in underserved areas. Cost overruns, under-performance, revenue shortfalls, and competitive disruptions can all occur, resulting in financial and technical setbacks. Recommended actions include:

- Draw on experiences from similar or demonstration projects.
- Complete an adequate local energy resource assessment.
- Develop an understanding of the local economy and supply/demand patterns.

4.5 Human

4.5.1. *Lack of trained personnel:* The lack of trained personnel is a barrier facing many energy projects throughout the world. It becomes even more critical in underserved areas and developing countries, particularly for less familiar technologies such as renewable energy systems. Recommended actions include:

- Assess and develop the scope of "human capacity building" – efforts to provide technical assistance and deliver training to build the capacity of communities.
- Recognize and account for the steep learning curves associated with new technologies.
- Offer troubleshooting practice for local staff through model equipment and via interactive media resources.
- Utilize telecommunication links to enable communities to request remote assistance.
- Build up to a three-level self-sustaining, education system, with the goal of 1) training 2) trainers to 3) train.

4.5.2. *Inadequate recognition of contributions to rural development:* The myriad positive externalities associated with the provision of electricity to underserved areas merit efforts to include them into overall analyses to help address other microbarriers. Recommended actions include:

- Promote integration of electricity project planning into regional and community planning in order to facilitate employment growth in rural areas.
- Enlist local community support by highlighting the direct and ancillary benefits of electrification.

4.6 Political

Involvement of local stakeholders: Political support at the local level is crucial to the success of any project. Key stakeholders include political authorities, opinion leaders, non-governmental organizations, and customer/community groups. Developing supportive involvement is critical in all stages, particularly the early stages. Recommended actions include:

- Secure the cooperation of a powerful local partner to facilitate projects.
- Utilize local firms in project construction and maintenance to increase local development.
- Recognize the dynamic relationship between governments and markets in the electricity sector, especially with regard to regulation, ownership, etc.
- Request cooperation from governments in conducting renewable energy resources assessments.

4.7 Technical

4.7.1. *Technical challenges:* Technical difficulties are encountered in all energy projects. The keys are to avoid major problems and to be able to respond adequately and swiftly to those that do arise. Recommended actions include:

- Ensure the quality of supporting products, or alternatively cost-effective defect mitigation measures (spares, etc.).
- Review technologies to be applied in order to recognize and adjust for unique characteristics and risks (e.g. cane shredding residue combustion).

4.7.2. *Management challenges:* Management issues often can be either key barriers to, or reasons for, success. Technology may work and finances may flow, but poor management can prove fatal to even the most promising projects. Recommended actions include:

- Apply technologies that are technically appropriate for locations.
- Draw upon and contribute to local knowledge, skills, and experience to optimize project operation.
- Recognize differences in technical management needs specific to project locations.
- Conduct appropriate localized R&D and testing.

5. Macrobarrier Recommendations

5.1. Broad, coordinated cooperation is needed from organizations to address the macrobarriers that constrain renewable energy technology diffusion across the spectrum of technologies and geographies. Such organizations include the energy industry, vendors/suppliers, international finance organizations, international organizations, NGOs, research and development centers, and government authorities. The timeframe for addressing the challenges posed by macrobarriers to renewable energy technology diffusion extends beyond the scope of any single project, and the resources necessary to overcome these obstacles exceeds those available from any single organization. Of particular importance among the macrobarriers identified in this assessment are financial, political/institutional, and technical concerns, which are summarized in Annex C.

5.2. In terms of *finance*, the challenges to financial feasibility in many renewable energy projects and the difficulties encountered in accessing capital call for cooperative actions from diverse partnerships, including:

- Cooperation with governments to provide transparent and consistent policy treatment of competing energy supply alternatives.
- Research to improve our understanding of the relationship between, and the externalities resulting from, electricity and development, including patterns of consumption, fuel displacement, and economic benefits associated with electrification.
- Cooperation with financial institutions to develop financing approaches suited to the scale and characteristics of renewable energy technologies.

5.3. In terms of *political/institutional* issues, partnerships should work to support:

- Recognition that while broad promotion of renewable energy is valuable, a diversity of models for public-private cooperation is appropriate.
- Development of appropriate and effective non-governmental associations, academic centers, and industry groups for renewable energy in developing countries with high renewable energy potential.

5.4. In terms of *technical* concerns, this assessment supports collaborations that encourage:

- Cooperation between governments, research centers, and private firms to develop appropriate renewable energy technologies for the challenging operating conditions that are often encountered in underserved regions of the world.
- "South-South" cooperation between developing countries on renewable energy technology diffusion.

6. Conclusions

6.1. The e_7 Technology Diffusion Working Group found evidence supporting its hypothesis that two major categories of barriers existed: those that stakeholders can influence directly and those that require coordinated action from coalitions to overcome. These two kinds of barriers are referred to as "microbarriers" (project-level) and "macro-barriers" (policy-level).

6.2. The TDWG's assessment of project-level microbarriers and recommendations for addressing them can help guide project participants in identifying and managing potential obstacles to the diffusion of renewable energy technologies that may be relevant to specific projects, geographies, or technologies. The microbarriers documented in the case studies have been distilled into general terms and coupled with summary descriptions of the recommendations for addressing these challenges in Annex B.

6.3. The Working Group's analysis of policy-level macrobarriers aims to help energy stakeholders to identify issues where collaboration is needed with regard to addressing constraints to the diffusion of renewable energy technologies for sustainable development. The findings and recommendations for macrobarriers are summarized in Annex C.

6.4. The findings and recommendations offered in this report are offered primarily to guide e_7 in its mission of promoting sustainable energy development. The microbarrier results can inform the human capacity building and capital project activities of the e_7 and other organizations involved in similar work. However, this report also concludes that broader and deeper cooperation will be needed from a wide range of stakeholders. Partnerships will be necessary to facilitate renewable energy technology diffusion on a large scale. The macrobarrier findings and recommendations should serve to refine the purposes and efforts of partnerships established between private, public, and civil society stakeholders to promote renewable energy technology diffusion.

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ANNEX A - e_7 Technology Diffusion Working Group Roster

Name	Company	Country	Position
John Harper	American Electric Power (AEP)	U.S.A.	TDWG Chair and Vice President, Corporate Technology Development
Michael Jung	American Electric Power (AEP)	U.S.A.	Manager, Environmental Affairs
Klaus Baumann	RWE	Germany	Senior Program Manager, International Business Development
Blair Seckington	Ontario Power Generation (OPG)	Canada	Senior Advisor, Technology
Pierre Mollon	e_7 Fund/ Electricité de France (EDF)	France	e_7 Fund Project Coordinator
Andy Riley	ScottishPower (SP)	U.K.	Director, Business Development
Takao Shiraishi	Kansai Electric Power Co. (Kansai)	Japan	Manager, International Network Group
Makoto Suto	Kansai Electric Power Co. (Kansai)	Japan	General Manager, International Network Group
Jacques Martel	Hydro-Québec (HQ)	Canada	Managing Director, Research and Development
Yves Langhame	Hydro-Québec (HQ)	Canada	Chef innovation Stratégique, Research and Development
Roberto Vigotti	Enel	Italy	Manager, International Relations
Andrea Biondo	Enel	Italy	Manager, Training and Diffusion, International Relations
Hiroyuki Aoki	Tokyo Electric Power Co. (TEPCO)	Japan	Manager, Research and Institutional Relations, Corporate Planning Department
Paul Aubé	e_7 Network Secretariat	Canada	Project Advisor

ANNEX B - Draft Findings and Recommendations: Microbarriers

Type	General Barriers	Recommendations
Cultural	Institutional integration with local community	- Do your cultural homework - Secure early buy-in - Establish transparency in procedures - Gain cooperation of local, independent NGO as intermediary - Designate a local, not external, point of contact for project
	Securing local acceptance, building social trust, commitment to project	- Secure early dialogue with the objective of establishing mutual commitment to project - Understand, respect, even defer to, local culture
Environment	Integration of environmental consideration	- Comply with local, national, regional standards - Seek to improve environmental laws, particularly through international standards - Apply EIA practices, where feasible - Pursue environmental sustainability
Financial	Lack of appropriate finance mechanisms	- Mobilize local finance, where practicable - Factor in local conditions and circumstances in revenue collection - Define degree of financial sustainability (capital? O&M? future investment? other?) - Identify alternative finance sources (CDM, foundations, etc.) - Promote ancillary income generating activities
	Lack of information regarding relevant technologies and systems	- Draw upon demonstration projects - Conduct local resource assessments - Develop understanding of local economy, supply and demand patterns
Human	Lack of trained personnel	- Engage in human capacity building - Demonstrate patience with learning curve associated with new technologies - Offer troubleshooting practice on model equipment - Utilize channels and tools for requesting remote assistance - Make sure to train trainers to train

ANNEX B - Draft Findings and Recommendations: Microbarriers

Type	General Barriers	Recommendations
Legal/Political	Involvement of local stakeholders	- Secure legitimate cooperation of effective local partners to facilitate projects - Utilize local firms in project construction and maintenance to increase local development - Recognize dynamic relationship between governments and markets in electricity sector - Request cooperation from governments in conducting resource assessments
	Inadequate recognition of energy's contribution to rural development	- Integrate with community planning to facilitate employment growth in rural areas - Undertake efforts to enlist local community support by highlighting ancillary benefits of electrification
Technical	Technical challenges	- Test and be aware of the quality of locally-manufactured supporting products - Recognize and account for unique characteristics of certain technologies (e.g. cane shredding residue combustion) - Utilize technologies that are technically appropriate for locations
	Management challenges	- Tap into local knowledge, skills, experience to optimize project operation - Recognize differences in management needs specific to various project locations - Conduct localized R&D, testing

ANNEX C - Draft Findings and Recommendations: Macrobarriers

Type	General Barriers	Recommendations
Financial	Unprofitable project economics	- Establish "level playing field" for all alternatives - Clarity on expected willingness to pay, desired return on investment, ancillary objectives - Factor, even seek to capture, positive externalities of electrification in financial calculus, where possible
	Lack of access to capital	- Increase research to better understand complex relationship between electrification and development and to enhance prospects for successful development stimulus through electric power - Enhance integration between electrification projects and rural development planning - Recognize the need for and value of "significant interventions" from governments through targeted assistance - Develop more financially viable "business plans" for rural electrification/development
Legal/Political	Sovereignty issues	- Respect the rules, defer to sovereign rights - Cultivate high-level relationships based on interests of beneficiaries
	Government policies that discourage electricity investments or fail to promote broad electrification	- Foster intergovernmental cooperation on sustainable energy policy development - Cultivate growth of sectoral and cross-sectoral industry associations to influence public policy
	Relationship dynamics between stakeholders	- Strive for "win-win" agreements - Recognize multi-stakeholder environment dynamics - Realize absence of any singular model for success when it comes to public-private cooperation in electricity sector
Technical	Challenging operating conditions	- Prioritize needs of customers/beneficiaries - Make logistics work with conditions - Fit appropriate equipment for location

ANNEX D – Additional Information Resources

Stanford University Program on Energy and Sustainable Development
http://pesd.stanford.edu

Electric Power Research Institute, Electricity Technology Roadmap Initiative
http://www.epri.com/corporate/discover_epri/roadmap

Resources for the Future WSSD Briefing Paper on Technology Diffusion
http://www.rff.org/sustainabledevelopment/Issuebriefs/joburg16.pdf

Best Practices for Photovoltaic Household Electrification Programs
http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/1996/08/01/000009265_3961214152456/Rendered/PDF/multi_page.pdf

Best Practices for Sustainable Development of Micro Hydro Power in Developing Countries
http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2001/03/01/000094946_01020805385089/Rendered/PDF/multi_page.pdf

The Rural Energy Story: Towards a New Paradigm
http://wbln0018.worldbank.org/infrastructure/infrastructure.nsf/b783857451bdbcf48525693c006609e5/8525690b0065f5d1852568e100579feb/$FILE/Ghana presentation 2.ppt

WRI Paper on Agenda 21, Chapter 34
http://www.wri.org/wri/rio-5/acrobat/techtran.pdf

Resources for the Future: International Cooperation for Reducing Greenhouse Gas Emissions – From Theory to Practice Through Technology Transfer
http://www.rff.org/conf_workshops/files/chinaworkshop.pdf

Resources for the Future: Promoting International Transfer of "Clean Technology"
http://www.rff.org/reports/PDF_files/cleantech.pdf

Energy Technology Transfers in China
http://www.rff.org/reports/PDF_files/cleantech.pdf

GEF Brochure: Ten Cases of Technology Transfer
http://www.gefweb.org/Outreach/outreach-PUblications/Tech_Transfer_Brochure.pdf

2000-2001 APEC Energy R&D and Technology Transfer Seminar
http://www.nedo.go.jp/english/informations/121218/seminar.pdf

Biomass Users Network Zimbabwe: Promotion of Renewable Energy Technologies
http://www.sei.se/red/red9703c.html

University of California Energy Institute: From Technology Transfer to Market Transformation
http://www.ucei.berkeley.edu/ucei/Recent_Presentations/From_Tech_Transfer_to_MT.pdf

e_7 /UNEP Electricity Sector Report for the World Summit on Sustainable Development, January 2002.
http://www.e7.org/NewsBriefs/Electricity Sector Report (E7 Version - Full).pdf

2001 G8 Renewable Energy Task Force Chairmen's Report, Corrado Clini and Mark Moody-Stuart
http://www.renewabletaskforce.org/pdf/G8_report.pdf

Edmonds, J.A., Y. Shi, and K. Storck, *Mid- and Long-term Strategies for Technology Deployment to Address Climate Change in China*, GTSP Beijing Workshop Report, 1999.

Gallagher, Kelly Sims, "U.S.-China Energy Cooperation: A Review of Joint Activities Related to Chinese Energy Development Since 1980," BCSIA Discussion Paper 21, Energy Technology Innovation Project, Kennedy School of Government, Harvard University, 2001.

International Energy Agency, *World Energy Outlook 2002*, Paris: International Energy Agency; Organization for Economic Cooperation and Development, 2002.

President's Committee of Advisors on Science and Technology, Energy Research and Development, *Federal Energy R&D for the Challenges of the 21st Century,* (Washington DC: Office of Science and Technology Policy, November 1997), http://www.ostp.gov/Energy/index.html.

President's Committee of Advisors on Science and Technology, Panel on International Cooperation in Energy Research, Development, Demonstration, and Deployment, *Powerful Partnerships: The Federal Role in International Cooperation on Energy Innovation,* (Washington DC: Office of Science and Technology Policy, June 1999), http://www.ostp.gov/html/P2E.pdf.

Storck, K. and S. Yoffee, "A Review of International Collaboration of Technology R&D to Prevent or Mitigate Global Climate Change," Presented to the Climate Technology Initiative, Bonn, Germany, June 10-12, 1998.

United Nations Development Programme, *World Energy Assessment: Energy and the Challenge of Sustainability*, New York: United Nations, 2000.

World Energy Council/United Nations Food and Agriculture Organization, *The Challenge of Rural Energy Poverty in Developing Countries*, London: World Energy Council; New York: United Nations, 1999.

e7, various project documents, 1996-2003

ANNEX E – Case Studies

1. Micro-Solar Distance Learning in Bolivia

Overview

Location:	Village of Porvenir, Department of Santa Cruz, northeastern Bolivia (a rainforest location approximately 400 km from nearest paved road)
Capacity:	2.5 kW
Generators:	48 Siemens 12 volt M55 photovoltaic modules, connected in series sets of two
Power System:	24 volt DC system with disconnects, overcurrent protection, charge control functions, and monitoring systems, is run through a 2.5 kW sinewave inverter, delivering 230 volts at 50 Hz to an all AC load
Energy Storage:	5 kWh power supply consisting of 16 lead acid batteries
End-Uses:	Three computer systems, wired fluorescent lighting for local elementary school, remote monitoring device, small refrigerator for vaccines, two-way Ku-band satellite service
Customers:	600 people
Partners:	USDOE, BP, Solarquest, New Visions Foundation, Friends of Nature Foundation (FAN), the Foundation for Environmental Education, and others
Total Cost:	Approximately US$70,000

Barriers and Solutions

The Porvenir Project encountered obstacles to successful implementation. Some of these were foreseen, while others appeared unexpectedly. The following list offers examples of some of the barriers encountered in the course of this project and the solutions that resolved them.

Legal/Political/Regulatory

The Bolivian government sought to impose steep tariffs on the equipment necessary to implement the project. Because this project had been identified by the U.S. White House as a pilot effort to address the "international digital divide", the U.S. Department of Energy intervened to secure tariff-exempt status for equipment by classifying project as U.S.-sponsored aid effort, not a commercial venture.

Citing the threat of political opposition posed by rural empowerment, the Bolivian government had shut down the nearby Miners' Radio network not long before the Porvenir project was initiated. The project was characterized as educational to minimize controversy, and project partners worked closely with Bolivian government to secure buy-in from high-level political circles.

Financial/Technology

Solar panels and associated equipment were expensive. Photovoltaic equipment was donated by AEP to the project due to its pilot status. Capital costs remain a primary hurdle for similar projects, although technical advances continue to lower this obstacle. Economic opportunities to use the electricity to power income-generating activities, such as organic Hearts-of-Palm and other high-end agricultural products for export, remain under evaluation by the village. It remains difficult to quantify the value of the educational opportunities afforded by the distance learning component of the project, but this social progress represents a substantial return on the capital investment, as well.

Poor airport freight facilities. Village was inaccessible to all but the most rugged transportation. Logistical delays and dead-ends were avoided by having equipment packaged in a manner that permitted unloading by hand and allowed for transport by pickup trucks to the village, at the recommendation of the Friends of Nature Foundation (FAN).

High heat and humidity presented challenging operating conditions. Equipment failures were not unavoidable, but villagers' ingenuity was tapped to devise clever solutions, such as the use of screens to reduce exposure of computers to sunlight and to reduce the impact of heat and humidity.

Human/Cultural

Villagers were skeptical of outsiders' interests. Project partners began by training Friends of Nature (FAN), a local and trusted NGO with which AEP had developed strong relations during the implementation of the nearby Noel Kempff Mercado Climate Action Project. FAN then introduced training and extended communication about the project to Porvenir, backed by the resources and training of the project partners. The use of FAN as the primary interface with the villagers helped to mitigate skepticism.

Insufficient local education available to operate and maintain equipment. One of FAN's first objectives was to train village residents in the skills necessary to operate and maintain the micro-solar distance learning system. Seven youths between the ages of 18 and 26 were trained and certified as system operators, and these youth went on to subsequently train other community members. This training has demonstrated its value, as the village, without outside assistance, has handled several on-site repairs and replacement procedures.

Decision-making process for issues regarding project issues needed to be clarified. Existing village committees were recruited to administer various aspects of the micro-solar distance learning system. A democratically elected committee was convened to help identify development objectives to be supported by the new power system. Tensions between local respect for seniority and the emerging importance of youth that was introduced by the micro-solar distance learning system initially were complicated but later proved manageable and, ultimately, rewarding.

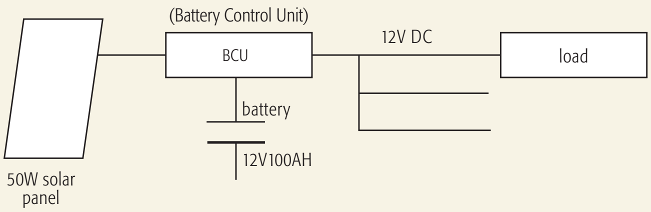
2. Solar Home Systems in Indonesia

Introduction

As a part of the Indonesia Rural Electrification Project (an e_7 AIJ project), Kansai Electric Power Co. implemented Solar Home Systems (SHS) in a remote area in Indonesia. This SHS project lasted from June 1996 to February 2001 with construction during February 1998 through December 1998. 100 SHS units of 50 Watts each (See Fig.1) were installed at households in Oelnaineno Village, Timor Island. A local management and operations entity, named PLD, was established as the villagers' company.

This project was implemented in cooperation with five Indonesian partners: the Ministry of Environment, the Ministry of Energy and Mining, the Ministry of Cooperatives, the local government and the village. The Ministry of Environment approved the project as an AIJ initiative to address global warming in September, 2000.

Fig.1 Solar Home System (SHS)



Economic Evaluation

(1) Rate setting and collection

- Capital cost of US$ 52,000, as well as other costs such as training and monitoring that were financed by e_7.
- The original plan was to recover capital and O&M costs during the system life of about ten years by collecting revenues, but this plan had to be modified when Indonesia was hit by the 1997 South East Asian economic crisis. Accordingly, electricity rates were lowered to the extent that only O&M costs were recovered, which made it impossible to recover the capital investment.
- Users make a down payment of 175,000 Rp (~22 US$; 8,000Rp = 1 US$) and pay fixed rates of 440,000 Rp/year (~55 US$/yr, <5 US$/month), which have been reliably collected since commercial operations began in January 1999.

(2) Maintainability

- A few batteries have been replaced, but generally the systems have been performing well.

Socioeconomic Evaluation

- Prior to the decision of site location, a socioeconomic study was undertaken in nine candidate villages and finally the Oelnaineno Village was chosen. The main selection criteria were:
  – No grid electrification is expected within the next ten years.
  – Adequate average cash income exists to afford rate payment.
  – Solid basis exists for implementing participatory, institutional arrangements.
- Local NGOs were asked to cooperate in setting up PLD for SHS maintenance and management.

Training

- Many of the previous household electrification projects with SHS in Indonesia ultimately failed due to inadequate maintenance and management. There is a village named Kualeu where the e_7 team visited and found that 20 sets of SHSs had been installed, but after two years most of SHSs were broken. The e_7 team was asked and agreed to perform repairs.
- In acknowledgement of this general situation, the e_7 SHS project was planned to provide training to PLD technicians so that they could undertake maintenance by themselves on a continuous and long-term basis.
- The training covered basic knowledge of electricity, safety, SHS equipment, maintenance, and trouble-shooting. Twice a year during the construction period, e_7 engineers contributed sufficient training hours for the villagers. Manuals and an SHS simulator to conduct trouble-shooting exercises were prepared for the training.

Lessons Learned

(1) Rate Collection

- SHS service is provided at a rate twice as high as most rural electrification schemes, aiming at an adequate financial pool to offer continuous, long-term maintenance services. In spite of this high rate, users are satisfied with the services such as quick restoration of problems, replacement of batteries, and supply of spare parts such as fluorescent lamps.
- Most of the users have fulfilled payments fairly and on a regular basis. However, when a user fails to pay for six months, the system is removed and transferred to a new customer. To date, 20% of users have delayed their payment from time to time, and five SHSs have been transferred to new customers after negotiations.

(2) Socioeconomic Evaluation

- Handicraft and weaving work in the evening hours have been made possible by electric lighting, which provides new opportunities for income generation. This additional income has helped to improve rate collection. Such opportunities for income generation thus offer good incentives for promoting rural electrification.
- Those who are unable to pay need subsidies from the government or aid organizations.

(3) Environmental Impacts

- Before electrification, mosquito nets quickly became sooty from using oil lamps. With SHS, mosquito nets do not have to be washed as often, and the elimination of soot creates healthier living conditions in terms of respiratory health.
- The understanding of such merits of electrification can accelerate electrification to other rural areas.

(4) Legal/Political

- Although this project was small, AIJ applications had to be laboriously submitted to each e_7 member country for approval.

(5) Training

- PLD has conducted training of its own staff to maintain skills since the project was turned over to the community. PLD's high quality of services has gained the trust of users, which greatly contributes to the reliability of rate collection.

(6) Management

- PLD has a president who is a key person in the village. This small company is operated with the cooperation of a local NGO. This kind of maintenance and management entity is essential to sustain the successful operation of SHS electrification systems.
- The cooperation of local people and an NGO was also essential in setting up the PLD entity. The local NGO was familiar with and understanding of the needs of beneficiaries and thus provides reliable supervision. Their contribution was invaluable.
- The clarification of roles and responsibilities within the PLD entity is crucial for the successful operation.
- Local procurement of materials should be taken into account at the time of construction to prepare for future maintenance. All SHS parts can be procured in Kupang, the local capital city of Indonesia located a half day away from the village. Wires, control units, pedestals and batteries are made in Indonesia. Batteries are an important part of SHSs, and the specification for the batteries in this project is the same as that for bus transportation use, improving availability.

(7) Income Generation

- Rural electrification with SHS is relatively costly and requires higher rates than grid-based power. Nevertheless, remote areas with no grid electrification expected within the next ten years have few other choices. To address this situation, governments should take measures to create cash income sources (e.g. pig farming) in remote areas to help pay for expensive electricity.
- It is difficult to tell which should happen first – electrification supported by the rate payment from local people, which will create additional income (e.g. handicrafts/weaving) or the creation of additional income for local people to afford electrification. But the former is an essential element of electrification conducted by private organizations. The development of rural income sources is one of the top items for the government in order to raise local motivation and resources for electrification.

3. Micro Hydropower in Indonesia

Introduction

e_7 resolved to undertake the Renewable Energy Supply Systems (RESS) project in Indonesia (Project e_7-1) with cooperation of the Indonesian Government in 1996. The main objectives of this Activity Implemented Jointly (AIJ) pilot project were: 1) to supply limited but reliable electricity to households in remote areas in Indonesia; 2) to develop and introduce a new sustainable and decentralized management concept for rural electrification; and 3) to obtain approval as an AIJ project under the United Nations Framework Convention on Climate Change (UNFCCC).

Project e_7-1 was implemented between 1997 and 2000 and was composed of socio-economic, financial and technical studies that laid the foundation for seven rural electrification schemes (200 solar home systems, 1 solar/wind power hybrid system and 4 micro hydropower (MHP) systems). The following MHP projects were implemented as a part of Project e_7-1.

Three MHP units were installed in isolated villages on Sulawesi Island and another unit was installed on Sumba Island. In Sulawesi, the power output of each unit was 50kW in the village of Ta'ba, 69kW in Tendan Dua, and 12kW in Bokin. Power distribution systems were built in each village, supplying 100W electricity to each connected household. The fourth MHP was installed in Waikerosawa, on the Island of Sumba. It is a small project of 15kW capacity, selling the electricity to the local power authority. All MHP projects were completed with the involvement of local NGOs and handed over to the Indonesian Government in 2000. With a total capacity of 146 kW, these MHPs electrified these isolated, rural villages by supplying 25,466 kWh between January and June 2002 to 653 households.

Local management entities named PLDs were established in the villages. PLDs are micro-utilities in the villages, operating and maintaining the MHPs and distribution systems, as well as supplying electricity to villagers and collecting fees.

Barriers and Solutions

The following list offers examples of barriers encountered in this project and the solutions that were devised.

Legal/Political/Regulatory

- No serious legal/political/regulatory problems were reported during the project, since the project was implemented under the umbrella of the Indonesian Government.
- All MHP sites were isolated, with no medical centers nearby. It would take ten hours to get a serum for poisonous snake bites. Keeping project engineers safe and healthy was a high priority. Future counter measures should be prepared in cooperation with the local government.
- Tax exemption could not be adapted to the MHP projects. The Indonesian Government kindly accepted the e_7's proposal to exempt the value-added tax on the project contracts. However, the application process to the tax office was complicated, and MHP projects failed to complete the application. The process should be examined carefully in advance.

Financial/Technology

- An objective of the project was to develop a financially sustainable and decentralized management concept for rural electrification. In order to cover full operation/ maintenance costs, as well as those of hardware replacements, e_7 and the NGO helped the villagers to establish micro-utilities in the villages and design electricity tariffs in consideration of residents' ability and willingness to pay for electricity.
- Since the villagers were unfamiliar with electric power engineering, it was difficult to find staff to operate and maintain the MHPs in the isolated villages. Since human resources were insufficient, the project actively conducted management/technical training for staff candidates. This training played a key role in making the project successful. Training was started as early as possible, so that the PLD staff candidates could be involved in the project from the very beginning.
- Since the MHP construction project involved civil construction works, it was necessary to redesign the details at the sites. Specialists often were required to visit the sites to re-examine the details of the design based on the situation.
- Defects in a 0.5A circuit breaker (MCB) that was manufactured in Indonesia and used in the project were reported, and all MCBs at each household subsequently were replaced. Since MHP is not an advanced technology, Indonesian domestic products were fully available, including the generator. The implemented technology/ equipment was procured domestically, which was advantageous for the MHP project to reduce the construction costs, and this made it easy to get the spare parts for maintenance. It is recommended that the quality of some domestic products be checked before they are put into use.
- In Ta'ba village, the local power authority unexpectedly extended service into the village. Although it had been previously identified that the village would not be electrified in the near future, the authority suddenly extended the power line to a part of the village and proposed low prices to the villagers to compete with the MHP in order to win over customers. Despite this development, the MHP system actually was able to *increase* its customer base. This is because the villagers highly appreciated the good performance of the MHP in villages, whereas power outages in the local authority's network were quite frequent.

Human/Cultural

- Villagers were skeptical of outsiders' interests. It was important to have a residential expert at the site and to give the management/ technical assistance to the villagers with the help of the local NGO. The transparent, competent and reliable rural electrification management scheme used by the trusted PLD micro-utilities contributed to the community's acceptance of the project.
- Some villagers requested the PLD to move power distribution poles based on reasons coming from local beliefs or superstitions. In some cases, the villagers demanded compensation for land used by the project. The local NGO played an important role in helping the villagers understand that the electricity would improve their standard of living.
- In the drought season, the Bokin MHP often could not operate because of the lack of river water. The water was being diverted by the upstream farmers to irrigate new rice fields, as well as by a coffee plantation to rinse harvested coffee beans. Water is a very important and often scarce resource. Although it will take time to solve this problem, the local government is taking the lead to find a solution.

4. Malavalli Biomass Power Plant in India

Overview

Location:	State of Karnataka, South India, 120 km from Bangalore, 2200 km from New Delhi
Capacity:	Gross 4.5 MW, net 4.0 MW
Boiler design:	Specifically for crop residues (i.e., furnace with large heating surface and low gas exit temperatures)
Fuel storage:	Open storage of cane trash and palm fronds, as well as plantation wood, 300 MT (~two days supply) at the plant., plus an additional 1500 MT storage at a fuel yard, located 1 KM from the plant
Fuel beneficiation:	Shredding of cane trash and palm fronds and chipping of tree toppings; two conveyer belts to the furnace
Fuel:	40,000 tpa crop residues as cane trash, coconut leaves, toppings of trees
Total investment:	~ US$4 million
Electricity sales:	24 million kWh/year, US$1.60 million/year
Organic fertilizer:	Production and distribution: 4000 tpa

Power Purchase Agreement

Purchaser:	Karnataka Power Transmission Corporation Ld.
Contracted:	4.5 MW
Grid synchronization:	July 15th, 2001
Duration:	10 years – 20 years extension
Tariff:	First 10 years - Rs 3.16/kWh = 6.66 UScents/kWh (2001-2002) with 5% annual increase

Key aspects of fuel supply agreement

Fuel manager:	Ambience Engineering Ltd.
Fuel supply/Price:	a) cane trash/coconut fronds 20,000 t pa (US$ 1.8/million BTU) b) rice /groundnut / coffee husk 10,000 t pa (US$ 2.0/million BTU) c) back up fuel, plantation wood/coconut shells 10,000 tpa (US$ 2.2/million BTU)

Rural Electricity Distribution Management

Ambience has promoted an entity called Grameena Vidyt Mandall (GVM), the objective of which is to provide services to the distribution utility called KPTCL (Karnataka Power Transmission Corporation Ltd). GVM's current activities relate to a rural electric network fed by the 66/11 KV substation, to which the project's output is transported. GVM covers 10,000 consumers spread over 51 villages. The associated distribution network consists of 200 km of 11 Kv/415 volt lines and 140 transformers.

Typical problems associated with rural electrification in India include: high transmission/distribution losses, opaquely subsidized tariffs, consumer indifference, negligence of rural areas by supply companies, etc. The only way to overcome these problems is to involve the rural communities. GVM aims to achieve this by providing the following services to the distribution utility:

- Sensitizing local communities;
- Conducting revenue operations (metering/collections); and
- Managing customer complaints.

Rural Job Creation

Ambience has promoted an entity called Grameena Udyog Samithi (GUS), the objective of which is to facilitate employment growth in rural areas. GUS endeavors currently relate to the following activities linked with the project's needs, including:

- Establishment of a biomass supply chain;
- Establishment of an organic fertilizer production unit;
- Establishment of a distribution network for organic fertilizer; and
- Undertaking works contracts related to power plant O&M.

Employment has been created for 500 persons, largely in the biomass supply chain. Previously, cane trash had been burned in the fields, causing environmental pollution. GUS has convinced farmers to allow it to collect the cane trash and, in return, to receive organic fertilizer. The key elements of the GUS sustainable crop residues supply scheme are:

- Procurement mechanisms that are easily understood;
- Cost-efficient collection mechanisms; and
- Mobilization of local entrepreneurs to manage collection and transportation activities.

This approach to sustainable development contributes both to the abatement of global GHG emissions, as well as to the mitigation of local and regional environmental pollution.

Promoter Profile

Ambience Management Services, Ltd is the promoter of the Malavalli Power Plant, Ltd. (MPPL). Ambience is focused on the energy sector, with competencies in project development and facility construction. Ambience, until recently, was a joint venture partner with ANSALDO in India. This joint venture acquired power plant projects totaling up to 1300 MW. Ambience's current involvement in the power sector is in its capacities as:

- Promoter & main shareholder in MPPL;
- Partner in Peenya Power, which is setting up a 100 MW combined cycle power plant at Bidadi with a power purchase agreement signed with KPTCL;
- Partner with MacNally Bharat/Technofab Engineering, leading providers of mechanical services to power plants; and
- Partner with SICIM Pipelines Pvt. Ltd., which undertakes construction of cross-country pipelines.

Main Barriers to the Project (past and ongoing)

Policy

- Lack of a well thought out policy framework for renewables. (*Widely divergent perspectives lead to poor implementation and increased development risks.*)
- Inadequate regulatory framework for biomass power generation. (*Indiscriminate growth will lead to depletion of forest/ground water resources apart from driving up biomass costs beyond sustainable levels.*)
- Generic institutional frameworks for all renewables, leading to inequities. (*Biomass power plants have high variable costs, unlike mini hydro/wind/solar, and hence need different financing instruments.*)
- Inadequate recognition of contributions to rural development. (*Biomass power plants create a significant number of jobs and directly impact rural GDP in many positive ways.*)
- Inadequate recognition of impacts on environmental issues. (*Usage of crop residues as boiler fuel mitigates pollution caused by the burning of such crop residues in fields.*)

Technical

- Lack of proven methods for establishing a sustainable biomass supply chain, particularly for crop residues.
- Lack of proven machinery for shredding/conveying low-density crop residues, with acceptable throughput and economical processing cost.
- Lack of proven boiler design/O&M protocols for firing low-density crop residues, the high alkali metal content of which causes slagging and corrosion.
- Lack of established performance data while firing low-density crop residues in combination with other biomass fuels.
- Lack of quality training products/infrastructure for imparting skills related to the biomass supply chain and preparation/combustion.

Other

- Lack of experienced & capable consultants to function as owner's engineer or lender's engineer.
- Lack of appropriate financing schemes for project construction as well as working capital, factoring in the cash flow pattern/risks, which are specific to biomass power plants.
- Mitigation of risks related to power purchase agreements resulting from SEB's flip-flop over renewable energy purchases and/or "wheeling & banking" policies.
- Mitigation of risks related to biomass availability & costs, particularly related to mill residues & wood.
- Efforts required to enlist local community support, without which a biomass power plant cannot function.
- Efforts required to recruit & train O&M manpower with skills as required for a continuous duty, thermo-electric power plant.
- Efforts required to develop local vendor base for various consumables and spares/repair works as required for a thermoelectric power plant.
- Efforts required to develop "downstream" activities such as ash utilization & power distribution.
- Efforts required to establish "upstream" activities including sustainable supply chain for crop residues and water resources.

Opportunities

The project aims to institutionalize its experiences into "knowledge assets" and to utilize its 4.5 MW unit as a "laboratory" for the multiple firing of biomass, all in order to facilitate replication. With the above approach, following opportunities could be pursued:

In India

- The MPPL scheme could be used to upgrade 5000 MW of cogeneration capacity in over 500 sugar mills (crushing over 250 million MT/year of cane).
- The MPPL approach can be used in cogeneration at paper mills and food processing/ preservation industries.
- The MPPL paradigm could be adopted in decentralizing power generation in rural areas.

Note: All above schemes contribute to sustainable development & GHG emissions abatement.

Outside India

- The MPPL experience could provide consultancy services (as owner's/lender's engineering) for biomass-fired power plants and cogeneration schemes.
- The knowledge accrued by MPPL can supply, from within India, multiple biomass-fired steam generators.
- The lessons learned from the MPPL project can provide training services related to biomass-fired power plants.

Note: All above activities would be carried out at significantly lower costs than a European consultant/contractor.

5. Olkaria Geothermal Plant in Kenya

Introduction

Enel participated in the early stages of the Olkaria project in Kenya, in which the World Bank approved three loans and two credits to support the development of Kenya's geothermal power program and resources. Five specific projects, carried out between 1979 and 1996, helped the Kenya Power Company (KPC) install the first geothermal-based power plants in Africa. KPC changed its name and identity to Kenya Electricity Generating Company Ltd (KenGen).

Funding of the first five contracts was supported by the World Bank (IDA), European Investment Bank (EIB), Kreditanstalt fur Wiederaufbau (KfW). Power-station, civil works, and electro-mechanical work were funded entirely by KenGen. Substations, transmission lines and steam gathering system are on tender and housing is under construction.

The first three projects (approved in 1979, 1980, and 1983) involved drilling of wells, set up of transmission facilities, and construction of a power plant with 45 MW of capacity in the Olkaria Geothermal field of Kenya's Rift Valley. After the plant was successfully put into operation, the government decided to expand its geothermal development program, with a view toward making it one of the main pillars of Kenya's future power generation system. The Bank supported this objective with two credits (approved in 1984 and 1989) for exploration, appraisal, and drilling in other parts of Olkaria and at the extinct volcano of Eburru.

The first three projects were completed on time and within cost estimates, though drilling performance was below par. All power generation units have operated at or above capacity for a number of years, and all currently are operating at their installed capacities without significant problems.

However, the fourth project was plagued by poor drilling performance, a problem that had emerged earlier but that the Bank began to address effectively only in 1987, when it organized bilateral aid for a technical assistance program designed to enable Kenyan staff to take over full operation of the program. By early 1988, drilling performance began to improve dramatically.

The fourth and fifth projects involved the drilling of 29 wells at Olkaria and demonstrated that the geothermal field there could support a total of 78 MW of steam, which will be used by a power plant currently financed under a Bank-funded follow-up project.

Barriers and Solutions

The Olkaria Project encountered some obstacles to implementation. Some of these were foreseen, while others appeared on the stage. A list of following examples illustrate some of the barriers encountered and the solutions that resolved them.

Legal/Political/Regulatory

The government and KenGen need to review commitments to geothermal exploration and development drilling and must identify the resources required to implement these programs efficiently. Geothermal development should become a self-supporting profit center within KPC's power generation activities, with the appropriate resources needed to support maintenance and expansion. The Government could intensify its commitment to expanding geothermal exploration and development and providing sufficient resources for maintenance, but it must balance these options against the alternative of increasing private sector participation in these activities.

The Bank suggested that most, if not all, of the future growth of Kenya's power supply should be met by the private sector. The government has agreed to offer the Olkaria West fields for private development and to promote private sector participation in conventional coastal power generation plants. Several private sector generation proposals are under discussion.

The Bank's procurement procedures were too inflexible to meet the project's needs. The Bank's Procurement Unit refused to accept the results of a limited international tender for cementing services when this process produced only one bid. The Bank subsequently requested that KPC issue an international competitive tender, although only a handful of companies worldwide provided this service and there was no evidence that other bidders would participate.

KPC eventually financed the services itself. In doing so, however, the Bank also stopped the use of an offshore agent for expedited purchase of drilling equipment and materials that were urgently needed, even though the revised procedures added an additional three to six months to the procurement process, creating considerable difficulties for KPC.

Financial/Technology

Initially, drilling production levels of the first three projects (1979-86) were low, but production greatly improved by 1987 and has remained high throughout the remaining operations. KPC has increased its own capabilities to the point that it can now operate its geothermal program entirely with its own staff, without full-time external consultants. However, its equipment is old and will need to be replaced if effective operation is to continue.

The Olkaria power plant has experienced problems in maintaining adequate steam levels to its turbines. After operating above its rated capacity through 1985, the Olkaria power plant began to have production problems because of inadequate investments in new wells, which were needed to offset steady declines of 3-5 percent a year in steam production from existing wells. Steam and power production gradually fell from 45 MW in 1989 to 30 MW in 1995. KPC was expected to use internally-generated funds to pay for urgent work needed to connect replacement wells and drill five new wells. Savings from reduced fuel oil imports could have offset the investments.

KPC was unable to finance the work. Only in 1992, when production fell more than 20 percent, was an agreement reached to divert funds from another Bank project to pay for the well connections.

The European Investment Bank (EIB) financed the third unit of the existing Olkaria I Power Plant built in 1985 at a cost of approximately US$ 2 million.

The Bank was late in taking action to strengthen KPC's drilling operations and was unable to take effective action to help KPC stem production drops until output had fallen by one-third, at a substantial cost in increased oil imports. For its part, KPC was slow to address the fall in power output and was unable to fund the ongoing costs of connecting the requisite new wells.

The Bank needed to make greater use of technical staff in reviewing drilling and resource development programs during both the appraisal and supervision stages of geothermal projects.

The Bank needed to be more flexible in its procurement to allow the borrower to make unscheduled rush orders more efficiently and at minimum cost.

The Government and the Bank will need to prepare an alternative approach to developing the Olkaria resource, one in which government institutions and private firms will play a more significant role. Such a strategy might include the provision of drilling services to investors or guarantees of competitive prices for steam, allowing the private sector to invest in lower-risk generating plants.The EIB granted a loan in 1999 of EUR 41 million (US$ 38.7 million) to Kenya for the construction of sub-stations and transmission lines for the Olkaria II geothermal power plant.

Human/Cultural
KPC has yet to develop a geothermal organization with sufficient autonomy, authority, and financial independence to procure the necessary resources in a reasonable time or to use its investment resources efficiently. Sustainability of KPC's exploration and appraisal efforts is unlikely unless additional resources are provided for new drilling rigs and for its geothermal unit.

Forced to ration power since September 1999, Kenya has a critical need for immediate additional installed capacity. A 100-year drought has caused water levels to fall in the country's hydroelectric dams. The United Nations has issued an emergency appeal for $88 million to feed 3.3 million Kenyans threatened with starvation as the result of the drought.

KenGen alone has 41 graduate professionals working on a full-time basis in geothermal activities. Several others, mainly based in the Head Office, provide services to the geothermal activities at different times. External professional services are obtained through a four-man Board of Consultants (BOC), which meets twice a year.

The Government should intensify its efforts in education programs, expand geothermal exploration and development, boost its expertise in the field, and provide sufficient resources for maintenance, while pursuing private sector participation.

6. Mokai Geothermal Plant in New Zealand

Introduction

The Mokai geothermal system is one of the five systems classified for development in the Waikato Region. The Tuaropaki Trust owns a geothermal power station at Mokai and wishes to sustainably manage and use the Mokai field for as long as possible.
The Mokai geothermal system lies 25 km north west of Taupo. The natural features of the Mokai system include warm and hot springs, mud pools, a rare mud geyser, and fumaroles. It also has one of the largest populations of a rare geothermal organism, the fern *Christella*.
The Tuaropaki Trust owns a large area of land overlying the Mokai geothermal system. The Mokai geothermal system is classified for development by Environment Waikato. At Mokai, the Tuaropaki Trust has sole access to the majority of the resource.

System Development
The Trust believes that developing the Mokai geothermal system is a unique opportunity for Maori to take the initiative and create a project that allows for self-determination. The Trust is staging the development to minimize adverse environmental effects and accommodate the needs of existing users and potential needs of future generations. They recognise geothermal taonga ("treasures") such as therapeutic and cooking pools. A key part of the development is re–injection of used geothermal fluid back into the deep geothermal aquifer to minimise the impact on existing geothermal features and natural ecosystems.

Future work
The Trust has exclusive rights to the first stage of development. In 1999 the Trust built a 55 megawatt geothermal power station on the site. Now that the power station is up and running, the Trust plans to use excess heat for glass house heating, timber drying, and tourist ventures. As well as making more efficient use of the geothermal resource, this will provide employment for the Mokai community and generate new revenue.

Barriers and Solutions

The Mokai Project has not yet encountered any major obstacles to successful implementation. This case study serves to highlight some of the distinguishing characteristics of this project that provides energy to an underserved area within the industrialized world.

The plant was commissioned in March 2000 and is the first geothermal installation to be wholly owned by a Maori Tribal Trust. One of the energy sector's lesser-known achievers, the privately owned Mokai geothermal power station is about to increase capacity by a third. Investment of more than $40 million in the station will boost output by 39 megawatts. Mokai is owned by the Tuaropaki Trust, which owns 2700ha of land around Taupo and has 1700 Maori beneficiaries. The Trust was the first indigenous group in the world to raise financing for such a project. Though financing for the expansion is still being finalised, the contract to build the new plant has been awarded to an Israeli company, Ormat, which hopes to have it finished by the end of 2004.

Pat Brown, one of the partners at Taupo accountancy firm Stretton & Co, which provides support for Tuaropaki, said the trust did its work quietly and without fanfare. Brown said he understood that when the station was completed in 1999, "Mokai was running extremely well, performing ahead of expectations and earning a profit, much of which went to paying off debt or was put aside for expansion. State-owned enterprise Mighty River Power runs the station and also has a commitment to buy some of the electricity it produces."

The Mokai project was implemented in a restrained manner. The geothermal plant is being expanded slowly as the nature and capacity of the field has become apparent, according to Brown. This is known in the sector as "suck and see". In the past, geothermal fields often were depleted quickly. According to Brown, "We are just plodding along at the start. We'll observe it for a few more years before we take the next step." The trust, he says, has taken a long-term view of the field and its use, wanting it to be available forever and a day, hence the caution at the beginning of the project. Chris Bromley, a geothermal scientist at the Institute of Geothermal and Nuclear Sciences, said, "The Mokai field has been developed slowly with the idea of finding out how quickly hot water could be taken from it." While the new expansion would take the station's output up to 100MW, there is probably potential to double this capacity. Bromley also thinks that the total amount of energy provided by geothermal fields could be doubled by expanding existing fields and developing new ones.

7. Koudia Al Baïda Wind Farm in Morocco

Overview

Location:	20 km north of Tetouan, 30 km east of Tangiers, near the Strait of Gibraltar
Number of air generators:	84, spread out along an 8 km long crest at an altitude of between 370m and 560m
Capacity:	600 kW per generator
Total installed capacity:	50.4 MW
Construction time:	March 1999 to July 2000
Commissioning:	30 August 2000
Full power generation:	4000 hours/year
Emissions reduction:	average of 140 000 t of CO2 per year over 19 operating years, as calculated in comparison to the average emissions of Moroccan generation plants

History

The Marrakech «Renewable Energies Development Center» carried out the first studies more than 10 years ago.

At the end of 1994, the National Electricity Office (ONE) launched an international invitation for private investors to create a wind generation unit at Koudia al Baïda, using the new institutional scheme of 'concessionary generation'.

Financing and operation

Koudia Al Beïda is financed and operated by a Moroccan company created specifically for this purpose in 1998: the *Compagnie Eolienne du Detroit* (CED). The capital of CED is divided as follows: EDF (49%), Parisbas Industrial Affairs (35.5%) and an individual, the promoter and president of the company (15.5%).

Legal status of the CED

Under Moroccan Law, a contract signed with the Moroccan *Office National d'Electricité* (ONE) is a BOOT (Build, Own, Operate, Transfer) type of contract. CED designs, builds and operates the wind power site for a period of 19 years before transferring the facilities to ONE. During this 19-year period, the ONE purchases all electricity generated.

Environmental aspects

An environmental impact assessment (EIA) was carried out before the construction of the wind farm, taking into account the effects of the wind farm on the physical environment, landscape, neighboring populations, and wildlife - particularly migrating birds which are numerous in the region of North Africa near the Strait of Gibraltar. In order not to hinder the bird migration corridors, the turbines are organized into three separate groups located several hundred meters apart.

An evaluation of the impact of the wind farm on migrating birds was carried out by the Morocco Ornithological Group during the post-courtship migration from the end of August to the end of October 2001. During this period, 9,000 long-flight birds and 1,300 passerines were observed within the west wind. (In the east wind, migration takes place in the Tangiers region.) The long-flight birds reacted to the presence of the generators by skirting them to the west, either by using the special corridors between the turbines or by flying at a higher altitude, while passerines use the corridors. Only two migrating birds died after collision with the blades of wind generators.

Experience and feedback gained during the implementation of the project

Prerequisite and positive aspects:

- Existence of a legal framework provided by the Moroccan Laws in the field of foreign investment and environment despite the difficulties in "concretizing" the Moroccan Concessionary Generation bill of October 1994.
- Strong involvement of the national and local authorities.
- Existence of a powerful local partner (the 15.5% partner in CED) facilitating the "stepping out" strategy and sale of electricity.
- Existence of local undertakings participating in the construction and maintenance of project facilities, contributing to local economic development.

Obstacles and main difficulties

Warranties and financing issues: Specifically, this refers to the specificity of the financing of such a project without payback return allowed by International Financing Institutions (EBI) in the absence of a state warranty. In case of cancellation of the project, the financial package is extremely complex. The potential payback by ONE of the corresponding amount is warranted by a consortium of five Moroccan banks that accepted to give their warranty at the initial request of CED.

Legal issues: ONE refused the arbitration of Le Centre International pour le Règlement des Différends relatifs aux Investissements (CIRDI) that is widely recognized as the relevant institution for international investments. Finally, an agreement was reached on arbitration by the International Chamber of Commerce. However, one might suspect that this potential arbitration will be contested, as it would concern proceedings and goods under the regime of the Moroccan Public Right.

As a result of the above, the contractual arrangements were particularly complicated, with consequences for the transaction costs of the project. For this relatively modest-sized project, the negotiations were quite long, lasting from mid 1996 to October 1999. Furthermore, four contracts had to be signed for the construction, ownership transfer, operation of the facilities, and the power purchase agreement with ONE.

Main lessons learned

Despite the existence of the Moroccan Concessionary Generation Bill, it took several years to implement this project. One might expect, however, that new projects will be developed more smoothly by taking advantage of the experience gained in the implementation of the Koudia Al Beïda Wind Farm. This case gives evidence that without the existence of an appropriate and developed "welcoming infrastructure" of policies and institutions within host countries, the development of any electricity projects in developing countries and economies in transition could be long and difficult, with little attractiveness to investors. Such "welcoming infrastructures" should include the necessary and relevant provisions for institutional, legal, fiscal, financial as well as Clean Development Mechanism (CDM) issues. In this light, the challenging set of actions to create such "infrastructures" appear to be prerequisite measures for facilitating diffusion of sustainable energy technologies.